Why Evaluate Corn Nitrogen Recommendation Systems?

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Nitrogen recommendations provided by land grant universities and extension services are receiving increasing scrutiny due to continuing concerns about the effects of agricultural N use on water quality. Specifically, N losses from agricultural systems have been identified as likely contributors to elevated groundwater nitrate concentrations and to Gulf of Mexico hypoxia. In addition, university N recommendations are being widely used as the technical criteria for nutrient management regulatory policy. These policies often view university recommendations as a vehicle for achieving environmental objectives, while the basis for developing the recommendations is usually economic. These issues, along with the need to provide producers with reasonable economic returns from N use in crop production, emphasize the importance for reliable, science-based N recommendations. This section will explore several concepts regarding N recommendation systems.

Historically, corn N recommendations were based on soil-specific criteria and/or on crop management variables such as rotation and manure application. For example, N recommendations for CC in Iowa (Voss, 1969) varied depending on soil productivity and the geographic location of the soil. In Wisconsin, recommendations were based on relative soil yield potential determined from soil type information and producer management level (Walsh and Schulte, 1970). These recommendations were also adjusted for manure and previous crop N contributions.

Currently, yield-based N recommendations are used in most Corn Belt states. The widespread interest in and adoption of yield goal-based N recommendations in much of the United States was stimulated by Stanford's classic paper (Stanford, 1973). That work described a mass balance approach for assessing corn N fertilizer needs by considering N uptake at a specific dry matter yield level and N contributions from nonfertilizer sources. Stanford's approach was probably intended to provide an assessment of total crop N requirement rather than a process for making N recommendations. However, it identified corn N requirements on a per-unit-of-yield basis, and it was widely adopted for making yield-based N recommendations. The typical yield-based approach is to multiply a yield goal value by a lb N/bu factor (often 1.2 lb N/bu) to obtain a fertilizer N recommendation that can be adjusted for N contributions from other sources, such as manure, previous legume crops, soil nitrate, and soil organic N mineralization.

Recently, the yield-based approach to N recommendations has been questioned for the following reasons:

- poor relationship between recommendations and the *economic optimum N rate* (EONR) observed in N rate response trials (Figure 4),

▪ uncertainty about how yield goals should be determined,

▪ the assumption that N use efficiency is constant across sites and years, and

▪ use of inadequate or inappropriate adjustments for nonfertilizer N sources.

While there should not necessarily be an expectation for a yield-based rate recommendation to precisely match each site EONR, lack of such a relationship does raise questions about the approach. Poor performance of yield-based recommendations becomes particularly apparent when observed crop N fertilization needs at current high corn yield levels are substantially less than the yield-based N recommendations (Figure 4). That is, high corn yields are not indicative of high N fertilization need.

The lack of relationship between EONR and yield occurs for both CC and SC, and is found in states across the Corn Belt. While plant N requirement does increase with greater plant biomass production (and higher grain yield), variation in soil N supply disrupts the direct relationship between yield and fertilization need. The soil N supply (as measured by the fraction of yield when no N is applied) varies among sites and can be quite large (Table 1). These variations have an important influence on the magnitude of yield increase from N application (N response), shape of the response curve, and EONR (Figure 5). Another issue with the yield-based approach is use of a lb N/bu factor derived from CC for calculating N fertilization rates for SC. Instead of using an N factor derived from CC, a direct determination of optimal N rate should be made for corn in each rotation. This approach eliminates the need to estimate N factors and rotation credits and removes the confounding of yields with different rotations.

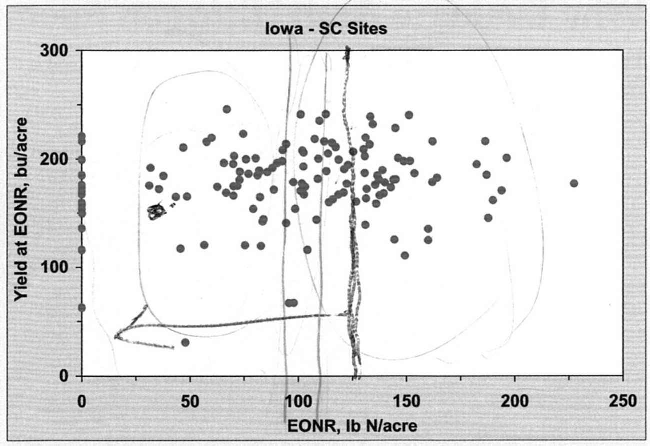

Figure 4. Example of the relationship between corn grain yield and EONR found in states across the Corn Belt. The graph is for SC sites in Iowa (0.10 price ratio). Points on the left axis represent sites where there was no response to N fertilizer rate.

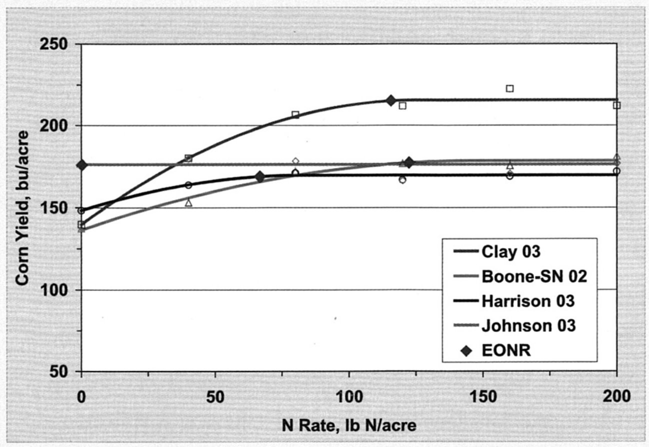

Figure 5. Types of responses found in N rate trials, with site examples showing corn yield increase with N application (EONR indicated at 0.10 price ratio).

Alternatives to yield-based N recommendations are in use in several states, and additional alternatives are explored in this publication. Nitrogen recommendations in Iowa are based on cropping system and results of a soil nitrate test (Blackmer et al., 1997). In Wisconsin, N recommendations were revised in 1990 using a soil-specific approach based on the results of numerous N response trials conducted on the major soils used for corn production. These recommendations recognize that corn yields can vary substantially from year to year on a given soil, and are consistent with results of N rate response trials that showed that EONR does vary, but not with the yield attained. Both the rationale and approach used in developing the recommendations are described by Vanotti and Bundy (1994a; 1994b).

Obviously, average corn yields and yield potential of today's corn hybrids are greater than those seen in previous decades. It is not clear, however, that these higher yields translate into higher rates of N needed to optimize yields. Corn yield response data were examined from about 20 site-years in Wisconsin that were separated by 10 to 12 years in time. The results showed no clear indication that current optimum N rates are higher than those of 10 years ago. Further investigation of this question using long-term data from two Iowa cropping systems studies allowed comparison of optimum N rates observed in a recent 10- to 12-year period with those from the preceding 10 to 12 years. These data showed that optimum N rates increased over time at one site and decreased at the other site. Again, the results provide no clear indication of a change in N rates over time. Potential reasons for similar or decreasing optimum N rates where yields have increased substantially include more efficient utilization of available N by the crop and increased soil N supplying capability.