The Delta Yield Concept: An Update

By T.S. Murrell

Delta yield is the measure of crop response. Relating it to fertilizer need may improve fertilizer recommendations in the future by incorporating both yield level and crop responsiveness.

In 1996, an article appeared in *Better Crops with Plant Food*, written by Dr. R.G. Kachanoski, that introduced the delta yield concept to readers of this magazine (Kachanoski, 1996b). The question being addressed at that time was whether or not yield maps provided a reasonable basis upon which to vary N application across the field, since many N recommendations were based on estimates of attainable yield.

In the original article, it was shown that economically optimum N rates (EONR) were poorly correlated to maximum yield or the yield associated with EONR. Since that time, other studies have noted similar results, such as those in a regional publication by Sawyer et al. (2006).

So why this lack of a relationship between EONR and the yield at EONR? **Figure 1** provides some possible reasons. The figure shows three possible responses of corn to applied N, holding maximum yield constant. The lowest curve illustrates a very large response to applied N. This type of response often results when the soil itself is not capable of supplying much N, indicated by a low yield without applied N and a high EONR. At the other end of the spectrum is the straight line across the top, showing no response to applied N and an EONR of zero. In this case, the soil supply is adequate, making subsequent additions unnecessary. The curve in the middle shows a case between these two extremes, where soil supplies of N and EONR are moderate. In each case, the final yield is the same, but the EONRs needed to attain that yield are very different. So rather than maximum yield or yield at EONR, it is the response to N that is better related to EONR – the concept proposed by Kachanoski (Kachanoski et al., 1996a; Kachanoski et al., 1996b).

The metric Kachanoski used to describe yield response was delta yield (ΔYield). The Greek letter delta (Δ) is often used as shorthand notation for "the difference in" or "the change in" some parameter. So delta yield is simply an abbreviated

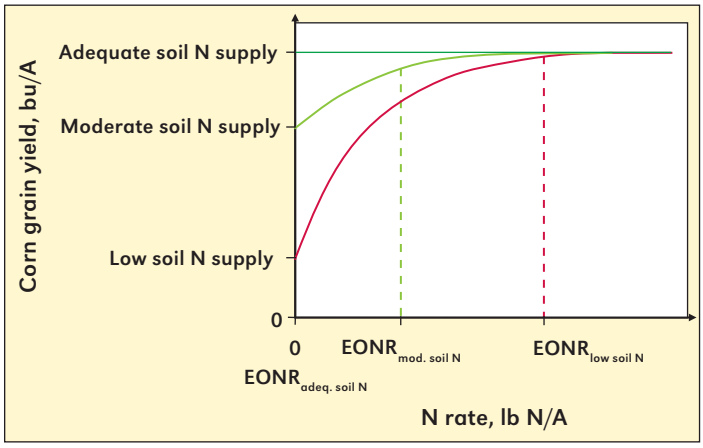

Figure 1. Conceptual responses of corn to applied N at different soil N supplies. Maximum yield is held constant for all responses.

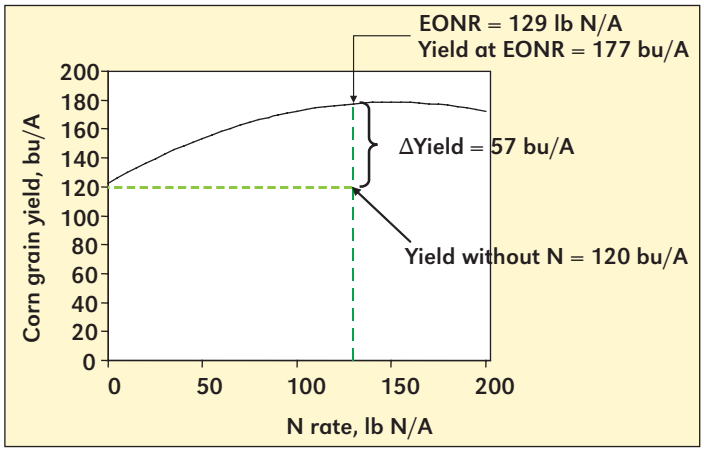

Figure 2. An example of corn response to applied N. Delta yield is the difference between the yield without applied N and either the maximum yield or the yield at EONR. The latter definition is illustrated

way of saying the difference in yield. As illustrated in **Figure 2**, this difference was between the yield where no N was applied and either 1) the maximum yield (ΔYield-max) or 2) the yield associated with EONR (ΔYield-econ). ΔYield-econ is illustrated in **Figure 2**.

In the past few years in the Corn Belt, scientists have been revisiting the validity of current recommendations that are based on yield goals and N credits. Dr. Paul Fixen, IPNI, recently wrote a retrospective of how such recommendations came into being and the requirements for their future use (Fixen, 2006). Recent work by many scientists at land grant universities has centered on creating recommendations from generalized N response curves. Such recommendations do not consider yield goals due to their lack of correlation with EONR (Sawyer et al., 2006).

Kachanoski noted that ΔYield-econ and EONR were well related. ΔYield-econ accounted for 50 to 75% of the variability in EONR in his studies (Kachanoski et al., 1996b). More recently, Lory and Sharf (2003) examined 298 N response experiments across five state (Illinois, Minnesota, Missouri, Pennsylvania, and Wisconsin). In 105 of the 298 locations, EONR was zero, reflecting the lack of responsiveness to any applied N at those sites. At the 193 remaining responsive sites, ΔYield-econ accounted for approximately 47% of the variability in EONR, when all data were grouped together. When such relationships were separated out by each state, the range in EONR variability accounted for by ΔYield-econ was 35 to 65%.

Fairly good relationships between delta yield and EONR led Lory and Sharf to propose a generalized approach to making

Abbreviations and notes for this article: N = nitrogen; EONR = economically optimum N rate; ISNT = Illinois Soil Nitrogen Test.

fertilizer N recommendations. Recommended N was expressed as a function of the yield without N, delta yield, and the change in grain N concentration with delta yield. This approach to making recommendations represented a fundamental shift away from using approaches based primarily upon yield goal. However, yield was still an important component and determined N requirements through both the yield without N and the delta yield factors in the equation.

The Future

The new generalized model for making recommendations proposed by Lory and Scharf creates fundamentally new types of information that must be collected on the farm if crop advisers wish to tailor such equations to fit their local conditions. Rather than just keeping records of historical yields, information will need to be gathered on the yields attainable when no N is applied as well as the magnitude of crop response to applied N, both in grain yield and in grain N concentration. Lory and Scharf determined, using economics current at the writing of their paper, that collecting data on yield without N, which also provides the basis for calculating delta yield, would cost less than $1.38/A if the strip were 60 ft. by 120 ft. and placed once every 10 A in the field. As Blackmer and White noted, with the advent of newer technologies, such information is much more readily collected now than in the past (Blackmer and White, 1998). However, university scientists and advisers will need to work together to develop protocols to collect, share, analyze, and interpret data.

In the ΔYield concept, yield without N is a biological indication of a soil's ability to supply N to the crop. Ongoing research has been conducted to develop soil tests that are able to indicate soil N supply. A newer example is the Illinois Soil Nitrogen Test (ISNT) (Khan et al., 2001). If such tests can be calibrated, they may be able to substitute for information gained from on-farm experiments. Williams et al. (2007) investigated several soil N tests, including ISNT, delta yield, and EONR relationships. **Figure 3a** shows the relationship between ΔYield-max and EONR for the mineral soils in their study, and is similar to the types of results obtained by Lory and Scharf (2003), with ΔYield accounting for 43% of the variability in EONR. **Figure 3b** demonstrates that ISNT was related to ΔYield and accounted for 49% of its variability, making it possible to relate ISNT to EONR, as shown in **Figure 3c**. This latter graph shows ISNT accounted for 90% of the variability in EONR on the mineral soils studied. Williams et al. state that much work remains to calibrate ISNT to crop response. Other studies have shown difficulties in relating ISNT with crop response when no other factors were considered (Klapwyk and Ketterings, 2006). In the future, soil tests or some other methods of detection may alleviate the need to conduct on-farm research to estimate delta yield measurements to further investigate their efficacy of use. BC

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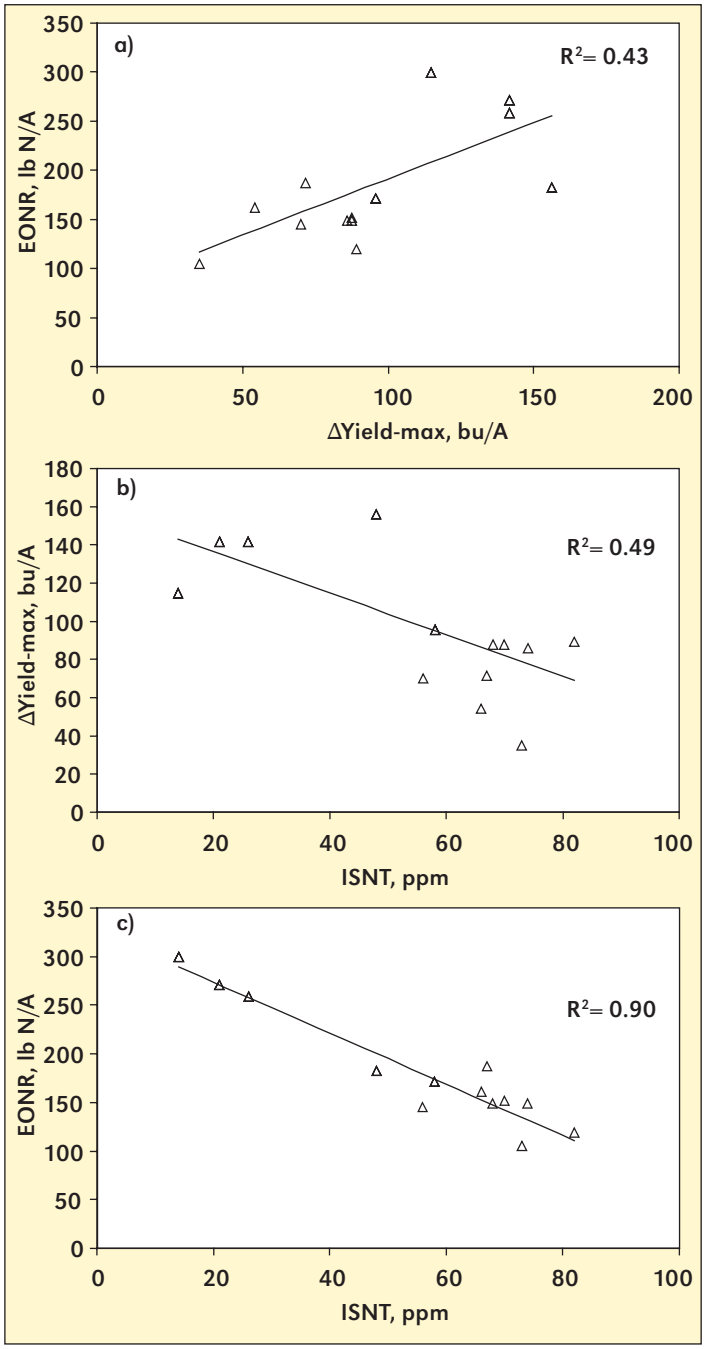

Figure 3. An example of how the delta yield concept is used when interpreting research results: a) a relationship showing that as responsiveness increases, optimum N rates increase; b) an example of how a soil N test might substitute for an actual measurement of delta yield; and c) an example showing how a soil N test might be able to predict EONR (adapted from Williams et al., 2007).

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