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*Department of Plant and Soil Sciences*

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## **The Corn Belt Multi-State Corn Nitrogen Rate Calculator: Not Reliable for Kentucky Corn Producers**

John H. Grove and Gregory J. Schwab

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**B**ecause of the rising price of nitrogen (N) fertilizer, university personnel across the country are in the process of fine tuning N recommendations for corn. Historically, each state has had different N recommendations based on research results obtained in different production systems and growing environments across each state. Some states in the Corn Belt have used a yield potential (yield goal) approach to N recommendations. The expected yield is multiplied by a factor (usually 1.2) and then N credits for previous crop, manure, etc. are subtracted. One problem with this method is that as corn yields increase N recommendations also increase. While this might seem logical, some studies show that N requirements are rising at a much slower pace than corn yield. This simply means the corn plant is becoming a more efficient user of N. States using the yield goal approach are realizing that, with time, their recommendations are increasingly exceeding the needs of the crop. For this reason, they are considering alternatives to the yield goal approach.

In Kentucky, our research data has always shown that yield is a poor predictor of N requirement. One explanation of this observation is that years with very favorable growing conditions (plenty of growing season precipitation) also have favorable conditions for N mineralization from soil organic matter. Conversely, years with poor growing conditions tend to have lower rates of mineralization. Because more N is supplied by the soil in productive years, the rate of N required per bushel of yield is less compared to the years with low mineralization. The net result is that corn requires about the same amount of fertilizer N, regardless of the yield potential in a given year.

Even though the amount of N taken up by a corn crop is about the same each year, not all Kentucky's corn fields require the same amount of fertilizer N. For example, consider two fields both having a 150 bu/acre corn yield. Nitrogen taken up by the plants would have been roughly the same for both fields, but the fertilizer required to achieve this uptake could be vastly

different. Remember that the fertilizer requirement of the crop is a function of three components: 1) the N uptake requirement of the crop, 2) the soil's ability to supply N (related to previous crop, manure applications, and to a lesser extent organic matter), and 3) the soil's potential for N loss. In fact, the loss potential has much greater impact on the fertilizer N requirement than the yield potential. In Kentucky, the predominant N loss mechanism is denitrification, the conversion of nitrate-N to  $N_2$  and  $N_2O$  gases. This loss process occurs when soils are not well-drained, becoming overly wet and oxygen-depleted. Poorly-drained soils are most prone to water saturated conditions and have the greatest potential to lose N to denitrification. Therefore, Kentucky's fertilizer N recommendations for corn change according to a soil's drainage classification. As the soil's drainage becomes increasingly imperfect (increasingly prone to wetness), more N must be added to offset likely losses. Because all soils are generally drier at the time of side-dress N application, lower fertilizer N rates are recommended at this time.

Recently, several states in the Corn Belt (Iowa, Illinois, Wisconsin, and Minnesota) have begun to combine and reexamine their data sets, in order to develop regional corn N recommendations. They too have found that yield is a poor predictor of corn N requirements, and have chosen to develop a model that only considers previous crop, price of corn, and price of N fertilizer to determine the economically optimal N rate (EONR). In this article, we will examine the regional approach to N fertilization and discuss why we found it to be inappropriate for Kentucky corn producers.

### **The Multi-State Corn N Rate Calculator**

The common approach decided upon by the Corn-Belt universities involved economic analysis of dryland (non-irrigated) corn yield versus N rate data taken at multiple locations for multiple years. Distinctions are made by state (Iowa, Illinois, Wisconsin, and Minnesota) and by previous crop (corn after corn versus corn after soybean). However, the calculator makes

no distinction for N application timing (pre-plant versus side-dress), soil drainage, tillage, fertilizer N source, or manure history. An individual state's multi-site-year data for corn after corn or corn after soybean were pooled and a single production function (corn yield versus fertilizer N rate) developed. This production function is the basis for the determination of EONR by the corn N rate calculator.

When using the calculator the corn grower chooses the state of interest, the expected prices for N and corn, and previous crop (either corn or soybean). The grower specifies whether the production function database should include all site-years of data or only those where a response to N was observed. The calculator then calculates the EONR at which the grower would expect the maximum return to N, based upon research data in the database (either with or without non-responsive sites). The calculator also determines the N rate on either side of the EONR at which the corn producer would expect a net economic loss of \$1.00 per acre from either under- or over-application of fertilizer N relative to the EONR.

We are going to work through an example for Illinois merely because it lies closest to Kentucky. Considering a corn price of \$2.00 per bushel and an N price of \$0.30 per pound of N, the EONR for the maximum return to N ranges from 136 lbs N/acre for corn after soybean, with non-responsive site-years included, to 141 lbs N/acre for corn after corn, with non-responsive site-years excluded. Inclusion of non-responsive site-years causes the singular production function being calculated to "maximize and flatten out" at lower fertilizer N rates, lowering the calculated EONR. A series of four graphs, produced by the calculator for corn after soybean, with non-responsive site-years excluded, are shown below. The first graph (Fig. 1) illustrates, as a function of the fertilizer N rate, the gross return to N ((yield at each N rate minus yield of the unfertilized control) x corn price), the fertilizer N cost (N rate x N price), and the net return to N (gross return to N minus the fertilizer N cost), using the single average

production function. Figure 1 highlights the calculated EONR giving the maximum return to N (141 lb N/acre), and also the range in fertilizer N rates around the EONR where the economic loss due to under- or over-fertilization is calculated to be no more than \$1.00 per acre (121 to 162 lb N/acre). The second graph (Fig. 2) illustrates, for the singular production function being calculated, the proportion of maximum yield (in %) to be expected as a function of fertilizer N rate. Figure 2 also highlights the proportion of maximum yield to be expected at the EONR giving the maximum return to N (97%), and also the range in the proportion of maximum yield due to under- or over-fertilization where the economic loss is calculated to be no more than \$1.00 per acre (95 to 98%). The third graph (Fig. 3), a vertical bar graph, shows the distribution of site-years against site-year EONR, for the specified corn and N prices. To do this, the calculator goes back to the original data set (172 site-years for corn after soybean, non-responsive sites excluded), applies the specified prices to the individual site-year production functions, and then determines each site-year's EONR. ***Careful examination of Figure 3 and the fourth graph (Fig. 4), where optimum yield is plotted against EONR for all individual sites, makes it clear that there are a large number of site-years (approximately 120 - 70%) whose calculated EONR values lie outside of the recommended fertilizer N rate range (121 to 162 lb N/acre).***

If the 172 responsive site-years of corn yield versus N fertilizer rate information adequately represent the "possible" corn after soybean "production environments" in the state of Illinois, then an Illinois corn producer using the calculator would have applied the actual

economic optimum N rate only 30% of the time. Some (about 36%) would have been over-fertilized, and others (about 34%) would have been under-fertilized. Because there is no Kentucky data in the model, the calculator is likely less accurate for a Kentucky corn producer.

## **Conclusions**

Similar to the Corn Belt's multi-state calculator, Kentucky's fertilizer N rate recommendations for corn incorporate the results of many site-years of research. The results of those many site-years of research imply that soil drainage class and primary tillage system are critical to the economically optimum N rate for Kentucky. Those recommendations are further modified according to various fertilizer N source/placement/timing options and manure and previous crop history. Within each drainage class and tillage system, University of Kentucky recommends a range (25-35 lbs N/acre) of N. These are the economically optimum N rates for corn grown in Kentucky. The actual rate selected (within the range) should be based on knowledge and experience as well as the price of N and the expected price of corn. In years with high fertilizer N relative to corn price (like 2006), we recommend producers select rates at the lower end of the range.

Kentucky's corn producers will be well served by targeting each field's N rate within the range appropriate for the field's soils, according to Kentucky's fertilizer N rate recommendations (AGR-1). Producer and county Extension agent knowledge and experience with corn's responsiveness to local growing conditions may guide the final N rate chosen for each field.

# Corn Nitrogen Rate Calculator

## Finding the Maximum Return To N

State: Illinois  
 Number of sites: 172  
 Rotation: Corn Following Soybean  
 Non-Responsive Sites Not Included

Nitrogen Price (\$/lb): 0.30  
 Corn Price (\$/bu): 2.00  
 Price Ratio: 0.15

	Profitable N Rate Range		
	LOW	MRTN	HIGH
Return to N (lb N/acre):	121	141	162
Yield (bu/acre):	168	172	174
Net Return to N (\$/acre):	\$84.73	\$85.73	\$84.73
Percent of Maximum Yield:	95%	97%	98%

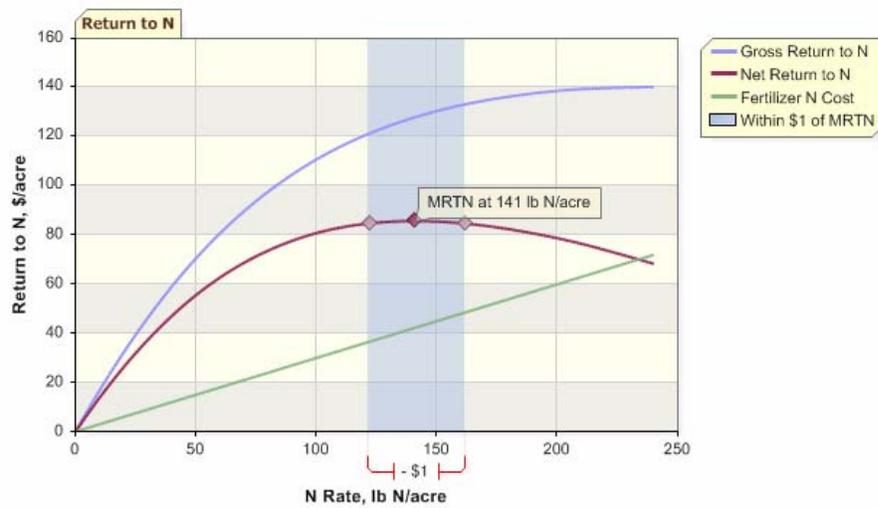


Figure 1. Maximum return to N for Illinois corn following soybean (\$2.00/bu corn and \$0.30 N/lb). Taken from the Multi-State Corn N Rate Calculator website (<http://extension.agron.iastate.edu/soilfertility/nrate.aspx>).

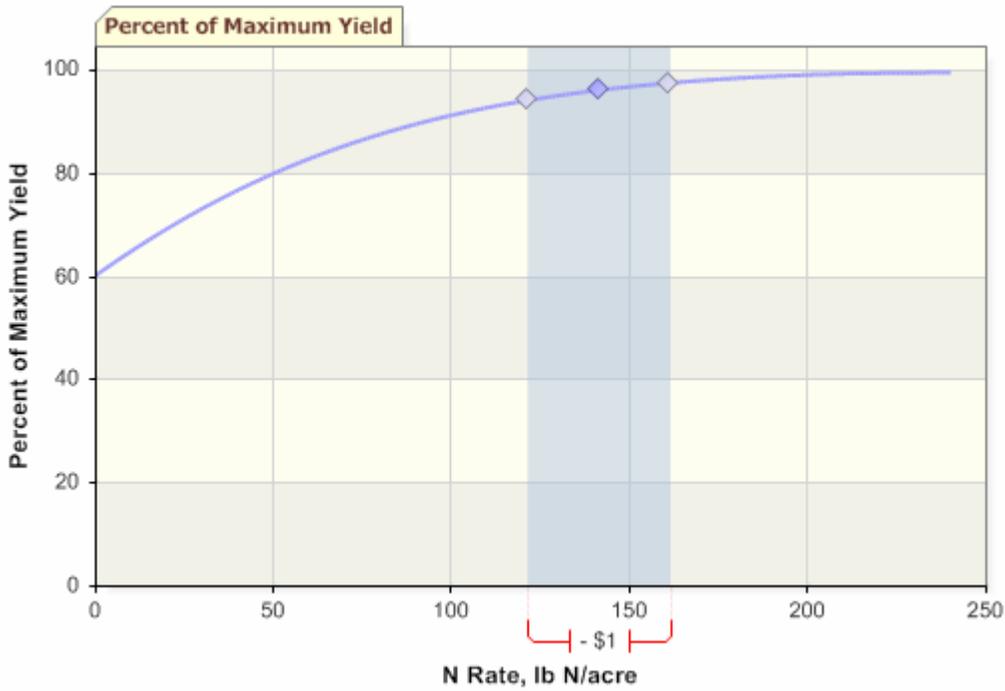


Figure 2. Percent of maximum yield expected for Illinois corn following soybean. Taken from the Multi-State Corn N Rate Calculator website.

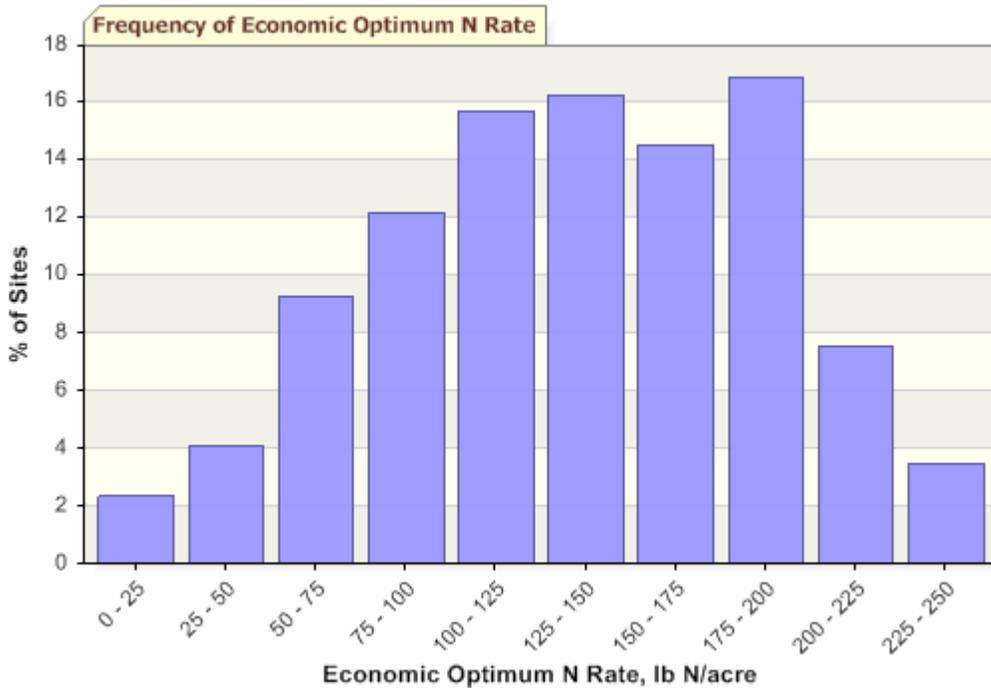


Figure 3. Distribution of economic optimum N rates for studies conducted in Illinois (corn following soybean) with the non-responsive sites removed. Taken from the Multi-State Corn N Rate Calculator website.

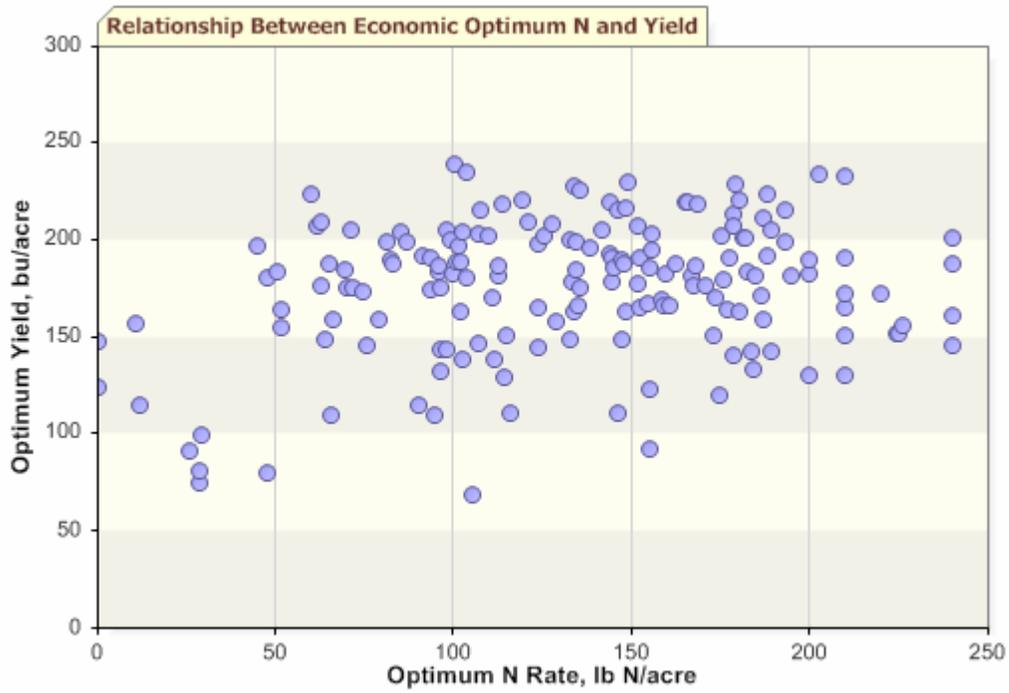


Figure 4. Relationship between economic optimum N rate and yield for corn following soybeans in Illinois. Taken from the Multi-State Corn N Rate Calculator website.

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Greg Schwab  
Extension Soils Specialist

Cooperative Extension Service  
U.S. Department Of Agriculture  
University Of Kentucky  
College Of Agriculture  
Lexington, Kentucky 40546

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