Nitrogen input decisions with tight crop production margins

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Introduction

High-yield corn production would not be possible without adequate nitrogen (N) supply. Unless corn follows established alfalfa, N application from fertilizer or manure is almost always needed in Iowa crop rotations with corn following soybean and corn following corn to meet crop demands. This N fertilization need is especially important considering the recent period of high rainfall years in Iowa where residual N is reduced and N response increased. In dry periods, such as the late 1980's to early 1990's, there were field situations where no response to applied N would occur, but that has not happened in the recent time period. For example, late-spring soil nitrate-N test levels when no manure or fertilizer was applied have been consistently below the test critical level in recent N rate research trials (94% below the critical level of 25 ppm nitrate-N from 1999-2014). This is a clear indication of the high N responsiveness in Iowa corn production.

Unfortunately, the need for N application does not allow many opportunities for adjustment when production margins become tight, as is the current situation with corn production. Unlike phosphorus (P) and potassium (K), where P and K is held in the soil and available to crops over multiple years, N must be a yearly input as crop available N cannot be held in the soil due to nitrification and the loss mechanisms of nitrate leaching and denitrification. Even following drought years, like 2012, much of the residual nitrate in the soil profile from N application not used by the 2012 corn crop did not remain in the rooting profile due to high rainfall in May of 2013. One rotation difference, as mentioned above, is corn following alfalfa where an important reduction (or no N application need) to N rate should be made. That rotation is an instance where, if not utilized before, significant N cost savings can occur.

Adjusting nitrogen rates for changing economics

Suggested N rates for corn in Iowa are determined by use of the Corn N Rate Calculator (CNRC), available at http://extension.agron.iastate.edu/soilfertility/nrate.aspx; and from ISU Extension and Outreach publication CROP 3073, Nitrogen Use is Iowa Corn Production, available free of charge at https://store.extension.iastate.edu/Product/Nitrogen-Use-in-Iowa-Corn-Production. These resources for determining suggested N rates use the principal of diminishing returns where the yield increase from N application decreases as N rates increases, and eventually an N rate is reached where additional N will not be paid for by a corn yield increase (Figure 1). Following from that, the CNRC uses net return to N application from many field-based N rate response trials to find the N rate that maximizes net return to N application (Maximum Return to N, MRTN). Due to uncertainty in where that MRTN rate falls, a range of most profitable N rates is provided that brackets the MRTN rate. An example of the MRTN approach is shown in Figure 2 for corn following soybean and corn following corn in Iowa. In all cases, the N rate is not determined from corn yield level, but instead from corn yield increase to N application (yield with no N applied compared to yield with N applied) because the yield increase is what pays for the applied N. In Iowa, N rate suggestions went away from a yield goal system at least eighteen years ago. Examples of the non-existent relationship between corn yield and optimal N rate is shown in Figure 3. You can see that even at very high corn yields, there is not a corresponding high N application rate requirement. In addition, N rate suggestions are derived for each crop rotation, with no “adjustment” for corn following soybean compared to continuous corn. Each rotation has a direct N rate guidance. Figure 4 shows the lack of relationship between the prior year soybean yield and the optimal N rate for the corn crop following soybean, which is one reason N rate suggestions went away from using a soybean yield "N credit" or amount per soybean yield level.

As we look to the 2016 corn production year, tight margins have farmers looking at ways to adjust production costs. For N fertilization, while there is most-often a need to apply N, adjustments can be made based on current or expected N and corn price. Use of the CNRC is a means to optimize rates for current pricing. Optimal rates may or may not help with overall production costs and meeting crop production margins because the ratio of N price and corn price determines economic optimal rates, not just one or the other. In recent years, N fertilizer price has been fairly stable, but corn prices have fluctuated greatly. Therefore, optimal rates now may be lower than just a few years ago. Figure 5 gives an example of the impact of changing corn price (at a set N price) on the optimal MRTN rate and profitable N rate range. Figure 6 gives the corresponding N cost for each corn price. While there is a reduction in MRTN rate at lower corn prices, and concurrent lower N input cost, the greatest effect is on reduction in net return from N application due to the lower corn price. Yield response to N input, while not the only factor that affects corn yield, does have one of the greatest impacts on corn yield available to pay for the total corn production cost, with the overall yield increase from N application much more than needed to pay for the N input. Therefore, N management is critical for high productivity and profitability, but corn price also has a dramatic effect on income to pay for production costs other than N.

Nitrogen management

For greatest return and N use efficiency, N applications should be managed as best possible to gain potential yield benefits. This means timing and method of application to avoid as much as possible N loss conditions. In Iowa, this usually means spring or sidedress/split application rather than fall application. The usual expectation is for fall application to have lower efficiency than spring and sidedress, and for spring and sidedress to be similar. We know that N rate need varies between years, due to N response variation and loss conditions. However, trying to manage yearly corn N requirements by applying high N rates every year is not economically feasible and can cause increased environmental issues for nitrate reaching water systems. If loss situations occur, or higher than normal N rates are needed, it is more appropriate to deal with supplemental applications when that determination has been made. Most years, however, suggested MRTN rates do provide full or nearly full yield production, and only in certain high N loss or high N response years are higher N rates required. Examples are shown in Figure 7 for corn following soybean with spring preplant or early sidedress applied N, where for the Ames site only 1 out of 15 years did the MRTN rate not provide adequate N compared to the site-year economic optimum N rate (EONR) – same for continuous corn, while at the Crawfordsville site 4 out of 16 years the MRTN rate did not provide adequate N – 3 times for continuous corn. While not high frequencies, in recent years (since 2007) there have been more occurrences of wet conditions and problems with N supply, especially in areas with soils that have poor drainage (like the Crawfordsville example), which means there should be greater attention to N management practices.

Summary

Use of the CNRC online tool, or ISU Extension and Outreach publication CROP 3073, can aid in determination of optimal N rates and if adjustment in rates are appropriate with current N and corn prices. Iowa has been divided into two regions for N rate determination; the main Iowa region and Southeast Iowa region. Publication CROP 3073 provides N rate suggestions for each of those regions (the online CNRC has not yet been updated with the two regions), with example N:corn price ratios ($/lb N:$/bu) provided in Table 1. Since the main region of Iowa has the majority of the N rate response trials, the suggested N rates for the main Iowa region are quite similar to the on-line CNRC for the entire state. Rates are higher for the Southeast region.

Table 1. Nitrogen rate suggestions for corn following soybean and corn following corn in the main area of Iowa and the Southeast region. See ISU Extension and Outreach publication CROP 3073 for delineation of the Southeast region.

Price	Corn Following Soybean		Corn Following Corn	
Ratio[1]	Rate[2]	Range[3]	Rate[2]	Range[3]
$/lb N:$/bu	lb N/acre			
Main Iowa Region				
0.05	155	141- 171	206	193 - 228
0.10	136	124 - 147	185	175 - 198
0.15	120	111 - 131	169	156 - 181
0.20	110	100 - 119	152	142 - 162
Southeast Iowa (Soil Regions 17, 21, 22)				
0.05	174	157 - 194	240	231 - 240
0.10	145	133 - 158	211	194 - 230
0.15	134	122 - 140	184	178 - 197
0.20	121	110 - 130	181	170 - 185

[1] Price per lb N divided by the expected corn price. For example, N at $0.50/lb N and corn at $5.00/bu is a 0.10 price ratio. Corn held at $5.00/bu for all price ratios.

[2] Rate is the lb N/acre that provides the Maximum Return To N (MRTN). All rates are based on results from the *Corn N Rate Calculator* as of July, 2014 (http://extension.agron.iastate.edu/soilfertility/nrate.aspx).

[3] Range is the range of profitable N rates that provides a similar economic return to N (within $1.00/acre of the MRTN).

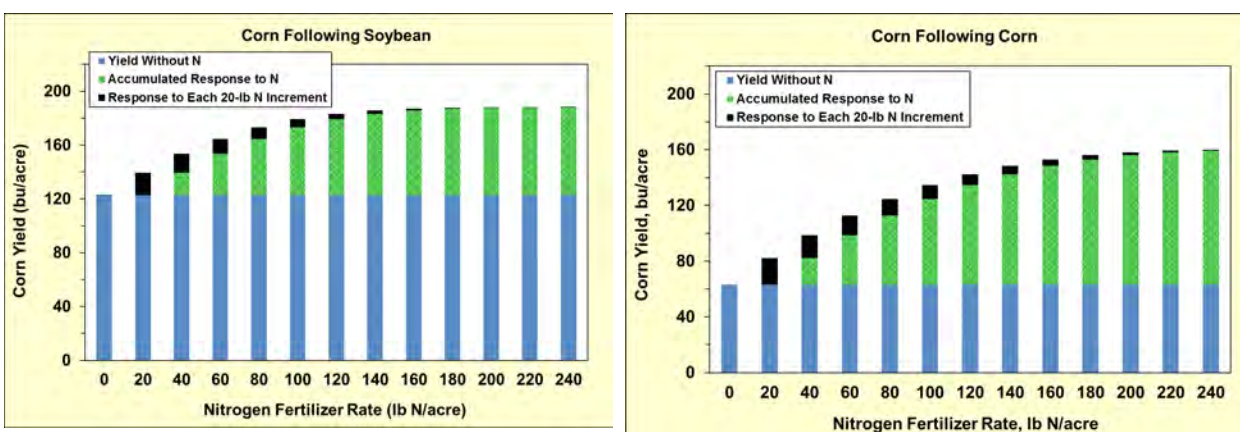

Figure 1. Concept of diminishing return to N application rate for the CNRC datasets for corn following soybean and corn following corn in Iowa.

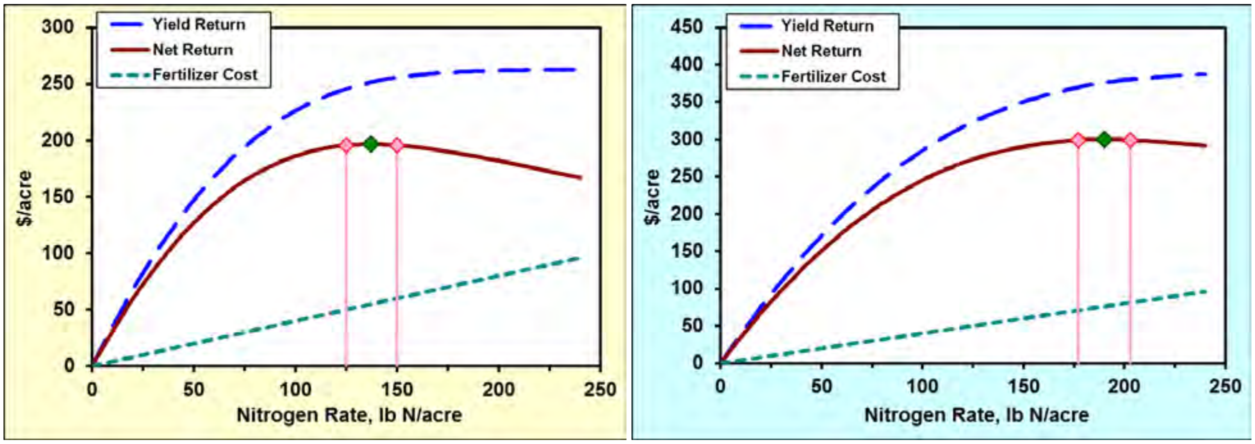

Figure 2. Fertilizer N cost, yield return, and net return to N application rate for the CNRC dataset for corn following soybean and corn following corn in Iowa. The N:corn price ratio was 0.10, with N at 0.40/lb N and corn at $4.00/bu.

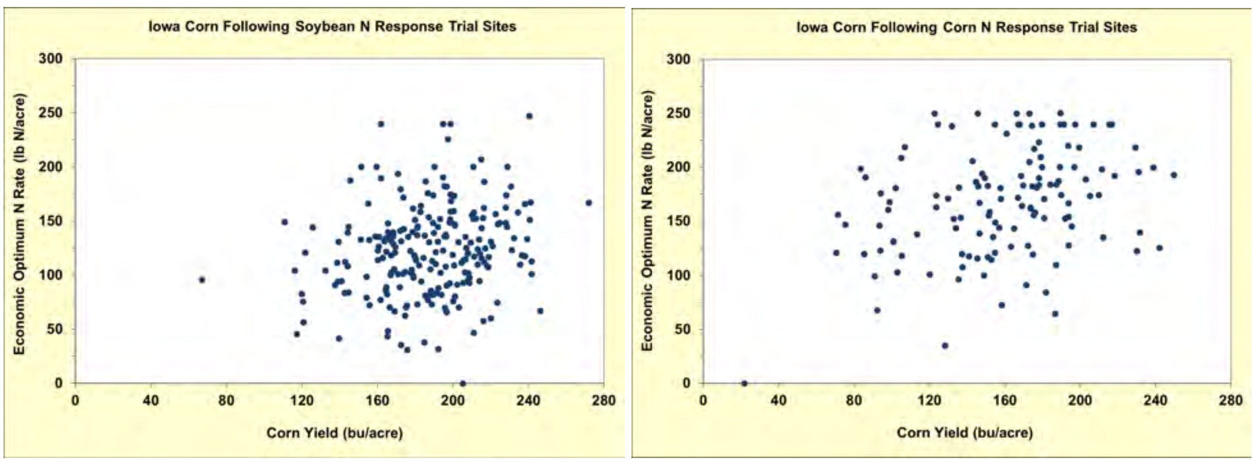

Figure 3. Lack of relationship between corn yield and economic optimum N rate for corn following soybean and corn following corn in Iowa (CNRC datasets).

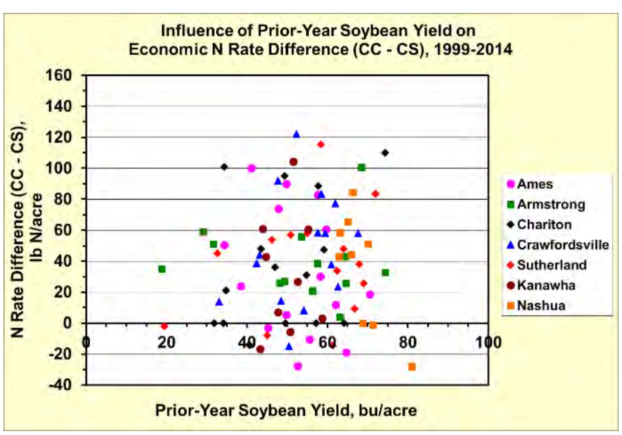

Figure 4. Lack of relationship between the prior-year soybean yield and difference between the optimal N rate for continuous corn (CC) and corn following soybean (SC) at multiple research sites in Iowa (Sawyer and Barker, 2014).

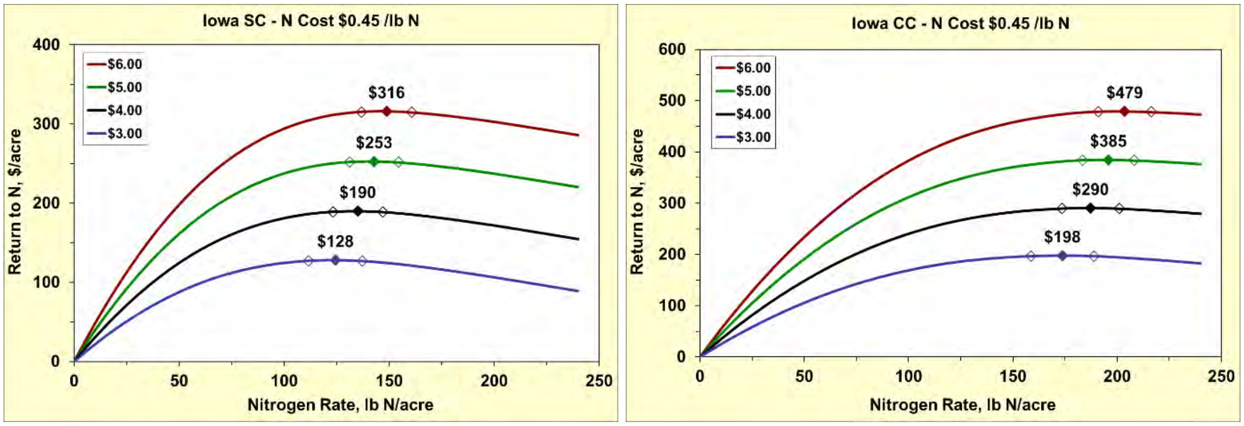

Figure 5. Effect of varying corn grain price on net return to N, optimal (MRTN) N rate, and most profitable rate range for corn following soybean and continuous corn in Iowa (CNRC datasets). Nitrogen price held at $0.45/lb N and corn varied from $3.00 to $6.00/bu. Actual return to N amount will vary by specific yield level and amount of yield increase from N application.

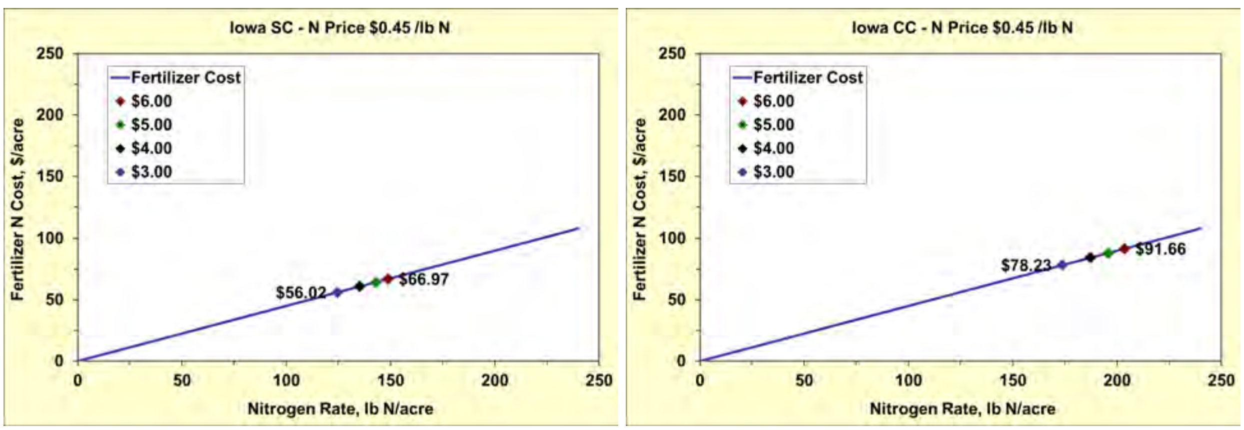

Figure 6. Effect of corn price on fertilizer N cost at the MRTN rate for corn following soybean and corn following corn (CNRC datasets, N price at $0.45/lb N).

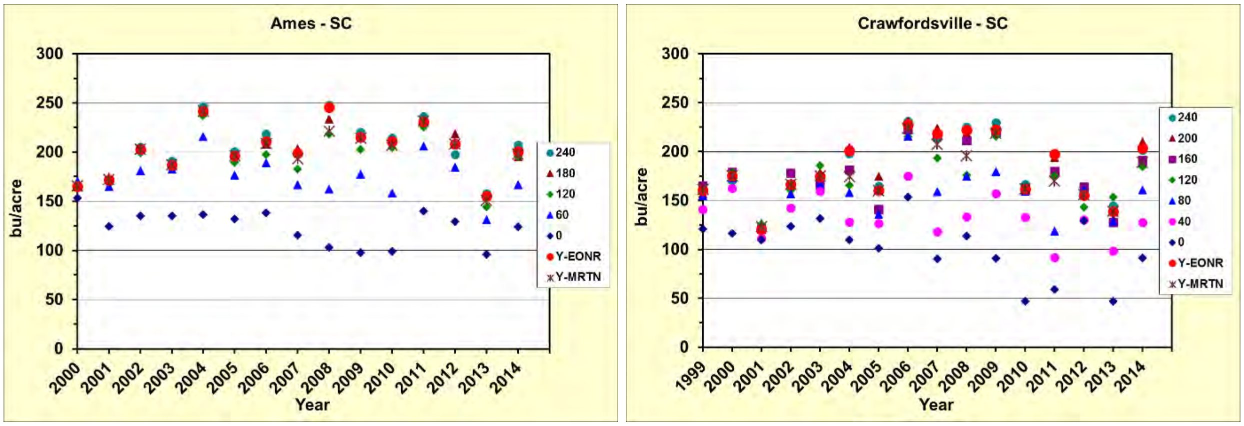

Figure 7. Yearly corn yield (corn following soybean) across fertilizer N rates, yield at the site-year economic optimum N rate (Y-EONR), and site-year yield at the MRTN rate (Y-MRTN) with the MRTN rate of 137 lb N/acre across years. The Ames site (Ag Engineering and Agronomy research farm) has a Clarion loam soil and the Crawfordsville site (Southeast research farm) a Kalona silty clay loam soil. Compared to the Ames site, Crawfordsville receives more rainfall and the soil has poor internal drainage. Sawyer and Barker, 2014.