

Nitrogen Management Update for Indiana

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4-YEAR SUMMARY OF CORN RESPONSE TO NITROGEN FERTILIZER

The average Agronomic Optimum N Rate (AONR) for all of our corn/soy sites since 2006 was 186 lbs/ac total applied N (with an average trial yield of 196 bu/ac). At the five Purdue locations where we conducted paired trials of corn/soy and corn/corn in 2007-2009, the average AONR for corn/corn was 47 lbs greater than for corn/soy while average corn/corn yields were 20 bu/ac less than the corn/soy yields.

Based on \$0.40/lb N and \$3.50/bu corn, the average Economic Optimum N Rate (EONR) for all of our corn/soy sites was 168 lbs/ac total applied N or 18 lbs less than the average AONR. However, the average yield at the EONR was only 0.5 bushel lower than that at the AONR. The EONR values for other combinations of N cost and grain price are listed in Table 1. If you want to determine EONR for other N and grain prices, use the on-line N calculator for Indiana² at this web site:
<http://extension.agron.iastate.edu/soilfertility/nrate.aspx>.

Nitrogen fertilizer costs remain volatile but continue to be one of the most expensive variable costs for corn. Applying “more than enough N” is no longer cheap “insurance” as it once was many years ago. Applying “more than enough N” is also not environmentally friendly. High N fertilizer costs should encourage growers to critically evaluate their N fertility program, including application rate, fertilizer material, and timing.

Nitrogen rate recommendations for a given field were traditionally linked to its historical yield levels³. For corn following soybean, the traditional rule of thumb was an N rate equal to about 1 lb of N per bushel of expected yield. For corn following either corn or wheat, the recommendation was equal to about 1.2 lbs. of N per bushel.

These rules of thumb infer that the more N you apply, the more grain you harvest. Actually, yield response to N is usually not a straight-line relationship. In reality, the first pounds of applied N typically return the greatest number of bushels and the last pounds of applied N typically return the fewest number of bushels. At some level of N, grain

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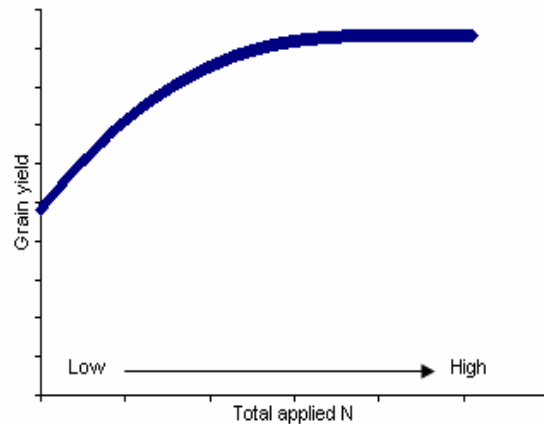
² As of 1/31/10, the on-line N calculator was not yet updated with our 2009 response data.

³ Indiana Nitrogen Rate Recommendations for Corn A Historical Perspective (1953 – 2007). On-line at <http://www.agry.purdue.edu/ext/soilfertility/historical-recommendations.html> [URL accessed Dec 2009].

yield stops increasing with more N. Consequently, applying N above what the crop can use is dollar wasteful and environmentally distasteful.

Throughout the Midwest, most land-grant universities have moved away from yield-based N rate recommendations toward data-driven recommendations that are sensitive to N and grain prices⁴. This so-called “new” approach to N rates is not necessarily new, but simply links documented yield responses to N with the relative economics of grain price and N cost.

A couple of new terms or acronyms have developed from this approach. The term “**Agronomic Optimum N Rate**” or **AONR** defines the N rate that will produce maximum grain yield, regardless of cost. The term “**Economic Optimum N Rate**” or **EONR** defines the N rate that will result in the maximum dollar return to N. The EONR will usually be less than the AONR, will usually decrease as N prices increase, will usually increase as grain prices increase, or may remain the same if the ratio between nitrogen cost and grain price (N:G) remains the same.



The “new” approach requires yield data from numerous field trials documenting corn yield responses to N fertilizer rates across different soil types, climates, crop rotations, hybrids, tillage systems, etc. Until recently, such yield response data available for Indiana were quite old and few in numbers. We began our current N rate trials in 2006 at seven of Purdue’s research centers plus a number of on-farm sites⁵.

To date, over 100 trials have been conducted around the state. About 69% of them are corn following soybean and the remainder are primarily corn following corn. The N rate treatments have ranged from nothing but starter N to as much as 286 lbs/ac applied N. Most of the trials have used sidedress liquid UAN simply to facilitate trial logistics. Similar N results would be expected from late pre-plant or sidedress anhydrous, but not necessarily from early pre-plant anhydrous or 28% or fall anhydrous. Most of the trials were conducted on fine-textured soils: silt loams, silty clay loams, and the like. All of the trials have been field-scale; meaning that the individual N rate “plots” are usually field length by some multiple of the combine header width. Most of the trials have been harvested with the aid of GPS-enabled yield monitors.

⁴ Concepts and Rationale for Regional Nitrogen Rate Guidelines for Corn (PM-2015). On-line at <http://www.extension.iastate.edu/Publications/PM2015.pdf> [URL accessed Dec 2009].

⁵ We gratefully acknowledge the support provided for these trials by the Indiana Corn Marketing Council, Pioneer Hi-Bred Int’l (seed contribution for Purdue trial sites), Beck’s Hybrids (additional trial data), A&L Great Lakes Labs (discounted analysis costs), individual farmers and crop consultants, Purdue Univ. Office of Ag Research Programs, and all of the Purdue Ag Center staff.

More Discussion on N Management

The specific AONR can vary from field to field and from year to year for a single field. This is not particularly surprising since we've always known that predicting optimum N rates for any given field in any given year is challenging, primarily due to the difficulty of predicting soil N supply and growing season weather. Soil N supply can provide as much as half of the total N available to the crop. Weather influences both soil and fertilizer N efficiency. Crop health, N uptake, and N use efficiency are weather and soil dependent.

Soil or fertilizer N lost to leaching, denitrification, or volatilization represents N that is no longer accessible to the plant. Anhydrous ammonia is the least risky of the N sources in this regard because it is the slowest to convert to the nitrate form that is susceptible to leaching or denitrification losses. Nitrification inhibitors can be used to further delay the conversion of anhydrous to nitrate. Urea-based forms of N should be incorporated to minimize volatilization losses. For surface-applied urea containing fertilizers, urease inhibitors can be used to delay the initial conversion of urea to ammonia (reducing the risk of volatilization loss). Finally, sidedressing N will minimize the “window of opportunity” for N loss prior to plant uptake⁶. Failure to recognize or manage these risks of N loss will require higher N rates to attain economic optimum yield.

Even if you take steps to minimize the risk of N loss, predicting the optimum N rate for a particular field in a particular year remains a challenge. Certain tests like the Pre-Sidedress Nitrate Test⁷ can be used for manured fields or soils with very high organic matter content. The end-of-season stalk nitrate test⁸ can be used as a “report card” to help you evaluate whether N was over-applied or under-applied this past year.

Another set of N management tools we have been evaluating are optical reflectance sensors that offer a “snapshot” of the current N status of a crop. These tools might be useful in fine-tuning sidedress N rate decisions later in the growing season (with the understanding that mineralization and N loss rates for the remainder of the growing season are difficult to predict).

The bottom line on N use in corn is that we're dealing with a biological system that interacts with everything under the sun, including the sun. We cannot accurately predict the weather. We cannot accurately predict soil N supply throughout the year. Yet, we cannot afford (financially or environmentally) to simply apply “more than enough”. We can minimize the risk of fertilizer N loss by understanding the processes and matching N source with placement and timing. We can develop average N rate recommendations that will work in “average” years. We can attempt to fine-tune those recommendations with tests, models, optical sensors, or simply educated guesses.

⁶ Nielsen, RL (Bob). 2006. N Loss Mechanisms and Nitrogen Use Efficiency. Handout for 2006 Purdue Nitrogen Management Workshops. <http://www.agry.purdue.edu/ext/pubs/2006NLossMechanisms.pdf>.

⁷ The Presidedress Soil Nitrate Test for Improving N Management in Corn (AY-314-W). On-line at <http://www.agry.purdue.edu/ext/pubs/AY-314-W.pdf>.

⁸ Cornstalk Testing to Evaluate the Nitrogen Status of Mature Corn (AY-322-W). On-line at <http://www.agry.purdue.edu/ext/pubs/AY-322-W.pdf>.

ADJUSTING NITROGEN RATE FOR SOIL NITROGEN SUPPLY AND NITROGEN LOSS POTENTIAL

In the absence of testing methods to fine-tune N rates for a given field in a given year, one can rely on educated guesses about the extent of soil N supply and N loss based on field history and current year weather patterns. **We know from our field trials that a reasonable average AONR for corn following soybean is 186 lbs/ac of applied N or a lower EONR that is based on current N cost and grain price (Table 1 or the on-line N calculator⁵). In fields with low soil N supplying capacity or high N loss potential, consider increasing the N rate by 20 to 30 lbs/ac. In fields with high soil N supplying capacity or minimal N loss potential, consider decreasing the N rate by 20 to 30 lbs/ac.**

Soil N supply and N loss potential are very much related to soil characteristics and, of course, soils vary geographically around the state. As we conduct more and more trials, we are beginning to see regional differences in AONR (Fig. 1) that make some sense as we consider the soils in those regions of the state. More trials are needed before we can confidently develop recommendations for every region or soil association in Indiana.

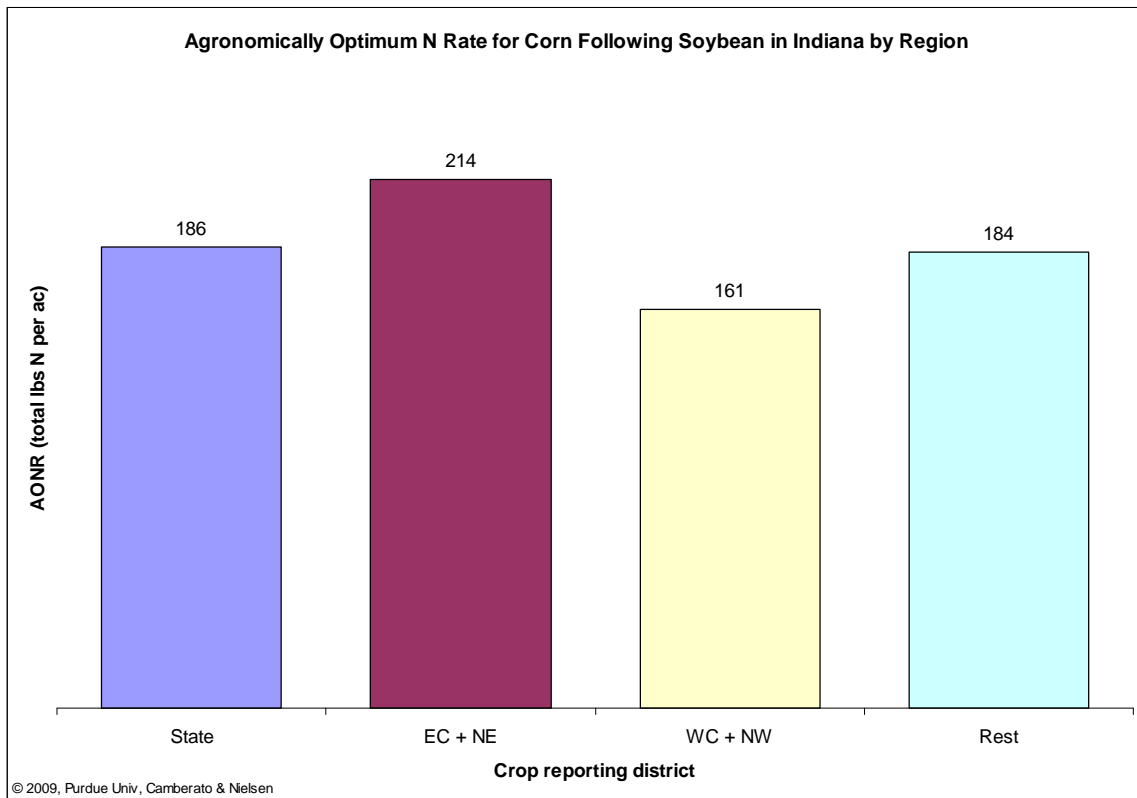


Fig. 1. Regional differences for AONR based on trials with corn following soybean to date since 2006. Note: Few of our trials since 2006 have involved sandy, well-drained soils.

We Are Looking for On-Farm Trial Cooperators

Our next step in developing “new” N rate recommendations is to evaluate the possibility of making region and/or soil type specific recommendations. Currently our research suggests that poorly-drained soils of northeast and east central Indiana require about 30 lb N/a more than the average N rate recommendation. We need more field research in several areas of Indiana to determine if other regional recommendations are warranted.

Conducting N rate trials on farmer’s fields is the best way for us to expand our efforts and increase the database for making regional recommendations. The general protocol for such trials is to apply strips of six N rates (e.g., 70-110-150-190-230 lbs/ac N), repeated no fewer than 2 times across a field. Size of individual plots (a single N rate strip) can be length of field by some multiple of combine header width. Use of combine yield monitors is strongly encouraged primarily because they greatly reduce the harvesting logistics of such a trial. The general protocol for such a trial can be downloaded from the Web at <http://www.kingcorn.org/research/PurdueNTrialProtocol.pdf>.

If you are interested in conducting on-farm N rate trials, contact Jim Camberato (765-496-9338 or jcambera@purdue.edu) or Bob Nielsen (765-494-4802 or rnielsen@purdue.edu). We will work with you to come up with the best compromise between our desires for statistical soundness and your desires for logistical practicality.

Table 1. Range of EONR values (lbs/ac applied N) for corn following soybean as influenced by nitrogen cost per lb. N (Table 2) and grain price per bushel.

N cost	Grain price						
	\$2.00	\$2.50	\$3.00	\$3.50	\$4.00	\$4.50	\$5.00
\$0.20	170	173	176	177	179	179	180
\$0.30	162	167	170	173	174	176	177
\$0.40	153	160	165	168	170	172	173
\$0.50	145	153	159	163	166	168	170
\$0.60	137	147	153	158	162	165	167
\$0.70	128	140	148	153	158	161	163
\$0.80	120	133	142	149	153	157	160
\$0.90	111	126	137	144	149	153	157
\$1.00	103	120	131	139	145	150	153

Based on field research conducted throughout Indiana 2006-2009. These rates assume N management practices that minimize the risk of N loss prior to plant uptake.

Table 2. Cost per lb. N for three common fertilizer sources of N at varying costs per ton of product.

N Source Cost per Ton & Equivalent Cost per lb N					
Anhydrous	N cost/lb	28% UAN	N cost/lb	Urea	N cost/lb
\$300	\$0.18	\$100	\$0.18	\$200	\$0.22
\$350	\$0.21	\$125	\$0.22	\$250	\$0.27
\$400	\$0.24	\$150	\$0.27	\$300	\$0.33
\$450	\$0.27	\$175	\$0.31	\$350	\$0.38
\$500	\$0.30	\$200	\$0.36	\$400	\$0.43
\$550	\$0.34	\$225	\$0.40	\$450	\$0.49
\$600	\$0.37	\$250	\$0.45	\$500	\$0.54
\$650	\$0.40	\$275	\$0.49	\$550	\$0.60
\$700	\$0.43	\$300	\$0.54	\$600	\$0.65
\$750	\$0.46	\$325	\$0.58	\$650	\$0.71
\$800	\$0.49	\$350	\$0.63	\$700	\$0.76
\$850	\$0.52	\$375	\$0.67	\$750	\$0.82
\$900	\$0.55	\$400	\$0.71	\$800	\$0.87
\$950	\$0.58	\$425	\$0.76	\$850	\$0.92
\$1,000	\$0.61	\$450	\$0.80	\$900	\$0.98

Don't forget, this and other timely information about corn can be viewed at the Chat 'n Chew Café on the Web at <http://www.kingcorn.org/cafe>. For other information about corn, take a look at the Corn Growers' Guidebook on the Web at <http://www.kingcorn.org>.

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