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Nitrogen Management Update for Indiana

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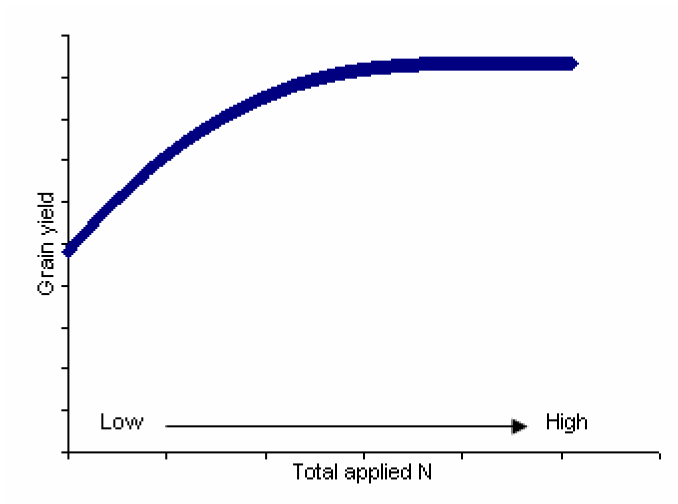
Nitrogen fertilizer costs remain volatile but continue to be one of the most expensive variable costs for corn. Applying "more than enough N" is no longer cheap "insurance" as it once was many years ago. Applying "more than enough N" is also not environmentally friendly. High N fertilizer costs should 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 levels[2]. 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 yield stops increasing with more N. Consequently, applying N above what the crop can use is dollar wasteful and environmentally distasteful.



Throughout the Midwest, there is a growing movement away from yield-based N rate recommendations toward data-driven recommendations that are sensitive to N and grain

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[2] 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 12/12/08].

prices[3]. 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 movement. 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 sites[4].

To date, 81 trials have been conducted around the state. About 69% of them are corn following soybean and the remainder are corn following corn. The N rate treatments have ranged from nothing but starter N to as much as 256 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.

The **average Agronomic Optimum N Rate for all of our corn/soy sites to date was 184 lbs/ac total applied N** (with an average trial yield of 190 bu/ac). At the five Purdue locations where we conducted paired trials of corn/soy and corn/corn in 2007-2008, **the average AONR for corn/corn was 37 lbs greater than for corn/soy** while average corn/corn yields were 21 bu/ac less than the corn/soy yields.

Based on $0.60/lb N and $3.00/bu corn, the average EONR for all of our corn/soy sites was 149 lbs/ac total applied N or 35 lbs less than the average AONR. However, the average yield at the EONR was only 5 bu/ac less 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 Indiana[5] at this web site: http://extension.agron.iastate.edu/soilfertility/nrate.aspx.

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[3] 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 12/12/08].

[4] 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), Purdue Univ. Office of Ag Research Programs, and all of the Purdue Ag Center staff.

[5] As of 12/12/08, the on-line N calculator was not yet updated with our 2008 response data.

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 uptake[6]. 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 Test[7] can be used for manured fields or soils with very high organic matter content. The end-of-season stalk nitrate test[8] can be used as a "report card" to help you evaluate whether N was over-applied or under-applied this past year.

Other possible N management tools we have been evaluating are optical sensors that offer a "snapshot" of the current N status of 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 expected to be "normal"). Two sensors we are looking at are the handheld Minolta® SPAD meter and a machine-mounted Crop Circle® sensor. The sensors measure transmittance (SPAD) through or reflectance (Crop Circle) of certain wavelengths of light from the crop canopy that correlate with N content and plant size.

Both sensors accurately detect differences in canopy reflectance from the V8 to silking stages of development that can be equated to the N status of plants. Obviously, such late growth stages would require the use of high-clearance sidedress applicators (e.g., Hagie, Spra-Coupe, Deere, CaseIH, Apache). Within each N rate trial, differences in canopy reflectance also correlate with differences in grain yield. We are optimistic that such sensors can eventually be used in conjunction with high N rate reference strips in a field to estimate how much additional N is required in a sidedressing operation. Three years of

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[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.

research data are promising and we intend to begin evaluating their implementation for N rate decision-making in 2009 field trials.

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 184 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 calculator). 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.**

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.

We need more field research with N rates in corn because determining yield responses to N requires a lot of field data to generate confidence in the results. We also need volunteers to conduct on-farm N rate trials. The general protocol for such trials would be to apply strips of four to six N rates (e.g., 70-110-150-190-230 lbs/ac N), replicated 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 and grain price per bushel.

	Grain price						
N cost	**$3.00**	**$3.50**	**$4.00**	**$4.50**	**$5.00**	**$5.50**	**$6.00**
$0.50	155	159	162	164	166	168	169
$0.60	149	154	157	160	163	165	166
$0.70	143	149	153	156	159	161	163
$0.80	137	144	149	153	156	158	160
$0.90	131	139	144	149	152	155	157
$1.00	125	134	140	145	149	152	155
$1.10	120	129	136	141	145	149	152
$1.20	114	124	131	137	142	146	149
$1.30	108	119	127	133	138	142	146

Based on field research conducted throughout Indiana 2006-2008. These rates assume N management practices that minimize the risk of N loss prior to plant uptake. Values for EONR were calculated with the on-line calculator available at http://extension.agron.iastate.edu/soilfertility/nrate.aspx

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

Anhydrous	N cost/lb	28% UAN	N cost/lb	Urea	N cost/lb
$500	$0.30	$250	$0.45	$420	$0.46
$550	$0.34	$275	$0.49	$455	$0.49
$600	$0.37	$300	$0.54	$490	$0.53
$650	$0.40	$325	$0.58	$525	$0.57
$700	$0.43	$350	$0.63	$560	$0.61
$750	$0.46	$375	$0.67	$595	$0.65
$800	$0.49	$400	$0.71	$630	$0.68
$850	$0.52	$425	$0.76	$665	$0.72
$900	$0.55	$450	$0.80	$700	$0.76
$950	$0.58	$475	$0.85	$735	$0.80
$1,000	$0.61	$500	$0.89	$770	$0.84
$1,050	$0.64	$525	$0.94	$805	$0.88
$1,100	$0.67	$550	$0.98	$840	$0.91
$1,150	$0.70	$575	$1.03	$875	$0.95
$1,200	$0.73	$600	$1.07	$910	$0.99

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.