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Nitrogen Management Guidelines for Indiana

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5-YEAR SUMMARY OF CORN RESPONSE TO NITROGEN FERTILIZER

Results from field trials conducted around the state with efficient methods and timings of N fertilizer application suggest that the average Agronomic Optimum N Rate (AONR) for corn following soybean (corn/soy) varies by region or soil type. The estimated AONR for fine textured soils in westcentral and northwest Indiana is 173 lbs N / ac. The AONR for fine textured soils in northeast, eastcentral, and central Indiana is approximately 221 lbs N / ac. The AONR for the remainder of the state (NC, SW, SC, and SE) is approximately 183 lbs N / ac. At the five Purdue locations where we conducted paired trials of corn/soy and corn following corn (corn/corn) in 2007-2010, **the average AONR for corn/corn was 44 lbs greater than for corn/soy** while average corn/corn yields were 18 bu/ac less than the corn/soy yields.

Based on $0.50/lb N and $5.00/bu corn, the average Economic Optimum N Rate (EONR) for corn following soybean was 160, 200, and 167 lbs N / ac for WC+NW, NE+EC+C, and the remainder of the state, respectively. The EONR values for other combinations of N cost and grain price are listed in Tables 1-3. If you want to determine EONR for other N and grain prices, use the on-line N calculator for Indiana[2] 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 and environmental impacts 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[3]. For corn/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.

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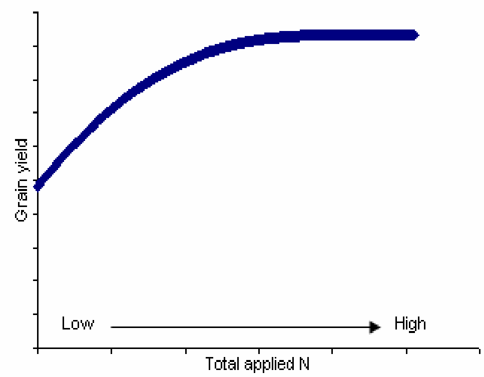
[2] As of 1/21/11, the on-line N calculator was not yet updated with our 2010 response data.

[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 Jan 2010].

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 (figure to right). At some level of N, grain yield stops increasing with more N. Consequently, applying more N than 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 prices[4]. This "new" approach to N rates 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 is usually 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, growing seasons, 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[5].

To date, nearly 150 trials have been conducted around the state. About 67% of them are corn/soy and the rest are primarily corn/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 used sidedress liquid 28% UAN simply to facilitate trial logistics. Similar 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.

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[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 Jan 2011].

[5] We gratefully acknowledge the support provided for these trials by the Indiana Corn Marketing Council, Pioneer Hi-Bred Int'l and LG Seeds (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.

Regional and Soil Differences in Optimum N Rate

Nitrogen used by the corn crop originates from soil organic matter and crop residues as well as from applied fertilizer. Some soils provide as little as 25% of the crop N requirement, the remainder coming from fertilizer N. Other soils provide in excess of 50% of the crop N demand, with a lesser amount needed from applied N. The N supply and N loss potential of a soil are related to soil properties and, of course, soils vary geographically around the state. In general higher organic matter and better drained soils provide more N to the crop and retain more fertilizer N than lower organic matter, more poorly drained soils. As we conduct more and more trials, we are identifying regional differences in AONR (Fig. 1) that make sense as we consider the soils in those regions. Our current research suggests that poorly-drained fine textured soils in northeast, eastcentral, and central Indiana require about 221 lb N/ac to optimize yield of corn/soy, whereas the AONR for better-drained fine textured soils in westcentral and northwest Indiana is about 173 lbs N/ac. These results were obtained with efficient fertilizer application methods and timings. The EONR is less than the AONR, based on the relative cost of N and value of grain. Economically optimum N rates can be found in Tables 1-3.

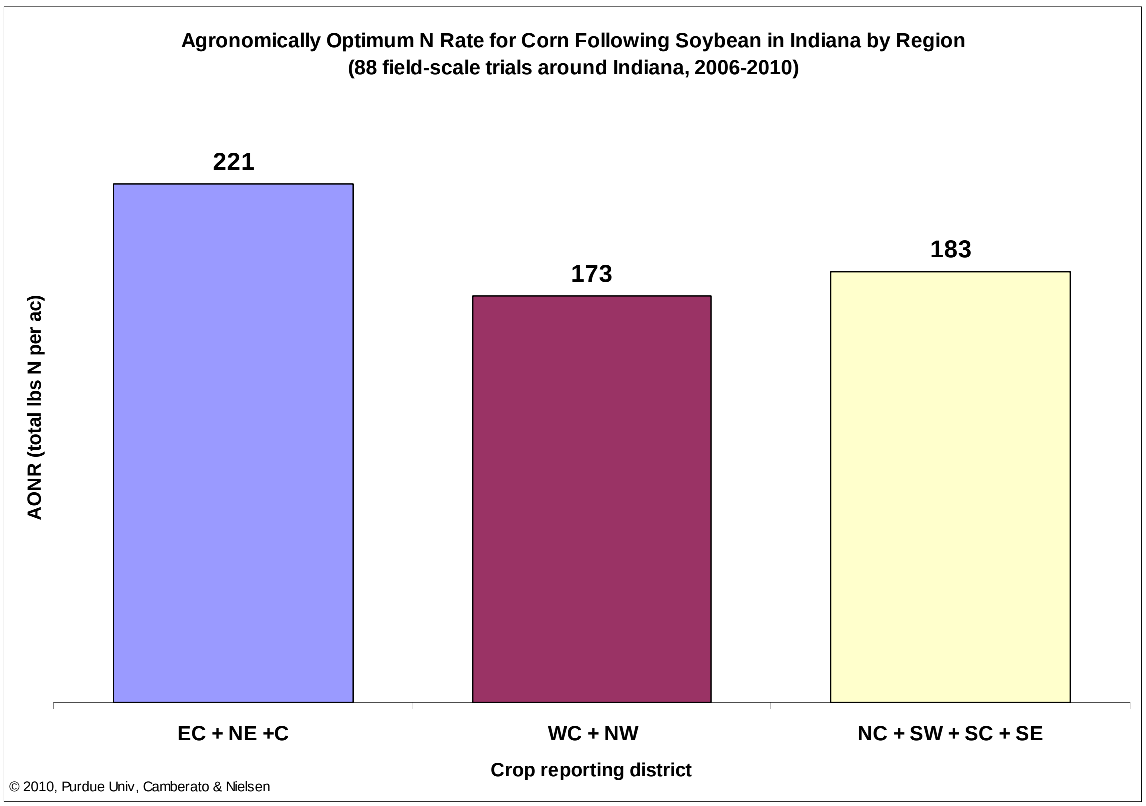

Fig. 1. Regional differences for AONR based on 82 trials with corn following soybean to date since 2006. Note: Few of our trials since 2006 have involved sandy, well-drained soils.

More field research is needed in several areas of Indiana and on coarse textured soils to determine whether other regional and soil specific recommendations are warranted. Please consider collaborating with us in conducting on-farm research N rate trials (see pg. 5 for more information).

More Discussion on N Management

Although we report a single AONR for a region the specific AONR can vary from field to field and from year to year for a single field. For example, the optimum N rate for our research site near West Lafayette was 165, 130, 186, 182, and 186 from 2006-2010, respectively. This variation in optimum N rate is not particularly surprising since we've always known the difficulty of predicting soil N supply, fertilizer N loss, and growing season weather. Weather influences both soil N supply and fertilizer N efficiency. Crop health, N uptake, and N use efficiency are also weather- and soil-dependent.

Soil or fertilizer N lost to leaching, denitrification, or volatilization is no longer accessible to the plant. Anhydrous ammonia is the least risky of the N sources 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 ammonium to nitrate. Urea-containing fertilizers should be incorporated to eliminate volatilization losses or a urease inhibitor 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 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. Several tools exist that may improve N management. These include: the Pre-Sidedress Nitrate Test[7] which can be used to estimate soil N supply in manured fields or soils with very high organic matter content, a chlorophyll meter[8] or active sensor in conjunction with a high-N reference strip which can be utilized during the growing season to evaluate crop N status, and the end-of-season stalk nitrate test[9] which can serve as a "report card" to determine whether N was over- or under-applied.

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.

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[6] N Loss Mechanisms and Nitrogen Use Efficiency. Handout for 2006 Purdue Nitrogen Management Workshops. http://www.agry.purdue.edu/ext/pubs/2006NLossMechanisms.pdf. [URL accessed Jan 2011]

[7] The Presidedress Soil Nitrate Test for Improving N Management in Corn. Purdue Extension publication AY-314-W, http://www.agry.purdue.edu/ext/pubs/AY-314-W.pdf. . [URL accessed Jan 2011]

[8] Determining Nitrogen Fertilizer Sidedress Application Needs in Corn Using a Chlorophyll Meter. Purdue Extension publication AY-317-W, http://www.agry.purdue.edu/ext/pubs/AY-317-W.pdf [URL accessed Jan 2011].

[9] Cornstalk Testing to Evaluate the Nitrogen Status of Mature Corn. Purdue Extension publication AY-322-W, http://www.agry.purdue.edu/ext/pubs/AY-322-W.pdf. . [URL accessed Jan 2011]

We Are Looking for On-Farm Trial Cooperators

Our long-term objective is to develop more region- or soil-specific N rate guidelines. 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 (for example, 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.agry.purdue.edu/ext/ofr/protocols.html.

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 desire for logistical simplicity.

Table 1. Range of EONR values (lbs/ac applied N) for corn following soybean as influenced by nitrogen cost per lb. N (Table 4) and grain price per bushel based on yield response data summarized over **central, eastcentral, and northeast Indiana**. The average agronomic optimum N rate for these regions of Indiana is estimated to be 221 lbs N/ac.

	Grain price						
N cost	**$3.00**	**$3.50**	**$4.00**	**$4.50**	**$5.00**	**$5.50**	**$6.00**
$0.20	207	209	210	212	212	213	214
$0.30	200	203	205	207	208	210	210
$0.40	194	197	200	203	204	206	207
$0.50	187	192	195	198	200	202	204
$0.60	180	186	190	194	196	198	200
$0.70	173	180	185	189	192	195	197
$0.80	166	174	180	184	188	191	194
$0.90	160	168	175	180	184	187	190
$1.00	153	163	170	175	180	184	187

Based on field research conducted throughout Indiana 2006-2010. These rates assume N management practices that minimize the risk of N loss prior to plant uptake.

Table 2. Range of EONR values (lbs/ac applied N) for corn following soybean as influenced by nitrogen cost per lb. N (Table 4) and grain price per bushel based on yield response data summarized over **westcentral and northwest Indiana**. The average agronomic optimum N rate for these regions of Indiana is estimated to be 173 lbs N/ac.

	Grain price						
N cost	**$3.00**	**$3.50**	**$4.00**	**$4.50**	**$5.00**	**$5.50**	**$6.00**
$0.20	165	166	167	167	168	168	169
$0.30	160	162	164	165	165	166	167
$0.40	156	159	160	162	163	164	165
$0.50	152	155	157	159	160	162	162
$0.60	148	152	154	156	158	159	160
$0.70	144	148	151	154	155	157	158
$0.80	140	144	148	151	153	155	156
$0.90	136	141	145	148	150	153	154
$1.00	131	137	142	145	148	150	152

Based on field research conducted throughout Indiana 2006-2010. These rates assume N management practices that minimize the risk of N loss prior to plant uptake.

Table 3. Range of EONR values (lbs/ac applied N) for corn following soybean as influenced by nitrogen cost per lb. N (Table 4) and grain price per bushel based on yield response data summarized over **northcentral, southwest, southcentral, and southeast Indiana**. The average agronomic optimum N rate for these regions of Indiana is estimated to be 183 lbs N/ac.

	Grain price						
N cost	**$3.00**	**$3.50**	**$4.00**	**$4.50**	**$5.00**	**$5.50**	**$6.00**
$0.20	172	174	175	176	177	177	178
$0.30	167	169	171	172	173	174	175
$0.40	161	164	167	168	170	171	172
$0.50	155	159	162	165	167	168	169
$0.60	150	154	158	161	163	165	167
$0.70	144	150	154	157	160	162	164
$0.80	138	145	150	153	156	159	161
$0.90	133	140	145	150	153	156	158
$1.00	127	135	141	146	150	153	155

Based on field research conducted throughout Indiana 2006-2010. These rates assume N management practices that minimize the risk of N loss prior to plant uptake.

Table 4. 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.