

Nitrogen Management Guidelines for Indiana

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6-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 180 lbs N / ac. The AONR for fine textured soils in northeast, eastcentral, and central Indiana is approximately 214 lbs N / ac. The AONR for the remainder of the state (NC, SW, SC, and SE) is approximately 186 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 \$6.00/bu corn, the average Economic Optimum N Rate (EONR) for corn following soybean was 169, 198, and 173 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 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 and environmental impacts should encourage growers to critically evaluate their N fertility program, including application rate, fertilizer material, and timing.

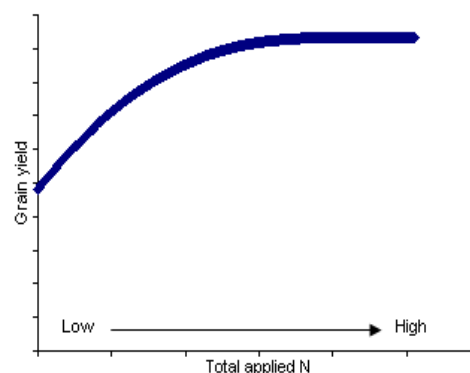
Nitrogen rate recommendations for a given field were traditionally linked to its historical yield levels³. For corn/soybean, the traditional rule of thumb was an N rate equal to about 1 lb of N per bushel of expected yield. For corn following either corn or wheat, the recommendation was equal to about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

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² As of 3/30/12, the on-line N calculator was not yet updated with our 2011 response data.

³ A Historical Perspective on Nitrogen Fertilizer Rate Recommendations for Corn in Indiana (1953-2011). On-line at <http://www.extension.purdue.edu/extmedia/AY/AY-335-W.pdf> [URL accessed Mar 2012].

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 prices⁴. 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 a range of growing conditions. We began our current N rate trials in 2006. To date, 175 field-scale trials have been conducted around the state. About 58% of them have been with rotation corn and the rest primarily continuous corn. Over 60% of the trials have been on-farm research trials with farmers and the remainder has been trials at Purdue research centers around the state⁵.

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.

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 Mar 2012].

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. For now, we have grouped the N guidelines according to Indiana Crop Reporting Districts (Fig. 2). Our current research suggests that poorly-drained fine textured soils in northeast, eastcentral, and central Indiana require about 214 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 180 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.

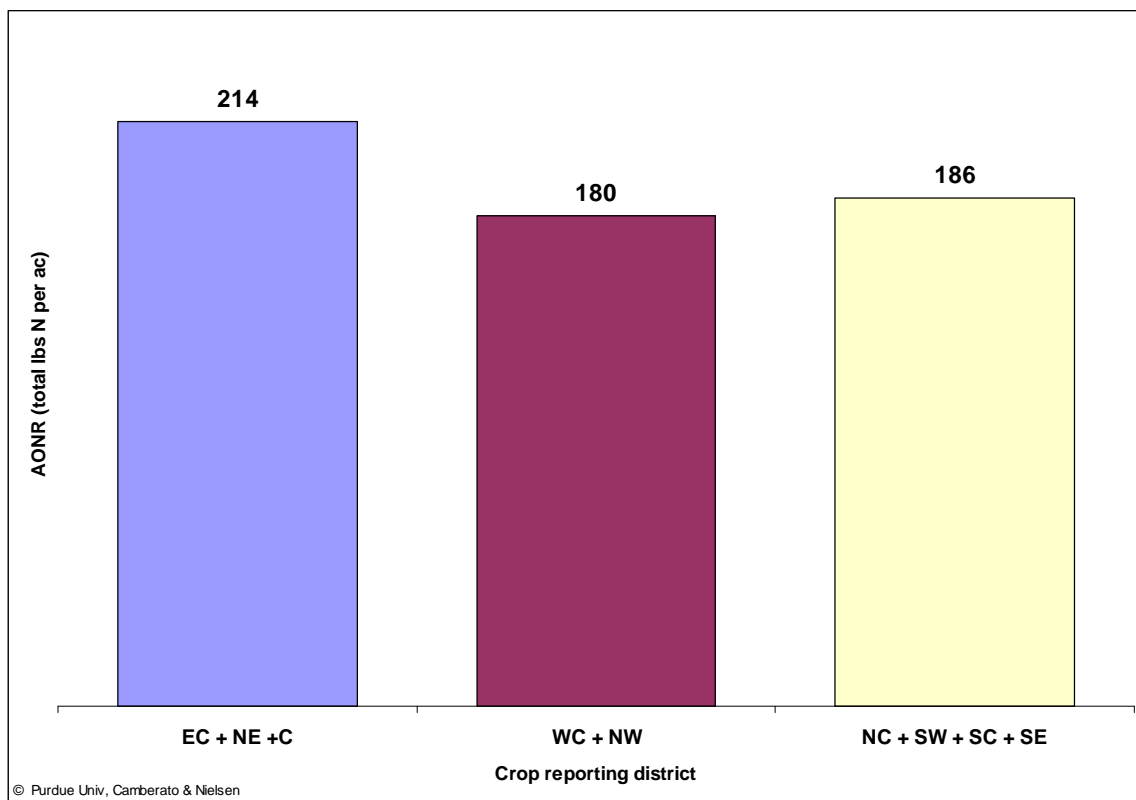


Fig. 1. Regional differences for agronomically optimum N rate (AONR) based on 105 trials with corn following soybean to date since 2006. Note: Few of our trials since 2006 have involved sandy, well-drained soils.

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, specific AONR values 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, 186, and 179 from 2006-2011, 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 N no longer available 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. 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). Nitrification inhibitors can be used with anhydrous, urea, or liquid N to further delay the conversion of ammonium to nitrate. Finally, sidedressing N will minimize the “window of opportunity” for N loss prior to plant uptake⁶. Practices such as fall-applied or early-spring applied N or surface-applied urea will require higher N rates than we recommend 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 Test⁷ which can be used to estimate soil N supply in manured fields or soils with very high organic matter content, a chlorophyll meter⁸ 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 test⁹ 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

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 Mar 2012]

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 Mar 2012]

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 Mar 2012].

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 Mar 2012]

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 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 nielsen@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 economic optimum N rate (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 214 lbs N/ac.

N cost	Grain price						
	\$3.00	\$4.00	\$5.00	\$6.00	\$7.00	\$8.00	\$9.00
\$0.20	201	204	206	208	209	209	210
\$0.30	194	199	202	204	206	207	208
\$0.40	187	194	198	201	203	204	205
\$0.50	181	189	194	198	200	202	203
\$0.60	174	184	190	194	197	199	201
\$0.70	167	179	186	191	194	197	199
\$0.80	160	174	182	187	191	194	196
\$0.90	154	169	178	184	188	192	194
\$1.00	147	164	174	181	185	189	192

Based on field research conducted throughout Indiana 2006–2011. 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 180 lbs N/ac.

N cost	Grain price						
	\$3.00	\$4.00	\$5.00	\$6.00	\$7.00	\$8.00	\$9.00
\$0.20	171	173	175	176	176	177	177
\$0.30	167	170	172	173	174	175	176
\$0.40	162	167	169	171	172	173	174
\$0.50	157	163	167	169	171	172	173
\$0.60	153	160	164	167	169	170	171
\$0.70	148	156	161	164	167	168	170
\$0.80	144	153	158	162	165	167	168
\$0.90	139	150	156	160	163	165	167
\$1.00	135	146	153	157	161	163	165

Based on field research conducted throughout Indiana 2006-2011. 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 186 lbs N/ac.

N cost	Grain price						
	\$3.00	\$4.00	\$5.00	\$6.00	\$7.00	\$8.00	\$9.00
\$0.20	175	178	180	181	182	182	183
\$0.30	170	174	176	178	179	180	181
\$0.40	164	170	173	175	177	178	179
\$0.50	159	166	170	173	175	176	177
\$0.60	154	162	167	170	172	174	175
\$0.70	148	158	163	167	170	172	174
\$0.80	143	154	160	164	168	170	172
\$0.90	137	149	157	162	165	168	170
\$1.00	132	145	154	159	163	166	168

Based on field research conducted throughout Indiana 2006-2011. 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.

<u>Anhydrous</u>	<u>N cost/lb</u>	<u>28% UAN</u>	<u>N cost/lb</u>	<u>Urea</u>	<u>N cost/lb</u>
\$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>.

INDIANA DISTRICT BOUNDARIES



Fig. 2. Indiana crop reporting districts as identified by USDA-NASS.

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