

Dialing in Profitable Nitrogen Rate and Timing Practices

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When choosing the best nitrogen (N) management practices, farmers and crop advisors must carefully consider the balancing act of achieving the most profitable N rate and timing practices while reducing risk for nitrate-N loss to surface and groundwater. Can

the two co-exist with today's high yielding corn hybrids?

Table 1 summarizes the results of an on-farm nitrogen rate and timing study conducted in 2017. This high yielding corn following soybean site is located in Fillmore County. Seven preplant rates and three timing treatments were evaluated. Treatments ranged from 30 to 210 lb N/ac and included a 30 lb N/ac incidental N credit from fall-applied diammonium phosphate (DAP) and starter N at planting. The N rate recommendation when using the high end of the acceptable MRTN range was to apply 140 lb N/ac for C/S and

170 lb N/ac for C/C rotations. The maximum N rate guidance is to apply is no more than 160 lb N/ac for C/S and 200 lb N/ac for C/C. (Corn N Rate Calculator V.1.9, 2017, rounded to nearest 10, <http://cnrc.agron.iastate.edu/>)

Average corn yields at this site were excellent and peaked at 265 bu/ac. Remarkably, rates below 100 lb N/ac produced 72% to 95% of the maximum yield while **rates between 120 and 150 lb N/ac produced 99% of the maximum yield**. A significant yield increase occurred in one of three timing treatments when 90 lb N/ac was split applied as opposed to when all N was applied preplant. The economic return to fertilizer N (when using average 2017 fertilizer and corn price) was greatest at the 120 lb N/ac split and preplant treatments. It's important to note that N rates with the greatest yield *did not* have the greatest profit. This is because the yield increase was not large enough to pay for the additional N fertilizer. When compared to the grower's normal nitrogen program on this field, profits could have been improved by **\$25/ac** when using the 120 lb N/ac preplant and split N rates. After three years of similar results, this producer has expressed interest in dialing back his nitrogen rates and shifting these savings into other aspects of his fertility program that will likely provide a better return on investment (i.e. liming and potash).

In addition to corn yield, soil samples were collected to a four-foot depth after harvest (early Nov.) to determine residual soil nitrate (RSN). High RSN increases nitrate leaching risk to ground and surface waters. RSN ranged from 15 lb N/ac to 121 lb N/ac across treatments, and the results showed that RSN was not significantly different among N rates less than or equal to 150 lb/ac. However, at 210 lb N/ac (40% greater than 150 lb), RSN increased 300%, clearly increasing risk for nitrate-N pollution to ground and surface waters.

In summary, this high-yielding site demonstrated that **when economically optimum nitrogen rates were exceeded, profitability decreased while nitrate leaching risk to groundwater increased**. How do your numbers compare? To help improve your bottom line while protecting water quality from controllable N losses, have a conversation with your crop retailer about your current N rate and timing program, and conduct your own on-farm nitrogen rate trial to see if there are opportunities to dial-in N management for improved profit and water quality.

Table 1. 2017 corn following soybean yield, economic return to nitrogen fertilizer and residual soil nitrate on a silt loam soil in Fillmore County

Total N Rate ¹	Timing	Average Yield	% of Max Yield	Economic ² Return to Fertilizer N	Profit Rank	Residual Soil Nitrate at 4.0'
lb/ac		bu/ac	%	\$/ac		lb/ac
30	Preplant	192 (e)	72%	564	10	15 (c)
60	Preplant	224 (d)	85%	648	9	
90	Preplant	237 (c)	89%	675	8	16 (c)
90 (60/30)	Preplant + V4	251 (b)	95%	709	6	28 (c)
120	Preplant	259 (ab)	98%	729	2	21 (c)
120 (60/60)	Preplant + V4	262 (ab)	99%	730	1	28 (c)
150	Preplant	262 (ab)	99%	726	3	40 (bc)
150 (60/90)	Preplant + V4	262 (a)	99%	718	5	
180	Preplant	265 (a)	100%	723	4	62 (b)
210	Preplant	263 (a)	99%	705	7	121 (a)

¹Total N rates include 30 lb N/ac of incidental nitrogen from fall applied DAP and starter at planting.

²Corn price = \$3.20/bu. (avg. Oct. 2017 price), N = .40/lb urea. Extra application costs associated with the in-season split application had an assumed cost of \$8/ac. The calculated MRTN at this site when using a 0.10 nitrogen price to corn price ratio was 153 lb N/ac with a corn yield of 263 bu/ac.

†Treatment means with the same letter in the respective column are not significantly different at the 90% level.

Testing Nitrogen Rate BMP Recommendations

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The **Maximum Return To Nitrogen (MRTN)** is the nitrogen (N) rate that optimizes net profit. Applying rates near the MRTN can reduce risk of nitrate-nitrogen leaching to groundwater and surface water and is a recommended **Best Management Practice (BMP)** when fertilizing corn in Minnesota. MRTN rates are derived from over 160 University N rate response trials conducted over a variety of years and locations across the state. Most N rate response trials in the MRTN database have been conducted in southern Minnesota. Less than 20% of these studies have been conducted in southeast counties, and most are older than ten years. Farmers have observed historic increases in yield potential in the past several years with proven field averages over 240 bu/ac. Legitimate questions often arise whether BMP recommended rates, which are based on MRTN response trials, are adequate for today's high yielding corn hybrids, farming systems and soil types in southeast Minnesota.

For these reasons, farmers and their advisors have requested additional studies to help improve confidence in nitrogen rate BMP recommendations. Furthermore, split applying nitrogen has gained popularity in recent years, but there are questions about how much in-season N to apply and how often split applications outperform preplant applications. In collaboration with Jeff Vetsch of the University of Minnesota and funding from MN Dept. of Agriculture's Clean Water Fund program, eight research-grade field studies were conducted over a three-year period to evaluate the relationship between corn yield, nitrogen rate and timing in southeast Minnesota.

Table 1 summarizes results across eight sites from the period 2015-2017. The growers' normal N fertilizer rate ranged from 170 lb N/ac to 220 lb N/ac for corn following soybean (C/S) and 200 lb N/ac to 205 lb N/ac for corn following corn (C/C). Total N rates included credits from incidental N sources such as MAP/DAP/AMS and starter fertilizer. The N rate recommendation when using the high end of the acceptable MRTN¹ range was to apply 140 lb N/ac for C/S and 170 lb N/ac for C/C rotations. The maximum N rate guidance is to apply no more than 160 lb N/ac for C/S and 200 lb N/ac for C/C. (Corn N Rate Calculator V.1.9, 2017, <http://cnrc.agron.iastate.edu/>)

TABLE 1. Southeast Minnesota Nitrogen Rate Test Plot Results (2015-2017)

Site ID	Year	County	Prev. Crop	Grower's Normal N Rate	BMP Recs. MRTN Acceptable Range ¹	Optimal N Rate ²	Yield at Optimal N Rate
					-----lb N/ac-----		bu/ac
GM15	2015	Mower	Soybean	180	110-140	103	245
GM16	2016	Mower	Soybean	180	110-140	142	246
GL17	2017	Fillmore	Soybean	220	110-140	153	263
GM17	2017	Mower	Soybean	170	110-140	203*	245
			AVG.	188	125	150	250
GL15	2015	Fillmore	Corn	200	150-170	125	206
GL16	2016	Fillmore	Corn	200	150-170	100	244
HM16	2016	Fillmore	Corn	200	150-170	118	208
UT17	2017	Winona	Corn	205	150-170	164	240
			AVG.	201	160	127	225

¹ Most profitable range when using 0.10 nitrogen price to corn price ratio and rounded to nearest 10 value (Corn N Rate Calculator, 2017).

² Calculated using yield response curve from test plot and 0.10 price ratio. Optimal nitrogen rates exceeding the upper range of the BMP recommendations are indicated in bold.

*When N rates were split applied at this site, (60 lb N/ac preplant and 90 lb N/ac at V4), the most profitable rate was 150 lb N/ac.

Results from this study found the optimal N rate ranged from 103 to 203 lb N/ac for C/S and 100 to 164 lb N/ac for C/C. When comparing test plot optimal N results to the upper range of the BMP rate recommendations, 5 out of 8 sites (63%) maximized yield and economics. Unexpectedly, the highest N rate requirements were all corn following soybean sites. At sites GM16 and GL17, the optimal N rate was greater than the recommended BMP rate by 2 lb N/ac and 13 lb N/ac respectively. It's predicted that BMP rates would have resulted in a marginal yield reduction of 0.2 bu/ac and 2.0 bu/ac. The largest difference between the test plot rate and BMP rate, 63 lb N/ac, occurred at site GM17. Its calculated that this would have resulted in a 19 bu/ac reduction. The increased yield response to N was likely attributed to leaching of fall-applied N credits and denitrification loss from compaction. It should be noted that when nitrogen was split applied at this site, the most profitable nitrogen rate was 150 lb N/ac. Surprisingly, three of the four corn following corn plots had optimal N rates below the BMP range. With the exception of the 2017 Mower county site, all sites had optimal N rates below the maximum BMP rate. Overall, results from these high yielding corn plots showed that in most cases, BMP N rates were the most profitable. Additional on-farm studies are planned and on-going. These will enhance the MRTN database in the southeast corner of the state.