EVALUATION OF ADAPT-N IN THE CORN BELT

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Introduction

Nitrogen is the plant nutrient required in the largest quantity, the most likely to be deficient, and the most impactful on corn yield as well as grower profit. Providing N to a corn crop in the right amount while minimizing loss is difficult because of complex biological and chemical reactions that result in the loss of N from the crop root zone via deep percolation to ground water, lateral flow, runoff and erosion to surface waters, and volatile losses to the atmosphere as ammonia, nitrogen gas, nitric oxide, nitrous oxide, etc. Increasing crop utilization of N and reducing loss of N outside the field is important to the sustainability of corn production in the Corn Belt.

Optimizing the rate of fertilizer N based on profit is one approach to reducing fertilizer N loss from corn production systems. Nitrogen rate recommendations for most Corn Belt states are based on the aggregation of results from numerous N response trials and a simple economic analysis that considers the value of grain and the cost of N. This approach is commonly referred to as MRTN – Maximum Return to Nitrogen (Sawyer et al., 2006). Nitrogen recommendations from this approach "should provide an N rate that reflects economic value and probability of achieving expected economic return across a range of locations and period of time". The recommendations are general in nature and therefore not responsive to variations in seasonal weather.

Adapt-N is a mechanistic model that utilizes several soil and management parameters, anticipated yield, and actual and historic weather to provide a field- and season-specific N recommendation that is purported to be more accurate than the general recommendation given by the MRTN approach (http://adapt-n.cals.cornell.edu/manual/index.html).

This project compared the accuracy and profitability of N recommendations from MRTN and Adapt-N in Iowa, Indiana, and Wisconsin.

Methods and Materials

Data from 79 replicated field strip and small plot corn N response trials in Iowa (n=24), Indiana (n=15), and Wisconsin (n=40) were compiled. Trial sites had corn following soybean or corn. All trials were conducted in 2013 except for two Indiana trials which were conducted in 2014. In Wisconsin, N application rates were applied to sites where N was previously applied at uniform rates across the study area. In Iowa and Indiana some sites were part of ongoing studies where N was applied at the same rates in consecutive years, others had uniform N rates in prior years. Twenty-seven of the Wiscosin sites were part of a larger manure application timing trial at three locations were manure (none, raw, or digested) was applied in early fall, late fall, or spring and sidedress N applications were imposed on the manure/timing treatments. Nitrogen was applied sidedress, with the exception of a small amount of starter fertilizer at some sites, for all N response trials in Wisconsin and Indiana, whereas N was applied either at sidedress or just prior to planting in Iowa. Regression models were used to fit the corn grain yield response to the total N application rate, including starter fertilizer, for each trial. The economic optimum N rate (EONR) was calculated at a N:corn price ratio of 0.10.

The MRTN recommended N rate for each site was determined using a 0.10 N:corn price ratio and the Corn Nitrogen Rate Calculator (http://extension.agron.iastate.edu/soilsfertility/nrate.aspx) or a tabular version of MRTN rate recommendations for Wisconsin (Laboski and Peters, 2012) and Indiana (Camberato et al., 2014). Manure N credits were subtracted from the MRTN rate as per Laboski and Peters (2012) using manure that was sampled at the time of application and subsequently analyzed. The corn yield at the MRTN rate was determined by inputting the MRTN rate into the N response model for each site.

The Adapt-N recommended rate was determined by entering required site information in the online model at http://adapt-n.cals.cornell.edu (2013) or http://www.adapt-n.com (2014). The required information included: geo-referenced location, soil texture or series name, slope, soil organic matter, rooting depth, tillage system, previous crop, corn hybrid maturity, planting date and population, expected yield range, starter fertilizer N, manure application date, manure ammonium-N and organic-N concentrations. The model predicted sidedress N application rate was determined with the actual sidedress N application date as the model run date in Wisconsin and Indiana and with June 1 as the sidedress application date in Iowa, regardless of when N was applied sidedress or preplant. The corn yield at the Adapt-N recommended rate was determined by entering the Adapt-N plus starter fertilizer rate into the N response model for each site.

Adapt-N and MRTN recommended N rates were compared to the site EONR by subtracting the EONR from the respective recommended rate. Positive numbers indicate an over recommendation while negative numbers indicate an under recommendation. The profitability of Adapt-N and MRTN were calculated by multiplying the yield from each N recommendation system by $4.00 per bushel and subtracting the cost of N. Cost of N was determined by multiplying the total N appliation rate, including starter, by $0.40 per pound of N. The MRTN advantage was calculated by subtracting Adapt-N profitability from MRTN profitability. The Adapt-N subscription fee was not included in the profitability calculation. MRTN recommendation tools are freely available to the public.

Results and Discussion

The distribution of Adapt-N or MRTN recommended N rate differences from site specific EONRs was variable among states and previous crops (Figures 1 and 2). It is very difficult for any N recommendation system to exactly estimate a site EONR due to many uncontrollable factors; however, N recommendation systems can be compared with regard to how close they come to providing a recommendation within 25 lb N/a of site EONRs. Adapt-N recommended N within 25 lb N/a of site EONR at 6, 7, and 39 % of the sites where corn followed soybean in IA, IN, and WI, respectively; while MRTN recommended N within 25 lb N/a of site EONR at 63, 36, and 50% of the sites in IA, IN, and WI, respectively. Where corn followed corn grain or silage, Adapt-N rates were within 25 lb N/a of site EONR at 13 and 23 % of sites in IA and WI, respectively; whereas MRTN rates were within 25 lb N/a of site EONR at 38 and 5 % of of sites in IA and WI, respectively. In all states, MRTN recommended rates were more likely to be within 25 lb N/a of site EONR compared to Adapt-N with the exception of corn following corn in WI.

An N recommendation system is considered to have under or over recommended N if the recommended N rate was more than 25 lb N/a different than the site EONR. Where corn followed soybean, Adapt-N under recommended N at 94, 86, and 39 % of sites in IA, IN, and WI, respectively; while MRTN under recommended N at 38, 50, and 39 % of sites in IA, IN, and WI, respectively. Where corn followed corn grain or silage, Adapt-N under recommeded N at 75 and 18 % of sites in IA and WI; while MRTN under recommended N at 38 and 27 % of sites in IA and WI. The general trend is for Adapt-N to under recommend N to a greater extent than MRTN in IA and IN. In WI, both Adapt-N and MRTN under recommend N at a similar percentage of sites. The IA data are consistent with data from 2011 and 2012 which was previously reported by Sawyer (2013). Spring 2013 was wet throughout much of the study region. The large under recommendations of N by Adapt-N in IA and IN suggest that Adapt-N may not be adequately modeling N loss from excessive spring rainfall in these environments.

The wider range in distribution of differences in N recommendation systems compared to site EONR in WI (Figure 2) was investigated more closely. The three locations that were part of a manure study contributed 27 sites for this analysis, nine per location. Each location was approximate 5 to 6 acres in size with one-third of the area devoted to each manure application timing. At each manure application timing, raw, digested, or no manure was applied in 4 replicates. Sidedress N application rates were imposed over all manure treatments at each time of application. Where no manure was applied the EONR ranged from 139 to 210, 130 to 205, and 0 to 132 lb N/a at each of the three locations. The large range in EONR at a location demonstrates within field variability in N response in a year following a major drought. The Adapt-N input parameters for each location would not vary across the manure application timings; thus Adapt-N would not be able to predict this variability. The previous crops at these locations were soybean, corn silage, and corn silage. At the corn silage locations (n=18), it is possible that residual N from the drought carried through to 2013, and even though spring 2013 was wet, perhaps not all of the residual N was lost and thus contributed to variability in N response. This hypothesis will be tested using soil profile nitrate concentrations in samples collected in spring of 2013. Where soybean was the previous crop, one manure application timing was in an area where the soil was a bit rockier on the surface and the slope was steeper, but not enough to change Adapt-N input parameters. There were a few weeks of dry weather from July into August, and in the rockier area, corn was visually showing signs of moisture stress that was not apparent in the other manure application timings.

At the manure study locations, there was substantial within field variability that can not fully be explained; thus, sites from these locations were excluded and the differences in N recommendation systems compared to site EONR were re-evaluated. Upon exclusion of these sites, there were nine sites where corn followed soybean and four where corn followed corn. The evaluation will focus on the larger corn following soybean data set. Figure 2 shows the distribution of differences in N recommendation systems compared to site EONR when corn follows soybean using this smaller data set. Recommended N rates were within 25 lb N/a of site

EONR at 44% of the sites using Adapt-N and 89% of sites using MRTN. Adapt-N under recommended N at 33% of sites, while there were no under recommendations with MRTN. Removing all sites from the manure study where manure was and was not applied, greatly reduced the extreme deviation in N recommendation systems compared to site EONR.

Profitability of N recommendations is important to farmers. Under application of N usually presents a larger risk of reduced profitability compared to over application. Difference in mean profitability of the N recommendation systems from site EONR, along with the mean difference in N recommendations, is provided in Table 1. In IA and IN, profitability of Adapt-N was $85 and $95 per acre less than site EONR. MRTN offers an average economic advantage over Adapt-N of $66 and $77 per acre, for all sites in IA and IN (Table 1). In contrast, Adapt-N had an average economic advantage over MRTN of $2 per acre in WI. MRTN was more profitable than Adapt-N for all previous crops in IA ($66/acre) and for a previous crop of soybean in IN ($84/acre). There was only one IN location with a previous crop of corn. In WI, there was no substantial economic advantage to either N recommendation system when all sites were considered. However, when sites from the manure study were excluded and where soybean was the previous crop, MRTN was more profitable than Adapt-N ($13/acre, Table 2).

The effect of manure applied for the 2013 crop on profitability of N recommendation systems in WI is provided in Table 2. Adapt-N was more profitable where corn was the previous crop and no manure was applied; however when soybean was the previous crop Adapt-N was more profitable when manure was applied. The difference in N recommendation systems may be a result of how well manure N credits are predicted, but is complicated by the high variablity in EONR when no manure was applied at these sites, as previously discussed. Further evaluation of Adapt-N where manure is applied is warranted.

Summary

- The general trend was for Adapt-N to under recommend N to a greater extent than MRTN in IA and IN. In WI, both Adapt-N and MRTN under recommended N at a similar frequency. In addition, Adapt-N did not reduce the variability in recommended N rates compared to site optima.
- In all states, MRTN recommended rates were more likely to be within 25 lb N/a of site EONR compared to Adapt-N with the exception of corn following corn in WI.
- The MRTN system was more profitable than Adapt-N in IA and IN. In WI, the two N recommendation systems had similar profitability when all sites were considered. However, when sites with large spatial variability in N response were removed from the WI dataset, MRTN was more profitable than Adapt-N.
- Adapt-N is unable to capture all spatial variability in N response because there are not enough input parameters to adequately characterize zones within fields, and some input parameters have little impact on the N rate recommendation.
- Adapt-N may not adequately model N loss from excessive rainfall or mineralization and subsequent availabilty of manure N.

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Table 1. Difference in profitability of Adapt-N or MRTN N recommendation systems compared to the site economic optimum N rate (EONR) (profitability of N recommendation system minus profitability of site EONR) for corn along with the economic advantage of MRTN over Adapt-N (profitability of MRTN minus profitability of Adapt-N) for corn N rate recommendations in Iowa, Indiana, and Wisconsin, 2013 all states and 2014 for 2 sites in IN. Negative MRTN advantage numbers indicate Adapt-N was more profitable than MRTN.

			Adapt-N - EONR	MRTN - EONR	MRTN Advantage		
State	Previous crop	n	Mean	Mean	Mean	Min	Max
			$/acre				
IA	All	24	-85 (-74) †	-19 (-18)	66	-9	180
	Corn grain	8	-78 (-64)	-15 (0)	63	-9	141
	Soybean	16	-89 (-80)	-21 (-27)	68	-3	180
IN	All	15	-95 (-78)	-17 (-17)	77	-21	166
	Corn grain	1	-15 (-33)	-29 (-47)	-14	--	--
	Soybean	14	-100 (-82)	-16 (-15)	84	-21	166
WI	All	40	-24 (24)	-26 (5)	-2	-87	56
	Corn grain/silage	22	-29 (51)	-29 (29)	0	-87	36
	Soybean	18	-19 (-9)	-23 (-25)	-3	-52	56

† Number in parenthesis is the N application rate, lb N/a, difference of the N recommendation system from the EONR.

Table 2. Effect of previous crop and manure application for 2013 sites on the economic advantage of MRTN over Adapt-N (profitability of MRTN minus profitability of Adapt-N) for corn N rate recommendations Wisconsin. Negative numbers indicate Adapt-N was more profitable than MRTN.

Previous crop	Manure	n	MRTN Advantage		
			Mean	Min	Max
			$/acre		
Corn grain/silage	No	10	-10	-87	10
	Yes	12	8	-50	36
Soybean	No	12	8	-12	56
	Yes	6	-27	-52	4
Soybean †	No	9	13	-3	56

† Excludes all sites from manure study.

Figure 1. Distribution of Adapt-N (sidedress + starter if applied) and MRTN (includes starter if applied) N recommendations compared to site economic optimum N (EONR) rates at a 0.10 N:corn price ratio in Iowa for 2013 and Indiana for 2013 (n=12) and 2014 (n=2).

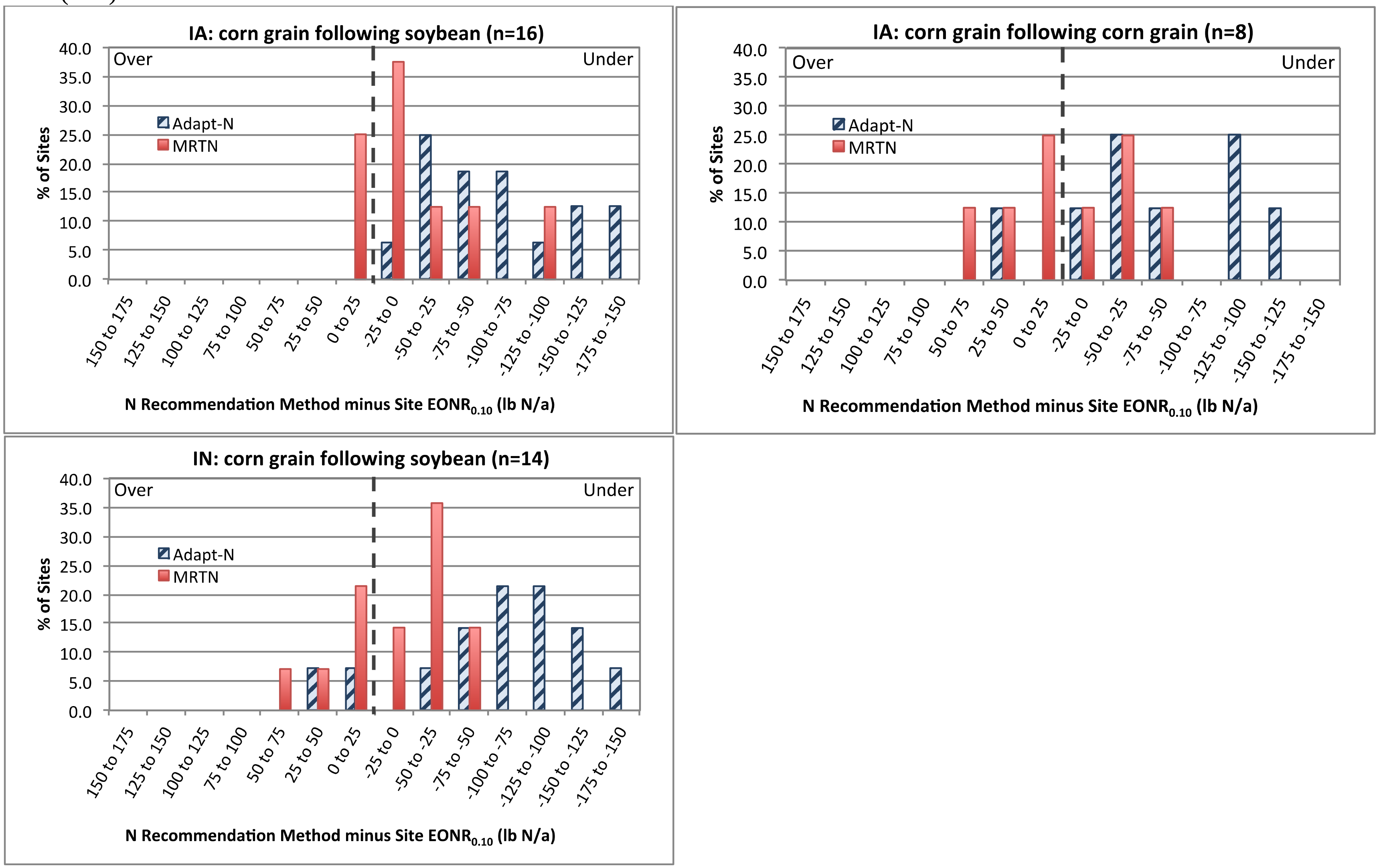
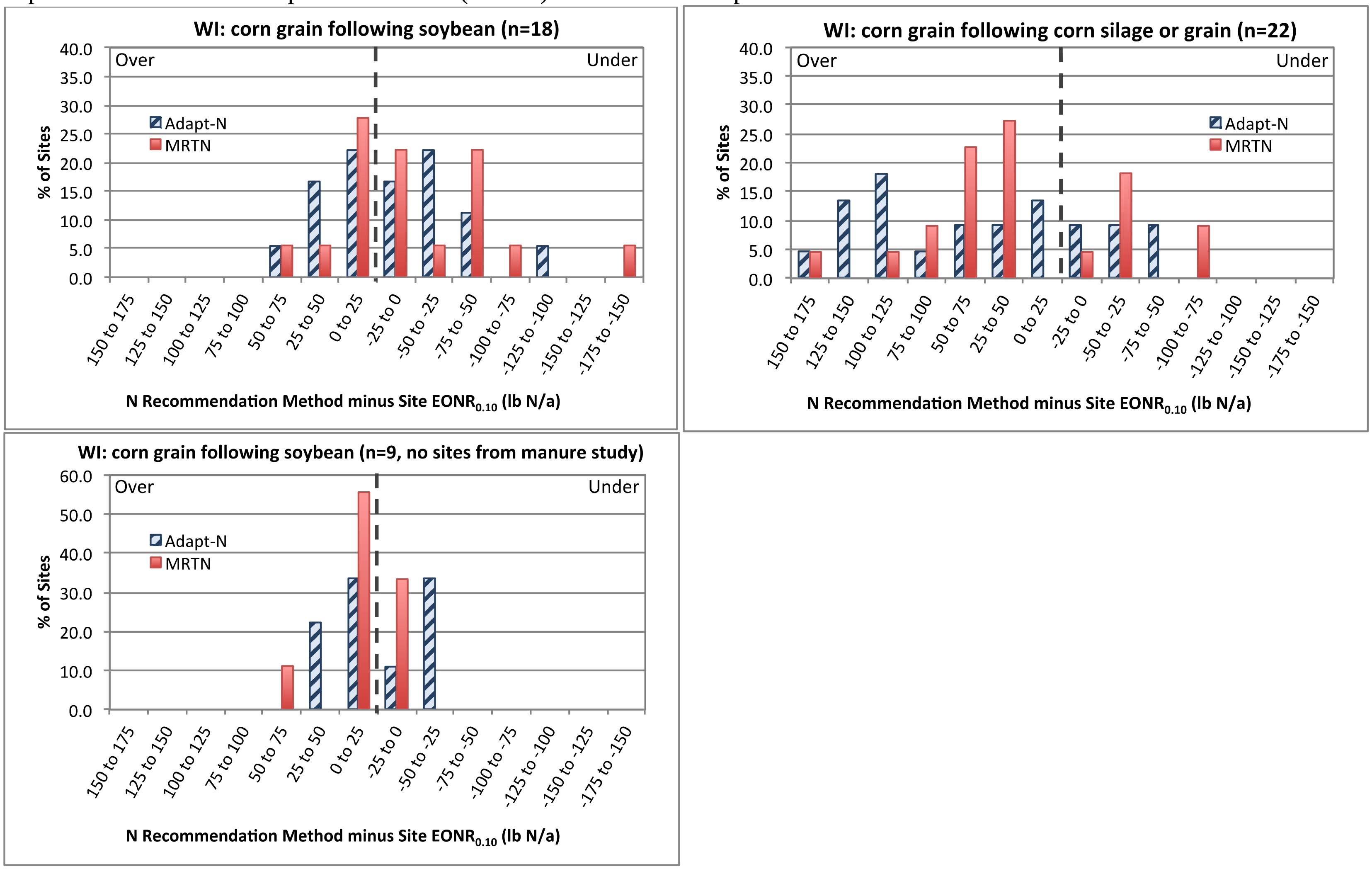


Figure 2. Distribution of Adapt-N (sidedress + starter if applied) and MRTN (includes starter if applied) N recommendations systems compared to site economic optimum N rates (EONR) at a 0.10 N:corn price ratio in Wisconsin for 2013.



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