# COMPARISON OF THE MRTN AND ADAPT-N DERIVED N RATES FOR CORN

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## Introduction

Nitrogen application to corn is a large determinant for high yield, and rate has important implications for economic profitability and off-field movement of nitrate-N. Nitrogen rate recommendation systems have varied over time. A popular system was yield-goal based, with grain yield multiplied by a per-bushel factor and then rate adjusted for previous crop and other N inputs. Modifications of this system are still used today in some states. Seasonal (site-year) variability in economic optimum N rate (EONR) has been widely recognized. However, to date there has been no recommendation system that provides a solution to accurately predict EONR.

Recently, seven states across the Corn Belt adopted the MRTN (Maximum Return To Nitrogen) recommendation approach which provides N rates based directly from analysis of large N response trial databases and maximization of return to N (Corn Nitrogen Rate Calculator; http://extension.agron.iastate.edu/soilfertility/nrate.aspx). Rate is determined from yield increase to applied N and current grain and fertilizer prices; but not yield level (Nafziger et al., 2004; Sawyer and Nafziger, 2005; Sawyer et al., 2006; Nafziger and Sawyer, 2008). The MRTN approach directly provides opportunity for user input and N rate adjustment, such as geographic location, previous crop, and price of N fertilizer (or other N inputs such as manure) and corn. The system provides a suggested N rate at the MRTN, but also provides a profitable range than can be used by producers to adjust rates based on experience, attitude toward risk, available capitol, water and air quality concerns, and local research information. The MRTN approach has some of the same limitations as other recommendation systems. It is well known there is large variability in temporal and spatial N response, which increases the most profitable RTN range and lowers certainty of getting the "correct" N rate in a given field in a given year. The MRTN approach incorporates this variability through response trial regression models, but does not solve the issue of site-specific N fertilization requirement or directly provide adjustment for yearly factors influencing N response. The MRTN approach does provide, however, a high level of confidence for achieving high yields over time within a reasonable N rate range.

With new technologies, such as those used in precision agriculture, and greater available site-specific field information, producers have increased expectation of more highly refined rate recommendation systems. Of great interest is incorporation of weather data to adjust N applications, especially in years of excess rainfall. The Adapt-N (http://adapt-n.cals.cornell.edu/) is an on-line system designed to use radar-interpolated rainfall, along with soil and crop models, to estimate sidedress N fertilization need (Melkonian et al., 2008; Moebius-Clune et al., 2011). The system uses a budget approach, with adjustments from an initial yield-based rate. Input information for running the models include geo-referenced location, soil, rooting depth, slope, sod or soybean previous crop, soil organic matter, tillage system, corn hybrid maturity, planting date, plant population, expected yield range, any manure or fertilizer application date and placement, and season end date (date of recommendation run or in-season N application date).

For full information about Adapt-N, go to http://adapt-n.cals.cornell.edu/. Expected yield is used to determine the base N rate for budget calculations. That amount is then adjusted for N currently in the crop (when Adapt-N is run), N currently in the soil (crop available), N in soil after sidedress, soybean credit if following soybean, losses after N applications, and an uncertainty of profit correction. The expect yield is assumed to be the economically optimum yield for the field, although as with all yield-based systems, the appropriate yield goal is nebulous. A recommended N rate and range is provided, with the range reflecting the uncertainty with post-application fertilizer losses for the remainder of the growing season. If N was applied and was in excess of the recommended amount, a negative or excess estimated amount is provided. With this recommendation system designed to be year-specific for individual fields, refined calculation of potential losses via denitrification/leaching and supply of soil N via mineralization, are of great importance. In addition, if the actual season-specific corn yield and complete-season N use efficiency does not match the entered expected yield and model assumptions, then the Adapt-N recommended rate may not reflect the actual field-specific economic optimum.

The objective of this evaluation was to compare N rate recommendations from the MRTN and Adapt-N systems to site-specific determined corn N fertilization requirements.

## Methods

The EONR from multiple N rate research trials in corn conducted across Iowa were used to evaluate rate recommendations from the MRTN and Adapt-N systems. There were a total of 51 trials, 15 in 2010, 15 in 2011, and 21 in 2012. At some sites the rotation was corn following soybean and corn following corn, and at some sites there was only corn following soybean or corn following corn. The response trials consisted of five to seven N rates (one site each year had five N rates, with the rest six or seven rates). The N fertilizer application was sidedress from mid-May to early June at most sites as UAN solution, with a few sites having spring preplant urea application. Regression models were fit to the corn grain response for each trial, and an EONR calculated at a 0.10 price ratio.

For the MRTN recommended rate, the Corn Nitrogen Rate Calculator output was computed each year, with the year-specific rate used for comparison within each year. Corn grain and fertilizer N prices were chosen to provide a 0.10 price ratio recommendation. For the Adapt-N recommended rate, specific site information was used as input into the on-line Adapt-N. This included all required input information, with the information varied by site depending on the specific practices such as geo-referenced location, soil, rooting depth, slope, soybean previous crop, soil organic matter, tillage system, corn hybrid maturity, planting date and plant population, and expected yield range. All Adapt-N online recommendations each year were completed after harvest. In 2010, all recommendations were for the end-of-growing season timing. In 2011 and 2012, Adapt-N recommendation timings were for preplant in mid-April, sidedress (June 1), and at end-of-growing season. For the preplant and sidedress timings, Adapt-N recommendations were with no prior N applied, and with the end-of-growing season timing 50 lb N/acre at the actual site N application date. The expected yield used varied between sites and was based on measured yields in good production years; not the highest yield ever attained and not an adjusted yield goal. Also, the yield range entered was not the actual yield of a site in a given year, even if

that yield was well below or above normal that year. Rather, yield ranges were selected as deemed appropriate for the site to represent realistic long-term high yield potential.

Each site-year EONR was compared to the MRTN or Adapt-N rate recommendation. For MRTN comparisons, the EONR was subtracted from the MRTN rate recommendation. For Adapt-N comparisons, if the starting rate was zero, then the EONR was subtracted from the Adapt-N rate recommendation; if the starting rate was 50 lb N/acre, then 50 lb was added to the Adapt-N recommendation and then the EONR was subtracted. Therefore, if a comparison to EONR was positive, then that recommended N rate was greater than the EONR; and if negative, the recommended N rate was less than the EONR. Results were grouped by crop rotation.

## Results and Discursion

Both the MRTN and Adapt-N systems had a distribution of recommendation differences from the site-specific EONR's (Figures 1 and 2) in 2011 and 2012. For the MRTN system with corn following soybean (SC), the distribution of differences was approximately centered at the zero difference, with a mean across-year difference of only 4 lb N/acre and with 52% of sites having a difference within 25 lb N/acre of the EONR. The +/- 25 lb N/acre was used an approximation of a realistically achievable (acceptable) N rate recommendation. For the MRTN with corn following corn (CC), the distribution was shifted to an over-recommendation in 2011 and 2012, with a mean across year difference of 29 lb N/acre and with 32% of sites that had a difference within 25 lb N/acre of the EONR. For the Adapt-N system with SC and CC, the distribution was shifted to an under-recommendation, with a mean across year difference of -66 and -63 lb N/acre, respectively, for SC and CC; and only 19 and 26% of sites that had a difference within 25 lb N/acre of the EONR.

The distribution of EONR vs. MRTN rate recommendation has been noted from the inception of that system. Evaluations of the distribution of site EONR's versus the MRTN rate has shown that only the instances (sites) when the EONR rate is considerable below or above the MRTN (tails of the distribution) is there significant economic loss; and as usual under-fertilization is a much greater loss than over-fertilization. Therefore, of most importance for improving N rate recommendation systems would be to predict the times (sites) where a site EONR is considerably different than the MRTN. The distribution with CC in the 2011 and 2012 years was less centered on the EONR than typical. Two things about the EONR vs. Adapt-N rate recommendation distribution comparison were not expected. One was the large under-recommendation and the second was the large range in differences from the site EONR's. With the Adapt-N system providing a site-year specific N recommendation, it was surprising that the recommendations were not more closely related to the site EONR's (that is, "correct"), and certainly did not result in an improvement (narrowing of the distribution range or centering close to the zero difference from site EONR's) compared to the MRTN recommendations. It is unknown why Adapt-N recommendations were consistently lower than needed N application rates. Since the Adapt-N system uses a base N rate derived from expected yield, and appears to be a rate of approximately 1 lb N/bu, choosing a higher yield would increase the Adapt-N rate, but increasing the yield range to the next higher range would only increase each recommendation by around 10-15 N/acre, not enough to shift the overall recommendation distribution to center around the zero

mean difference from the EONR, and would not remove the distribution variation. Increasing yields enough to account for the under-recommendation would not be agronomically justified.

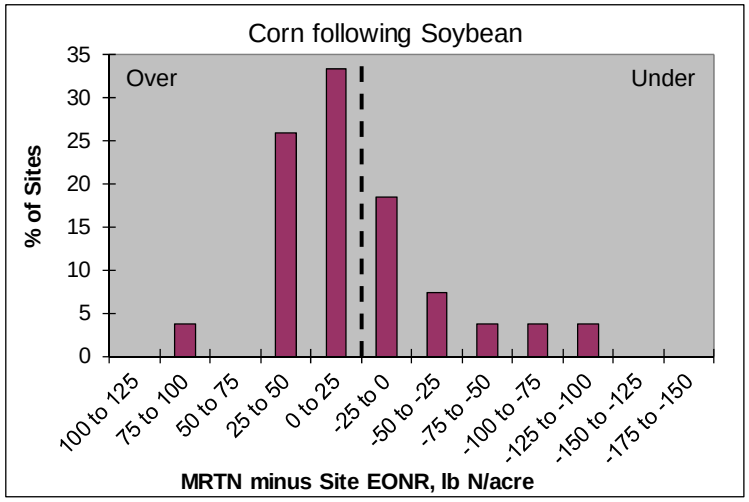
Table 1 gives a summary of all three years for the MRTN and Adapt-N recommendation comparisons. Across the three years, the MRTN recommendation averaged only -10 lb N/acre for SC and 6 lb N/acre for CC compared to the site EONR's. The mean difference for the three years compared to the results for the last two years presented in Figure 1 reflects a different response year in 2010 where the needed N rate was greater than in 2011 and 2012. Across the three years, the percent of sites within 25 lb N/acre of the site EONR's was 43% for SC and 21% for CC. It appears the across-site N rate requirement is more stable with SC than CC, that is, less seasonal variation in EONR with SC. The Adapt-N recommendations were determined three ways, preplant, sidedress, and at the end-of-growing season (Table 1). The data for sidedress in Table 1 is the same as presented in Figure 2. The results of the comparison for the end-of-growing season had a greater mean difference from the EONR than for the sidedress timing, and a smaller percent of sites within 25 lb N/acre of the site EONR's (10 and 14%, respectively for SC and CC). Interestingly, the preplant timing had a closer mean difference to the site EONR's than with sidedress or end-of-growing season (-30 and -40 lb N/acre, respectively for SC and CC), but a similar distribution range. Also, the percent of sites within 25 lb N/acre of the site EONR's was generally higher than the other timings, 26 and 21%, respectively, for SC and CC.

## Summary

It is unknown why the Adapt-N system recommendations were considerably less than the site EONR's and had a large distribution compared to each site EONR, despite being a site-year recommendation system. Those results could be due to many factors related to input information and model parameters used for factors such as rainfall distribution, soil properties, mineralization, nitrification, denitrification, leaching, N uptake, use efficiency, and lack of estimation for soil/plant N processing and losses after the Adapt-N recommendation timing. The results indicate that the models and calculations within Adapt-N need calibration to Iowa soils, climatic, and corn production conditions.

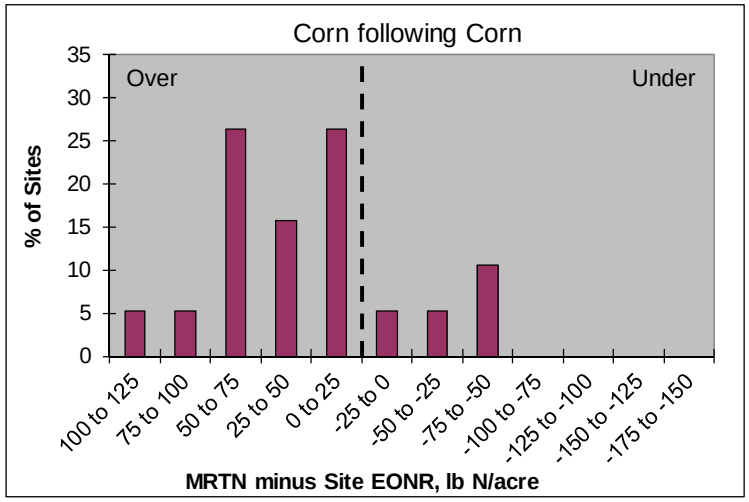
The MRTN system is not a site-year recommendation system, nor has it been promoted as such. It is based on large N rate response trial databases, with trials from many years and locations, and therefore provides rate guidance based directly from recent research. It is a system that should provide rate recommendations for corn N fertilization that are most profitable on the long-term. This is evidenced by how close the three-year MRTN recommended rates were to the average difference from the site-year EONR's (-10 and 6 lb N/acre, respectively, for SC and CC). The distribution of site-year differences does show that improvement could be made for field-specific N rate recommendations, principally when needed N fertilization will be considerably different than expected. It's just that a reliable and well calibrated system needs to be developed, if possible.

Figure 1. Distribution of MRTN rate recommendations compared to site economic optimum N rates (EONR).




| Mean | 2010 | 2011 | 2012 | All | |
|---|---|---|---|---|---|
| Diff. | . | -15 | 21 | 4 | lb N/acre |
| EONR | . | 148 | 114 | 130 | lb N/acre |
| MRTN | . | 133 | 135 | 134 | lb N/acre |
| n | . | 13 | 14 | 27 | |

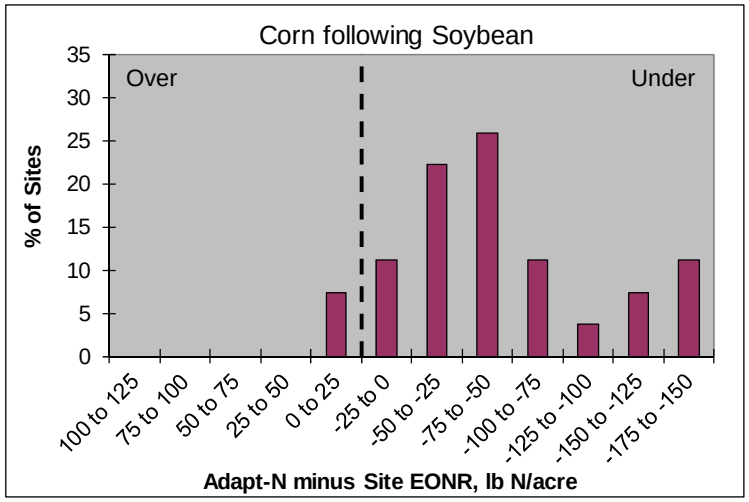
Percent of Sites +/- 25 lb N/acre of the EONR: 52%.




| Mean | 2010 | 2011 | 2012 | All | |
|---|---|---|---|---|---|
| Diff. | . | 15 | 42 | 29 | lb N/acre |
| EONR | . | 175 | 150 | 162 | lb N/acre |
| MRTN | . | 190 | 192 | 191 | lb N/acre |
| n | . | 9 | 10 | 19 | |

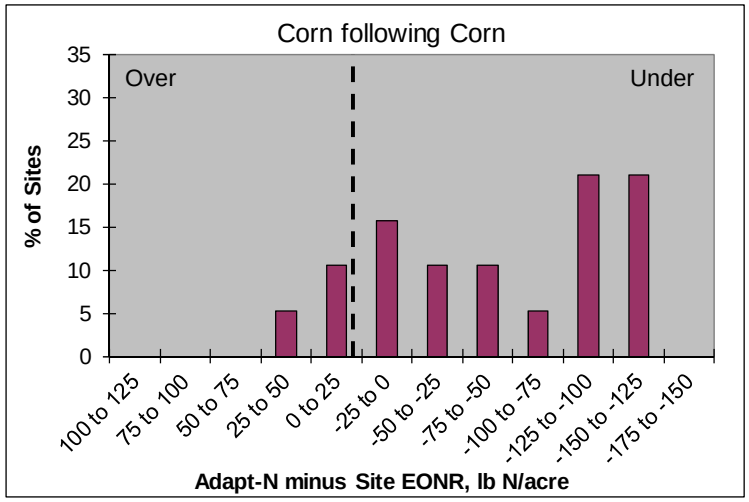
Percent of Sites +/- 25 lb N/acre of the EONR: 32%.

Figure 2. Distribution of Adapt-N rate recommendations (sidedress timing) compared to site economic optimum N rates (EONR).




| Mean | 2010 | 2011 | 2012 | All | |
|---|---|---|---|---|---|
| Diff. | . | -75 | -57 | -66 | lb N/acre |
| EONR | . | 148 | 114 | 130 | lb N/acre |
| n | . | 13 | 14 | 27 | |

Percent of Sites +/- 25 lb N/acre of the EONR: 19%.




| Mean | 2010 | 2011 | 2012 | All | |
|---|---|---|---|---|---|
| Diff. | . | -67 | -59 | -63 | lb N/acre |
| EONR | . | 175 | 150 | 162 | lb N/acre |
| n | . | 9 | 10 | 19 | |

Percent of Sites +/- 25 lb N/acre of the EONR: 26%.

Table 1. Comparison of the Maximum Return to N (MRTN) and Adapt-N rate recommendations to site economic optimum N rates (EONR).

| | 2010 | 2011 | 2012 | All | 2010 | 2011 | 2012 | All |
|---|---|---|---|---|---|---|---|---|
| | - - - - - - - - - - - - - - - - - - lb N/acre - - - - - - - - - - - - - - - - - - | | | | | | | |
| | MRTN - SC | | | | MRTN - CC | | | |
| Mean Dif.† | -38 | -15 | 21 | -10 | -44 | 15 | 42 | 6 |
| Max. Dif. | 51 | 47 | 94 | -- | 80 | 74 | 118 | -- |
| Min. Dif. | -112 | -107 | -13 | -- | -70 | -50 | -17 | -- |
| EONR | 166 | 148 | 114 | 142 | 224 | 175 | 150 | 182 |
| MRTN | 128 | 133 | 135 | 132 | 180 | 190 | 192 | 188 |
| LOW‡ | 116 | 119 | 121 | -- | 166 | 175 | 177 | -- |
| HIGH‡ | 142 | 146 | 148 | -- | 192 | 203 | 205 | -- |
| n | 13 | 13 | 14 | 40 | 9 | 9 | 10 | 28 |
| | Adapt-N Preplant†† - SC | | | | Adapt-N Preplant†† - CC | | | |
| Mean Dif. | -- | -39 | -22 | -30 | -- | -44 | -37 | -40 |
| Max. Dif. | -- | 39 | 54 | -- | -- | 45 | 50 | -- |
| Min. Dif. | -- | -135 | -81 | -- | -- | -105 | -109 | -- |
| n | -- | 13 | 14 | 27 | -- | 9 | 10 | 19 |
| | Adapt-N Sidedress†† - SC | | | | Adapt-N Sidedress†† - CC | | | |
| Mean Dif. | -- | -75 | -57 | -66 | -- | -67 | -59 | -63 |
| Max. Dif. | -- | -1 | 14 | -- | -- | 25 | 30 | -- |
| Min. Dif. | -- | -170 | -136 | -- | -- | -130 | -139 | -- |
| n | -- | 13 | 14 | 27 | -- | 9 | 10 | 19 |
| | Adapt-N End-of-Season§ - SC | | | | Adapt-N End-of-Season§ - CC | | | |
| Mean Dif. | -119 | -84 | -65 | -89 | -134 | -67 | -62 | -87 |
| Max. Dif. | -2 | -3 | 31 | -- | -49 | 45 | 40 | -- |
| Min. Dif. | -220 | -180 | -151 | -- | -205 | -135 | -134 | -- |
| n | 13 | 13 | 14 | 40 | 9 | 9 | 10 | 28 |

† Dif., difference is each site EONR subtracted from the rate recommendation.

‡ LOW and HIGH, lower and upper end of the most profitable MRTN rate range.

†† Adapt-N recommendation with no prior N applied.

§ Adapt-N recommendation with 50 lb N/acre applied at site N application date.

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