Comparing Yield Goal and Maximum Return to Nitrogen Prediction Methods for Determining Corn Economic Optimal Nitrogen Rates

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October 2023

Introduction

Nitrogen (N) is an essential plant nutrient commonly applied to South Dakota (SD) corn crops and is critical for optimizing corn yield and profitability. However, excessive N fertilizer applications can reduce fertilizer efficiency, create environmental contamination issues, and reduce grower profits. Thus, it is imperative to continually improve the accuracy of our corn N rate recommendations. At this time, there are two main N rate recommendation systems used in the U.S.–Yield goal and maximum return to N (MRTN).

The yield goal approach was developed in the 1970s and was the main system for determining corn N rate recommendations until the maximum return to N approach was developed in 2005 (Sawyer et al., 2006; Morris et al., 2018). One of the greatest strengths of the yield goal approach is simplicity, but that simplicity is likely not able to account for some of the challenges in using the yield goal approach, including being able to estimate yield, internal corn plant N efficiency (i.e., lbs N/bu corn) and other fertilizer use efficiency factors at the beginning of the season (Morris et al., 2018). The MRTN approach determines N rate recommendations based on N response curves from N rate studies conducted in each state or region within a state and is continually updated with new research data. Some of the advantages of the MRTN approach are the ability to incorporate economics into the N recommendation and group sites by different criteria that can influence N response like previous crop, soil type, location, or tillage practice. Some potential disadvantages of the MRTN approach include not accounting for residual N that is especially important in drier climates, the inability to tailor a recommendation for an individual field or zone within a field, and it is often difficult to estimate the price of corn and fertilizer as the selling of corn and purchasing of fertilizer are often at different times of the year. In this fact sheet we will evaluate the accuracy of corn N rate recommendations for South Dakota corn using the yield goal and MRTN methods.

Materials and Methods

Forty-five corn N rate response trials were conducted at field locations across central and eastern SD from 2018-2022. Site locations varied in tillage practice, crop rotation, and soil type. Specifically, 32 in conventional till and 13 in no-till fields. The previous crop was soybean at 35 locations, and wheat, corn, or sunflower at 10 locations. Nitrogen fertilizer was applied before planting at rates from 0 to 200 lbs N ac-1 in 40 lb increments. Nitrogen fertilizer as urea (46-0-0) with a urease and nitrification inhibitor to minimize N loss potential was broadcast on the soil surface. Fertilizer was incorporated if conventional tillage practices were used or remained on the soil surface when no tillage

was used. Soil samples were collected before planting and fertilizer application from the 0-6 and 6-24 in. depth increments and analyzed for nitrate-N. Corn grain yield was determined by harvesting the center two rows of each plot and adjusting grain weight to 15.5% moisture.

Economic optimal N rates were determined by modeling the relationship between corn yield and N fertilizer rate by averaging the results from both the linear-plateau and quadratic-plateau models using a N fertilizer price to corn price ratio of 0.1 (Miguez and Poffenbarger, 2022). If no plateau was reached within the N rates used in the study, the economic optimal N rate was set to the maximum N rate used at that location. The lbs N/bu multiplier (coefficient) was calculated for each site by adding the amount of N fertilizer needed to optimize corn yield and the nitrate-N in the soil from 0 to 24 in. and dividing it by the optimal corn yield (e.g., (soil test N + economic optimal N fertilizer rate) / optimal grain yield). Four of the 45 sites were not included due to extreme drought conditions. For the yield goal approach, the N rate recommendation for each of the remaining 41 locations was calculated using the following equation:

N fertilizer rate =
Yield potential × 1.0 lbs N/bu - Soil Test N - Legume Credits - manure credits + no-till debit

The 41 site-years of response trials were input into a database developed by John Sawyer at Iowa State University (Sawyer et al., 2006, personal communication). This spreadsheet was used to calculate an MRTN for all of SD as well as divided into a central and eastern region. The accuracy of the N recommendation for the yield goal and MRTN approaches was calculated by subtracting the actual EONR from the predicted EONR. The closer these numbers were to 0, the more accurate the recommendation. If numbers were positive, it meant an over application of N was recommended while negative numbers meant an under application of N was recommended. The mean, median, lower 25th quartile, upper 75th quartile and root mean square error (RMSE) of these calculations was completed to help in comparing the accuracy of each N recommendation approach.

Results

Across the 41 locations, corn yields ranged from 75 to 255 bu/ac with an average of 185 bu/ac while the optimal N rate ranged from 0 to 200 lbs N/ac with an average of 96 lbs N/ac (Figure 1).

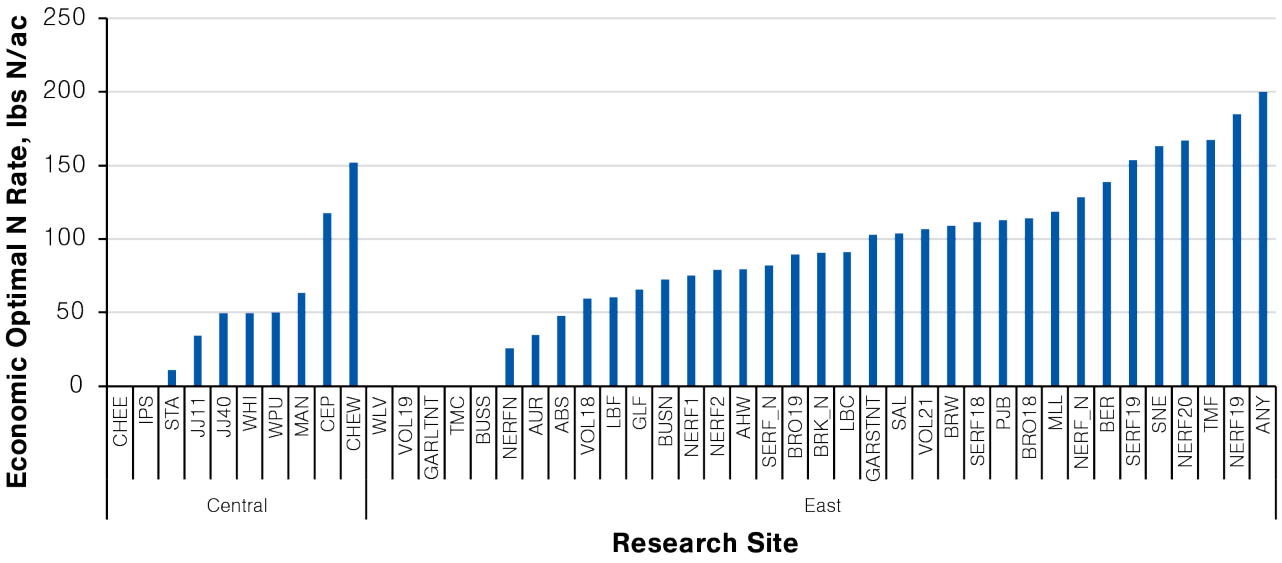

Figure 1. The corn economic optimal N rate (EONR) at research sites across South Dakota from 2018 to 2022.

Yield Goal Approach

The N fertilizer rate equation accuracy was assessed by taking the recommended N rate using the yield goal method and then subtracting it from the actual N rate determined at each location. The closer these numbers were to 0, the more accurate the recommendation. If numbers were positive, it meant an over application of N was recommended while negative numbers meant an under application of N was recommended. Across all locations using the yield goal method, the accuracy ranged between -112 and +133 lbs N/ac (Figure 2 and Table 1). On average across all locations, there was an over application of 13 lbs N/ac. The average difference in the accuracy averages positive and negative numbers together and can make the accuracy seem better than it is so another way to compare the accuracy is to take the difference between the actual and predicted needed N rate, square it to get rid of any negative numbers, and then take the square root to get it back to the correct units. This calculation is commonly referred to as the root mean square error (RMSE) or absolute average difference between the actual and predicted values. For the yield goal approach, the RMSE was ±55 lbs N/ac.

MRTN Approach

The MRTN for the state of SD at a N price to corn price ratio of 0.15 (N price: $1.03/lb N and corn price: $6.95/bu) was 97 lbs. N/ac and when divided into regions it was 60 lbs. N/ac for central and 102 lbs. N/ac for eastern SD (Figure 2 and Table 1). Across all locations using the MRTN for all of SD, the accuracy ranged between -103 and +97 lbs N/ac. For only the eastern region the accuracy ranged between -98 and +102 lbs N/ac while the central region ranged between -92 and +60 lbs N/ac. Averaged across all sites, there was a mean over application of 8 lbs N/ac, and when divided into eastern and central regions a mean overapplication of 1 and 7 lbs N/ac, respectively. The RMSE decreased from ±51 lbs N/ac when using an MRTN for the entire state to ±46 and ±47 lbs N/ac when divided into eastern and central regions, respectively. These results indicate that the MRTN approach is more accurate when dividing SD into central and eastern regions, which is likely due to the greater chance of moisture limiting corn yields in central compared to eastern SD.

Yield Goal vs. MRTN

Compared to using the yield goal approach, using the MRTN approach improved the average accuracy of N recommendations by 4 to 12 lbs N/ac and the RMSE by ±4 to ±9 lbs N/ac (Table 1). Overall, the MRTN compared to the yield goal approach is slightly more accurate using the current dataset from 2018-2022. However, the results between the yield goal and MRTN approach are not large enough to say one approach is definitively better than the other. Nitrogen response trials will continue to be conducted and added to the yield goal and MRTN databases to see how these approaches differ over time and with an increased number of sites in the database.

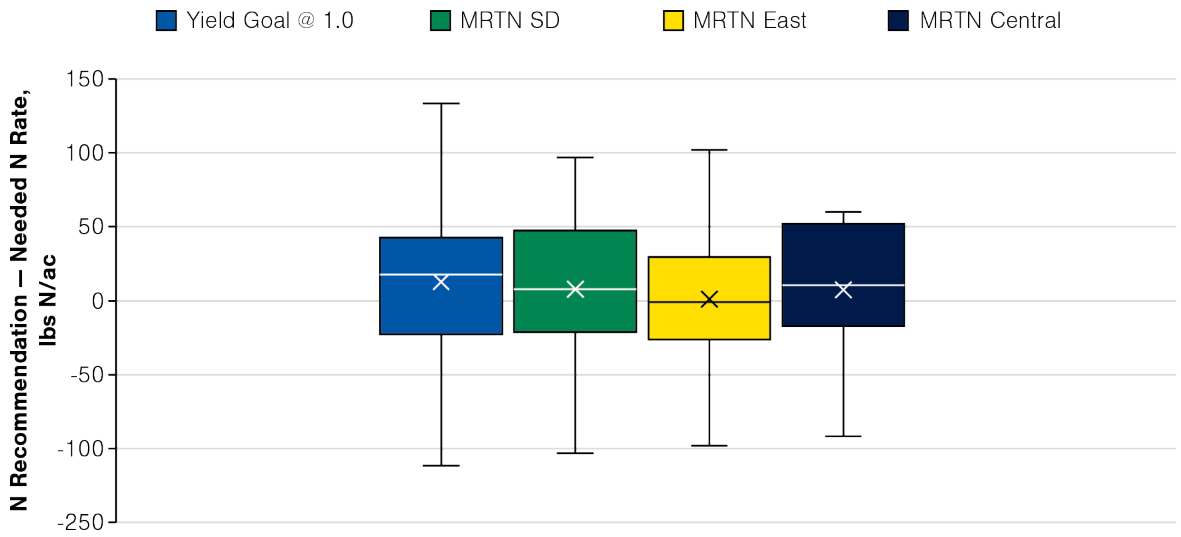

Figure 2. The accuracy of N fertilizer recommendations using yield goal approach and three maximum return to N methods across all sites or divided into eastern and central regions. Accuracy as shown by the Y axis is determined by taking the N recommendation calculated using each method and subtracting it from the N fertilizer rate needed at each location. Values closest to 0 are most accurate. Values above 0 are over applications and values below 0 are under applications. The box midline represents the median, the 'x' marks the mean, the upper and lower edges of the box represent the 25th to 75th percentiles, and the whiskers represent the range of data.

Table 1. Descriptive statistics regarding the accuracy of N rate recommendations using yield goal approaches with three different lbs N/bu corn multipliers and the maximum return to N (MRTN) approach with the state as one region and divided into east and central regions.

Statistic	Yield Goal @ 1.0	MRTN SD	MRTN East	MRTN Central
	---------- lbs N/ac ----------			
Min	-112	-103	-98	-92
Max	133	97	102	60
Mean	13	8	1	7
Median	18	8	-1	11
Upper 75th quartile	42	47	28	43
Lower 25th quartile	-17	-20	-21	-0.12
RMSE, ±	55	51	46	47

Acknowledgement

Research funded by the SD Nutrient Research and Education Council and NIFA Hatch project SD000H676-18.

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P-00280