UPDATING OAT NITROGEN FERTILIZER RATE GUIDELINES

Jason Clark[1], David Karki,[1], Anthony Bly[1], and Peter Sexton[1]
[1]South Dakota State University–Brookings, SD
Jason.D.Clark@sdstate.edu (801) 644-4857

ABSTRACT

The current yield-goal based system for calculating oat N rate recommendations in SD has not been evaluated for accuracy recently. There are two main N rate recommendation systems used in the U.S.–Yield goal and maximum return to N (MRTN). Therefore, the objective of this project was to 1) evaluate the accuracy of the current yield goal-based equation and 2) evaluate the accuracy of using the MRTN approach for predicting N rate requirements. Twenty-eight oat N rate response trials were conducted at field locations across central and eastern SD from 2017-2022. Nitrogen fertilizer was applied before planting at rates from 0 to 150 lbs N/ac. Soil samples were collected before planting and fertilizer application from the 0-6 and 6-24 in. depth increments and analyzed for nitrate-N. Accuracy of the N recommendation for the yield goal and MRTN approaches were calculated by subtracting the actual EONR from the predicted EONR. The lbs N/bu oat multiplier (coefficient) used in the yield goal approach ranged between 0.4 and 2.4 lbs N/bu oats with an average of 0.9 lbs N/bu oats, indicating that the average amount of N to produce a bushel of oats has decreased from the previous 1.3 value. Across all locations, the median accuracy was +37, +20, +3, -16, -38, and -57 lbs N/ac using a multiplier of 1.3, 1.1, 0.9, 0.7, 0.5, and 0.3, respectively. Therefore, the multiplier (coefficient) of 0.9 instead of 1.3 provides the most accurate yield-goal based N fertilizer rate recommendation. The MRTN for the state of SD at a N price to oats price ratio of 0.12 was 54 lbs N/ac. In comparing the MRTN and yield goal results, the median accuracy for the MRTN approach was +48 lbs N/ac compared to +3 for the 0.9 yield goal approach. Subtracting the soil nitrate-N from the top two feet from the MRTN recommendation improved the median accuracy to 0.5 lbs N/ac. This result indicates that the MRTN approach is most accurate when subtracting soil test N (2 ft.) from the initial 54 lbs N/ac recommendation. Overall, once soil test N is subtracted from the initial MRTN recommendation both the yield goal approach and MRTN approaches had similar accuracies and both methods can be used with confidence.

INTRODUCTION

Nitrogen (N) is an essential plant nutrient commonly applied to South Dakota (SD) oat crops and is critical for optimizing yield. The correct fertilizer-N rate is important as too low of a rate reduces economic return while too high of a rate can lead to N loss, potential negative environmental effects, and reduced economic return. Therefore, it is important to always work on improving the accuracy of oat N rate recommendations. Common N rate recommendation approaches at this time include the yield goal approach and the maximum return to N (MRTN) approach (Morris et al., 2018).

The yield goal approach was developed in the 1970s and was the main system

for creating crop N recommendations until the maximum return to N approach was developed in 2005 (Morris et al., 2018; Sawyer et al., 2006). South Dakota currently uses a yield goal-based system to determine N fertilizer recommendations. However, it is unknown when these recommendations were last evaluated. Therefore, the objective of this project was to 1) evaluate the accuracy of the current yield goal-based equation used in SD, which includes yield potential (goal), 1.3 lbs N/bu oats multiplier (coefficient), pre-plant soil test N (0 to 24 inches), and previous crop and 2) evaluate the accuracy of using the MRTN approach for predicting N requirements.

MATERIALS AND METHODS

Twenty-eight oat N rate response trials were conducted at field locations across central and eastern SD from 2017-2022. Site locations varied in tillage practice, crop rotation, and soil type. Specifically, 9 were in conventional till and 19 in no-till fields. The previous crop was soybean at 25 locations, and corn at 3 locations. Nitrogen fertilizer was applied before planting at rates from 0 to 150 lbs N ac^{-1}. Nitrogen fertilizer as urea (46-0-0) 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 (Nathan et al., 2015). Oat grain yield was determined by harvesting the center five feet of each plot and adjusting grain weight to 13% moisture.

Economic optimal N rates were determined by modeling the relationship between oat yield and N fertilizer rate by averaging the results from both the linear-plateau and quadratic-plateau models using a N fertilizer price to oat price ratio of 0.12 (Miguez & 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 oats multiplier (coefficient) was calculated for each site by adding the amount of N fertilizer needed to optimize oat yield and the nitrate-N in the soil from 0 to 24 in. and dividing it by the optimal oat yield (e.g., (soil test N + economic optimal N fertilizer rate) / optimal grain yield). For the yield goal approach, the N rate recommendation was calculated using 1.3 (current value), 1.1, 0.9, 0.8, 0.7, 0.5, and 0.3) as the coefficient. The 28 site-years of response trials were input into a database developed by John Sawyer at Iowa State University (Sawyer et al., 2006). This spreadsheet was used to calculate a maximum return to N (MRTN) rate. 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 RMSE values were calculated to help in comparing the accuracy of each N recommendation approach.

RESULTS AND DISCUSSION

Yield Goal Approach

Across the 28 locations, maximum oat yields ranged from 65 to 162 bu/ac with an average of 100 bu/ac while the optimal fertilizer-N rate ranged from 0 to 125 lbs N/ac

with an average of 27 lbs N/ac (Figure 1). The optimal fertilizer-N + Soil nitrate-N amount ranged from 28 to 172 lbs N/ac with an average of 64 lbs N/ac. The lbs N/bu oats multiplier (coefficient) ranged between 0.4 and 2.4 lbs N/bu oats with an average of 0.9 lbs N/bu oats (Figure 2). These results demonstrate that the average amount of N to produce a bushel of oats has decreased from the previous 1.3 value.

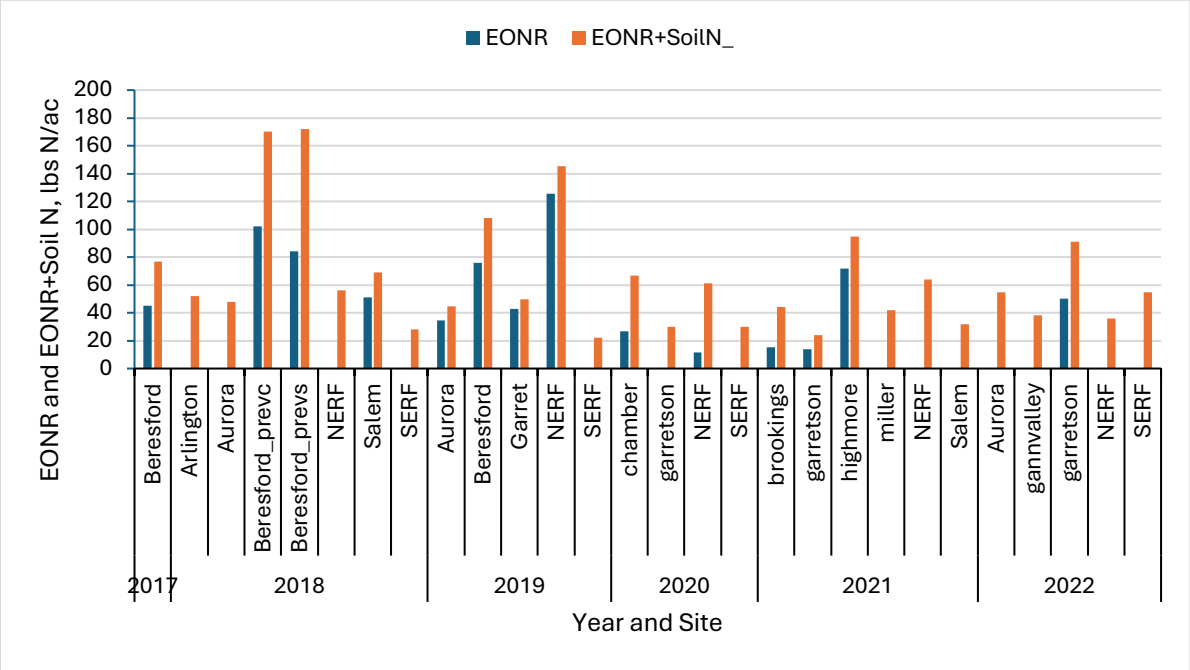

Figure 1. The oats economic optimal N rate (EONR) and EONR + soil nitrate-N from the top two feet at research sites across South Dakota from 2017 to 2022.

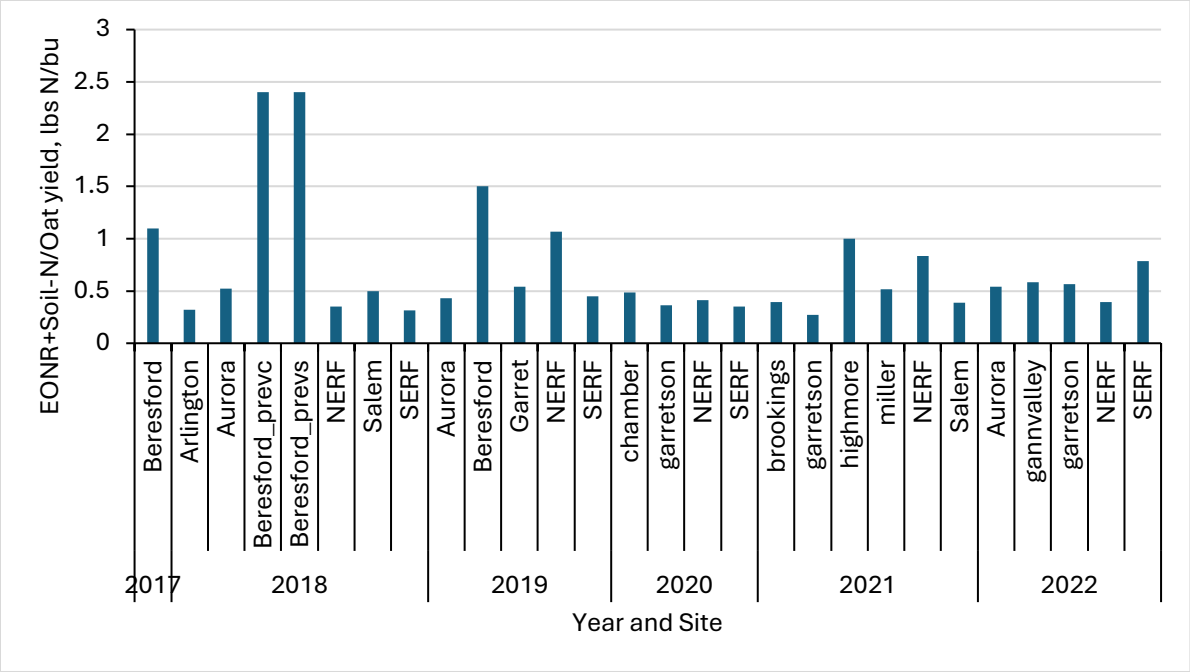

Figure 2. The amount of N fertilizer + soil nitrate-N before planting needed to produce one bushel of oats at research sites across South Dakota from 2017 to 2022.

The N fertilizer rate equation accuracy was assessed using six different multipliers (0.3, 0.5, 0.7, 0.9, 1.1, and 1.3) with the 1.3 value being the currently used multiplier. The N rate recommendation for each of the 28 locations was calculated using all six multipliers. The recommended N rate was then subtracted from the actual rate needed 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 a multiplier of 1.3 the median accuracy was +37 lbs N/ac (Figure 3; Table 1). Reducing the multiplier led to median accuracies of +20, +3, -16, -38, and -57 lbs N/ac using a multiplier of 1.1, 0.9, 0.7, 0.5, and 0.3, respectively. These results demonstrate that reducing the multiplier from 1.3 to 0.9 improved the accuracy of the N rate recommendations the most. Reducing the multiplier from 1.3 to 0.9 improved the N rate accuracy by 34 lbs N/ac and resulted in the closest distribution around zero difference between the predicted and actual N requirements. Therefore, the multiplier (coefficient) of 0.9 instead of 1.3 provided the most accurate N fertilizer rate recommendations. Economically, the 34 lbs N/ac improvement in N rate recommendations by changing from a multiplier of 1.3 to 0.9 can save SD farmers $15/ac ($0.43/lb N).

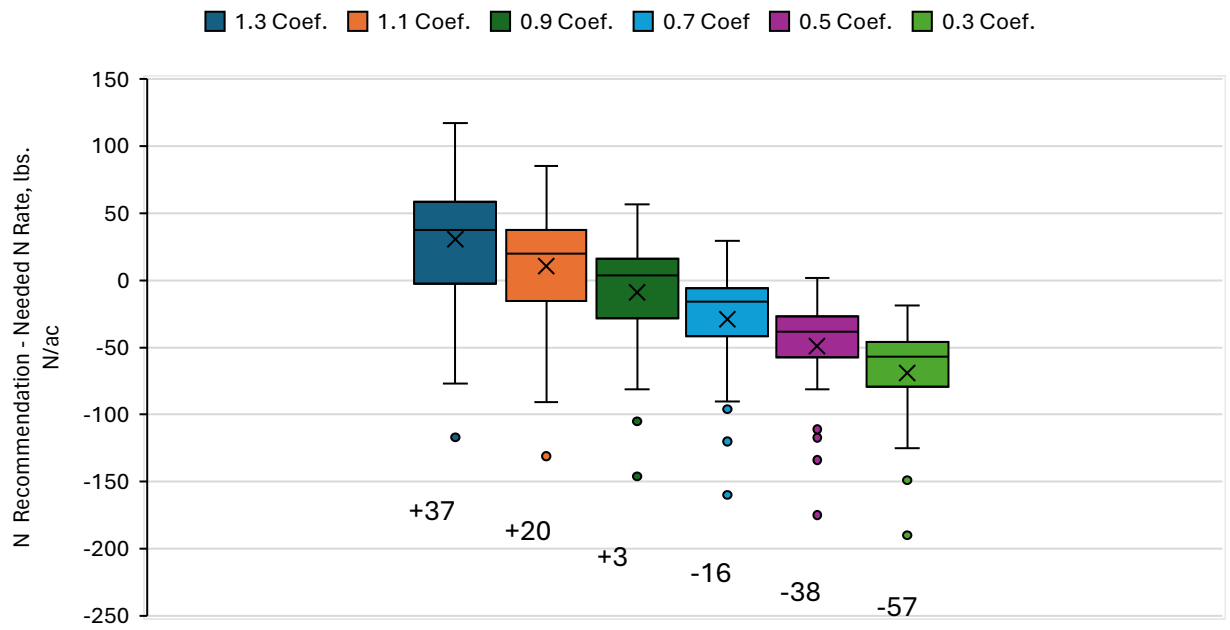

Figure 3. The accuracy of N fertilizer recommendations using six different lbs N/bu oats multipliers (1.3, 1.1, 0.9, 0.7, 0.5, and 0.3) across 28 locations from 2017 to 2022. Accuracy as shown by the Y axis is determined by taking the N recommendation calculated using each of the multipliers and subtracting 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, the whiskers represent the range of data within 1.5 times the middle 50% of data, and points beyond the whiskers represent points beyond that.

MRTN Approach

The MRTN for the state of SD at a N price to oats price ratio of 0.12 was 54 lbs. N/ac. Using the MRTN across all locations led to a median accuracy of +48 lbs N/ac, demonstrating that using the MRTN would normally lead to over applying N fertilizer (Figure 4 and Table 1). However, subtracting soil nitrate-N in the top two feet improved the accuracy of the MRTN method. For example, subtracting 1/2 of the N led to a median accuracy of +25 lbs N/ac, subtracting 2/3 of the N had an accuracy of +17 lbs N/ac, and subtracting the full soil test value had an accuracy of +0.5 lbs N/ac. These results indicate that the MRTN approach is most accurate when subtracting soil test N (full 2 ft.) from the initial 54 lbs N/ac recommendation, demonstrating that accounting for soil test N is an important step in making recommendations for N fertilizer rates for oats.

Compared to the yield goal approach using a multiplier of 0.9, the MRTN method alone was less accurate by 45 lbs N/ac. However, once soil test N was subtracted from the initial MRTN recommendation both the yield goal approach and MRTN approaches had similar accuracy. Therefore, both methods can be used reliably when soil test N is incorporated into the recommended rate value.

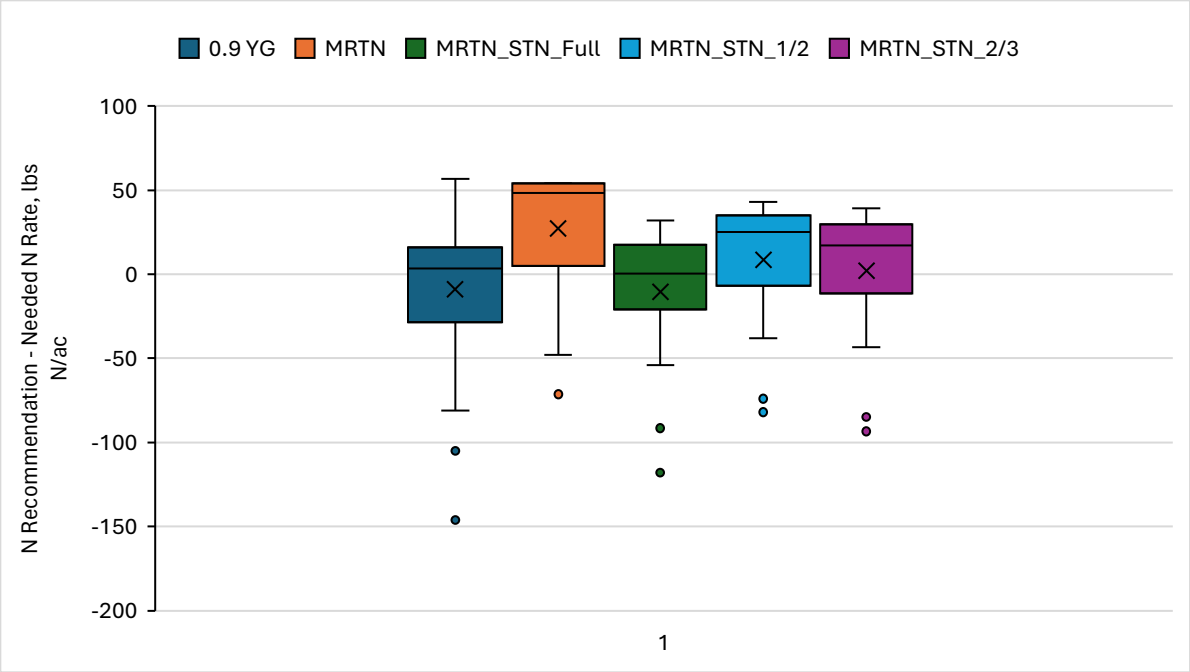

Figure 4. The accuracy of N fertilizer recommendations across all sites using yield goal approach with the 0.9 lbs N/bu oats multiplier (0.9 YG) and three maximum return to N (MRTN) methods where MRTN alone was used or the full (MRTN_STN_Full), 2/3 (MRTN_STN_2/3), or 1/2 (MRTN_STN_1/2) amount of the soil test N (2 ft. depth) was subtracted from the initial MRTN value. 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, the whiskers represent the range of data within 1.5 times the middle 50% of data, and points beyond the whiskers represent points beyond that.

Table 1. Descriptive statistics regarding the accuracy of N rate recommendations using yield goal (YG) approaches with six different lbs N/bu oats multipliers (1.3, 1.1, 0.9, 0.7, 0.5, and 0.3) and three maximum return to N (MRTN) methods where MRTN alone was used or the full (MRTN_STN_Full), 2/3 (MRTN_STN_2/3), or 1/2 (MRTN_STN_1/2) amount of the soil test N from the top 2 ft. was subtracted from the initial MRTN value.

Statistic	YG @ 1.3	YG @ 1.1	YG @ 0.9	YG @ 0.7	YG @ 0.5	YG @ 0.3	MRTN	MRTN STN Full	MRTN STN 2/3	MRTN STN 1/2
Min	-117	-131	-146	-160	-175	-190	-71	-91	-93	-81
Max	117	85	57	29	2	-25	54	30	39	43
Mean	51	40	31	34	49	69	41	-10	2	8
Median	37	20	3	-16	-39	-57	48	1	17	25
75th quartile	58	37	16	-6	-27	-45	54	18	30	35
25th quartile	-3	-16	-28	-42	-58	-79	5	-21	-11	-7

RMSE	51	40	31	34	49	69	41	27	30	32

ACKNOWLEDGEMENT

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