Updating Oat Nitrogen Fertilizer Rate Recommendations in South Dakota

David Karki, Assistant Professor and SDSU Extension Crop Production Specialist
Jason Clark, Assistant Professor and SDSU Extension Soil Fertility Specialist
Anthony Bly, SDSU Extension Soils Field Specialist
Peter Sexton, Associate Professor, SDSU Extension Sustainable Cropping Systems Specialist and Southeast Research Farm Supervisor

January, 2026

Introduction

Nitrogen (N) is an essential plant nutrient commonly applied to South Dakota (SD) oat crop and is critical for optimizing yield. The correct fertilizer-N rate is important as applying lower than required reduces economic return while higher rate can lead to N loss, potential negative environmental effects, and reduced economic return. Therefore, it is important to keep improving the accuracy of oat N rate recommendations.

South Dakota currently uses a yield goal-based system to determine N fertilizer recommendations, which is-

N Fertilizer rate = 1.3 lbs N/bu × Yield Goal (potential) – Soil Test N – Legume Credits

However, it is unknown when the oat N recommendations were last evaluated and updated. Therefore, oat N rate response studies were conducted from 2017 to 2022 to evaluate and update the current recommendations. In this fact sheet we will discuss results from these oat N rate studies.

Methods

Twenty-eight oat N rate response trials were conducted at field locations across eastern and central SD from 2017-2022. Site locations varied in tillage practice, crop rotation, and soil type. Nine sites used conventional tillage and 19 used no-till. The previous crop was soybean at 25 locations, corn at two locations, and sunflower at one location. Nitrogen fertilizer as urea was broadcast applied before planting at rates from 0 to 150 lbs N/ac. 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 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 13.5% moisture.

Economic optimal N rates (EONR) 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 coefficient or multiplier (lbs N/bu oats) 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 the 0 to 24 in. depth and dividing it by the optimal oat yield [e.g., (soil test N + economic optimal N fertilizer rate) / optimal grain yield)].

Using the current yield goal approach framework, the N rate recommendation was calculated using 1.3 lbs N/bu oats (current value) and 1.1, 0.9, 0.8, 0.7, 0.5, and 0.3 as the coefficient. The accuracy of the N recommendation using these different coefficients were 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,

and upper 75th quartile values were calculated to help in comparing the accuracy of each N recommendation approach.

Results and Discussion

lbs N/bu oat coefficient

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 (lbs N/ac from 0-24 in.) 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.

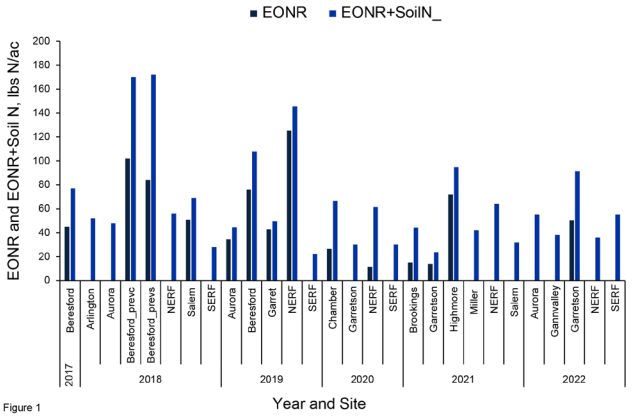

Figure 1. The oats economic optimal N rate (EONR) and EONR + soil nitrate-N from the top two feet at research sites across South Dakota from 2017 to 2022.

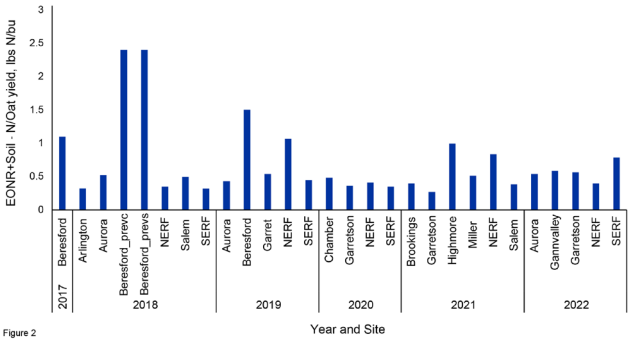

Figure 2. The amount of N fertilizer + soil nitrate-N before planting needed to produce one bushel of oats at research sites across South Dakota from 2017 to 2022.

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).

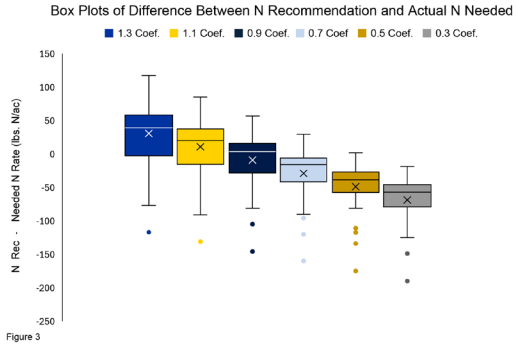

Figure 3. The accuracy of N fertilizer recommendations using six different lbs N/bu oats multipliers (1.3, 1.1, 0.9, 0.7, 0.5, and 0.3) across 28 locations from 2017 to 2022. Accuracy as shown by the Y axis is determined by taking the N recommendation calculated using each of the multipliers and subtracting 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.

Legume Credit

The traditional legume N credit given for growing oats after soybean is 40 lbs N/ac. Using the 0.9 lbs N/bu oats coefficient in the N recommendation formula and a legume credit of 40 lbs N/ac credit led to a mean accuracy of -10 lbs N/ac (Figure 4). As shown in figure four, the 40 lb legume credit box plot shows a skew where most of the box is below zero, meaning that the use of this recommendation equation as is has a good chance of recommending less N fertilizer than would be needed to optimize oat yield. However, if the legume credit is reduced to 30 lbs N/ac, the box plot is more evenly distributed around zero with a mean value of -0.6 lbs N/ac. Further reduction of the legume credit to 20 or 10 lbs N/ac increased probability of over applications of N fertilizer by eight and 17 lbs N/ac, respectively. Based on these results the legume credit value for when oats follow soybean will be reduced from 40 to 30 lbs N/ac.

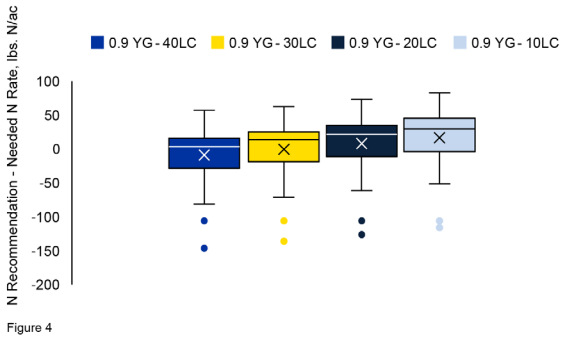

Figure 4. The accuracy of N fertilizer recommendations using four different N legume credit values (40, 30, 20, and 10 lbs N/ac) across 28 locations from 2017 to 2022. Accuracy as shown by the Y axis is determined by taking the N recommendation calculated using each of the multipliers and subtracting 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.

Conclusions

- The average amount of N to produce a bushel of oat decreased from the previous 1.3 value to 0.9.
- The legume N credit given to oat when grown after soybeans will be reduced from 40 to 30 lbs N/ac.
- The new N fertilizer recommendation formula will be as follows:
  - N recommendation = 0.9 lbs N/bu × Yield Goal (potential) – Soil Test N – Legume Credit (30 lbs N/ac when following soybean)
- We highly recommend testing soils for accurate nutrient recommendations; however, in situations where soil tests are not performed and/or legume credits (if any) are not considered, we have estimated a coefficient of 0.6 lbs N/bu oats to be sufficient for optimal yield.

Acknowledgment

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

References

Miguez, F. E., & Poffenbarger, H. (2022). How can we estimate optimum fertilizer rates with accuracy and precision? Agricultural and Environmental Letters, 7(1), 1–5. https://doi.org/10.1002/ael2.20075

Nathan, M. V, Gelderman, R., Joern, B., Mallarino, A., Mengel, D., Dahl, J., Kaiser, D., Shaver, T., Franzen, D., Culman, S., & Peters, J. (2015). Recommended chemical soil test procedures for the North Central Region. North Central Regional Publication, no. 221

P-00367