Updating Corn Nitrogen Fertilizer Rate Recommendations in South Dakota

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Nitrogen (N) is an essential plant nutrient commonly applied to South Dakota corn crops and is critical for optimizing corn yield. For commercial agriculture, there are two main sources of N for corn—N from decomposing manure, residue, and soil organic matter (mineralization) and synthetic N fertilizers. Each year, corn plants take up 98 to 250 lbs N/ac (average = 150 lbs N/ac). Nitrogen derived from decomposing organic matter (i.e., mineralization) can provide 20 to 100% of the N required to optimize yield depending on factors like weather, soil type, previous crop, and management practices. The crop N need that is not supplied through mineralization is most often supplied by N fertilizer. However, excessive N fertilizer applications can reduce fertilizer efficiency, create environmental contamination issues, and reduce grower profits. Programs such as the 4 Rs of nutrient management (right: source, rate, timing, and placement) were created to educate farmers of the best ways to manage inorganic fertilizers to optimize crop production and minimize N loss. Recommended 4R N fertilizer management practices for corn are designed to avoid environmental losses and maximize uptake of N. Some of these practices include applying N fertilizer rates that account for all N sources, incorporating or placing N in the soil, using enhanced efficiency fertilizers (e.g., urease and/or nitrification inhibitors and slow and/or controlled-release fertilizers), and timing N application close to when the crop needs it.

The corn N rate recommendation equation includes the following factors: yield potential (goal), lbs N/bu corn multiplier (coefficient), pre-plant soil test N (0 to 24 inches), previous crop, manure application, and tillage type. The accuracy of the N fertilizer rate equation was tested and validated by additional research conducted between 2002 and 2006 (Kim et al., 2013). Recent research conducted between 2018 and 2022 showed that an adjustment could be made in the lbs N/bu corn multiplier to improve the accuracy of the N recommendation equation. Before 2023, the equation used a multiplier of 1.2 lbs N/bu corn, but our recent research shows that a multiplier of 1.0 lbs N/bu corn is more accurate. In this fact sheet we will discuss the methods used to evaluate the current N rate recommendation equation and discuss the results found and used to improve the equation that will now stand as follows.

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

Methods

Forty-five corn N rate trials were conducted at various field locations across central and eastern SD from 2018-2022 (Figure 1). Site locations varied in tillage practice, crop rotation, and soil type. Specifically, 32 in conventional tillage 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 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 (Figure 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 corn 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).

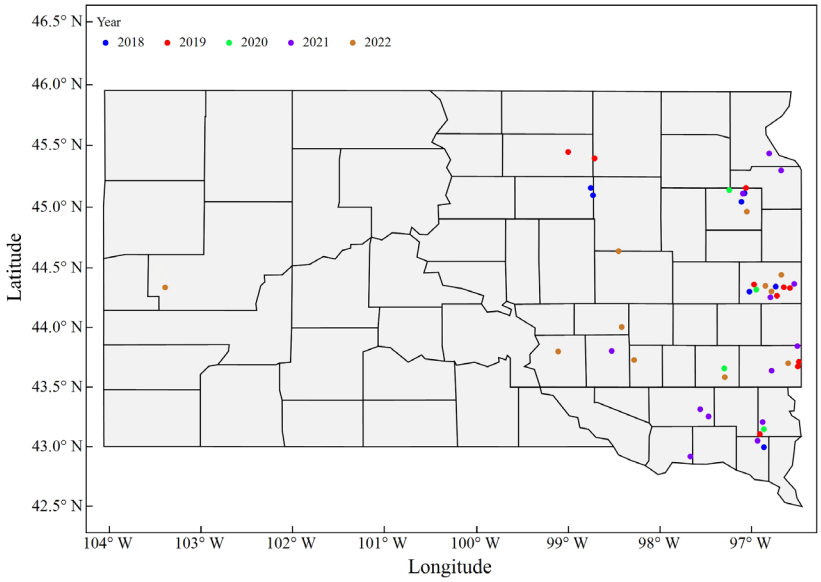

Figure 1. Map of corn N rate response trial locations across South Dakota from 2018 to 2022.

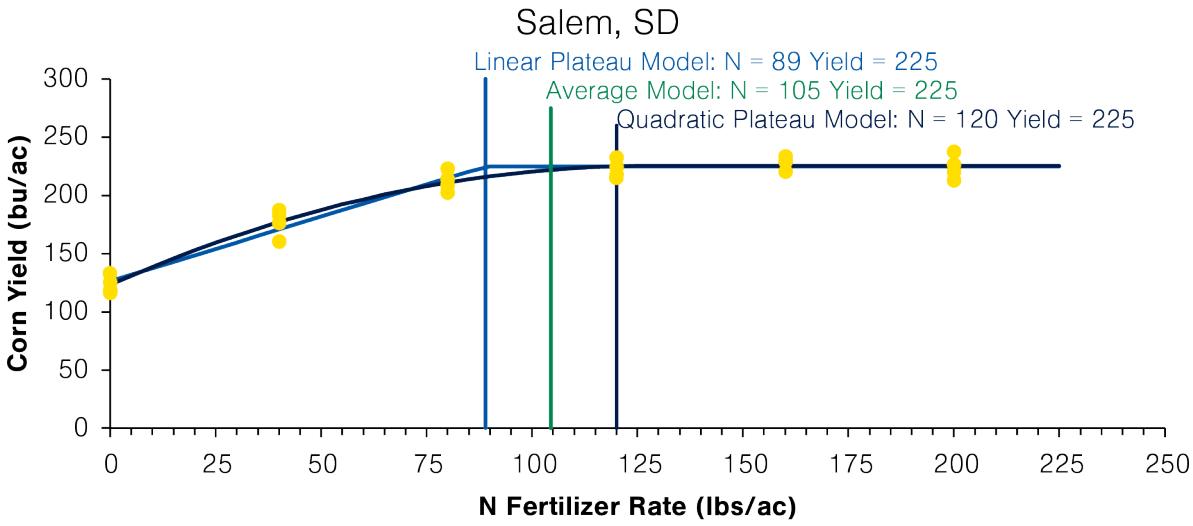

Figure 2. Example of data from one of the 45 locations where the relationship between corn yield and N fertilizer rate was graphed with the linear and quadratic plateau models used to determine economic optimal N rate and yield at that optimal N rate. The green line represents the average results of the linear and quadratic plateau models.

Results

Across the 45 locations, corn yields (excluding drought condition sites) 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 3). The lbs N/bu corn multiplier (coefficient) ranged between 0.4 and 1.8 lbs N/bu corn with an average near 1.0 lbs N/bu corn (Figure 4). These results demonstrate that the average amount of N to produce a bushel of corn has decreased from the previous 1.2 value. The reduction of this value is not new. In 1975, the multiplier (coefficient) was 1.45 and was reduced to 1.3 in 1982, to 1.2 in 1991, and in 2023 our research supports it being reduced to 1.0.

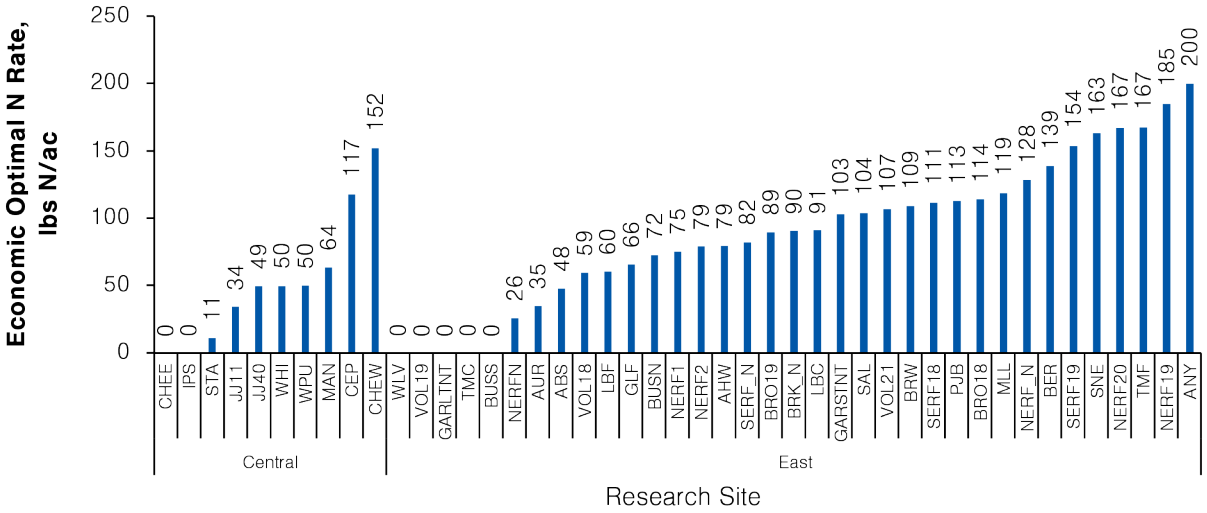

Figure 3. Corn economic optimal N rate at research sites across South Dakota from 2018 to 2022.

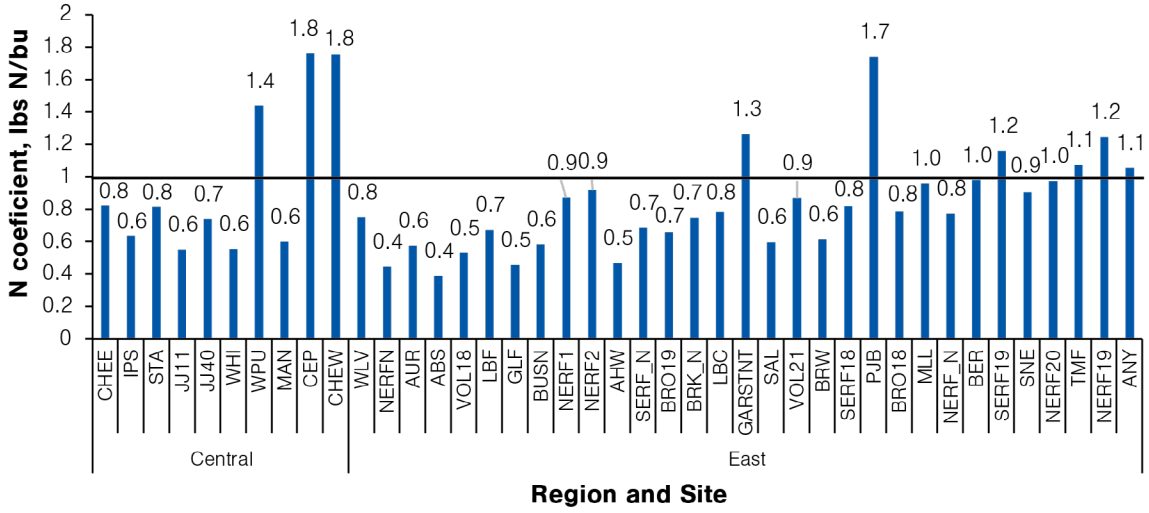

Figure 4. The amount of N fertilizer needed to produce one bushel of corn at research sites across South Dakota from 2018 to 2022. Black line represents the mean lbs N/bu corn multiplier value.

Accuracy of N Rate Recommendation

The N fertilizer rate equation accuracy was assessed using three different multipliers—the previously used 1.2 lbs N/bu corn, the new average of 1.0 lbs N/bu corn and a multiplier of 0.8 lbs N/bu corn. We calculated the N rate recommendation for each of the 45 locations using the three multipliers (1.2, 1.0, and 0.8). The recommended N rate was then subtracted from the actual 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. On average across all locations, using a multiplier of 1.2 resulted in an over application of 48 lbs N/ac, a multiplier of 1.0 an over application of 13 lbs N/ac, and a multiplier of 0.8 an under application of 22 lbs N/ac. These results demonstrate that reducing the multiplier from 1.2 to 1.0 or 0.8 improved the accuracy of N rate recommendations by 35 and 26 lbs N/ac, respectively. However, using the 1.0 multiplier compared to the 1.2 and 0.8 multipliers more evenly distributed the accuracy results around the 0-difference value (Figure 5). This result is demonstrated as using the 1.2 multiplier overestimated 78% and underestimated 22% of the time, the 0.8 multiplier overestimated 34% and underestimated 66% of the time, and the 1.0 multiplier overestimated 63% and underestimated 37% of the time (Figure 5). Thus, the 1.2 multiplier most frequently overestimated, while the 0.8 multiplier underestimated, and the 1.0 multiplier most evenly split whether it over- or underestimated N fertilizer requirement. It is clear that changing the multiplier (coefficient) to 1.0 instead of 1.2 or 0.8 provides the most accurate N fertilizer rate recommendations. Economically, the 35 lbs N/ac improvement in N rate recommendations by changing from a multiplier of 1.2 to 1.0 can save South Dakota farmers $36/ac. This savings spread across approximately 6 million acres of corn planted each year in South Dakota would be $216M.

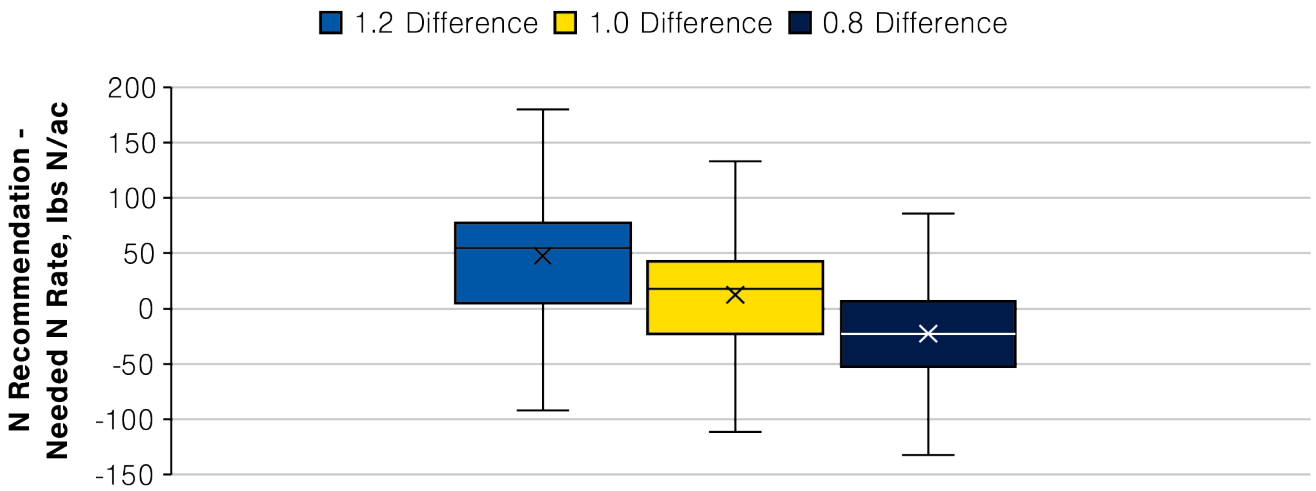

Figure 5. The accuracy of N fertilizer recommendations using three different lbs N/bu corn multipliers (1.2, 1.0, and 0.8) across 45 locations from 2018 to 2022. Accuracy as shown by the Y axis is determined by taking the N recommendation calculated using each of the multipliers and subtracting it from 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, and the whiskers represent the range of data.

For further information and examples on using the updated corn N fertilizer rate recommendation equation please see the updated South Dakota Fertilizer Recommendations Guide and chapter 23 (Estimating Yield Goals and Nitrogen, Phosphorus, Potassium, Iron, and Zinc Recommendations) in Best Management Practices for Corn Production publications.

References

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