REVAMPING NITROGEN FERTILIZER RECOMMENDATIONS FOR MISSOURI

G. Singh[1], J.A. Lory[1], K.A. Nelson[1], M. Davis[1], L. Abendroth[2], G. Kaur[1], J. Calhoun[1], and J. Chlapecka[1]
[1]University of Missouri, Columbia, MO
[2]Cropping Systems and Water Quality Research, USDA-ARS, Columbia, MO
singhgu@missouri.edu (660)-739-4410

ABSTRACT

Multiple nitrogen (N) fertilizer rate decision tools have been developed over the years for recommending N to growers. These tools are based on mass balance equations with expected yield and yield goal, economically optimum N rate, preplant soil nitrate test, pre-sidedress and late spring soil nitrate test, plant tissue nitrogen, crop growth models, and canopy reflectance sensing. These tools rarely include biological N in the rate recommendations. Advances in soil health assessment providing soil health scores and soil respiration estimates have been documented to improve N recommendations for corn in the Midwest. In Missouri, N fertilizer rate recommendations are based on yield goals and include organic matter adjustment factors for most crops. This N recommendation system does not integrate practices that improve soil health such as cover crops, applying biological N efficiency enhancers to increase plant-available nitrogen, N stabilizers such as nitrification and urease inhibitors, and variations in N supply across the landscape. A multi-site project funded by the Missouri Fertilizer Control Board began in 2023 to address these gaps and connect soil health practices and N supply to N fertilizer recommendations for Missouri. The specific objectives are to quantify the N impact of biological input products; cover crops; nitrification inhibitors; and other biological management technologies on N supply, evaluate soil health indicators and weather data as predictors of changes in landscape position and soil conditions impact productivity and soil organic N supply at different landscape positions, calibrate the integration of soil health measurements into fertilizer N recommendations, and improve calibrations of in-season N prediction tools. To achieve these objectives, 12 multilocation trials were established in Missouri in 2023 and first-year results are presented from upstate Missouri sites.

INTRODUCTION

The Missouri soil test interpretations and recommendation handbook was last updated in year 2004 (Brown et al., 2004). Crop N requirements are based on yield goals and are adjusted on plant population, N removal, and organic matter content. The total N requirement for corn grain is determined as (population/acre) x (4 lbs N/1000 plants) + (0.9 lbs N/bu) x (Yield Goal) – Organic matter adjustment factor. The organic matter adjustment factor is based on three soil textural classes including sand to sandy loam, silt loam to loam, and clay loam to clay. Soil N credit is provided based on organic matter and varies from 20 to 80 lbs. N/ac for these soil textural classes. Similarly, N rate recommendations for other major row crops and small grains are provided in the soil test interpretations and recommendation handbook (Brown et al., 2004). With advances in new products such as N stabilizers, biological N efficiency enhancers, and soil health management practices, the N rate recommendation needs further improvement for Missouri growers.

Historically, most of the research studies in Missouri have been conducted on N source, rate, timing, and placement (Scharf, 2001; Scharf, et al., 2002; Scharf, et al., 2005; Noellsch, et al, 2009; Nelson, et al, 2014; Johnson, et al, 2017). In some of the recent publications, spatial variability caused by landscape has been identified as an important factor for N management in Missouri claypan soils. Landscape positions accumulating water like toeslopes were reported to have denitrification enzyme activity fluxes as high as 1.7 lbs. N ac^{-1} d^{-1} (Johnson, et al., 2022). Nitrogen rate recommendation for the high, mid, and low productive ground classified based upon the topographic positions is not explored to a larger extent due to challenges related to conducting controlled trials on the spatially variable fields. Spatial variability results from differences in the accumulation and deposition of organic matter and soil particles which controls soil water storage and movement, thereby impacting the overall results of the N response trials. In Missouri, management practices such as tillage on soils with slopes used for row crop production resulted in significant soil loss, therefore soil health management practices including cover crops and no-till adoption are been prompted throughout the state. Nitrogen rate recommendation for row crop production systems with cover crops is not available for Missouri. Biological N mineralization (aerobic incubation) and chemical extraction (5-min tetraphenylborate) assays are some of the soil tests that have been reported to improve N fertilizer recommendations in the Midwest US, where, on average these tests can reduce 40% over-application and 37% under-application of N fertilizer (McDaniel et al., 2020). Ransom et al. (2020) evaluated the performance of N fertilizer recommendation tools in eight Midwest states and reported that all N fertilizer recommendation tools produced similar returns compared to the economically optimal N rate tool except the Corn-N crop growth model. Ranson et al., (2022) also reported that the environmental cost of yield goal-based method of N fertilizer rate recommendation was highest among all N fertilizer recommendation tools evaluated in their study. The overall goal of this study is to improve N fertilizer stewardship and update recommendations to enhance 4R management. The specific objectives include 1) quantifying the N impact of cover crops, N inhibitors, and other biologicals, 2) evaluating soil health measurements and weather data as predictors of how changes in landscape position and soil conditions impact productivity and soil organic N supply, 3) calibrate the integration of soil health measurements into fertilizer N recommendations and 4) improve calibrations of in-season N prediction tools.

MATERIALS AND METHODS

A multi-location project funded by the Missouri Fertilizer Control Board began in 2023 to address gaps and connect soil health practices and N supply to N fertilizer recommendations for Missouri. The cropping systems in Missouri are different when evaluated from Bootheel Hill Missouri, to central Missouri and upstate Missouri. The seven delta counties in Missouri have cotton, rice, corn, and soybean as major crops, and the cropping system is different from the rest of the state. More than 90% of the cropland in central and upstate Missouri is under dryland corn and soybean production. In Bootheel Missouri, more than 90% of the agricultural land is irrigated. Therefore, this project is not crop-specific and addresses regional priorities for understanding the impact of biological management and landscape on N recommendations for the state. A total of 12 locations were established with the following projects in 2023:

Lee Greenley Jr. Memorial Research Farm (GRF): Timing (3) X Inhibitor (2) X N rate (5) - Corn, GRF. Evaluate N response with and without the inhibitor Centuro in fall with anhydrous ammonia, at preplant with anhydrous ammonia, and V6 with urea ammonium nitrate (UAN). Landscape (3) X Inhibitor (3*) X N rate (5) – Corn, GRF. Evaluate N response in three slope positions down a slope testing the inhibitors Centuro and N-serve at 120 and 180 lbs. N/acre. Biological (3) X N rate (5) - Corn, GRF. Evaluate N response with three biologicals including Biological 1, Envita, and UtrishaN, with an untreated control.

Bradford Research Farm (BRF): Landscape (2) X Cover Crop (2) X N rate (6) – Corn, BRF. Evaluate N response with and without cover crop at two landscape positions. Cover crop (2) X N rate (6) – Corn, BRF. Evaluate N response with and without a cover crop.

Fisher Delta Research, Extension, and Education Center (FDREEC): Biological (2) X N rate (7) – Corn, Evaluate N response with and without biologicals. Crop rotation (2) X Timing (3) X N rate (7) – Cotton, FDREEC. Evaluate N response in rotation with peanut versus cotton. Late application N response tested at three early application rates. N rate (5) – Rice, FDREEC. Evaluate N response at three irrigation positions (top, middle, bottom).

South Farm: Landscape position (3) X N rate (5) – Fall stockpile fescue, South Farm. Evaluate response to August N fertilizer at three landscape positions down a slope. Landscape position (3) X Grazing (2) X N rate (7) – Fescue, South Farm. Evaluate spring N response with and without fall grazing at three landscape positions down a slope. Fall N rate (7) – Fall stockpile fescue, South Farm. Determine the optimum N rate. Previous N rate (7) X Spring N rate (7) – Fescue, South Farm. Evaluate the impact of fall N rate on spring N response of fescue.

In this proceeding, data from upstate Missouri is provided from 2023. In upstate Missouri, corn response to N fertilizer rate, source, and timing was evaluated at the GRF near Novelty in the first trial. The N rates selected for the study were 0, 60, 120, 180, and 240 lbs N/ ac. Anhydrous ammonia with and without centuro (nitrification inhibitor) was applied in the fall and in the spring as pre-plant. Additionally, UAN with and without centuro at the same rates as anhydrous ammonia was applied at the V6 corn growth stage as a single application. In the second trial at GRF, three landscape positions were classified using a topographic position model using LiDAR data in ArcGIS (Esri). The N rate response on corn was evaluated for anhydrous ammonia applied as spring pre-plant at 0, 60, 120, 180, and 240 lbs N/ ac rate. Additionally, 120 and 180 lbs N/ac nitrification inhibitors (Centuro and N-serve) were also included as treatments. In the third-rate response trial, we evaluated three biological products applied at 0, 60, 120, 180, and 240 lbs N/ ac N rate. Urea ammonium nitrate (32%) was used as an N-source applied at the V6 growth stage. The weather data for these locations was collected from Missouri Mesonet (Figure 1). Nitrogen rate response curves were developed from these three trials and are provided in Figures 2 to 5. The statistical analysis was performed in r-studio and graphs were developed in Origin Pro software.

RESULTS AND DISCUSSION

The year 2023 was dry. From April to July, the study locations received between 1.7 to 4.8 inches. lower precipitation when compared to the historical average (Figure 1). Lower precipitation during the reproductive stages of corn results in lower grain yield. For the first trial at GRF, corn grain yield for fall-applied anhydrous ammonia averaged 156 bu/ac at an N rate of 133 lbs N/ac. Corn grain yield for fall-applied anhydrous ammonia with centuro peaked at 160 bu/ac with 122 lbs N/ac. Nitrification inhibitor increased corn grain yield by ~5 bu/ac compared to no nitrification inhibitor for fall N applications. Additionally, a lower 11 lbs N/ ac was needed to make the 160 bu/ac yield when compared to for use and no use of nitrification inhibitor in the fall (Figure 2).

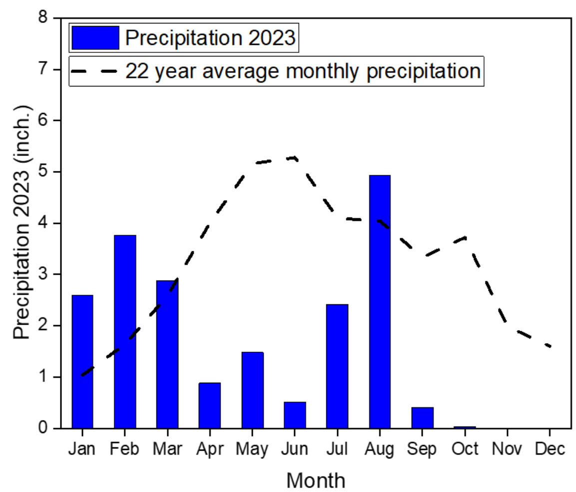


Figure 1. Monthly precipitation for the year 2023 is represented by bars and twenty-two years of historical precipitation data is represented by line from Novelty, MO weather station.

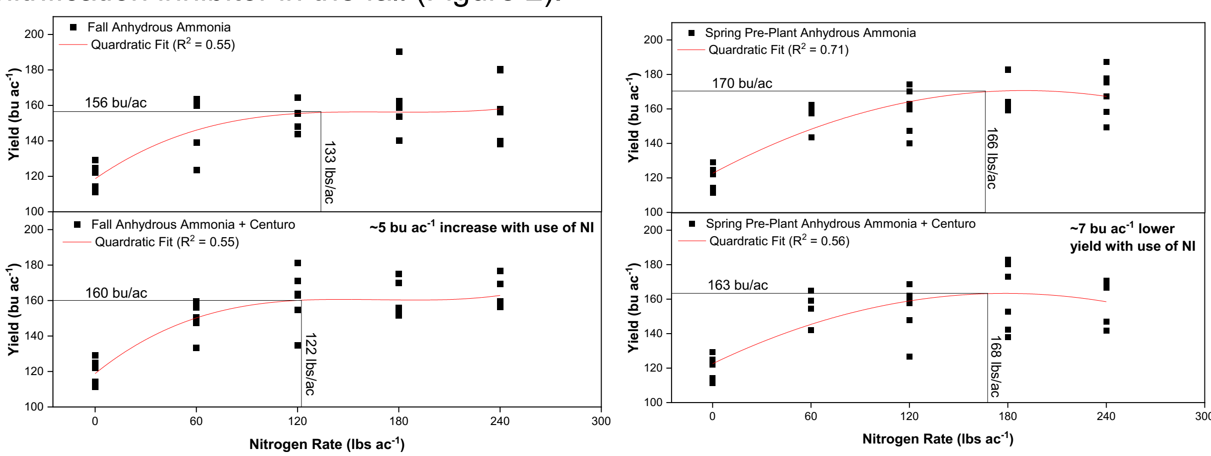


Figure 2. Nitrogen rate response curves for fall and spring pre-plant applied anhydrous ammonia with and without nitrification inhibitor Centuro at the Lee Greenley Jr. Memorial Research Farm.

Nitrification inhibitors are meant to slow the mineralization process thereby making the availability of fertilizer N for a longer period. During the dry year, this process can impact N availability as seen in Figure 3 where 16 lbs N/ac of additional N was needed to make a similar yield when no nitrification inhibitor was added with UAN.

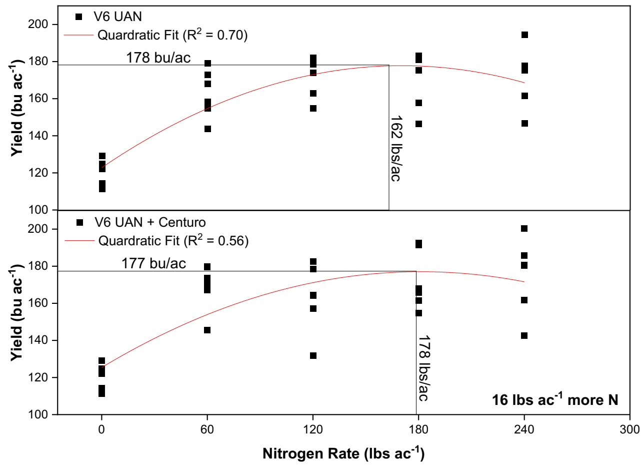
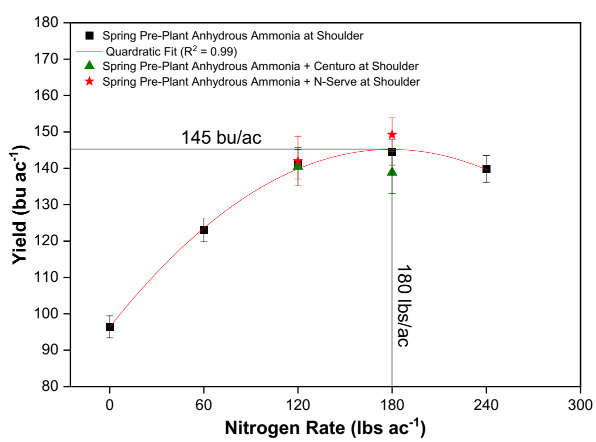
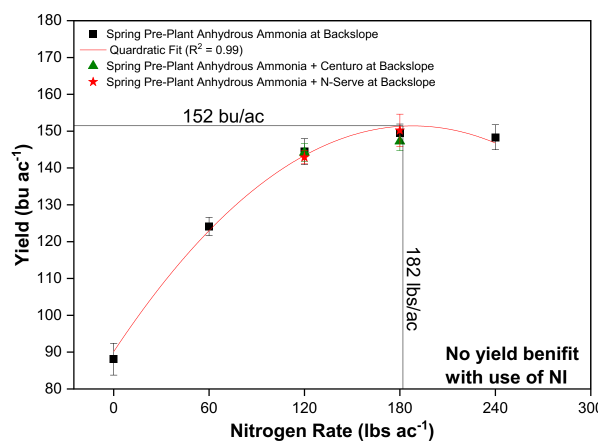


Figure 3. Nitrogen rate response curves for fall and spring pre-plant applied UAN with and without nitrification inhibitor Centuro at the V6 growth stage of corn.

Nitrogen rate response curves for three landscape positions shoulder backslope and footslope representing high, mid, and low productive ground are presented in Figure 4. The optimum N fertilizer rate for continuous corn at the shoulder and backslope position was 180 lbs N/ac whereas it was 10 lbs N/ac lower for the footslope position. The highest corn grain yield of 152 bu/ac was observed at the backslope position with 182 lbs N/ac. Biological products evaluated at the third study location did not result in any yield benefit (Figure 5)





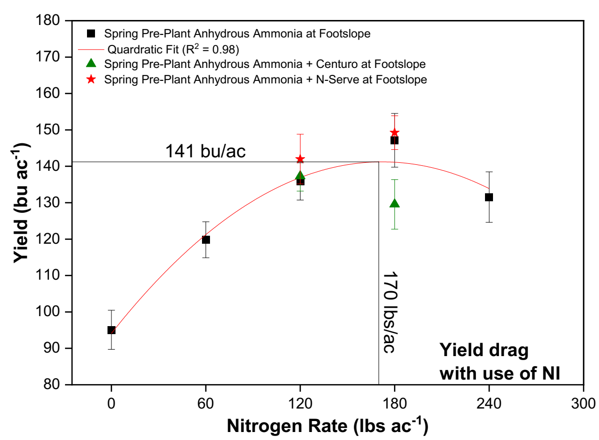


Figure 4. Nitrogen rate response curves for spring pre-plant applied anhydrous ammonia with and without nitrification inhibitor Centuro and N-serve at three landscape positions. The rotation was continuous corn.

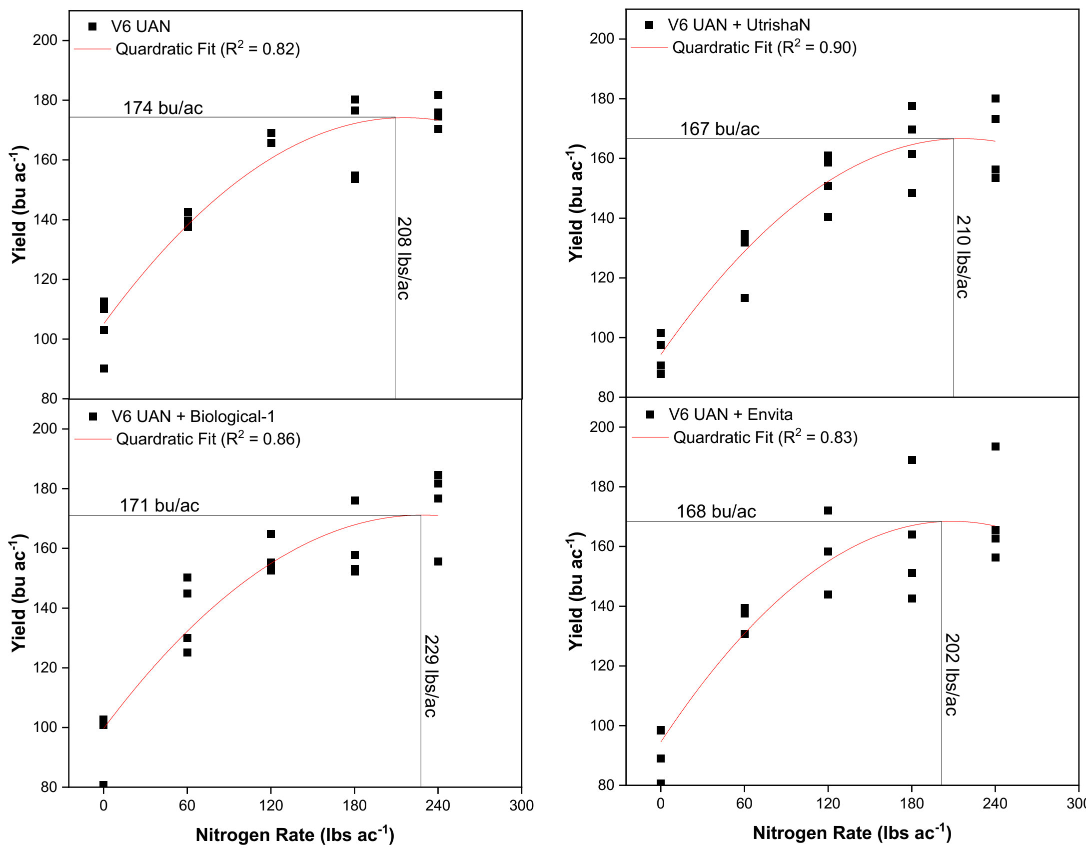


Figure 5. Nitrogen rate response curves for V6 applied UAN with and without biological N efficiency enhancers.

References:

Brown, J. R., Buchholz, D. D., Garret, J. D., Hanson, R. G., & Wheaton, H. N. (2004). Soil test interpretations and recommendations handbook. Columbia, MO, USA: University of Missouri-College of Agriculture, Division of Plant Sciences.

Johnson, F. E., Lerch, R. N., Motavalli, P. P., Veum, K. S., & Scharf, P. C. (2022). Spatial variability of denitrification enzyme activity and actual denitrification emissions on Missouri claypan soils. Soil Science Society of America Journal, 86(6), 1582-1596.

Johnson, F., Nelson, K. A., & Motavalli, P. P. (2017). Urea fertilizer placement impacts on corn growth and nitrogen utilization in a poorly-drained claypan soil. Journal of Agricultural Science, 9(1), 28-40.

McDaniel, M. D., Walters, D. T., Bundy, L. G., Li, X., Drijber, R. A., Sawyer, J. E., ... & Horwath, W. R. (2020). Combination of biological and chemical soil tests best predict maize nitrogen response. Agronomy Journal, 112(2), 1263-1278.

Nelson, K. A., Motavalli, P. P., & Nathan, M. (2014). Nitrogen fertilizer sources and application timing affects wheat and inter-seeded red clover yields on claypan soils. Agronomy, 4(4), 497-513.

Noellsch, A. J., Motavalli, P. P., Nelson, K. A., & Kitchen, N. R. (2009). Corn response to conventional and slow-release nitrogen fertilizers across a claypan landscape. Agronomy Journal, 101(3), 607-614.

Ransom, C. J., Kitchen, N. R., Camberato, J. J., Carter, P. R., Ferguson, R. B., Fernández, F. G., ... & Shanahan, J. F. (2020). Corn nitrogen rate recommendation tools' performance across eight US midwest corn belt states. Agronomy Journal, 112(1), 470-492.

Scharf, P. C. (2001). Soil and plant tests to predict optimum nitrogen rates for corn. Journal of Plant Nutrition, 24(6), 805-826.

Scharf, Peter C., William J. Wiebold, and John A. Lory. "Corn yield response to nitrogen fertilizer timing and deficiency level." Agronomy Journal 94.3 (2002): 435-441.

Scharf, P. C., Kitchen, N. R., Sudduth, K. A., Davis, J. G., Hubbard, V. C., & Lory, J. A. (2005). Field-scale variability in optimal nitrogen fertilizer rate for corn. Agronomy journal, 97(2), 452-461.