2023 South Dakota Nutrient Research and Education Council (NREC)

Title: ***Breeding for improved nitrogen use efficiency (NUE) in South Dakota winter wheat under regenerative agriculture management*** **(Locations: Winner, DLRF Pierre, and Brookings) Year 2**

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Interim Report

Summary: The primary goal of this project is to develop winter wheat varieties with improved NUE through the characterization and selection of genetic factors affecting this complex trait. In the first year of the project, the nitrogen (N) rate treatments (50, 100, 150 lbs N/A) demonstrated significant variability for grain yield, protein content, grain N, and NUE when compared to the control (0 lbs N/A) at Brookings location. The average NUE for 50 lbs N/A application was 0.63, but it dropped to 0.36 (100 lbs N/A) and 0.26 (150 lbs N/A) due to drought and heat stresses observed during the 2022 crop season. For the 2023 season, trials were planted at three locations Winner, DLRF/Pierre, and Brookings. The 2023 trials are affected by drought, especially at Winner and DLRF but data on various traits are being collected for planned objectives.

Objective 1: In year two the goal was to evaluate the effectiveness of different nitrogen application rates on winter wheat genotypes (common varieties and advanced breeding lines) under a no-till system and its effect on grain yield and protein content and identify lines with superior NUE.

Progress: We planted 16 (10 advanced breeding lines and 6 released varieties (public/industry)) in the trial under four nitrogen application rates at three locations Winner, DLRF Pierre, and Brookings. The trials were planted in decent moisture at Brookings and Pierre, however, the Winner location was exceptionally dry. The no-till trial is planted in oat residue at Brookings and Winner and Flax residue at Dakota Lakes Research Farm (DLRF), Pierre, SD. The plots are 20' long and 5' wide 7-row plots (7.5-inch row spacing) in three replications using a randomized complete block design. All entries were planted at a seed rate of 28 seeds/sq. ft (1.2 million seeds/acre). All lines received a starter of 10 gallons of 10:34:0 (N:P:K) at the seeding stage (fall). Soil samples were collected in fall 2022, the top 24 inches at the Brookings location had a soil N of 32 lbs N/A, the Winner location had 34 lbs N/A and DLRF had 24 lbs N/A. In spring 2023 additional was applied N was applied at four rates of 0, 25, 50, and 100 lbs of N per acre as liquid UAN at Brookings and Winner and 0, 30, 60, and 120 lbs of N per acre as liquid UAN at DLRF. Additionally, 10 ppm S (Gypsum) was applied at Winner and DLRF, however, at Brookings soil sample had 26 ppm of S, so no additional S was applied at Brookings.

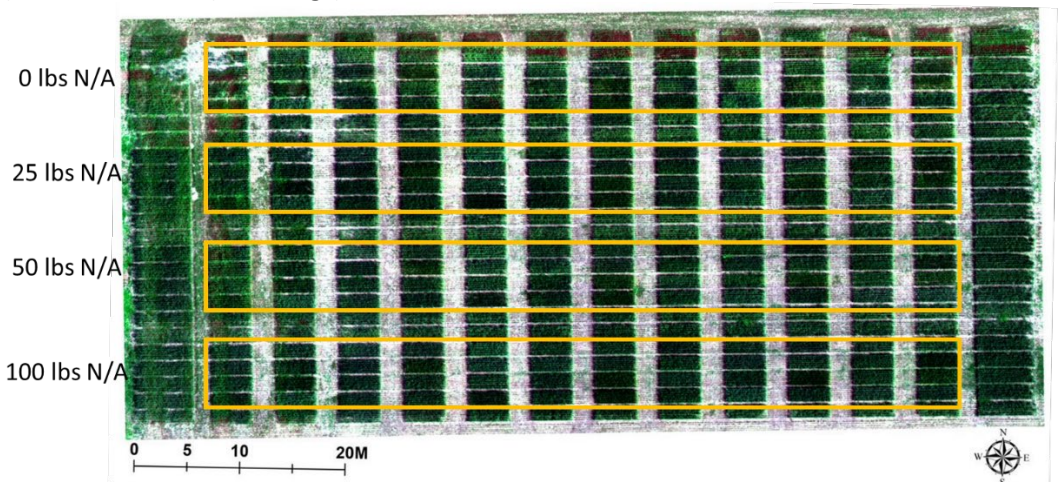
Additional soil samples were collected after the spring N application and have been submitted for analysis. More soil samples will be collected soon after harvest.

The 2023 growing season has been rough with very little rain in all three locations and the trials are under moderate to several drought stress.

Data has been collected on tillers per unit, day to heading, chlorophyll content, and leaf area index (LAI) was collected at tillering, boot, and heading stages. Multispectral traits like GNDVI were recorded using UAV (DJI Matrice 210 RTK v2 using MicaSense Altum PT Sensor) to monitor the

growth of wheat at all three locations every week. Biomass data has been collected at Dakota Lakes farm (Figure 1). Plant height and lodging data will be recorded, and the plots will be harvested at maturity to calculate grain yield, grain protein content, grain protein deviation, and test weight. Data for these traits for each line will be compared to estimate the N treatments and genotype effects, and genotypic-specific NUE (yield/N applied) will be determined (Moll et al. 1982). The grain samples will also be subjected to grain quality analysis including milling efficiency, flour protein, ash, wet and dry gluten content, and mixograph analysis to study the impact of N rates on wheat milling and baking quality.

A) 2023 NUE trial (Brookings)



B) 2023 NUE trial (Dakota Lakes)

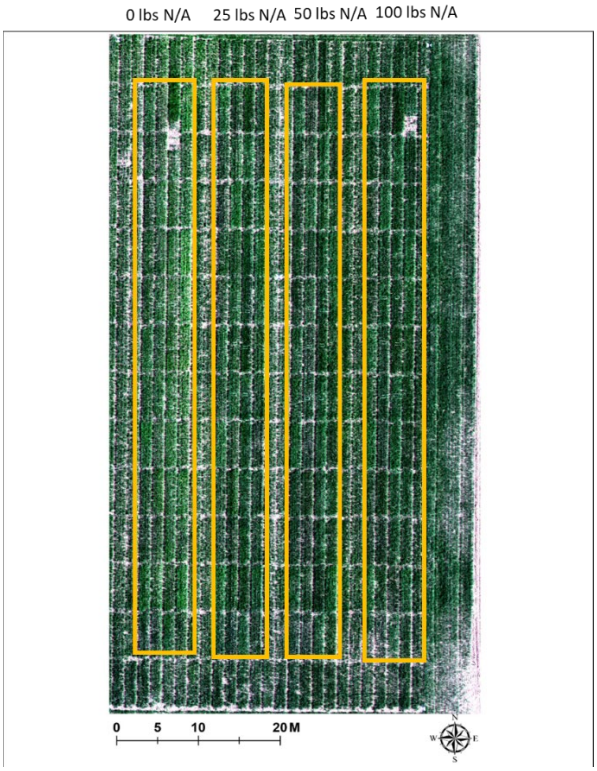


Figure 1: a) Experimental layout of plots as shown in aerial photo mosaic taken on June 12 at Brookings, SD (top); B) Experimental layout of plots as shown in aerial photo mosaic taken collected on May 20, 2023, at Dakota Lakes Research Farm (bottom left), harvesting samples for biomass on June 30, 2023, at DLRF (bottom right) wheat matured early due to drought. Orange dividing lines indicate boundaries N application rate 0, 25, 500, and 100 lbs of N per acre.

Objective 2. Identification of quantitative trait loci (QTLs) and evaluation of genomic selection models for breeding hard winter wheat varieties with improved NUE.

A large trial of about 250 hard winter wheat varieties or experimental breeding lines representing the US Great Plains was planted at two locations Felt Farm and Aurora Farm in 5x5 square feet plots (Figure 2). In spring at a low (0 N/A) and sub-optimal N (100 N/A) was applied to the trials as UAN 28%.

a) Felt Farm

b) Aurora Farm

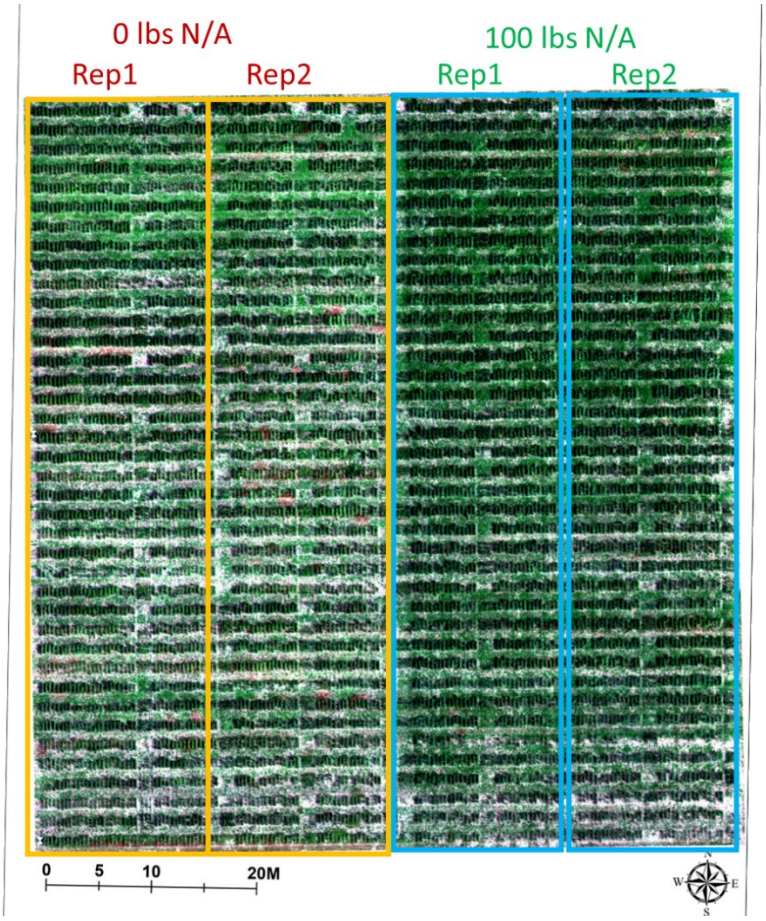


Figure 2: a) Experimental layout of nearly 250 winter wheat varieties evaluated low 0 lbs N/A and sub-optimal N (100 lbs N/A) at a) Felt Farm; b) Aurora Farm. The data from the trials will be used to develop predictive models for NUE in winter wheat and also for the characterization of genomic regions after NUE-related traits in wheat.

The data was recorded for days of heading, chlorophyll content, LAI, plant sample for N content at heading, and 3 weeks past heading. The multispectral traits like GNDVI were recorded using UAV (DJI Matrice 210 RTK v2 using MicaSense Altum PT Sensor) to monitor the growth of wheat at two locations. The data for plant height, biomass grain yield, grain protein content, grain protein deviation, and test weight following harvest. The phenotype data along with genotypic data will be used to develop prediction models for NUE-related traits and the characterization of genomic regions affecting NUE in Wheat.