Project FY22-DU-006: Recurrent Selection to Improve FHB Resistance in Durum Wheat

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1. **What are the major goals and objectives of the research project?**
   The objectives of this project are to (1) improve FHB resistance through recurrent phenotypic selection in a durum wheat population and (2) develop genomic selection (GS) models and utilize GS to accelerate genetic improvement of FHB resistance in durum wheat.

2. **What was accomplished under these goals or objectives?** *(For each major goal/objective, address these three items below.)*

   What were the major activities?

   Towards Objective 1

   In 2024, the sixth cycle of phenotypic selection was conducted. A total of 184 S0:1 lines from the Cycle 5 population were evaluated for FHB disease index at Prosper, ND. The top 20 families were selected and intercrossed to generate the Cycle 6 population during the winter of 2024. Additionally, phenotypic selection was applied to the top five S0:1 lines from the Cycle 4 population. F2 and F3 individuals were evaluated for FHB severity in the greenhouse from September 2023 to April 2024, while F3:4 lines were assessed for FHB disease index at Prosper, ND, from May to August 2024.

   Towards Objective 2

   A GS model was developed using data from the Cycle 3, Cycle 4, and Cycle 5 populations, achieving a prediction accuracy of 0.53 for the FHB disease index. Two GS cycles were conducted between September 2024 and April 2025. In the first cycle (September–December 2024), 192 remnant seeds from the top 20 families of the Cycle 5 population—designated as the RGS-C0 population—were planted in the greenhouse and genotyped using a 40K SNP array. Based on genomic estimated breeding values (GEBVs), the top 40 plants were selected and intercrossed.

   In the second cycle (January–April 2025), 192 seeds from the resulting RGS-C1 population were planted and genotyped. The top 40 plants were again selected and intercrossed. These selected plants were subsequently self-pollinated, and their S0:1 lines will be evaluated in a field nursery from May to August 2025. This evaluation aims to quantify the genetic gain from two GS cycles and to compare the efficiency of GS with that of phenotypic selection.

   What were the significant results?

   Objective1

   From the 2024 field evaluation, 11 S0:1 lines from the Cycle5 population exhibited significantly lower FHB disease index than the check cultivar, ND Riveland. Of the 11 S0:1 lines, five were sampled and tested for deoxynivalenol (DON) concentration. Of them, two lines showed lower DON levels than the check cultivar, ND Riveland. Additionally, three F3:4 lines, selected from the top three S0:1 lines of the Cycle 4 population, also showed significantly lower FHB disease index compared to ND Riveland.

Objective2
A GS prediction model was developed using the Cycle3, Cycle4, and Cycle5 populations. Two cycles of GS were conducted on the Cycle5 population.

List key outcomes or other achievements.

Objective1
Root rot was observed in the Prosper field nursery in 2024, which may have led to an overestimation of the FHB disease index for the Cycle 5 population.

3. **What opportunities for training and professional development has the project provided?**
All graduate and hourly students participated in inoculation and disease scoring activities in both greenhouse and field nurseries, providing valuable hands-on training in phenotypic evaluation of FHB resistance. In addition, graduate students received training in marker genotyping and genomic prediction modeling.

4. **How have the results been disseminated to communities of interest?**
The results from the recurrent selection experiments were shared with wheat breeders and research scientists through personal communications and presentations at the annual FHB Forum.

5. **What do you plan to do during the next reporting period to accomplish the goals and objectives?**
Towards Objective 1
One cycle of phenotypic selection will be conducted in the summer of 2025 at Prosper, ND, where approximately 180 S0:1 lines from the Cycle 6 population will be evaluated for FHB disease index. The top 20 lines will be selected based on their performance. Additionally, phenotypic selection will be carried out on the top S0:1 lines previously selected from the Cycle 5 population.

Towards Objective 2
Two cycles of GS were conducted on the Cycle 5 population between September 2024 and April 2025. The resulting populations—RGS-C0, RGS-C1, and RGS-C2—will be evaluated for FHB disease index during the summer of 2025 at Fargo and Prosper, ND. Genetic gain from GS will be compared with that from phenotypic selection. The GS prediction model will be updated by incorporating data from the Cycle 6 population. Subsequently, two cycles of GS will be conducted on the Cycle 6 population between September 2025 and April 2026.