Report for FY22-BA-021: Developing Scab Resistant and Low DON Winter Barley Varieties for the Great Plains

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Note: Report must cover the *entire* duration of the project period of performance, May 1, 2022-July 30, 2026.

This final report was drafted in part using AI to summarize all previous performance reports.

1. **What are the major goals and objectives of the research project?**
   The primary goal of our project was to establish, expand, and optimize an integrated breeding pipeline for scab-resistant, winter-hardy barley.

   Obj. 1: Increase phenotypic screening of UNL barley germplasm for FHB resistance and DON accumulation. Establish and expand dedicated inoculated, mist-irrigated disease nurseries in Lincoln, NE to evaluate UNL advanced lines and collaborative regional trials (Winter NABSEN, Winter Malting Barley Trial) for FHB severity, incidence, and index, FDK, and DON accumulation.

   Obj. 2: Develop new FHB resistant barley germplasm and develop mapping populations for the University of Nebraska barley program. Introgress native resistance, major alleles, and new QTLs from spring and winter barley sources into Great Plains adapted 6-row feed and 2-row malting winter barley backgrounds. Develop populations using both standard bulk breeding methods and doubled haploid (DH) technology.

   Obj. 3: Improve selection of germplasm with increased FHB resistance and reduced DON accumulation. Implement genome-wide marker profiling (USDA 3K array) and establish a genomic prediction pipeline to predict FHB traits and optimize parental crossing decisions.

2. **What was accomplished under these goals or objectives?**

Obj. 1: Increase phenotypic screening of UNL barley germplasm for FHB resistance and DON accumulation.

What were the major activities?

Managed dedicated inoculated mist nurseries annually at the Havelock Farm in Lincoln, NE. Replicated 0.9-m rows were planted into corn residue, inoculated with corn spawn (~4 weeks pre-anthesis), and conidial spray-inoculated at anthesis with virulent *F. graminearum* conidial mixtures. UNL advanced trials were phenotyped alongside the Winter NABSEN and Winter Malting Barley Trials.

What were the significant results?

247 unique UNL winter barley lines and 151 unique regional trial entries were phenotyped during the five seasons of this project (2022–2026).

- UNL barley lines exhibited a range of phenotypic variation. Across the 5 seasons, we saw average incidence ranged from 31% to 93%, severity from 18% to 42%, and index from 9.9% to 40%. DON levels averaged 0.46 to 10.6 ppm across 2022-2025.
- The barley lines entered in regional trials also exhibited a range of phenotypic variation. Across the 5 seasons, we saw average incidence ranged from 30% to 80%, severity from 13% to 17%, and index from 9% to 32%. Average DON levels ranged from 0.4 to 6.2 ppm across 2022-2025.
- The inoculated nursery was affected by both severe drought and harsh winters in various years during this project. We tended to see more severe winterkill in the regional trial entries that are less adapted to Nebraska, but our UNL winter feed barley lines exhibited excellent winter survival. This shows that UNL germplasm provides a resilient agronomic chassis for FHB resistance introgression.
- Analysis of 2024 harvest data identified artificially reduced FDK (2.2–3.7%) and DON (0.4–0.6 ppm) levels due to settings on the field thresher during seed cleaning. We revised post-harvest handling protocols to better retain FHB-damaged grain.

- In 2026, we updated our inoculation protocol to spray each row at its anthesis date rather than at the average anthesis date for the trial. While FHB infection was lower than normal due to severe drought through most of the anthesis period, we believe that we saw better infection on early or late lines that could have escaped severe infection with our previous protocol. We will continue this method and ideally reduce the correlation of FHB severity and incidence with plant flowering date and plant height.

List key outcomes or other achievements.

- Established multi-year FHB/DON screening for winter barley in the southern Great Plains, and served as the central Southern Plains screening hub for Winter NABSEN.
- Identified lines such as NB19422 and NB22233 as a FHB resistant, lower DON, and winter-hardy parents.
- To reduce field variation during recurring regional drought conditions, UNL invested in an upgraded misting irrigation infrastructure, providing reliable humidity for disease development.

Obj. 2: Develop new FHB resistant barley germplasm and develop mapping populations for the University of Nebraska barley program.

What were the major activities?

Restructured crossing blocks to systematically introgress native resistance and major QTLs from external programs (NDSU, UMN, OSU, Virginia Tech) into adapted Nebraska 6-row feed and 2-row malting backgrounds. Utilized three-way crosses ([Nebraska Winter x Spring FHB Donor] x Nebraska Winter) to maintain winter-survival.

What were the significant results?

- More than doubled FHB-focused crossing intensity: FHB-targeted crosses rose from ~15% (FY22) to 32% (FY25 crossing block: 20 crosses for primary FHB resistance plus 13 crosses utilizing moderately tolerant nursery parents).
- Advanced 7 cross combinations to the OSU DH facility, successfully receiving 3 DH populations that were vernalized, phenotyped for row type and growth habit in winter greenhouses, and advanced to field disease nurseries.

List key outcomes or other achievements.

- In order to participate in the BAR-CP Doubled Haploid program, we shifted specialized our crossing blocks to better align with the Oregon State University facility cycle.
- We continue to broadened the genetic diversity of Southern Great Plains winter barley particularly to increase FHB resistance.

Obj. 3: Improve selection of germplasm with increased FHB resistance and reduced DON accumulation.

What were the major activities?

Genotyped 376 historical and elite UNL barley lines using the USDA-SoyWheOatBar-3K Illumina array via the USDA-ARS Central Small Grains Genotyping Lab with 300 more in progress. Established a GBLUP prediction modeling architecture in R (BGLR, ASReml-R) evaluating random 80/20 splits, year-to-year forward prediction (e.g. training on 2022–2024 to predict 2025), and 5-fold cross-validation.

What were the significant results?

- We validated the USDA 3K array using 20 years of historical UNL barley yield trials (2002–2022) and achieved good prediction accuracy (r = 0.39) for yield related traits. This confirmed that the USDA 3K platform captures ample genome-wide polymorphisms in our barley breeding program.
- Initial genomic prediction models across 165 phenotyped lines yielded low to moderate prediction accuracies for FHB traits (r = 0.10 to 0.25 for severity and incidence; r = 0.04

to 0.14 for index, FDK, and DON). These baseline accuracies reflect constraints in small initial training sets and environmental sensitivity.

- Incorporating heading date and plant height as secondary traits in multi-trait models improved prediction stability across environments. Improved inoculation methods started in the 2026 nursery should reduce the effect of heading date and plant height, so we anticipate eventually being able to remove these covariates from the genomic prediction models.

List key outcomes or other achievements.

- We built a robust, reproducible genomic prediction foundation that could be used to develop collaborative regional GS models pooling data across Winter NABSEN testing stations.

3. **What opportunities for training and professional development has the project provided?**
Completed graduate students: Drs. Fang Wang, Sheryl Sierra, and Sydney Graham successfully completed their Ph.D. dissertations. All three students led the UNL barley breeding breeding program during this project and utilized the data provided to design crossing blocks and make selection and advancement decisions. Dr. Wang became a post doc with Dr. Xiwen Cai. Dr. Sierra is faculty at Cavita State University in the Philippines. Dr. Graham was a key leader for developing the UNL barley genomic selection pipeline and is now a sorghum breeder for Corteva.

Current graduate students: Ph.D. student Rafael Bley Cottica assumed leadership of the barley breeding pipeline in 2025 and is optimizing FHB genomic prediction models. He attended the 2025 CANVAS meeting with support from this project to present a poster on utilizing genomic prediction to select increase FHB resistance in our barley program.

Postdoctoral researchers: This project partially supported postdoctoral research associates Dr. Ibrahim El Basyoni and Dr. Sandeep Sakhale, providing experience in statistical genomics, GBLUP modeling, and breeding pipeline optimization.

Undergraduate training: This project also partially supported 5 summer research interns (undergraduate level) over the four years of the project. One intern received direct training in disease evaluation, mist nursery management, threshing, and multi-year data curation.

4. **How have the results been disseminated to communities of interest?**

- **Scientific & Breeding Community:** Annual distribution of Lincoln mist nursery evaluation datasets to collaborative small grains breeders participating in the Winter NABSEN and Winter Malting Barley Trials. Shared advanced lines, parental selections, and crossing lists with USWBSI BAR-CP colleagues at NDSU, UMN, OSU, and Virginia Tech. Presented research updates and breeding findings at annual USWBSI National Fusarium Head Blight Forums and regional breeding conferences.
- **Producer & Stakeholder Outreach:** Delivered timely disease alerts, FHB risk assessments, and varietal resistance updates to Great Plains agricultural producers at annual field days, including the UNL Wheat & Small Grains Variety Tours. Partnered with the UNL Dryland Cropping and State Variety Trial extension teams to formulate production guides and crop bulletins emphasizing the dual economic advantage of planting resistant winter cultivars and applying fungicides at anthesis.

5. **What do you plan to do during the next reporting period to accomplish the goals and objectives?**
Not applicable, this is the final report for the agreement.