Project FY22-BA-009: Developing Barley Varieties with Enhanced FHB Resistance and Lower DON

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1. **What are the major goals and objectives of the research project?**
   1) Create new breeding populations by crossing parents that carry resistance to FHB and other desirable traits.
   2) Conduct selection for FHB resistance and lower DON concentration in segregating breeding populations using genetic markers and field screening.
   3) Advance lines to regional testing and industry evaluation that are candidates for new cultivar releases.

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

1) Create new breeding populations by crossing parents that carry resistance to FHB and other desirable traits.

What were the major activities?

In our spring breeding program, we selected 8 entries from our 3rd year yield trials, 14 entries from our 2nd-year trials, and 5 entries from outside our program as parents in our 2024 fall crossing block. A total of 44 crosses were made and advanced as F1's in our winter greenhouse. We planted F2's from 42 crosses this spring on the St. Paul campus that will be harvested this summer to advance as F3's in our 2025 Fall greenhouse.

In our winter breeding program, we selected 17 entries from our 1st year trials, 7 entries from our second year trials, and 13 entries from advanced trials and materials from other breeding programs as parents in our 2024 fall crossing block. A total of 29 crosses were advanced as F1's's in our winter greenhouse. We planted F2's from 30 crosses this spring on the St. Paul campus that will be harvested this summer to advance as F3's in our 2025 Fall greenhouse.

What were the significant results?

Approximately 6,700 and 4,800 F2s were planted for our spring and winter breeding programs, respectively, from which new breeding populations will be developed this year.

List key outcomes or other achievements.

We met our goals for initiating new populations this year from our spring and winter breeding programs.

2) Conduct selection for FHB resistance and lower DON concentration in segregating breeding populations using genetic markers and field screening.

What were the major activities?

Spring Barley Program

Summer 2024 Trials

In the summer of 2024, we used genomic predictions and field observations to select among ~2500 first year F5 lines. We evaluated 68 2nd year, 41 3rd year breeding lines and 35 entries in the North American Scab Evaluation Nursery (NABSEN) in misted and inoculated FHB nurseries in St. Paul and Crookston, MN. The nurseries were observed for symptom development and severity ratings were taken from some trials. All rows were harvested, and the grain samples were cleaned and ground and sent to the toxicology labs at St. Paul, MN and Fargo, ND. A total of 1123 samples were sent, and the DON data received was used to advance lines in the breeding program and select parents for future crossing (Objective 1).

Summer 2025 Trials

We advanced F4 plants from our winter greenhouse to produce seed for F4:5 head rows in St. Paul and Crookston. We genotyped 926 lines and selected 510 based on genomic predictions for DON and other traits to plant as head rows. We will make visual observations and revisit the predictions to further select the lines that will be advanced to trials in 2026. We advanced 125 and 26 breeding lines into our second-year and third-year spring barley yield trials, respectively, and planted them at our FHB nurseries in St. Paul and Crookston.

Winter (Facultative) Barley Program

Summer 2024 Trials

In the summer of 2024, we used visual observation for disease (powdery mildew and barley yellow dwarf virus) and agronomic traits to select among ~2100 F4:5 lines planted in single row plots. 305 lines were selected to advance to fall planted preliminary yield trials. We evaluated 33 3rd year breeding lines in misted and inoculated FHB nurseries in St. Paul and Crookston, MN. The nurseries were observed for symptom development and severity ratings were taken from some trials. All rows were harvested, and the grain samples were cleaned and ground and sent to the toxicology labs at St. Paul, MN and Fargo, ND. Samples were sent for DON analysis and the data was used to advance lines in the breeding program and select parents for future crossing (Objective 1).

Summer 2025 Trials

We advanced F4 and genotyped 1010 plants from our winter greenhouse to produce seed for F4:5 head rows in St. Paul and Crookston. We planted all of the lines as head rows and will make selections based on genomic predictions for DON and other traits to advance to our 2025 preliminary yield trials. We advanced 40 and 25 breeding lines into our second-year and third-year winter barley yield trials, respectively, and planted them at our FHB nurseries in St. Paul and Crookston.

What were the significant results?

We observed substantial variation in DON concentration from our trials in FHB nurseries in 2024. Based on the average of the two locations from 2023 and 2024 approximately 50% of our 2nd year lines were lower in DON compared to the currently most popular variety ND-Genesis. Similarly, in our 3rd year entries 50% of the breeding lines were lower in DON compared to ND-Genesis.

DON levels in the winter breeding line trials were higher in general compared to the spring lines. In the 3rd year trial, only six of the 17 entries were lower in DON compared to spring variety ND-Genesis and only three were lower in DON compared to our recent winter variety release MN-Equinox.

List key outcomes or other achievements.
Our prediction accuracies for DON are still low, but have improved somewhat. The cross-validation accuracy this past year was 0.48. We expect prediction accuracy to improve as we continue to add more data to the model training data set.

3) Advance lines to regional testing and industry evaluation that are candidates for new cultivar releases.

What were the major activities?
In the 2024 crop year, 3 lines from our spring breeding program were advanced to American Malting Barley Association (AMBA) Quality Evaluation Program (QEP) an all three were rated unsatisfactory. We selected two winter two-rowed advanced breeding lines for AMBA QEP with the 2024/2025 crop.

What were the significant results?
We received the results of our entries from crop year 2024 to the American Malting Barley Association (AMBA) Quality Evaluation Program (QEP) in April of 2025 and all three lines submitted were rated unsatisfactory.

List key outcomes or other achievements.
Our most advanced line, S2M184, is eligible for plant scale evaluation. This line is similar to ND-Genesis for yield, but is earlier maturing, shorter in height, and has better stem strength. S2M184 has about 20% lower DON based on the mean of seven inoculated nursery trials. It is also a GN non-producer, a trait that is important to the distilling industry. We contracted a 40 acre increase of this line last year. This seed was to be used for plant scale evaluation. Rahr Malt is interested in the line, but want to evaluate it again in 2025 before deciding on plant scale evaluation.

3. What opportunities for training and professional development has the project provided?
A Postdoc in my group, Adenike Ige, has been working with DON and SNP marker data to evaluate and optimize genomic predictions. New graduate student Kayla Grennes is working on characterizing DON in naked barley. Another new student Reecha Acharya is beginning to evaluate a multi-parent population for FHB and DON to be used in genetic mapping.

4. How have the results been disseminated to communities of interest?
Research reports were provided at the annual Barley U Field Day on the St. Paul campus and the NW Regional Outreach Center Field Day in Crookston, MN. The PI and research team presented a talk entitled “Developing winter barley for Minnesota cropping systems” at the weekly Forever Green Initiative series. We hosted a field tour as part of the World Brewing Congress held in Minneapolis last August. The PI presented a webinar for the Artisan Grain Collaborative - Brewing & Distilling Working Group August 6, 2024 and a talk at the University of Minnesota Plant Breeding Center Retreat in June. We published barley variety

performance information in the Minnesota Agricultural Experiment Station Variety Trials Report. The NABSEN Report is published on the USWBSI website.

5. **What do you plan to do during the next reporting period to accomplish the goals and objectives?**
   We will conduct each of the stages of the breeding pipeline as described in our proposal for both the spring and winter barley programs. Based on the decision by Rahr to continue evaluation, we will propose spring breeding line S2M184 for variety release to our Crop Variety Review Committee.