Project FY22-BA-014: Developing Two-rowed Malting Barley Cultivars with Reduced FHB and DON

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1. **What are the major goals and objectives of the research project?**
   This project aims to develop two-rowed malting barley cultivars with improved resistance to FHB and lower DON accumulation. Our goals for this project are: 1) ongoing development and screening of two-rowed barley lines in our breeding program for reduced FHB and DON, 2) growing the North American Barley Scab Evaluation Nursery (NABSEN) at our Osnabrock, ND research site, and 3) collecting FHB and DON data on cultivars and advanced breeding lines to help growers decide which cultivar(s) to plant.

2. **What was accomplished under these goals or objectives?** *(For each major goal/objective, address these three items below.)*
   Progress was made on all three objectives and will be described in more detail below, by objective.
   Objective 1: Ongoing development and screening of two-rowed barley lines in our breeding program for reduced FHB and DON
   What were the major activities?
   Important commercial barley varieties, new varieties, and promising advanced selections were evaluated at seven locations in North Dakota. Planting was delayed in the spring due to wet soil conditions; however, once the crop emerged, foliar disease and FHB were minimal. All yield trials at Fargo were abandoned because of poor emergence and excessive rain following planting. Rain during harvest at all locations, except Williston, damaged crops due to pre-harvest sprouting (PHS). All entries evaluated in all of our yield trials are grown in inoculated, mist-irrigated nurseries in Langdon and Osnabrock, ND.

   Thirty-one experimental two-rowed lines were harvested from yield trials at six North Dakota locations in their third or later years of field evaluation. The NDSU barley pathology project assessed lines for resistance to pathogens causing spot and net blotch in greenhouse tests using seedlings.

   Forty-four experimental two-rowed lines were grown in the Intermediate Yield Trial at five locations in North Dakota for their second year of field evaluation. Selected lines from the yield trials were assessed for malt quality by the USDA-ARS Cereal Crops Research Unit in Madison, WI, and for spot blotch and net blotch reactions in greenhouse tests conducted by the NDSU barley pathology project.

   The Preliminary Yield Trial, conducted at two locations (Casselton and Fargo), included 458 experimental two-row lines. Since GS effectively predicts wort beta-glucan, we reduced the number of tested lines from 1,200 to fewer than 500, while maintaining a larger total number of lines with wort beta-glucan levels lower than those of ND Genesis.
   F_3 and F_4 head rows were grown in Fargo. The head row nursery contained 9,996 rows, of which 2,267 were selected for harvest. From each selected row, three spikes were harvested.

Seeds from two of these spikes were planted as individual rows in the winter nursery of 2024-2025 near Yuma, AZ. Remnant seed from these rows was grown in the greenhouse to provide leaf tissue for DNA extraction. Rows with acceptable molecular marker genotypes for resistance to net blotch, spot blotch, and PHS; predictions of reduced wort ß-glucan concentration, turbidity, and viscosity; acceptable levels of wort protein, alpha-amylase, DP, and FAN; increased malt extract; and earlier heading date using GS; as well as desirable straw strength, maturity, and uniformity in the Yuma nursery will be harvested and advanced to the 2025 Preliminary Yield Trial. The prediction for DON is poor. Work is underway to improve this model, so it can be integrated into our GS program. This includes optimizing the training population and updating the experimental design for the FHB nurseries to allow for spatial analyses.

In the summer of 2024, 30 two-rowed F_2 populations were cultivated in Fargo. Twenty-three of these populations were selected for advancement. The 23 two-row F_3 populations were sown in the off-season nursery in Leeston, New Zealand. Spikes from the selected F_3 populations were then advanced to North Dakota's 2025 F_4 short-row nursery.

Thirty two-rowed crosses were made in the spring greenhouse of 2024. F_1 seed from these crosses was grown in the summer greenhouse, and F_2 populations were planted in October in the New Zealand off-season nursery. Selected spikes were advanced to the 2025 F_3 short-row nursery. Thirty-five two-rowed crosses were made in the fall greenhouse of 2024. All crosses aim to combine favorable agronomic characteristics, disease resistance, and malt quality traits. Each cross involved at least one parent with FHB resistance.

What were the significant results?
Malteurop plans to contract 500 acres in 2025 and up to 5,000 acres in 2026 of 2ND36638 for commercial-scale evaluation. In our inoculated, mist-irrigated FHB nurseries in Langdon and Osnabrock, 2ND36638 accumulated 35% less DON than ACC Synergy, the most widely grown barley variety in North Dakota. Additional benefits of 2ND36638 over ND Genesis and AAC Synergy include stronger straw, higher yield potential, better resistance to PHS, higher malt extract, and being glycosidic nitrile (GN)-free.

List key outcomes or other achievements.
The experimental lines 2ND40316, 2ND40324, and 2ND40363 were tested in their second year of AMBA Pilot Scale evaluation, while lines 2ND40351 and 2ND41042 entered their first year of Pilot Scale evaluation in fall 2024. All five lines accumulate less DON than AAC Synergy. 2ND41042 also accumulates less DON than ND Genesis. The seed of these lines is being increased so that a commercial-scale evaluation can be conducted in 2027, if desired.

<u>Objective 2: Growing the North American Barley Scab Evaluation Nursery (NABSEN) at our Osnabrock, ND research site,</u>

What were the major activities?
We grew the NABSEN trial at our Osnabrock research site under uninoculated, unmisted conditions. These are conditions a grower would typically experience in their fields. We harvested the NABSEN, combined each entry across replicates, and sent the samples to Zhou Jin's mycotoxin lab at NDSU for DON analysis.

What were the significant results?

DON levels ranged from 0.0 to 0.9 ppm. The susceptible checks in the nursery included Stander, which accumulated 0.9 ppm DON, and AAC Synergy, which accumulated 0.0 ppm DON. The resistant check Chevron also accumulated 0.0 ppm DON.

List key outcomes or other achievements.

NDSU lines in the nursery at Osnabrock had DON values ranging from 0.0 to 0.3 ppm.

Objective 3: Collect FHB and DON data on cultivars and advanced breeding lines that growers can use for making decisions on what cultivar(s) to grow.

What were the major activities?

Thirteen named varieties grown in our Variety Yield Trial were grown in our FHB nurseries at Langdon and Osnabrock. DON levels in the Langdon nursery were significantly higher than those in the Osnabrock nursery.

Table 1. DON accumulation in named varieties and 2ND36638 grown in the mist-irrigated, inoculated FHB nurseries in Langdon and Osnabrock, ND in 2024.

		DON (ppm)†	
NAME	Row type	Langdon	Osnabrock
CONLON	2	11.0	0.5
PINNACLE	2	23.6	0.8
ND GENESIS	2	19.6	0.5
AAC SYNERGY	2	32.6	0.8
EXPLORER	2	16.6	0.7
AAC PRAIRIE	2	36.6	0.5
CDC FRASER	2	32.7	0.5
ABI CARDINAL	2	39.6	0.6
BREWSKI	2	15.9	0.8
2ND36638	2	19.2	0.8
TRADITION	6	28.6	0.7
LACEY	6	23.3	0.4
STELLAR ND	6	40.8	0.9
QUEST	6	25.0	0.4
ND TREASURE	6	36.1	1.4

†DON data provided by Dr. Zhou Jin, NDSU.

List key outcomes or other achievements.

2ND36638 accumulated less DON than AAC Synergy and similar DON to ND Genesis. Since 2ND36638 is the next potential release from NDSU, it has consistently shown over the years that it accumulates less DON than AAC Synergy.

3. What opportunities for training and professional development has the project provided?

Cameron Mathews, a PhD student from Indiana, is working on improving our genomic selection model for DON accumulation.

4. **How have the results been disseminated to communities of interest?**
   Results are shared through peer-reviewed journals, popular press articles, field day presentations, and stakeholder group meetings at local and regional levels. Results from the 2024 NABSEN can be viewed at https://scabusa.org/pdfs_dbupload/nabsen-report_24.pdf.

5. **What do you plan to do during the next reporting period to accomplish the goals and objectives?**
   Breeding barley lines with better FHB resistance and lower DON levels is an annual effort. Our breeding pipeline encompasses every stage of the program. Each year, we assess how to improve our methods to more effectively advance lines toward becoming varieties. We aim to update and optimize our training population so that a GS model for DON can be integrated into our program.