Project FY22-BA-003: Determining FHB Susceptibility in Barley Cultivars in the Western US

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1. What are the major goals and objectives of the research project?

The major goal of the project is to determine the level of resistance and susceptibility in currently produced and recently released varieties and advanced breeding lines of barley. FHB damage in spring grain continues to increase in southern and eastern Idaho. In 2015, fields of barley showed signs of disease, and many spring wheat fields tested at >5 ppm DON, even after appropriate treatments with fungicides. Large production areas north of Idaho Falls resulted in rejection of barley for malting due to high levels of DON. In 2018, 40,000 bu of barley was rejected from one producer alone near Rupert, Idaho. In 2024, FHB was found in winter barley production in the Magic Valley. The level of FHB-affected grain in the region continues to increase with temperatures and the expansion of corn acres for the dairy industry. The majority of the barley varieties that are available to growers in the area are susceptible to FHB and growers need information to improve management. Breeders need information on advanced lines and breeding material to release selections with reduced vulnerability to FHB damage and DON accumulation. Management practices need to be tested under the unique conditions in the irrigated production regions of the Intermountain West to develop appropriate management practices to reduce FHB and DON.

> Project goals and objectives: Our specific objectives for this proposal were to: 1) determine the degree of susceptibility that exists in currently grown varieties and advanced lines to local *Fusarium graminearum* isolates; and 2) provide DON data to local breeders and growers to increase the ability to select the best varieties for breeding and production.

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

In adding to the body of knowledge associated with determining the genetics of resistance, we also initiated a barley association mapping study as part of a Master of Science research project in 2023. A four-location GWAS panel was planted in cooperation with Dr. Belayneh Yimer at the USDA-ARS in Aberdeen, ID. In 2025, the GWAS panel was planted for seed increase with the intention that in 2026, the panel will be planted for the second year of screening for FHB.

What were the major activities?

An assessment of released barley cultivars and advanced lines from 2023-2024 entries in the University of Idaho Extension Variety trials was conducted in on-station FHB nurseries at the Aberdeen Research and Extension Center and at the USDA-ARS research facility at Kimberly, Idaho. Winter barley from the UI Extension Variety Trials and the NABSEN entries were planted as well at Kimberly. Resistant and susceptible checks for the spring barley nursery were: Chevron was included as the six-row resistant check; PI383933 and Stander as susceptible checks. ICB111809 was the two-rowed susceptible check, and Clho4196 was the 2-row resistant check. Experimental units consisted of two row plots with two replications using a randomized complete block design. Plots were 5-foot rows planted with a Hege 1000 headrow planter. Separate irrigation systems were designed and installed to provide an environment conducive for FHB infection while simultaneously meeting the irrigation needs of the crop.

Autoclaved corn was inoculated with *F. graminearum* and allowed to grow for three weeks before drying. Corn spawn was spread in the field approximately three weeks prior to anthesis or head emergence of the earliest lines at 60 grams per plot. Barley plots were inoculated with a spore suspension of macroconidia of *F. graminearum* at head emergence. Barley symptom development of FHB has been more difficult to induce and disease development was greater after inoculation with both corn spawn and a spore suspension of 100,000 conidia per L. Plots were inoculated twice (100,000 conidia per L) with conidial suspension starting at head emergence (Feekes GS 10.1, June 9) using a CO_2 backpack sprayer with three 8003 VS nozzles at a ground speed of 1 sec/ft at 40 psi. A second inoculation of each barley plot occurred one week after the first. An irrigation system with sprinkler nozzles every 20 feet was used both for irrigation and increasing humidity in the plant canopy. After inoculation, plots were irrigated every other day for two hours. A supplementary misting system with nozzles every 10 feet was also used for the barley screening nursery. The misters ran every 3 minutes every 2 hours between 9PM to 3AM and 9AM to 11AM.

The barley association mapping study evaluated 300 USDA-ARS Pacific Northwest adapted spring barley breeding lines for FHB reaction. In 2023, trials were planted at mist-irrigated nurseries in Aberdeen and Kimberly, in Fargo, ND and hill plots in Sidney, MT. We used local isolates of *F. graminearum* on infested corn spawn and macro-conidial suspension spray for artificial inoculation. Corn spawn was applied at rate of 30g/m^2 at tillering (2-3 weeks before heading). Macroconidial suspension was applied using a CO2 backpack sprayer, 8003 VS nozzle tips, calibrated to 40 psi, at a rate of 1 sec/ft near 50% heading and again 5-7 days later. At Sidney and Fargo locations, we relied on natural infection and a conducive climate for disease development. The experimental design was a randomized complete block with 2 replications per cultivar per location. Known resistant and susceptible lines were used as controls. Disease incidence and severity was assessed three weeks after macroconidial inoculation by in-field visual rating. DON accumulation was be measured at the UMN DON Testing Lab in collaboration with Dr. Yanhong Dong. A genome-wide association study was executed to identify QTL associated with low disease incidence, severity, and DON. A graduate student processed the data and completed a Master's program, defensing in Aberdeen and graduating May, 2024.

What were the significant results?

Low disease formed in the barley spring nurseries in 2024 compared to previous years. DON levels were obtained with the collaboration of Dr. Yanhong Dong, University of Minnesota. Winter barley had very little to no disease and was not rated. Disease development in 2024 as determined by the FHB Index in spring barley varieties ranged from "Resistant" of 0.2 (CDC Copeland, not significantly different from the resistant checks Clho4196 and Chevron) to Susceptible at 6.8 (Moravian 69, not significantly different form the susceptible checks PI383933). DON levels in harvested grain varied from a low of 0.5 ppm (Chevron) to 14 ppm (LG Korok).

List key outcomes or other achievements.

The results of the previous FHB experiments and this study was/will be presented numerous times at the local, national and international level. Consultants and breeding companies in the area have used this data to improve variety recommendations, and growers now regularly spray to reduce FHB and DON in susceptible and moderately susceptible spring barley cultivars when planted after corn. Growers are now aware of the varieties that are less likely to get FHB and suffer high DON, and to spray those varieties they know are vulnerable, especially when following corn in their crop rotations.

Several cultivars were identified in the GWAS panel as potential sources of resistance to Fusarium head blight (FHB). These include GemCraft, CDC Meredith, CDC Mindon, CDC

Copeland, Conlon, Julie, Kardia, Newdale, and Transit. It's possible that additional sources of resistance exist within the USDA-ARS breeding program and amongst the genetic resources available at the National Small Grains Collection, either yet to be characterized for FHB reaction or awaiting publication of data. A second year of data from the GWAS is planned for 2026 following seed increases of the panel in 2025.

3. What opportunities for training and professional development has the project provided?
The 2024 funding provided support for a master's student who completed his thesis in 2024.

4. How have the results been disseminated to communities of interest?
The results of all the barley screening trials are published in our Annual Small Grains Report, disseminated to collaborating breeders, presented at various grower seminar and field events, and / or reported annually at the Scab Forum.

5. What do you plan to do during the next reporting period to accomplish the goals and objectives?
The barley entries for the GWAS experiment will be increased in 2025 to repeat the study a second year for publication. The trial locations will be reduced from four to two, to repeat the trial at the most effective locations (Aberdeen and Kimberly) for identifying QTL for resistance to FHB. The resulting publication will be developed in the fall of 2025.
There are no proposed changes in the 2025 experiments to continue the trials.
The screening of released barley cultivars and those entered into the Extension Variety Trials will continue. Advanced lines from regional barley breeders also will continue to be solicited for inclusion in the screening trials. The winter screening will be discontinued due to lack of funding.

Table 1. Spring barley summary sorted by FHB Index, combined across two locations (Kimberly and Aberdeen). Chevron was included as the six-row resistant check; PI383933 was the six-row susceptible checks. Clho4196 was the 2-row resistant check, and ICB111809 was the two-row susceptible check.

Variety/Line	Severity Estimate	Incidence Estimate	INDEX Estimate	DON PPM
CDC Copeland	4.5 C D	9 L	0.2 I	3.2 G F H
Clho4196	4.3 D	13 L	0.6 I	1.8 G H
Chevron	4.1 D	24 J L K	0.8 I H	0.5 H
AAC Connect	5.0 C D	20 L K	1.0 I H	3.0 G F H
AAC Prairie	6.4 B C D	21 L K	1.3 I H	3.4 G F H
2IM17-2221	5.5 C D	25 J L K	1.3 I H	3.4 G F H
ABI Eagle	5.4 C D	25 J L K	1.4 I H	4.2 G F H
Transit	6.5 B C D	21 J L K	1.6 I H G	2.6 G F H
CDC Fraser*	5.8 C D	30 J L I K	1.7 I H G	5.2 G E F
2IM16-0154	4.7 C D	30 J L I K	1.7 I H G	3.1 G F H
ABI Voyager	4.5 C D	34 J L H I K	1.7 I H G	3.6 G F H
17ARS069-1	5.1 C D	36 J L H I K	1.9 I H G	6.3 G E F D C
Carleton	4.6 C D	41 J H I G K	2.1 I H G	2.1 G H
HO516-429	4.8 C D	43 J H I G K F	2.2 I F H G	2.1 G H

16ARS295-1	4.6	C D	45	J H I G K F	2.2	I F H G	3.2	G F H
BC Leandra	5.0	C D	45	J H I G K F	2.2	I F H G	6.3	G E F D C
ABI Raptor	5.4	C D	41	J H I G K	2.4	I F H G	3.3	G F H
17ARS072-5	4.6	C D	56	E D H I G F	2.6	E I F H G	4.9	G E F H
Golf	5.5	C D	51	E J H I G F	2.7	E I F H G	3.2	G F H
16ARS067-13	4.7	C D	60	E B D H G C F	2.9	E F H G	5.3	G E F
GemCraft	4.5	D	65	E B D H A G C F	3.0	E F H G	3.2	G F H
C15-314-181-001	4.9	C D	63	E B D H A G C F	3.2	E D F H G	8.7	E D C
Esma	4.8	C D	63	E B D H A G C F	3.2	E D F H G	6.0	G E F D
HO517-126	4.9	C D	66	E B D H A G C F	3.5	E D F H C G	2.5	G H
DH131756	5.4	C D	68	E B D A G C F	3.6	E D F H C G	6.1	G E F D
ICB111809	5.8	C D	66	E B D H A G C F	3.7	E B D F H C G	5.9	G E F
LGBU17-1320A	5.8	C D	68	E B D A G C F	4.0	E B D F C G	11.3	B C
LG Slovan	5.1	C D	79	B D A C	4.0	E B D F C G	7.3	E F D C
LCS Odyssey	5.3	C D	76	E B D A C	4.1	E B D F C G	11.1	B C
Successor	6.2	B C D	66	E B D H A G C F	4.1	E B D F C G	4.6	G E F H
Claymore	5.9	C D	74	E B D A C	4.1	E B D F C G	2.2	G H
Rulon	5.7	C D	74	E B D A C	4.3	E B D F C	4.5	G E F H
Champion	5.6	C D	78	B D A C	4.4	E B D F C	4.4	G E F H
LG Diablo	6.3	B C D	73	E B D A C F	4.6	E B D C	10.4	B D C
Goldenhart	5.8	C D	79	B D A C	4.7	E B D A C	2.9	G F H
Moravian 179	6.8	B C D	70	E B D A G C F	4.7	E B D A C	3.5	G F H
18ARS205-2	6.4	B C D	80	B D A C	5.2	B D A C	2.1	G H
LCS Genie	6.1	C D	85	B A	5.2	B D A C	11.3	B C
Kardia	7.0	B C	75	E B D A C	5.4	B A C	2.3	G H
BC Elinor	6.4	B C D	84	B A C	5.5	B A C	8.0	E F D C
Altorado	6.1	C D	88	A	5.6	B A C	4.1	G F H
LG Korok	9.9	A	59	E D H G C F	6.0	B A	14.0	B A
PI383933	9.3	B A	71	E B D A G C F	6.3	B A	3.0	G F H
Moravian 69	9.9	A	68	E B D A G C F	6.8	A	4.7	G E F H