Project FY22-BA-015: Developing FHB Resistant Barley Cultivars for California

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

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

The goal of this project is to develop California-adapted barley with improved resistance to FHB and reduced DON accumulation.

The project has three main objectives: 1) identify FHB resistance in UC Davis malting and naked barley germplasm through multi-year screening; 2) determine which lines show reliable resistance based on both FHB severity and DON accumulation; and 3) use resistant lines as parents to increase FHB resistance in new breeding populations.

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

What were the major activities?

UC Davis barley germplasm was evaluated for FHB severity and DON accumulation in inoculated nurseries in Minnesota. Screening began in 2019 in St. Paul, before the project started, and continued in Crookston from 2021 onward.
During the screening, promising lines were retained for additional testing, while new breeding materials were continuously introduced. In 2023, for example, 33 of 65 genotypes were in their second year of testing, 12 in their third, and 8 in their fourth.
Resistance lines identified through screening were incorporated directly into the breeding program. Six families were advanced to F4 head rows, 36 lines were advanced for further agronomic evaluation, and 12 additional crosses were made using resistant and agronomically adapted parents.

What were the significant results?

First, the multi-year data demonstrate that repeated testing is essential. Repeatability was high in some year pairs but weak in others. For example, FHB severity between 2021 and 2022 had a Spearman correlation of 0.58($n = 31$, $P < 0.001$), and DON had 0.59 ($n = 27$, $P < 0.01$). In contrast, despite 77 common entries between 2019 and 2021, their FHB severity ranking were only weakly associated (0.05). Thus, a single nursery is not sufficient to identify stable resistance.

Second, FHB severity and DON represent related but distinct components of resistance. Correlations between severity and DON were generally only moderate and varied among years. For example, UC-Alameda generally had lower FHB severity but average DON, whereas UC-Butta12 and UC-Capay showed consistently low DON across multiple years
(**Fig. 1**). Thus, both traits should be used in breeding decisions.

Third, multi-year analysis identified lines with favorable and relatively consistent resistance across environments. After standardizing FHB severity and DON within each nursery to account for differences in disease pressure, several lines, including B9K66, Scarlett, UYP545, B9K62, B9K85, and B9K24, showed FHB resistance across years (**Fig. 1**). These results provide a set of resistance resources that can be prioritized for further evaluation and use in crossing.

Fourth, heading date can affect FHB evaluation in the UC Davis population, but the effect is environment-dependent. Heading date was associated with FHB severity in some nurseries, particularly 2022 ($\rho = -0.66$, $P < 0.001$), but showed little relationship with severity in 2024. ($P = 0.75$). Late flowering UCD lines can be difficult to evaluate in the Minnesota nursery. Thus, flowering time should be considered when interpreting FHB resistance.

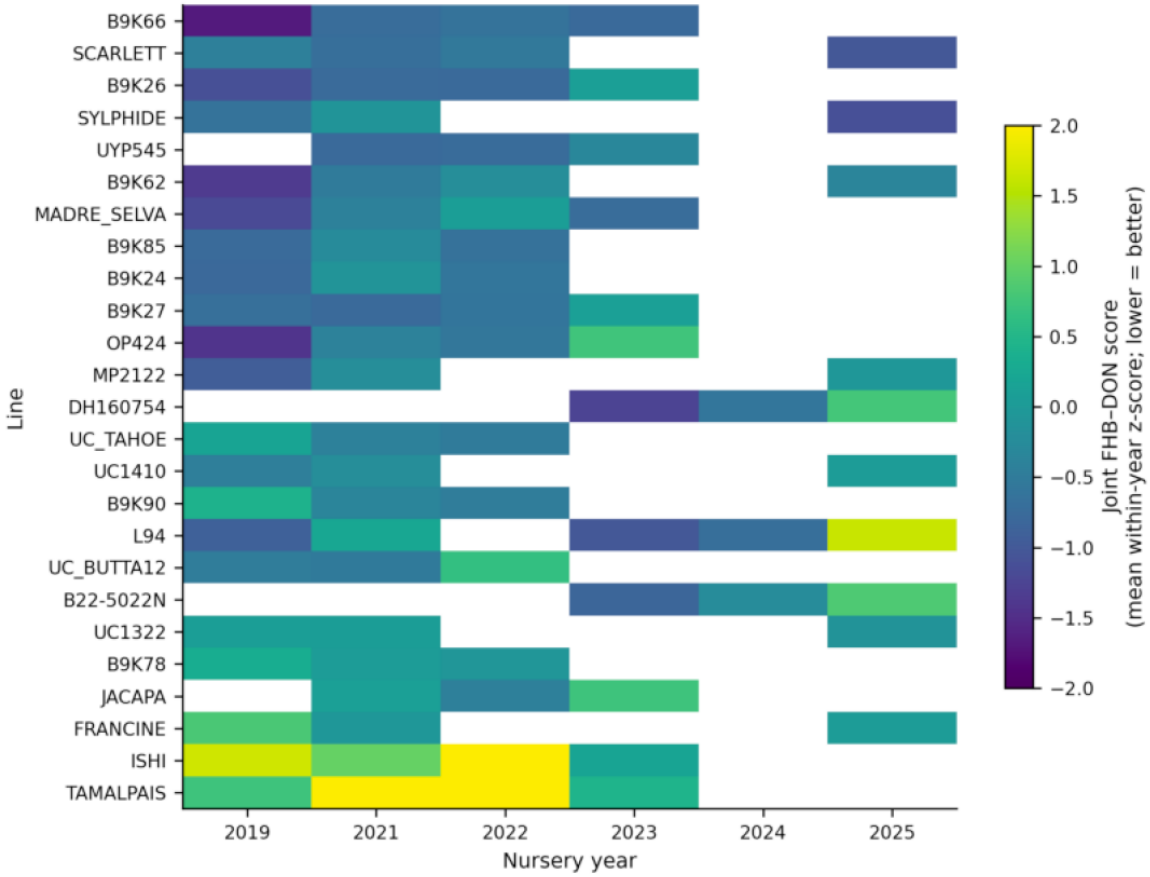


Figure 1. Multi-year FHB resistance and DON accumulation in repeatedly evaluated barley lines. Heatmap shows barley lines with paired FHB severity and deoxynivalenol (DON) measurements in >= 3 nursery years. Because disease pressure differed substantially among years, FHB severity and DON were standardized separately within each nursery year as z-scores. A joint FHB–DON score was then calculated as the mean of the within-year severity and DON z-scores. Blue indicates lower FHB severity and DON relative to the nursery-year mean (greater resistance), whereas yellow indicates higher severity and/or DON (greater susceptibility). White cells indicate that the line was not evaluated for both traits in that year. Lines are ordered by their mean joint score across evaluated years, from lower to higher values.

List key outcomes or other achievements.

1) **FHB resistance has been incorporated into the UC Davis barley breeding pipeline. Resistant materials have been used as parents.** Breeding populations have been advanced to head row stages for continued evaluation under California conditions.
2) **New resistance sources are available for cultivar development.** The project identified adapted materials that can serve as resistant donors while maintaining the agronomic and quality characteristics required by the California growers and industry. This expands the resistance based available for both malting and naked barley improvement.

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

Two undergraduate students and research personnel (Christina Carter, Dr. Alicia del Blanco) involved in the UC Davis barley breeding program participate in the complete breeding process, including crossing, selfing, selecting adapted materials, and using FHB severity and DON data to make advancement and crossing decisions.

The collaboration with the Minnesota FHB nursery and NDSU Analytical lab also shows trainees how to coordinate disease screening and multi-institutional crop improvement. The project has benefited substantially from the FHB screening conducted by Dr. Brian Steffenson's team and DON measurement by Dr. Zhao Jin's team.

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

Results have been shared primarily through the UC Davis barley breeding program, collaborating FHB researchers, and U.S. Wheat & Barley Scab Initiative. Results from each nursery are communicated among collaborators and used directly to identify resistant lines, select parents, and advance breeding populations. Project progress and results are also reported through USWBSI annual reporting and program activities. Resistant germplasm identified through the project is being incorporated into UC Davis breeding populations, providing a direct pathway for the results to reach California growers and end users.

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.