

USDA-ARS | U.S. Wheat and Barley Scab Initiative
FY21 FINAL Performance Progress Report

Due date: July 26, 2023

Cover Page

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|-------------------------------------|---|
| USDA-ARS Agreement ID: | 59-0206-0-171 |
| USDA-ARS Agreement Title: | Preparing Barley for FHB in California |
| Principle Investigator (PI): | Jorge Dubcovsky |
| Institution: | University of California-Davis |
| Institution UEI: | TX2DAGQPENZ5 |
| Fiscal Year: | 2021 |
| FY21 USDA-ARS Award Amount: | \$35,680 |
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| Period of Performance: | 5/15/21 - 5/14/23 |
| Reporting Period End Date: | 5/14/2023 |

USWBSI Individual Project(s)

| USWBSI Research Category* | Project Title | ARS Award Amount |
|------------------------------------|--|------------------|
| BAR-CP | Preparing Barley for FHB in California | \$35,680 |
| FY21 Total ARS Award Amount | | \$35,680 |

I am submitting this report as a: FINAL Report

I certify to the best of my knowledge and belief that this report is correct and complete for performance of activities for the purposes set forth in the award documents.



Principal Investigator Signature

07/23/2023

Date Report Submitted

† BAR-CP – Barley Coordinated Project
 DUR-CP – Durum Coordinated Project
 EC-HQ – Executive Committee-Headquarters
 FST-R – Food Safety & Toxicology (Research)
 FST-S – Food Safety & Toxicology (Service)
 GDER – Gene Discovery & Engineering Resistance
 HWW-CP – Hard Winter Wheat Coordinated Project

MGMT – FHB Management
 MGMT-IM – FHB Management – Integrated Management Coordinated Project
 PBG – Pathogen Biology & Genetics
 TSCI – Transformational Science
 VDHR – Variety Development & Uniform Nurseries
 NWW – Northern Soft Winter Wheat Region
 SPR – Spring Wheat Region
 SWW – Southern Soft Red Winter Wheat Region

Project 1: Preparing Barley for FHB in California

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

The project goals are to characterize variation in resistance to FHB in the University of California (UC) barley germplasm, to identify any novel sources of resistance, and to develop FHB-resistant barley germplasm adapted to California growing conditions. The objectives are to 1) Screen UC germplasm in an FHB nursery 2) genotype material to improve selection of FHB resistant material and identify any genomic regions of interest and 3) develop CA adapted varieties with FHB resistance.

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

a) What were the major activities?

The first FHB screening of UC germplasm was done in 2019 in MN with Dr. Dill-Macky (100 lines x 3 reps). Based on this preliminary screening we chose 100 lines (x 1 rep), to screen again in 2021 in MN with Dr. Steffenson. The most susceptible germplasm was replaced with new lines and 75% of the lines were reevaluated. In 2022, we again screened 100 plots in MN with Dr. Steffenson. The top three most promising lines were replicated, 18 lines from the previous nurseries were tested again and 76 new lines were added. Around 90% of all the lines tested were 2R malting types. FHB Severity (%), DON (ppm) and heading date data were collected for all plots. Over 500 lines were genotyped for ~50K genome wide SNPs, including those in the FHB nurseries.

Non-UC germplasm known to have good FHB resistance, according to the literature and previous USWBSI reports, were evaluated in the field in Davis in 2019. Twenty crosses were made in 2019 between UC elite 2R lines, which showed promise for greater FHB resistance (based on one year of data), and some of these FHB resistant germplasm lines. These crosses were evaluated as F₂ rows in Davis in 2021. F₃ populations were selected for advancement and evaluated in plots in Davis in 2022. Spikes were collected from six of the selected F₃ populations for F_{3:4} head-row evaluation in 2023. F_{3:4} head-rows were selected this year (2023) for advancement to F_{3:5} single evaluation plots in Davis and for testing in the MN FHB nursery in 2024. Four advanced UC lines that showed promise for improved FHB resistance were incorporated as parents in the 2R malting and naked barley breeding programs.

A double-haploid population using one of our best lines for FHB resistance and malting quality (B9K62, UC Alameda) was developed in 2022 and is being increased and evaluated for agronomics and quality.

b) What were the significant results?

The 2019 FHB nursery showed a greater percent of FHB severity across all lines than the 2021 and 2022 FHB nurseries (Figure 1, Table 1). However, 2022 saw the highest levels of DON across all three years, with an average of 22 ppm and a high of 143 ppm (Table 1). There was an average correlation of 40% between FHB severity and ppm DON.

Initial FHB populations from known FHB resistant material and elite UC lines are currently advance to the F_{3:4} stage. Approximately 50-100 spikes each were collected in 2022 from six selected F₃ populations for F_{3:4} head row evaluation in 2023. An average of 10 rows per population were selected this year (2023) for advancement to F_{3:5} single evaluation plots in Davis and for testing in the MN FHB nursery in 2024. Several of the initial populations were poorly adapted to California. We selected four UC 2R elite lines that have good agronomic and quality traits and show potential for improved resistant to FHB (based on 3 years of data), to use as parents in the barley breeding programs in order to incorporate more FHB resistance into the germplasm (Figure 2). One of these lines (tested as B9K62) was released in 2022 as UC Alameda. This variety has better FHB resistance than previously released 2R malting varieties (UC Butta12, UC Tahoe and UC Capay).

All lines were clustered into five groups for phenotypic values and five groups for genomic values using normal mixtures to use for selecting germplasm with most potential for resistance (Figures 4 and 5). Genotype data from 536 lines were included in the genotypic (G) clusters, including those with phenotypic values for FHB traits (195 lines). Phenotypic (P) Clusters were based on 285 lines across all years. We select new lines for testing in the FHB nursery from the most promising G clusters, such as Cluster 2 (Figure 4). Lines in G Cluster 5 will not be tested. This method allows us to select or eliminate lines that have not been tested and prioritize those with the most likely chance of showing resistance. We can also use these data to keep a balance of diverse and related material for FHB testing. The P clusters are used in a similar method with lines in P Clusters 3 & 5 dropped from testing, unless used as a S check. The best P Clusters (1 & 4) are represented over several G Clusters.

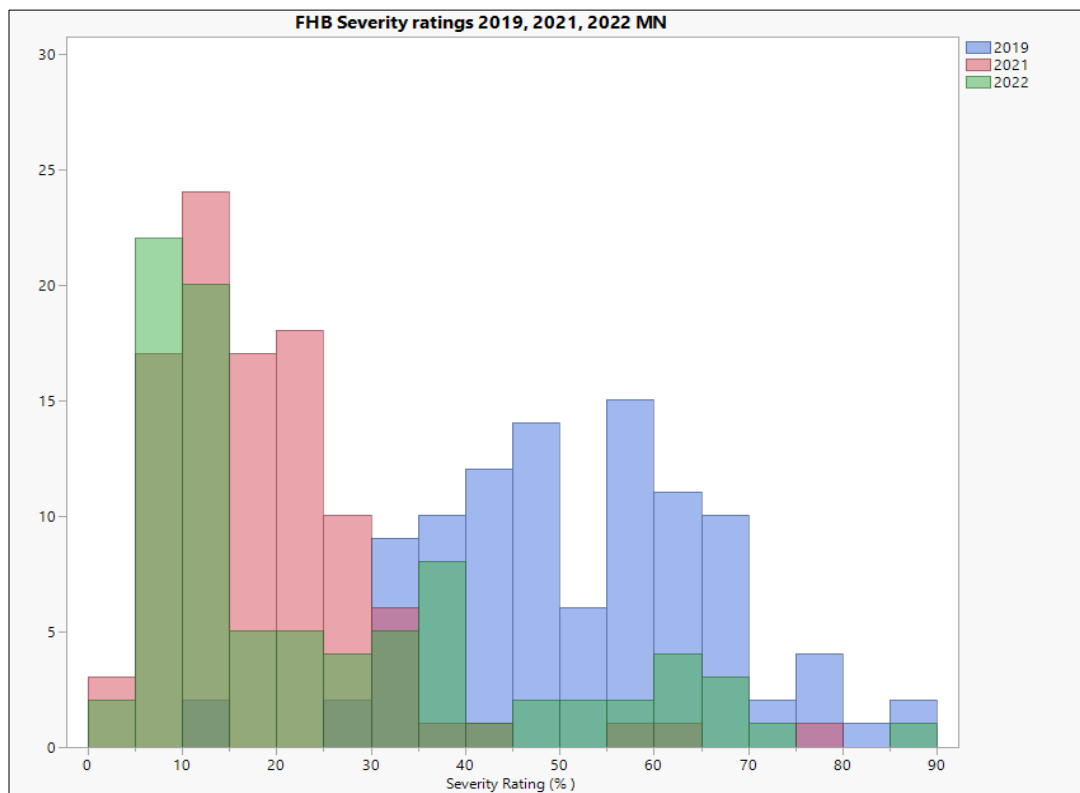


Figure 1. Histogram of the FHB severity (%) of UC Barley lines in MN FHB nurseries in 2019, 2021 and 2022. 100 lines from each year were tested.

Table 1. FHB severity (%) and DON (ppm) of UC Barley lines in MN FHB nurseries in 2019, 2021 and 2022. 2019 showed the highest average severity of FHB but 2022 showed the highest ppm for DON.

| | | YEAR | | |
|---------------------|-------------|--------------|--------------|--------------|
| | | 2019 | 2021 | 2022 |
| DON (ppm) | Mean | 16.84 | 1.70 | 22.23 |
| | Min | 2.90 | 0.10 | 2.40 |
| | Max | 35.60 | 15.70 | 143.90 |
| | Std Err | 0.74 | 0.23 | 2.51 |
| Severity (%) | Mean | 51.85 | 16.31 | 22.36 |
| | Min | 13.20 | 0.00 | 0.00 |
| | Max | 88.50 | 75.00 | 90.00 |
| | Std Err | 1.54 | 1.13 | 2.11 |

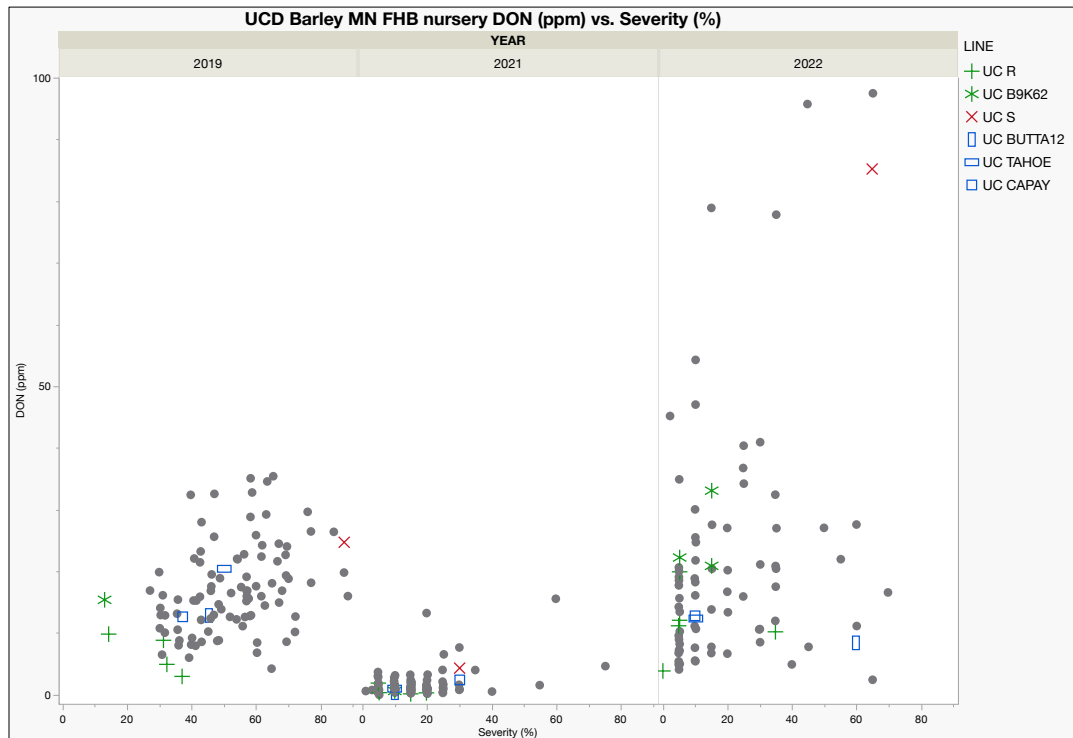


Figure 2. FHB severity (%) vs DON (ppm) for years 2019, 2021 and 2022. Several elite UC lines (green) were chosen as parents for incorporation of better FHB resistance, including a 2R malting line (B9K62) released as UC Alameda in 2023. Blue boxes indicate other UC 2R malting varieties (UC Butta12, UC Tahoe and UC Capay). The Red X indicates a 6R variety (Ishi) that was chosen as a UC susceptible check.

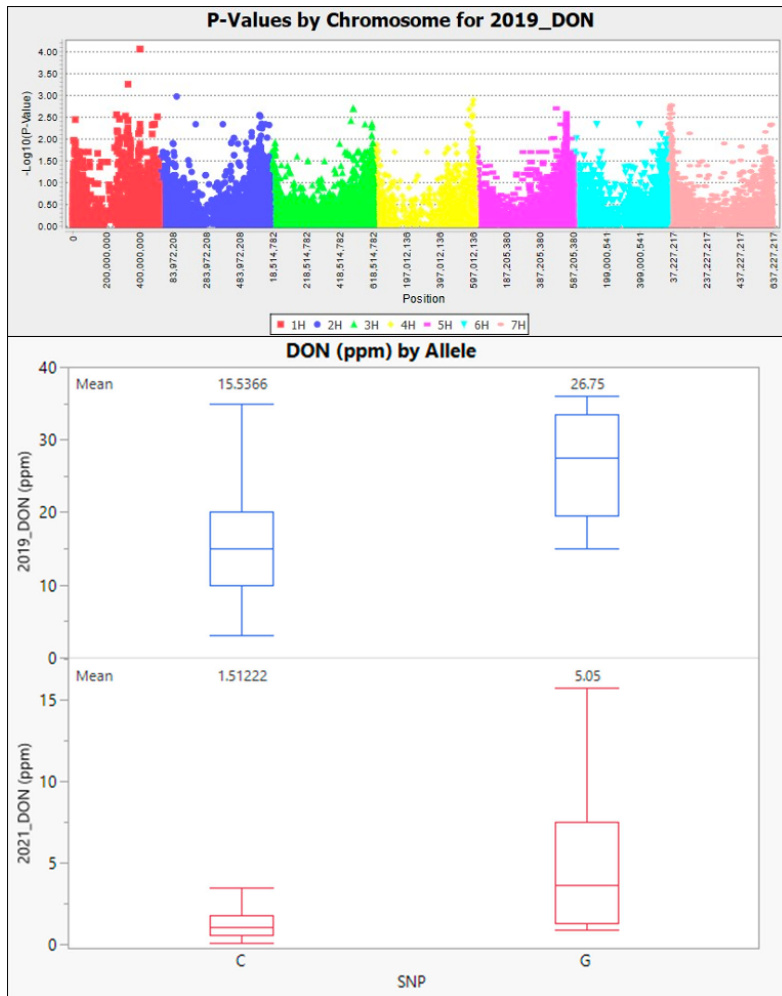


Figure 3. (Top) Manhattan plot for 2019 DON using MLM GWAS in TASSEL. The most significant QTL falls on CHR1. (Bottom) The allelic effect on the most significant SNP on CHR1 can have up to a 10ppm difference in DON levels.

| P Cluster | N | Sevity (%) | DON (ppm) |
|------------------|-----|------------|-----------|
| 1 | 88 | 14.08 C | 1.16 D * |
| 2 | 4 | 26.25 BC | 38.08 B |
| 3 | 138 | 47.87 A | 15.78 C |
| 4 | 44 | 7.57 D | 14.28 C |
| 5 | 11 | 32.91 B | 81.03 A |
| G Cluster | | | |
| 1 | 79 | 34.00 B | 10.13 B |
| 2 | 189 | 27.14 C | 9.00 B * |
| 3 | 198 | 26.89 BC | 8.39 B |
| 4 | 42 | 34.66 BC | 11.99 B |
| 5 | 28 | 57.09 A | 46.35 A |

Figure 4. Genotypic (G) and Phenotypic (P) Clusters across all years (2019, 2021, 2022). Lines in G Cluster 5 will not be tested, those in G Cluster 2 will be prioritized for testing.

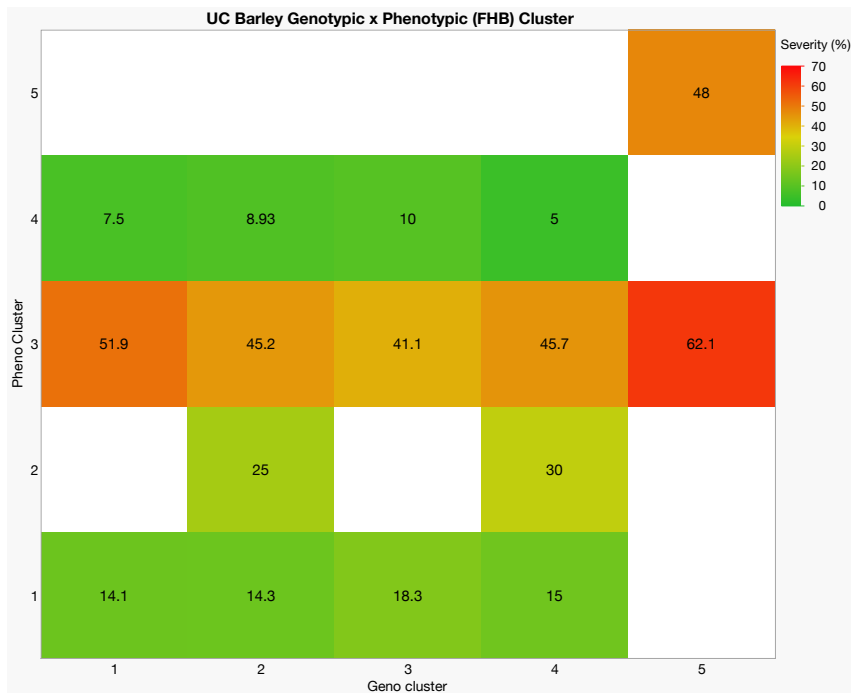


Figure 5. Genotypic vs Phenotypic Clusters across all years (2019, 2021, 2022). Severity (%) shown in boxes.

c) List key outcomes or other achievements.

UC-Alameda (tested as B9K62) was released in 2022. This variety shows some of the best resistance to FHB in our material across all years, has very good agronomic performance and malting quality. This will be the first California 2R malting variety with some resistance to FHB.

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

Five undergraduate students and one visiting PhD student benefited from participation in this project.

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

The new FHB resistant variety UC-Alameda was presented to barley growers and the malting industry representatives during field days. Admiral Maltings in Alameda, CA will be testing this variety for production at their malthouse, with potential for use in craft breweries throughout California.

Publications, Conference Papers, and Presentations

Please include a listing of all your publications/presentations about your FHB work that were a result of funding from your FY21 grant award. Only citations for publications published (submitted or accepted) or presentations presented during the **award period** should be included.

Did you publish/submit or present anything during this award period?

- Yes, I've included the citation reference in listing(s) below.
 No, I have nothing to report.

Journal publications as a result of FY21 award

List peer-reviewed articles or papers appearing in scientific, technical, or professional journals. Include any peer-reviewed publication in the periodically published proceedings of a scientific society, a conference, or the like.

Identify for each publication: Author(s); title; journal; volume; year; page numbers; status of publication (published [include DOI#]; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).

Books or other non-periodical, one-time publications as a result of FY21 award

Report any book, monograph, dissertation, abstract, or the like published as or in a separate publication, rather than a periodical or series. Include any significant publication in the proceedings of a one-time conference or in the report of a one-time study, commission, or the like.

Identify for each one-time publication: Author(s); title; editor; title of collection, if applicable; bibliographic information; year; type of publication (book, thesis, or dissertation, other); status of publication (published; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).

Other publications, conference papers and presentations as a result of FY21 award

Identify any other publications, conference papers and/or presentations not reported above. Specify the status of the publication.