USDA-ARS | U.S. Wheat and Barley Scab Initiative

FY21 Performance Progress Report

Due date: July 26, 2022

Cover Page

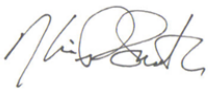
Principle Investigator (PI):	Kevin Smith
Institution:	University of Minnesota
E-mail:	smith376@umn.edu
Phone:	612-625-1211
Fiscal Year:	2021
USDA-ARS Agreement ID:	59-0206-0-134
USDA-ARS Agreement Title:	Evaulation and Implementation of Breeding Methods to Improve FHB Resistance in Barley
FY20 USDA-ARS Award Amount:	$172,948
Recipient Organization:	University of Minnesota Department of Agronomy and Plant Genetics 411 Borlaug Hall, 1991 Upper Buford Circle St. Paul, MN 55108
DUNS Number:	555917996
EIN:	41 -6007513
Recipient Identifying Number or Account Number, if any:	CON000000086376
Project/Grant Period:	5/13/21 - 5/12/23
Reporting Period End Date:	5/12/2022

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
BAR-CP	Developing Malting Barley Varieties with Enhanced FHB Resistance and Lower DON	$148,062
BAR-CP	Optimizing Parent Combinations to Improve FHB/DON Resistance in Barley	$24,886
	FY21 Total ARS Award Amount	$172,948

I am submitting this report as an: ☒ Annual Report ☐ 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.



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Principal Investigator Signature Date Report Submitted

ǂ 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: Developing Malting Barley Varieties with Enhanced FHB Resistance and Lower DON

1. **What are the major goals and objectives of the research project?**
   The overall goal of this project is to develop malting barley varieties with enhanced resistance to FHB and lower concentration of the mycotoxin deoxynivalenol (DON). To accomplish this goal, we are conducting a comprehensive FHB breeding effort utilizing greenhouse for crossing and single-seed advance, extensive field trials for FHB and DON evaluation, various uses of markers to improve selection, regional yield and quality testing, and collaborative regional nurseries to evaluate elite breeding lines. This project focuses on line development and evaluation for lower FHB/DON. Our breeding efforts have concentrated on two-row barley in response to industry needs. We have added a winter barley program to explore more sustainable production systems and potential avoidance of FHB.

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

   In the fall of 2021, we identified a set of 76 parents from our breeding program to make crosses to develop new breeding populations. A subset of these parents were used in crosses based on DON data as it came in. Most of these 89 new crosses have at least one parent that is lower in DON concentration compared to ND Genesis or is predicted based on genomic selection modeling to have progeny that are lower in DON compared to ND Genesis. In the winter greenhouse of 2022, we selected 38 parents and made 43 crosses with lines that should provide better winterhardiness. Many of these sources were outside of our breeding program and we have not yet assessed their FHB resistance. In most cases they were paired with a parent from our program with lower DON compared to ND-Genesis.

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

   In the summer of 2021, we conducted FHB evaluation in misted and inoculated field nurseries at Crookston and St. Paul, MN totaling just over 2,000 plots. We evaluated FHB severity and harvested selected plots for DON. These nurseries included trials from first year yield trial entries, advanced breeding lines, and varieties from our spring and winter (facultative) two-row breeding programs. This data was used to select parents and advance lines in our breeding program. We genotyped 1,290 F3 breeding lines in the Fall of 2021 with genome-wide markers to produce predictions for agronomic performance, malting quality, FHB severity, and DON concentration. This genotypic data was used to select 344 new lines to be entered into first year yield and FHB evaluations for the 2022 growing season.

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

Eight first year and two second year entries from crop year 2021 were advanced to American Malting Barley industry pilot testing for malting quality.

b) What were the significant results?

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

These crosses resulted in the advancement and planting of 74 F2 populations in the spring of 2022.

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

Based on re-evaluation of parents and marker-based prediction for seven traits including DON, 344 lines were harvested and the seed used to plant preliminary yield trials at three locations and FHB nurseries at two locations in the spring of 2022.

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

One of our advanced line (S2M184) was rated satisfactory for a second time in AMBA pilot testing with the 2021 crop. It has lower DON compared to ND Genesis and is earlier, shorter and has better straw strength. It is now eligible for plant scale testing.

c) List key outcomes or other achievements.

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

These activities maintain the steady flow of breeding lines created and advanced to field trials, marker genotyping, and FHB field screening to improve resistance to FHB.

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

We successfully met our target of generating new first year breeding lines for evaluation and evaluating advanced breeding lines for industry evaluation and consideration as new variety candidates.

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

One line that was advanced from AMBA Pilot testing to consideration for Plant Scale testing has lower DON and better agronomic performance compared to ND-Genesis.

3. **What opportunities for training and professional development has the project provided?**
   I have one post-doc and one graduate student (both not paid from the USWBSI) that are currently gaining experience with barley breeding and FHB by working with materials and data from this project.

4. **How have the results been disseminated to communities of interest?**
   All of our raw data is uploaded to the public database, T3 Barley, and is freely available to researchers. Results of the North American Barley Evaluation Nursery (NABSEN) are posted on the USWBSI website. We report the FHB rating for all varieties grown in Minnesota in the MAES Minnesota Field Crop Trials extension publication and in Prairie Grains Magazine. I also discuss FHB breeding research at field days in Minnesota. We provide annual updates to Scab Smart with current variety information.

Project 2: Optimizing Parent Combinations to Improve FHB/DON Resistance in Barley

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1. **What are the major goals and objectives of the research project?**
   The major goal was to directly compare the performance, in our breeding program, of those breeding lines that trace back to crosses informed by a new cross selection procedure to those breeding lines from cross combinations designed conventionally.

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?**
   Evaluate parent selection based on genome-wide marker effects to increase genetic variance and reduce unfavorable trait correlations.

   We generated 36 crosses in the fall of 2020 that were among a set of parents that had undergone 2 years of testing. Sixteen of these crosses were designed based on marker-based predictions of parent combinations that should produce progeny with lower DON or reduced correlation of DON with heading date and plant height. The other 20 were designed based on traditional parent selection. Progeny of these crosses were advanced through the breeding program and treated the same in terms of selection. In the spring of 2021 selected lines from these progeny were advanced to preliminary yield trials.

   b) **What were the significant results?**
   Of the 36 crosses made in 2020, breeding lines from eight of those crosses selected by traditional selection and five crosses selected by parent prediction were advanced to preliminary yield trials in 2022. In terms of actual breeding lines, 33 traditional selection and 28 parent prediction lines were advanced. The next step will be to compare the actual performance of these lines once we have DON data from the disease nurseries.

   c) **List key outcomes or other achievements.**
   Very early indications do not suggest that marker-based selection of parent combinations is superior to traditional selection of parent combinations, however this is based on very little data so far.

3. **What opportunities for training and professional development has the project provided?**
   None

4. **How have the results been disseminated to communities of interest?**
   All of our raw data is uploaded to the public database, T3 Barley, and is freely available to researchers. A manuscript entitled “Multi-Trait Improvement by Predicting Genetic Correlations in Breeding Crosses” was published in the journal G3 in 2019.

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 grant 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).

Huang Y, Yin L, Sallam AH, Heinen S, Li L, Beaubien K, Dill-Macky R, Dong Y, Steffenson BJ, Smith KP, Muehlbauer GJ. Genetic dissection of a pericentromeric region of barley chromosome 6H associated with Fusarium head blight resistance, grain protein content and agronomic traits. Theor Appl Genet. 2021 Dec;134(12):3963-3981. doi: 10.1007/s00122-021-03941-9; acknowledgement of federal support - yes.

Note: technically this work did not result from the FY21 grant award. It is highly unlikely that research actually conducted in FY21 would be published in the first half of 2022. Nevertheless, this published work was based on past USWBSI funding.

Books or other non-periodical, one-time publications as a result of FY21 grant 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).

N/A

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

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

Yadong Huang, Shane Heinen, Brian Steffenson, Kevin P. Smith and Gary J. Muehlbauer. (2021). Fine Mapping of FHB and DON Quantitative Trait Loci on Chromosome 2H in Barley. *Proceedings of the 2021 National Fusarium Head Blight Forum*; Virtual. December 6-7, 2021. Retrieved from: https://scabusa.org/forum/2021/2021NFHBForumProceedings.pdf

Ahmad H. Sallam, Matthew Haas, Yadong Huang, Yanhong Dong, Zenith Tandukar, Gary Muehlbauer, Kevin P. Smith, and Brian J. Steffenson. (2021). Meta-Analysis of the Genetics of Resistance to FHB and DON Accumulation Based on a New Barley Consensus Map. *Proceedings of the 2021 National Fusarium Head Blight Forum*; Virtual. December 6-7, 2021. Retrieved from: https://scabusa.org/forum/2021/2021NFHBForumProceedings.pdf

John Hawkins and Kevin Smith. (2021). Exploring Variation for FHB Resistance and Toxin Mitigation in Naked Barley. Proceedings of the 2021 National Fusarium Head Blight Forum; Virtual. December 6-7, 2021. Retrieved from: https://scabusa.org/forum/2021/2021NFHBForumProceedings.pdf