

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

Due date: July 26, 2023

Cover Page

USDA-ARS Agreement ID:	59-0206-0-184
USDA-ARS Agreement Title:	Developing FHB Resistant Wheat and Barley Cultivars
Principle Investigator (PI):	Vijay Tiwari
Institution:	University of Maryland
Institution UEI:	NPU8ULVAAS23
Fiscal Year:	2021
FY21 USDA-ARS Award Amount:	\$56,490
PI Mailing Address:	University of Maryland, Dept. of Plant Science & Landscape Architecture 4291 Field House Drive, 2102 Plant Sciences Building College Park, MD 20742-4452
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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
VDHR-SWW	Developing FHB Resistant Soft Red Wheat Cultivars for Maryland	\$37,306
VDHR-SWW	Double Haploids to Expedite Development of FHB Resistant Soft Winter Wheat Varieties	\$19,184
FY21 Total ARS Award Amount		\$56,490

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

7/26/2023

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: Developing FHB Resistant Soft Red Wheat Cultivars for Maryland

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

- 1) Breeding soft red winter wheat adapted to the Mid-Atlantic with resistance to scab and to increase the increase adaptation of FHB-resistant lines by the wheat growers in the Mid-Atlantic region.
- 2) Evaluation of advanced lines in Uniform Scab nurseries, Maryland State Test, and Uniform Regional Nurseries.
- 3) Map and integrate new sources for Scab resistance into breeding germplasm and enhance collaborations with regional breeders using Mason-Dixon trials, DHs, screening nurseries, and other resources.

Data on resistant germplasm will be disseminated to ensure that the work completed by the MD-wheat breeding program will have a regional effect in support of USWBI's objectives.

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?

We have made significant progress in developing FHB wheat-breeding germplasm. Adopting Speed Breeding and double haploid approaches have allowed the MD wheat-breeding program to develop improved wheat varieties. Three elite cultivars developed under the PI's program ranked in the top 10 cultivars in the Maryland wheat variety trial 2022. These three cultivars contained FHB-resistant Fhb1 and Fhb_6A, Fhb1B. Two of these lines are in progress for licensing with seed companies.

PI participated in several regional tests where he provided yield, diseases, and FHB data on the wheat cultivars coming in from various wheat-breeding programs. These included Gulf Atlantic Wheat Nursery (GAWN), US Southern Nursery, US Eastern Nursery, US Southern Scab Nursery, Mason Dixon trials. PI tests FHB resistance of the soft red winter and barley cultivars under misted FHB nursery at Beltsville Research station of the University of Maryland. FHB severity and incidence data were collected on the germplasm. Samples were prepared for their DON content analysis and shipped to Dr. Yanhong Dong at Minnesota. Timely data was disseminated to the public breeding programs as well as our stakeholders.

PI also runs UMD's small-grain variety test that also records FHB resistance of the elite cultivars under natural as well as inoculated scab nursery. During years 2020-2021 and 2021-2022, PI tested a total of 175 wheat and 45 barley varieties at 4 different locations in Maryland for their adaptability, yield and FHB resistance and presented the results in factsheet. This is a very important data and growers rely on this information to make their planting decision on selected FHB-resistant cultivars.

We are also integrating new sources for scab resistance into breeding germplasm. These sources include new resistance source that we identified from triticale, Shirley and jagger mutant populations. We have introduced Fhb7 gene from the wheat-Thinopyrum translocation line in our MD cultivars and combined these with Fhb1. These combinations will be advanced and tested for their phenotypic expressions.

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b) What were the significant results?

We have two soft red wheat cultivars with enhanced FHB resistance in the licensing process. More than 45 new experimental cultivars (all derived from three way crosses to include FHB resistance) are being tested under state yield trails as well as in the regional tests. This is very significant results as we were a new program that started 4 years back and now, we have a continuous pipeline to develop and release wheat cultivars with enhanced FHB resistance.

c) List key outcomes or other achievements.

New sources of FHB resistance: from mutant population, triticale germplasm screening and einkorn wheat evaluations. Optimization of speed breeding for cultivar development as well as FHB evaluations.

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

Two PhD students, one PostDoc, and two undergraduate students were trained under this project. All the trainees worked with the PI to conduct the nursery, and collect and analyze data. The graduate students and PostDocs also participated in conferences and commodity board meetings with their work.

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

The PI presented the results in oral presentations and disseminated updates on FHB in wheat and barley through emails. PI presented the research updates in the FHB forum as well as online project update meeting. The graduate students in the team presented the results as posters and handouts to the stakeholders in commodity board meetings. The results were published as Barley disease Factsheets and was disseminated via emails and the UMD extension system to the broader grower community.

Project 2: Double Haploids to Expedite Development of FHB Resistant Soft Winter Wheat Varieties

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

This project strategically addresses each of the three priorities in the VDHR-SWW Action Plan.

(1) Increase the number of FHB resistant varieties available to farmers to reduce DON in the US grain supply. Utilizing doubled haploid (DH) technology decreases the breeding cycle from inception to pure line evaluation by a minimum of two years, which results in releasing FHB resistant varieties at a faster rate with improved efficiency. Saturating the number of FHB resistant varieties in the commercial marketplace for farmers is key to reducing DON presence within the national wheat supply chain. Approximately 1,400 DH lines will be generated from this project, with all of them potentially possessing multiple FHB resistance QTL in addition to high yield potential and quality.

(2) Increase efficiency of coordinated project breeding programs to develop and release FHB resistant varieties. Promising lines (from the 1,400 total DHs) selected by individual breeders will be shared among the VDHR-SWW group to evaluate within scab nurseries in additional locations for regional adaptation. This will practically ensure that no line goes unnoticed and robust, multilocation data for individual lines will provide appropriate information needed to justify release and licensing to companies for marketing to growers.

(3) Implement breeding technologies to enhance short term and long-term improvement of FHB resistance and to efficiently introgress effective resistance genes into breeding germplasm. Prior to selection of crosses for DH production, enrichment of FHB QTL and QTL for other agronomically important traits was completed for carefully chosen topcross populations using established markers and genotyping by Dr. Gina Brown-Guedira at the USDA ARS Eastern Regional Small Grains Genotyping Lab. This improves efficiency of the DH technology by eliminating undesirable lines and increasing the chance of stacking the appropriate genetics (FHB QTL + other QTL) in a DH line that will meet the requirements for release, or at a minimum, be used as a FHB donor parent in future crosses to effectively introgress resistance.

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

The grant period covers harvest (May-June) through preparation for planting for the programs of the VDHR-SWW. As per our group protocol we submitted F1 seed from crosses made in the spring of 2021 for creating new DHs for their planting in fall 2022. The parents of these F1s submitted for DH development were chosen to pyramid FHB resistance genes and have a high probability of combining yield, agronomic traits, other biotic pest resistance and resistance to FHB. Similarly, in spring 2020, wheat DH lines were developed at NCSU using FHB-MAS plants selected by southern breeding programs and UKY from four top cross populations developed at VT and genotyped by the Eastern Regional Genotyping Lab. We evaluated the DH lines in headrows in 2021-2022 as well as in year 2022-2023. A total of 400

DH lines were generated in the performance period and tested in the headrows for the selection of high-yielding FHB resistant germplasm.

a) What were the major activities?

Selection of F1 lines based on genotypic data for making decision of DH creation.
Shipping of selected F1 seeds to Heartland Plant Innovation for DH production
Test and evaluation of selected DH lines for FHB resistance
Seed increases for plot testing for yield evaluations

b) What were the significant results?

Tested DH provided enhanced level of FHB resistance
Effectively reducing the generation time of cultivar development pipeline

c) List key outcomes or other achievements.

About 45 lines out of 400 DHs showed high-yield and very good FHB resistance
These were selected for seed increases and large-scale tests.

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

Two PhD students, one postdoc, and two undergraduate students were trained under this project. All the trainees worked with the PI to conduct the nursery and collect and analyze data. The graduate students and PostDocs also participated in conferences and commodity board meetings with their work.

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

The PI presented the results in oral presentations and disseminated updates on FHB in wheat and barley through emails. PI presented the research updates in the FHB forum as well as online project update meeting. The graduate students in the team presented the results as posters and handouts to the stakeholders in commodity board meetings. The results were published as Barley disease Factsheets and was disseminated via emails and the UMD extension system to the broader grower community.

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).

1. Chhabra, B.; Singh, L.; Wallace, S[†].; Schoen, A[†].; Dong, Y.; Tiwari, V.K.; Rawat, N. Screening of an Ethyl Methane Sulfonate Mutagenized Population of a Wheat Cultivar Susceptible to Fusarium Head Blight Identifies Resistant Variants. *Plant Disease* 2021, 105 (11), 3669–3676. <https://doi.org/10.1094/PDIS-03-21-0670-RE>.
2. Chhabra, B.; Tiwari, V.K.; Gill, B. S.; Dong, Y.; Rawat, N. Discovery of a Susceptibility Factor for Fusarium Head Blight on Chromosome 7A of Wheat. *Theoretical and Applied Genetics* 2021. <https://doi.org/10.1007/s00122-021-03825-y>.

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).

Tiwari et al. Factsheet: Wheat trial and disease -2022. Published and distributed.
Acknowledgement of federal support: Yes

Tiwari et al. Factsheet: Field evaluation and disease data on barley varieties-2021. Published and distributed. Acknowledgement of federal support: Yes

Chhabra, B., Tiwari VK., Rawat, N. (2020) Identification of susceptibility factors in wheat for *Fusarium graminearum* infection for designing resistance in crops. *Amer Phytopathological Soc.* 110 (7) 39-39

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.

1. Tiwari VK: Progress on 'Developing winter barley cultivars for Maryland'. In: Maryland Grain Producer Board Meeting (January 7, 2022).
2. Tiwari VK: Progress on 'Evaluation of yield and agronomic traits of small grains in Maryland'. In Maryland Grain Producer Board Meeting (January 7, 2022).

3. Tiwari VK: Progress on 'Developing soft red winter wheat cultivars for Maryland'. In: Maryland Grain Producer Board Meeting (January 6, 2022).
4. Tiwari VK: Progress on 'Developing winter barley cultivars for Maryland'. In: Maryland Grain Producer Board Meeting (January 6, 2022).
5. Tiwari VK: Progress on 'Field evaluation of winter wheat and barley cultivars for Maryland'. In: Maryland Grain Producer Board Meeting (January 6, 2022).
6. Tiwari VK: Progress on 'Developing winter barley cultivars for Maryland'. In: Maryland Grain Producer Board Meeting (January 2021).
7. Tiwari VK: Progress on 'Developing triticale as a cover crop for Maryland'. In: Maryland Grain Producer Board Meeting (January 2021).
8. Tiwari VK: Progress on 'Evaluation of yield and agronomic traits of small grains in Maryland'. In Maryland Grain Producer Board Meeting (January 2021).
9. Kajla, A., Schoen, A., Mahlandt, A., Rawat, N., Tiwari, V. K. (2022, May 26). Identification and characterization of winter barley 'Nomini' mutants through TILLING [Poster presentation]. MAS-ASPB & UMD Plant Symposium, College Park, MD. [Poster presentation]
10. Hosseinirad, A., Saripalli, G., Schoen, A. W., Paulson, C. W., Chhabra, B., Livesay, J. L., Rawat, N., and V. K. Tiwari. (2022). Towards sustainable breeding for Fusarium Head Blight resistant; combining major genes and QTL in soft red winter wheat, ASA, CSSA, SSSA International Annual Meeting, Baltimore, MD, USA. [Poster presentation]
11. Tiwari, V.K. (2022). Combining germplasm, genetics, and genomics tools to enhance FHB resistance in wheat. Proceedings of the 2022 National Fusarium Head Blight Forum; Tampa, FL. December 4-6, 2022. Retrieved from: <https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf>
12. Tiwari VK: Speeding up gene discovery in wheat by integrating genomes and germplasm. In: Invited talk at the School of Computational and Integrative Sciences, Jawahar Lal Nehru University, New Delhi, India. (August 1, 2022)