

FY22 Performance Progress Report**Due date:** July 26, 2023**Cover Page**

USDA-ARS Agreement ID:	59-0206-2-163
USDA-ARS Agreement Title:	Develop Fusarium Head Blight-Resistant Maryland Wheat & Barley Cultivars
Principle Investigator (PI):	Vijay Tiwari
Institution:	University of Maryland
Institution UEI:	NPU8ULVAAS23
Fiscal Year:	2022
FY22 USDA-ARS Award Amount:	\$88,031
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:	May 1, 2022 – April 30, 2026
Reporting Period End Date:	April 30, 2023

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
GDER	Winter Barley Mutant Resource to Increase FHB Resistance and to Reduce DON Content	\$14,535
VDHR-SWW	A Double Haploid Initiative to Speed Development of FHB Resistant Soft Winter Wheat.	\$18,263
VDHR-SWW	Developing FHB Resistant Soft Red Wheat Cultivars for Maryland	\$40,698
VDHR-SWW	Mutant Population in Adapted SRW Wheat to Reduce FHB Susceptibility and DON Content	\$14,535
FY22 Total ARS Award Amount		\$88,031

I am submitting this report as an: Annual 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: Winter Barley Mutant Resource to Increase FHB Resistance and to Reduce DON Content

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

- 1) Phenotypic Evaluation of M4 plants in head row design under misted scab nursery
- 2) Evaluation of selected mutant families in the greenhouse under point inoculation
- 3) Confirmation of the mutants and sharing the germplasm

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 generated two mutant populations in winter barley cultivars (Nomini and Thoroughbred). Both these cultivars are susceptible to the FHB. During first phase of the project, we enhanced number of seeds from the M2 derived M3 plants. A total of 1100 headrows from M3 derived M4 seeds from Nomini TILLING population were planted in the misted trials at the Beltsville. A total of 800 headrows from the similar generation Thoroughbred mutant population was also planted in the misted FHB nursery at the Beltsville.

b) What were the significant results?

Although, due to very different MD weather conditions, we did not see any significant FHB disease in our trials, still a small number of mutants (8 from Nomini population and 6 from Thoroughbred population) were tentatively identified. To ensure good data, we are now going to validate these results in GH but due to very low disease pressure in our misted nursery, we are going to reevaluate our TILLING populations in GH under spray inoculation.

c) List key outcomes or other achievements.

Work in progress.

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

Three PhD students, one MS student, one postdoc, and three undergraduate students were trained under this project. All the trainees worked with the PI to conduct the nursery and collect and analyze data. These students 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 meetings. 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 wheat trial Factsheets and was disseminated via emails and the UMD extension system to the broader grower community.

Project 2: A Double Haploid Initiative to Speed Development of FHB Resistant Soft Winter Wheat.

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 2022 for creating new DHs for their planting in fall 2023. 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 536 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
We tested a highly selected set of 45 DH lines from previous DH cycles. These lines showed high yield and significant improvement on FHB resistance.

c) List key outcomes or other achievements.

Two DH lines that ranked in top five cultivars in MD trials have advanced to large scale seed production for their potential release.

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

Three PhD students, one MS student, one postdoc, and three undergraduate students were trained under this project. All the trainees worked with the PI to conduct the nursery and collect and analyze data. These students 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 meetings. 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 wheat trial Factsheets and was disseminated via emails and the UMD extension system to the broader grower community.

Project 3: 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 environment with resistance to scab and to increase the adaptation of FHB resistant lines by the wheat growers in Mid-Atlantic region.
- 2) Map and integrate new sources for FHB resistance in to breeding germplasm and to enhance the collaborations with regional breeders.
- 3) Evaluation of advanced MD lines in Uniform Scab nurseries, Maryland State Test and Uniform Regional Nurseries and release of improved MD cultivars.

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

It was the first year of the MD wheat breeding program that contained all set of germplasm in the wheat breeding pipelines. Since all the parental lines were genotyped and well characterized, we made 400 hundred new crosses and ensured at least one prominent FHB resistant QTL was included in all the parental lines in the three-way crosses. New crosses were made to incorporate additional sources of FHB resistance in our breeding germplasm. Germplasm Jamestown, Bess/Truman, Neuse, and lines with major *Fhb1*, 2DL, 5AS have shown high resistance and increased grain yields. MAS, DH, and GS will be used to identify and incorporate resistant germplasm combining FHB with high yield, and resistance other biotic stresses. The resulting F1s from various FHB resistance sources will pyramid scab resistance in 3-way crosses. These crosses will include FHB-R parent, a rust-R parent, and a high-yielding adapted parent (powdery mildew-resistant) which will be used as female in the last cross. To accelerate the development of scab resistant germplasm, we have recently established the speed breeding protocol in our greenhouse that allowed us in advancing 4 generations per year. Following this, marker-assisted selection was used in selected crosses to increase the number of scab resistant progenies by enriching breeding populations with markers. We used three independent approaches to combine FHB resistance with high yielding background to develop SRWW cultivars with improved FHB resistance: 1) Speed Breeding; 2) Double Haploids; 3) Genomic Selection. This year, a set of 50 advanced lines coming out of advanced yield and DH trials were tested in the statewide test along with highly competitive public and commercial cultivars.

a) What were the major activities?

Making FHB resistant germplasm using two-way and three-way crosses
Top 25 crosses were used for the speed breeding pipeline (100 lines per population)
Another top 5 crosses were used for DH generation (80 per population)
Rest of the germplasm was used for GS and marker assisted breeding pipeline.

b) What were the significant results?

Enhanced FHB resistance in the MD germplasm. In our advanced lines that we tested under 2022-2023 trial cycle about 75% of our germplasm contained *Fhb1*, about 65 percent of lines contained a combination of at least two *Fhb* resistance genes including *Fhb1*. Our nine MD lines (with excellent FHB resistance) were in top 25 entries compared against several public and commercial wheat cultivars. Three of our lines ranked 1, 4, and 6th ranks.

c) List key outcomes or other achievements.

Based on three years of yield results and field performance, we are advancing to license two wheat cultivars to two famous seed companies. These prospective cultivars have excellent FHB resistance.

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

Three PhD students, one MS student, one postdoc, and three undergraduate students were trained under this project. All the trainees worked with the PI to conduct the nursery and collect and analyze data. These students 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 meetings. 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 wheat trial Factsheets and was disseminated via emails and the UMD extension system to the broader grower community.

Project 4: Mutant Population in Adapted SRW Wheat to Reduce FHB Susceptibility and DON Content

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

- 1) Development of an advanced generation mutant platform in adapted high-yielding FHB susceptible soft red winter wheat cultivar “Shirley”
- 2) Screening of mutant population to identify mutant lines showing moderate to resistant phenotypes and validate the phenotypes
- 3) Confirm the phenotypic mutants by characterizing them in greenhouse and field tests

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

We have identified 12 Jagger and 8 Shirley mutant lines showing enhanced resistance under initial GH and field evaluations. Samples are being prepared for the DON analysis and in the next phase these mutants will be validated under point FHB inoculation in the greenhouse tests.

a) What were the major activities?

Advancing the generation of the mutant populations using single seed descend to avoid loss of undetected mutants due to segregation and mutant dilution. Field testing of mutant lines in the inoculated misted nursery and tagging the possible mutant plants with in the headrows. Harvesting the individual spike showing positive response.

b) What were the significant results?

We have identified 20 Jagger and 8 Shirley mutant lines showing enhanced resistance under initial GH and field evaluations.

c) List key outcomes or other achievements.

Work in progress.

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

Three PhD students, one MS student, one postdoc, and three undergraduate students were trained under this project. All the trainees worked with the PI to conduct the nursery and collect and analyze data. These students 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 meetings. 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 wheat trial 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 FY22 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 May 1, 2022 – April 30, 2023?

Yes, I've included the citation reference in listing(s) below.

No, I have nothing to report.

Journal publications as a result of FY22 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. Boyles, RE.; Brown-Guedira, Gina.; Costa.; Cowger, C.; DeWitt, N.; Griffey, C.; Harrison, S.A.; Ibrahim, A.; Johnson, J.; Lyerly, J.; Marshall, D.S.; Mason, E.R; Mergoum, M.; Murphy, J.P.; Winn, Z.; Santantonio, N.; Sutton, R.; Sarripalli, G^.; **Tiwari, V.K.**; van Sanford, D. 25 Years of Progress Toward Fusarium Head Blight Resistance In Soft Red Winter Wheat. **Plant Breeding (Accepted)**.
2. Schoen, A[†].; Wallace, S.[†]; Meghan, F. H.; Brown-Guidera, G.; Harrison, S.; Murphy, P.; Sanantonio, N.; Van, S. D.; Boyles, R.; Mergoum, M.; Rawat, N.; and **Tiwari, V.K***. Reducing The Generation Time in Winter Wheat Cultivars Using Speed Breeding. **Crop Science**. <https://doi.org/10.1002/csc2.20989>
3. Chhabra, B.; Schoen, A[†]; Wallace, S.[†]; Thrasu, S[†].; Shahoveshi, F.; Dong, Y.; **Tiwari, V.K***.; Rawat, N*. Evaluation of Speed Breeding Conditions For Accelerating Fusarium Head Blight And Deoxynivalenol Screening In Wheat. **Crop Science (under review)**

Books or other non-periodical, one-time publications as a result of FY22 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).

1. Hosseinrad, S.; Rawat, N.; Fiorellino, N.; Tiwari, V.K*. Managing Fusarium Head Blight (FHB) in small grains: Symptoms, Favorable Environments, and Disease Management Strategies. The University of Maryland Agronomy Extension News (June 2023). <https://extension.umd.edu/resource/managing-fusarium-head-blight-small-grains-symptoms-favorable-environments-and-disease-management>
2. Tiwari et al. Factsheet: Wheat trial and disease -2023. Published and distributed. Acknowledgement of federal support: Yes
3. Tiwari et al. Factsheet: Field evaluation and disease data on barley varieties-2022. Published and distributed. Acknowledgement of federal support: Yes
4. 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 FY22 award

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

1. Tiwari VK: Exploring resistance in winter barley through two independent EMS-induced mutant populations. In: Invited talk at GDER-PBG Virtual conference under Wheat Barley Scab Initiative. (April 27th, 2023)
2. Tiwari VK: Feeding the 10 billion. In: Invited talk at Plant Science and Landscape Architecture Seminar series, University of Maryland, College Park. (April 10th, 2023)
3. Tiwari VK: Plant Breeding Partnership to improve bread wheat. In: Invited talk at Plant and Animal Genome Conference San Diego California USA. (January 14th, 2023)
4. Tiwari VK: Einkorn Genomics for gene discovery and Validation. In: Invited talk at Crop and Soil Science Society of America meeting, Baltimore. (September 6, 2022)
5. Tiwari VK: 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/2022/2022NFHBFForumProceedings.pdf>
6. 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]
7. 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)
8. Tiwari VK: Integrating forward and reverse genetics tools to develop next-generation wheat cultivars. In: Invited talk at the School of Agricultural Biotechnology, Punjab Agricultural University, Ludhiana, India. (August 2, 2022)
9. Tiwari VK: Combining Genetics and Genomic Tools for Translational Research in Wheat. In: Invited talk at the National Agricultural Biotechnology Institute Mohali, India. (August 4, 2022)
10. Tiwari VK: Progress on 'Developing winter barley cultivars for Maryland'. In: Maryland Grain Producer Board Meeting (January 5, 2023).
11. Tiwari VK: Progress on 'Developing triticale as a cover crop for Maryland'. In: Maryland Grain Producer Board Meeting (January 5, 2023).
12. Tiwari VK: Progress on 'Evaluation of yield and agronomic traits of small grains in Maryland'. In Maryland Grain Producer Board Meeting (January 5, 2023).
13. Tiwari VK: Progress on 'Developing soft red winter wheat cultivars for Maryland'. In: Maryland Grain Producer Board Meeting (January 5, 2023).
14. Tiwari VK: Progress on 'Developing winter barley cultivars for Maryland'. In: Maryland Grain Producer Board Meeting (January 7, 2022).
15. Tiwari VK: Progress on 'Evaluation of yield and agronomic traits of small grains in Maryland'. In Maryland Grain Producer Board Meeting (January 7, 2022).
16. Tiwari VK: Progress on 'Developing soft red winter wheat cultivars for Maryland'. In: Maryland Grain Producer Board Meeting (January 6, 2022).
17. Tiwari VK: Progress on 'Developing winter barley cultivars for Maryland'. In: Maryland Grain Producer Board Meeting (January 6, 2022).
18. Tiwari VK: Progress on 'Field evaluation of winter wheat and barley cultivars for Maryland'. In: Maryland Grain Producer Board Meeting (January 6, 2022).