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

FY21 Performance Progress Report

Due date: July 26, 2022

Cover Page

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Fiscal Year:	2021
USDA-ARS Agreement ID:	59-0206-0-184
USDA-ARS Agreement Title:	Developing FHB Resistant Wheat and Barley Cultivars
FY20 USDA-ARS Award Amount:	$56,490
Recipient Organization:	University of Maryland Dept. of Plant Science & Landscape Architecture 4291 Field House Drive, 2102 Plant Sciences Building College Park, MD 20742-4452
DUNS Number:	80-388-2299
EIN:	45-6002439
Recipient Identifying Number or Account Number, if any:	5252532
Project/Grant Period:	5/15/21 - 5/14/23
Reporting Period End Date:	5/14/2022

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 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.

_____ 07/20/2022 _____

Principal Investigator Signature Date Report Submitted

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‡ 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

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1. **What are the major goals and objectives of the research project?**
   FHB is one of the biggest challenges for the wheat growers in the state of Maryland and the broader Mid-Atlantic region. Maryland has wet spring seasons, which is the time of highest susceptibility to Fusarium graminearum infections, leading to high disease incidence in the state. Breeding for resistance against FHB is the most sustainable solution for managing this devastating disease. Development and release of high-yielding FHB resistant varieties are required to keep wheat production profitable for the farmers in the Mid-Atlantic region. The overall goal of this proposal is to develop and release high yielding scab resistant cultivars with excellent quality traits. We will be integrating native resistance, known QTL, and TILLING based knockout mutants of identified susceptibility factors in the elite MD lines and perform marker assisted selection for their deployment for the control of scab.

Specific objectives

1) Breeding soft red winter wheat adapted to the Mid-Atlantic with resistance to scab and to increase the increase the adaptation of FHB resistant lines by the wheat growers in 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 in to breeding germplasm and to enhance collaborations with regional breeders using Mason-Dixon trials, DHs, screening nurseries, and other resources.

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?**
   PI started a new breeding program so initial focus was to develop breeding germplsm that has wide range of FHB resistance genes and alleles. To achieve this goal, PI performed introduction of Fhb1, Fhb7, Fhb1B, Fhb2DL genes / QTL in the MD germplasm and advanced the lines under speed breeding method. A total of 300 crosses made and the resulting F1s were designed to 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. We then used speed breeding on 50 selected best crosses with Fhb1 and Fhb1B and other important combinations to accelerate the development of scab resistant germplasm using our recently established the speed breeding protocol that allowed us in advancing 4 generations per year. In addition, we also used 10 crosses to generate DH lines with specific focus on increasing the frequency of Fhb1 resistant allele in MD breeding germplasm. Combination of speed breeding and DH has allowed us to generate advanced lines that are currently being tested for yield and scab resistance. Two lines MDW-17 and 21-MDW148 showed excellent Fhb resistance and were listed in top 10 lines in MD commercial wheat trials. These two lines are being processed for their respective release.

b) What were the significant results?

Introduction of Fhb1 and other important genes to MD advanced lines. Identification of novel resistant lines arising from the deletion of a chromosomal segment on chromosome 7AS. Also forward genetics screen of the M4 derived M5 mutant population in hard red winter wheat cultivar Jagger identified highly resistant lines. The identified mutants are being used to transfer recessive resistance in soft red winter wheat cultivars.

c) List key outcomes or other achievements.

1. High yielding lines MDW17 and MDW148 with enhanced FHB resistance
2. Speed breeding pipeline for scab testing and germplasm development
3. Novel EMS mutants with enhanced FHB resistance
4. Reestablished MD wheat breeding program

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

Project trained one postdoc, 2 PhD student and 4 undergraduate students. All these students and scientists were involved in genotyping, inoculation in greenhouse and field work and data recording. These wide range of training opportunities helped students to look at the broader picture of the important work they are doing. Students also presented the results to the stakeholders in commodity board meetings.

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

Through peer reviewed publication, invited talks, and presentations at national and international conferences. PI presented their FHB resistance related work at the MD commodity Classic meeting, Maryland Grain Producers and Utilization board, Maryland Crop Improvement Association, field day and several other platforms. Students also presented poster in regional meetings.

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

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1. **What are the major goals and objectives of the research project?**
   In the Southern Soft Wheat Variety Development and Host Resistance Cooperative Project, information provided from extensive and collaborative phenotypic and genotypic characterization of both exotic and native FHB resistance in breeding lines, commercial cultivars, and mapping populations is now being deployed through marker-assisted (MAS) and genomic (GS) selection, resulting in the pyramiding of complementary FHB resistance genes. Despite these collaborative efforts, the long-life cycle (8-12 months) of winter wheat compared to spring wheat (3-4 months) and other crops is still a constraint to breeders. The process of inbred line development can be expedited through the use of Double haploid technology, where inbred lines can be produced in 12-18 months and will reduce the variety development time to 4-5 years.

   Specific Objectives:
   1. Develop 350+ DH lines to combine and pyramid validated FHB QTL and other traits of interest in adapted MD cultivars. For this proposal, each program (AR, VA, LA, GA, SC, TX, NC, and MD) will use one or more of these crosses to develop 350+ double haploid lines per year.
   2. Genotyping of developed DH lines in collaboration with the Eastern Regional Genotyping Center and collaboratively phenotyped through exchange after initial selection for basic adaptation.
   3. Exchange and share the DH lines between programs. Many of these lines contain a pyramid of multiple genes, such as FHB1, 2DL, 3BS and 5AS of Ning 7840 (Sumai 3 derivative), 2B, 3BSc, 4B and 5A of Ernie, Neuse_1A, Neuse_4A, Bess_2B, Bess_3B and JT_1B, combined with other favorable agronomic traits.

   This proposal addresses Research Priorities: 1) Increase and document acreage seeded to varieties with improved FHB resistance; 2) Increase efficiency of coordinated project breeding programs, and 3) Implement new breeding technologies and 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?
   1. More than 350 DH lines with multiple genes / QTLs were generated to stack up multiple genes, such as Fhb1, 2DL, 3BS and 5AS of Ning 7840 (Sumai 3 derivative), 2B, 3BSc, 4B and 5A of Ernie, Neuse_1A, Neuse_4A, Bess_2B, Bess_3B and JT_1B, combined with other favorable agronomic traits in MD breeding germplasm.
   2. Field evaluation of DH lines for FHB resistance and yield
   3. Selection of high-yielding Dh lines and seed increases for state-wide testing
   4. Analyzing the impact of QTLs in uniform backgrounds.

b) What were the significant results?

Identification of 32 DH lines with excellent resistance against FHB and high yielding background. These lines are being tested under state trials.

c) List key outcomes or other achievements.

1. Speeding up the crop improvement process by cutting down generation time and proving homozygosity of the lines
2. Combining FHB resistance with excellent agronomic traits
3. A set of high-performing lines for regional tests for their respective releases.

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

Project trained one postdoc, 2 PhD student and 4 undergraduate students. All these students and scientists were involved in genotyping, inoculation in greenhouse and field work and data recording. These wide range of training opportunities helped students to look at the broader picture of the important work they are doing. Students also presented the results to the stakeholders in commodity board meetings.

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

Through peer reviewed publication, invited talks, and presentations at national and international conferences. PI presented their FHB resistance related work at the MD commodity Classic meeting, Maryland Grain Producers and Utilization board, Maryland Crop Improvement Association, field day and several other platforms. Students also presented poster in regional meetings.

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).

1. Chhabra, B.†, Singh, L.†, Wallace, S.†, Schoen, A., Dong, Y., Tiwari, V.K., Rawat, N.* (2021). Screening of an EMS mutagenized population of a wheat cultivar susceptible to Fusarium head blight identifies resistant variants. Plant Disease DOI: 10.1094/PDIS-03-21-0670-RE; acknowledgment of federal support - yes.
2. Chhabra, B.†, Tiwari V.K., Gill, B.S., Dong, Y., Rawat, N.* (2021). Discovery of a susceptibility factor for Fusarium head blight on chromosome 7A of wheat. Theoretical and Applied Genetics 134(7):2273-2289. DOI: 10.1007/s00122-021-03825-y; acknowledgment of federal support - yes.
3. Wallace, S.; Chhabra, B.; Dong, Y.; Ma, X.; Coleman, G.; Tiwari, V.; Rawat, N. Exploring Fusarium Head Blight Resistance In a Winter Triticale Germplasm Collection. Preprints 2021, 2021040300 (doi: 10.20944/preprints202104.0300.v1); acknowledgment of federal support - yes.

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).

None

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.

1. Development and evaluation of soft red winter wheat cultivars for Maryland. In Maryland Commodity Classic (July 26, 2021).
2. Small grain field day demonstration on Wye Research farm. (May 25, 2021)
3. Progress on 'Developing winter barley cultivars for Maryland'. In: Maryland Grain Producer Board Meeting (January 2021).
4. Progress on 'Evaluation of yield and agronomic traits of small grains in Maryland'. In Maryland Grain Producer Board Meeting (January 2021).