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

FY22 Performance Progress Report

Due date: July 26, 2023

Cover Page

USDA-ARS Agreement ID:	59-0206-2-144
USDA-ARS Agreement Title:	Scab Resistant Wheat Germplasm Adapted to GA and Southeast
Principle Investigator (PI):	Mohamed Mergoum
Institution:	University of Georgia
Institution UEI:	NMJHD63STRC5
Fiscal Year:	2022
FY22 USDA-ARS Award Amount:	$97,527
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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
VDHR-SWW	Development of Scab Resistant Wheat Germplasm Adapted to GA and the Southeast Regions	$79,264
VDHR-SWW	A Double Haploid Initiative to Speed Development of FHB Resistant Soft Winter Wheat.	$18,263
	FY22 Total ARS Award Amount	$97,527

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.

DocuSigned by:
Mohamed Mergoum
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Principal Investigator Signature

06/08/2023
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: Development of Scab Resistant Wheat Germplasm Adapted to GA and the Southeast Regions

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

Fusarium Head Blight (FHB) disease also called scab, is a global threat to wheat in many US wheat growing regions including the Southeast (SE) regions. In the SE and GA in particular, scab epidemics can result in significant loss revenue due to low grain production and unacceptable toxin levels (DON). The problem is being solved by UGA breeding program by developing and releasing adapted soft red winter wheat (SRWW) varieties and germplasm with improved FHB resistance and evaluating them in FHB, GA and regional nurseries for FHB reaction and agronomic performance. Specific objectives of this project are (1) increase acreage planted to wheat varieties exhibiting improved FHB resistance; (2) generate SRWW germplasm with high yield and improved diseases resistances including FHB; (3) improve efficiency of coordinated project breeding programs to develop and release FHB resistant varieties; and (4) Implement new breeding technologies to further enhance short-term and long-term improvement of FHB resistance and to efficiently introgress effective resistance genes into new germplasm. This project is a collaborative effort with SUNGRAINS and many USDA-ARS labs including the Genotyping Center at Raleigh NC (Dr. Gina Brown-Guedira and her team).

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

Objective 1: develop high yielding soft red winter wheat (SRWW) germplasm/cultivars with improved FHB resistance and end-use quality.

a) What were the major activities?

Our objective is to continue introgressing FHB resistance in SRWW varieties adapted to GA and the SE region. About 800 bi-parental, backcrossing and 3-way crosses are made in 2022-23 crop cycle. These crosses involved GA elite breeding lines from different sources of FHB resistance and most adapted grown cultivars in the region. Among these, crosses between elite breeding lines and adapted genotypes with Fhb1 are among our top priority. Segregating breeding populations derived from the above crosses (about 40,000 entries) were evaluated and advanced to select desirable advanced lines with improved over-all agronomic performance and diseases/insect/viruses/bacteria resistances including FHB. More than 1000, 150, and 20 selected lines were included in PYTs, Elite, State and regional yield trials in 2022-23 crop cycle.

The most elite germplasm, particularly on recently released and major commercial cultivars in the Georgia Official Variety Testing trial were evaluated in GA and the SE region. Seed samples of major growing cultivars and elite lines included the state variety trial and regional nurseries were collected and sent to USDA-ARS lab in the University of MN for DON testing.

b) What were the significant results?

About 25 SRWW elite lines with improved FHB resistance were entered in the GA State trial, regional SUGRAINS and Uniform regional trials in 2022-23. All the lines newly entered in the GA and regional OVTs (20-22nd series), have some level of FHB resistance and mny have Fhb1 gene. Among the recently released UGA lines (18 and 19 series), many have improved resistance and low DON level. Another 20 elite lines (23 series) are being tested in the State trials. Among the five 18 and 19 series lines, 6 of them are being released and three of them have *Fhb1* or *Fhb-1BJT* genes providing them good FHB resistance.

We also collected data on the reaction of the major commercial grown cultivars; recently released cultivars; and elite lines. Data will be published in the Georgia Wheat Performance Bulletin and /or GA Small Grain Performance Tests. Similarly, information on the DON levels in grain is disseminated and made available to end-users including flourmills in the state. Additionally, **we have released 2 in 2022 and 4 cultivars in 2021** (Table: Release Germplasm/ cultivars). These cultivars have improved FHB and are contributing to the wheat production in GA and SE region

c) List key outcomes or other achievements.

In 2022, we released TWO cultivars: GA151313-LDH224-19E38 and GA111055-1-19LE12. These have improved FHB resistance compared to susceptible checks. Particularly, GA111055-1-19LE12, it has *Fhb-1BJT* gene. Previously, in 2021, we released four cultivars with various FHB resistance. These are AGS 3026 (GA10127-18E26); AGS 4043 (GA15VDH-18LE43F); AGS 4023 (GA12505B14-18LE23F) and USG 3725 (GA131246-18E35). These were all licensed to private companies and two of them had *Fhb1* gene. Information on FHB reaction and DON levels of these cultivars and major commercial grown cultivars are made available to wheat growers and industry in GA and the SE. This will encourage them to grow those wheat cultivars with improved FHB resistance.

Objective 2: Increase efficiency of coordinated project breeding programs to develop and release FHB resistant varieties for the SE region.

a) What were the major activities?

The collaborative effort among the VDHR (SWW), the SUNGRAINS Universities and Virginia Tech has been very successful for all programs. It allows a smooth movement and exchange of germplasm including FHB resistant elite and adapted germplasm. This collaboration also included many of the USDA-ARS labs, in particular, the Genotyping Center, Raleigh, NC which assists with GS and MAS of elite germplasm. We also included in our crosses sources of FHB resistance from Northern germplasm with an Rht-b1 background to transfer it into Rht-D1 background for better adaptation to the Southeast germplasm pool.

b) What were the significant results?

We successfully conducted and evaluated the cooperative nurseries including the Southern Uniform Scab, the Uniform Eastern and bread Wheat, the SUGRAINS nurseries GAWN, SUNPre and SUNWHEAT. We also exchanged FHB resistant germplasm, crosses, and double haploid lines and we conducted joint evaluation over many locations in the SE of this germplasm.

c) List key outcomes or other achievements.

Many elite and DH lines were selected with pyramiding QTL of FHB resistance derived from different sources including advanced and elite lines with Jamestown (Fhb-1BJT), Hilliard, MD03W61-09-7 (Fhb1), MD08-26-H2-7 (Fhb1 5AS 2DL), MD08-29-E9-26 (Fhb1 5AS 2DL), recently released UGA cultivars (GA19E38, GA19LE12, AGS3026, 3043, USG 3725, …) as FHB resistance parent donors. In addition, many new lines from the 20 series such GA161240-20LE6F that has Fhb1 gene; 21st series including GA17634DH-08-21E36, GA15036 ID-13-21E22, GA141045-9-3-2-21LE7 and GA12213-10-7-21LE24 which have Fhb1 or other QT, are added to this list. These are evaluated for their performance and FHB reaction 2023-23 crop cycle.

Objective 3: Implement modern breeding technologies to enhance the efficiency to introgress FHB resistance into elite germplasm.

a) What were the major activities?

Combining FHB resistant QTLs from different sources of resistance coupled with good field and consistent screening test is facilitating well the development of cultivars that are adapted and have improved and effective FHB resistance due to pyramiding of several FHB genes. Genomic selection (GS), Marker Assisted Selection (MAS) and Marker Assisted Backcrossing (MABC) methods were used to select/advance elite lines and introgress many known FHB QTL (Fhb1 (many sources), 2DL, 5AS (Ning 7840), and 3BL (Massey), 1B (Jamestown), 1A, 4A (Neuse), and 2B, and 3B (Bess)) into GA SRWW germplasm background. Derived elite lines with Fhb1 and other QTLs are evaluated among elite lines and segregating populations. Widely adapted and recently released cultivars (AGS3030, AGS3026, AGS3043…), are used as adapted recurrent parents to develop homozygous lines with combinations of Fhb1, 2DL, 5AS, and other QTL with improved FHB resistance. We are cooperating with the USDA Genotyping Centers, (Dr. Gina Brown –Guedira) to evaluate populations with Fhb1 and other fhb QTLs pyramided with leaf and stripe rust, and hessian fly genes.

b) What were the significant results?

20 elite lines selected from 22 E/LE series identified as a good yielding lines with many QTL including *Fhb1*. These were subjected to GS/MAS to validate the existence of genes for traits that were selected for and are being increased for release or potential release. These lines are also tested in GA OVT, SUNGRAINS and next year, they will be included on the Uniform outh Wheat (USW) regional trials or SUNGRAINS regional trial GAWN. Similarly, many DH promising lines with various levels of FHB resistance and having multiple FHB QTL, including Fhb1 are being tested.

c) List key outcomes or other achievements.

Among the two 19 series that were released in 2022 (GA19E38, GA19LE12) the GA 19LE 12 has the Fhb-1BJT. Similarly, two among four of the 18 series released in 2021 (GA12505-18LE23Fand GA15VDH-FHB-MAS23-18LE43F) have good yield with the QTL *Fhb1*. The later are the FIRST SRWW cultivars that were released with *Fhb1* gene. In addition, many other DH lines (including, GA15VDH-FHB-MAS23-18LE43F that was released in 2021) and many of the 21 and 22 series lines were identified with Fhb1 QTL and good performance.

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

Two graduates and several undergraduate students were trained in evaluating/screening germplasm included in the scab nurseries. They were also involved in preparing samples for DON testing and FAB nursery preparation. Similarly, a lab/field tour was given to graduate students and teachers involved in the PBGG 6000 practicum course in 2022 and 2023 highlighting the importance of scab, research being conducted, and achievements made.

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

A poster was presented at the 2022 Annual Forum of the Wheat and Barley Scab Initiative (see publications section). Similarly, a lab/field tour was given to graduate students and teachers involved in the PBGG 6000 practicum course in 2022 highlighting the importance of scab, research being conducted, and achievements made. Scores of visitors have been updated on current FHB research and achievements made because of USWBSI funding. Reaction of major grown cultivars are also published in Georgia Wheat Performance Bulletin and /or GA 2021-2022/2022-2023 Small Grain Performance Tests.

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

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

The goal of using double haploid (DH) technique is increase the efficiency of coordinated project breeding programs in developing and releasing FHB-resistant varieties. The DH technique shortens the variety development time in fall-sown small grains by approximately 3-4 years. We are expanding the use of this technique for the whole Southern Winter Wheat region by the coordinated development of at least five breeding populations through DH production followed by collaborative phenotyping across the region once the DH lines are developed and seed is increased for testing. The DH facility at Kansas State University (Heartland/Plant Innovations Facility) is used to produce the DH lines from several crosses.

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 DH technique allows us to generate rapidly homozygous lines with many QTL of FHB resistance from various sources without going through many generations of segregation. In 2022-23, we evaluated 45 DH lines in the yield trials (13 in PYTs, 10 in EYT, and 12 in GA OVT) and 222 DH lines were evaluated in head-rows. Selected DH lines (10 and 75 lines) were advanced to State and elite trials in 2020-21. The DH with FHB resistance sources originated from different breeding programs in the region. Among these, sources with Fhb1 and QTL from our UGA and regional programs (Jamestown, Hilliard, MD03W61-09-7 (Fhb1), MD08-26-H2-7 (Fhb1 5AS 2DL), MD08-29-E9-26 (Fhb1 5AS 2DL), AGS 3030 (GA JT141-14E45), AGS 3015(GA 09129-16E55), GA15VDH-FHB-MAS23-18LE43F, and GA12505B14-18LE23F, GA151313-DH224-19E38 …). Additionally, several UGA elite DH with FHB resistance are being used in crosses to generate new generation of DH with scab resistance from various sources and from elite lines in the GA and regional trials.

b) What were the significant results?

Many UGA elite DH and the coordinated program with FHB resistance are tested in Elite, GA State or regional trials. This includes the 2021 released cultivar AGS4043 (GA15VDH-FHB-MAS23-18LE43F) and several lines from the 19-22 series. Another DH UGA line GA151313-DH224-19E38 was released in 2022. Among other lines with high yield, many DH lines with a wide array of pyramided scab QTL (Fhb1, 2DL, 5AS, 1B, 1A, 4A and 3B) were found also to have good resistances to other foliar disease and Hessian fly. These include UGA DH GA151313-LDH-192 -20E48 and GA161240LDH-113 -20LE6F, Two DH from 21 series and 6one elite lines from the 22 series that are being increased as potential release in 2023, 2024 and 2025, respectively.

c) List key outcomes or other achievements.

GA131246DH-18E35 and GA15VDH-FHB-MAS23-18LE43F were released as DH in 2021. These two lines were licensed to private companies under the name of USG3725 and AGS 4043. Among the six 19 series that are increased for potential release, GA 151313-DH224-19E38, a DH line was released in 2022. Currently, several DH lines from the 20, 21 and 22 series are being tested and increased for potential release.

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

Two graduate students and several undergraduate students were trained in protocol for screening and evaluating germplasm for scab resistance. Similarly, a lab/field tour was given to graduate students and teachers involved in the PBGG 6000 practicum course in 2022 and 2023 highlighting the importance of scab, research being conducted, and achievements made.

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

Four articles related to FHB were published in JPR (cultivar release) and others in Plant Health Progress, TAG and The Plant Genome. A poster was presented at the 2022 Annual Forum of the Wheat and Barley Scab Initiative (see publications section). Similarly, a lab/field tour was given to graduate students and teachers involved in the PBGG 6000 practicum course in 2022 and 2023 highlighting the importance of scab, research being conducted, and achievements made. Scores of visitors have been updated on current FHB research and achievements made because of USWBSI funding. Reaction of major grown cultivars are also published in Georgia Wheat Performance Bulletin and /or GA 2021-2022/2022-2023 Small Grain Performance Tests.

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?

[X] 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. Zachary J Winn; Jeanette Lyerly; Gina Brown-Guedira; Richard E. Boyles; **Mohamed Mergoum**; Jerry Johnson; Stephen Harrison; Ali Babar; Richard E. Mason; Russell Sutton; J. Paul Murphy. **2022**. Prediction of Fusarium Head Blight Resistance QTL Haplotypes Through Molecular Markers, Genotyping-by-Sequencing, and Machine Learning. **Theoretical and Applied Genetics**. **https://doi.org/10.1007/s00122-022-04178-w.**
2. Bikash Ghimire, **Mohamed Mergoum**, Alfredo D. Martinez-Espinoza, Suraj Sapkota, Sumit Pradhan, Md Ali Babar, Guihua Bai, Yanhong Dong, and James W. Buck. **2022**. Genetics of Fusarium Head Blight Resistance in Soft Red Winter Wheat Using a Genome-Wide Association Study. **The Plant Genome. http://doi.org/10.1002/tpg2.20222.**
3. **Mergoum Mohamed**, Jerry W. Johnson, James W. Buck, Steve Sutton, Benjamin Lopez, Daniel Bland, Z. Chen, G.D. Buntin, Daniel J. Mailhot, Md A. Babar, Richard E. Mason, Stephen A. Harrison, J. Paul Murphy, Amir M. H. Ibrahim, Russell L. Sutton, Bryan E. Simoneaux, Carl A. Griffey, Harold E. Bockelman, Byung-Kee Baik, David Marshall, Christina Cowger, Gina L. Brown-Guedira, James A. Kolmer, Yue Jin, X. Chen, Richard Boyles, Sue E. Cambron. **2022**. A New Soft Red Winter Wheat Cultivar 'GA 08535-15LE29' Adapted to Georgia and the USA. **Journal of plant Registration**. **http://doi.org/10.1002/plr2.20235.**
4. Ghimire, B., J. W. Buck, **M. Mergoum**, A. D. Martinez-Espinoza. **2022**. Fusarium Head Blight Epidemics in Soft Red Winter Wheat Fields in Georgia from 2018 to 2019. **Plant Health Progress. https://doi.org/10.1094/PHP-08-21-0111-RS**.

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).

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. Ghimire, B., Bahri, B., Martinez-Espinoza, A. D., Mergoum, M., Glenn, A. E., Bowen, L. L., and Buck, J. W. **2022.** Genetic diversity, mycotoxin profiling, and population structure of Fusarium spp. Recovered from wheat and corn fields in Georgia. Abstract. In Plant Health 2022. August 6-10, 2022. Pittsburg, PA, USA.