

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:	59-0206-0-147
USDA-ARS Agreement Title:	Development of Scab Resistant Soft Red Winter Wheat Germplasm Adapted to the US Southeast
Principle Investigator (PI):	Mohamed Mergoum
Institution:	University of Georgia
Institution UEI:	NMJHD63STRC5
Fiscal Year:	2021
FY21 USDA-ARS Award Amount:	\$96,752
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Period of Performance:	6/21/21 - 6/20/23
Reporting Period End Date:	6/20/2023

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
VDHR-SWW	Developing Scab (FHB) Resistant Wheat Germplasm Adapted to GA and the Southeast	\$82,364
VDHR-SWW	Double Haploids to Expedite Development of FHB Resistant Soft Winter Wheat Varieties	\$14,388
FY21 Total ARS Award Amount		\$96,752

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.

DocuSigned by:

Mohamed Mergoum

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Principal Investigator Signature

5/26/23

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 Scab (FHB) Resistant Wheat Germplasm Adapted to GA and the Southeast

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

Scab, also called Fusarium Head Blight (FHB) disease is a major threat to wheat in many US wheat growing regions including the Southeast (SE) regions. In GA and SE, scab epidemics can result in significant loss revenue due to low grain production and unacceptable toxin levels (DON). The problem is being addressed 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 nurseries and regional nurseries for agronomic performance and FHB reactions. The 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: Increase acreage planted to wheat varieties exhibiting improved FHB resistance.

a) What were the major activities?

The evaluation of our HRSW germplasm to FHB is conducted, particularly on recently released and major commercial cultivars in the Georgia Official Variety Testing trial. Similarly, seed samples of major growing cultivars and elite lines included the state variety trial and regional nurseries are collected and sent to USDA-ARS lab in the University of MN for DON testing.

b) What were the significant results?

Data on the reaction of the major commercial grown cultivars; recently released cultivars; and elite lines are published in the Georgia Wheat Performance Bulletin and GA Small Grain Performance Tests. Similarly, information on the DON levels in grain were disseminated and made available to end-users including flourmills in the state. Additionally, **we have released 2 cultivars in 2022, 3 cultivars in 2021.** These cultivars have improved FHB and are being contributing to this objective.

c) List key outcomes or other achievements.

Information on FHB reaction and DON levels of major commercial grown cultivars and recently released or potential releases cultivars are made available to wheat growers in GA and the SE will encourage them to grow those wheat cultivars with improved FHB resistance.

In 2022 we released two cultivars (GA151313-LDH224-19E38 and GA111055-1-19LE12) and four cultivars in 2021(AGS 3026 (GA10127-18E26); AGS 4043 (GA15VDH-18LE43F); AGS 4023 (GA12505B14-18LE23F) and USG 3725 (GA131246-18E35)). This in addition to the three and four cultivars released and licensed to companies in 2020 and 2019, respectively. This has enhance the wheat acreages grown to FHB resistant cultivars in the region.

Objective 2: Generate SRWW germplasm with high yield and improved diseases resistances including FHB.

a) What were the major activities?

With the aim 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 2020. 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 priorities. Segregating breeding populations derived from the above crosses 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 2020-21 crop cycle.

b) What were the significant results?

More than 25 elite lines with improved FHB resistance were entered in the GA State trial, regional SUGRAINS and Uniform regional trials. All the lines newly entered in the 2020 and 2021 GA and regional OVTs (18-19-20 series), have FHB resistance and some of them have *Fhb1* gene. Among the recently released UGA lines (16 and 17 series), many have improved resistance and low DON level. Another 20 elite lines (18, 19 and 20 series) that are being tested in the State trials. Among the five 18 series lines, 4 of them are being released and two of them have *Fhb1* gene providing them with good FHB resistance.

c) List key outcomes or other achievements.

In 2022 we released two cultivars (GA151313-LDH224-19E38 and GA111055-1-19LE12) and four cultivars in 2021(AGS 3026 (GA10127-18E26); AGS 4043 (GA15VDH-18LE43F); AGS 4023 (GA12505B14-18LE23F) and USG 3725 (GA131246-18E35)). This in addition to the three and four cultivars released and licensed to companies in 2020 and 2019, respectively. All of them have improved FHB resistance compared to susceptible checks.

Objective 3: Improve efficiency of coordinated project breeding programs to develop and release FHB resistant varieties.

a) What were the major activities?

The collaborative effort between SUNGRAINS Universities and Virginia Tech has been very successful for all programs. It allows a smooth movement and exchange of elite and adapted germplasm with FHB resistance among collaborative programs. This collaboration also included many of the USDA-ARS labs. This includes, the Genotyping Center, Raleigh, NC with assistance in 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?

A well and successful cooperative evaluation of nurseries including the Southern Uniform Scab, the Uniform Eastern and bread Wheat, GAWN, and SUNWHEAT nurseries; and the exchange of resistance germplasm, crosses, and double haploid lines and joint evaluation over locations of these germplasm sources is well established.

c) List key outcomes or other achievements.

Many elite and DH lines were selected with pyramiding QTL of FHB resistance from different sources including advanced and elite lines with 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), and AGS 3015 (GA 09129-16E55) as FHB resistance parent donors. In addition, many new elite lines from our program including recently released cultivars with FHB resistance (GA111055-1-19LE12, AGS 3026 (GA10127-18E26); AGS 4043 (GA15VDH-18LE43F); AGS 4023 (GA12505B14-18LE23F) and USG 3725 (GA131246-18E35) etc.) were added to this list. These were evaluated for their agronomic performance and FHB reaction in 2021 to 2023.

Objective 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.

a) What were the major activities?

Pyramiding and combining FHB resistant QTLs 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. Genomic, Marker Assisted Selection (MAS) and Backcrossing (MABC) methods to select/advance elite lines and introgress of many known FHB QTL (Fhb1, 2DL, 5AS (Ning 7840), and 3BL (Massey), 1B (Jamestown), 1A, 4A (Neuse), and 2B, and 3B (Bess)) into SRWW background are performed. Derived elite lines with Fhb1 and other QTLs are evaluated among elite lines and backcross populations. Widely adapted and recently released cultivars, are used as 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?

Many lines from 21E/LE series identified as good yielding lines with the QTL Fhb1, were subjected to GS/MAS are being increased for release or potential release. These lines are also tested in GA OVT, SUNGRAINS and Uniform regional trials. 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.

Two of the four released in 2021 (GA12505B14-18LE23F and GA15VDH-FHB-MAS23-18LE43F) have good yield with the QTL *Fhb1*. These are the FIRST SRWW cultivars that will be released

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with *Fhb1* gene. In addition, many other DH lines (including, GA15VDH-FHB-MAS23-18LE43F that is being released) and many 19 series lines were identified with *Fhb1* QTL and good performance. Among the two 19 series that were released in 2022 (GA19E38, GA19LE12) the GA 19LE 12 has the *Fhb-1BJT*.

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

Three graduates and several undergraduate students were trained in screening and evaluating germplasm for scab resistance. 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 2021 and 2022 highlighting the importance of scab, research being conducted, and achievements made.

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

Four publications re. the release of 4 cultivars were published in the JPR. Three posters were presented: One at the 2022 Plant Health conference; One in the 2021 Annual Forum of the Wheat and Barley Scab Initiative (see publications section) and the third in the 2021 International ASA-CSSA-SSSA annual meetings. Similarly, a lab/field tour was given to graduate students and teachers involved in the PBGG 6000 practicum course in 2020 and 2021 highlighting the importance of scab, research being conducted, and achievements made.

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?

The double haploid (DH) main goal is increasing the efficiency of coordinated project breeding programs in developing and releasing FHB-resistant varieties using DH techniques. This shortens the variety development time in fall-sown small grains by approximately four 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. From about 200 DH lines evaluated in yield trials and 300 DH lines were evaluated in head-rows, about 15 and 150 lines were advanced to State and elite trials in 2021-22. About the same number of DH were tested in 2022-23 yield trials. These include sources 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). In addition, several UGA elite DH with FHB resistance are being in crosses to generate new generation of DH with scab resistance sources mentioned above and elite lines in the GA and regional trials.

b) What were the significant results?

Several UGA elite DH with FHB resistance are tested in Elite, GA State or regional trials. This includes GA15VDH-FHB-MAS23-18LE43F and several 19 series lines. 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 GA131246LDH-18E35 and GA14436LDH-18LE26, and 6 elite lines from the 19 series that are being increased as potential release in 2022

c) List key outcomes or other achievements.

Among the four UGA released cultivars in 2021, two (GA131246LDH-18E35 and GA15VDH-FHB-MAS23-18LE43F) had Fhb1 gene. Similarly, two among the six 19 series that are increased for potential release, two were DH (GA 151313-LDH224-19E38 and GA 151254-LDH071-19E32) and two were released (GA 151313-LDH224-19E38; GA 111055-19LE12) including one DH and one had Fhb-1BJT gene.

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

Many graduate students and several undergraduate students are trained in protocol for screening and evaluating germplasm for scab resistance. In addition, a lab/field tour was given to graduate students and teachers involved in the PBGG 6000 practicum course in 2021 and 2022 highlighting the importance of scab, research being conducted, and achievements made.

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

Four publications re. the release of 4 cultivars were published in the JPR. Three posters were presented: One at the 2022 Plant Health conference; One in the 2021 Annual Forum of the Wheat and Barley Scab Initiative (see publications section) and the third in the 2021 International ASA-CSSA-SSSA annual meetings. Similarly, a lab/field tour was given to graduate students and teachers involved in the PBGG 6000 practicum course in 2021 and 2022 highlighting the importance of scab, research being conducted, and achievements made.

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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. **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, Harold E. Bockelman, Byung-Kee Baik, David Marshall, Christina Cowger, Gina L. Brown-Guedira, James A. Kolmer, Yue Jin, X. Chen, Sue E. Cambron. **2021**. 'GA JT141-14E45': A New Soft Red Winter Wheat Cultivar Adapted to Georgia and the South East US Environments. **Journal of Plant Registrations**.
<https://doi.org/10.1002/plr2.20070>
2. **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, Harold E. Bockelman, Byung-Kee Baik, David Marshall, Christina Cowger, Gina L. Brown-Guedira, James A. Kolmer, Yue Jin, X. Chen, Sue E. Cambron. **2021**. A New Soft Red Winter Wheat Cultivar, 'GA 07353-14E19', Adapted to Georgia and the US South East Environments. **Journal of Plant Registrations**.
<http://doi.org/10.1002/plr2.20113>.
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, Harold E. Bockelman, Byung-Kee Baik, David Marshall, Christina Cowger, Gina L. Brown-Guedira, James A. Kolmer, Yue Jin, Richard Boyles, X. Chen, Sue E. Cambron. **2021**. 'GA 051207-14E53' Soft Red Winter Wheat, an Adapted Cultivar to Georgia and the South East US Region. **Journal of Plant Registrations**. **Published online:** <https://doi.org/10.1002/plr2.20102>
4. Amir M.H. Ibrahim, Russell Sutton, Jerry W. Johnson, **Mohamed Mergoum**, Bryan Simoneaux, Stephen A. Harrison, J. Paul Murphy, R. Esten Mason, Md A. Babar, Clark Neely, Geraldine Opeña, Yue Jin, Jim Kolmer, Richard Boyles, Sue E. Cambron, Byung-Kee Baik, Gina L. Brown-Guedira, David Marshall, and Myron O. Fountain. **2021**. Registration of 'GA06343-13E2 (TX-EL2)' Soft Red Winter Wheat. **Journal of Plant Registrations**. **Published online:**
<https://access.onlinelibrary.wiley.com/doi/full/10.1002/plr2.20031>

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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).

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. 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.
2. Bikash Ghimire, **Mohamed Mergoum**, Alfredo D. Martinez-Espinoza, Md Ali Babar, and James W. Buck. **2021**. Genome-Wide Association Studies for *Fusarium* Head Blight Resistance in Soft Red Winter Wheat. In ASA-CSSA-SSSA International Annual Meeting Abstracts 2021 [CD-ROM], November 7-10, 2021, Salt Lake City, Utah, USA.
3. Bikash Ghimire, **Mohamed Mergoum**, Anthony E. Glenn, Kira L. Bowen, Alfredo D. Martinez-Espinoza, and James W. Buck. (**2021**). Population Diversity of *Fusarium* Species Causing *Fusarium* Head Blight in Wheat and Greenhouse Pathogenicity Tests of *F. poae* Isolated from Georgia. *Proceedings of the 2021 National Fusarium Head Blight Forum*; Virtual. December 6-7, 2021. Retrieved from: <https://scabusa.org/forum/2021/2021NFHBForumProceedings.pdf>