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

FY21 FINAL Performance Progress Report

Due date: December 15, 2023

Cover Page

USDA-ARS Agreement ID:	59-0206-0-172
USDA-ARS Agreement Title:	Developing FHB-resistant Winter Wheat for Texas and the Southern U.S.
Principle Investigator (PI):	Amir Ibrahim
Institution:	Texas A&M Agrilife Research
Institution UEI:	KU3DCFJJTVN3
Fiscal Year:	2021
FY21 USDA-ARS Award Amount:	$92,675
PI Mailing Address:	Texas A&M Agrilife Research, Soil & Crop Sciences Dept. 2474 TAMU, College Station, TX 77845
PI E-mail:	aibrahim@tamu.edu
PI Phone:	979-845-8274
Period of Performance:	5/15/22 – 9/30/23
Reporting Period End Date:	9/30/2023

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
HWW-CP	Developing FHB-resistant Hard Red Winter Wheat for Texas and the S. Great Plains	$38,957
VDHR-SWW	Developing FHB-resistant Soft Red Winter Wheat for Texas and the Gulf-Atlantic Region	$37,306
VDHR-SWW	Double Haploids to Expedite Development of FHB Resistant Soft Winter Wheat Varieties	$16,412
	FY21 Total ARS Award Amount	$92,675

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.

12/13/2023

Principal Investigator Signature — Date Report Submitted

ǂ 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 Hard Red Winter Wheat for Texas and the S. Great Plains

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1. **What are the major goals and objectives of the research project?**
   The overarching goal of this proposal is to use traditional breeding techniques and markerassisted selection (MAS) to develop FHB-resistant HRW cultivars adapted to Texas and the Southern Great Plains. Our specific objectives are to 1) develop, screen, and release HRW that combine superior yield and end-use quality with tagged or native FHB resistance, 2) use MAS to complement traditional breeding methods and improve gain from selection, and 3) enter promising FHB-resistant lines into regional nurseries to facilitate development of resistant cultivars. New FHB-resistant HRW cultivars with high yield, tolerance to other stresses, and superior quality will provide effective means of resistance not only in Texas but also in other areas of the central and southern Great Plains where TAM wheat is adapted and where FHB levels require adequate host plant resistance.

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?**
   A mist-irrigated FHB evaluation nursery was successfully planted November 16, 2022, at the main campus for evaluating incidence and disease severity. We evaluated the Southern Regional Germplasm Nursery (SRPN), Northern Regional Germplasm Nursery (NRPN), the Southern Scab Nursery in addition to Texas advanced yield trials in addition to our advanced trials and selected F2, F3, and F4 populations with known FHB resistance. Another nursery was planted near Dumas, TX for hard red winter wheat. Wheat plots and head-rows were planted into heavy corn residue and irrigated with an overhead sprinkler system. The trial was surrounded with triticale as a wind-block to increase humidity. The current year planting took place on November 28, 2023 and has fully emerged.

   b) **What were the significant results?**
   During our third year of testing in the scab misted nursery at College Station, we had uniform symptoms. The FHB index ranged from 2.0 to 6.5, based on a scale of 0 - 9 in the Southern Scab Nursery and the FDK ranged from 19.0% - 47.0% in the same nursery. The FHB index and FDK were not correlated this year ($r = -0.40$, $P = 0.2$). Heading date was highly negatively correlated with the FHB index, indicating that the earlier lines typically expressed higher symptoms. However, heading date was not correlated with FDK ($r= 0.5$, $P = 0.10$).. The FHB disease ratings in the nursery near Dumas ranged from 2.5% to 72% with an average of 29%. The data was consistent across replications and was used for advancement decisions. Some breeding lines were discarded because of significant susceptibility two years in a row while others were marked to advance because of low FHB scores last year and this year.

   c) **List key outcomes or other achievements.**
   Our third-year nursery showed that we can produce and apply inoculum appropriately, mist irrigate, establish symptoms, and take good readings of wheat head scab. The correlation between FHB index and heading was -0.90 ($P < 0.01$), which indicates that

the later lines had lower FHB symptoms. This association is still high despite the grouping of entries we followed during symptom evaluation. We applied the corn spawn early right at the beginning of stem elongation. FHB pressure was higher compared to the 2021-2022 growing season, when we had dryer than normal weather conditions across the region. This is also confirmed by higher FDK ratings compared to year 2. The scab nursery at Dumas, TX had significant FHB symptoms and the known resistant and susceptible lines were consistent with data from previous nurseries. Several lines with good resistance were forwarded from Advanced trials in 2022 to Elite trials in 2023 and some of the 2023 elite entries will become variety candidates. The trials were rated for diseases index in the field. The grain will be evaluated for FDK, and 100 selected samples will be sent to NDSU for DON testing.

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

Two technicians and several undergraduate students were trained in symptom rating, including disease incidence, severity, and FDK, as part of this project.

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

The data of regional nurseries has been shared with colleagues in the HRW region. Results will be communicated in producers' meeting and field days. Any future significant outcomes of this project will also be highlighted in popular press articles. Furthermore, results will be communicated to scientific peers via peer-reviewed scientific journals upon the release of current candidates screened during 2021 and 2022

Project 2: Developing FHB-resistant Soft Red Winter Wheat for Texas and the Gulf-Atlantic Region

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1. **What are the major goals and objectives of the research project?**
   The overarching goal of this proposal is to use traditional breeding techniques, a mistednursery, and MAS to develop FHB resistant SRWW cultivars and to share germplasm with other Southern U.S. programs. Our specific objectives are to 1) develop, screen, and release SRWW that combine superior yield and end-use quality with tagged or native FHB resistance, 2) use MAS to complement traditional breeding methods and improve gain from selection, and 3) enter promising FHB-resistant lines into Southeastern University Grains (SunGrains) scab nurseries to facilitate development of resistant cultivars. New FHBresistant SRWW cultivars with high yield potential, tolerance to other biotic and abiotic stresses, and superior end-use quality will provide effective means of resistance not only in Texas but also in other areas in the Southern U.S. where TAM wheat is adapted and where FHB levels require adequate host plant resistance.

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

   a) **What were the major activities?**
   A mist-irrigated FHB evaluation nursery was established at the main campus for evaluating incidence and disease severity. We have specifically evaluated the Texas Soft Uniform Variety Trial (SUVT), Uniform Southern SRWW Nursery (USSRWWN), and the Southern Uniform Winter Wheat Scab Nursery (SUWWSN) in 2022– 2023, and we will continue to do the same during the 2023–2024, and 2024 – 2025 wheat growing seasons. We will harvest seed for FDK evaluation, and we will send the seed to Minnesota for DON evaluation. The current year planting took place on November 28, 2023 and has fully emerged.

   b) **What were the significant results?**
   During the third year of testing in the scab misted nursery, we had excellent uniform symptoms. The FHB index ranged from 1.0 to 6.5, based on a scale of 0 - 9 in the Southern Scab Nursery and the FDK ranged from 10% - 48% in the same nursery. The FHB index and FDK were not correlated ($r = 0.-0.2$, $P = 0.10$). Earlier lines had more DON content. The best performers were lines possessing the Fhb1 gene.

   c) **List key outcomes or other achievements.**
   Our third-year nursery showed that we can produce and apply inoculum appropriately, mist-irrigate, establish symptoms, and take good readings of wheat head scab. The correlation between FHB index and heading was - 0.80 ($P < 0.001$), which indicates that the later lines had lower FHB symptoms despite grouping of entries by heading for symptom evaluation. We applied the corn spawn right at the beginning of stem elongation in 2023. FHB pressure was higher in the third year compared to the 2021-2022 growing season when we had dryer than normal weather conditions across the region. This is confirmed by higher FDK ratings compared to year 2. There is an increase in the Fhb1 frequency in our germplasm; thanks to the USWBSI efforts. We expect to release this type of resistance in about two years.

2. **What opportunities for training and professional development has the project provided?**
   Two technicians and several undergraduate students were trained in symptom rating, including, disease incidence, severity, and FDK, as part of this project.

3. **How have the results been disseminated to communities of interest?**
   The data of regional nurseries has been shared widely with colleagues in the SunGrains. Results will be communicated in producers' meeting and field days. Any future significant outcomes of this project will also be highlighted in popular press articles. Furthermore, results will be communicated to scientific peers via peer-reviewed scientific journals upon the release of current candidates screened during 2021

Project 3: 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?**
   Each year the southern VDHR breeding programs make multiple single- and three-way crosses to pyramid validated FHB QTL and other traits of interest. The goal of this project is to collectively develop and share DHs that lead to release of FHB resistant varieties more quickly than possible using traditional breeding protocol. The objective of this project is to increase the rate of genetic gain by decreasing the cycle time using double haploids. This will be accomplished by creating DHs from crosses that combine multiple effective FHB QTL in high yielding adapted backgrounds and sharing selection from those among all collaborators. Each of the VDHR breeding programs will use one or more crosses to develop 350+ double haploid lines per year. These lines will be genotyped in collaboration with the Eastern Regional Genotyping Center and collaboratively phenotyped through exchange after initial selection for basic adaptation.

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

   d) What were the major activities?
   Double Haploids were created from five crosses in 2022 that have *Fhb1* and other sources of resistance parents on one or both sides of the pedigree, include four recently released and highly productive Fhb-resistant varieties, and combine multiple other Fhb QTL with QTL for resistance to Hessian Fly, soil borne mosaic virus, stripe rust, leaf rust, and other genes important to the success of varieties in the southeastern U.S. These DHs will be planted as head-rows in Greenville, Texas.

   Selected DHs from each VDHR-SWW institution will be shared with all other cooperators for selection and variety development to obtain maximum benefit from the expenditure of resources.

   e) What were the significant results?
   Use of DHs sped the breeding pipeline and led to an increase in the *Fhb1* frequency in our germplasm. We expect to release this type of resistance in about two years. As for FY22, all of the DH lines were received too late to plant in 2022, so they will be planted in the fall of 2023.

   f) List key outcomes or other achievements.
   Use of DHs has increased our program efficiency and decreased the length of the breeding pipeline. As the DHs are pure and homozygous, we can screen for several KASP-based SNP markers, including *Fhb1*. That led to an increase in these FHB-resistance genes in our program. We share selected DH lines with colleagues in the SunGrains programs in the VDHR-SWW. This initiative is expected to increase impact and leverage the USWBSI funding and result in the release of additional FHB resistant varieties that also possess good yield potential, end-use quality, and tolerance to other biotic and abiotic stresses.

3. **What opportunities for training and professional development has the project provided?**
   Three technicians and several graduate and undergraduate students were trained in symptom rating, including, disease incidence, severity, and FDK, as part of this project.

4. **How have the results been disseminated to communities of interest?**
   Results have been communicated in producers' meetings and field days. Any future significant outcomes of this project will also be highlighted in popular press articles. Furthermore, results will be communicated to scientific peers via peer-reviewed scientific journals upon the release of current candidates screened during 2022.

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 5/15/22 – 9/30/23?

☐ 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).

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.

In addition to the required inclusion in this report, to increase the visibility of your work we encourage you to also submit your publications in the new USWBSI ScabSource Publication Database, an open-access resource for all FHB researchers to reference.