

## FY21 Performance Progress Report

**Due date:** July 26, 2022

### Cover Page

<b>Principle Investigator (PI):</b>	Guihua Bai
<b>Institution:</b>	USDA-ARS
<b>E-mail:</b>	guihua.bai@usda.gov
<b>Phone:</b>	785-532-1124
<b>Fiscal Year:</b>	2021
<b>USDA-ARS Agreement ID:</b>	N/A
<b>USDA-ARS Agreement Title:</b>	Identification and Deployment of FHB Resistance QTL in US Hard Winter Wheat
<b>FY20 USDA-ARS Award Amount:</b>	\$130,000
<b>Recipient Organization:</b>	USDA-ARS Plant Science and Entomology Research Unit (PSERU) 4008 Throckmorton Hall, 1712 Chafin Rd. Manhattan, KS 66506
<b>DUNS Number:</b>	N/A
<b>EIN:</b>	N/A
<b>Project/Grant Period:</b>	5/1/21 - 4/30/22
<b>Reporting Period End Date:</b>	4/30/2022

### USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
HWW-CP	Identification and Deployment of FHB Resistance QTLs in US Hard Winter Wheat	\$80,000
GDER	Function Analysis of FHB1 using BSMV-mediated CRISPR/Cas9 Gene Editing System	\$50,000
<b>FY21 Total ARS Award Amount</b>		<b>\$130,000</b>

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.*



Principal Investigator Signature

7/18/2022

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: Identification and Deployment of FHB Resistance QTLs in US Hard Winter Wheat

---

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

Map QTLs for type I resistance to FHB from the source of Everest; pyramid *Fhb1* with *Fhb7* and a major QTL from 2DL in US HWW Everest by marker-assisted backcross (MAB); and develop functional markers for *Fhb7* for marker-assisted breeding.

### 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. Completed the greenhouses and field experiments for type I resistance and data analysis.
2. 2DL QTL was pyramided with *Fhb1* in Everest and Overland backgrounds. Five selected resistant lines were phenotyped for agronomic performances in three Kansas locations.
3. Two near-diagnostic markers for *Fhb7* were developed and the paper was published online
4. Backcross was made between Everest*Fhb1*/*Fhb7*F1 and Everest.

#### b) What were the significant results?

- a). Two selected lines with *Fhb1* and 2DL QTL showed acceptable agronomic performance in field conditions.
- b). *Fhb7* marker paper has been published
- c). *Fhb7* transgenic lines were phenotyped and showed high FHB resistance in greenhouse experiments

#### c) List key outcomes or other achievements.

- a). Selected lines with *Fhb1* and 2DL QTL showed high resistance and some of them show acceptable agronomic performance
- b). Protocol for *Fhb7* diagnostic markers has been released through publication in Crop Science
- c). An EMS mutant M2 population of 2000 lines with *Fhb7* in Chinese Spring background has been advanced to M4 for future screening of yellow flour gene mutant.
- d). Eight *Fhb7* transgenic lines with GST gene were evaluated in two greenhouse cycles for FHB resistance and most of them showed high *Fhb7* expression and high FHB resistance.

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

Three graduate students (Mr. Volodymyr Kavetsky, Ms. Ruolin Bian and Mr. Yuzhou Xu) have worked on these projects. They learnt gene cloning and sequencing, Fusarium inoculum culturing and taking note for disease and other traits, marker and QTL data analysis, poster presentation and writing reports.

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

- Selected wheat FHB resistance gene pyramiding lines with high level of FH resistance have been distributed to several breeding programs by request and used as parents for further crosses.
- Several graduate students and post-docs gave presentations in 2021 FHB Forum.
- The several manuscripts on FHB research have been published.

## Project 2: Function Analysis of FHB1 using BSMV-mediated CRISPR/Cas9 Gene Editing System

---

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

Goal 1: Select wheat edited lines with improved resistance to FHB

Goal 2: Release to other programs for further breeding activities.

### 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?

For goal 1:

1. We edited three different sites (one before and one within and one after the nuclear localization signal domain, NLS) of wild-type allele TaHRC\_S in a susceptible wheat cultivar 'Bobwhite' using our recently optimized BSMV-mediated gene-editing system.
2. We identified one mutant each at the three different target sites, respectively, with two insertion mutations and one deletion mutation.
3. We selected the homozygous M2 mutant plants and inoculated with a conidiospore suspension of *F. graminearum* (GZ3639) by single spikelet injection at early anthesis in a growth chamber.
4. We scored the percentage of symptomatic spikelets (PSS) in a spike in the edited mutants and determined reduced FHB susceptibility in the mutants with the disrupted N-terminus is due to abolished TaHRC function and the NLS domain in the N-terminus is critical for regulating FHB susceptibility in wheat.

For goal 2:

We successfully identified two TaHRC-edited 'Bobwhite' lines and three TaHRC-edited 'Everest' and evaluated all the edited lines with improved resistance to FHB. The mutants will be released to wheat breeding programs for further breeding activities

#### b) What were the significant results?

1. We successfully edited TaHRC\_S at the three different target sites and identified two mutant lines with improved FHB resistance.
2. We successfully determined the NLS domain in the N-terminus of TaHRC\_S is critical for regulating FHB susceptibility in wheat.

#### c) List key outcomes or other achievements.

1. We successfully confirmed the hypothesis that wheat have FHB susceptible genes.
2. We provided new strategies for developing new sources of FHB resistance by knocking out susceptible genes in wheat cultivars using CRISPR/Cas9 gene editing.

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

Trained one visiting scientist and one MS student with gene editing techniques.

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

1. Presented two posters in USWBSI 2021 FHB Forum
2. Two related papers have been published in the high-impacted journals.
3. HRC-S gene edited Bobwhite seeds were requested by McGill University in Canada for FHB research
4. We have been contacted by the USDA lab in Albany and a lab in Virginia Tech University for assistance and collaboration in using the technology to edit wheat for different traits.

## 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. H Chen, Z Su, B Tian, G Hao, HN. Trick and G Bai. (2022) Wild-type allele of TaHRC suppresses calcium-mediated plant immune response by hijacking TaCAXIP4 to trigger FHB susceptibility in wheat. Plant Physiol.  
Status: Accepted  
Acknowledgement of Federal Support: Yes
2. Zhao L, Ge W, Lyu Z, Xu S, Xu Y, Bernardo A, Zhang Q, Xu SS, Wang H, Kong L, Bai G. (2022) Development and validation of diagnostic markers for the wheat Fusarium head blight resistance gene Fhb7. Crop Sci. DOI:10.1002/csc2.20754  
Status: Published  
Acknowledgement of Federal Support: Yes
3. Ghimire B, Mergoum M, Martinez-Espinoza AD, Sapkota S, Pradhan S, Babar MA, Dong Y, and Buck JW. (2022) Genetics of Fusarium head blight resistance in soft red winter wheat using a genome-wide association study. DOI: 10.1002/tpg2.20222  
Status: Published  
Acknowledgement of Federal Support: Yes
4. H Chen, Z Su, B Tian, Y Liu, Y Pang, V Kavetskyi, HN. Trick and G Bai. (2022) Development and optimization of a Barley stripe mosaic virus (BSMV)-mediated gene editing system to improve Fusarium head blight (FHB) resistance in wheat. Plant Biotech J. 20:1018-1020. DOI: 10.1111/pbi.13819  
Status: Published  
Acknowledgement of Federal Support: Yes
5. H Li, F Zhang, J Zhao, G Bai, P St. Amand, A Bernardo, Z Ni, Q Sun, Z Su. (2022) Identification of a novel major QTL from Chinese wheat cultivar Ji5265 for Fusarium head blight resistance in greenhouse. Theor Appl Genet. <https://doi.org/10.1007/s00122-022-04080-5>  
Status: Published  
Acknowledgement of Federal Support: Yes

6. J Zhang, HS Gill, NK Brar, J Halder, S Ali, X Liu, A Bernardo, P St. Amand G Bai, US Gill, B Turnipseed, SK Sehgal. (2022) Genomic prediction of Fusarium head blight resistance in early stages using advanced breeding lines in hard winter wheat. *Crop J.* <https://doi.org/10.1016/j.cj.2022.03.010>

Status: Published

Acknowledgement of Federal Support: Yes

7. L Zhao, P Su, B Hou, H Wu, Y Fan, W Li, J Zhao, W Ge, S Xu, S Wu, X Ma, A Li, G Bai, H Wang, L Kong. (2022) The black necrotic lesion enhanced Fusarium graminearum resistance in wheat. *Front in Genet.*

Status: published

Acknowledgement 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).
---

### 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. Y Xu, R Bian, Y Dong, L Zhao, Y Xu, A Bernardo, P St. Amand, J Rupp, M Bruce, and G Bai. 2021. Characterization of Quantitative Trait Loci for Resistance to Fusarium Head Blight in a Winter Wheat Population. *Proceedings of the 2021 National Fusarium Head Blight Forum*; Virtual. December 6-7, 2021. Retrieved from: <https://scabusa.org/forum/2021/2021NFHBForumProceedings.pdf>
2. SK. Sehgal, J Zhang, HS Gill, NK Brar, J Halder, S Ali, X Liu, A Bernardo, P St Amand, G Bai, B Turnipseed 2021. Breeding for FHB Resistance in Hard Winter Wheat. *Proceedings of the 2021 National Fusarium Head Blight Forum*; Virtual. December 6-7, 2021. Retrieved from: <https://scabusa.org/forum/2021/2021NFHBForumProceedings.pdf>
3. R Bian, A Bernardo, P St. Amand, G Bai. Quantitative Trait Loci Mapping for Fusarium Head Blight Resistance in a Wheat EMS Mutant from 'Jagger'. *Proceedings of the 2021 National Fusarium Head Blight Forum*; Virtual. December 6-7, 2021. Retrieved from: <https://scabusa.org/forum/2021/2021NFHBForumProceedings.pdf>
4. L Zhao, W Ge, Z Lyu, S Xu, Y Xu, A Bernardo, Q Zhang, SS. Xu, H Wang, L Kong, and G Bai. 2021. Development and Validation of Diagnostic Markers for the Wheat Fusarium Head Blight Resistance Gene Fhb7. *Proceedings of the 2021 National Fusarium Head Blight Forum*; Virtual. December 6-7, 2021. Retrieved from: <https://scabusa.org/forum/2021/2021NFHBForumProceedings.pdf>

5. V Kavetskyi, H Chen, G Bai, 2021. Using a New Genome Editing System to Validate the Functions of Wheat Candidate Genes of FHB1 in Fusarium Head Blight Resistance. *Proceedings of the 2021 National Fusarium Head Blight Forum; Virtual*. December 6-7, 2021. Retrieved from: <https://scabusa.org/forum/2021/2021NFHBForumProceedings.pdf>
6. H Chen, V Kavetskyi and G Bai. 2021. Nanoparticle-mediated Genome Editing System for FHB Resistance Improvement in Wheat. *Proceedings of the 2021 National Fusarium Head Blight Forum; Virtual*. December 6-7, 2021. Retrieved from: <https://scabusa.org/forum/2021/2021NFHBForumProceedings.pdf>