USDA-ARS
U.S. Wheat and Barley Scab Initiative
FY19 Performance Report
Due date: July 24, 2020

Cover Page

Principle Investigator (PI):	Guihua Bai
Institution:	USDA-ARS Plant Science and Entomology Research Unit (PSERU) 4008 Throckmorton Hall 1712 Chaflin Rd. Manhattan, KS 66506
E-mail:	guihua.bai@USDA.GOV
Phone:	785-532-1124
Fiscal Year:	2019
USDA-ARS Agreement ID:	N/A
USDA-ARS Agreement Title:	Identification and Deployment of FHB Resistance QTL in US Hard Winter Wheat
FY19 USDA-ARS Award Amount:	$ 105,000

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
HWW-CP	Identification and Deployment of FHB Resistance QTL in US Hard Winter Wheat	$ 75,000
GDER	Barley Stripe Mosaic Virus-Mediated CRISPR/Cas9 Genome Editing for FHB Resistance Improvement	$ 30,000
	FY19 Total ARS Award Amount	**$ 105,000**

7-20-2020

Principal Investigator Date

* MGMT – FHB Management
FST – Food Safety & Toxicology
GDER – Gene Discovery & Engineering Resistance
PBG – Pathogen Biology & Genetics
EC-HQ – Executive Committee-Headquarters
BAR-CP – Barley Coordinated Project
DUR-CP – Durum Coordinated Project
HWW-CP – Hard Winter Wheat Coordinated Project
VDHR – Variety Development & Uniform Nurseries – Sub categories are below:
SPR – Spring Wheat Region
NWW – Northern Soft Winter Wheat Region
SWW – Southern Soft Red Winter Wheat Region

Project 1: *Identification and Deployment of FHB Resistance QTL in US Hard Winter Wheat*

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

   - Map QTLs from moderately resistant cultivar Yangmai158, Zheng 9023, Everest and Overland
   - Pyramid QTLs on chromosome 5A from PI 277012 and 2DL QTL with Fhb1 in Overland and Everest backgrounds

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

   a) What were the major activities?
      - Completed data analysis of Yangmai158 / Zheng 9023 F7 RILs, prepared and submitted manuscript for publication.
      - Evaluated Overland/Overley F7 population in greenhouse for type I resistance.
      - For the QTL pyramiding project, selected 60 Bc2F4 lines with different combinations of the QTLs and phenotyped then for one season in a field experiment.

   b) What were the significant results?
      - Identify 6 QTLs in Yangmai158 / Zheng 9023 and developed KASP SNP markers linked to three repeatable QTLs for marker-assisted selection
      - *Fhb1* was stacked with 2DL QTL and 5AS/5AL QTL, respectively.

   c) List key outcomes or other achievements.
      - We determined the QTLs in Chinese wheat Yangmai158 and Zheng 9023 and developed KASP markers for these QTLs. Some of these KASP markers can be used for MAS in breeding.
      - We selected lines with all combinations of the three QTLs (Fhb1, 5AS and 5AL) with improved agronomic traits in hard winter wheat backgrounds and these lines showed high level of resistance in this year's field experiment.
      - We selected lines with Fhb1 and 2DL QTLs and they showed high resistance in a field experiment. These lines will be further tested and released to breeders for crossing.

3. **Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.**

   No

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

Five graduate students (Dr. Yaoguang Li, Dr. Abdul Hashimi, Ms. Umara Rena, Ms. Ruolin Bian and Mr. Yuzhou Xu) have worked on these projects. They learnt high-throughput DNA isolation and PCR, FHB inoculation and taking note for disease and other traits, marker and QTL data analysis, poster presentation and writing reports.

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

- Selected lines with high level of FH resistance will be distributed to breeding programs for further evaluation of FHB resistance or used as parents for further crosses later this year.
- Two graduate students deposited their thesis in KSU library for public access.
- Several manuscripts have been published.
- The paper on cloning of Fhb7 gene has been published in Science. Drs. Lanfei Zhao and Guihua Bai contributed to the paper as coauthors. USDA-ARS had news release about this breakthrough. Many media published the news and gave us a interviews on this work.

Project 2: *Barley Stripe Mosaic Virus-Mediated CRISPR/Cas9 Genome Editing for FHB Resistance Improvement*

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

Develop a new efficient gene delivery method to accelerate the utilization of genome editing technology in improvement of wheat resistance to FHB in breeding programs.

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

a) What were the major activities?

- US hard winter wheat variety 'Everest' that carries *TaHRC-S* allele but with very low transformation efficiency was edited by BSMV-mediated genomr editing method.
- We crossed Bobwhite carrying Cas9-overexpressed (Cas9-OE) to Everest, selected plants with Cas9-OE, optimized BSMV-mediated gene-editing system, and knocked out *TaHRC-S* in the Cas9-OE Everest, identified three edited Everest-*TaHRC-S* mutants with 2 bp and 21 bp inserts in two plants, and a 4 bp sequence deletion in one plant after screening 318 plants.
- Phenotyping all the three edited Everest-mutant lines showed a significant increase in FHB resistance compared to original Everest.

b) What were the significant results?
We successfully recovered three stable edited *TaHRC-S* mutants from plants with Everest background, demonstrated *TaHRC*-edited mutants showed significant lower FHB severity than non-edited plants after phenotyping them for FHB resistance.

c) List key outcomes or other achievements.
We successful editing the *TaHRC-S* in a non-transformable hard winter wheat Everest background without direct wheat transformation process and confirmed that loss-of-function mutation of *TaHRC-S* is the cause of *Fhb1* resistance, and demonstrated that new sources of FHB resistance can be created by knocking out susceptible genes using the gene editing system.

3. Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.

No.

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

Trained two visiting scientists (Drs. Yuhui Pan and Yang Liu) with gene editing and FHB phenotyping techniques.

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

- Co-PI Dr. Hui Chen presented a poster in 5th Plant Genomics and Gene Editing Congress.
- Co-PI Dr. Hui Chen was invited to give an oral presentation in USWBSI 2018 FHB Forum and his presentation was highlighted in USWBSI Fusarium Focus, 2019 (Volume 19, Issue 1).
- Presented a poster in USWBSI 2019 FHB Forum.
- Presented a poster in 2020 World Congress on In Vitro Biology.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY19 award period (N/A). The term "support" below includes any level of benefit to the student, ranging from full stipend plus tuition to the situation where the student's stipend was paid from other funds, but who learned how to rate scab in a misted nursery paid for by the USWBSI, and anything in between.

1. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their MS degree during the FY19 award period?**
   No.

   If yes, how many?

2. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY19 award period?**
   Yes.

   If yes, how many? One student. Mr. Yuzhou Xu.

3. **Have any post docs who worked for you during the FY19 award period and were supported by funding from your USWBSI grant taken faculty positions with universities?**
   Yes.

   If yes, how many? One. Dr. Hui Chen

4. **Have any post docs who worked for you during the FY19 award period and were supported by funding from your USWBSI grant gone on to take positions with private ag-related companies or federal agencies?**
   No.

   If yes, how many?

Release of Germplasm/Cultivars

Instructions: In the table below, list all germplasm and/or cultivars released with full or partial support through the USWBSI during the FY19 award period. All columns must be completed for each listed germplasm/cultivar. Use the key below the table for Grain Class abbreviations.

NOTE: Leave blank if you have nothing to report or if your grant did NOT include any VDHR-related projects.

Name of Germplasm/Cultivar	**Grain Class**	**FHB Resistance** (S, MS, MR, R, where R represents your most resistant check)	**FHB Rating** (0-9)	**Year Released**

Add rows if needed.

NOTE: List the associated release notice or publication under the appropriate sub-section in the 'Publications' section of the FPR.

Abbreviations for Grain Classes

Barley - BAR
Durum - DUR
Hard Red Winter - HRW
Hard White Winter - HWW
Hard Red Spring - HRS
Soft Red Winter - SRW
Soft White Winter - SWW

Publications, Conference Papers, and Presentations

Instructions: Refer to the FY19-FPR_Instructions for detailed more instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY19 grant award. Only citations for publications published (submitted or accepted) or presentations presented during the **award period (N/A**) should be included. If you did not publish/submit or present anything, state 'Nothing to Report' directly above the Journal publications section.

NOTE: Directly below each citation, you **must** indicate the Status (i.e. published, submitted, etc.) and whether acknowledgement of Federal support was indicated in the publication/ presentation.

Journal publications.

Wang, H., S. Sun, W. Ge, L. Zhao, B. Hou, K. Wang, Z. Lyu, L. Chen, S. Xu, J. Guo, M. Li, P. Su, X. Li, G. Wang, C. Bo, X. Fang, W. Zhuang, X. Cheng, J. Wu, L. Dong, W. Chen, W. Li, G. Xiao, J Zhao, Y. Hao, Y. Xu, Y. Gao, W. Liu, Y. Liu, H. Yin, J. Li, X. Li, Y. Zhao, X. Wang, F. Ni, X. Ma, A. Li, S. S. Xu, G. H. Bai, E. Nevo, C. Gao, H. Ohm, L. Kong. 2020. *Triticeae* E genome encodes a GST of *Fhb7* bringing novel solution for Fusarium head blight resistance. Science 10.1126/science.aba5435.
Status: Published
Acknowledgement of Federal Support: No.

Zhang, P., C. Guo, Zhao Liu, Amy Bernardo, Hongxiang Ma, Peng Jiang, Guicheng Song, Guihua Bai. 2020. Quantitative trait loci for Fusarium head blight resistance in wheat cultivars Yangmai 158 and Zhengmai 9023. Crop J. DOI: https://doi.org/10.1016/j.cj.2020.05.007
Status: Published
Acknowledgement of Federal Support: Yes.

Gong, X., X. He, Y. Zhang, L. Li, Z. Sun, G. H. Bai, P. K. Singh, and T. Li. 2020. Development of an evaluation system for Fusarium resistance in wheat grains and its application in assessment of the corresponding effects of *Fhb1*. Plant Dis. https://doi.org/10.1094/PDIS-12-19-2584-RE
Status: Published
Acknowledgement of Federal Support: No.

Bakhsh, P. S. Baenziger, G. Bai and W. Berzonsky. 2019. Agronomic performance of hard red winter wheat lines introgressed with the Fhb1 gene. Pak. J. Agri. Sci. 56(3):623- 628
Status: Published
Acknowledgement of Federal Support: Yes.

Zhu, Z., Y. Hao, M. Mergoum, G. Bai, G. Humphreys, S. Cloutier, X. Xia, Z. He. 2019. Breeding wheat for resistance to Fusarium head blight in the Global North: China, USA and Canada. Crop J. https://doi.org/10.1016/j.cj.2019.06.003
Status: Published
Acknowledgement of Federal Support: No.

Cai, J., S. Wang, Z. Su, T. Li, X. Zhang, G. Bai. 2019. Meta-analysis of QTL for Fusarium head blight resistance in Chinese wheat landraces. https://doi.org/10.1016/j.cj.2019.05.003
Status: Published
Acknowledgement of Federal Support: Yes.

Books or other non-periodical, one-time publications.

Bai G. 2020. Advances in genetic improvement of durable resistance to Fusarium head blight in wheat. In Richard Oliver (Ed) 'Achieving durable disease resistance in cereals'. Will be published by Burleigh Dodd Scientific Publishing.
Status: Submitted
Acknowledgement of Federal Support: Yes.

Other publications, conference papers and presentations.

Chen, H., Su, Z. Q., Tian, B., Liu, Y., Trick, H. and Bai, G. H. "Improvement of FHB Resistance in Hard Winter Wheat Using BSMV-mediated CRISPR/Cas9 Gene Editing System." In: S. Canty, A. Hoffstetter, H. Campbell and R. Dill-Macky (Eds.), *Proceedings of the 2019 National Fusarium Head Blight Forum* (p. 45), Milwaukee, WI; December 8-10. University of Kentucky, Lexington, KY.
Status: Published
Acknowledgement of Federal Support: Yes.

Chen, H., Tian, B., Liu, Y., Trick, H. and Bai, G. H. Development of An Efficient Barley Stripe Mosaic Virus-mediated CRISPR/Cas9 System for Gene Editing in Wheat. 2020 World Congress on In Vitro Biology. San Diego, CA, USA, Jun 6-10, 2020.
Status: Published
Acknowledgement of Federal Support: Yes.

Tian, B., Chen, H., Bai, G., Trick, H.N. Plant Transformation and Genome Editing Systems for Hexaploid Wheat. 2020 World Congress on In Vitro Biology. San Diego, CA, USA, Jun 6-10, 2020.
Status: Published
Acknowledgement of Federal Support: Yes.