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

FY22 Performance Progress Report

Due date: July 26, 2023

Cover Page

USDA-ARS Agreement ID:	59-0206-2-156
USDA-ARS Agreement Title:	Genetic Characterization and Field Evaluation of Fusarium Head Blight (FHB) Resistance in Spring Wheat and Durum Wheat
Principle Investigator (PI):	Shaobin Zhong
Institution:	North Dakota State University
Institution UEI:	EZ4WPGRE1RD5
Fiscal Year:	2022
FY22 USDA-ARS Award Amount:	$113,128
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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
DUR-CP	Maintenance and Operation of FHB Screening Nurseries for Durum Wheat	$24,224
DUR-CP	Genetic Characterization and Introgression of FHB Resistance in Durum Wheat	$54,989
VDHR-SPR	Maintenance and Operation of Two Coordinated FHB Nurseries for Spring Wheat	$33,915
	FY22 Total ARS Award Amount	$113,128

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.

Shaobin Zhong
Principal Investigator Signature

07/24/2023
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: Maintenance and Operation of FHB Screening Nurseries for Durum Wheat

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

The major goal of this project is to enhance and maintain the capacity and efficiency of FHB screening for durum wheat CP in two field FHB nurseries. The specific objectives of the project are to: 1) Maintain and operate the current Fargo nursery for FHB screening of durum materials from PIs working in the durum CP, 2) Establish and operate the FHB nursery at the Langdon location for durum wheat.

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?

- In the summer season of 2022, we planted 3,360 hill plots of durum wheat materials submitted by durum wheat researchers in durum wheat CP (1660 hills from Dr. Shaobin Zhong, 1200 hills from Dr. Steven Xu, and 500 hills from Dr. Xuehui Li) at the Fargo location. These durum wheat materials included advanced breeding lines, mapping populations, introgression germplasm, and recurrently selected populations. One mapping population consisting of 200 recombinant inbred lines (RILs) and one EMS mutant population of 500 lines from Kronos were inoculated by the point inoculation method and the remaining durum materials were inoculated by the Fusarium-infested corn inoculum spread on the field in mid-June. Overhead misting systems were used for disease development for both inoculation methods.
- We established a new FHB nursery at Langdon for FHB screening in collaboration with Dr. Venkata Chapara at the NDSU Langdon Research Station. In the summer season of 2022, we planted and evaluated a mapping population (660 hill plots) from Dr. Zhong's group and a recurrent selection population (480 hill plots) from Dr. Li's group. Fusarium-infested corn inoculum and overhead misting systems were used for disease infection and development at the Langdon location.

b) What were the significant results?

- For both Fargo and Langdon locations, high quality FHB data were collected and they are useful for germplasm development and QTL mapping of FHB resistance in durum wheat.

c) List key outcomes or other achievements.

- The FHB nurseries at the Fargo and Langdon locations provided larger capacity for screening of durum wheat materials from PIs involved in the USWBSI program. The two FHB nurseries are very valuable for FHB phenotyping under two field environmental conditions.

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

Four Ph.D. students participated in the planting, disease inoculation and ratings in the two FHB nurseries, and had obtained training for disease phenotyping in the field experiments.

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

Noting to report.

Project 2: Genetic Characterization and Introgression of FHB Resistance in Durum Wheat

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

The major goal of this project is to genetically characterize FHB resistance sources and transfer the resistance into durum wheat. The specific objectives of the research are: 1) Finely map the 2A QTL for FHB resistance derived from the Divide X PI 254188 cross. 2) Develop user-friendly DNA markers for the 2A QTL. 3) Introgress the 2A QTL into durum wheat varieties. 4) Screen EMS mutants derived from ND Riverland and Kronos for FHB resistance. 5) Identify genes related to FHB susceptibility in durum wheat.

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?

- We phenotyped a recombinant inbred line (RIL) population from a cross between Joppa and an FHB resistant RIL (LPA-4) derived from the Lebsock/PI254188/Alkabo cross in both greenhouse and field in the summer season of 2022.
- We genotyped the RIL population from the Joppa x LPA-4 cross through the genotyping by sequencing (GBS) approach.
- We selected seven FHB resistant RILs derived from the cross between Joppa and LPA-4 for crossing with Joppa in order to Introgress the FHB resistance QTL into durum wheat varieties.
- We screened 500 EMS mutants derived from Kronos in both greenhouse and field in order to identify genes related to FHB susceptibility in durum wheat.
- We developed a near-isogenic line (ND Riverland-Fhb1) carrying Fhb1 using ND Riverland as the recurrent parent in cross and ND2710 as the Fhb1 donor.
- We treated the seeds of ND Riverland-Fhb1 with EMS to generate M1 mutant plants.

b) What were the significant results?

- Three QTL on chromosome 1B, 3A and 5B for FHB resistance were detected in the mapping population derived from the cross between Joppa and LPA-4.
- BC1F1 seeds were produced from crosses between Joppa and seven RILs with FHB resistance derived from the Joppa x LPA-4 cross.
- EMS mutants of Kronos varied in susceptibility to FHB and some of them were less susceptible compared to the wildtype Kronos and will be further verified in another greenhouse inoculation.
- A near-isogenic line (ND Riverland-Fhb1) with Fhb1 was developed in the genetic background of durum wheat cultivar ND Riverland.

- A total of 300 M1 mutants were generated from ND Riverland-Fhb1 by EMS treatment of the seeds.

c) List key outcomes or other achievements.

- Novel QTL for FHB resistance were detected in the mapping population derived from the cross between Joppa and LPA-4, a durum wheat line derived from the Lebsock/PI254188/Alkabo cross. Interestingly, the 2A QTL previously identified from a mapping population from the Divide and PI254188 cross was not detected in the Joppa x LPA-4 population.

- The EMS mutants generated from ND Riverland-Fhb1 will be phenotyped for FHB to determine if any genes inhibiting Fhb1 resistance exist in durum wheat genetic background.

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

Three Ph.D. students are involved in this project and have obtained training in FHB screening, genotyping, QTL analysis, marker-assisted selection, generation of EMS mutants.

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

Two elite durum wheat lines derived from cross between Joppa and LPA-4 have a high level of FHB resistance and have been provided to Dr. Elias Elias's durum wheat breeding program for further evaluation and use as germplasm to develop FHB resistant durum wheat varieties. Some of the research results were presented in conference presentations and peer-reviewed articles published in scientific journals.

Project 3: Maintenance and Operation of Two Coordinated FHB Nurseries for Spring Wheat

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

The major goal of this project is to maintain the capacity and efficiency of FHB screening for the spring wheat CP. The specific objective is to: maintain and operate the two FHB nurseries located at Fargo and Langdon for FHB screening of spring wheat materials.

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?

- In the summer season of 2022, we planted a total of 5,580 hill plots of spring wheat materials from multiple researchers working in the spring wheat CP (2,620 hills from Dr. Shaobin Zhong, 1,000 hills from Dr. Steven Xu, 1,360 hills from Dr. Andrew Green, and 600 hills from Dr. Jason Fiedler) in the FHB nursery at Fargo location. These materials included advanced breeding lines, mapping populations, introgression germplasm, and commercially grown wheat varieties (for variety trials). Among them, 2,415 hill plots were point-inoculated at anthesis and the rest of hill plots were inoculated with Fusarium-infested corn kernels. Overhead misting systems were used for disease development for both inoculation methods.

- We also established a disease nursery at Langdon for FHB screening of spring wheat materials in collaboration with Dr. Venkata Chapara at the NDSU Langdon Research Station. In the summer season of 2022, we planted a mapping population (660 hill plots) and spring wheat materials (480 hill plots) derived from various crosses and backcrosses for introgression of FHB resistance. Fusarium-infested corn kernels were spread on the field as inoculum and overhead misting systems were used for disease infection and development at the Langdon location.

b) What were the significant results?

- FHB developed well in both locations and high-quality disease data were collected.

c) List key outcomes or other achievements.

- The FHB data are very useful for variety and germplasm development, QTL mapping of FHB resistance, and development of a guide for farmers to select varieties for planting.

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

Four Ph.D. students obtained trainings in field design and planting, disease inoculation and ratings in the two FHB nurseries.

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

Nothing to report.

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?

☐ 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).

Zhang, W., Danilova, T., Zhang, M., Ren, S., Zhu, X., Zhang, Q., **Zhong, S.,** Dykes, L., Fiedler, J., Xu, S., Frels, K., Wegulo, S., Boehm, J., and Cai, X. 2022. Cytogenetic and genomic characterization of a novel tall wheatgrass-derived Fhb7 allele integrated into wheat B genome. Theor. Applied. Genet. 135:4409–4419.
Status of publication: published.
Acknowledgment of federal support: yes.

Green, A., Mergoum, M., Frohberg, R., Underdahl, J. L., Horsley, R. D., Walz, A., Simsek, S., Otteson, B. N., Heilman, A. M., Friskop, A., Ransom, J., Rickertsen, J. R., Ostlie, M. H., Schatz, B. G., Hanson, B. K., Eriksmoen, E., Pradhan, G., Martin, G. B., Rasmussen, J. B., **Zhong, S.,** Friesen, T. L., Rouse, M., Jin, Y., Chao, S., Acevedo, M. 2022. Registration of ND VitPro Hard Red Spring Wheat. J. Plant Regist. 16:606–612.
Status of publication: published.
Acknowledgment of federal support: yes.

Poudel, B., Mullins, J., Puri, K.D., Leng, Y., Karmacharya A., Liu, Y., Hegstad, J., Li, X., and ***Zhong, S**. 2022. Molecular mapping of quantitative trait loci for Fusarium head blight resistance in the Brazilian spring wheat cultivar 'Surpresa'. Front. Plant Sci. 12:778472.
Status of publication: published.
Acknowledgment of federal support: yes.

Zhu, X., Boehm, J. D., **Zhong, S**., Cai, X. 2022. Genomic compatibility and inheritance of hexaploid-derived Fusarium head blight resistance genes in durum wheat. The Plant Genome 15(2):e20183.
Status of publication: published.
Acknowledgment of federal support: yes.

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).

N/A

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.

Leng, Y., Zhao, M., Xi, P., Li, D., Molnar, I., Dolezel, J., Fielder, J., Du, Y., Xu, S and ***Zhong, S**. 2023. Long-read HiFi sequencing facilitates identification of a genomic region carrying a major QTL for Fusarium head blight resistance in wheat line PI277012. PO0539 In: Plant and Animal Genome Conference 30, San Diego, CA. (Poster).
Status of publication: published.
Acknowledgment of federal support: yes.

Wang, R., Axtman, J., Salsman, E., Hegstad, J., Fiedler, J., Xu, S., **Zhong, S**., Elias, E and Li, X. 2022. Recurrent Selection for Fusarium Head Blight Resistance in a Durum Wheat Population. Proceedings of the 2022 National Fusarium Head Blight Forum; Tampa, FL. December 4-6, 2022. Retrieved from: https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf.
Status of publication: published.
Acknowledgment of federal support: yes.

Wang, F., Charif, A., Danilova, T., Zhang, W., Zhang, M., Ren, S., Zhu, X., **Zhong, S**., Fiedler, J., Xu, S., Frels, K., Wegulo, S., Boehm, J and Cai, X. 2022. Molecular Marker-Assisted Fhb7 Introgression in Common and Durum Wheat. Proceedings of the 2022 National Fusarium Head Blight Forum; Tampa, FL. December 4-6, 2022. Retrieved from: https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf.
Status of publication: published.
Acknowledgment of federal support: yes.

Szabo-Hever, A., Sharma, J. S., Faris, J. D., **Zhong, S**., Friesen, T. L., Green, A. J., Bai, G and Xu, S. S. 2022. Identification and Mapping of Quantitative Trait Loci for Fusarium Head Blight Resistance in Synthetic Hexaploid and Spring Wheat. Proceedings of the 2022 National Fusarium Head Blight Forum; Tampa, FL. December 4-6, 2022. Retrieved from: https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf.
Status of publication: published.
Acknowledgment of federal support: yes.

Karmacharya, A., Li, D., Leng, Y., Shi, G., Liu, Z., Yang, S., Du, Y., Dai, W and ***Zhong, S**. 2022. Editing Wheat Genome through Wide Hybridization with Maize Expressing Cas9 and Guide RNA. Proceedings of the 2022 National Fusarium Head Blight Forum; Tampa, FL. December 4-6, 2022. Retrieved from: https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf.
Status of publication: published.
Acknowledgment of federal support: yes.

Karmacharya, A., Leng, Y., and ***Zhong, S**. 2022. Targeting wheat TaHRC gene for FHB resistance through haploid induction coupled with CRISPR/Cas9 genome editing. APS Meeting, Pittsburgh, PA. P200. (Poster)
Status of publication: published.
Acknowledgment of federal support: yes.

Safar, S., and *Zhong, S. 2022. Development and evaluation of near-isogenic spring wheat lines with the FHB resistance gene Fhb1. North Central Division Meeting, Lincoln, NE (Poster) Status of publication: published.
Acknowledgment of federal support: yes.