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

FY22 Performance Progress Report

Due date: July 26, 2023

Cover Page

USDA-ARS Agreement ID:	N/A
USDA-ARS Agreement Title:	Characterization of FHB resistance in wheat and barley
Principle Investigator (PI):	Xiwen Cai
Institution:	USDA-Agricultural Research Service
Institution UEI:	N/A
Fiscal Year:	2022
FY22 USDA-ARS Award Amount:	$97,527
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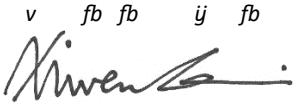
Period of Performance:	May 1, 2022 - April 30, 2023
Reporting Period End Date:	April 30, 2023

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
BAR-CP	Transferring FHB Resistance Genes from Wheat and Wild Species to Barley	$45,000
DUR-CP	Introgression and Understanding of Hexaploid-derived FHB Resistance Genes in Durum	$52,527
	FY22 Total ARS Award Amount	$97,527

I am submitting this report as an: ☒ Annual Report



7/14/2023

Principal Investigator Signature — Date Report Submitted

DUR-CP and VDHR-SPR

* 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: Transferring FHB Resistance Genes from Wheat and Wild Species to Barley

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1. **What are the major goals and objectives of the research project?**
   The major goal of this project is to incorporate FHB resistance genes from wild grass and wheat into barley for germplasm/variety development using genomics-enabled chromosome engineering. The objectives of this research project are: 1) Induce meiotic recombination of Thinopyrum chromosome 7E (*d*) with its homoeologue in barley using wheat *d* mutant; 2) Recover 7H-7E recombinants containing *d* using molecular markers and fluorescent in situ hybridization (FISH)/genomic in situ hybridization (GISH); and 3) Develop barley germplasm/varieties containing *d* .

2. **What was accomplished under these goals or objectives?** *fb* *d fb ij fb* *fb* *fbfb* *fbfbij fb* *dfb*

   a) **What were the major activities?**
   - Developed chromosome/ *d* -specific markers for the detection of chromosomes 7E, 7H, and 7D.
   - Selected CS wheat group-7 monosomics by chromosome counting.
   - Verified wheat-barley 7H addition line by FISH.
   - Made crosses of the monosomics to the 7H addition line.
   - Analyzed and selected the critical F1's from the crosses of M7B TA3047x DA7H TA3697, M7D TA3061x DA7H TA3697, and M7A TA3047x DA7H TA3697 by FISH.
   - Advanced the plants with 2n=42 (40W+7B+7H) and 2n=42 (40W+7D+7H) for the production of the disomic substitution (DS) lines 7H(7B) and 7H(7D).
   - Screened three populations originated from the crosses of DS 7E(7W) x CS ph1b mutant by DNA markers and FISH to select DS 7E(7W) containing *d* and *d* *d*.

   b) **What were the significant results?**
   - Produced the double monosomic lines for the homoeologous pair 7B+7H and 7B+7D.
   - Selected individuals containing chromosome 7E (*d*) and *d*. They are the critical intermediate materials for inducing 7E-7H recombination in this *d* introgression project.

   c) **List key outcomes or other achievements.**
   - Chromosome-specific markers for 7E, 7B, and 7D useful in chromosome engineering of the chromosomes in group 7.
   - Bridging materials for the *d* introgression from wheat into barley.

3. **What opportunities for training and professional development has the project provided?**
   One postdoc has been hired to work on this research project. This research project has offered them a great opportunity to learn the procedure and principles of FISH and chromosome-specific marker development from reference genomes and cDNA sequences. In addition, the postdoc has received trainings in genetic analysis, chromosome engineering,

genomics, and bioinformatics. These learning and research experience have facilitated their career preparation in plant genetics and breeding.

4. **How have the results been disseminated to communities of interest?**
   Since this is the initial stage of a new research project, we have not presented/published the results we have obtained. We expect to present the progress we have made in the 2023 or 2024 FHB Forum.

Project 2: Introgression and Understanding of Hexaploid-derived FHB Resistance Genes in Durum

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1. **What are the major goals and objectives of the research project?**
   The major goals of this research project are to provide a better understanding of the effects of the durum genetic background and wheat D-genome chromosomes on the hexaploid-derived FHB resistance and to manipulate the genetic background to incorporate the hexaploid-derived FHB resistance genes into durum for germplasm development. The specific objectives of this project are to: 1) Characterize inheritance of the hexaploid-derived FHB resistance genes in durum background and understand the effect of D-genome chromosomes on FHB resistance; 2) Incorporate hexaploid wheat-derived FHB resistance genes into durum for germplasm development; and 3) Develop and validate the molecular markers tagging FHB resistance QTL in durum.

2. **What was accomplished under these goals or objectives?** *fb* *d fb ij fb* *fb* *fbfb* *fbfbij fb* *dfb*

   a) **What were the major activities?**
   - Advanced two generations of the progeny from the crosses of adapted durum varieties with hexaploid FHB-resistant sources for RIL population development using a modified single-seed descent procedure.
   - Increased seed of six RIL populations in the greenhouse.
   - Collected leaf tissues for genotyping of the three new RIL populations using wheat 90K SNP arrays.
   - FHB resistance evaluation of the resistant RILs and other durum introgression lines in the Lincoln FHB nursery.
   - Phenotyped one durum RIL population (n=203) for FHB resistance in a replicated greenhouse experiment.
   - Performed *d* introgression in spring and winter durum through a marker-assisted backcrossing breeding pipeline.
   - Developed and verified new *d* -specific STS and KASP markers for MAS.
   - Continued chromosome substitution-mediated FHB resistance gene introgression from hexaploid into durum for epistatic analysis and germplasm development.

   b) **What were the significant results?**
   - Wheat 90K SNP genotyping data and phenotyping data (one season) of one FHB-resistant hexaploids x durum RIL population.
   - Identified the RILs with improved FHB resistance from the previously developed RIL populations in the field nurseries.
   - Developed durum introgression lines containing *d* in early BC generations (BC1-2F1).
   - New *d* -specific STS and KASP markers useful for *d* introgression and pyramiding in durum.

c) List key outcomes or other achievements.

- The wild grass-derived FHB resistance gene *d* has been incorporated into spring and winter durum at the early stage of introgression, which will enable durum wheat to gain a new FHB resistance gene.
- Early introgression materials derived from major hexaploid-derived FHB resistance genes.
- Six RIL populations ideal for the characterization of epistatic effects and FHB-resistant germplasm development.
- New diagnostic DNA markers specific for *d* . They are useful for MAS in the deployment of *d* in adapted durum varieties.

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

One undergraduate student and one postdoc have been hired to work on this research project. This research project has offered them a great opportunity to learn the procedure and principles underlying FHB inoculum preparation, inoculation, and disease development and evaluation. In addition, the postdoc has received trainings in genetic analysis, chromosome engineering, genomics, and bioinformatics. These learning and research experience have facilitated their career preparation in plant genetics and breeding.

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

Research results from this project have been presented in the FHB Forum and published in the peer-reviewed journal.

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

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 FY22 award

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 FY22 award

Identify any other publications, conference papers and/or presentations not reported above. Specify the status of the publication.

Wang, F., Charif, A., Danilova, T., Zhang, W., Zhang, M., Ren, S., Zhu, X., Zhong, S., Fiedler, J., Xu, S. 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 Bay, FL. December 4-6, 2022. Retrieved from: https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf

Hale, C. O., Crutcher, F. K., Cai, X., Fiedler, J. D., Hogg, A. C., Martin, J. M., and Giroux, M. J. (2022). Fusarium Head Blight Resistant Durum Wheat in Montana, Development and Testing. Proceedings of the 2022 National Fusarium Head Blight Forum; Tampa Bay, FL. December 4-6, 2022. Retrieved from: https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf