USDA-ARS
U.S. Wheat and Barley Scab Initiative
FY19 Final Performance Report
Due date: September 30, 2020

Cover Page

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Fiscal Year:	2019
USDA-ARS Agreement ID:	59-0206-7-002
USDA-ARS Agreement Title:	Characterization of Resistance to Fusarium Head Blight in Wheat and its Relatives
FY19 USDA-ARS Award Amount:	$ 104,301
Recipient Organization:	North Dakota State University Office of Grant & Contract Accouting NDSU Dept 3130, PO Box 6050 Fargo, ND 58108-0650
DUNS Number:	80-388-2299
EIN:	45-6002439
Recipient Identifying Number or Account Number:	FAR0026950
Project/Grant Reporting Period:	7/10/19 - 7/9/20
Reporting Period End Date:	7/9/2020

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
DUR-CP	Introgression and Characterization of Hexaploid-Derived FHB Resistance in Durum Wheat	$ 48,697
VDHR-SPR	Enhancing Resistance of Spring Wheat to FHB Using Alien Species	$ 55,604
	FY19 Total ARS Award Amount	**$ 104,301**

Xiwen Cai

Principal Investigator — 9/18/20 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: *Introgression and Characterization of Hexaploid-Derived FHB Resistance in Durum Wheat*

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

The major goals/objectives of this research project are to provide a better understanding of the inheritance and expression of hexaploid-derived FHB resistance genes in durum, and to deploy the resistance genes in durum for germplasm development.

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?

- Increased the sizes of the two RIL populations (n=234 for the PI 277012 x LDN RIL population and n=280 for the Sumai 3 x LDN population) for FHB resistance QTL analysis in the tetraploid backgrounds using the single seed descent method.
- Performed FHB evaluation for the PI 277012 x LDN and Sumai 3 x LDN RIL populations in the greenhouse for two seasons.
- Detected novel major FHB resistance QTL on chromosome 3A and 3B in addition to those on chromosome 5A in the PI 277012 x LDN RIL population.
- Developed new SNP-derived STARP markers to saturate the QTL regions using the reference genome sequences of durum and common wheat.
- Identified the RILs that contain the PI 277012-derived resistance alleles at the QTL and used them to develop large segregating populations for fine mapping of the QTL and FHB-resistant durum germplasm for durum breeding.
- Made crosses of the three best FHB-resistant RILs containing the resistance alleles to LDN, and performed embryo rescue for rapid development of large fine mapping populations.
- Evaluated FHB resistance of the resistant RILs and other durum introgression lines with replications in the Fargo FHB nursery.
- Developed D genome-specific STARP markers to detect D-genome chromosomes in the RILs.

b) What were the significant results?

- We have identified novel PI 277012-derived FHB resistance QTL on chromosomes 3A and 3B in the PI 277012 x LDN RIL population in addition to those previously detected on chromosome 5A in the hexaploid populations. Also, we have observed significant shift of the phenotypic variation explained by the QTL in this PI 277012 x LDN RIL population comparing to the QTL analysis in the hexaploid populations. These results suggest that hexaploid-derived FHB resistance genes might act differently in the durum background or be affected by the durum background. Further

research is being performed for a better understanding of the hexaploid-derived FHB resistance genes in the durum background.

- Several RILs and some of the other introgression lines exhibited good resistance in the Fargo FHB nursery summer 2020. They represent good sources of FHB resistance for germplasm development and breeding in durum wheat.
- We have developed new SNP-derived PCR markers (STARP- semi-thermal asymmetric reverse PCR) for saturation mapping of the QTL regions. These user-friendly STARP markers have saturated the genomic regions harboring the QTL targeted in this research project, and positioned the QTL to smaller regions. In addition, these new markers are useful in fine mapping of the QTL and MAS in germplasm development and breeding.
- We have developed a new set of D-genome chromosome-specific STARP markers for D-genome chromosome analysis in both RIL populations.
- We have obtained two additional seasons of FHB evaluation data for the two RIL population in the greenhouse, and one season of field data for the durum introgression lines and selected RILs in the FHB nursery.

c) List key outcomes or other achievements.

- We have identified new FHB resistance QTL derived from the resistance parent PI 277012, which were not detected in the previous studies. This finding will facilitate our further study on the inheritance and expression of the hexaploid-derived resistance genes in the durum background.
- The newly-developed STARP markers tagging the FHB resistance QTL are useful in assisting selection of the QTL in durum breeding.
- The RILs and introgression lines showing consistent resistance will be released for use in durum breeding after verified in large-scale evaluation trials.

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.

This research project has been impacted by the COVID-19 pandemic in multiple ways, including lab/facility access limitations due to social distancing requirements.

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

One graduate student, one research specialist, and two undergraduate students have participated in this research project. This research project has provided them an opportunity to learn the procedure and principles underlying FHB inoculum preparation, inoculation, and disease development and evaluation. In addition, the graduate student has received various training in genetic analysis, chromosome engineering, genomics, and bioinformatics. These

learning and research experience have facilitated preparation for their career in plant genetics and breeding.

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

Research results from this project have been presented in the FHB Forum and local commodity groups.

Project 2: *Enhancing Resistance of Spring Wheat to FHB Using Alien Species*

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

The major goals/objectives of this project are to strengthen and diversify FHB resistance by alien introgression in spring wheat and to characterize and manipulate alien chromatin containing FHB resistance genes for a better understanding and utilization of the resistance genes in spring wheat.

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?

- Evaluated 178 advanced spring wheat introgression lines for FHB resistance in a replicated trial in the Fargo FHB nursery. We are analyzing the disease data of the lines.
- Incorporating wild species-derived FHB resistance genes into the wheat genome by inducing homoeologous recombination using *ph1b* mutant.
- Deploying wild species-derived FHB resistance genes into the adapted spring wheat cultivars and elite breeding lines for germplasm development.
- Developed SNP-derived STARP and KASP markers for FHB resistance gene mapping and MAS in germplasm development and breeding.
- Advancing generations of the progeny from 30 crosses involving different FHB resistance sources and spring wheat cultivars and breeding lines in the greenhouse.

b) What were the significant results?

- Some of the introgression lines exhibited good levels of resistance to FHB in the Fargo FHB nursery in the summer 2020. They will be potentially usable in spring wheat breeding.
- The STARP and KASP markers we have developed are useful to tag the FHB resistance genes we target and to assist selection of the genes in germplasm and variety development.

c) List key outcomes or other achievements.

- The advanced introgression lines with verified resistance under different environments will be provided to the breeding programs for variety development. This will potentially diversify and strengthen FHB resistance of spring wheat.
- The new STARP/KASP markers we have developed for the resistance genes will improve the throughput and efficacy of selection for FHB resistance in spring wheat breeding.

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.

This research project has been impacted by the COVID-19 pandemic in multiple ways, including lab/facility access limitations due to social distancing requirements.

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

One graduate student, one research specialist, one postdoctoral research fellow and two undergraduate students have participated in this research project. This research project has provided them an opportunity to learn the procedure and principles underlying FHB inoculum preparation, inoculation, and disease development and evaluation. In addition, the graduate student has received various training in genetic analysis, chromosome engineering, genomics, and bioinformatics. These learning and research experience have helped them prepare their career in plant genetics and breeding.

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

Research results from this project have been presented in the FHB Forum and local commodity groups.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY19 award period (7/10/19 - 7/9/20). 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? 1

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?**
   No

   If yes, how many?

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 (7/10/19 - 7/9/20**) 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. See example below for a poster presentation with an abstract:

De Wolf, E., D. Shah, P. Paul, L. Madden, S. Crawford, D. Hane, S. Canty, R. Dill-Macky, D. Van Sanford, K. Imhoff and D. Miller. 2019. "Impact of Prediction Tools for Fusarium Head Blight in the US, 2009-2019." In: S. Canty, A. Hoffstetter, H. Campbell and R. Dill-Macky (Eds.), *Proceedings of the 2019 National Fusarium Head Blight Forum* (p. 12), Milwaukee, WI; December 8-10. University of Kentucky, Lexington, KY.
Status: Abstract Published and Poster Presented
Acknowledgement of Federal Support: YES (Abstract and Poster)

Journal publications.

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

Other publications, conference papers and presentations.

Ren, S., Zhu, X., Leng, Y., Zhang, W., Talukder, Z., Zhong, S., Fiedler, J., Qi, L., and Cai, X. 2019. "Molecular mapping of hexaploid wheat-derived Fusarium head blight resistance in durum wheat". In: S. Canty, A. Hoffstetter, H. Campbell and R. Dill-Macky (Eds.), *Proceedings of the 2019 National Fusarium Head Blight Forum* (p. 117), Milwaukee, WI; December 8-10. University of Kentucky, Lexington, KY.
Status: Abstract Published and Poster Presented
Acknowledgement of Federal Support: YES (Abstract and Poster)