USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY19 Performance Progress Report - NCE
Due date: July 29, 2021

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 - 7/9/21
Reporting Period End Date:	7/9/2021

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**

Shaobin Zhong 07/29/2021

Principal Investigator Date

* MGMT – FHB Management
FST – Food Safety & Toxicology
R – Research
S – Service (DON Testing Lab)
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 FHB resistance genes in durum for germplasm development.

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?
   - 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 three 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.
   - Performed whole genome mapping and FHB resistance QTL analysis in both RIL populations and detected novel major FHB resistance QTL in the durum backgrounds in addition to those derived from the hexaploidy resistance sources.
   - 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.
   - Selected FHB-resistant durum RILs for germplasm development.
   - Developed D genome-specific STARP markers to detect D-genome chromosomes in the RILs.

   b) What were the significant results?
   - Detected and verified 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.

- Identified new FHB resistance QTL in the Sumai 3 x LDN RIL population in addition to those in Sumai 3. Apparently, the Sumai 3-derived FHB resistance genes perform in a different way due probably to epistatic effect in the durum background.
- Multiple RILs and some of the other introgression lines exhibited good resistance in the Fargo FHB nursery summer 2020. We will re-evaluate and verify their resistance for germplasm development. Potentially, some of them will represent good sources of FHB resistance usable in durum breeding.
- 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 parents PI 277012 and Sumai 3, which have not been detected in the previous studies. These findings will facilitate further studies 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 and/or restrictions, 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 their career preparation 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 these three items 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.
- Analyzed the FHB disease data of the 178 advanced spring wheat introgression lines and selected most resistant introgression lines for further verification and germplasm development.
- Incorporated wild species-derived FHB resistance genes, such as *Fhb7*, into the wheat genome by genomics-enabled chromosome engineering.
- 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 by single-seed descent approach in the greenhouse.
- Made multiple crosses for chromosome substitution-mediated FHB resistance gene introgression.

b) What were the significant results?

- Some of the introgression lines exhibited good levels of resistance to FHB in the Fargo FHB nursery. They will be potentially usable in spring wheat breeding.
- Transferred *Fhb7* and other wild species-derived FHB resistance genes to wheat by inducing chromosome translocation.
- 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 and/or restrictions, 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 - 7/9/21)**. 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?**
   ☐Yes ☒No
   If yes, how many? Click to enter number here.

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 ☒No
   If yes, how many? Click to enter number here.

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 ☒No
   If yes, how many? Click to enter number here.

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?**
   ☐Yes ☒No
   If yes, how many? Click to enter number here.

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 (7/10/19 - 7/9/21)**. 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	FHB Rating (0-9)	Year Released
Nothing to report.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
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Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
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Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year

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

Publications, Conference Papers, and Presentations

Instructions: Refer to the 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 - 7/9/21**) 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:

Z.J. Winn, R. Acharya, J. Lyerly, G. Brown-Guedira, C. Cowger, C. Griffey, J. Fitzgerald, R.E. Mason and J.P. Murphy. 2020. "Mapping of Fusarium Head Blight Resistance in NC13-20076 Soft Red Winter Wheat." In: S. Canty, A. Hoffstetter, and R. Dill-Macky (Eds.), *Proceedings of the 2020 National Fusarium Head Blight Forum (*p. 12.), Virtual; December 7-11. Online: https://scabusa.org/pdfs/NFHBF20_Proceedings.pdf.
Status: Abstract Published and Poster Presented
Acknowledgement of Federal Support: YES (Abstract and Poster)

Journal publications.

Nothing to report.

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

Nothing to report.

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)

Ren, S., Zhu, X., Leng, Y., Zhang, W., Talukder, Z., Zhong, S., Fiedler, J., Qi, L., and Cai, X. 2020. Toward a better understanding of the hexaploid wheat-derived Fusarium head blight resistance in durum wheat. 2020 National Fusarium Head Blight Forum, Virtual Forum via Zoom, December 7-11, 2020.
Status: Abstract Published and Poster Presented
Acknowledgement of Federal Support: YES (Abstract and Poster)