USDA-ARS
U.S. Wheat and Barley Scab Initiative
FY16 Final Performance Report – NCE for FY17
Due date: July 31, 2018

Cover Page

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Fiscal Year:	2016 (NCE for FY17)
USDA-ARS Agreement ID:	59-0200-3-001
USDA-ARS Agreement Title:	Characterization of Resistance to Fusarium Head Blight in Wheat and its Relatives.
FY16 USDA-ARS Award Amount:	$ 81,864 (NCE for FY17)
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:	FAR0020589
Award Reporting Period:	5/1/17 - 4/30/18
Reporting Period End Date:	04/30/18

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
DUR-CP	Characterization and Introgression of Hexaploid FHB Resistance Genes in Durum.	$ 40,028
VDHR-SPR	Enhancing Resistance of Spring Wheat to FHB using Alien Species.	$ 41,836
	FY16 Total ARS Award Amount	**$ 81,864**

7/26/18

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: *Characterization and Introgression of Hexaploid FHB Resistance Genes in Durum.*

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

The major goals and objectives of this project were to understand the effects of durum background and D-genome chromosomes on FHB resistance and to develop durum germplasm by FHB resistance gene introgression from hexaploid wheat into durum.

2. What was accomplished under these goals?

1) Major activities

- Searching for new sources of resistance from wheat-wild species derivatives.
- Made crosses of newly identified resistance sources to adapted durum varieties/lines and manipulated chromosomes for gene introgression and germplasm development.
- Evaluated the segregation populations for FHB resistance (F_2-F_4) from the crosses of durum varieties/lines (Divide, Grenora, Alkabo, and D87450) with eight FHB-resistant hexaploid wheat lines that contain non-*fhb1* or wild species-derived resistance genes in the greenhouse and selected resistant segregants for generation advancement and further FHB evaluation.
- Advanced generations (F_1-F_3) of the new crosses between durum cultivars and the wild species-derived common wheat lines.
- Screened advanced durum introgression lines with varied levels of FHB resistance derived from different hexaploid sources in the FHB nurseries at Fargo/Langdon, ND and Hangzhou/Jianyang, China.
- Developing the RIL populations for mapping and genetic analysis of hexaploid-derived FHB resistance genes (Sumai 3 and PI 277012) in durum background.
- Characterizing the RIL populations for the D-genome chromosome constitution in each of the RILs.
- Increasing seed of the RILs for FHB resistance evaluation.
- Evaluating the RIL populations for FHB resistance in the greenhouse environments;
- Genotyping the RILs at the molecular marker loci closely linked to the hexaploid-derived FHB resistance QTL.

2) Specific objectives

- Characterize the hexaploid-derived FHB resistance genes in durum background and the role of D-genome chromosomes in FHB resistance;
- Incorporate FHB resistance QTL from hexaploid wheat into adapted durum backgrounds for germplasm development; and
- Validate the molecular markers tagging resistance QTL in durum germplasm.

3) Significant results

- Developed 59 advanced hexaploid-derived durum germplasm lines that have exhibited improved FHB resistance in the multi-year/location evaluation experiments. They have been provided to the durum breeding program for variety development.

- Selected 310 new hexaploid-derived durum introgression lines (F_{4-5}) exhibiting FHB resistance in the greenhouse screening experiments. We are re-evaluating these introgression lines to verify their resistance in the FHB nurseries at Fargo and Langdon, ND.
- Screened the F_2 populations (n=696) derived from the crosses involving 13 hexaploid FHB resistance sources and 7 adapted durum cultivars/lines for FHB resistance in the greenhouse and selected FHB-resistant segregants for generation advancement and further evaluation of FHB resistance in the advanced generations.
- Increased seed of two RIL populations (n=173 and 350) from the crosses of two major hexaploid FHB resistance sources (Sumai 3 and PI 277012) with FHB-susceptible durum wheat 'Langdon' for FHB evaluation and genotyping.
- Determined D-genome chromosome constitution in some of the RILs by chromosome-specific molecular markers.
- Evaluated one of the two RIL populations for FHB resistance in two greenhouse seasons.

4) Key outcomes or other achievements

- Fifty-nine durum germplasm lines with improved FHB resistance
- Hundreds of introgression materials with potential FHB resistance
- Two RIL populations useful for characterizing the effect of the durum background and D-genome chromosomes on FHB resistance

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

Two graduate students, one research specialist, and three undergraduate students have been involved 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 students have received various training in genetic analysis, chromosome engineering, genomics, and bioinformatics. These learning and research experience have facilitated their preparation for a prosperous career in plant genetics and breeding.

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

Research results from this project have been published in the international scientific journals and presented in the international and national scientific conferences 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 project?

The major goals and objectives of this project were to: 1) Strengthen and diversify FHB resistance by alien introgression in spring wheat; and 2) 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?

1) Major activities
   - Searching for new sources of FHB resistance from wheat-related wild species by screening wheat-wild species derivatives we have developed and collected for FHB resistance.
   - Made crosses of the newly identified resistance sources with adapted spring wheat cultivars/breeding lines and generated segregating populations for FHB resistance.
   - Manipulated chromosomes to eliminate unwanted alien chromatin for the development of breeder-friendly germplasm using genomic *in situ* hybridization (GISH) and molecular markers.
   - Screened thousands of progeny at early generations (F_2-F_4) for FHB resistance in the greenhouse and selected resistant segregants from the segregating populations for generation advancement.
   - Selected advanced spring wheat introgression lines derived from the crosses involving non-*fhb1* resistance sources and evaluated their resistance to FHB with replications in the FHB nurseries at Fargo/Langdon, ND, Brookings, SD, and Hangzhou/Jianyang, China.

2) Specific objectives
   - Incorporate FHB resistance genes from wheat-alien species derivatives into adapted spring wheat genotypes.
   - Position the alien chromatin containing FHB resistance genes incorporated into the wheat genome and minimizing linkage drag associated with resistance genes.
   - Pyramid alien and wheat FHB resistance genes.
   - Develop FHB-resistant germplasm directly usable in spring wheat breeding.

3) Significant results
   - Provided 167 FHB-resistant spring wheat germplasm lines and 87 spring wheat breeding populations with FHB resistance to the hard red spring wheat breeding programs for variety development. They are derived from the crosses involving different FHB resistance sources and contain the genes for various agronomic traits and resistance to other major diseases in addition to FHB.
   - Selected 192 new spring wheat introgression lines (F_{4-5}) exhibiting FHB resistance in the greenhouse screening experiments. We are re-evaluating these introgression lines

to verify their resistance in the FHB nurseries at Fargo and Langdon, ND and Brookings, SD.

- Screened the F_2 populations (n=774) derived from the crosses involving 16 newly identified resistance sources with 9 adapted spring wheat genotypes for FHB resistance in the greenhouse, and selected the FHB-resistant segregants for generation advancement and further evaluation of FHB resistance.

4) Key outcomes or other achievements
   - Developed FHB-resistant spring wheat germplasm (n=167) and breeding populations (n=87) usable for variety development.
   - Generated and identified hundreds of introgression materials and a large number of FHB-resistant segregants at early generations. Further evaluation of these materials for FHB resistance and other agronomic traits will lead to the development of new spring wheat germplasm with FHB resistance.

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

Two graduate students, one research specialist, and three undergraduate students have been involved 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 students have received various training in genetic analysis, chromosome engineering, genomics, and bioinformatics. These learning and research experience have facilitated their preparation for a prosperous career in plant genetics and breeding.

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

Research results from this project have been published in the international scientific journals and presented in the international and national scientific conferences and local commodity groups.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY16 award period. 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 FY16 award period?**

   None

2. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY16 award period?**

   None

3. **Have any post docs who worked for you during the FY16 award period and were supported by funding from your USWBSI grant taken faculty positions with universities?**

   None

4. **Have any post docs who worked for you during the FY16 award period and were supported by funding from your USWBSI grant gone on to take positions with private ag-related companies or federal agencies?**

   One

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 FY16-NCE award period. All columns must be completed for each listed germplasm/cultivar. Use the key below the table for Grain Class abbreviations.
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 FY16-FPR_Instructions for detailed instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY16 grant. Only include citations for publications submitted or presentations given during your award period (5/1/17 - 4/30/18). If you did not have any publications or presentations, state 'Nothing to Report' directly above the Journal publications section.

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

Journal publications.

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

Other publications, conference papers and presentations.

Cai, X. 2017. Meiotic homoeologous recombination-based alien gene introgression in wheat. Annual Wheat Newsletter vol. 63.

Status: Published

Acknowledgement of Federal Support: No