USDA-ARS
U.S. Wheat and Barley Scab Initiative
FY18 Performance Report
Due date: July 12, 2019

Cover Page

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Fiscal Year:	2018
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USDA-ARS Agreement Title:	Characterization of Resistance to Fusarium Head Blight in Wheat and its Relatives.
FY18 USDA-ARS Award Amount:	$ 104,302
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
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Recipient Identifying Number or Account Number:	FAR0026950
Project/Grant Reporting Period:	7/10/18 - 7/9/19
Reporting Period End Date:	07/09/19

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.	$ 48,698
VDHR-SPR	Enhancing Resistance of Spring Wheat to FHB Using Alien Species.	$ 55,604
	FY18 Total ARS Award Amount	$ 104,302

Xiwen Cai 6/11/19
Principal Investigator Date
DUR-CP and VDHR-SPR

* 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

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Project 1: *Introgression and Characterization of Hexaploid-Derived FHB Resistance in Durum Wheat.*

1. **What are the major goals and objectives of the project?**
   The major goals/objectives of this project are 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?** *Address items 1-4) below for each goal or objective.*

   1) Major activities
   - Evaluated wheat-wild species derivatives for new sources of resistance to FHB.
   - Made crosses of newly identified resistance sources to adapted durum varieties/lines and manipulated chromosomes for gene introgression and germplasm development.
   - Screened the segregating populations for FHB resistance (F_2-F_4) from the crosses of durum varieties/lines with 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 screening.
   - 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 in Fargo FHB nursery.
   - Developed the RIL populations for mapping and genetic analysis of hexaploid-derived FHB resistance genes (Sumai 3 and PI 277012) in the durum background.
   - Characterized the RIL populations for the D-genome chromosome constitution in each of the RILs.
   - Increased seed of the RILs for FHB resistance evaluation.
   - Evaluated the RIL populations for FHB resistance in the greenhouse environments;
   - Genotyped the RILs at the molecular marker loci closely linked to the hexaploid-derived FHB resistance QTL and the entire LDN x PI 277012 RIL population using wheat 90K SNP arrays.
   - Performed linkage and QTL mapping in the LDN x PI 277012 RIL population.

   2) Specific objectives
   - Understanding the effects of the durum background and wheat D-genome chromosomes on FHB resistance;
   - Incorporating the hexaploid-derived FHB resistance genes into durum for germplasm development;
   - Developing and validating user-friendly molecular markers useful in breeding for FHB resistance in durum.

   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 were provided to the durum breeding program for further evaluation of FHB resistance in the Prosper FHB nursery and for potential use in variety development.

- Selected 55 new hexaploid-derived durum introgression lines exhibiting improved FHB resistance in the FHB nursery. We are re-evaluating these introgression lines to verify their resistance in the FHB nursery at Fargo, ND.
- Screened the individuals at F_4 generation (n=380) 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.
- Obtained FHB phenotyping data for the LDN x PI 277012 RIL population in two additional greenhouse seasons.
- Obtained wheat 90K SNP genotyping data for the LDN x PI 277012 RIL population and verified the FHB resistance QTL in the RIL population.
- Developed new SNP-based PCR markers (STARP) within the QTL region.

4) Key outcomes or other achievements

- A total of 114 durum germplasm lines with improved FHB resistance
- Hundreds of intermediate 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
- Mapping and marker results for the genetic analysis of FHB resistance genes in durum

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 preparation for their 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/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?

1) Major activities

- Evaluated the wheat-wild species derivatives we have developed and collected for new sources of FHB resistance derived from wheat-related wild species.
- 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_3-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.

2) Specific objectives

- Incorporating alien FHB resistance genes into adapted spring wheat genotypes;
- Characterizing the alien chromatin containing FHB resistance genes incorporated into the wheat genome and minimize linkage drag associated with resistance genes; and
- Developing breeding-friendly germplasm with improved FHB resistance.

3) Significant results

- Provided hundreds of FHB-resistant spring wheat germplasm lines and over 80 spring wheat breeding populations with FHB resistance to the hard red spring wheat breeding programs for potential use in 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 58 new spring wheat introgression lines (F_{5-6}) exhibiting improved FHB resistance in the Fargo FHB nursery. We are re-evaluating these introgression lines to verify their resistance in the FHB nursery at Fargo, ND.
- Advanced F_3 generation to F_4 for the crosses involving 16 newly identified resistance sources with 9 adapted spring wheat genotypes for FHB resistance in the greenhouse.
- Screening the F_4 progenies (n=1,872) derived from the crosses to select FHB-resistant segregants for further generation advancement and FHB evaluation.

4) Key outcomes or other achievements

- Developed new FHB-resistant spring wheat introgression lines (n=58) usable for variety development.
- Generated over 100 breeding populations and identified 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 FY18 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 FY18 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 FY18 award period?**

   No
   If yes, how many?

3. **Have any post docs who worked for you during the FY18 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 FY18 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 FY18 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 FY18-FPR_Instructions for detailed instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY18 grant. Only include citations for publications submitted or presentations given during your award period (7/10/18 - 7/9/19). 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. See example below for a poster presentation with an abstract:

> Conley, E.J., and J.A. Anderson. 2018. Accuracy of Genome-Wide Prediction for Fusarium Head Blight Associated Traits in a Spring Wheat Breeding Program. In: Proceedings of the XXIV International Plant & Animal Genome Conference, San Diego, CA.
> Status: Abstract Published and Poster Presented
> Acknowledgement of Federal Support: YES (poster), NO (abstract)

Journal publications.

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

Other publications, conference papers and presentations.