USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY15 Final Performance Report
Due date: July 15, 2016

Cover Page

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Fiscal Year:	2015
USDA-ARS Agreement ID:	59-0200-3-001
USDA-ARS Agreement Title:	Characterization of Resistance to Fusarium Head Blight in Wheat and its Relatives.
FY15 USDA-ARS Award Amount:	$ 80,368
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
Project/Grant Reporting Period:	05/01/15-04/30/16
Reporting Period End Date:	04/30/16

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
DUR-CP	Introgression of Fusarium Head Blight Resistance from Hexaploid Wheat to Durum.	$ 40,330
VDHR-SPR	Enhancing Resistance of Spring Wheat to FHB Using Alien Species.	$ 40,038
	FY15 Total ARS Award Amount	**$ 80,368**

7/6/16

Principal Investigator Date

VDHR and DUR-CP

* 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 of Fusarium Head Blight Resistance from Hexaploid Wheat to Durum.*

1. **What are the major goals and objectives of the project?**
   The major goals and objectives of this project are to: 1) Develop durum germplasm with improved FHB resistance from hexaploid FHB resistance sources; and 2) Understand the effects of durum background and D-genome chromosomes on FHB resistance.

2. **What was accomplished under these goals?**
   1) Major activities
   - Searching for new sources of resistance from wheat-related wild species and wheat-wild species derivatives.
   - Made crosses of 8 newly identified resistance sources to 4 adapted durum varieties/lines and manipulated chromosomes for gene introgression and germplasm development.
   - Evaluated thousands of progenies for FHB resistance from the crosses of durum varieties/lines, i.e. 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 about 200 FHB-resistant segregants for generation advancement and FHB evaluation.
   - Advancing generations (F_1-F_3) of the crosses we made with six durum cultivars (Joppa, Alkabo, Divide, Tioga, Carpio, and Grenora) to Truman and 27 FHB-resistant wild species-derived common wheat lines.
   - Screening 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, China.
   - Developing disomic D-genome chromosome addition lines in the durum background to further evaluate the effect of D-genome chromosomes on FHB resistance.
   - Developing RI populations for mapping and genetic analysis of hexaploid-derived FHB resistance genes in durum background.

   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 gemplasm development.
   - Validate the molecular markers tagging resistance QTL in durum germplasm.

   3) Significant results
   - Identified four hexaploid wheat lines with wild species-derived FHB resistance and made crosses of these hexaploid resistance sources with two adapted durum cultivars (Divide and Alkabo);
   - Selected about 200 FHB-resistant segregants (F_{3-4}) from thousands of progenies from the crosses of four durum varieties/lines, i.e. 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.

- Developed a total of 223 advanced durum introgression lines with varied levels of FHB resistance derived from different hexaploid sources and re-evaluated those lines for FHB resistance in the FHB nursery at Fargo, ND. Seventy-eight introgression lines were selected with highest resistance levels and were further evaluated in the FHB nursery at Hangzhou, China.
- Developed two RI populations at F_5 generation (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'.
- Positioned the wild emmer-derived FHB resistance QTL *Qfhs.ndsu-3AS* into a smaller genomic region and developed new PCR-based DNA markers flanking the QTL in durum.

4) Key outcomes or other achievements

The major challenges we have been facing in durum are the shortage of native durum resistance sources and complex inheritance of FHB resistance in durum background. We have been constantly enriching the gene pool for FHB resistance in durum by performing gene introgression from hexaploid wheat and wild species in this research project. A number of durum introgression lines with improved FHB resistance have been developed. They will be utilized in durum breeding for FHB resistance. However, the hexaploid-derived resistance genes do not seem to be fully expressed in durum due to possible background effect and/or suppression factors. We are developing large durum RI populations that are segregating at two major hexaploid-derived FHB resistance loci. These two populations will be useful in the identification and mapping of the genetic factors that interact with the FHB resistance genes. This will potentially provide new insights into the genetic basis of FHB resistance in durum and eventually strengthen resistance of durum to FHB.

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

Three 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 are 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 16 newly identified resistance sources with 9 adapted spring wheat cultivars/breeding lines and generated 144 F_2 populations
   - 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 for FHB resistance in 2-3 greenhouse seasons 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 and Hangzhou, 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
   - Identified four spring wheat lines with wild species-derived FHB resistance and made crosses of these resistance sources with adapted spring wheat genotypes.
   - Produced 144 F_2 populations from the crosses of 16 newly identified resistance sources with 9 adapted spring wheat genotypes and being advancing generations of the FHB-resistant segregants in the greenhouse.
   - Selected 124 advanced spring wheat introgression lines derived from non-*fhb1* resistance sources based on FHB screening under the greenhouse environment. They will be evaluated for FHB resistance and agronomic performance in the FHB nurseries in ND and China.

- Evaluated the 124 advanced spring wheat introgression lines with two replications in the FHB nursery at Fargo, ND and selected 55 most resistant lines for further evaluation in the FHB nursery at Hangzhou, China.
- Forty-three spring wheat introgression lines have consistently exhibited improved FHB resistance across all field locations in ND (Fargo and Langdon) and China (Hangzhou). They will be made available for variety development.

4) Key outcomes or other achievements

We aim to strengthen and diversify resistance of spring wheat to FHB using wheat-related wild species in this project. We have constantly developed and identified wheat-wild species derivatives with FHB resistance. The wild species-derived FHB resistance has been incorporated into adapted spring wheat genotypes without obvious deleterious traits from wild species by DNA marker-assisted chromosome engineering. Spring wheat germplasm with improved FHB resistance and various agronomic characteristics have been developed and utilized in wheat breeding. We anticipate that these germplasm lines with wild species-derived FHB resistance would strengthen and diversify FHB resistance of spring wheat. In addition, these FHB-resistant spring wheat germplasm will be useful in improving FHB resistance of other US wheat classes.

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

Three 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 FY15 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 FY15 award period?**

   Yes. One

2. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY15 award period?**

   Yes. One

3. **Have any post docs who worked for you during the FY15 award period and were supported by funding from your USWBSI grant taken faculty positions with universities?**

   No

4. **Have any post docs who worked for you during the FY15 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. 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 FY15 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

Refer to the FY15-FPR_Instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY15 grant. If you did not have any publications or presentations, state 'Nothing to Report' directly above the Journal publications section.

Journal publications.

Zhu, X., Zhong, S., Chao, S., Gu, Y., Kianian, S., Elias, E., and Cai, X. 2016. Toward a better understanding of the genomic region harboring Fusarium head blight resistance QTL Qfhs.ndsu-3AS in durum wheat. Theor Appl Genet 129:31-43.
Status: Published
Acknowledgement of Federal Support: Yes

Zhu, X., Zhong, S., and Cai., X. 2016. Effects of D-genome chromosomes and their A/B-genome homoeologs on Fusarium head blight resistance in durum wheat. Crop Sci 56:1049-1058.
Status: Published
Acknowledgement of Federal Support: Yes

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

Nothing to Report.

Other publications, conference papers and presentations.

Zhu, X., Zhong, S., and Cai, X. 2015. Cytogenetic dissection of A, B, and D genome provides new insights into Fusarium head blight resistance in durum wheat (poster). In: S. Canty, A. Clark, S. Vukasovich and D. Van Sanford (Eds.), *Proceedings of the 2015 National Fusarium Head Blight Forum (*p. 110). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
Status: Abstract Published and poster presented
Acknowledgement of Federal Support: YES (poster), NO (abstract)