USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY14 Final Performance Report
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Cover Page

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Fiscal Year:	FY14
USDA-ARS Agreement ID:	59-0200-3-001
USDA-ARS Agreement Title:	Characterization of Resistance to Fusarium Head Blight in Wheat and its Relatives.
FY14 USDA-ARS Award Amount:	$ 77,739

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.	$ 37,662
VDHR-SPR	Enhancing Resistance of Spring Wheat to FHB Using Alien Species.	$ 40,077
	FY14 Total ARS Award Amount	**$ 77,739**

7-7-15

Principal Investigator Date

DUR-CP and VDHR-SPR

* MGMT – FHB Management
FSTU – Food Safety, Toxicology, & Utilization of Mycotoxin-contaminated Grain
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
WES-CP – Western 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 major problem or issue is being resolved relevant to Fusarium head blight (scab) and how are you resolving it?

Sources of resistance to FHB have been identified in durum landraces and tetraploid relatives of durum. Significant efforts have been made to incorporate those resistance genes into adapted durum backgrounds. Those resistance genes, however, have become less effective when they are incorporated into adapted durum backgrounds. Similar results have been observed with other disease resistance genes in durum. Apparently, there are genetic factors that interfere expression of disease resistance genes in the adapted durum genotypes. Also, we have found that hexaploid wheat-derived FHB resistance genes become less effective when transferred to durum backgrounds. In addition to the background effects, we suspect that D-genome chromosomes may play a role in the expression of FHB resistance genes in wheat. We have employed the entire set of disomic Langdon (LDN) durum D-genome chromosome substitution lines (n=14) that dissect the durum genome (i.e. A and B) to investigate the effect of individual A-, B-, and D-genome chromosomes on FHB resistance. We have evaluated the 14 disomic LDN D-genome substitution lines with three replications for FHB resistance in seven greenhouse seasons and identified individual LDN durum and D-genome chromosomes with critical effects on FHB resistance. Meanwhile, we have generated several segregating populations from the crosses of two hexaploid resistance sources (Sumai 3 and PI 277012) with LDN and its D-genome substitution lines, and investigated inheritance of the hexaploid-derived FHB resistance genes in durum. Results from these studies have revealed new insights into inheritance of hexaploid-derived FHB resistance genes in the durum background. Moreover, we developed synthetic hexaploid wheat (SHW) lines and derived durum-D genome chromosome addition lines. Evaluation of the SHW lines and D-genome chromosome addition lines has allowed us to determine the effect of individual D-genome chromosomes as well as different D-genome chromosome combinations on FHB resistance in the durum background. Molecular marker and chromosome analyses have been used to identify the durum lines with additional D-genome chromosomes. These studies have provided a better understanding of FHB resistance in durum and facilitate further characterization of the genetic and molecular basis of FHB resistance in durum.

In addition, we have been continuously searching for new sources of resistance from relatives of wheat and making crosses of newly identified resistance sources to adapted durum varieties/lines for germplasm development. We have screened thousands of progenies for FHB resistance 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 2-3 greenhouse seasons each year. About 200-300 FHB-resistant segregants are selected from those crosses in each season and advanced to the next generation for further evaluation in the greenhouse. Also, we have developed a total of 223 advanced durum
introgression lines with varied levels of FHB resistance derived from different hexaploid sources. We re-evaluated those lines for FHB resistance in the FHB nursery at Fargo, ND during summer 2014. Seventy-eight introgression lines selected with highest resistance

levels were further evaluated in the FHB nursery at Hangzhou, China in the 2014-2015 season. The introgression lines that consistently exhibit FHB resistance and acceptable agronomic performance will be released to the durum breeding programs for variety development. Also, we have been advancing generations (F1-F3) of the crosses we made with six durum cultivars (Joppa, Alkabo, Divide, Tioga, Carpio, and Grenora) to Truman and other 27 FHB-resistant wild species-derived common wheat lines. These FHB introgression efforts will potentially diversify and improve resistance of durum to FHB.

2. List the most important accomplishments and their impact (i.e. how are they being used) to minimize the threat of Fusarium Head Blight or to reduce mycotoxins. Complete both sections; repeat sections for each major accomplishment:

Accomplishment:

- Developed segregating populations (F2-F3) from the crosses of six durum cultivars with Truman and 27 FHB-resistant hexaploid wheat lines derived from different wild species.
- Developed 171 advanced durum introgression lines exhibiting improved FHB resistance and various agronomic characteristics in our greenhouse and field evaluation experiments.
- Screened about 1,000 progenies for FHB resistance from the crosses of four durum varieties/lines with eight FHB-resistant hexaploid wheat lines that contain non-*fhb1* or wild species-derived resistance genes in the greenhouse and selected 10-20 FHB-resistant segregants from each of the crosses for further evaluation of FHB resistance in the advanced generation.
- Identified LDN durum chromosome 5A and Chinese Spring common wheat chromosome 6D that possibly contain genes for FHB susceptibility and/or suppression of FHB resistance.
- Identified *Aegilops tauschii* chromosomes 1D and 5D that contain FHB resistance genes with additive effect in the durum background based on our preliminary results.

Impact:

- The durum introgression lines that consistently exhibit FHB resistance under multiple environments will be released to the durum breeding programs for variety development. This will make the hexaploid- and wild species-derived resistance genes usable in durum breeding and eventually enhance FHB resistance of durum.
- This research has revealed new insights into the role of individual D-genome and durum chromosomes in the expression and inheritance of FHB resistance genes in wheat. A better understanding of the genetic basis for FHB resistance in both tetraploid and hexaploid wheat will facilitate identification and utilization of FHB resistance genes in the development of superior durum varieties.

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

1. What major problem or issue is being resolved relevant to Fusarium head blight (scab) and how are you resolving it?

Sumai 3 and its derivatives remain the most effective source of FHB resistance and have been widely utilized in wheat breeding worldwide. Strengthening and diversifying FHB resistance has been one of the primary research goals in spring wheat and other classes of common wheat. One of the strategies to achieve this research goal is to search for novel resistance genes from wheat-related wild grass species and incorporate them into the wheat genome. There are two major challenges for alien gene introgression, including 1) low meiotic recombination frequency between wheat and alien chromosomes, and 2) linkage drag associated with the alien chromatin harboring FHB resistance genes. We have used *ph1b* mutant to enhance meiotic recombination between wheat and alien homoeologous chromosomes. Alien chromatin-associated deleterious effects have been minimized in the alien introgression lines through this approach. Meanwhile, we have been consistently searching for new sources of resistance from wheat-related wild species and wheat-wild species derivatives we have developed and collected. Chromosome engineering-mediated alien gene introgression has been repeatedly performed to incorporate newly identified wild species-derived FHB resistance genes into adapted spring wheat backgrounds for germplasm development. Another challenge for alien introgression is the evaluation and selection of introgression materials with FHB resistance due to complex inheritance of FHB resistance genes in wheat and its relatives. To deal with this challenge, we have screened the segregating materials at early generations for FHB resistance under greenhouse environments and selected resistant segregants to advance generations. Advanced introgression lines selected with FHB resistance in the greenhouse have been verified for FHB resistance under field conditions at multiple locations in ND and China. Also, we have submitted the resistant lines for DON testing to select FHB-resistant germplasm with low DON accumulation. This alien introgression approach has been effectively used in FHB resistance gene transfer from wild species to spring wheat in this project. The breeder-friendly alien introgression lines with FHB resistance and reduced DON developed in the project have been made available to the spring wheat breeding programs for variety development. This will potentially strengthen and diversify resistance of spring wheat to FHB.

We have identified sixteen additional wheat-alien species derivatives with FHB resistance and made crosses of these sixteen FHB-resistant lines to nine spring wheat varieties/lines. A total of 144 F2 populations were developed from these crosses for FHB resistance gene introgression. They will be evaluated for FHB resistance in the greenhouse. During FY14 funding period, we evaluated a total of 150 advanced spring wheat introgression lines derived from non-*fhb1* resistance sources with two replications in the FHB nursery at Fargo, ND. Seventy-nine spring wheat introgression lines selected in the 2014 Fargo FHB nursery and thirty winter wheat accessions identified as FHB-resistant in the greenhouse were evaluated for FHB resistance with two replications in the 2014-2015 FHB nursery at Hangzhou, China. The introgression lines that consistently exhibit resistance to FHB under different environments and low DON accumulation will be provided to the wheat breeding programs for variety development.

List the most important accomplishments and their impact (i.e. how are they being used) to minimize the threat of Fusarium Head Blight or to reduce mycotoxins. Complete both sections; repeat sections for each major accomplishment:

Accomplishment:

- Evaluated a total of 150 advanced spring wheat introgression lines derived from several resistance sources and selected 79 lines that exhibited improved FHB resistance in the FHB nursery at Fargo, ND.
- Verified FHB resistance of the 79 spring wheat introgression lines and 30 winter wheat accessions identified as FHB-resistant in the FHB nursery at Hangzhou, China. Forty spring wheat introgression lines have been provided to the spring wheat breeding program at South Dakota State University for re-evaluation of FHB resistance and other agronomic characteristics.
- Screened about 1,000 F_4 progenies for FHB resistance from the crosses involving non-*fhb1* or wild species-derived resistance genes in the greenhouse and selected about 90 FHB-resistant segregants for further FHB evaluation in the greenhouse.
- Developed 144 F2 populations derived from the crosses of spring wheat varieties/lines with Truman and other 27 wild species-derived common wheat lines with FHB resistance

Impact:

- We have developed new spring wheat germplasm lines from the non-*fhb1* and wild species-derived resistance sources identified in this project. These germplasm will potentially enhance and diversify FHB resistance of spring wheat and other classes of common wheat.
- Germplasm lines developed in this project have been and will be continuously made available to the spring wheat and other classes of wheat breeding programs for the development of superior wheat cultivars with durable and diversified resistance to FHB and reduced DON accumulation in kernels.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY14 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 FY14 award period?**

   Yes.

   If yes, how many? One.

2. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY14 award period?**

   Yes.

   If yes, how many? One.

3. **Have any post docs who worked for you during the FY14 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 FY14 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

Include below a list of all germplasm or cultivars released with full or partial support of the USWBSI during the FY14 award period. List the release notice or publication. Briefly describe the level of FHB resistance. *If not applicable because your grant did NOT include any VDHR-related projects, enter N/A below.*

All spring and durum wheat introgression lines developed in this project have not been officially released. They have diverse agronomic characteristics in addition to varied levels of resistance to FHB. Some of the spring wheat introgression lines (n=65) have been provided to the wheat breeding programs for use in variety development. Crosses have been made with the FHB-resistant spring wheat lines in the breeding programs. All durum introgression lines developed in this project are still under field evaluation of FHB resistance and other agronomic traits. We anticipate 8-10 durum introgression lines with hexaploid-derived FHB resistance will be made available to the breeding programs for variety development in 2016.

Include below a list of the publications, presentations, peer-reviewed articles, and non-peer reviewed articles written about your work that resulted from all of the projects included in the FY14 grant. Please reference each item using an accepted journal format. If you need more space, continue the list on the next page.

1) Zhu, X., Zhong, S., Chao, S., Gu, Y. Q., Kianian, S. F., Elias, E., and Cai, X. 2015. Toward a better understanding of the genomic region harboring Fusarium head blight resistance QTL *Qfhs.ndsu-3AS* in durum wheat. Theor Appl Genet (under revision).

2) Zhang, Q., Axtman, J. E., Faris, J. D., Chao, S., Zhang, Z., Friesen, T. L., Zhong, S., Cai, X., Elias, M. E., and Xu, S. S. 2014. Identification and molecular mapping of quantitative trait loci for Fusarium head blight resistance in emmer and durum wheat using a single nucleotide polymorphism-based linkage map. Mol Breed 34: 1677–1687.

3) Zhu, X., Zhong, S., Xu, S. S., Elias, E., Jyoti, J., Cai, X. 2014. Effects of durum wheat background on the expression of hexaploid wheat-derived Fusarium head blight resistance genes. 2014 National Fusarium Head Blight Forum, St. Louis, MO, December 7-9, 2014.