**USDA-ARS/**
**U.S. Wheat and Barley Scab Initiative**
**FY13 Final Performance Report**
**July 15, 2014**

# Cover Page

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| **Fiscal Year:** | FY13 |
| **USDA-ARS Agreement ID:** | 59-0200-3-001 |
| **USDA-ARS Agreement Title:** | Characterization of Resistance to Fusarium Head Blight in Wheat and its Relatives. |
| **FY13 USDA-ARS Award Amount:** | $ 74,019 |

**USWBSI Individual Project(s)**

| USWBSI Research Category* | Project Title | ARS Award Amount |
|---|---|---|
| DUR-CP | Transferring FHB Resistance from Hexaploid Wheat to Durum. | $ 39,939 |
| VDHR-SPR | Enhancing Resistance of Spring Wheat to FHB Using Alien Species. | $ 34,080 |
| | **FY13 Total ARS Award Amount** | **$ 74,019** |

July 10, 2014

Principal Investigator Date

* MGMT – FHB Management
FSTU – Food Safety, Toxicology, & Utilization of Mycotoxin-contaminated Grain
GDER – Gene Discovery & Engineering Resistance
PBG – Pathogen Biology & Genetics
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:** *Transferring FHB 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?**

Multiple sources of FHB resistance have been successfully deployed in common wheat cultivars. However, effective resistance to FHB has not been achieved in durum wheat. FHB resistance sources have been identified in durum landraces and its tetraploid relatives. Extensive efforts have been made to incorporate those resistance genes into adapted durum backgrounds. Apparently, the resistance genes have become less effective when they are incorporated into adapted durum backgrounds. Similar results have been observed with other disease resistance genes in durum. All these results suggest there might be genetic factors that suppress expression of disease resistance genes in the adapted durum genotypes. Also, we have been transferring FHB resistance from common wheat to durum. It seems we have been facing the same challenge as the gene introgression from tetraploid relatives to durum, i.e. less effective of the common wheat-derived resistance genes in adapted durum backgrounds. In addition to the background effects, we have found D-genome chromosomes 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) to dissect the durum genome (i.e. A and B) and investigated the effect of individual A-, B-, and D-genome chromosomes on FHB resistance. To date, we have evaluated the 14 disomic LDN D-genome substitution lines with three replications for FHB resistance in three greenhouse seasons. Meanwhile, we have produced $F_1$ hybrids of two hexaploid resistance sources (Sumai 3 and PI 277012) with the entire set of LDN D-genome substitution lines and evaluated the $F_1$ hybrids for FHB resistance in two greenhouse seasons. Moreover, we developed synthetic hexaploid wheat (SHW) lines by crossing durum, including LDN, Divide, LDN-ISA substitution line 3A (FHB-resistant), Lebsock, Tun 7 (FHB-resistant), with *Ae. tauschii* and chromosome doubling of resultant hybrids. Evaluation of these SHWs has allowed us to determine the effect of whole D genome on FHB resistance in durum. Also, we have backcrossed these SHWs with their respective durum parents and developed durum lines with different D-genome chromosomes. Molecular marker and chromosome analyses have been used to identify the durum lines with additional D-genome chromosomes. Evaluation of these durum D-genome chromosome addition lines for FHB resistance provides new insights into the effect of individual D-genome chromosomes on FHB resistance in durum backgrounds.

Meanwhile, we screened 1,300 $F_3$ 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. A total of 154 FHB-resistant segregants selected in the $F_3$ generation are being evaluated for FHB resistance in the greenhouse. In addition, a total of 247 advanced durum introgression lines were re-evaluated for FHB resistance in the FHB nursery at Fargo, ND during summer 2013. Seventy-eight introgression lines selected with highest resistance levels were evaluated in the FHB nursery at Hangzhou, China during the 2013-2014 season. The introgression lines that consistently exhibit FHB resistance and acceptable agronomic performance will be released

to the durum breeding program for variety development. Also, we have made new crosses of six durum cultivars (Joppa, Alkabo, Divide, Tioga, Carpio, and Grenora) with Truman and other 27 wild species-derived common wheat lines with FHB resistance. This 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:**

- Made over 100 new crosses of six durum cultivars with Truman and 27 FHB-resistant hexaploid wheat lines derived from different wild species.
- Developed 78 advanced durum introgression lines with improved FHB resistance and various agronomic characteristics and their resistance has been verified in the greenhouse and at two field locations (Fargo, ND and Hangzhou, China).
- Screened 1,300 $F_3$ 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 154 FHB-resistant segregants for the development of introgression lines with improved FHB resistance.
- Developed 55 LDN durum lines that contain 1-2 different D-genome chromosomes from LDN-*Aegilops tauschii* amphiploid and evaluated their resistance to FHB.
- Produced $F_1$ hybrids of two hexaploid resistance sources (Sumai 3 and PI 277012) with the entire set of LDN D-genome substitution lines and evaluated the $F_1$ hybrids for FHB resistance in two greenhouse seasons.
- Determining the role of D-genome chromosomes in FHB resistance based on the reaction of the LDN D-genome chromosome addition lines and the $F_1$ hybrids of the hexaploid resistance sources with LDN D-genome chromosome substitution lines.

**Impact:**

- The durum introgression lines that have been verified with consistent resistance under multiple environments will be utilized directly in durum breeding for variety development. This will make the hexaploid- and wild species-derived resistance genes usable in durum breeding and enhance FHB resistance of durum.
- This research has been providing new insights into the role of D-genome chromosomes and other genetic factors in the expression and inheritance of FHB resistance 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?**

Strengthening and diversifying FHB resistance is one of the primary research goals in spring wheat. One of the strategies to achieve this research goal is to search for novel resistance genes from wheat-related alien 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 genes of interest in the alien chromatin integrated into the wheat genome. We have used the *Ph* inhibitor gene and *ph1b* mutant to induce meiotic recombination between wheat and alien homoeologous chromosomes. Unwanted alien chromatin has been further reduced in some of the introgression lines we have developed through this approach. Another challenge for alien introgression of FHB resistance genes is the evaluation and selection of introgression materials with FHB resistance due to complex inheritance of FHB resistance genes in wheat and its relatives. We have screened the materials at early generations for FHB resistance under greenhouse environments and verify resistance of advanced introgression lines 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. Introgression of alien FHB resistance genes into adapted spring wheat backgrounds strengthens and diversifies resistance of spring wheat to FHB. We expect to develop breeder-friendly alien introgression lines with FHB resistance and reduced DON and make them immediately available to the spring wheat breeding programs for variety development.

We have identified FHB resistance from additional wheat-alien species derivatives we have developed and collected from different sources. Spring wheat introgression lines with FHB resistance have been developed from the wheat-alien species derivatives using chromosome engineering and molecular markers. During FY13 funding period, we evaluated a total of 152 advanced spring wheat introgression lines derived from non-*fhb1* resistance sources with two replications and selected 79 lines that exhibited improved FHB resistance in the FHB nursery at Fargo, ND. The 79 introgression lines were re-evaluated for FHB resistance in the FHB nursery at Hangzhou, China and will be tested for DON accumulation in kernels. 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. In addition, we screened 864 $F_3$ progenies for FHB resistance from the crosses of three spring wheat varieties (Steele, Alsen, and Russ) with eight FHB-resistant hexaploid wheat lines that contain non-*fhb1* or wild species-derived resistance genes in the greenhouse. A total of 110 FHB-resistant segregants selected in the $F_3$ generation are being evaluated for FHB resistance in the greenhouse. Moreover, we have made new crosses of eight spring wheat cultivars (Alsen, Glenn, Russ, Reeder, Choteau, AC Vista, AC Lillian, and Parshall) with Truman and other 27 wild species-derived common wheat lines with FHB resistance. Introgression of these non-*fhb1* and wild species-derived resistance sources into spring wheat will potentially diversify and strengthen resistance of spring wheat 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:**

- Evaluated a total of 152 advanced spring wheat introgression lines derived from non-*fhb1* resistance sources and selected 79 lines that exhibited improved FHB resistance in the FHB nursery at Fargo, ND.
- Verified FHB resistance of the 79 introgression lines in the FHB nursery at Hangzhou, China. Some of the introgression lines that exhibit FHB resistance, low DON accumulation, and favorable agronomic traits will be made available to the wheat breeding programs for variety development.
- Screened 864 $F_3$ progenies for FHB resistance from the crosses involving non-*fhb1* or wild species-derived resistance genes in the greenhouse and selected 110 FHB-resistant segregants for further FHB evaluation and selection in the greenhouse.
- Made over 100 new crosses of spring wheat cultivars 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* or wild species-derived resistance sources identified in this project. Those germplasm will potentially enhance and diversify FHB resistance of spring wheat and other classes of common wheat.
- Germplasm lines developed in this project will be immediately made available to the spring wheat and other wheat breeding programs for the development of superior wheat cultivars with durable and diversified resistance to FHB and reduced DON accumulation in kernels.

**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 FY13 grant. Please reference each item using an accepted journal format. If you need more space, continue the list on the next page.**

Proceedings Abstract:

Zhu, X., Zhong, S., Chao, S., Elias, E., and Cai, X. 2013. "Fine mapping of the genomic region harboring the Fusarium head blight resistance QTL *Qfhs.ndsu-3AS* in durum wheat (poster)." In: S. Canty, A. Clark, Y. Salat, and D. Van Sanford (Eds.), *Proceedings of the 2013 National Fusarium Head Blight Forum*. East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative. p. 48.

Presentation:

FHB resistance in durum wheat - progress and challenge (invited seminar – X. Cai), Hubei Academy of Agricultural Sciences, Wuhan, China, June 9, 2013.