USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY12 Final Performance Report
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Cover Page

PI:	Xiwen Cai
Institution:	North Dakota State University
Address:	Department of Plant Sciences NDSU Dept. 7670 PO Box 6050 Fargo, ND 58108-6050
E-mail:	xiwen.cai@ndsu.edu
Phone:	701-231-7404
Fax:	701-231-8474
Fiscal Year:	FY12
USDA-ARS Agreement ID:	59-0790-8-068
USDA-ARS Agreement Title:	Characterization of Resistance to Fusarium Head Blight in Wheat and its Relatives.
FY12 USDA-ARS Award Amount:	$ 74,091[*]

USWBSI Individual Project(s)

USWBSI Research Category[**]	Project Title	ARS Award Amount
DUR-CP	Transferring FHB Resistance from Hexaploid Wheat to Durum.	$ 39,979
VDHR-SPR	Enhancing Resistance of Spring Wheat to FHB Using Alien Species.	$ 34,112
	Total ARS Award Amount	**$ 74,091**

7/10/13

Principal Investigator Date

[*] Partial funding for this research is under ARS agreement # 59-0206-9-062

[**] 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?

Effective sources of resistance to FHB have been identified in common wheat and wheat-related wild species, but not in durum wheat. These resistance sources have been successfully utilized in the development of FHB-resistant varieties in common wheat. However, the progress of using these resistance sources in developing durum varieties has been limited due primarily to complex inheritance of the hexaploid- and wild species-derived FHB resistance genes in the tetraploid durum backgrounds and possible role of D-genome chromosomes in FHB resistance. We have found that hexaploid-derived FHB resistance QTL exhibited less effectiveness of resistance in durum than hexaploid wheat. It has been anticipated that D-genome chromosomes of hexaploid wheat might play a role in the expression of FHB resistance genes in wheat. Recently we have observed significant variation in Type II FHB resistance among a complete set of Langdon (LDN) durum D-genome disomic substitution lines, where one pair of A- or B-genome chromosomes of LDN were replaced by one pair of homoeologous D-genome chromosomes from common wheat 'Chinese Spring', suggesting the potential role of D-genome chromosomes in FHB resistance. Also, suppression effects on hexaploid-derived FHB resistance genes have been detected in tetraploid wheat. We produced F_1 hybrids of two hexaploid resistance sources (Sumai 3 and PI 277012) with the complete set of LDN D-genome substitution lines and have been evaluating the F_1 hybrids for FHB resistance. This allows us to further characterize the role of D-genome chromosomes in FHB resistance and the suppression effects of durum backgrounds on FHB resistance. 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. Currently we are screening these SHWs for FHB resistance. Also, we are backcrossing these SHWs with their respective durum parents to develop durum lines with different D-genome chromosomes. Analyses of these materials on their genetic and chromosomal composition and reaction to FHB are expected to provide new insights into inheritance and expression of FHB resistance genes in durum.

Meanwhile, we have made new 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. We have been screening early generations of the crosses to select FHB-resistant segregants in the greenhouse. In addition, we have evaluated 271 F_{6-8} durum lines selected from the previous crosses of durum varieties with hexaploid resistance sources for FHB resistance in the replicated greenhouse experiments. Also, these 271 durum introgression lines have been grown in the FHB nurseries at Fargo, ND and Hangzhou, China to verify their resistance under different field conditions. About one third of the introgression lines exhibited improved FHB resistance comparing to their durum parents at both locations. The durum introgression lines that consistently exhibit improved resistance over the multiple seasons and locations will be utilized immediately in the development of durum varieties.

2. List the most important accomplishment and its impact (i.e. how is it 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 32 new crosses of four durum cultivars/lines with eight FHB-resistant hexaploid wheat lines that contain non-*fhb1* or wild species-derived resistance genes and selected resistant segregants from these crosses.
- Developed 271 durum introgression lines with improved FHB resistance and various agronomic characteristics and have been verifying their resistance in the greenhouse and at two field locations (Fargo, ND and Hangzhou, China).
- Genotyped resistant durum lines and verified the molecular markers tagging FHB resistance QTL.
- Produced F_1 hybrids of two FHB-resistant hexaploid wheat accessions 'Sumai 3' and PI 277012 with a complete set of LDN D-genome substitution lines (14) for investigating inheritance of FHB resistance in durum and the role of D-genome chromosomes in FHB resistance.
- Developed five synthetic hexaploid wheat (SHW) lines from the crosses of LDN, Divide, LDN-ISA substitution line 3A (FHB-resistant), Lebsock ,Tun 7 (FHB-resistant) with *Ae. tauschii*; and being generating durum lines containing various D-genome chromosomes to further characterizing the role of D-genome chromosomes in FHB resistance.

Impact:

- The durum germplasm lines developed with improved FHB resistance will be further verified for resistance in the field at multiple locations. The germplasm lines that are verified with true resistance under multiple environments will be utilized directly to enhance FHB resistance of durum, making the hexaploid-derived resistance genes usable in durum breeding.
- 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 the 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 introgression, including 1) the low recombination frequency between wheat and alien chromosomes, and 2) the 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 homoeologous recombination between wheat and alien chromosomes. Unwanted alien chromatin has been further minimized to reduce linkage drag in some of the introgression lines we have developed through this approach. Another challenge specific for alien introgression of FHB resistance genes is the evaluation and selection of introgression materials with FHB resistance. We have screened the materials for FHB resistance at early generations under greenhouse environments and verify resistance of advanced introgression lines under field conditions 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 wheat-alien species derivatives we have developed and collected, and developed advanced spring wheat introgression lines with FHB resistance from different crosses through chromosome manipulation. Twenty-five breeder-friendly spring wheat germplasm lines with FHB resistance and various agronomic traits have been provided to the spring wheat breeding programs for variety development. Recently, we have identified additional wheat-alien species derivatives with FHB resistance derived from relatives of wheat, containing non-*fhb1* resistance QTL. We have been characterizing and genotyping those non-*fhb1* resistance sources using molecular markers and incorporate these sources of resistance into adapted spring wheat backgrounds. Further chromosome manipulation, if necessary, will be performed to reduce linkage drag associated with alien chromatin. We anticipate developing elite spring wheat germplasm with FHB resistance and low DON accumulation from these resistance sources.

2. List the most important accomplishment and its impact (i.e. how is it 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 247 spring wheat lines derived from the previous crosses between spring wheat and wheat-alien species derivatives for FHB resistance in the greenhouse and FHB nursery in Fargo, ND summer 2012. One hundred and sixty-nine of them exhibited a FHB severity of less than 20%, which was comparable to the resistant check 'Alsen'. Out of the 169 lines, 55 most resistant lines were evaluated for FHB resistance in a replicated field experiment at Hangzhou, China in the 2012-2013 season. Over 50% of the lines consistently showed resistance comparable to their respective resistant parents in that FHB nursery;
- Re-evaluating FHB resistance of the 169 lines selected last season (2012) in a replicated field experiment in the Fargo FHB nursery;
- Made 24 new crosses of eight newly identified non-*fhb1* resistance sources (wheat-alien species derivatives and hexaploid wheat varieties) with spring wheat varieties 'Steele', 'Alsen', and 'Russ'; a total of 440 F_2 progeny from these crosses are being screened in the greenhouse to select FHB-resistant segregants;
- Genotyped the progeny and lines derived from all these crosses using molecular markers to assist selection of FHB resistance in the germplasm development;

Impact:

- We anticipate developing new spring wheat germplasm lines with non-*fhb1* resistance from the sources identified in this project. Those germplasm will potentially enhance and diversify FHB resistance of spring 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 varieties 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 grant. Please reference each item using an accepted journal format. If you need more space, continue the list on the next page.

PUBLICATIONS

Peer-reviewed

McArthur, R.I., Zhu, X., Oliver, R. E., Klindworth, D.L., Xu, S.S., Stack, R.W., Wang, R.R.-C., and Cai, X. (2012) Homoeology of *Thinopyrum junceum* and *Elymus rectisetus* chromosomes to wheat and disease resistance conferred by the *Thinopyrum* and *Elymus* chromosomes in wheat. Chromosome Research 20: 699-715.

Proceeding abstract

Zhu, X., Zhong, S., Xu, S. S., Cai, X. 2012. Fusarium head blight reactions of Langdon durum D-genome disomic substitution lines. *In* Proc. 2012 National Fusarium Head Blight Forum, Orlando, FL, December 4-6, 2012. p. 110.

Presentations

Understanding and manipulating the wheat genome for wheat improvement (invited), Life Science and Technology Center, China Seed Group Co., Ltd., Wuhan, China, October 16, 2012.

FHB resistance in durum wheat: progress and challenge (invited), The College of Pant Science and Technology, Huazhong Agricultural University, Wuhan, China, October 30, 2012.