USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY11 Final Performance Report
July 13, 2012

Cover Page

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Fiscal Year:	FY11
USDA-ARS Agreement ID:	59-0790-8-067
USDA-ARS Agreement Title:	Identification and QTL Mapping of Fusarium Head Blight Resistance in Wheat and Durum Wheat.
FY11 USDA-ARS Award Amount:	$ 88,136

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
DUR-CP	Identify FHB Resistance in Timopheevii Wheats.	$ 14,634
VDHR-SPR	Enhancing FHB Resistance Screening Capacity for Spring Wheat Breeding Programs.	$ 11,708
VDHR-SPR	Fine Mapping of QTLs for FHB Resistance in PI 277012 - An excellent Novel Resistance Source for Wheat Breeding.	$ 22,282
PBG	Effect of Host Resistance, Fungicide, and Environmental Factors on Population Shift in Fusarium graminearum.	$ 39,512
	Total ARS Award Amount	**$ 88,136**

Shaobin Zhong July 9, 2012
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: *Identify FHB Resistance in Timopheevii Wheats.*

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

Wild and relative species of durum wheat are important sources of resistance to many diseases in wheat, but screening of these materials for FHB resistance has not been extensive. The USDA National Small Grains Collection (NSGC) at Aberdeen, Idaho, has a large collection of *Triticum timopheevii* accessions, but their reactions to FHB have not been evaluated. We are testing these *T. timopheevii* accessions in field nurseries and greenhouse for resistance to FHB. The goal is to identify new sources of FHB resistance from these *T. timopheevii* accessions and use them for durum wheat breeding program.

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:

a. We have increased and obtained enough seeds of 240 accessions of *Triticum timopheevii* subsp. *armeniacum*, which are of winter growth habit and require vernalization for flowering. The original seeds from NSGC were not enough for FHB evaluation.
b. We have evaluated 120 of these winter type accessions of *Triticum timopheevii* subsp. *armeniacum* for FHB resistance using the single floret point inoculation method in the greenhouse. The disease severity ranged from 40% to 100%, indicating that most of the winter type accessions were susceptible to FHB although the levels of susceptibility varied among them.

Impact:

a. Information about the FHB susceptibility of *Triticum timopheevii* subsp. *armeniacum* is known.
b. Those accessions with less susceptibility to FHB may be used as alternative sources of resistance for durum wheat improvement.

Project 2: *Enhancing FHB Resistance Screening Capacity for Spring Wheat Breeding Programs.*

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

Due to the complexity of factors affecting FHB infection and development, FHB resistance must be tested and validated in multiple locations and multiple years. We are addressing the issues by evaluating spring wheat lines from the three breeding programs (ND, MN, SD) in scab nurseries located in Jianyang and Hangzhou, China, where environmental conditions are consistently conducive for FHB development and disease epidemics each year.

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:

a. We evaluated a total of 382 advanced breeding lines (120 from SD, 150 from ND, and 112 from MN) in the Jianyang nursery from November 2011 to May 2012. The disease severity ranged from 8.5% to 71.1% among the entries evaluated. Forty eight of the materials showed a disease severity below 15%, indicating a good level of FHB resistance in these advanced breeding materials under natural infection conditions.
b. We also evaluated the same 382 advanced breeding lines for Type II resistance in the Hangzhou location by the single floret inoculation method. The results showed that the disease severity ranged from 7% to 96% and 87 of the entries exhibited a high level of Type II resistance with a disease severity of less than 15%.

Impact:

a. The oversea FHB nurseries are very effective in enhancing FHB resistance evaluation for the three spring wheat breeding programs. They provide accurate field data to measure the FHB resistance level of breeding lines and other germplasm and thus can speed up the release of FHB resistant varieties to minimize the threat of FHB and/or reduce mycotoxins.

Project 3: *Fine Mapping of QTLs for FHB Resistance in PI 277012 - An excellent Novel Resistance Source for Wheat Breeding.*

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

To diversify the resistance sources and further improve wheat for resistance to the FHB disease, novel and effective sources of resistance to FHB are desperately needed for wheat breeding programs. DNA markers associated with the QTL for FHB resistance are essential for resistance gene selection. In a large-scale evaluation of tetraploid wheat (*Triticum turgidum*) germplasm for reactions to FHB, Dr. Steven Xu at the USDA-ARS, Fargo, identified an accession (PI 277012) that consistently showed a high level of resistance across all environments in both greenhouse and field experiments. Two major QTL on 5A were identified and mapped based on a mapping population consisting of 130 doubled haploid (DH) lines from the cross between PI 277012 and the hard red spring wheat cultivar 'Grandin' (susceptible to FHB). The overall goals of this proposal are to provide further more information about this novel FHB resistance resource and to saturate the mapped two QTL regions with additional markers for easy identification of the FHB resistance QTL loci in wheat breeding programs.

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:

1) We evaluated FDK and DON of each DH line in the mapping population derived from the PI 277012/Grandin cross in two disease nurseries located in Fargo and Langdon, respectively;
2) We mapped QTL associated with resistance to FDK and DON accumulation and established the relationship between QTLs for the three FHB traits (FHB severity, FDK and DON accumulation); The QTL for all the three traits mapped to the same genomic regions.
3) We developed additional markers to saturate the regions around the QTLs associated with the FHB resistance.

Impact:

The resistant DH lines will be used as resistant sources for the spring wheat breeding programs in the region. The new resistance alleles and DNA markers associated with them will accelerate the development of new FHB resistant wheat varieties by marker assisted selection and gene pyramiding.

Project 4: *Effect of Host Resistance, Fungicide, and Environmental Factors on Population Shift in Fusarium graminearum.*

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

Previous studies indicated that the 15-ADON producing isolates were predominant in the *F. graminearum* population in North America. However, several recent studies have shown a dramatic increase of 3-ADON isolates in the pathogen population in Canada and the US, especially in the northern Great Plains. In this project, we address the following questions: 1) Is there any competition between the two chemotypes for their survival under field conditions? 2) Does the Sumai 3 resistance play a role in the fungal population shift? 3) Does fungicide application affect the fungal population shift? To answer these questions, we conducted field experiments with two wheat cultivars (Briggs, susceptible and Alsen, moderately resistant to FHB) and well-characterized 3-ADON and 15-ADON isolates of *F. graminearum*. The field experiment was conducted at Fargo with a split plot experimental design and three replications. Three plots (10x10 feet each) of each cultivar will be inoculated individually with (A) mixture of ten 15-ADON isolates, (B) mixture of 10 3-ADON isolates, and (C) mixture of A+B isolates and sprayed or not sprayed with fungicide. FHB incidence and severity data as well as DON accumulation in grains were collected from all treatments to determine the difference between the two fungal populations as individual and as mixture in disease development. We also recovered the fungal isolates from all treatments to determine the competiveness of the two chemotypes in causing FHB in resistant and susceptible cultivars.

4. 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):

<u>Accomplishment:</u>

a. In the summer of 2011, we spray inoculated spring wheat cultivars Briggs (susceptible to FHB) and Alsen (moderately resistant to FHB) with individual populations of 3ADON and 15ADON chemotypes (ten isolates each) and a mixed population (ten isolates from each chemotype), and added a flowering-time fungicide treatment, under field conditions.
b. The results indicated that the disease severity was higher in the 3ADON inoculated plots compared to the 15ADON inoculated plots in both susceptible cultivar Briggs and the moderately resistant cultivar Alsen.
c. For untreated, inoculated plots, the DON levels were higher in inoculations with the 3ADON isolates (29.7 ppm in Alsen and 39.7 ppm in Briggs), as compared to inoculations with the 15ADON isolates (9.0 ppm in Alsen and 15.9 ppm in Briggs).
d. In the plots treated with the fungicide, the disease incidence, severity, and DON were significantly lower as compared to non-fungicide treated plots, regardless of which types of isolates were used as the source of inoculum.

e. Fungal isolates were recovered from Briggs and Alsen inoculated with a mixture of ten 3ADON isolates and ten 15ADON isolates. The result indicated that the recovery rates of 3ADON and 15ADON isolates were not significantly different from either of the cultivars, suggesting that both types of isolates had a similar infection and survival rate under the field conditions in Fargo, ND.
f. The results from the 2011 experiments are consistent with those obtained from the 2010 experiments.

Impact:

The experiments showed that the 3ADON population is more aggressive than 15ADON population in disease development and DON accumulation in the susceptible cultivar Briggs, but not in the resistant cultivar Alsen. The research also indicated the value in using variety resistance and fungicide treatment in reducing FHB disease and DON levels, regardless of the chemotype of the inoculum source. This information has implications for the development of FHB-resistant wheat cultivars and disease management. First, the *F. graminearum* population in North America consists of chemotypes with different aggressiveness and mycotoxin productivity. Thus, screening of resistance for FHB should be made with inocula combining representative isolates with different trichothecene types in breeding programs. This will ensure the development of cereal crops with broad resistance to FHB pathogens. Second, wheat genotypes with different sources of FHB resistance may react differentially to different chemotypes in DS and DON accumulation. This highlights the need and importance of using different sources of host resistance in combating the disease. Finally, use of FHB resistant varieties in combination of fungicide is still effective management of the FHB disease regardless of the population composition.

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.

Chu, C. –G., Niu, Z. –X., **Zhong, S.**, Chao, S., Friesen, T., Halley, S., Elias, E., Dong, Y., Faris, J., and Xu, S. X. 2011. Identification and molecular mapping of two QTLs with major effects for resistance to Fusarium head blight in wheat. Theor. Appl. Genet. 123:1107-1119 (peer-reviewed article).

Zhong, S., Chu, C. G., Xu, S. S., Ali, S., Puri, K. D., Mergoum, M., and Chao, S. 2011. Identification and mapping of QTLs for FHB resistance in a synthetic hexaploid wheat line. Proceedings of the 2011 National Fusarium Head Blight Forum, Dec 4-6, 2011, St. Louis, MO. P64. (Poster)

Ali, S., Puri, K. D., McMullen, M., **Zhong, S**. 2011. Effect of *Fusarium graminearum* chemotypes 3ADON and 15ADON and fungicide application on Fusarium head blight (FHB) development and DON production in spring wheat under North Dakota field conditions in 2011. Proceedings of the 2011 National Fusarium Head Blight Forum, Dec 4-6, 2011, St. Louis, MO. P116. (Poster)

Ali, S., Puri, K. D., McMullen, M., **Zhong, S**. 2011. Chemotypes of *Fusarium graminearum* from wheat in 2009 and 2010 in North Dakota. Proceedings of the 2011 National Fusarium Head Blight Forum, Dec 4-6, 2011, St. Louis, MO. P70. (Poster)

Cai, X., Elias, E., Xu, S., Kianian, S., **Zhong, S**., Chao, S. 2011. Fusarium head blight resistance in durum wheat-progress and challenges. Proceedings of the 2011 National Fusarium Head Blight Forum, Dec 4-6, 2011, St. Louis, MO. P12. (Poster)

Ali, S., **Zhong, S**., and Puri, K. D. 2011. Virulence variability and genetic diversity among *Cochliobolus sativus* isolates recovered from barley and wheat in North Dakota. Phytopathology 101:S5. (Poster)