USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY10 Final Performance Report
July 15, 2011

Cover Page

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Fiscal Year:	FY10
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.
FY10 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	Identification and Validation of FHB Resistance QTLs in Synthetic Wheat Lines.	$ 22,282
VDHR-SPR	Enhancing FHB Resistance Screening Capacity for Spring Wheat Breeding Programs.	$ 11,708
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 07-13-2011
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

PI: Zhong, Shaobin
USDA-ARS Agreement #: 59-0790-8-067
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?

Lack of highly resistant sources of FHB resistance in durum wheat varieties is a problem for developing durum varieties with good FHB resistance. In the past several years, over 10000 durum accessions from worldwide collections have been evaluated for reactions to Fusarium head blight (FHB), but only a very small number of accessions exhibited moderately resistance to FHB. Wild and relative species of durum wheat are important sources of resistance to many diseases, 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 evaluated 42 accessions of *Triticum timopheevii* subsp. *timopheevii* (spring growth habit) for FHB resistance in the misted and inoculated scab nursery located at the Fargo location. The disease severity ranged from 30% to 83%, indicating that these accessions showed a various level of susceptibility to FHB under the misted and inoculated field conditions.
b. We increased the seeds of 240 accessions of *Triticum timopheevii* subsp. *armeniacum* that are of winter growth habit and require vernalization for flowering, because the original seeds were not enough for FHB evaluation.
c. Approximately half of these winter growth habit accessions are being grown in the greenhouse for FHB inoculation and the data will be available in the fall of 2011.

Impact:

The accessions that show a good level of FHB resistance can be used as new sources of FHB resistance for durum wheat and common wheat. Crosses will be made to the durum cultivars and the FHB resistance will be introgressed into the durum background to minimize the threat of FHB.

PI: Zhong, Shaobin
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Project 2: *Identification and Validation of FHB Resistance QTLs in Synthetic Wheat Lines.*

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

The synthetic hexaploid wheat (SHW) lines derived from crosses between tetraploid wheat (AABB genome) and *Aegilops tauschii* (D genome) possesses resistance to various diseases including Fusarium head blight (FHB). However, the genetics of FHB resistance in these synthetic lines is poorly understood. In the past two years, we identified three QTLs (on 5A, 5B and 7D, respectively) in the double haploid (DH) mapping population derived from the cross between the synthetic hexaploid wheat (SHW) line TA4152-60 (Scoop1/*Ae.tauschii* [358]) and a spring wheat line ND495 (susceptible to FHB). The QTLs were identified based on two seasons of greenhouse phenotyping and one season of field experiment. To confirm and validate these QTLs, we continue phenotyping the DH mapping populations in greenhouse and field nurseries and documenting the DNA markers associated with the resistance loci (QTL).

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):

<u>Accomplishment:</u>

a. In the summer of 2010 (May-Sept.), 120 doubled haploid lines from the mapping population derived from TA4152-60/ND495 were planted in three replicates in both misted FHB nurseries located at Fargo and Prosper, ND.
b. FHB severity data were obtained from each DH line of the TA4152-60/ND495 population. The grains were also harvested from each line and sent to a service lab for measurement of DON content.
c. QTL analysis indicated that the QTL on 5A and 5B identified in the TA4152-60/ND495 population are consistent with those identified in the previous seasons. The 5A QTL peaked at the interval between *Xgdm132.1* and *Xgwm410.4*, and explained up to 11% of the phenotypic variation. Whereas the 5B QTL explained up to 20% of the trait variation and peaked at the interval between markers *Xbarc100.5* and *Xwmc75*.
d. Another mapping population consisting of 236 recombinant inbred (RI) lines (F_7 generation) from the cross between "Largo" and ND 495 was also evaluated in the Fargo nursery. The RIs showed good segregation for FHB severity ranging from 15.8% to 83.6%.

<u>Impact:</u>

a. The new QTLs for FHB resistance identified from the synthetic wheats can be incorporated into wheat germplasm for FHB resistance improvement.
b. Some DH lines or RI lines derived from the crosses between the synthetic lines (TA4152-60 and Largo) and the spring wheat parent (ND495) are much more resistant to

FHB compared to their parents. These lines could be used directly in the wheat breeding programs because they have better agronomic traits than the synthetic wheat parents.

Project 3: *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?**

   A key element in developing FHB resistance varieties is to evaluate various germplasm and advanced breeding lines for reaction to FHB in disease nurseries. Due to the complexity of factors affecting FHB infection and development, FHB resistance must be tested and validated in multiple locations and multiple years. Therefore, selecting FHB nurseries with optimum conditions for disease development is crucial for ensuring the success of FHB resistance evaluation. However, environmental conditions in local nurseries are not always optimum for FHB screening. Therefore, we are addressing the issues by evaluating spring wheat lines from the three breeding programs (ND, MN, SD) in China 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 388 advanced breeding lines (120 from SD, 150 from ND, and 118 from MN) and 96 accessions of PI lines along with checks in the Jianyang nursery from November 2010 to May 2011. The disease severity ranged from 7% to 62% among the 484 entries evaluated. Half 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 388 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 92% and 163 of the entries exhibited a high level of Type II resistance with a disease severity of less than 15%.

   Impact:

   Establishment of the oversea FHB nurseries has enhanced FHB resistance evaluation for the three spring wheat breeding programs. It provides 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 4: *Effect of Host Resistance, Fungicide, and Environmental Factors on Population Shift in Fusarium graminearum.*

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

   The Fusarium head blight pathogen *Fusarium graminearum* produces various types of mycotoxins and trichothecenes [Deoxinevalenol (DON) and its acetylated forms 3-ADON and 15-ADON]. 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 population shift, i.e., increase of 3-ADON isolates over 15-ADON isolates, in the pathogen population in Canada and the US, especially in the northern Great Plains. However, little information is available regarding the causes of this population shift and the impact on FHB management. 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.

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. In the summer of 2010, 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 incidence (42.33%) and severity (58.63%) were higher in the 3ADON inoculated plots compared to the 15ADON inoculated plots (incidence = 32% and severity = 35.01%) in susceptible cultivar Briggs. Similarly, DON accumulation was higher (36.4 PPM) and lower (18.8 PPM) in 3ADON and 15ADON inoculated grain samples, respectively. As expected, FHB severity (18.58 %) and DON (12.56) accumulation was significantly lower in FHB resistant cultivar "Alsen" than the susceptible cultivar "Briggs"; however, there was no difference in disease severity and

DON accumulation in 3ADON and 15ADON inoculated grains samples of the resistant cultivar Alsen. Fungicide treatment significantly decreased disease incidence, severity, and DON accumulation in both cultivars.

c. 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.
d. 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.
e. The similar experiment is being conducted under field conditions in the summer growing season of 2011.

Impact:

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 all germplasm or cultivars released with full or partial support of the USWBSI. List the release notice or publication. Briefly describe the level of FHB resistance.

N/A

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. (in press) (peer-reviewed article).

Puri, K. D., and **Zhong, S**. 2010. The 3ADON population of *Fusarium graminearum* found in North Dakota is more aggressive and produces a higher level of DON than the prevalent 15ADON population in spring wheat. Phytopathology 100:1007-1014. (peer-reviewed article).

Ali, S., Puri, K. D. McMullen, M., **Zhong, S**. 2010. Aggressiveness of *Fusarium* graminearum 3ADON and 15ADON populations as affected by wheat cultivar resistance and fungicide treatment, under field conditions in North Dakota. Proceedings of the 2010 National Fusarium Head Blight Forum, Dec 7-9, 2010, Milwaukee, WI. p65-68.

Xu, S. S., Chu, C. -G., Friesen, T. L., Chao, S., **Zhong, S**., Halley, S., Cai, X., Elias, E. 2010. Introgression of two major FHB-resistance QTLs into durum and hard red spring wheat. Proceedings of the 2010 National Fusarium Head Blight Forum, Dec 7-9, 2010, Milwaukee, WI. p172. (Poster)

Chu, C. -G., **Zhong, S**., Chao, S., Friesen, T. L., Halley, S., Elias, E., Faris, J. D., Xu, S. S. 2010. Fighting against FHB-An excellent novel resistance source for future wheat breeding. Proceedings of the 2010 National Fusarium Head Blight Forum, Dec 7-9, 2010, Milwaukee, WI. p14. (Poster)

Cai, X., McArthur, R. I., Zhang, Q., Oliver, R. E., Zhong, S., Chao, S., Hareland, G. A., Berzonsky, W., Mergoum, M., Hanson, B., Dong, Y., Xu, S. S. 2010. Development of advanced spring wheat lines with FHB resistance through alien introgression. Proceedings of the 2010 National Fusarium Head Blight Forum, Dec 7-9, 2010, Milwaukee, WI. p136. (Poster)

Ali, S., Puri, K. D, M. McMullen, M., and **Zhong, S**. 2010. Frequency of 3ADON and 15ADON isolates of *Fusarium graminearum* from field plots of wheat inoculated with mixed pathogen populations in North Dakota. Phytopathology 100:S4. (Poster)

Puri, K. D., Chao, S., Bockelman, H., Mergoum, M., and **Zhong, S**. 2010. Validation and haplotyping of Fusarium head blight resistance genes in a diverse spring wheat germplasm**.** Phytopathology 100:S104. (Poster)