USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY15 Final Performance Report
Due date: July 15, 2016

Cover Page

Principle Investigator (PI):	Shaobin Zhong
Institution:	North Dakota State University
E-mail:	Shaobin.Zhong@ndsu.edu
Phone:	701-231-7427
Fiscal Year:	2015
USDA-ARS Agreement ID:	59-0200-3-004
USDA-ARS Agreement Title:	Identification and QTL Mapping of Fusarium Head Blight Resistance in Wheat and Durum Wheat.
FY15 USDA-ARS Award Amount:	$ 76,839
Recipient Organization:	North Dakota State University Office of Grant & Contract Accouting NDSU Dept 3130, PO Box 6050 Fargo, ND 58108-0650
DUNS Number:	80-388-2299
EIN:	45-6002439
Recipient Identifying Number or Account Number:	FAR0020575
Project/Grant Reporting Period:	04/24/15-04/23/16
Reporting Period End Date:	04/30/16

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
DUR-CP	Identify and Map Novel QTL for FHB Resistance Introduced into Durum Wheat.	$ 32,718
VDHR-SPR	Fine Mapping and Utilization of FHB Resistance QTL Derived from PI 277012 in Spring Wheat.	$ 31,681
VDHR-SPR	Increase FHB Resistance Screening Capacity and Efficiency for Spring Wheat Breeding.	$ 12,440
	FY15 Total ARS Award Amount	**$ 76,839**

Shaobin Zhong 7-12-2016

Principal Investigator Date

* MGMT – FHB Management
FST – Food Safety & Toxicology
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
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 and Map Novel QTL for FHB Resistance Introduced into Durum Wheat.*

1. What are the major goals and objectives of the project?

Our major goal is to identify and map QTL for FHB resistance from tetraploid and hexaploid wheat accessions into adapted durum wheat cultivars. Most of the FHB resistance QTL existing in the introgression lines are not well characterized or validated. Here we aim to identify and map QTLs for FHB resistance in 10Ae564 and Joppa, which carry known and unknown sources of FHB resistance. 10Ae564 is a FHB-resistant, BC1F8 durum wheat line, which is derived from cross and backcross of the durum wheat cultivar Lebsock to a hexaploid wheat line PI 277012 with major FHB resistance QTL on 5A. Joppa is a newly released durum wheat cultivar with a relatively higher level of FHB resistance compared to other durum wheat cultivars currently grown in ND. However, the QTL for FHB resistance in Joppa have not been identified and mapped. We developed a mapping population consisting of 241 recombinant inbred lines derived from the cross between Joppa and 10Ae564. We are collecting phenotype and genotype data for QTL analysis.

2. What was accomplished under these goals?

1) Major activities:
   A. We genotyped 210 recombinant inbred lines (RIL) (F2:7) derived from the cross between 10Ae564 and Joppa using the wheat 90K-SNP arrays.
   B. We phenotyped the 210 recombinant inbred lines (F2:6) in two more FHB inoculation experiments, including one in the Fargo FHB nursery in the summer of 2015 and one in the greenhouse in the fall of 2015.
   C. We also collected DON data from the 2015 Fargo field nursery and greenhouse inoculation experiments.
2) Specific objectives:
   A. Develop a genetic linkage map with SNP markers for the mapping population.
   B. Identify SNP markers associated with QTL for FHB resistance in 10Ae564 and Joppa.
3) Significant results:
   A. A total of 6323 SNP markers were identified in the mapping population. Excluding the co-segregated markers, 1676 SNP markers were used to construct a genetic linkage map which consisted of 34 linkage groups covering 626.42 cM in length.
   B. The disease severity ranged from 14% to 93% and 18% to 91% among the RILs in the 2015 fall greenhouse and field evaluations respectively, suggesting that resistance to FHB segregated in the population. Transgressive segregation was observed in the mapping population for both inoculation experiments.
   C. DON contents ranged from 4.8 to 72.2 ppm and 11.4 to 59.8 ppm among the RILs in the 2015 fall greenhouse and field evaluations respectively, indicating that the population segregated for DON accumulation in grains as well. Transgressive segregation was also observed for DON contents in this mapping population.
   D. Preliminary analysis indicated that QTL for FHB resistance on 5A as well as 2A were detected.
4) Key outcomes or other achievements:

A. Major QTL from 10Ae564 with resistance source coming from PI 277012 and minor QTL from Joppa were detected in the mapping population, suggesting that FHB resistance can be improved by accumulation of existing and new FHB resistance QTL in wheat breeding program.
B. Some of the RILs in the mapping population showed better resistance than their parents, suggesting that they may contain QTL from both parents.

3. What opportunities for training and professional development has the project provided?

1) A Ph.D. student is working on this project and has been trained for FHB phenotyping.
2) A visiting scientist is working on this project and received one on one training for marker development and QTL mapping.

4. How have the results been disseminated to communities of interest?

Nothing to report

Project 2: *Fine Mapping and Utilization of FHB Resistance QTL Derived from PI 277012 in Spring Wheat.*

1. What are the major goals and objectives of the project?

The major goal of this project is to fine map the two QTL for FHB resistance from PI 277012, a hexaploid wheat line consistently exhibiting a high level of FHB resistance across all environments in both greenhouse and field experiments. The two FHB resistance QTL were previously identified and mapped on 5A using 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). However, the regions surrounding the two QTL loci were not saturated with enough DNA markers and thus DNA markers closely linked to the QTL loci are needed for marker-assisted selection. In this project, we aim to (1) fine map the two QTL regions with additional markers for easy identification of the FHB resistance QTL loci in wheat breeding programs, and (2) introgress the QTLs into adapted spring wheat cultivars.

2. What was accomplished under these goals?

1) Major activities:
   A. We phenotyped 958 recombinant inbred lines (RILs) for FHB reaction in two more inoculation experiments, one in the 2015 Fargo FHB nursery and one in the greenhouse.
   B. Based on the known genomic regions for the two FHB resistance QTL, we developed more than 50 PCR-based SNP markers and tested polymorphism using the 958 RILs.
   C. We tested 3 markers closely associated with the 5AL QTL and 4 markers closely associated with the 5AS QTL in 68 spring wheat varieties and 96 PI lines.
   D. We continued backcross of the BC3F1 plants to Grandin and Wheaton.
2) Specific objectives:
   A. Develop additional PCR-based SNP markers for selection of FHB resistance QTL derived from PI 277012.
   B. Develop near-isogenic lines with the FHB resistance QTL in the two adapted spring wheat varieties Grandin and Wheaton.
3) Significant results:
   A. Thirty PCR-based SNP markers have been mapped to the two QTL regions, with 23 on the 5AL QTL region and 7 on the 5AS QTL region. The two closest flanking markers are 2.0 and 2.3 cM from the 5AL QTL and the two flanking markers are 0.8 and 0.9 cM from the 5AS QTL.
   B. BC4F1 plants were obtained from four cross combinations. FHB evaluation of individual backcrossed plants indicated that they were more resistant than their susceptible parents although not as resistant as their resistant parent PI 277012.
4) Key outcomes or other achievements:
   A. Two SNP markers associated with the 5AL QTL have the allele specific to the resistant donor and are potentially useful for marker-assisted selection in the wheat breeding programs.
   B. We also found that the expression of FHB resistance from PI 277012 varied in crosses with different susceptible parents used. Further investigation is needed to

understand the factors causing the differences in expression of FHB resistance in different genetic background.

3. What opportunities for training and professional development has the project provided?

1) A visiting scientist from China has been trained for FHB phenotyping.
2) Two Ph.D. students are working on this project and received one on one training for marker development and QTL mapping.
3) A postdoctoral research associate is working on the project and received one on one training for FHB phenotyping and marker development.

4. How have the results been disseminated to communities of interest?

1) Two SNP markers have been provided to three labs for marker-assisted selection
2) The results have been presented in two professional conferences

Project 3: *Increase FHB Resistance Screening Capacity and Efficiency for Spring Wheat Breeding.*

1. What are the major goals and objectives of the project?

FHB resistance is a quantitative trait, which needs evaluation and validation in multiple locations and multiple years. Local nurseries in the US are sometimes not producing quality data for FHB reactions due to the occurrence of poor weather conditions (too hot, too dry, flooding and so on). We are addressing the issues by screening selected advanced spring wheat breeding lines from the three wheat breeding programs (ND, MN, and SD) in a scab nursery located in China, where environmental conditions are consistently conducive for FHB development and disease epidemics each year.

2. What was accomplished under these goals?

1) Major activities: 108 spring wheat breeding lines from University of Minnesota and 120 spring wheat breeding lines from South Dakota State University have been evaluated for FHB resistance in the China nursery located in Nanjing, China. Due to the loss of seeds during the shipment in the Chinese custom, FHB evaluation was not conducted in Hangzhou.
2) Specific objectives: To screen advanced spring wheat breeding lines from the major hard red spring wheat breeding programs for FHB resistance in an oversea FHB nursery in China.
3) Significant results: We evaluated 228 spring wheat breeding lines (120 from SDSU and 108 from U of MN) in the Nanjing nursery from November 2014 to May 2015. The disease severity ranged from 7.0% to 100% among the entries evaluated. Approximately 30% of the materials showed a disease severity below 15%, indicating they have a very good level of FHB resistance under natural infection conditions.
4) Key outcomes or other achievements: The oversea FHB nursery provides high quality field data for measuring the FHB resistance level of advanced breeding lines from the spring wheat breeding programs in the Mid-west region. The data are used to select potential advanced breeding lines for the future release or eliminate those with FHB susceptibility so farmers can use FHB resistant varieties to minimize the threat of FHB and/or reduce mycotoxins.

3. What opportunities for training and professional development has the project provided?

Nothing to report

4. How have the results been disseminated to communities of interest?

The data have been provided to the two spring wheat breeders (Dr. James Anderson and Dr. Karl Glover).

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY15 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 FY15 award period?**

   No

2. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY15 award period?**

   Yes, one

3. **Have any post docs who worked for you during the FY15 award period and were supported by funding from your USWBSI grant taken faculty positions with universities?**

   Yes, one

4. **Have any post docs who worked for you during the FY15 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

Release of Germplasm/Cultivars

Instructions: In the table below, list all germplasm and/or cultivars released with full or partial support through the USWBSI during the FY15 award period. All columns must be completed for each listed germplasm/cultivar. Use the key below the table for Grain Class abbreviations. *Leave blank if you have nothing to report or if your grant did NOT include any VDHR-related projects.*

Name of Germplasm/Cultivar	**Grain Class**	**FHB Resistance** (S, MS, MR, R, where R represents your most resistant check)	**FHB Rating** (0-9)	**Year Released**

Add rows if needed.

NOTE: List the associated release notice or publication under the appropriate sub-section in the 'Publications' section of the FPR.

Abbreviations for Grain Classes

Barley - BAR
Durum - DUR
Hard Red Winter - HRW
Hard White Winter - HWW
Hard Red Spring - HRS
Soft Red Winter - SRW
Soft White Winter - SWW

Publications, Conference Papers, and Presentations

Refer to the FY15-FPR_Instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY15 grant. If you did not have any publications or presentations, state 'Nothing to Report' directly above the Journal publications section.

Journal publications.

Mergoum, M., Simsek, S., Zhong, S., Acevedo, M., Friesen, T. L., Xu, S. S., Liu, Z. 2016. 'Elgin-ND' Spring Wheat: A Newly Adapted Cultivar to the North-Central Plains of the United States with High Agronomic and Quality Performance. J. Plant Reg. 10:130-134.
Status: Paper Published in the Peer-reviewed Journal
Acknowledgement of Federal Support: NO

Zhu, X., **Zhong, S**., Xu, S. S., Jyoti, J., and Cai, X. 2016. Effects of D-genome chromosomes and their A/B-genome homoeologs on Fusarium head blight resistance in durum wheat. Crop Sci. 56:1049-1058.
Status: Paper Published in the Peer-reviewed Journal
Acknowledgement of Federal Support: YES

Zhu, X., **Zhong, S**., Chao, S., Gu, Y. Q., Kianian, S. F., Elias, E., and Cai, X. 2016. Toward a better understanding of the genomic region harboring Fusarium head blight resistance QTL *Qfhs.ndsu-3AS* in durum wheat. Theor. Appl. Genet. 129:31-43.
Status: Paper Published in the Peer-reviewed Journal
Acknowledgement of Federal Support: YES

Yu, G., Klindworth, D., Friesen, T. L., Faris, J. D., **Zhong, S.**, Rasmussen, J. B., Xu. S. S. 2015. Development of a diagnostic co-dominant marker for stem rust resistance gene *Sr47* introgressed from *Aegilops speltoides* into durum wheat. Theor. Appl. Genet. 128:2367-2374.
Status: Paper Published in the Peer-reviewed Journal
Acknowledgement of Federal Support: YES

Yu, G., Zhang, Q., Friesen, T. L., Rouse, M. N., Jin, Y., **Zhong, S.**, Rasmussen, J. B., Lagudah, E. S., Xu. S. S. 2015. Identification and mapping of *Sr46* from *Aegilops tauschii* accession CIae 25 conferring resistance to race TTKSK (Ug99) of wheat stem rust pathogen. Theor. Appl. Genet. 128:431–443.
Status: Paper Published in the Peer-reviewed Journal
Acknowledgement of Federal Support: YES

Zhong, S., Ali, S., Wang, R., Leng, Y., and Garvin, D. F. 2015. *Brachypodium distachyon-Cochliobolus sativus* pathosystem is a new model for studying plant-fungal interactions in cereal crops. Phytopathology 105:482-489.
Status: Paper Published in the Peer-reviewed Journal
Acknowledgement of Federal Support: YES

Books or other non-periodical, one-time publications.
None

Other publications, conference papers and presentations.

Szabo-Hever, A., Zhang, Q., Zhong, S., Friesen, T. L., Elias, E. M., Xu, S. S., and Chao, S. 2015. Characterization of new synthetic wheat germplasm for resistance to Fusarium head blight. In: S. Canty, Clark, S. Vukasovich and D. Van Sanford (Eds.), *Proceedings of the 2015 National Fusarium Head Blight Forum*. East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative. p. 107.
Status: Abstract Published and poster presented
Acknowledgement of Federal Support: YES

Zhao, M., Liu, Y., Leng, Y., Li, J., Wang, R., Long, Y., Chao, S., Xu, S. S., and Zhong, S. 2015 Development of User-Friendly DNA Markers for Fusarium Head Blight Resistance QTL in PI 277012. In: S. Canty, Clark, S. Vukasovich and D. Van Sanford (Eds.), *Proceedings of the 2015 National Fusarium Head Blight Forum*. East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative. p. 114.
Status: Abstract Published and poster presented
Acknowledgement of Federal Support: YES

Zhu, X., Zhong, S., and Cai, S. 2015. Cytogenetic Dissection of A, B, and D Genome Provides New Insights into Fusarium Head Blight Resistance in Durum Wheat. In: S. Canty, Clark, S. Vukasovich and D. Van Sanford (Eds.), *Proceedings of the 2015 National Fusarium Head Blight Forum*. East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative. p. 116
Status: Abstract Published and poster presented
Acknowledgement of Federal Support: YES