USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY16 Final Performance Report
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Cover Page

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Fiscal Year:	2016
USDA-ARS Agreement ID:	N/A
USDA-ARS Agreement Title:	Introgression of Scab Resistance from Emmer and Timopheev Wheat into Durum Wheat.
FY16 USDA-ARS Award Amount:	$ 88,341

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
DUR-CP	Development and Characterization of Elite Durum Wheat Lines with Scab Resistance.	$ 53,341
VDHR-SPR	Evaluation and Characterization of Scab Resistance in New Synthetic Wheat Germplasm.	$ 35,000
	FY16 Total ARS Award Amount	**$** 88,341

Steven Xu — July 27, 2017
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: *Development and Characterization of Elite Durum Wheat Lines with Scab Resistance.*

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

The major goals and objectives of the project are 1) to determine the FHB resistance QTLs in the resistant durum lines and 2) to rapidly incorporate these elite durum lines into ND durum breeding program for developing new durum germplasm and cultivars with combination of low cadmium, high yield, and excellent quality with FHB resistance.

2. What was accomplished under these goals? *Address items 1-4) below for each goal or objective.*

Objective 1: Determine the FHB resistance QTLs in the resistant durum lines

1) Major activities
   - A panel of 288 (3 96-well plates) tetraploid wheat genotypes consisting of 271 newly-developed durum lines, their parents, and checks (9 ND durum cultivar, 4 *T. dicoccum* accessions, and 4 *T. carthlicum* accessions) have been assembled and genotyped with the Illumina wheat 90K-SNP array.
   - The panel of the 288 tetraploid wheat genotypes has been evaluated using replicated experiments in the FHB field nurseries (Fargo and Prosper, ND) in the summer of 2016 and in greenhouse in the winter of 2016. The panel is also being evaluated in the FHB field nursery (Fargo, ND) in the summer of 2017. The marker and disease data will be used to identify the genomic regions associated with FHB resistance using genome wide association analysis (GWAS) in the coming season.
   - A set of 37 durum lines derived from crosses involved hexaploid wheat 'Sumai 3' and/or PI 277012 were genotyped with eight CAPS (cleaved amplified polymorphic sequence) markers associated with the 5AL QTL from PI 277012. Three of the durum lines with a high level of FHB resistance, low DON, and good agronomic traits were also genotyped using five new PCR-based SNP markers tightly linked to *Fhb1* from Sumai 3 using the semi-thermal asymmetric reverse PCR (STARP) technique.

2) Specific objectives
   - Identify the FHB-resistant QTL introduced to adapted durum germplasm from hexaploid bread wheat and other tetraploid wheat species or subspecies.

3) Significant results
   - The 90K marker data of 288 tetraploid wheat genotypes and the FHB disease data from five environments (two field locations in two years and one greenhouse season) are available.
   - Among 37 durum lines derived from crosses involved hexapoid wheat 'Sumai 3' and/or PI 277012 genotyped with eight CAPS markers, 14 lines carry PI 277012 alleles for all eight markers

- Three durum lines with a high level of FHB resistance, low DON, and good agronomic traits carry *Fhb1* and they also have PI 277012 alleles for two CAPS markers linked to the 5AL QTL.

4) Key outcomes or other achievements
   - The presence of *Fhb1* from Sumai 3 and 5AL QTL from PI 277012 were detected in the new durum wheat germplasm with improved FHB resistance.
   - The expression of FHB-resistance QTL derived from hexaploid wheat in durum is highly affected by genetic background.

Objective 2: Incorporate elite durum lines into ND durum breeding program for developing new durum germplasm and cultivars with combination of low cadmium, high yield, and excellent quality with FHB resistance.

2) Major activities
   - Among the newly-developed durum lines with FHB resistance derived from cultivated emmer and hexaploid wheat, 10 lines were evaluated in a preliminary trial for evaluating agronomic performance, yield, and quality in two locations (Prosper and Langdon, ND) in the summer 2016. The 10 lines are being evaluated in the yield trials in the same locations for the 2nd year in the summer of 2017. Eight of the lines were also evaluated in the NDSU FHB field nursery in Jianyang (China) in the summer of 2017.
   - Three of the durum lines with a high level of FHB resistance, low DON, and good agronomic traits carry *Fhb1* have been crossed with five new ND durum breeding lines carrying *Cdu1* for low cadmium accumulation. Approximately 6,000 F_2 plants have been genotyped with DNA markers for *Fhb1* and *Cdu1*. About 250 F_2 plants that are homozygous for *Fhb1* and *Cdu1* have been selected and 123 of the F_2 plants were evaluated in the greenhouse. A total 87 lines (F_3) are being evaluated using a randomized complete block design (RCBD) with three replications in the field FHB nursery (Fargo, ND) in the summer of 2017.
   - In addition to the marker-assisted selection of *Fhb1* and *Cdu1*, approximately 3,000 F_2 plants were planted in the field FHB nurseries in Prosper and Fargo, ND. The individual F_2 plants exhibiting a high level of FHB resistance, adaptability (height and heading date), and excellent agronomic characteristics will be selected.

3) Significant results
   - Four of the durum lines developed from the crosses involved in bread wheat lines PI 277012 and/or Sumai 3 exhibited a high level of FHB resistance, low DON, and good agronomic traits.
   - About 250 F_2 plants that are homozygous for *Fhb1* and *Cdu1* have been selected. The preliminary evaluation indicated a number of lines (F_3) have a high level of FHB resistance and good agronomic traits.

4) Key outcomes or other achievements
   - The four durum lines having a high level of FHB resistance, low DON, and good agronomic traits represent the first success globally in developing elite durum

germplasm with a high level of FHB resistance and provide a high promise to have the first FHB-resistant durum cultivar developed in the U.S. in the near future. Several lines have been extensively used in ND durum breeding program.

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?

Nothing to Report.

Project 2: *Evaluation and Characterization of Scab Resistance in New Synthetic Wheat Germplasm.*

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

The major goals and objectives of the project are to: 1) Identify new synthetic hexaploid wheat (SHW) lines and wheat-alien species amphiploids carrying FHB resistance and 2) identify putative novel FHB-resistant QTLs in the FHB-resistant SHW lines.

2. What was accomplished under these goals? *Address items 1-4) below for each goal or objective.*

Objective 1: Identify the new SHW lines and wheat-alien species amphiploids carrying FHB resistance.

1) Major activities
   - All the SHW and amphiploid lines and their wheat parents were divided into two different groups in order to appropriately manage the experiments with efficient uses of greenhouse and field spaces in the FHB disease evaluation. The first group consists of 153 SHW lines with normal maturity and their tetraploid wheat parents (75 lines and accessions). The second group consists of the remaining 102 SHW lines, 81 wheat-alien species amphiploids, and their tetraploid and hexaploid wheat parents.
   - In the first group, 150 SHW lines and their 73 tetraploid wheat parents have been successfully evaluated for resistance to FHB by using RCBD with three replications in greenhouse for two seasons and field nurseries at two locations (Fargo and Prosper, ND) for two years.
   - In the second group, approximately 230 genotypes, including 49 tetraploid wheat genotypes (10 durum lines and cultivars, 14 *T. dicoccum* accessions, 18 *T. carthlicum* accessions, 4 *T. polonicum* accessions, 1 *T. turanicum* accession, and 2 *T. turgidum* accessions), 97 SHW lines, 81 wheat-alien species amphiploids and their wheat parents, have been evaluated for FHB resistance in the greenhouse in the summer of 2017.
   - A total of 190 genotypes with adequate seed stocks in the second group are also being evaluated in the field nurseries in two locations (Fargo and Prosper, ND) in the summer of 2017.

2) Specific objectives
   - Identify the SHW lines and the wheat-alien species amphiploids carrying FHB resistance by evaluating 255 SHW lines, 81 amphiploids, and their tetraploid and hexaploid wheat parents for reactions to FHB.

3) Significant results
   - Thirteen SHW lines and one wheat-*Thinopyrum ponticum* amphiploid line with a high level of FHB resistance have been identified.
   - Comparative analysis on a set of SHW lines and their tetraploid wheat parents for FHB resistance revealed that the SHW lines had 42% reduction of FHB severity compared with their durum parents.

4) Key outcomes or other achievements
   - The SHW and amphiploid lines with a high level of FHB resistance identified in this project are useful germplasm for developing adapted bread wheat germplsm.
   - Comparative analysis on a set of SHW lines and their tetraploid wheat parents for FHB resistance clearly demonstrates the positive effects of D genome on the FHB resistance.

Objective 2: Identify putative novel FHB-resistant QTLs in the FHB-resistant SHW lines.

2) Major activities
   - A set of 150 SHW lines and their 73 tetraploid wheat parents in the first group were genotyped with Illumina's iSelect wheat 9K array containing 9,000 gene-derived SNPs and a final SNP data set consisted of 3,330 and 4,674 markers were selected for tetraploid parents and SHW lines, respectively.
   - The marker and FHB severity data were used to identify resistant genes/QTL using association mapping analysis

2) Specific objectives
   - Identify putative novel FHB-resistant QTLs in the FHB-resistant SHW lines using association analysis.

3) Significant results
   - The analysis of population structure revealed that there are three clusters of the tetraploid parents consisted of 1, 22 and 50 individuals, respectively. While SHW lines were divided into three subpopulations, each containing 30, 44 and 76 individuals.
   - No associations with significant effects on FHB resistance were detected in either the SHW population or the tetraploid genotypes. This is likely due to small number of SHW lines used and the low frequency of resistance genes present in the population.

4) Key outcomes or other achievements
   - The results from this study provided guidance in selecting SHW lines for development of mapping populations to study the inheritance of resistance to FHB and to identify and map the resistance QTL.

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?

Nothing to Report.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY16 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 FY16 award period?**

   No.

   If yes, how many?

2. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY16 award period?**

   No.

   If yes, how many?

3. **Have any post docs who worked for you during the FY16 award period and were supported by funding from your USWBSI grant taken faculty positions with universities?**

   No.

   If yes, how many?

4. **Have any post docs who worked for you during the FY16 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.

   If yes, how many?

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 FY16 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

Instructions: Refer to the FY16-FPR_Instructions for detailed instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY16 grant. Only include citations for publications submitted or presentations given during your award period. If you did not have any publications or presentations, state 'Nothing to Report' directly above the Journal publications section.

Journal publications.

Nothing to Report.

Books or other non-periodical, one-time publications.

Nothing to Report.

Other publications, conference papers and presentations.

Szabo-Hever, A., Q. Zhang, S. Zhong, T.L. Friesen, E.M. Elias, S. Chao, and S.S. Xu. 2016. Association mapping for Fusarium head blight resistance in synthetic hexaploid wheat. In: S. Canty, A. Clark, K. Wolfe, and D. Van Sanford (Eds.), Proceedings of the 2016 National Fusarium Head Blight Forum. East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative. p. 97.
Status: Abstract Published and poster presented
Acknowledgement of Federal Support: YES

Zhao, M., Y. Leng, S. Chao, S.S. Xu, and S. Zhong. 2016. Molecular mapping of QTL for FHB resistance introgressed into durum wheat. In: S. Canty, A. Clark, K. Wolfe, and D. Van Sanford (Eds.), Proceedings of the 2016 National Fusarium Head Blight Forum. East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative. p. 105-106.
Status: Abstract Published and poster presented
Acknowledgement of Federal Support: YES

Kumar, A., F. Ghavami, S.M. Pirseyedi, R. Dill-Macky, S. Xu, E.M. Elias and S. Kianian. 2016. Epigenetic control of FHB in durum wheat. In: S. Canty, A. Clark, K. Wolfe, and D. Van Sanford (Eds.), Proceedings of the 2016 National Fusarium Head Blight Forum. East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative**.** p. 82.
Status: Abstract Published and poster presented
Acknowledgement of Federal Support: YES