USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY18 Performance Report
Due date: July 12, 2019

Cover Page

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Fiscal Year:	2018
USDA-ARS Agreement ID:	N/A
USDA-ARS Agreement Title:	Introgression of Scab Resistance from Emmer and Timopheev Wheat into Durum Wheat.
FY18 USDA-ARS Award Amount:	$ 125,489

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
DUR-CP	Development and Characterization of Elite Durum Wheat Germplasm with Scab Resistance.	$ 61,140
DUR-CP	Evaluation and Characterization of Einkorn Wheat Germplasm for Scab Resistance.	$ 26,760
VDHR-SPR	Identify and Introgress Scab Resistance from Synthetic Wheat into Spring Wheat.	$ 37,589
	FY18 Total ARS Award Amount	**$ 125,489**

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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 Germplasm with Scab Resistance.*

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

The major goal of this project is to develop high breeding value durum lines with a high level of FHB resistance that can be directly utilized in the U.S. durum breeding programs. The specific objectives of this project are to: 1) Continue developing elite durum germplasm with improved FHB resistance derived from other tetraploid wheat subspecies and hexaploid wheat and 2) determine the expression of the FHB-resistant quantitative trait loci (QTL) derived from hexaploid wheat.

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

Objective 1: Continue developing elite durum germplasm with improved FHB resistance derived from other tetraploid wheat subspecies and hexaploid wheat.

1) Major activities
   - Three durum lines carrying *Fhb1* with a high level of FHB resistance, low DON, and good agronomic traits were previously crossed with five new ND durum lines carrying *Cdu1* for low cadmium accumulation. Approximately 7,600 F_2 plants were genotyped with the STARP markers for *Fhb1* and *Cdu1* and approximately 400 F_2 plants homozygous for *Fhb1* and *Cdu1* have been selected. Among the F_2 plants that are homozygous for *Fhb1* and *Cdu1*, 123 were first selected and their F_3 families were initially evaluated in the FHB field nursery (Fargo, ND) and greenhouse in summer 2017 and 14 elite durum lines with FHB resistance were selected and advanced to F_6 generation. The 14 elite durum lines, along with their parents and checks, were evaluated in the FHB field nurseries in two locations (Fargo and Prosper, ND) in summer 2018. The 14 durum lines were also evaluated in a preliminary trial to evaluate performance, yield, and quality in two locations (Prosper and Langdon, ND).
   - The durum lines (F_4- F_5) derived from the remaining 328 F_2 plants that were homozygous for *Fhb1* and *Cdu1* were evaluated in the field FHB nurseries in two locations and about 80 lines with low FHB severity were selected.
   - Made new crosses and backcrosses to the two durum lines carrying *Fhb1* with a high level of FHB resistance, low DON, and good agronomic traits with ND new durum variety 'ND Riveland'. A large number of hybrid (F_1) and backcross (BC_1) seeds have been developed.
2) Specific objectives
   - Develop elite durum germplasm with improved FHB resistance that can be directly used in durum breeding program
3) Significant results
   - A large number of hybrid (F_1) and backcross (BC_1) seeds have been developed by crossing and backcross the two durum lines carrying *Fhb1* with a high level of FHB resistance, low DON, and good agronomic traits with ND new durum variety 'ND

Riveland'. The F_1 and BC_1 seeds will be used to develop large numbers of doubled haploid (DH) and BC_1-derived lines in the coming season.
- About 80 new lines with low FHB severity were selected.

4) Key outcomes or other achievements
   - Although the durum lines derived from these F_2 plants carrying *Fhb1* exhibited further improved agronomic traits, none of them showed a level of FHB resistance comparable to three durum lines used as their parents. In addition, 14 durum lines evaluated in the yield trial in Prosper in 2018 all had lodging problem. Based on these observations, we proposed to use DH and single seed descend (SSD) methods to rapidly develop a large number of elite durum lines. From these lines, we will then select the lines that can maintain the high level of FHB resistance and superior agronomic traits as breeding-ready germplasm by disease evaluation and marker analysis.

Objective 2: Determine the expression of the FHB-resistant quantitative trait loci (QTL) derived from hexaploid wheat.

2) Major activities
   - A population of 200 durum lines (F_6) that are homozygous for Fhb1 derived from the cross D151343 × Joppa-Cdu1 were evaluated for FHB resistance in the field FHB nurseries in Fargo and Prosper.

2) Specific objectives
   - Determine the expression of Fhb1 in durum wheat

3) Significant results
   - The field disease severity data from the population of 200 durum lines (F_6) that are homozygous for *Fhb1* derived from the cross D151343 × Joppa-Cdu1 have been collected from two locations.

4) Key outcomes or other achievements
   - The field disease severity data from evaluating the D151343 × Joppa-Cdu1 population showed that none of line showed a level of FHB resistance comparable to D151343 used as their parent. This prompted us to reconsider the strategy for developing elite durum lines that can maintain a high level of FHB resistance in adapted background.

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 Einkorn Wheat Germplasm for Scab Resistance.*

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

The major goal of this project is to search for novel sources of resistance to FHB in durum and its relatives. The specific objectives of the project are to: 1) Identify einkorn wheat accessions carrying FHB resistance by screening the einkorn wheat collection at USDA-ARS National Small Grain Collection (NSGC) for reactions to FHB and 2) introgress the FHB resistance einkorn wheat to durum wheat.

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

Objective 1: Identify einkorn wheat accessions carrying FHB resistance by screening the einkorn wheat collection at USDA-ARS National Small Grain Collection (NSGC) for reactions to FHB.

1) Major activities
   - By screening approximately 1,276 einkorn wheat accessions (857 *T. monococcum* subsp. *aegilopoides*, 203 *T. monococcum* subsp. *monococcum*, and 216 *T. urartu* accessions) from USDA-ARS National Small Grain Collection (NSGC), Aberdeen, ID in a non-replicated experiment in greenhouse in the summer of 2017, 84 accessions with putative resistance were selected and further evaluated using a replicated (3 replications) trial in greenhouse for the 2nd season.
2) Specific objectives
   - Identify the einkorn accessions carrying FHB resistance by screening the einkorn wheat collection at USDA-ARS NSGC for reactions to FHB.
3) Significant results
   - Approximately 24 *T. monococcum* and *T. urartu* accessions showed moderate levels of FHB resistance from the evaluation in the 2nd season in greenhouse.
   - Two "*T. monococcum*" accessions (PI 352476 and PI 352477) were identified with a high level of FHB resistance, but they were verified to be hexaploid wheat based on plant and spike morphology and chromosome number.
4) Key outcomes or other achievements
   - *T. monococcum* and *T. urartu* accessions with moderated FHB resistance have been identified and they can be useful for improvement of durum wheat for FHB resistance.
   - Two hexaploid wheat accessions (PI 352476 and PI 352477), which are currently misclassified as *T. monococcum* at USDA-ARS NSGC, were identified to have a high level of FHB resistance. They can be used as source of FHB resistance for durum and bread wheat.

Objective 2: Introgress the FHB resistance from einkorn wheat to durum wheat.

1) Major activities
   - Crossed 15 *T. monococcum* accessions (PI 167591, PI 167634, PI 168805, PI 191383, PI 277135, PI 286068, PI 290511, PI 341413, PI 355546, PI 554596, PI 352482, PI 428156, PI 428157, PI 428165, and PI 591871) with moderate FHB resistance to durum variety ND Riveland.

2) Specific objectives
   - Introgress the FHB resistance from einkorn wheat to durum wheat.
3) Significant results
   - Hybrid seeds from 15 crosses made above have been successfully produced.
4) Key outcomes or other achievements
   - Hybrid seeds from 15 crosses made above will be used for subsequent backcrosses for developing adapted durum germplasm in the coming season.

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 3: *Identify and Introgress Scab Resistance from Synthetic Wheat into Spring Wheat.*

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

The major goal of the project is to efficiently introgress effective resistance genes into breeding germplasm. The specific objectives of the project are to: 1) identify and map the FHB-resistance QTL in synthetic hexaploid wheat (SHW) germplasm and 2) transfer the QTL into hard red spring wheat (HRSW) varieties by using the SHW lines

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

Objective 1: Identify and map the FHB-resistance QTL in synthetic hexaploid wheat germplasm

1) Major activities
   - A population of 190 recombinant inbred lines (RILs) previously developed from the cross between HRSW line ND495 and SHW line Largo (durum Langdon/*Aegilops tauschii* PI 268210) have been genotyped with wheat 90K iSelect array and evaluated in field nursery in Fargo and two greenhouse seasons in 2018. This population has been planted for evaluation in field nursery in the summer of 2019.
   - Performed preliminary QTL analysis using the marker data and phenotypic data and five QTL on 1D, 2D, 3D, 7A and 7D were tentatively identified.
   - Crossed SHW line SW91 (*Triticum dicoccum* CItr 14133/*Aegilops tauschii* CIae 26) to HRSW variety 'Wheaton' to initiate development of new population.
2) Specific objectives
   - Identify and map the FHB-resistance QTL in synthetic hexaploid wheat germplasm
3) Significant results
   - The disease severity data of the RIL population (ND495/Largo) have been successfully obtained from one field and two greenhouse experiments.
   - The 90K marker data of the RIL population (ND495/Largo) are now available and a high-density linkage map has been constructed.
4) Key outcomes or other achievements
   - Five QTL on 1D, 2D, 3D, 7A and 7D were tentatively identified based preliminary QTL analysis, suggesting that *Ae. tauschii* germplasm may have FHB resistance genes that can be used to improve FHB resistance in bread wheat.

Objective 2: Transfer the QTL into hard red spring wheat (HRSW) varieties by using the SHW lines

1) Major activities
   - Developed hybrid seeds from 21 cross combinations by crossing SHW lines SW93 (CItr 14133/PI 268210), SW183 (PI 191091/CIae 26), and SW187 (PI 272527/CIae 26) to HRSW varieties 'Glenn', 'Barlow', 'Vitpro', 'Grandin', 'Linert' and 'Bolles' and breeding lines ND828, NDHRS16-14-36, and NDHRS16-13-89.
   - About 100 elite HRSW lines with improved FHB resistance derived from hexaploid wheat line PI 277012 have been developed and evaluyed for FHB resistance in the field nursery in 2018. This set of lines were planted for repeat evaluation for validating the 5AL QTL in field nursery this summer.

2) Specific objectives
   - Transfer the QTL into HRSW varieties by using the SHW lines
3) Significant results
   - Hybrid seeds from 21 crosses made above have been successfully produced.
4) Key outcomes or other achievements
   - Hybrid seeds from 21 crosses made above will be used for subsequent backcrosses for developing adapted HRSW germplasm in the coming seasons.
   - Five of the HRSW lines with combination of improved resistance and agronomic traits have been tested and used in the spring wheat 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.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY18 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 FY18 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 FY18 award period?**

   No
   If yes, how many?

3. **Have any post docs who worked for you during the FY18 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 FY18 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 FY18 award period. All columns must be completed for each listed germplasm/cultivar. Use the key below the table for Grain Class abbreviations.

NOTE: 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 FY18-FPR_Instructions for detailed instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY18 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.

NOTE: Directly below each reference/citation, you must indicate the Status (i.e. published, submitted, etc.) and whether acknowledgement of Federal support was indicated in publication/ presentation. See example below for a poster presented at the FHB Forum:

> Conley, E.J., and J.A. Anderson. 2018. Accuracy of Genome-Wide Prediction for Fusarium Head Blight Associated Traits in a Spring Wheat Breeding Program. In: Proceedings of the XXIV International Plant & Animal Genome Conference, San Diego, CA.
> Status: Abstract Published and Poster Presented
> Acknowledgement of Federal Support: YES (poster), NO (abstract)

Journal publications.

Szabo-Hever, A., Q. Zhang, T.L. Friesen, S. Zhong, E.M. Elias, X. Cai, Y. Jin, J.D. Faris, S. Chao, S.S. Xu. 2018. Genetic diversity and resistance to Fusarium head blight in synthetic hexaploid wheat derived from *Aegilops tauschii* and diverse *Triticum turgidum* subspecies. Frontiers in Plant Science 9: 1089. Doi: 10.3389/fpls.2018.01829.
Status: Published
Acknowledgement of Federal Support: YES

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

Nothing to Report.

Other publications, conference papers and presentations.

Green, A., J. Leier, Y. Lin, S. Zhong, X. Li, A. Friskop, S. Xu, X. Cai, R. Frohberg, R. Stack, and M. Mergoum. 2018. Breeding for FHB resistance in North Dakota: More questions than answers. In: Canty, S., A. Hoffstetter, B. Wiermer and R. Dill-Macky (Eds.), P*roceedings of the 2018 National Fusarium Head Blight Forum* (p. 114). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
Status: Abstract Published and Talk Presented
Acknowledgement of Federal Support: YES

Kumar, A., S. Xu, E.M. Elias, R. Dill-Macky, and S. Kianian. 2018. Epigenome modification in durum wheat provides FHB resistance. In: Canty, S., A. Hoffstetter, B. Wiermer and R. Dill-Macky (Eds.), *Proceedings of the 2018 National Fusarium Head Blight Forum* (p. 117). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
Status: Abstract Published and Poster Presented
Acknowledgement of Federal Support: YES