USDA-ARS
U.S. Wheat and Barley Scab Initiative
FY19 Performance Report
Due date: July 24, 2020

Cover Page

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Fiscal Year:	2019
USDA-ARS Agreement ID:	N/A
USDA-ARS Agreement Title:	Introgression of Scab Resistance from Emmer and Timopheev Wheat into Durum Wheat
FY19 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
	FY19 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 research 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 or objectives? *(For each major goal/objective, address items a-b) below.)*

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

a) What were the major activities?

- We previously crossed three durum lines (D151343, D151344, and D151345) carrying *Fhb1* with a high level of FHB resistance, low DON, and good agronomic traits to five new ND durum breeding lines carrying *Cdu1*. A total of 86 elite durum lines carrying *Fhb1* and *Cdu1* in the advanced generations (F_6) were evaluated in the field FHB nurseries in two locations (Fargo and Prosper, ND) in the summer 2019.
- A total 43 elite durum lines carrying *Fhb1* and *Cdu1* in the advanced generations (F_6 or F_7) were evaluated for yield and agronomic traits in a preliminary yield trial in two locations (Langdon and Prosper, ND) in 2019.
- Based on the FHB disease evaluation and yield trials conducted in the summer 2019, we selected 68 promising lines for testing in the field FHB nurseries in two locations (Fargo and Prosper, ND) in the summer 2020 and 30 of the durum lines and their parents are also being included for comprehensive testing in a yield trial in Prosper, ND in the summer of 2020.
- Made backcrosses to 10 durum lines carrying *Fhb1* and/or PI 277012-derived 5AL and 5AS QTL with a high level of FHB resistance, low DON, and good agronomic traits with ND new durum variety 'ND Riveland'. A large number of backcross (BC_1 and BC_2) seeds have been developed. Approximately 3,000 BC_2F_2 plants are being testing in the field FHB nurseries in two locations (Fargo and Prosper, ND) in the summer 2020. They are also being genotyped using STARP markers for *Fhb1* and PI 277012-derived 5AL and 5AS QTL.

b) What were the significant results?

- Approximately 30 durum lines with improved FHB resistance and agronomic performance have been selected.
- Fourteen large (10 BC_1 and four BC_2) populations derived from backcrossing 10 durum lines carrying *Fhb1* and/or PI 277012-derived 5AL and 5AS QTL with ND

Riveland have been developed. These populations are currently being genotyped and phenotyped for developing FHB resistant durum germplasm that can be directly used in durum wheat breeding.

c) List key outcomes or other achievements.
- Twelve elite durum lines with improved FHB resistance and yield have been provided to NDSU durum wheat program.
- New diagnostic STARP markers for *Fhb1* were developed for marker-assisted selection in breeding.

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

a) What were the major activities?
- A population of 200 durum lines (F_7) 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 for the 2nd season in the summer of 2019.

b) What were the significant results?
- The field disease severity data from the population of 200 durum lines (F_7) that are homozygous for *Fhb1* derived from the cross D151343 × Joppa-Cdu1 have been collected from two locations.

c) List key outcomes or other achievements.
- The FHB disease pressures were extremely high in both Fargo and Prosper in 2019. Most of the lines in the D151343 × Joppa-Cdu1 population showed high disease severities. However, several lines showed a good level of FHB resistance.

3. Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.

This research has been impacted by the COVID-19 pandemic due to USDA ARS teleworking status, travel restriction, and university shutdown.
- One planned trial in Langdon (190 miles from Fargo) was not planted. We had planned to evaluate 30 durum lines and their parents in a yield trial at two locations (Prosper and Langdon, ND) in the summer of 2020. Although we have prepared the seed for the trials, we planted the trial in one location in Prosper, which is within 35-mile travel limit.
- Evaluation, marker-assisted selection, and generation advancing in greenhouse were interrupted.
- Evaluation and selection of FHB-resistant germplasm are been seriously impacted by maintaining social distance. The guidelines require only one person per vehicle when travel to field plots, restricting the disease scoring, selection, and harvesting, which require team work.

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

Nothing to Report.

5. 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 research 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 or objectives? *(For each major goal/objective, address items a-b) below.)*

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.

a) What were the major activities?
- The major activities for 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 were completed in FY18. No activities were performed in FY19.

b) What were the significant results?
- Approximately 24 *T. monococcum* and *T. urartu* accessions were identified with moderate FHB resistance.

c) List key outcomes or other achievements.
- *T. monococcum* and *T. urartu* accessions with moderated FHB resistance identified in this project can be useful for improvement of durum wheat for FHB resistance.

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

a) What were the major activities?
- Fifteen *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 were crossed to durum variety ND Riveland in FY18. The F_1 hybrids from 13 crosses were grown in greenhouse for backcrosses with ND Riveland. However, no backcrossed seed were produced due to the sterility before university shutdown and USDA-ARS teleworking status started in March 2020.

b) What were the significant results?
- There are no significant results produced from this project.

c) List key outcomes or other achievements
- There are no key outcomes or other achievements.

3. Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.

This research was seriously impacted by the COVID-19 pandemic due to university shutdowns and reduced hours of the postdoc working in greenhouse. The postdoc firstly backcrossed the F_1 plants derived from three *T. monococcum* accessions with ND Riveland, but failed to produce BC_1 seed due to the sterility of the F_1 hybrid plants or incompatibility. We had planned to make a large number of backcrosses. However, university shutdown and USDA-ARS teleworking status started in March 2020 have restricted us to make more crosses.

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

Nothing to Report.

5. 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 research 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 or objectives? *(For each major goal/objective, address items a-b) below.)*

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

a) What were the major activities?
- Evaluated 188 recombinant inbred lines (RILs) previously developed from the cross between HRSW line ND495 and SHW line Largo (durum Langdon/*Aegilops tauschii* PI 268210) in field nurseries at two locations (Fargo and Prosper, ND) in the summer of 2019.
- Performed QTL analysis using the marker data and phenotypic data from four environments and identified six FHB-resistant QTL on chromosomes 1D, 2D, 3D, 7D, and 5B.
- Produced F_2 populations from the cross of SHW line SW91 (*Triticum dicoccum* CItr 14133/*Aegilops tauschii* CIae 26) to HRSW variety 'Wheaton'.

b) What were the significant results?
- Identified six FHB-resistant QTL on chromosomes 1D, 2D, 3D, 7D, and 5B.

c) List key outcomes or other achievements.
- Several RILs showed a high level of FHB resistance and they may be useful for improving FHB resistance in bread wheat.

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

a) What were the major activities?
- Grew F_1 plants of 24 cross combinations from 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.
- Produced 18 BC_1F_1 populations by backcrossing the F_1 plants which had normal plant growth and development. Six planned backcrosses were not made because the F_1 plants from crosses of SW187 to ND828, NDHRS16-14-36, NDHRS16-13-89, Glenn, Linkert, and Vitpro were grass dwarf and not heading.

- Evaluated a HRSW panel of 98 elite HRSW lines with improved FHB resistance derived from hexaploid wheat line PI 277012, their parents, and checks for FHB resistance in two separated experiments using point and seed spawn inoculations, respectively, in the field nursery in Fargo in 2019. This set of lines were planted for repeat evaluation for validating the *Fhb1*, 5AL QTL, and other QTL in field nurseries at two locations (Fargo and Prosper, ND) in the summer of 2020.
- Conducted a preliminary yield trial for 26 elite HRSW lines with improved FHB resistance derived from hexaploid wheat line PI 277012 in two locations (Prosper and Langdon, ND) in the summer of 2019. Thirteen elite HRSW lines have been selected and are currently being grown in yield trial at two locations (Langdon and Thompson, ND) in the summer of 2020
- Developed two new short translocation lines carrying *Fhb7* and a functional marker for the gene.

b) What were the significant results?
- Eighteen BC_1F_1 populations have been successfully produced from backcrossing 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.
- Thirteen elite HRSW lines with both high yield and FHB resistance derived from PI 277012 have been selected.
- Two new short translocation lines carrying *Fhb7* and a functional marker for the gene were developed.

c) List key outcomes or other achievements.
- Eighteen BC_1F_1 populations developed above will be used for developing adapted HRSW germplasm in the coming seasons.
- Thirteen HRSW lines with combination of improved resistance and agronomic traits have been tested and provided to spring wheat breeding program.
- Two new short translocation lines carrying *Fhb7* and a functional marker for the gene have been provided to several breeding programs.

3. Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.

This research was seriously impacted by the COVID-19 pandemic due to university shutdowns and reduced hours of the postdoc working in greenhouse. We had planned to grow and evaluate18 BC_1F_1 populations derived from SHW lines in the spring 2020. However, university shutdown and USDA-ARS teleworking status started in March 2020 have restricted us to do this work.

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

Nothing to Report.

5. 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 FY19 award period (N/A). 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 FY19 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 FY19 award period?**
   No
   If yes, how many?

3. **Have any post docs who worked for you during the FY19 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 FY19 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 FY19 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 FY19-FPR_Instructions for detailed more instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY19 grant award. Only citations for publications published (submitted or accepted) or presentations presented during the **award period (N/A**) should be included. If you did not publish/submit or present anything, state 'Nothing to Report' directly above the Journal publications section.

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

De Wolf, E., D. Shah, P. Paul, L. Madden, S. Crawford, D. Hane, S. Canty, R. Dill-Macky, D. Van Sanford, K. Imhoff and D. Miller. 2019. "Impact of Prediction Tools for Fusarium Head Blight in the US, 2009-2019." In: S. Canty, A. Hoffstetter, H. Campbell and R. Dill-Macky (Eds.), *Proceedings of the 2019 National Fusarium Head Blight Forum* (p. 12.), Milwaukee, WI; December 8-10. University of Kentucky, Lexington, KY.
Status: Abstract Published and Poster Presented
Acknowledgement of Federal Support: YES (Abstract and Poster)

Journal publications.

Wang, H., S. Sun, W. Ge, L. Zhao, B. Hou, K. Wang, Z. Lyu, L. Chen, S. Xu, J. Guo, M. Li, P. Su, X. Li, G. Wang, C. Bo, X. Fang, W. Zhuang, X. Cheng, J. Wu, L. Dong, W. Chen, W. Li, G. Xiao, J. Zhao, Y. Hao, Y. Xu, Y. Gao, W. Liu, Y. Liu, H. Yin, J. Li, X. Li, Y. Zhao, X. Wang, F. Ni, X. Ma, A. Li, S.S. Xu, G. Bai, E. Nevo, C. Gao, H. Ohm, and L. Kong. 2020. Horizontal gene transfer of *Fhb7* from fungus underlies Fusarium head blight resistance in wheat. Science 368:844 eaba5435. https://doi.org/10.1126/science.aba5435
Status: Published
Acknowledgement of Federal Support: NO (This work is not supported by fund from USWBSI)

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

Other publications, conference papers and presentations.

Kumar, J., K.M. Rai, S.M. Pirseyedi, S. Xu, E.M. Elias, R. Dill-Macky and S. Kianian. 2019. "Epigenetic modifications: A novel source of FHB resistance in durum wheat" In: S. Canty, A. Hoffstetter, H. Campbell and R. Dill-Macky (Eds.), *Proceedings of the 2019 National Fusarium Head Blight Forum* (p. 98-99), Milwaukee, WI; December 8-10. University of Kentucky, Lexington, KY.
Status: Abstract Published and Poster Presented
Acknowledgement of Federal Support: YES (Abstract and Poster)