

USDA-ARS
U.S. Wheat and Barley Scab Initiative
FY20 Annual Performance Progress Report
Due date: July 29, 2021

Cover Page

Principle Investigator (PI):	Steven Xu
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Fiscal Year:	2020
USDA-ARS Agreement ID:	N/A
USDA-ARS Agreement Title:	Introgression of Scab Resistance from Emmer and Timopheev Wheat into Durum Wheat
FY20 USDA-ARS Award Amount:	\$ 139,556
Project/Grant Reporting Period:	5/1/20 - 4/30/21
Reporting Period End Date:	4/30/2021

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
DUR-CP	Developing Elite Durum Lines with Scab Resistance Derived from Wheat-related Species	\$ 73,670
VDHR-SPR	Development of Elite Spring Wheat Germplasm with Scab Resistance	\$ 65,886
FY20 Total ARS Award Amount		\$ 139,556

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Principal Investigator

Date

* MGMT – FHB Management
FST – Food Safety & Toxicology
R- Research
S – Service (DON Testing Labs)
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: *Developing Elite Durum Lines with Scab Resistance Derived from Wheat-related Species*

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

The objective of this project is to continue developing elite durum germplasm with improved FHB resistance derived from diploid, tetraploid and hexaploid wheat accessions.

2. What was accomplished under these goals or objectives? *(For each major goal/objective, address these three items below.)*

a) What were the major activities?

- Developed and genotyped 10 new BC1F1, BC1F2, and BC2F1 populations from backcrossing elite durum lines (15Entry 65, 104, 111, 129, 237, 246, 269, 271, 279, and 295) carrying Fhb1 and/or two PI277012-derived 5A QTL to durum variety ND Riverland.
- Developed four large BC2F2 populations derived from backcrossing durum line D151343 (15Entry 255) to Carpio_Cdu1, Joppa_Cdu1, and ND Riverland for improving agronomic traits and genotyped over 7,000 plants using STARP markers for Fhb1 and Cdu1. A total of 855 and 405 lines with homozygous Fhb1 and Cdu1 have been selected and advanced to BC2F4 and BC2F5 generations, respectively. These lines are currently being tested in FHB nurseries in Fargo, Prosper, and Langdon in 2021. The 405 BC2F5 lines are also being evaluated for agronomic traits and performance in single-row plots in Prosper and Langdon in 2021.
- Developed more than 200 BC1F1 seeds by backcrossing a wheat-Thinopyrum ponticum 7D/7eI2 introgression line RWG52 (591) with durum Divide ph1b line to transfer Fhb7 from chromosome 7D to 7A or 7B in durum wheat.
- Made new crosses between Chinese wheat landrace 'Wangshuibai' and ND Riverland to develop new durum germplasm by simultaneously transferring major FHB resistance QTL Fhb1, Fhb2, Fhb4, and Fhb5.
- Evaluated 30 durum lines and their parents in a yield trial in Prosper, ND in the summer of 2020 and elite line 20Entry24 has been selected and included in a yield trial in Prosper and Langdon ND in the summer of 2021.

b) What were the significant results?

- A total of 1,336 elite durum germplasm lines, which carry Cdu1, Fhb1 and/or two PI277012-derived 5A QTL in BC1F3 (76 lines), BC2F4 (855 lines), and BC2F5 (405 lines), have been developed.
- Yield and quality analysis showed that four durum lines, including 20Entry 24, with Fhb1 had the quality and yield that matched with the ND varieties used as checks.

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- New BC1F1, BC1F2, and BC2F2 populations have been developed by backcrossing elite durum lines (15Entry 65, 104, 111, etc.) to ND Riverland.
- New hybrid seed have been produced by crossing Wangshuibai to ND Riveland for transferring major FHB resistance QTL Fhb1, Fhb2, Fhb4, and Fhb5 into durum.
- A population of over 200 BC1F1 seeds has been produced by backcrossing wheat-Th. ponticum 7D/7eI2 introgression line RWG52 (591) with Divide ph1b line.

c) List key outcomes or other achievements.

- The 1,336 elite durum germplasm lines carrying Cdu1, Fhb1 and/or two PI277012-derived 5AS/5AL QTL are being evaluated for potential new varieties by ND durum wheat breeding program.
- The elite line 20Entry 24 has also included in the breeding trial in the ND durum wheat breeding program in the summer of 2021.
- The new populations carrying Fhb1, Fhb2, Fhb4, Fhb5, Fhb7, and two PI277012-derived 5A QTL provide base materials to pyramid these major FHB resistance QTL into durum varieties.

3. Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns and/or restrictions, 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 shortage of laboratory supplies. Field experiments have been seriously impacted by maintaining social distance and travel restriction. Requirement for one person per vehicle has negative impacts on the tasks requiring team work such as disease scoring, selection, and harvesting. Due to variables in weather, plant growth, and weekends, it was often difficult to submit travel requests to Langdon (190 miles from Fargo) three days ahead of anticipated travel dates. Marker development and genotyping have been seriously impacted by shortage of PCR plates and other plastic consumables on the markets. The DH production, a consecutive process from emasculation to embryo rescue, was interrupted by the maximized telework status.

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?

The results have been disseminated through presentations at various workshops and seminars and communications with breeders and collaborators.

Project 2: Development of Elite Spring Wheat Germplasm with Scab Resistance

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

The major goal and objective of this project is to develop adapted hard red spring wheat (HRSW) germplasm by transferring FHB resistance from unadapted sources into the HRSW cultivars.

2. What was accomplished under these goals or objectives? (For each major goal/objective, address these three items below.)

a) What were the major activities?

- Advanced 18 BC1 populations derived from backcrosses of SHW lines SW93 (Citr 14133/PI 268210), SW183 (PI 191091/Clae 26), and SW187 (PI 272527/Clae 26) to HRSW varieties 'Glenn', 'Barlow', 'Vitpro', 'Grandin', 'Linert', and 'Bolles' and breeding lines ND828, NDHRS16-1436, and NDHRS16-13-89 for two generations using single seed descent.
- Genotyped 98 elite HRSW lines with improved FHB resistance derived from PI 277012 using STRAP markers for Fhb1 and the 5AS/5AL QTL from PI 277012.
- Evaluated 98 elite HRSW lines derived from PI 277012, their parents, and checks for FHB resistance in greenhouse for two seasons and field nurseries at two locations (Fargo and Prosper, ND) in 2020 and three locations (Fargo, Langdon, and Prosper, ND) in 2021.
- Developed doubled haploids from the F1 hybrids from the cross of 15FAR1157-1 to ND Frohberg using wheat × maize hybridization.
- Developed BC1 populations by backcrossing the F1 plants from the crosses of the lines 15FAR1157-1, 15FAR1162-1, 15FAR1143-3, and 15FAR1162-2 to HRSW varieties ND Frohberg, Glenn, Bolles, Vitpro, Linkert, 'Faller', and 'Alsen'.
- Developed F2 and BC1 populations from the crosses of Wangshubai to ND Frohberg to develop new HRSW germplasm lines by simultaneously transferring several major FHB resistance QTL Fhb1, Fhb2, Fhb4, and Fhb5 to ND varieties.
- Conducted yield trials to evaluate yield and quality of the 12 elite HRSW lines with improved FHB resistance derived from PI 277012 in two locations in 2020 (Langdon and Thompson, ND) and 2021 (Langdon and Prosper, ND).

b) What were the significant results?

- A total of 18 BC1 populations consisting approximately 1,400 lines derived from backcrossing SHW lines SW93, SW183, and SW187 to HRSW varieties have been advanced to BC1F4 generation.
- Marker genotyping revealed that among 98 elite HRSW lines, nine carry the 5AL QTL from PI 277012, eight of the nine lines with 5AL QTL also carry 5AS QTL either

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from PI 277012 or Faller with one line (15FAR1157-1) carrying the two 5A QTL combined with Fhb1. In addition, 18 lines have combined Fhb1 with 5AS QTL either from PI 277012 or Faller.

- Preliminary analysis from yield trial in 2020 showed that several lines 15FAR1157-1, 15FAR1162-1, 15FAR1162-2, 15FAR1143-3 had the quality and yield that matched with the HRSW varieties.
- A total of 11 large F2 populations and 17 BC1F1 populations (~1,500 BC1 seeds) were developed from crossing and backcrossing 15FAR1157-1, 15FAR1162-1, 15FAR1143-3, 15FAR1162-2, and Wanshubai to HRSW varieties. These populations will be genotyped using STRAP markers for Fhb1, PI 277012-derived 5AS/5AL QTL, and other major QTL (Fhb2, Fhb4, and Fhb5) in the coming seasons.
- A total of 24 haploid plants from the F1 hybrids from the cross of 15FAR1157-1 to ND Frohberg were produced and they will be treated with colchicine for DH production.

c) List key outcomes or other achievements.

- Several elite lines 15FAR1157-1, 15FAR1162-1, 15FAR1162-2 have been extensively evaluated for FHB resistance, agronomic performance, yield, and quality in breeding programs, they have been used in the HRSW breeding programs in North Dakota and Minnesota.
- The new populations and germplasm carrying Fhb1, Fhb2, Fhb4, Fhb5, Fhb7, and two PI277012-derived 5A QTL provide base materials to pyramid these major FHB resistance QTL into HRSW varieties.

3. Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns and/or restrictions, 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 shortage of laboratory supplies. Details have been described in Project 1.

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?

The results have been disseminated through presentations at various workshops and seminars and communications with breeders and collaborators.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY20 award period (5/1/20 - 4/30/21). 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 FY20 award period?

Yes No

If yes, how many? [Click to enter number here.](#)

2. Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY20 award period?

Yes No

If yes, how many? [Click to enter number here.](#)

3. Have any post docs who worked for you during the FY20 award period and were supported by funding from your USWBSI grant taken faculty positions with universities?

Yes No

If yes, how many? [Click to enter number here.](#)

4. Have any post docs who worked for you during the FY20 award period and were supported by funding from your USWBSI grant gone on to take positions with private ag-related companies or federal agencies?

Yes No

If yes, how many? [Click to enter number here.](#)

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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 FY20 award period (5/1/20 - 4/30/21). 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	FHB Rating (0-9)	Year Released
Nothing to report.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
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Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year

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

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Publications, Conference Papers, and Presentations

Instructions: Refer to the PR_Instructions for detailed more instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY20 grant award. Only citations for publications published (submitted or accepted) or presentations presented during the **award period (5/1/20 - 4/30/21)** 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:

Z.J. Winn, R. Acharya, J. Lyerly, G. Brown-Guedira, C. Cowger, C. Griffey, J. Fitzgerald, R.E. Mason and J.P. Murphy. 2020. "Mapping of Fusarium Head Blight Resistance in NC13-20076 Soft Red Winter Wheat." In: S. Canty, A. Hoffstetter, and R. Dill-Macky (Eds.), *Proceedings of the 2020 National Fusarium Head Blight Forum* (p. 12.), Virtual; December 7-11. Online: https://scabusa.org/pdfs/NFHB20_Proceedings.pdf.
Status: Abstract Published and Poster Presented
Acknowledgement of Federal Support: YES (Abstract and Poster)

Journal publications.

J. Kumar, J., K.M. Rai, S. Pirseyedi, E.M. Elias, **S. Xu**, R. Dill-Macky & S.F. Kianian. 2020. Epigenetic regulation of gene expression improves Fusarium head blight resistance in durum wheat. *Scientific Reports* 10:17610. doi: 10.1038/s41598-020-73521-2.
Status: Published.
Acknowledgement of Federal Support: Yes.

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

Nothing to Report.

Other publications, conference papers and presentations.

Y. Leng, B. Poudel, A. Bernardo, R. Bian, A. Karmacharya, J. Mullins, G. Bai, S. S. Xu and S. Zhong. 2020. "Identification and molecular mapping of a major QTL on chromosome 2A conferring resistance to Fusarium head blight in emmer wheat." In: Canty, S., A. Hoffstetter, and R. Dill-Macky (Eds.), *Proceedings of the 20120 National Fusarium Head Blight Forum* (p. 19), Virtual; December 7-11, 2020. Online:

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https://scabusa.org/pdfs/NFHBF20_Proceedings.pdf. East Lansing, MI: U.S. Wheat & Barley Scab Initiative.

Status: Abstract Published and Poster Presented.

Acknowledgement of Federal Support: YES (Abstract and Poster).

R. Wang, J. Hegstad, S. Xu, E. Elias, S. Zhong, and X. Li. 2020. "Developing durum wheat FHB resistant germplasm using interspecific crosses and phenotypic selection at early generations." . In: Canty, S., A. Hoffstetter, and R. Dill-Macky (Eds.), Proceedings of the 20120 National Fusarium Head Blight Forum (p. 22), Virtual; December 7-11, 2020.

Online: https://scabusa.org/pdfs/NFHBF20_Proceedings.pdf. East Lansing, MI: U.S. Wheat & Barley Scab Initiative.

Status: Abstract Published and Poster Presented.

Acknowledgement of Federal Support: YES (Abstract and Poster).