USDA-ARS | U.S. Wheat and Barley Scab Initiative

# FY22 Performance Progress Report

**Due date:** July 26, 2023

## Cover Page

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| **USDA-ARS Agreement ID:** | N/A |
| **USDA-ARS Agreement Title:** | Improving Durum and Spring Wheat for Scab Resistance |
| **Principle Investigator (PI):** | Steven Xu |
| **Institution:** | USDA-Agricultural Research Service |
| **Institution UEI:** | N/A |
| **Fiscal Year:** | 2022 |
| **FY22 USDA-ARS Award Amount:** | $145,282 |
| **PI Mailing Address:** | USDA-ARS, Western Regional Research Center<br>800 Buchanan Street<br>Albany, California 94710, USA |
| **PI E-mail:** | steven.xu@usda.gov |
| **PI Phone:** | (510) 559-5614 |
| **Period of Performance:** | May 1, 2022 - April 30, 2023 |
| **Reporting Period End Date:** | April 30, 2023 |

## USWBSI Individual Project(s)

| USWBSI Research Category* | Project Title | ARS Award Amount |
|---|---|---|
| DUR-CP | Integration of major FHB-resistant QTL into modern durum wheat varieties | $68,622 |
| VDHR-SPR | Development of Elite Spring Wheat Germplasm with Fusarium Head Blight Resistance | $76,660 |
| | **FY22 Total ARS Award Amount** | $145,282 |

I am submitting this report as an: ☒ Annual Report

*I certify to the best of my knowledge and belief that this report is correct and complete for performance of activities for the purposes set forth in the award documents.*

STEVEN XU Digitally signed by STEVEN XU Date: 2023.07.25 20:47:12 -07'00'

Principal Investigator Signature

July 25, 2023

Date Report Submitted

* BAR-CP – Barley Coordinated Project
DUR-CP – Durum Coordinated Project
EC-HQ – Executive Committee-Headquarters
FST-R – Food Safety & Toxicology (Research)
FST-S – Food Safety & Toxicology (Service)
GDER – Gene Discovery & Engineering Resistance
HWW-CP – Hard Winter Wheat Coordinated Project
MGMT – FHB Management
MGMT-IM – FHB Management – Integrated Management Coordinated Project
PBG – Pathogen Biology & Genetics
TSCI – Transformational Science
VDHR – Variety Development & Uniform Nurseries
NWW –Northern Soft Winter Wheat Region
SPR – Spring Wheat Region
SWW – Southern Soft Red Winter Wheat Region

**Project 1:** Integration of major FHB-resistant QTL into modern durum wheat varieties

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**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?**

- A total of 167 $BC_2F_3$ lines that are homozygous for *Fhb1*, PI277012-derived 5A QTL, and *Cdu1* were previously selected by genotyping over 2,500 $BC_2F_2$ plants derived from backcrossing durum lines 15Entry 104, 15Entry 111, 15Entry 129, 15Entry 269, 15Entry 271, and 15Entry 295 with durum variety 'ND Riveland'. These 167 lines with *Fhb1* and 5A QTL and 23 lines without *Fhb1* and 5A QTL as checks were evaluated and increased in the greenhouse and they were planted for testing in the field FHB nurseries in two locations in the summer of 2023.
- Planted and evaluated 212 breeding lines ($BC_2F_6$) derived from backcrossing durum line D151343 (15Entry 255) to ND Riveland and breeding linea Carpio_Cdu1 and Joppa_Cdu1 in FHB nurseries at Fargo and Prosper, ND and single row plots at Prosper and Langdon during the summer of 2022.
- Conducted a yield trial for 37 breeding lines selected from the 212 lines described above and three varieties (Carpio, Joppa, and Riveland) with three replications at Prosper and Langdon during the summer of 2022.
- Prepared and planted the trail for the 37 breeding lines and three varieties (Carpio, Joppa, and Riveland) in the 2$^{nd}$ year in the summer of 2023.
- Five of the 37 breeding lines with higher grain yields than check varieties (Carpio, Joppa) were included in the elite yield trials in multiple locations in the NDSU (North Dakota State University) durum wheat breeding programs in the summer of 2023.
- Developed $BC_3F_1$ populations by backcrossing a wheat-*Thinopyrum ponticum* 7D/7el2 introgression line RWG52 (591) with durum Divide and Divide *ph1b* line to transfer *Fhb7* from chromosome 7D to 7A or 7B in durum wheat.
- Produced $BC_1F_1$ hybrids by crossing and backcrossing a wheat-*Th. elongatum* 7B/7E introgression line XWC14-255-13-1 (WGC002) carrying new *Fhb7* allele *Fhb7*$^{The2}$ to ND Riveland.

**b) What were the significant results?**

- Over 300 elite durum germplasm lines carrying *Cdu1*, *Fhb1* and/or two PI277012-derived 5A QTL in the backgrounds of modern durum germplasm have been developed. These lines have a high potential for developing new durum varieties and adapted germplasm with FHB resistance combined with good agronomic performance, high yield, and accepted end-use quality.

- Ten elite durum lines (22P-YT-1, 10, 16, 22, 25, 26, 27, 29, 32, 37) tested in the yield trail in Prosper in 2022 had higher grain yields than check varieties Carpio and Joppa. Four (22P-YT-16, 27, 29, 37) of the 10 lines from backcrossing 15Entry 255 with Joppa had a yield increase of 9.57%, 14.61%, 12.20%, and 8.85% higher than Joppa. The four lines also had similar yields compared to ND Riveland. These lines may have FHB resistance combined with good agronomic performance and high yield.

**c) List key outcomes or other achievements.**

A total of 205 breeding lines carrying *Cdu1*, *Fhb1,* and/or two PI277012-derived 5AS/5AL QTL were provided to the NDSU durum wheat breeding program and they were evaluated in a preliminary yield trial and about 60 lines showed similar or higher yield than the current durum varieties used in the checks in the summer of 2022. Because a challenge in durum FHB resistance breeding is that it is difficult to integrate the FHB resistance with adaptability, the durum lines having similar or higher yields than the current durum varieties provide high promise for the development of new durum varieties with improved FHB resistance.

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

**Project 2:** Development of Elite Spring Wheat Germplasm with Fusarium Head Blight Resistance

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## 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?

- Evaluated approximately 900 $BC_1F_5$ lines derived from 18 $BC_1F_1$ populations from backcrossing the synthetic hexaploid wheat (SHW) lines SW93, SW183, and SW187 to hard red spring wheat (HRSW) varieties 'Glenn', 'Barlow', 'Vitpro', 'Grandin', 'Linert' and 'Bolles' and breeding lines ND828, NDHRS16-1436, and NDHRS16-13-89 in the FHB nurseries in Fargo and Prosper, ND in summer (May – August) of 2022.
- Selected 276 SHW-derived HRSW lines ($BC_1F_6$) with moderate and high levels of FHB resistance based on field evaluation in 2022 described above. These lines and 12 parents were genotyped using wheat 90K SNP array and these lines and 12 parental lines as checks were grown and evaluated for two seasons in the greenhouse.
- Prepared and planted the 276 SHW-derived HRSW lines ($BC_1F_7$) and 12 checks in the FHB nurseries in Fargo and Prosper, ND for field FHB evaluations in the summer of 2023.
- A large population of over 10,000 $BC_1F_2$ individuals derived from 113 $BC_1F_1$ plants (15FAR1157-1/2*ND Frohberg), which were heterozygous for PI 277012 derived 5AL QTL and homozygous for *Fhb1*, and 15 DH lines (15FAR1157-1/ND Frohberg) were previously developed. A total of 700 $BC_1F_2$ plants and 15 DH lines have been genotyped using the STARP markers for PI 277012 derived 5AL QTL and *Fhb1*. Six DH lines and 164 $BC_1F_2$ plants were identified to be homozygous for 5AL QTL and *Fhb1*. These homozygous lines were increased in the greenhouse and 92 of the lines have been planted in the FHB nurseries in Fargo and Prosper, ND for field FHB evaluations in the summer of 2023.
- Produced $BC_1F_1$ hybrid seeds by backcrossing a wheat-*Th. elongatum* 7B/7E introgression line XWC14-255-13-1 (WGC002) carrying new Fhb7 allele $Fhb7^{The2}$ to ND Frohberg.
- Developed $BC_2F_1$ populations by backcrossing a wheat-*Thinopyrum ponticum* 7D/7el2 introgression line RWG52 (591) with HRSW variety 'Alsen' and Alsen-*ph1b* line to eliminate yellow pigment gene Y tightly linked to *Fhb7* on chromosome 7D. Approximately 2,300 $BC_2F_1$ seeds have been genotyped and 10 new tentative homoeologous recombinants without the yellow pigment gene Y have been developed.

### b) What were the significant results?

- A total of 276 SHW-derived HRSW lines ($BC_1F_7$) lines with moderate and high levels of FHB resistance have been selected.
- Genotypic (90k SNP marker) data set for the 276 SHW-derived HRSW lines ($BC_1F_7$) and their parents have been generated and will be used for identifying and mapping FHB resistance genes and QTL.

- Six DH lines and 164 $BC_1F_2$ plants that are homozygous for 5AL QTL and *Fhb1* were identified.
- Ten new tentative *Fhb7* introgression lines without the yellow pigment gene Y have been developed.

**c) List key outcomes or other achievements.**

- The six DH lines and 164 $BC_1F_2$-derievd lines that are homozygous for 5AL QTL and *Fhb1*, new *Fhb7* introgression lines without the yellow pigment gene, and 276 SHW-derived HRSW lines ($BC_1F_7$) lines with moderate and high levels of FHB resistance will be useful germplasm for developing adapted HRSW germplasm and varieties for resistance to FHB and other diseases. Interestingly, approximately 120 of the SHW-derived HRSW lines also showed resistance to the bacteria leaf streak (BLS, caused by *Xanthomonas translucens*), which had a serious outbreak in the spring wheat region in 2022. About 70% of 120 lines showing BSL resistance in the field also showed BSL resistance in the greenhouse testing in the winter of 2022.
- Genotypic (90k SNP marker) data set for the 276 SHW-derived HRSW lines ($BC_1F_7$) and their parents will serve as a useful resource for identifying and mapping the genes and QTL for resistance to FHB and other major wheat diseases.

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

# Publications, Conference Papers, and Presentations

Please include a listing of all your publications/presentations about your FHB work that were a result of funding from your FY22 grant award. Only citations for publications published (submitted or accepted) or presentations presented during the **award period** should be included.

**Did you publish/submit or present anything during this award period?**

X Yes, I've included the citation reference in listing(s) below.

☐ No, I have nothing to report.

## Journal publications as a result of FY22 award

*List peer-reviewed articles or papers appearing in scientific, technical, or professional journals. Include any peer-reviewed publication in the periodically published proceedings of a scientific society, a conference, or the like.*

Identify for each publication: Author(s); title; journal; volume: year; page numbers; status of publication (published [include DOI#]; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).

Zhang W, Danilova T, Zhang M, Ren S, Zhu X, Zhang Q, Zhong S, Dykes L, Fiedler J, Xu S, Frels K, Wegulo S, Boehm J, Cai X (2022) Cytogenetic and genomic characterization of a novel tall wheatgrass derived *Fhb7* allele integrated into wheat B genome. Theor Appl Genet 135:4409–4419 https://doi.org/10.1007/s00122-022- 04228-3.
Status: Published.
Acknowledgment of Federal Support: Yes.

Li X, Li D, Xuan Y, He Z, Zhao L, Hao Y, Ge W, Xu S, Hou B, Wang B, Guo J, Liu W, Li M, Han Y, Bo C, Bao Y, Qi Z, Xu SS, Bai G, Wang H, Kong L (2023) Elimination of the yellow pigment gene *PSY-E2* tightly linked to the Fusarium head blight resistance gene *Fhb7* from *Thinopyrum ponticum*. The Crop Journal 11:957-962. https://doi.org/10.1016/j.cj.2022.12.005.
Status: Published.
Acknowledgment of Federal Support: Yes.

Wang R, Axtman J, Leng Y, Salsman E, Hegstad J, Fiedler J, Xu S, Zhong S, Elias E, Li X (2023) Recurrent selection for Fusarium head blight resistance in a durum wheat population. Crop Sci.
Status: Submitted, under review.
Acknowledgment of Federal Support: Yes.

## Books or other non-periodical, one-time publications as a result of FY22 award

*Report any book, monograph, dissertation, abstract, or the like published as or in a separate publication, rather than a periodical or series. Include any significant publication in the proceedings of a one-time conference or in the report of a one-time study, commission, or the like.*

Identify for each one-time publication: Author(s); title; editor; title of collection, if applicable; bibliographic information; year; type of publication (book, thesis, or dissertation, other); status of publication (published; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).

## Other publications, conference papers and presentations as a result of FY22 award

Identify any other publications, conference papers and/or presentations not reported above. Specify the status of the publication.

Wang F, Charif A, Danilova T, Zhang W, Zhang M, Ren S, Zhu X, Zhong S, Fiedler J, Xu S, Frels K, Wegulo S, Boehm J, Cai X (2022). Molecular marker-assisted Fhb7 introgression in common and durum wheat. Proceedings of the 2022 National Fusarium Head Blight Forum; Tampa, Florida. December 4-6, 2022. Retrieved from: https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf
Status: Abstract Published and Poster Presented.
Acknowledgment of Federal Support: YES (Abstract and Poster).

Wang R, Axtman J, Leng Y, Salsman E, Hegstad J, Fiedler J, Xu S, Zhong S, Elias E, Li X (2023). Recurrent selection for Fusarium head blight resistance in a durum wheat population. p. 103. Proceedings of the 2022 National Fusarium Head Blight Forum; Tampa, Florida. December 4-6, 2022. Retrieved from: https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf
Status: Abstract Published and Poster Presented.
Acknowledgment of Federal Support: YES (Abstract and Poster).

Szabo-Hever A, Sharma JS, Faris JD, Zhong S, Friesen TL, Green AJ, Bai G, Xu SS (2022). Identification and mapping of quantitative trait loci for Fusarium head blight resistance in synthetic hexaploid and spring wheat. Proceedings of the 2022 National Fusarium Head Blight Forum; Tampa, Florida. December 4-6, 2022. Retrieved from: https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf
Status: Abstract Published and Poster Presented.
Acknowledgment of Federal Support: YES (Abstract and Poster).

Li W, Kyum M, Zhang Y, Santantonio N, Sorrells ME, Steffenson B, Xu SS (2022). Transfer *Fhb7* to barley through CRISPR-mediated targeted gene insertion. Proceedings of the 2022 National Fusarium Head Blight Forum; Tampa, Florida. December 4-6, 2022. Retrieved from: https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf
Status: Abstract Published and Poster Presented.
Acknowledgment of Federal Support: YES (Abstract and Poster).