USDA-ARS
U.S. Wheat and Barley Scab Initiative
FY19 Final Performance Report
Due date: September 30, 2020

Cover Page

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Fiscal Year:	2019
USDA-ARS Agreement ID:	59-0206-7-004
USDA-ARS Agreement Title:	Transfer of FHB Resistance to NDSU Hard Red Winter Wheat Breeding Material
FY19 USDA-ARS Award Amount:	$ 42,070
Recipient Organization:	North Dakota State University Office of Grant & Contract Accouting NDSU Dept 3130, PO Box 6050 Fargo, ND 58108-0650
DUNS Number:	80-388-2299
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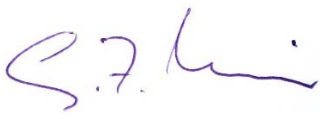
Project/Grant Reporting Period:	7/10/19 - 7/9/20
Reporting Period End Date:	7/9/2020

USWBSI Individual Project(s)

USWBSI Research Category*	**Project Title**	**ARS Award Amount**
HWW-CP	Transfer of FHB Resistance to NDSU Hard Red Winter Wheat Breeding Material	$ 42,070
	FY19 Total ARS Award Amount	**$ 42,070**



9/9/2020

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: *Transfer of FHB Resistance to NDSU Hard Red Winter Wheat Breeding Material*

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

It aims to transfer the validated resistance QTL *Fhb1, Qfhs.ifa-5A* (CM82036); *Qfhb.rwg-5A.1; Qfhb.rwg-5A.2* (PI277012); *Qfhs.ifa-3A* (Frontana) and *Fhb6* (TA5660) to winter-hardy wheat backgrounds; evaluate their usefulness (particularly in combination with *Fhb1*) and utilize them in breeding. At the onset of the report period, all of the genes except *Qfhb.rwg-5A.2*, had been transferred to winter wheat. The project objectives for 2019-20 were:

a. Complete the introgression and evaluation of *Qfhb.rwg-5A.1* and *Qfhb.rwg-5A.2*.
b. Continue to increase the frequency of *Fhb1* and those FHB resistance QTL that strengthen its effect in the NDSU hard red winter wheat germplasm.
c. Broaden the overall genetic variability of the FHB-resistant germplasm, i.e. combine FHB resistance with resistance to other prevailing diseases, broad adaptation, yield and quality.

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

Objective 1. Transfer of *Qfhb.rwg-5A.2* (PI277012) from HRSW line GP80:

a.) What were the major activities?
This QTL proved difficult to transfer as the original source (RWG21) turned out not to have the gene and the initial markers lacked specificity. The transfer was re-attempted with a newer source of the gene (GP80 = PI277012/Grandin). The Illumina iSelect 90K SNP array was first used to construct a GP80 chromosome 5A map by comparing 130 chromosome 5A SNPs (polymorphic in PI277012 and Grandin) with corresponding SNPs in line GP80. The 130 SNPs occurred in 46 map positions that spanned 140 cM of the length of chromosome 5A. GP80 chromosome 5A was found to contain an intercalary region from Grandin within otherwise PI277012-derived chromatin. The likely location of *Qfhs.rwg.5A.2* on GP80 chromosome 5AL (within a region of PI277012 chromatin that includes the *Q* gene) was then determined from the results of Zhao (2017). GP80 was crossed with Novus-4 and F_1 backcrossed twice to winter wheat. The parents and 70 B_2F_1 were SNP genotyped and characterized. Polymorphic SNP markers that were of PI277012 origin and occurred closest to *Qfhb.rwg-5A.2* were located at 113 cM, 115 cM and 118 cM. Using these loci, potentially useful haplotypes with different lengths of PI277012-derived chromatin were identified in the B_2F_1 populations. B_2F_2 families were then evaluated for FHB Type II resistance in a greenhouse trial.

b.) What were the significant results?
The data showed that the cross GP80/Novus-4//Monument/3/ND Noreen progenies had the best average resistance. Eight families from this cross segregated for both *Qfhb.rwg-*

5A.1 and *Qfhb.rwg-5A.2* (based on the haplotype data). Two F_3 plants, apparently homozygous for both genes (markers) were selected in family VR67 and used in a further round of backcrosses to ND Noreen. The B_3F_1 are being analyzed with the purpose of doing back- and foreground selection. Depending on the results, backcrosses will be continued or near-isogenic lines will be established. Early indications are that *Qfhb.rwg-5A.1* (previously transferred and also present in the breeding line Novus-4) provides significant resistance that is improved by the presence of *Qfhb.rwg.5A.2*.

c.) List key outcomes or other achievements.
The greenhouse FHB trial results suggested that the GP80 resistance is reduced compared to the original source, PI277012. This could be due to additional resistance QTL in PI277012, or the absence of the *Q* gene in GP80, or both. However, the *Qfhb.rwg-5A.1* and *Qfhb.rwg-5A.2* gene combination still provides very useful resistance.

Objective 2: Inclusion of lines with new resistance QTL among breeding program parents.

a.) What were the major activities?
Pyramids of *Fhb1* & *Qfhs.ifa-5A* & *Fhb6* (*Fhb6* occurs on an *Elymus tsukushiensis* translocation) were used for the first time in 23 breeding program crosses. Another 25 crosses were made with plants that were believed to segregate for the presence of *Qfhb.rwg-5A.2* (PI277012) (selected with the use of SNP haplotypes). An attempt was also initiated to pyramid *Qfhb.rwg-5A.1* and *Qfhb.rwg-5A.2* in the moderately FHB resistant genetic background of ND Noreen.

b.) What were the significant results?
Preliminary assessment of Type II resistance in greenhouse tests suggested that *Fhb1* in combination with either *Qfhs.ifa-5A* or *Fhb6* significantly reduced infection depending on the background genes present.

c.) List key outcomes or other achievements.
F_2 segregating progenies were established for field selection of the relevant genes in hybrid combinations that not only involve FHB resistance but also a wide range of resistance and adaptation traits.

Objective 3. Focused introgression of *Fhb1* and *Qfhs.ifa-5A and selection for broader disease resistance and adaptation*:

a.) What were the major activities?
(i) In 2019-20, 28 crosses of which 16 crosses had at least one parent with *Fhb1* and 12 crosses had at least one parent with *Fhb1 & Qfhs.ifa-5A* were used to initiate single seed descent (SSD) inbreeding. The second parent of each cross contributed resistance to other diseases and additional desirable traits such as cold-hardiness, agrotype, yield or combinations thereof. F_2 plants were pre-screened with mixed leaf rust and stem rust inoculum and resistant plants were transplanted to a greenhouse. Following selection for plant type and height, the F_3 were replanted (greenhouse) and again selected for height

and fertility/plant type. Approximately 300 plants were harvested and the F_4 replanted as individual rows at Casselton in the fall of 2020. These populations will be subjected to single spike selection in 2021 to establish $F_{4:5}$ pure lines for continued agronomic and marker selection to identify plants with good yield, FHB and broad disease resistance. (ii) Previously established populations (2018/19) were evaluated: 408 F_4 families that were initiated from 21 crosses (each involving at least one parent with FHB resistance and a second with additional useful traits) were selected (single spikes) at Casselton in the summer of 2020 to establish inbred lines for continued marker and agronomic tests. (iii) Early generation yield selection was done in a double cross that segregated for *Fhb1 & Qfhs.ifa-5A*: SSD was used to develop 141 F_4 lines that were evaluated in an un-replicated yield trial (Casselton 2019). The 40 best yielding lines were then yield tested in a replicated trial at Casselton (2020) to identify the very best yielding lines. Marker analyses are being done to determine whether *Fhb1* carriers that yield as well as those without the gene can be derived.

b) What were the significant results?
Many lines with *Fhb1* have now been produced and evaluated in the breeding project and regional yield trials; however, they never yielded as well as counterparts without *Fhb1*. It is not clear yet whether *Fhb1* comes with a yield penalty; however, attempts to develop high-yielding lines with *Fhb1* resistance are ongoing.

c) List key outcomes or other achievements.
In 2020, breeding line 14Nord-01 was released as the variety ND Noreen. Based on the 2016 Northern FHB Nursery results obtained by Dr. Bill Bockus, KSU; ND Noreen performed similar to the control, Emerson. If in the latter trial the most resistant entry was rated 0 and the most susceptible entry was rated 9, Emerson (resistant control) would have rated 1.5 and ND Noreen 2.8.

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.

Yes. The shutdown and need for social distancing reduced personal interaction and made communication and team activities (greenhouse, field evaluation, selection, seed cleaning, harvesting, seed preparation and planting) more difficult.

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

Three MS students are enrolled. (i) Dylan Barry (graduation target date: December 2020) did early generation yield selection in a double cross (segregating for *Fhb1, Qfhs.ifa-5A*) with the purpose to select high yielding, FHB resistant lines. (ii) Venkata Ganaparthi (graduation target date: December 2020) used SNP haplotype markers to facilitate the transfer of

Qfhb.rwg-5A.2 to winter wheat. (iii) Sagar Adhikari (graduation target date December 2021) aims to use SNP haplotypes to backcross *Qfhb.rwg-5A.1* and *Qfhb.rwg-5A.2* into ND Noreen.

5. How have the results been disseminated to communities of interest?

- Research progress reports were submitted to the North Dakota Wheat Commission and Minnesota Wheat Research and Promotion Council.
- Fifteen new, potentially FHB resistant NDSU inbred lines were entered for evaluation in the 2021 ND Regional Yield Trials and Northern FHB Trial (five entries have *Fhb1*; three have *Fhb1 & Qfhs.ifa-5A*).
- Advanced lines (10 having *Fhb1*) were included in regional winter wheat evaluation nurseries (NRPN = 5; RGON = 30).

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY19 award period (7/10/19 - 7/9/20). 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**
ND Noreen	HRW	MR	3	2020

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 (7/10/19 - 7/9/20**) 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.

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

Other publications, conference papers and presentations.

College of Agriculture, Food Systems and Natural Resources, North Dakota State University (2020). Release Letter: Release of 14Nord-01 winter wheat. Greg Lardy, Vice President for Agricultural Affairs, 314 Morrill Hall, P.O. Box 6050, Fargo, ND 58108-6050.
Status: Submitted
Acknowledgement of Federal Support: Yes