USDA-ARS
U.S. Wheat and Barley Scab Initiative
FY16 Final Performance Report – NCE for FY17
Due date: July 31, 2018

Cover Page

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Fiscal Year:	2016 (NCE for FY17)
USDA-ARS Agreement ID:	59-0200-3-006
USDA-ARS Agreement Title:	Transfer of FHB Resistance to NDSU Hard Red Winter Wheat Breeding Material.
FY16 USDA-ARS Award Amount:	$ 27,138 (NCE for FY17)
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Award Reporting Period:	7/10/17 - 7/9/18
Reporting Period End Date:	07/09/18

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
HWW-CP	Development of Winter-hardy HRWW Lines with Pyramided QTL for FHB Resistance.	$ 27,138
	FY16 Total ARS Award Amount	**$ 27,138**

7/19/2018
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

FY16 Final Performance Report
PI: Marais, Gideon
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Project 1: *Development of Winter-hardy HRWW Lines with Pyramided QTL for FHB Resistance.*

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

The NDSU HRWW breeding program aims to develop new varieties with improved cold-hardiness, regional adaptation, yield, disease resistance and processing quality. This project focuses specifically on accelerating progress with FHB resistance breeding. Literature-validated resistance QTL (*Fhb1, Qfhs.ifa-5A* ex CM82036*; Qfhb.rwg-5A.1* and *Qfhb.rwg-5A.2* from PI277012; a QTL on 3A of Frontana (here called *Qtl-3A*), and *Fhb6* (a translocation from *Elymus tsukushiensis* derived by Dr B Friebe), were targeted for transfer from spring wheat. The purpose is to establish *Fhb1* as the baseline of FHB resistance in the breeding population and to develop and evaluate simple gene pyramids consisting of *Fhb1* plus 1-2 of the remaining QTL to identify those that would add substantively to the effect of *Fhb1*. In this context, the following gene pyramids were/are being produced and evaluated through marker analyses and greenhouse FHB resistance phenotyping: (a) Two-gene pyramids of (i) *Fhb1* and *Qfhs.ifa-5A*, and, (ii) *Qfhb.rwg-5A.1* and *Qfhb.rwg-5A.2*. (b) Two- and 3-gene pyramids of *Fhb1* with *Qfhs.ifa-5A*, *Qfhb.rwg-5A.1* and *Qfhb.rwg-5A.2*. (c) *Fhb1* and *Qtl-3A* pyramids. (d) Two- and 3- gene pyramids of *Fhb1* with *Fhb6* and *Qfhs.ifa-5A*.

2. What was accomplished under these goals?

1) Major activities. To raise the frequency *Fhb1* and additional, useful resistance QTL in the crossing blocks and breeding population, we involved at least one parent with at least one of *Fhb1*, *Qfhs.ifa-5A* and *Qfhb.rwg-5A.1* in approximately 90% of the 2017 breeding program crosses. Transferred QTL and QTL pyramids were employed in crosses as soon as they have been derived and tentatively confirmed. Only a limited number of near-isogenic and inbred lines with *Fhb1* (including Norstar-*Fhb1*, Wesley-*Fhb1*, Decade-*Fhb1*, Overland-*Fhb1* and Jerry-*Fhb1*) have thus far been acquired. A small number of inbred lines with *Qfhb.rwg-5A.1, Qfhs.ifa-5A* or *Fhb1* plus *Qfhs.ifa-5A* have also been derived and used. In the absence of dependable markers for the two 5A QTL, their integration and identification is difficult and selection is based on artificial or natural infection of field planted populations. A further problem with the introgression of the new FHB resistance is that over-dependence on this small, initial group of FHB-resistant parents will erode overall genetic and phenotypic variability of the program and limit future selection for non-FHB traits. To counter these effects, new, diverse and desirable agrotypes (mostly lacking FHB resistance) from our and other programs/nurseries are obtained annually and used in crosses with the available FHB-resistant lines. Their F_1 are then used as FHB-resistant parents in the next season. In this manner, structured crosses are conducted with the long-term aim to continuously combine these resistances in more complicated combinations, while simultaneously broadening overall genetic variability.

2) Specific objectives. (a) For the development of pyramids of *Fhb1* with 5A QTL, HRWW lines derived from CM82036 (pre-selected for FHB resistance and winter-survival in the field) were tested with published markers: four of the best lines appeared to have both *Fhb1*

and *Qfhs.ifa-5A*, and another four lines had *Fhb1* only, while one line showed intermediate FHB resistance in the field, however, lacked the marker polymorphisms. The selected lines and controls were then tested for FHB type II resistance in a greenhouse trial. Based on the marker and resistance data, three lines (12DH172, 11M221-24-1 and 14K456-K-1) are believed to have both *Fhb1* and *Qfhs.ifa-5A.* The three lines showed resistance similar to the HRSW donor line CM82036, and significantly stronger resistance than lines with *Fhb1* only. Thus, *Fhb1* and *Qfhs.ifa-5A* QTL do have additive effect. (b) Two lines that were derived from the HRSW donor line RWG21 (believed to have *Qfhb.rwg-5A.1* and *Qfhb.rwg-5A.2* from PI277012) produced marker polymorphisms that were not fully consistent with those in PI277012. Since none of the markers proved to be useful for the selection of the PI277012 resistance QTL, it was necessary to do disease phenotyping in an attempt to confirm the resistance. PI277012 showed strong resistance, which was similar to that of CM82036. However, the RWG21 plants that were included as controls in the FHB trial showed no resistance. The two RWG21 progeny lines (11M228-19-1 and Novus-4), showed intermediate resistance. Thus, it appeared that the RWG21 germplasm line that was used as donor was heterogeneous and segregated at one of *Qfhb.rwg-5A.1* or *Qfhb.rwg-5A.2* loci. (c) An attempt was also made to combine resistance QTL present in Novus-4 (*Qfhb.rwg-5A.1* and/or *Qfhb.rwg-5A.2*) and 14K456-K-1 (*Fhb1* and *Qfhs.ifa-5A*). 400 F_2 from a cross of the two lines were screened with *Fhb1* and *Qfhs.ifa-5A* markers and two sets of plants were identified, i.e. (i) 17 F_2 homozygous for *Fhb1* only, and (ii) 19 F_2 homozygous for both *Fhb1* and *Qfhs.ifa-5A*. Within each set of $F_{2:3}$ families, four F_3 plants per family were grown and leaves were cut on each for doing 9K SNP analyses. This was done in an attempt to find additional, mapped chromosome 5A marker loci that could aid in the interpretation of the data. The 144 F_4 sub-families were then evaluated for FHB type II resistance in a replicated greenhouse trial. The data from this experiment are presently being analyzed. Preliminary indications are that *Qfhb.rwg-5A.1* from PI277012 occurs within the same chromosome region and produces a similar effect to *Qfhs.ifa-5A*. Like *Qfhs-ifa-5A* it appears to add to the *Fhb1* effect and *Fhb1* plus *Qfhs-ifa-5A* pyramids appears to be similar to *Fhb1* plus *Qfhb.rwg-5A.1* pyramids. However, due to the suspected heterogeneity of the donor source, RWG21, the second PI277012 locus, *Qfhb.rwg-5A.2*, has not been transferred to our winter material. (d) Pyramiding *Fhb1* with *Qtl-3A*: A near-isogenic line, Norstar-*Fhb1*, was crossed with the F_1: Frontana (*Qtl-3A*)/Norstar and the F_1 marker screened to identify dihybrid plants. Following their self-pollination, 200 F_2 progeny were marker-screened to identify the *Fhb1* homozygotes. The selected homozygotes were then tested with a *Qtl-3A* marker and 34 F_3 families that are homozygous for both QTL were identified. Since Frontana is a HRSW, the lines also segregate for winter habit and winter types need to be identified before the two groups of homozygotes will be compared in a greenhouse trial during 2018. (e) Pyramids of *Fhb1* with *Qfhs.ifa-5A*, and *Fhb6*: F_1 heterozygotes from the cross: *Fhb6*/Jerry//Accipiter were crossed with 12DH172 (*Fhb1* and *Qfhs.ifa-5A*). The F_1 was marker-screened to identify trihybrid (*Fhb1*, *Qfhs.ifa-5A*, *Fhb6*) plants. F_2 have been derived and will be screened in 2018 to identify ±100 *Fhb1* homozygotes. The latter homozygotes will then be marker screened in an attempt to derive selections homozygous for *Fhb1* only, *Fhb1* & *Qfhs.ifa-5A*; *Fhb1* & *Fhb6*; and *Fhb1* & *Qfhs.ifa-5A* & *Fhb6*. Such plants will be compared in a greenhouse FHB trial.

3) Significant results. (a) The attempt to produce and evaluate QTL pyramids in HRWW and employ these in new crosses is on schedule and has mostly been successful. (b) *Qfhb.rwg-5A.2* has not been transferred due to heterogeneity in the donor and a renewed attempt has to be made.

4) Key outcomes or other achievements. Additional FHB resistant cross parents have been produced and employed in breeding program crosses. These parents carry mostly single FHB resistance QTL and are often lacking in phenotype, yield capacity and resistance to other diseases. However, they provide a good basis for continued pre-breeding and selection to significantly raise the level of FHB resistance in coming years.

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

The project accommodated and funded a PhD student

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

Fourteen of fifteen new NDSU inbred lines that might carry FHB resistance QTL *Fhb1 +* were entered for evaluation in the 2018 Northern FHB Trial.

It has not been possible to publish any of the pyramiding results per se due to most of the attempts still being in progress.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY16 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 FY16 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 FY16 award period?**
   No

   If yes, how many?

3. **Have any post docs who worked for you during the FY16 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 FY16 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 FY16 award period. All columns must be completed for each listed germplasm/cultivar. Use the key below the table for Grain Class abbreviations. *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 FY16-FPR_Instructions for detailed instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY16 grant. Only include citations for publications submitted or presentations given during your award period (7/10/17 - 7/9/18). 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.

Nothing to report

Journal publications.

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

Other publications, conference papers and presentations.