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

Cover Page

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Fiscal Year:	2017
USDA-ARS Agreement ID:	59-0206-7-004
USDA-ARS Agreement Title:	Transfer of FHB Resistance to NDSU Hard Red Winter Wheat Breeding Material.
FY17 USDA-ARS Award Amount:	$ 27,138
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Project/Grant Reporting Period:	7/1/17 - 6/30/18
Reporting Period End Date:	06/30/18

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.	$ 27,138
	FY17 Total ARS Award Amount	$ 27,138

S.J. Marais

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

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Project 1: *Transfer of FHB Resistance to NDSU Hard Red Winter Wheat Breeding Material.*

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 USWBSI project focuses specifically on accelerating progress with FHB resistance breeding. In previous funding cycles, literature-validated resistance QTL (*Fhb1* and *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 transferred from spring wheat. This project aims to establish *Fhb1* as the baseline of FHB resistance in the breeding population and since 2016 we also developed and studied 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*.

2. What was accomplished under these goals? *Address items 1-4) below for each goal or objective.*

1) Major activities.

In order to raise the frequency of *Fhb1* and additional, useful resistance QTL in the crossing blocks and breeding population, we try to involve at least one parent with at least one significant resistance QTL in approximately 90% of annual breeding program crosses. Initial transfer of the resistance from HRSW into winter-hardy genetic backgrounds created a serious bottleneck for total genetic variability. Over-dependence on a small, initial group of cold-tolerant, FHB-resistant parents in consecutive crossing blocks erodes overall genetic and phenotypic variability of the program and limits future selection progress for non-FHB traits such as yield, adaptation, quality and resistance to diseases other than FHB. To offset this undesirable inbreeding effect, we resorted to:

- Crossing new introgressions/pyramids to a diverse collection of genotypes and then using the F_1 as cross parents.
- Annual introduction of a number of unrelated genotypes having good resistance to diseases other than FHB into the crossing blocks.
- Conducting structured, convergent crosses among breeding lines with the long-term aim to forge these resistances into more complex combinations.
- Utilization of recurrent selection steps to increase the frequency of resistance QTL while maintaining overall genetic variability.

2) Specific objectives. The more significant of the single gene introgressions and pyramids established in HRWW are summarized below.

QTL combination and Cross #	**Pedigree**
Fhb1 (= 11M225)	RWG10/Jerry
Fhb1 (= 11M237)	RWG28/Norstar
Qfhb.rwg-5A.1 (= Novus-4)	RWG21/Jerry
Fhb1, Qfhs.ifa-5A (= 11M221-24-1)	CM82036/Jerry

QTL combination and Cross #	**Pedigree**
Fhb1, Qfhs.ifa-5A (= 14K456-K-1)	CM82036/Jerry/3/*Lr56*-157/Superb//4*Jerry
Fhb1, Qfhs.ifa-5A (= 14M7)	*Fhb6*/Jerry//Radiant/3/14K456-K-1
Fhb1, Qfhs.ifa-5A (= 15K353)	Novus-4/14K456-K-1
Fhb1, Fhb6 (= 14M7)	*Fhb6*/Jerry//Radiant/3/14K456-K-1
Fhb1, Fhb6, Qfhs.ifa-5A (= 14M7)	*Fhb6*/Jerry//Radiant/3/14K456-K-1
Fhb1, Qfhb.rwg-5A.1 (= 15K353)	Novus-4/14K456-K-1
Qfhb.rwg-5A.1, Qfhb.rwg-5A.2	PI277012/Grandin// 2*Novus-4
Fhb1, Qfhb.rwg-5A.1, Qfhb.rwg-5A.2	PI277012/Grandin//14K456-K-35F-9/3/14K456-K-1

3) Significant results.

(a) HRWW derivatives with *Fhb1* and *Qfhs.ifa-5A* showed strong resistance comparable to that of CM82036. Lineage 14K456 has the better agrotype and cold-hardiness and has been employed most in subsequent crosses. (b) At the onset of the pyramiding attempt, donor line RWG21 was believed to have both *Qfhb.rwg-5A.1* and *Qfhb.rwg-5A.2* from PI 277012. However, it turned out that only *Qfhb.rwg-5A.1* was present and thus the derived SSD-line, Novus-4, has only *Qfhb.rwg-5A.1* and shows intermediate resistance in greenhouse tests. From the cross: Novus-4/14K456-K-1, 34 homozygous resistant F_4 lines were selected. 17 lines had *Fhb1* & *Qfhs.ifa-5A* and another 17 lines had *Fhb1* & *Qfhb.rwg-5A.1*. SNP haplotype data showed that *Qfhs.ifa-5A* and *Qfhb.rwg-5A.1* occur in the same chromosome 5A region. Furthermore, the two sets of lines showed similar, strong FHB resistance comparable to that in CM82036. This suggested that *Qfhs.ifa-5A* and *Qfhb.rwg-5A.1* could be alleles at the same locus. In an attempt to also acquire *Qfhb.rwg-5A.2*, HRSW line GP80 (supplied by Dr Xu and derived from PI277012) was used as donor in new crosses. GP80 that carries the *Q* and *Qfhb.rwg-5A.2* loci in coupling phase was pollinated with both Novus-4 and 14K456-K-1. The F_1 has been backcrossed to the respective parents and marker-selection will now be done to transfer the target gene. 3-4 backcrosses will be made; however, BF_1 plants will already be crossed with NDSU breeding germplasm as from February 2019. Eventually, we aim to recover pyramids involving combinations of *Fhb1*, *Qfhs.ifa-5A*/*Qfhb.rwg-5A.1* and *Qfhb.rwg-5A.2*. (c) F_1 from the cross: *Fhb6*/Jerry//Radiant/3/14K456-K-1 were marker-screened to identify trihybrid (*Fhb1*, *Qfhs.ifa-5A*, *Fhb6*) plants. F_2 were screened to identify ±100 *Fhb1* homozygotes. The *Fhb1* homozygotes were then marker screened to derive selections homozygous for *Fhb1* only (54 plants), *Fhb1* & *Qfhs.ifa-5A* (17 plants); *Fhb1* & *Fhb6* (16 plants); and *Fhb1* & *Qfhs.ifa-5A* & *Fhb6* (5 plants). The F_3 families have been used to establish a greenhouse trial in the second half of 2018 to determine to what extent addition of the respective QTL will add to the *Fhb1* resistance. A preliminary assessment (greenhouse) of possible associated agronomic effects will also be made. The families derived from the best F_2 agrotypes in each class will be utilized in breeding program crosses as from February 2019. (d) 200 F_2 progeny of the cross: Norstar-*Fhb1*//Norstar/Frontana, were analyzed to derive 46 *Fhb1* homozygotes which were then tested with *Qtl-3A* markers. 12 plants that were *Fhb1* homozygotes and 13 plants that were *Fhb1* and *Qtl-3A* homozygotes were identified and their progeny were compared in a greenhouse trial. No consistent differences were found between the level of resistance

in plants with and plants without *Qtl-3A* and it was therefore decided not to pursue this QTL any further.

4) Key outcomes or other achievements.

(a) A strong presence of promising resistance QTL has been established in winter wheat that will now be used to systematically breed diverse genotypes with broad resistance to FHB and other major diseases. (b) Pyramided resistance based on the use of several diverse QTL is likely to involve and combine different resistance mechanisms that could result in more stable FHB resistance.

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

It accommodated a PhD student (expected to graduate in the Spring of 2019).

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

- A poster was presented at the National Fusarium Head Blight Forum meeting of 2017: Hongbin Tao, Bradley Bisek, and Francois Marais. Combining Chromosome 5A FHB resistance QTL with *Fhb1* in Hard Red Winter Wheat lines.
- Nine of fifteen new NDSU inbred lines that carry resistance QTL transferred from HRSW were entered for evaluation in the 2018 Northern FHB Trial.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY17 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 FY17 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 FY17 award period?**
   No
   If yes, how many?

3. **Have any post docs who worked for you during the FY17 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 FY17 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
   If yes, how many? One

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 FY17 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 FY17-FPR_Instructions for detailed instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY17 grant. Only include citations for publications submitted or presentations given during your award period (7/1/17 - 6/30/18). 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.

Journal publications.
Nothing to report.

Books or other non-periodical, one-time publications.
Nothing to report.

Other publications, conference papers and presentations.

Hongbin Tao, Bradley Bisek, and Francois Marais, 2017. Combining Chromosome 5A FHB resistance QTL with *Fhb1* in Hard Red Winter Wheat lines. National Fusarium Head Blight Forum, December 3-5, Milwaukee, Wisconsin (Poster).
Status: Abstract Published and Poster Presented
Acknowledgement of Federal Support: YES (poster), YES (abstract)