USDA-ARS
U.S. Wheat and Barley Scab Initiative
FY18 Performance Report
Due date: July 12, 2019

Cover Page

Principle Investigator (PI):	G. Francois Marais
Institution:	North Dakota State University
E-mail:	gideon.marais@ndsu.edu
Phone:	701-231-8155
Fiscal Year:	2018
USDA-ARS Agreement ID:	59-0206-7-004
USDA-ARS Agreement Title:	Transfer of FHB Resistance to NDSU Hard Red Winter Wheat Breeding Material.
FY18 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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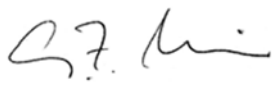
Project/Grant Reporting Period:	7/10/18 - 7/9/19
Reporting Period End Date:	07/09/19

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
	FY18 Total ARS Award Amount	$ 42,070



6/5/2019

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 project?**
   The project began in 2012 with the purpose to develop FHB resistant germplasm for the NDSU winter wheat breeding program. Towards this end, literature-validated resistance QTL discovered in spring wheat, i.e. *Fhb1, Qfhs.ifa-5A* (CM82036), *Qfhb.rwg-5A.1; Qfhb.rwg-5A.2* (PI277012), *Qfhs.ifa-3A* (Frontana) and *Fhb6* (TA5660) were transferred to winter-hardy wheat backgrounds. The derived germplasm is now being tested and systematically bred to continue to improve its versatility in breeding and commercial applications. The specific objectives of the 2018-19 cycle were to:

   a) Complete an evaluation of the ability of individual resistance QTL to complement *Fhb1*.
   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?** *Address items 1-4) below for each goal or objective.*
   1) ***Major activities.*** The primary project objective is to establish FHB resistance QTL combinations in HRWW that will allow for their direct employment in breeding program crosses to improve the overall level of resistance in the program. Utilizing published markers, it was possible to incorporate all but one of the targeted QTL (*Qfhb.rwg-5A.2*) in winter wheat. Failure to incorporate *Qfhb.rwg-5A.2* was the result of the gene not being present in the original spring wheat donor source (RWG21). A renewed attempt to transfer *Qfhb.rwg-5A.2* from a different donor (GP80) is progressing well and winter wheat B_2F_1 are currently being grown for greenhouse inoculation and SNP haplotype analysis to identify families with the target gene. The latter will be used for single seed descent (SSD) inbreeding or doubled haploid development.

   2) ***Specific objectives***
   - Ability of the individual resistance QTL to complement *Fhb1.* Excepting *Qfhs.ifa-3A*, all of the transferred QTL appeared to strengthen the effect of *Fhb1*. However, the importance of genetic background in determining the overall level of resistance of a genotype was evident. For example, those lines developed from Jerry (HRWW) and CM82036 (spring wheat derived from Sumai3) showed strong type II resistance in the greenhouse, whereas lines developed from Norstar, such as Norstar-*Fhb1*, showed comparatively poor type II resistance. The data implied absence of small effect resistance QTL/ epistatic genes in the Norstar genetic background, and it is even possible that Norstar could possess QTL that makes it more sensitive to FHB attack. The marker and disease phenotypes found with respect to the chromosome 5AS genes *Qfhs.ifa-5A* and *Qfhb.rwg-5A.1* suggested that the two genes are probably alleles of the same locus with similar effects on *Fhb1* and the overall resistance phenotype.

- Increase the frequency of *Fhb1* and resistance QTL that strengthen its effect in winter wheat germplasm. Winter wheat sources with newly-introduced resistance QTL (primarily *Fhb1* and *Qfhs.ifa-5A*) were again used in approximately 90% of routine breeding program crosses that were made in January 2019. Based on marker analyses on 535 advanced lines in 2019 field plots, *Fhb1* and *Qfhs.ifa-5A* are respectively present in 37% and 17% of the lines. Due to their more recent transfer, we began introducing *Fhb6* in a smaller number of breeding program crosses in 2019 while we hope to employ *Qfhb.rwg-5A.2* for the first time in the 2020 crossing block.
- Combine FHB resistance with resistance to other prevailing diseases, broad adaptation, yield and quality. In addition to the routine breeding program crosses, four projects were initiated to improve the yield and broader disease resistance of the FHB resistant introgression material. (a) Extensive early generation selection for yield and FHB resistance is being done in a promising double cross (pedigree 14K456-K-1/SD09227//14K456-K-1/Jerry) that segregates for *Fhb1* and *Qfhs.ifa-5A* plus the rust resistance genes *Sr2; Sr6; Sr24; Lr16; Lr46; Lr56; Lr77* and *Yr17*. (b) Three crosses with the general pedigree: GP80/Novus-4//HRWW/3/[three advanced HRWW breeding lines] are being subjected to SNP-haplotype mapping coupled with greenhouse type II FHB resistance tests to transfer *Qfhb.rwg-5A.1* and *Qfhb.rwg-5A.2* into high yielding winter wheat backgrounds with good agrotype. (c) SSD, negative mass selection and marker-aided selection are being employed to develop F_4 populations with one or more of *Fhb1*, *Qfhs.ifa-5A* and *Fhb6* from 12 crosses to improve winter-hardiness, phenotype, yield, leaf-, stem- and stripe rust resistance. (d) SSD inbreeding was initiated from 20-30 crosses that each segregate for phenotype and broad disease resistance, including against FHB.

3) ***Significant results.*** Since *Fhb6* occurs on a translocation that derives from the wild-species *Elymus tsukushiensis*, it was necessary to test whether it is free of deleterious, linked genes. While preliminary, the results of a greenhouse trial suggested that this is the case. Preliminary data also suggest that *Fhb1* and *Fhb6* may have complementary effect. *Qfhs.ifa-3A* (Frontana) appears to be the least useful of the QTL and the existing markers are inadequate.

4) Key outcomes or other achievements. The "stronger-effect" resistance QTL being transferred here map to non-homologous chromosome regions of common wheat. These include: *Fhb6* (sub-telomeric region of chromosome $1E^{ts}$#1S of *Elymus tsukushiensis*); *Fhb1* (on 3BS of Sumai3); *Qfhs.ifa-5A/Qfhb.rwg.5A.1* (on 5AS) and *Qfhb.rwg-5A.2* (*T. timopheevii*-derived chromatin on 5AL of PI277012). This raises the possibility that at least some of the four loci could be non-orthologous and employ different underlying resistance mechanisms. In addition, favorable interactions occur among at least some of the QTL. Diversification of the resistance germplasm pool in terms of the nature and origin of the FHB resistance QTL will help to deal with future shifts in the virulence of the pathogen population. Hence, the material constitutes a very valuable breeding resource.

3. **What opportunities for training and professional development has the project provided?** The project funded one graduate research assistant (PhD study). Two additional graduate research assistants (MS) participated in the project and conducted studies that directly furthered the project objectives, yet they were funded from other sources.

4. **How have the results been disseminated to communities of interest?**
   - A poster was presented at the National Fusarium Head Blight Forum meeting of 2018.
   - Five of fifteen new NDSU inbred lines that carry resistance QTL transferred from HRSW were entered for evaluation in the 2019 Northern FHB Trial.
   - Research progress reports were submitted to the North Dakota Wheat Commission and Minnesota Wheat Research and Promotion Council.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY18 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 FY18 award period?**
   No
   If yes, how many?
   NA

2. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY18 award period?**
   Yes
   If yes, how many?
   One

3. **Have any post docs who worked for you during the FY18 award period and were supported by funding from your USWBSI grant taken faculty positions with universities?**
   No
   If yes, how many?
   NA

4. **Have any post docs who worked for you during the FY18 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?
   NA

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 FY18 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**

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 FY18-FPR_Instructions for detailed instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY18 grant. Only include citations for publications submitted or presentations given during your award period (7/10/18 - 7/9/19). 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. See example below for a poster presentation with an abstract:

> Conley, E.J., and J.A. Anderson. 2018. Accuracy of Genome-Wide Prediction for Fusarium Head Blight Associated Traits in a Spring Wheat Breeding Program. In: Proceedings of the XXIV International Plant & Animal Genome Conference, San Diego, CA.
> Status: Abstract Published and Poster Presented
> Acknowledgement of Federal Support: YES (poster), NO (abstract)

Journal publications.

Nothing to report

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

Nothing to report

Other publications, conference papers and presentations.

Tao, H., and F. Marais. 2018. *Qfhs.ifa-5A* and *Qfhb.rwg-5A.1* - Alleles of the same Chromosome 5AS Locus? In: Proceedings of the National Fusarium Head Blight Forum, St Louis, Mo.
Status: Abstract published and Poster Presented.
Acknowledgement of Federal Support: YES (poster), YES (abstract)