USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY16 Final Performance Report
Due date: July 28, 2017

Cover Page

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Fiscal Year:	2016
USDA-ARS Agreement ID:	59-0206-4-019
USDA-ARS Agreement Title:	Breeding and Genomic Selection for Fusarium Head Blight Resistance in Spring Wheat.
FY16 USDA-ARS Award Amount:	$ 147,386
Recipient Organization:	Regents of the University of Minnesota Suite 450 Sponsored FIN RPT-P100100001 Minneapolis, MN 55455-2003
DUNS Number:	555917996
EIN:	41 -6007513
Recipient Identifying Number or Account Number:	CON000000017418
Project/Grant Reporting Period:	5/13/16 - 5/12/17
Reporting Period End Date:	05/12/17

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
VDHR-SPR	Breeding Fusarium Head Blight Resistant Spring Wheat.	$ 108,622
VDHR-SPR	Optimization and Establishment of Genomic Selection for FHB Resistance in Wheat.	$ 38,764
	FY16 Total ARS Award Amount	**$ 147,386**

July 27, 2017

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: *Breeding Fusarium Head Blight Resistant Spring Wheat.*

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

The overall goal of this project is to develop spring wheat varieties with improved Fusarium head blight resistance with good adaptation to the North Central region of the U.S. and provide growers with FHB ratings of available varieties. The specific objectives of this research are to:

1) Develop Fusarium head blight resistant wheat germplasm and varieties adapted for commercial production in Minnesota and the surrounding region.
2) Characterize the level of FHB resistance of all wheat varieties grown in the region.
3) Utilize genomic selection to improve the efficiency of identifying FHB susceptible lines.

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

1) major activities – see below, listed by Objective

2) specific objectives

Objectives 1-2: Scab nurseries were established at two field sites, Crookston and St. Paul, in 2016. A total of 3,489 genotypes were evaluated in 6,982 total rows at the two locations. We evaluated the FHB reaction of external germplasm from the 2016 Uniform Regional Scab Nursery (40 lines), 2016 Regional Performance Nursery (32 lines), and University of Idaho (200 lines).

Objective 3: The genomic selection aspect of this project integrates with my other USWBSI-funded project *Optimization and Establishment of Genomic Selection for FHB Resistance in Wheat.* As part of our breeding efforts we genotyped using GBS and phenotyped 1,958 F_5 lines for FHB severity in our two scab field nurseries. This information, combined with the predictions from genomic selection from a training population of 500 lines that were also phenotyped to include VSK and test weight, and observations from our winter nursery in New Zealand were used to select a set of 432 for entry in to preliminary yield trials in spring 2017.

3) significant results:

- Both FHB screening nurseries were excellent, and provided highly discriminatory data. As a result of these nurseries and results from previous years, the FHB resistance of 38 spring wheat cultivars was assessed.
- The hard red spring wheat variety 'Lang-MN' was released in January, 2017. Lang-MN is rated as a '3' (moderately resistant) to FHB and has competitive grain yields, high grain protein and good end-use quality. Other varieties with as good a scab rating as Lang-MN are grown on <2% of the Minnesota wheat acreage, so Lang-MN will improve the overall FHB resistance if it becomes widely adopted across the state and spring wheat region.
- We used genomic selection at the F_5 stage for FHB to help select lines to advance to preliminary yield trials.

4) key outcomes or other achievements

High yielding wheat varieties with high grain protein content, good straw strength and good scab resistance are in demand by wheat growers because they greatly influence the profitability of wheat production in Minnesota. Publicly developed varieties accounted for an estimated 60% of Minnesota wheat acres in 2016 and 67% of the public share was from varieties developed primarily at the University of Minnesota (Minnesota Wheat Growers survey). Recent releases include 'Rollag' (2011, [3] for FHB reaction), co-release of 'Prosper' (2011 [5]), 'Norden' (2012 [4]), 'Linkert' (2013 [5]), 'Bolles' (2015 [4]), 'Shelly' (2016 [4], and 'Lang-MN (2017 [3]). Our breeding program continues to develop some of the most scab resistant germplasm in the region and this material is used as parents by private and public breeding programs. In addition, we coordinate the testing of 30-40 wheat varieties per year in statewide trials to assess their performance in yield nurseries and reactions to important diseases. This information is critical to growers to make informed choices among varieties.

We have also developed germplasm with *Fhb1* and *Sr2* in coupling (Mol Breeding 36:85). This work was not directly supported by USWBSI but has important implications for breeding for FHB and stem rust resistance. *Fhb1* and *Sr2* are closely linked in repulsion, meaning that any given germplasm line may contain one (or usually neither) of the genes, but rarely both. In regions of the world where both FHB and stem rust are threatening diseases, this germplasm should be valuable in breeding for resistance. We are currently filling requests for seed of these unique recombinants from the U.S., Canada, Mexico, and Uruguay.

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

All members of my project, regardless of what species they work on (wheat, intermediate wheatgrass, or field pennycress) help with inoculation and scoring of our FHB nurseries. This provides them with knowledge of the importance of this disease and our screening methodologies.

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

Wheat cultivar performance, including FHB reaction, of 38 spring wheat cultivars was assessed and reported to growers via print media, web-accessible publications, winter meetings, and field day presentations. We routinely enter five lines in the regional FHB nursery and a variety candidate performance nursery. The data of these nurseries is publicly available and other participants in the nursery have access to cross with this germplasm. Variety and germplasm releases are published in the Journal of Plant Registrations. Registration articles for 'Linkert' and 'Norden' have been submitted and 'Bolles' will be submitted within the next month. I gave an invited plenary lecture on *Fhb1* at the 8th Canadian Workshop on Fusarium Head Blight in Ottawa, Canada,

Project 2: *Optimization and Establishment of Genomic Selection for FHB Resistance in Wheat.*

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

The objectives of this research are to determine if:

1. The Genomic Selection accuracies using F_5 lines to predict F_5 lines are higher compared to using advanced lines.
2. The Genomic Selection accuracies could be improved (and reduced) by incorporating training population design methods.
3. The combined use of target markers and genome wide markers will further improve prediction accuracies.

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

1) major activities – see below, listed by Objective

2) specific objectives

1. The Genomic Selection accuracies using F_5 lines to predict F_5 lines are higher compared to using advanced lines.

Using cross-validation (4/5 to predict 1/5) of a training population of 500 F_5 lines, prediction accuracies ranged from 0.25-0.46 for FHB traits over 2 locations. This compares to 0.28-0.34 using a training population of advanced lines to predict the F5's.

2. The Genomic Selection accuracies could be improved (and reduced) by incorporating training population design methods.

We selected a training population of 500 F_5 individuals, optimized so that all parents of the F_5's are represented by at least one line in the training set and additional training population lines, up to 500, are selected proportionately to represent frequency of parental contribution. In 2016 we did more intensive phenotyping (thru TWT and VSK) on the training population, but also collected field severity data and did GBS genotyping on the entire set of 1958 F_5's. This information will be used to simulate different training populations to assess if our training population selection methodology was superior to random and if similar prediction accuracies could be achieved with a smaller training population.

3. The combined use of target markers and genome wide markers will further improve prediction accuracies.

This objective has not yet been assessed due to personnel turnover (two partially funded postdocs left for other positions during this funding period). This objective will be investigated in the current funding period, using both 2016 and 2017 F_5 genomic selection populations.

3) significant results

- We obtained good FHB data from both nurseries where the F_5 populations were grown. Genomic selection prediction accuracies of 0.25-0.46 were observed. These accuracies were lower than expected but we anticipate will be improved by 0.10 or more after incorporation of known QTLs in the models as fixed effects.

4) key outcomes or other achievements
Our genomic selection results continue to be promising, but also suggest a need for further investigation to improve prediction accuracy and efficiencies. Our genomic selection results have motivated a FY18-19 LOI to explore alternative training population selection algorithms and reduce population size. If successful, these results have important implications for those breeding for FHB resistance and may allow breeders and pathologists to reduce the size of some selection nurseries and focus on more intensive phenotyping of smaller training populations.

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

Postdocs Liang Gao and Xiaofei Zhang coordinated the phenotypic evaluations, GBS genotyping, and genomic selection work for this project with the assistance of Emily Conley and undergraduate researchers. Other graduate students and postdocs on our project and others in our Department have also learned about our experiences with genomic selection.

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

Emily Conley, Ph.D. candidate, presented a poster on this work at the Scab Forum in December 2016. I gave an invited presentation on "Genomic Selection for FHB" at the 2017 International Wheat Genetics Symposium in Vienna, Austria.

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?** Yes

   If yes, how many? 1

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?** Yes

   If yes, how many? 1

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?

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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**
Lang-MN (cultivar)	HRS	MR	3	2017
MN11394-6 (germplasm)	HRS	MR	3	2017

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 (5/13/16 - 5/12/17). If you did not have any publications or presentations, state 'Nothing to Report' directly above the Journal publications section.

Journal publications.

Anderson, J.A., J.J. Wiersma, G.L. Linkert, S. Reynolds, J.A. Kolmer, Y. Jin, M. Rouse, R. Dill-Macky, and G.A. Hareland and J.-B. Ohm. 201X. Registration of 'Linkert' Spring Wheat with Good Straw Strength and Field Resistance to the Ug99 Family of Stem Rust Races**.** J. Plant Registrations, submitted.
Status: Submitted
Acknowledgement of Federal Support: YES

Anderson, J.A., J.J. Wiersma, G.L. Linkert, S. Reynolds, J.A. Kolmer, Y. Jin, M. Rouse, R. Dill-Macky, and G.A. Hareland and J.-B. Ohm. 201X. Registration of 'Norden' Hard Red Spring Wheat. J. Plant Registrations, submitted.
Status: Submitted
Acknowledgement of Federal Support: YES

Rawat, N., M.O. Pumphrey, S. Liu, X. Zhang, V.K. Tiwari, K. Ando, H.N. Trick, W.W. Bockus, E. Akhunov, J.A. Anderson, and B.S. Gill. 2016. Wheat *Fhb1* encodes a chimeric lectin with agglutinin domains and a pore-forming toxin-like domain conferring resistance to Fusarium head blight. Nature Genetics. doi:10.1038/ng.3706
Status: Published
Acknowledgement of Federal Support: YES

Zhang, X., M.N. Rouse, I.C. Nava, Y. Jin, and JA. Anderson. 2016. Development and verification of wheat germplasm containing both Sr2 and Fhb1. Mol. Breeding. 36:85.
Status: Published
Acknowledgement of Federal Support: YES

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

Anderson, J.A. 2017. Advances in disease-resistant wheat varieties. *In* Langridge, P. (ed.), Achieving sustainable cultivation of wheat Volume 1: Breeding, quality traits, pests and diseases, Burleigh Dodds Science Publishing, Cambridge, UK (ISBN: 978 1 78676 016 6; www.bdspublishing.com)
Status: Published
Acknowledgement of Federal Support: NO

Other publications, conference papers and presentations.

Anderson, J.A. J. Wiersma, R. Dill-Macky, J. Kolmer, M. Rouse, and Y. Jin., M. Smith, and L. Dykes. 2016. Hard Red Spring Wheat. *In* Minnesota Field Crop Trials, University of Minnesota Agricultural Experiment Station.
Status: Published
Acknowledgement of Federal Support: NO

Conley, E.J., and J.A. Anderson. 2016. Association mapping in a panel of Minnesota spring wheat breeding lines reveals QTL maintained over decades of phenotypic selection. In: S. Canty, A. Clark, K. Wolfe and D. Van Sanford (Eds.), *Proceedings of the 2016 National Fusarium Head Blight Forum* (p. 77). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
Status: Abstract Published and Poster Presented
Acknowledgement of Federal Support: YES (poster), YES (abstract)

Conley, E.J., and J.A. Anderson. 2017. Combining QTL-based markers and genomewide prediction with phenotypic screening for efficient selection of Fusarium head blight resistance in wheat. *In*: Buerstmayr H, Lang-Mladek C, Steiner B, Michel S, Buerstmayr M, Lemmens M, Vollmann J, Grausgruber H (Eds.), *Proceedings of the 13th International Wheat Genetics Symposium*. Tulln, Austria; April 23-28, 2017; BOKU - University of Natural Resources and Life Sciences, Vienna, Austria; ISBN: 978-3-900932-48-0
Status: Abstract Published and Oral Presentation
Acknowledgement of Federal Support: YES (presentation), NO (abstract)

Rawat, N. B.S. Gill, and J.A. Anderson. 2016. Overview on Fhb1. Proceedings of the 8th Canadian Workshop on Fusarium Head Blight, Ottawa, Canada, November, 2016.
Status: Abstract Published and Oral Presentation
Acknowledgement of Federal Support: YES (presentation), NO (abstract)

Thurston, Y., J.T. Eckard, K.D. Glover, J.A. Anderson, M. Mergoum, S. Ali, and J.L. Gonzalez-Hernandez. 2016. Development of Fusarium head blight resistance germplasm in highly adapted spring wheat background. In: S. Canty, A. Clark, K. Wolfe and D. Van Sanford (Eds.), *Proceedings of the 2016 National Fusarium Head Blight Forum* (p. 99). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
Status: Abstract Published and Poster Presented
Acknowledgement of Federal Support: YES (poster), NO (abstract)

Wang, R., J. Chen, J. Zhang, W. Zhao, J. Wheeler, N. Klassen, J.A. Anderson, D.R. See, and Y. Dong. 2016. Genome-wide association mapping of Fusarium head blight resistance in spring wheat lines grown in Pacific Northwest and CIMMYT. In: S. Canty, A. Clark, K. Wolfe and D. Van Sanford (Eds.), *Proceedings of the 2016 National Fusarium Head Blight Forum* (p. 103). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
Status: Abstract Published and Poster Presented
Acknowledgement of Federal Support: YES (poster), YES (abstract)