USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY15 Final Performance Report
Due date: July 15, 2016

Cover Page

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Fiscal Year:	2015
USDA-ARS Agreement ID:	59-0206-4-019
USDA-ARS Agreement Title:	Breeding and Genomic Selection for Fusarium Head Blight Resistance in Spring Wheat.
FY15 USDA-ARS Award Amount:	$ 153,997
Recipient Organization:	Regents of the University of Minnesota Suite 450 Sponsored FIN RPT-P100100001 Minneapolis, MN 55455-2003
DUNS Number:	555917996
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Recipient Identifying Number or Account Number:	CON000000017418
Project/Grant Reporting Period:	05/13/15-05/12/16
Reporting Period End Date:	05/12/16

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
VDHR-SPR	Breeding Fusarium Head Blight Resistant Spring Wheat.	$ 111,907
VDHR-SPR	Genomic Selection for Fusarium Head Blight Resistance in Spring Wheat.	$ 42,090
	FY15 Total ARS Award Amount	**$ 153,997**

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: *Breeding Fusarium Head Blight Resistant Spring Wheat.*

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

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) Use FHB markers to characterize potential parental lines and utilize MAS to increase frequency of FHB QTLs in advanced lines
4) Produce doubled haploids to speed development of FHB resistant varieties

2. What was accomplished under these goals?

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 2015. A total of 3,714 genotypes were evaluated in 7,496 total rows at the two locations. We evaluated the FHB reaction of external germplasm from the 2015 Uniform Regional Scab Nursery (36 lines), SDSU breeding program (192 lines), 2015 Regional Performance Nursery (33 lines), and University of Idaho (200 lines).

   - Objective 3: DNA markers were used to screen for genes that provide resistance to Fusarium head blight (*Fhb1* and 5AS), leaf rust, Ug99 stem rust resistance, tan spot and for the presence of high molecular weight glutenins that are necessary for good baking quality. The USDA-ARS Fargo Genotyping Center screened 723 pre-yield trial lines with 10 gene-specific DNA markers, generating 7,230 data points in the past year. In addition, since Fall 2015 we screened 1,404 individual F_1 plants from topcrosses and backcrosses for one to six markers in-house, generating a total of 3,309 datapoints.

   - Objective 4: Seed of 234 DH lines from two crosses was received from Heartland Plant Innovations in Nov. 2015. These lines were grown in our St. Paul greenhouse in Spring 2016 for initial seed increase and planted in 2-row 1m or 7-row 3m plots, depending on seed amount in St. Paul fields in April 2016. An aliquot of the resulting seed will be distributed to NDSU and SDSU breeding programs in August, 2016.

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 31 spring wheat cultivars was assessed.
   - The hard red spring wheat variety 'Shelly' was released in January, 2016. Shelly has comparable grain yields to the highest yielding, most popular varieties in the region (based on 2015 grower survey), but has improved FHB resistance. Shelly is rated as a '4' for FHB whereas the No. 1 variety in Minnesota, 'Prosper', is rated as a '5'. Shelly will improve the overall FHB resistance if it becomes widely adopted across the spring wheat region.

- Of the 28 entries and 5 checks in the Uniform Regional Scab Nursery, two MN lines ranked among the four most resistant experimental lines in the nursery.

4) key outcomes or other achievements

High yielding wheat varieties with high grain protein content 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 58% of wheat acres in 2015 (Minnesota Wheat Growers survey). More than 34% of the public share was varieties developed primarily at the University of Minnesota. Recent releases include 'Rollag' (2011, [3] for FHB reaction), co-release of 'Prosper' (2011 [5]), 'Norden' (2012 [4]), 'Linkert' (2013 [5]), 'Bolles' (2015 [4]), and 'Shelly' (2016 [4]). 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 approximately 30 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. This work was not directly supported by USWBSI and is reported in *Molecular Breeding* and will be detailed as part of the FY16 report because the paper was published during FY16.

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 31 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.*

Project 2: *Genomic Selection for Fusarium Head Blight Resistance in Spring Wheat.*

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

Objective 1: Genotype 384 F_5 lines using GBS; apply genomic selection models to F_5 lines to assess its effectiveness in identifying the susceptible F_5's.

Objective 2: Apply genomic selection models to NDSU and SDSU spring wheat lines to predict FHB reaction of these lines.

2. What was accomplished under these goals?

1) Major activities:
- We grew and phenotyped 384 F_5's in Crookston and St. Paul in 2015
- We genotyped the 384 F_5 lines using genotyping by sequencing (GBS)
- We performed cross validation using only the F_5 genotype and phenotype data
- We tested the accuracy of using GS models trained with advanced breeding lines and 90K SNP data to predict the F_5s.
- To obtain more markers to enable testing of GS models between populations genotyped using different marker platforms (90K chip vs GBS), we further genotyped half (192) of the advanced University of Minnesota breeding lines using GBS method
- NDSU and SDSU lines are being assembled and will be genotyped using GBS method. More analysis will be done to apply GS models trained using University of Minnesota breeding lines onto predicting FHB performance of NDSU and SDSU lines

2) Specific objectives:
Objective 1 has been completed

Objective 2 is in progress. The change in leadership of the NDSU breeding program resulted in a delay in selecting the NDSU lines. SDSU has a set of >200 lines with at least 3 environments of data. Additional FHB data will be collected by SDSU in 2016 so that additional lines can be added to the SDSU set.

3) Significant results:
- Approximately one billion Illumina sequence reads were generated for 384 F_5 lines, resulting in more than 3,000 useful markers
- We performed genomic selection using F_5 phenotype and genotype data. The prediction accuracy based on cross validation method is good (0.4-0.5)
- We tested the F_5 prediction accuracy using GS models trained based on advanced breeding lines and 90K SNP data. The accuracy was low, likely due to low overlap between 90K and GBS markers
- We re-genotyped half of the advanced lines using GBS. Over 200 million Illumina reads were obtained, results are being analyzed

4) Key outcomes or other achievements:
   - We anticipate that shared genotyping methods will allow detection of more common markers between our training population and validation population (F_5's).
   - Genomic selection prediction accuracy should be improved by using more common markers
   - Alternative genomic selection models (using subset of F_5's to predict remaining F_5's) may result in improved prediction accuracy (FY16-17 proposal)

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

One postdoc, Dr. Liang Gao, was partially supported by USWBSI funds. Liang was trained to score FHB in the field and VSK. Dr. Gao has worked with other members of my research group to learn Genomic Selection and Genotyping by Sequencing (GBS) technologies. He has also provided instruction to other members of my group regarding bioinformatics and R programming.

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

I gave an invited presentation at the 2015 US Wheat & Barley Scab Forum on our results from this project and Emily Conley, Ph.D. candidate, presented a poster on this work at PAG, San Diego in January 2016.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY15 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 FY15 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 FY15 award period?** Yes

   If yes, how many? 1

3. **Have any post docs who worked for you during the FY15 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 FY15 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 FY15 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**
Shelly	HRS	MR	4	2016

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

Refer to the FY15-FPR_Instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY15 grant. If you did not have any publications or presentations, state 'Nothing to Report' directly above the Journal publications section.

Journal publications.

Eckard, J.T., K.D. Glover, M. Mergoum, J.A. Anderson, and J.L. Gonzalez-Hernandez. 2015. Multiple Fusarium head blight resistance loci mapped and pyramided onto elite spring wheat Fhb1 backgrounds using an IBD-based linkage approach. Euphytica 204:63-79.
Status: Abstract Published and poster presented
Acknowledgement of Federal Support: YES

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

None.

Other publications, conference papers and presentations.

Anderson, J. J. Wiersma, D. Holen, J. Kolmer, Y. Jin, R. Dill-Macky, M. Smith, and L. Dykes. 2015. Hard Red Spring Wheat. *In* Minnesota Field Crop Trials, University of Minnesota Agricultural Experiment Station (accessible at http://www.maes.umn.edu/publications/field-crop-trials/2015)
Status: Published
Acknowledgement of Federal Support: NO

Chen, J., J. Zhang, W. Zhao, J. Wheeler, N. Klassen and J. Anderson. 2015. Assessment of Resistance to Fusarium Head Blight in Spring Wheat Lines Grown in the Pacific Northwest and CIMMYT. In: S. Canty, A. Clark, S. Vukasovich and D. Van Sanford (Eds.), *Proceedings of the 2015 National Fusarium Head Blight Forum (*p. 15). 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)

Conley, E.J., and J. A. Anderson. 2016. 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)

Thurston, Y., J.T. Eckard , K.D. Glover, J.A. Anderson, M. Mergoum, M. Caffee, S. Ali, S.K. Sehgal, F.G. Marais and J.L. Gonzalez-Hernandez. 2015. Validation of Fusarium Head Blight Resistance QTL in Wheat using Double Haploids Derived from Four-Way Crosses. In: S. Canty, A. Clark, S. Vukasovich and D. Van Sanford (Eds.), *Proceedings of the 2015 National Fusarium Head Blight Forum (*p. 110). 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)