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

Cover Page

Principle Investigator (PI):	Jim Anderson
Institution:	University of Minnesota
E-mail:	ander319@umn.edu
Phone:	612-625-9763
Fiscal Year:	2018
USDA-ARS Agreement ID:	59-0206-8-202
USDA-ARS Agreement Title:	Breeding and Genomic Selection for Fusarium Head Blight Resistance in Spring Wheat.
FY18 USDA-ARS Award Amount:	$ 206,509
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:	CON000000075555
Project/Grant Reporting Period:	5/12/18 - 5/11/19
Reporting Period End Date:	05/12/19

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
VDHR-SPR	Breeding Fusarium Head Blight Resistant Spring Wheat.	$ 136,108
VDHR-SPR	Optimization of Training Population Content and Size for Genomic Selection for FHB.	$ 55,187
VDHR-SPR	Introgression to Wheat and Candidate Gene Discovery for Resistance Gene Fhb7.	$ 15,214
	FY18 Total ARS Award Amount	$ 206,509

July 11, 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

FY18 Performance Report
PI: Anderson, Jim
USDA-ARS Agreement #: 59-0206-8-202
Reporting Period: 5/12/18 - 5/11/19

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) 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 – summarized by Objective below
2) specific objectives

Objectives 1-2: Scab nurseries were established at two field sites, Crookston and St. Paul, in 2018. A total of 1,728 genotypes were evaluated in 1 to 3 replications for a total of 4,486 across the two locations. We evaluated the FHB reaction of external germplasm from the 2018 Uniform Regional Scab Nursery (24 lines) and 2018 Regional Performance Nursery (38 lines). We completed Visual Scabby Kernel (VSK) assessment of all materials from the St. Paul nursery and received DON data from select materials, mostly the most advanced nurseries.

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 2,533 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 545 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 360 for entry in to preliminary yield trials in spring 2019. Marker-assisted selection was used to characterize parental lines (all done in-house) and Preliminary yield trial candidates (in cooperation with the USDA Fargo Genotyping Lab). We routinely use DNA markers to screen for genes that provide resistance to Fusarium head blight, leaf rust, Ug99 stem rust resistance, tan spot and high molecular weight glutenins that are necessary for good baking quality. The Genotyping Center screened 1,277 pre-yield trial lines with 11 gene-specific DNA markers, generating 14,047 data points. In addition, since Fall 2018 we screened 558 individual F_1 plants from topcrosses and backcrosses and 82 parents from Fall 2018 and Spring 2019 crossing blocks for as many as 22 markers in-house, generating a total of 2,776 datapoints.

3) significant results

- The St. Paul FHB screening nursery was excellent, and provided highly discriminatory data. The Crookston nursery did not receive enough irrigation water

and as a result about 50% of the later heading lines largely escaped infection. As a result, only limited severity data was collected and the rows were not harvested for further assessment. From the 2018 St. Paul FHB nursery data and results from previous years, the FHB resistance of 38 spring wheat cultivars was assessed.

- We used genomic selection at the F_5 stage for FHB to help select lines to advance to preliminary yield trials.
- 'MN-Washburn' was released in 2019. It is moderately resistant (4 on 1-9 scale) to FHB and is meant to replace Linkert, the leading HRS variety which is rated as a '5' for FHB.

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. University of Minnesota developed varieties accounted for an estimated 52% of 1.6 million Minnesota wheat acres in 2018 which is the highest proportion in more than 3 decades. Recent releases include 'Linkert' (2013), 'Bolles' (2015), 'Shelly' (2016), 'Lang-MN' (2017), and 'MN-Washburn' (2019). Germplasm from our breeding program is increasingly being used as parents by private and public breeding programs in the region, too. 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.

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. The registration article for 'Shelly' was published during this reporting period.

Project 2: *Optimization of Training Population Content and Size for Genomic Selection for FHB.*

1. **What are the major goals and objectives of the project?**
   We tested the hypothesis that a smaller training population (200 lines) selected based on genomic relationships will be as effective in predicting FHB traits as a larger training population (500 lines) selected based on pedigree relationships.

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

   1) major activities

   In the past year, 2,533 F_5 lines and 45 parental lines were genotyped with the Genotyping by Sequencing method. A Euclidean distance matrix between the F_5 lines was calculated from the genotypic markers. A k-means clustering analysis was then applied to the Euclidean distances to generate partitions that represent the groups/structure present in the F_5 population. Three clusters (K-1, K-2, and K-3) were generated with this algorithm so that the lines within a cluster are more similar to each other than lines belonging to other clusters. A subset of lines proportional to the size of the cluster was selected to serve as the training population to predict the performance of other lines within that cluster. For this study, 200 F_5 lines (95 lines from K-1, 46 lines from K-2 and 59 lines from K-3) were selected to represent a portion of the training population. A supplementary 300 F_5 lines selected based on pedigree relationship, and 45 parental lines were also included to make a training population with a total size of 545 lines. All 545 lines were phenotyped for FHB severity and some post-harvest traits such as visual scabby kernels and micro test weight.

   2) specific objectives

   We did a five-folds cross-validation to compare the predictive ability in two scenarios:
   a. within the entire training population (500 F_5 lines with parents, 545 total)
   b. within each cluster with parents (n = 140 in cluster one, 91 in cluster two and 104 in cluster three)

   2) significant results

   Predictive abilities ranged from 0.12 to 0.39 in the first scenario (large population) but ranged from 0.17 to 0.60 in the second scenario (smaller populations).

   3) key outcomes or other achievements

   The results from last year's genomic selection study was very encouraging. We are also investigating this method in the 2019 study. If the trend holds, we could significantly reduce the size of the F_5 training population that would be phenotyped. In fact, instead of testing 500 lines in just one replication, we can test 200 lines selected by genotypic profile in two replications to increase the quality of our training data, yet still reduce the number of lines phenotyped.

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

All members of my project, regardless of the 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. Specifically, Prabin Bajgain (postdoc) and Emmanuel Adeyemo (graduate student) carried out the phenotypic evaluations, GBS genotyping, and genomic selection work for this project. Other graduate students, 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?

We have discussed this research with many colleagues, including those on the cutting edge of genomic selection research. Emmanuel Adeyemo (graduate student) presented a poster at the 2018 USWBI meeting in St Louis, MO and a manuscript that summarizes the results is in preparation.

FY18 Performance Report
PI: Anderson, Jim
USDA-ARS Agreement #: 59-0206-8-202
Reporting Period: 5/12/18 - 5/11/19

Project 3: *Introgression to Wheat and Candidate Gene Discovery for Resistance Gene Fhb7.*

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

1. Map the FHB resistance on chromosome 7E and develop introgression lines for wheat FHB resistance breeding.
2. Introgress the 7E FHB resistance into the Wheaton and Rollag spring wheat genetic backgrounds, compare expression, and assess synergy with the *Fhb1* gene.

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

1) major activities

We provided seed of 'Rollag', 'Wheaton', and 'MN-Washburn' to Dr. Dvorak in March 2019 so that he could initiate backcrossing of Fhb7 into this germplasm. We plan to take possession of the F1's during summer 2019 and continue backcrossing in our September planted greenhouse.

2) specific objectives

3) significant results

Introgression of Fhb7 into adapted spring wheat materials has been initiated.

4) key outcomes or other achievements

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

None in the Anderson lab as yet.

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

Nothing to date.

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?

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?** No

   If yes, how many?

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?

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?

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**
MN-Washburn	HRS	MR	4	2019

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 (5/12/18 - 5/11/19). 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.

Anderson, J.A., J.J. Wiersma, S.K. Reynolds, G.L. Linkert, R. Caspers, J.A. Kolmer, Y. Jin, M.N. Rouse, R. Dill-Macky, M.J. Smith, L. Dykes, and J.-B. Ohm. 2019. Registration of 'Shelly' hard red spring wheat. J. Plant Registrations, doi:10.3198/jpr2018.07.0049crc
Status: Published
Acknowledgement of Federal Support: YES

Singh, L., J.A. Anderson, J. Chen, B.S. Gill, V.K. Tiwari, and N. Rawat. 2019. Development and Validation of a Perfect KASP Marker for Fusarium Head Blight Resistance Gene *Fhb1* in Wheat. The Plant Pathology Journal, 35:200-207, https://doi.org/10.5423/PPJ.OA.01.2019.0018.
Status: Published
Acknowledgement of Federal Support: YES

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

None.

Other publications, conference papers and presentations.

Adeyemo, E., P. Bajgain, and J.A. Anderson. 2018. Optimizing Training Population Size to Improve Prediction Accuracy of Fusarium Head Blight Traits in Wheat. In: S. Canty, A. Hofstetter, B. Wiermer, and R. Dill-Macky (Eds.), *Proceedings of the 2018 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)

Qiu, R., C. Yang, M. Ali, J. Anderson, B. Steffenson, P. Marchetto. 2018. Detection of Fusarium head blight in small grains using hyperspectral imaging. In: S. Canty, A. Hofstetter, B. Wiermer, and R. Dill-Macky (Eds.), *Proceedings of the 2018 National Fusarium Head Blight Forum* (p. 32). 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)

Singh, L. J. Anderson, B.S. Gill, and N. Rawat. 2018. Expression of phytohormone related wheat defense genes in PFT-mediated resistance against Fusarium graminearum. In: S. Canty, A. Hofstetter, B. Wiermer, and R. Dill-Macky (Eds.), *Proceedings of the 2018 National Fusarium Head Blight Forum* (p. 74). 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)