USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY14 Final Performance Report
July 15, 2015

Cover Page

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Fiscal Year:	FY14
USDA-ARS Agreement ID:	59-0206-4-032
USDA-ARS Agreement Title:	Mapping and Accelerated Introgression of FHB Resistance into Superior Wheat and Barley Varieties.
FY14 USDA-ARS Award Amount:	$ 172,198

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
BAR-CP	Variety Development, Selection, and Characterization of Resistance to FHB and DON in Winter Barley.	$ 57,393
VDHR-SWW	Improving FHB Resistance in SRW Wheat via Integrated Mapping, Phenotypic and MAS.	$ 102,140
VDHR-SWW	Developing Doubled Haploids to Expedite Variety Development in SRWW.	$ 12,665
	FY14 Total ARS Award Amount	**$ 172,198**

Carl A. Griffey

7/2/2015

Principal Investigator Date

* MGMT – FHB Management
FSTU – Food Safety, Toxicology, & Utilization of Mycotoxin-contaminated Grain
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
WES-CP – Western 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: *Variety Development, Selection, and Characterization of Resistance to FHB and DON in Winter Barley.*

1. What major problem or issue is being resolved relevant to Fusarium head blight (scab) and how are you resolving it?

Scab is a perpetual problem for barley growers and end users in Virginia, and epidemics such as that occurring in 2013 and prior years not only reduce yields and quality, but also reduce barley's marketability due to low test weights and DON toxin. In the past several years, we have developed and advanced populations and pure lines derived from crosses between superior winter barley breeding lines and cultivars from our program with FHB resistant spring barley lines. However, the FHB resistant spring barley lines are not adapted to our environment and lack resistance to other prevalent diseases. Thus, the program has more recently initiated research to characterize and validate QTL and to identify diagnostic markers for FHB resistance in our native barley sources. Current diagnostic markers for FHB resistance (ten SSR markers each for QTL on chromosomes 2H and 6H) from spring barley along with markers for other diseases (three SNP markers for leaf rust, three SNP markers for powdery mildew, eleven markers for net blotch, three SSR markers for spot blotch), yield (one SNP marker) and quality (one SNP marker) are being used for MAS in the Virginia Tech barley program. Mapping populations to characterize FHB resistant in the winter barley cultivars Nomini and Eve have been developed in our program. About 300 recombinant inbred lines (RIL) each for the populations Eve/Doyce and Eve/VA07H-35WS were phenotyped in 2015 for FHB in VA, KY, NC, and in the scab nursery in Nanjing, China in 2015. A second year of phenotyping will be conducted on the mapping populations at these locations in 2016. A Thoroughbred/Nomini mapping population will be used to characterizing FHB resistance in hulled barley cultivar Nomini. About 200 RIL for the Thoroughbred/Nomini mapping population have been developed at Virginia Tech and will be evaluated for FHB in the field (KY, NC, VA, and possibly in Nanjing, China) in 2016 and 2017. An attempt to develop a doubled haploid population from a cross of Secretariat / Nomini failed due to albinism. Therefore, a cross was made between Nomini and the elite 2-row winter malt barley cultivar Violetta. The F_1 seed will be sent to Dr. Pat Hayes' lab at Oregon State University to develop DH lines this summer. Genotyping of the mapping populations will be done at Virginia Tech in collaboration with USDA-ARS, Fargo, ND.

Breeding populations derived from crosses made with FHB resistance sources (AC Alberte, Atahulpa, MN Brite, and Fredrickson) are in advanced generations. This season (2014-15), three elite FHB resistant barley lines were evaluated in Virginia's State Variety Trial, 19 advanced FHB resistant lines were evaluated in a preliminary yield test, 21 FHB resistant lines were tested in an observation yield trial, and 75 pure lines and 80 populations were evaluated for FHB resistance in our scab nursery and advanced in the program.

2. List the most important accomplishments and their impact (i.e. how are they being used) to minimize the threat of Fusarium Head Blight or to reduce mycotoxins. Complete both sections; repeat sections for each major accomplishment:

Accomplishment:

We have continued to make progress improving resistance to FHB in the breeding program. Pure lines from populations derived from crosses between known FHB resistant spring barley lines and adapted winter barley lines are being evaluated for FHB resistance and agronomic performance. This season (2014-15), three elite FHB resistant barley lines were evaluated in Virginia's Official Variety Trial (OVT). Marker analysis of Nomini, VA06H-48, and Eve showed that the FHB marker haplotypes for these genotypes are different than the haplotypes of the FHB resistant genotypes Chevron and Fredrickson. Recombinant inbred lines have been developed from crosses between Thoroughbred/Nomini, Eve/Doyce and Eve/VA07H-35WS, and FHB phenotypic data was obtained for the latter two mapping populations in 2015 at two locations in VA and NC and at one site in KY. These RIL mapping populations will be used to characterize FHB resistance in Nomini and Eve.

Impact:

Data on FHB and DON is collected each year on all barley cultivars and experimental lines included in Virginia's Official Variety Trial and provided to growers and stakeholders in the annual Small Grains bulletin and online. Screening resistant genotypes in our program with molecular markers on chromosomes 2H and 6H for FHB and DON revealed QTL regions which may confer unique resistance in the Virginia Tech germplasm. Use of diagnostic markers for FHB and also to select for resistance to other diseases, yield, and quality will enhance variety development in the Virginia Tech barley program. Breeding populations and pure lines derived from crosses to incorporate FHB resistance from Chevron, Frederickson, Atahulpa, Tibetan, Island, ND 20448, AC Alberte, MN-Brite, Quest (M1222), and other elite genotypes are being advanced and tested in the program and will provide for superior cultivars and/or germplasm.

Project 2: *Improving FHB Resistance in SRW Wheat via Integrated Mapping, Phenotypic and MAS.*

1. What major problem or issue is being resolved relevant to Fusarium head blight (scab) and how are you resolving it?

Development of competitive wheat cultivars having FHB resistance derived from exotic sources, such as *Fhb1* derived from Sumai 3, has been hindered by linkage drag. In addition, progress has been hindered by the lack of adequate characterization and validation of FHB resistance in adapted native sources and unavailability of diagnostic markers needed to implement marker assisted incorporation and pyramiding of diverse QTL for FHB resistance. FHB resistance in the SRW wheat cultivar Massey was mapped and resistance in Ernie was validated and fine mapped previously in our program. Mapping of FHB resistance in the SRW wheat cultivars Roane and Jamestown was conducted in a northern and southern set of RILs and phenotyped by cooperators in AR, GA, KY, LA, MD, MO, NC, and VA for two years. Double haploid lines of a Pioneer26R46/Tribute mapping population were evaluated for FHB phenotypes in AR, KY, NC and VA for two years. Marker assisted selection (MAS) is being used to both enhance the level of scab resistance and to accelerate the development of superior scab resistant cultivars. Markers linked to scab resistance genes located on wheat chromosomes 3BS (*Fhb1*) and 5AS of Ning 7840 (Sumai 3 derivative), 1B of Jamestown, 2B, 3BSc, 4B and 5A of Ernie and 3BSc of Massey are being used to screen, characterize and select parents and their progeny for scab resistance genes. Twelve top cross populations developed between 2008 and 2010 with either Ernie or Ning 7840 (or other Sumai3 derivatives) in their pedigrees were screened via MAS to enrich FHB resistance in these breeding populations. In 2013, FHB breeding materials evaluated in scab nursery and/or field tests included: 199 populations, 2000 headrows, and more than 800 pure lines.

2. List the most important accomplishments and their impact (i.e. how are they being used) to minimize the threat of Fusarium Head Blight or to reduce mycotoxins. Complete both sections; repeat sections for each major accomplishment:

<u>Accomplishment:</u>

A QTL for FHB resistance on chromosome 1B in a Pioneer 25R47/Jamestown (P47/JT) mapping population was validated in FG95195/Jamestown (FG/JT) and Jamestown/LA97UC113-124 (JT/LA) populations. Markers Xwmc500 (SSR marker) and Kukri_c31554_437 (SNP marker) are diagnostic markers for the QTL on chromosome 1B. Another QTL on 6A in P47/JT could not be validated on FG/JT and JT/LA. However, the 6A QTL region identified in P47/JT was also identified in a Bess/NC-Neuse mapping population (Paul Murphy; NCSU). This QTL region will be re-tested for validation in Jamestown populations with more markers on 6A chromosome. The diagnostic markers Wmc500 and Kukri_c31554_437 for QTL on chromosome 1B are being used in MAS in the Virginia Tech wheat breeding program and USDA-ARS genotyping center at Raleigh, NC. The SRW wheat cultivar Hilliard having the FHB resistance QTL on 1B was released in 2015.

Additionally, putative QTL on chromosomes 1A and 5A were observed in the JT/LA population, while a putative QTL on chromosome 2B was observed in FG/JT. The QTL on chromosomes 1A, 2B, and 5A will be tested for validation in all Jamestown mapping populations.

During 2012-2013 and 2013-2014, phenotypic data was collected in a Pioneer26R46/Tribute double haploid (DH) population in AR (Milus), KY (Van Sanford), NC (Murphy), MD (Costa), and VA (Griffey). In preliminary analysis, five consistent QTL were observed on chromosome 1A, 2A, 2D, 3BSc, and 5A. The population is being genotyped with 90,000 SNP markers in collaboration with USDA-ARS genotyping laboratory at Raleigh, NC and Fargo, ND. Diagnostic markers will be identified for use in MAS breeding in the Virginia Tech and other wheat breeding programs.

Impact:

Data on FHB and DON is collected each year on all wheat cultivars and experimental lines included in Virginia's Official Variety Trial and provided to growers and stakeholders in the annual Small Grains bulletin and online. The SRW wheat cultivar Hilliard, having the FHB resistance QTL on 1B, provides growers with a widely adapted and high yielding variety that also has resistance to other prevalent diseases in the eastern U.S. Identification and validation of consistent QTL in native sources such as Ernie (on chromosomes 2B, 3BSc, 4B and 5A), Massey (3BSc), and Jamestown (1B) has potential to enhance both breeding effectiveness and level of FHB resistance in SRW wheat. Once these QTL and those postulated in Tribute are validated and diagnostic markers identified, they can be used for MAS to enhance scab resistance in wheat breeding programs.

Project 3: *Developing Doubled Haploids to Expedite Variety Development in SRWW.*

1. **What major problem or issue is being resolved relevant to Fusarium head blight (scab) and how are you resolving it?**

   Research is focused on shortening breeding cycles through the development of doubled haploid populations and enhancing FHB resistance via MAS breeding efforts in selection of parents, designing crosses, gene introgression and pyramiding, population enrichment, and selection of pure lines. Marker haplotypes of parents for validated FHB resistance QTL and other traits of importance such as dwarfing genes, disease and insect resistance, rye translocations, and quality are being assessed and utilized to enhance breeding efficiency. Markers linked to scab resistance genes located on wheat chromosomes 1B of Jamestown, 2DL, 3BS (*Fhb1*) and 5AS of Ning 7840 (Sumai 3 derivative), 2B, 3BSc, 4B and 5A of Ernie are being used to screen, characterize and select parents and their progeny for scab resistance genes. Seven crosses were made to pyramid *Fhb1*, and QTL on chromosomes 5AS, 2DL, and 3BSc (Ernie) in spring 2014. Doubled haploid populations were developed at Heartland Plant Innovations and are being evaluated in yield trials and the scab nursery. Lines selected from DH populations will be shared with and evaluated in breeding programs in AR, GA, KY, LA, NC, and VA.

2. **List the most important accomplishments and their impact (i.e. how are they being used) to minimize the threat of Fusarium Head Blight or to reduce mycotoxins. Complete both sections; repeat sections for each major accomplishment:**

   Accomplishment:

   A top cross (MD03W61-09-7 (*Fhb1*) / Jamestown (QTL on 1B) // GA04570-10E46) was made in spring 2013. The doubled haploid (DH) population consisting of 250 lines was developed at Heartland Plant Innovations in Manhattan, KS in 2013. The DH lines were genotyped for the 1B QTL of Jamestown, *Fhb1*, *Lr9*, *Sbm1*, and 1B.1R in our lab and evaluated in headrows at Warsaw in 2014. Selected DH lines were grown to increase seed stocks, and will be shared with other cooperators. The DH lines from a single cross MDC07027-12-24 (QTL on 2DL, 3BS (*Fhb1*) and 5AS from Ning 7840) / Hilliard (QTL on 1B) were developed by Heartland in 2015 and will be evaluated in headrows in 2016. Selected lines will be genotyped and subsequently shared with cooperators.

   Impact:

   Use of a combination of DH and MAS technologies will shorten the breeding cycle and enhance development of FHB resistance germplasm and varieties. The DH lines selected on the basis of marker genotypes and desirable agronomic traits will be distributed to cooperating breeders for use in their programs. Select DH lines will be advanced and tested in routine yield and scab nurseries and superior lines will be released as varieties.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY14 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 FY14 award period?**
   Yes
   If yes, how many?
   One

2. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY14 award period?**
   None.
   If yes, how many?

3. **Have any post docs who worked for you during the FY14 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 FY14 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?

Include below a list of all germplasm or cultivars released with full or partial support of the USWBSI during the FY14 award period. List the release notice or publication. Briefly describe the level of FHB resistance. *If not applicable because your grant did NOT include any VDHR-related projects, enter N/A below.*

HILLIARD

In the Uniform Eastern SRW Wheat Nursery, Hilliard had mean values for FHB Incidence, Severity, FHB Index (Incidence x Severity / 100), fusarium damaged kernels (FDK), and ISK Index (0.3 x Incidence + 0.3 x Severity + 0.4 x FDK) of 82%, 47%, 37%, 51%, and 61% compared to values of 88%, 61%, 54%, 70%, and 78% for the susceptible cultivar Shirley. Hilliard also was evaluated for reaction to FHB in the 2014 Southern Uniform Winter Wheat Scab Nursery over seven environments. Hilliard had values for FHB incidence (73%), FHB severity (40%), FHB Index (32%), FDK (38%), ISK Index (44%) and deoxynivalenol (11.2 ppm), which were lower in magnitude than those of the susceptible check 'Coker 9835' (88%, 62%, 56%, 51%, 63%, and 16.6 ppm).

VA10W-21

In the 2012 and 2013 Uniform Eastern SRW Wheat Nursery, VA10W-21 had mean values for FHB Incidence, Severity, and Index of 49 to 64%, 10 to 42%, and 8 to 26, respectively versus values of 58 to 89%, 41 to 49%, and 20 to 42 for Shirley. In the 2013 nursery, means for fusarium damaged kernels (FDK) and ISK Index for VA10W-21 were 50% and 64.8 compared to values of 75% and 81.4 for Shirley. VA10W-21 was evaluated for reaction to FHB in the 2012 Northern Uniform Winter Wheat Scab Nursery over eight environments. VA10W-21 had low mean values for FHB incidence (34%), severity (17%), Index (8.3), FDK (12.5%), and deoxynivalenol (5.6 ppm), which did not differ significantly ($P \geq 0.05$) from those of the most resistant entry.

Include below a list of the publications, presentations, peer-reviewed articles, and non-peer reviewed articles written about your work that resulted from all of the projects included in the FY14 grant. Please reference each item using an accepted journal format. If you need more space, continue the list on the next page.

Berger, G., A. Green, P. Khatibi, W. Brooks, L. Rosso, S. Liu, S. Chao, C. Griffey, and D. Schmale, III. 2014. Characterization of Fusarium Head Blight (FHB) Resistance and Deoxynivalenol Accumulation in Hulled and Hulless Winter Barley. Plant Dis. 98(5):599-606.

Khatibi, P., G. Berger, J. Wilson, W. Brooks, N. McMaster, C. Griffey, K. Hicks, N. Nghiem, and D. Schmale, III. 2014. A comparison of two milling strategies to reduce the mycotoxin deoxynivalenol in barley. Jour. of Agri. and Food Chem. DOI:10.1021/jf501208x

Presentations

Malla, S., C. Griffey, J.P. Murphy, E. Milus, A. Clark, D. Van Sanford, J. Costa, N. McMaster, D. Schmale III, S. Chao, and G. Brown-Guedira. 2014. Identification of FHB resistance QTL in Native SRW wheat cultivar Tribute. In: S. Canty, A. Clark, Y. Salat, and D. Van Sanford, editors, Proceedings of the 2014 National Fusarium Head Blight Forum, St. Louis, MO. 7-9 Dec. 2014. U.S. Wheat & Barley Scab Initiative, East Lansing, MI/Lexington, KY.

Wright, E., C. Griffey, S. Malla, D. Van Sanford, S. Harrison, J.P. Murphy, J. Costa, E. Milus, J. Johnson, A. McKendry, D. Schmale III, A. Clark, N. McMaster, S. Chao, and G. Brown-Guedira. 2014. Identification of New QTL for Native Resistance to FHB in SRW wheat. In: S. Canty, A. Clark, Y. Salat, and D. Van Sanford, editors, Proceedings of the 2014 National Fusarium Head Blight Forum, St. Louis, MO. 7-9 Dec. 2014. U.S. Wheat & Barley Scab Initiative, East Lansing, MI/Lexington, KY.

Wright, E., C. Griffey, S. Malla, D. Van Sanford, S. Harrison, J.P. Murphy, J. Costa, E. Milus, J. Johnson, A. McKendry, D. Schmale III, A. Clark, N. McMaster, S. Chao, and G. Brown-Guedira, H. Wanjugi, M. Grosz, and N. Carpenter. 2014. Identification of QTL for FHB Resistance in SRW Wheat - Jamestown. In: C.A. Griffey, J.E. Seago, and N.R. Carpenter, editors, Proceedings of the 2015 Eastern Wheat and Southern Small Grain Workers Conference, Richmond, VA. 28-30 Apr., 2015.