**USDA-ARS/**
**U.S. Wheat and Barley Scab Initiative**
**FY12 Final Performance Report**
**July 16, 2013**

# Cover Page

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| **Fiscal Year:** | FY12 |
| **USDA-ARS Agreement ID:** | 59-0206-9-084 |
| **USDA-ARS Agreement Title:** | Evaluation, Breeding, and Genomics of FHB Resistance in Wheat and Barley. |
| **FY12 USDA-ARS Award Amount:** | $ 147,340* |

**USWBSI Individual Project(s)**

| USWBSI Research Category** | Project Title | ARS Award Amount |
|---|---|---|
| BAR-CP | Development and Characterization of Winter Barley for Resistance to FHB and DON. | $ 28,985 |
| VDHR-SWW | Improving FHB Resistance in SRW Wheat via MAS and Mapping in Native Sources. | $ 112,075 |
| VDHR-SWW | Developing Double Haploids to Expedite Mapping and Enhance FHB Resistance in SRWW. | $ 6,280 |
| | **Total ARS Award Amount** | **$ 147,340** |

Carl A. Griffey

7/12/13

Principal Investigator Date

* Partial funding for this research is under ARS agreement # 59-0206-2-082

** MGMT – FHB Management
FSTU – Food Safety, Toxicology, & Utilization of Mycotoxin-contaminated Grain
GDER – Gene Discovery & Engineering Resistance
PBG – Pathogen Biology & Genetics
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:** *Development and Characterization of Winter Barley for Resistance to FHB and DON.*

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

In the past several years, we have initiated population development from crosses made 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. There is need to characterize and validate the diagnostic markers for FHB resistance in the native sources. Also, the diagnostic markers for FHB resistance from spring barley along with markers for other disease and quality traits will be validated in our winter barley program to be used for MAS. Winter barley cultivars possessing FHB resistance and lower DON levels have been identified and confirmed in the Virginia Tech barley program. RIL populations for Eve/Doyce and Eve/VA07H-35WS are being generated through single seed descent in the greenhouse. Crosses were made between Nomini and Thoroughbred this spring and the populations are being advanced in the greenhouse. RIL populations will be used to identify potential QTL conferring FHB resistance in Virginia Tech winter barley germplasm. Crosses made with resistant FHB sources (AC Alberte, Atahulpa, MN Brite, and Fredrickson) are in advanced generations. This season, (2012-2013), FHB breeding materials evaluated in scab nursery and/or field tests included: 80 advanced barley lines from Virginia State Variety Trial, 63 FHB resistant pure lines in an Observation test, 85 populations, and 800 headrows.

**2. List the most important accomplishment and its impact (i.e. how is it 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. Haplotyping of Nomini, VA06H-48, and Eve showed that the haplotype for these genotypes were different than the haplotype from the FHB resistant genotypes Chevron and Fredrickson. Recombinant inbred lines are being developed from crosses between Nomini/Thoroughbred, Eve/Doyce and Eve/VA 07H-35WS. The recombinant inbred lines will be used to characterize FHB resistance in Thoroughbred and Eve. In addition, pure lines from populations derived from crosses between known FHB resistant spring barley lines and adapted winter barely lines are being evaluated for FHB resistance and agronomic performance.

**Impact:**

Screening the genotypes with molecular markers on chromosomes 2H and 6H for FHB and DON revealed QTL regions which may confer resistance in the Virginia Tech germplasm. Crosses are being made to incorporate resistance from Chevon, Frederickson, Atahulpa, Tibetan, Island, ND 20448, AC Alberte, MN-Brite, Quest (M1222), Pinnacle, and other elite genotypes.

**Project 2:** *Improving FHB Resistance in SRW Wheat via MAS and Mapping in Native Sources.*

**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. Mapping for FHB resistant SRW wheat cultivars Roane and Jamestown were 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 from Pioneer26R46/Tribute will be sent to cooperators in AR, KY, NC and VA for the second year of FHB phenotyping, fall 2014. 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), 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 2012, FHB breeding materials evaluated in scab nursery and/or field tests included: 140 populations, 1,500 headrows, and more than 800 pure lines.

**2. List the most important accomplishment and its impact (i.e. how is it being used) to minimize the threat of Fusarium head blight or to reduce mycotoxins. Complete both sections (repeat sections for each major accomplishment):**

**Accomplishment:**

In Jamestown and Roane populations, a total of 173 QTL was identified where 94 and 79 QTL were associated with the FHB resistance and susceptibility, respectively. The QTL were detected in all chromosomes except 4D, 5D, and 7D. Two consistent QTL on chromosomes 2B and 7B were identified in all three Jamestown populations, while 15 QTL on chromosomes 1A, 1B, 1D, 2A, 2B, 2D, 3A, 3B, 4A, 4B, 5A, 5B, 6A, 7A, and 7B were identified in two populations. In all three Jamestown populations (Jamestown/LA97113UC-124 (JT/LA), FG95195/Jamestown (FG/JT), and Pioneer25R47/Jamestown (P47/JT)) a common QTL was identified on chromosome 7B. This QTL decreased FHB severity in JT/LA and P47/JT populations as well as DON concentration in FG/JT population, whereas the QTL increased FHB incidence in JT/LA population. Another QTL on chromosome 2B was consistently associated with FHB traits in one Roane population (Roane/Allegiance) and in two of the Jamestown populations (JT/LA and FG/JT). The putative QTL on 2B conferred resistance to FHB incidence and severity in the Roane/Allegiance population and resistance

to DON concentration in the JT/LA population, whereas the 2B QTL was associated with susceptibility to FHB in the JT/LA and FG/JT populations. These QTL were identified using SNP marker data and will be confirmed with SSR markers.

**Impact:**

Progress in introgression and pyramiding of FHB resistance in SRW wheat has been hindered by lack of knowledge of the identity and diversity of QTL governing resistance and by lack of reliable diagnostic markers to deploy in MAS. Identification and validation of consistent QTL in native sources such as Ernie (on chromosomes 2B, 3BSc, 4B and 5A), Massey (3BSc), Roane (2B), and Jamestown (2B and 7B) has potential to enhance both breeding effectiveness and level of FHB resistance in SRW wheat. Once these QTL are validated and diagnostic markers identified, they can be used in MAS for scab resistance in wheat breeding programs.

**Project 3:** *Developing Doubled Haploids to Expedite Mapping and Enhance FHB Resistance in SRWW.*

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

   Research will focus on shortening FHB breeding cycles through the development of doubled haploid populations and enhanced 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 will be assessed and utilized to enhance breeding efficiency. Markers linked to scab resistance genes located on wheat chromosomes 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 2013. One or more of these crosses will used to develop doubled haploid populations at Heartland Plant Innovations. Phenotyping of the populations will be conducted in AR, GA, KY, LA, NC, and VA.

2. **List the most important accomplishment and its impact (i.e. how is it 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 single cross between VA09W-73 (Roane and Tribute in parentage) / MD03W61-09-7 (*Fhb1*) was made in 2011 to incorporate *Fhb1* and QTL from Roane and Tribute into superior progeny. The doubled haploid (DH) population consisting of 196 lines was developed at Heartland Plant Inovations in Manhattan, KS in 2012. The DH lines were genotyped for *Fhb1*, *Lr9*, *Sbm1*, and 1B.1R in our lab and evaluated in headrows at Warsaw in 2013. Selected DH lines will be grown to increase seed stocks, and then will be shared with other cooperators. A top cross MD03W61-09-7 (*Fhb1*) / Jamestown (native resistance) // GA04570-10E46 was made in spring 2013. About 300 DH lines from the cross will be developed at Heartland Plant Inovations in Manhattan, KS in 2013, and the DH lines will then be genotyped and advanced in 2014.

   **<u>Impact:</u>**

   Using 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 nurseries and superior lines will be released as varieties.

**Include below a list of all germplasm or cultivars released with full or partial support of the USWBSI. List the release notice or publication. Briefly describe the level of FHB resistance.**

Brooks, W. S. M. E. Vaughn, C. A. Griffey, W. E. Thomason, J. J. Paling, R. M. Pitman, D. W. Dunaway, R. A. Corbin, J. C. Kenner, E. G. Hokanson, H. D. Behl, B. R. Beahm, S. Y. Liu, P. G. Gundrum, A. M. Price, D. E. Brann, D. L. Whitt, J. T. Custis, D. E. Starner, S. A. Gulick, S. R. Ashburn, E. H. Jones Jr., D. S. Marshall, M. O. Fountain, T. D. Tuong, D. P. Livingston, R. Premakumar, M. J. Kurantz, F. Taylor, R. A. Moreau, and K. B. Hicks. 2011. Registration of 'Dan' Winter Hulless Barley. Journal of Plant Registrations 5: 4 pages. doi: 10.3198/jpr2010.03.0161crc. In comparison to 'Doyce', Dan barley is moderately resistant to FHB with an Index of 33 versus 48, FDK of 24 versus 31 and DON of 16 versus 30 ppm.

Griffey, C. A., W. E. Thomason, R. M. Pitman, B. R. Beahm, P. G. Gundrum, S. Y. Liu, J. Chen, J. J. Paling, D. W. Dunaway, W. S. Brooks, M. E. Vaughn, J. E. Seago, B. C. Will, E.G. Hokanson, H. D. Behl, R. A. Corbin, T. R. Lewis, M. D. Hall, J. T. Custis, D. E. Starner, S. A. Gulick, S. R. Ashburn, D. L. Whitt, H. E. Bockelman, J. P. Murphy, R. A. Navarro, E. J. Souza, G. L. Brown-Guedira, J. A. Kolmer, D. L. Long, Y. Jin, X. Chen, and S. E. Cambron. 2011. Registration of 'SW049029104' Wheat. Journal of Plant Registrations 5:91-97. doi: 10.3198/jpr2010.03.0146crc. FHB resistance of SW049029104 (USG3315) is similar to that of 'Jamestown' with a three year index of 6 versus 22 for USG 3592.

Hall, M. D., W. Rohrer-Perkins, C. A. Griffey, S. Y. Liu, W. E. Thomason, A. O. Abaye, A. Bullard-Schilling, P. G. Gundrum, J. K. Fanelli, J. Chen, W. S. Brooks, J. E. Seago, B. C. Will, E. G. Hokanson, H. D. Behl, R. M. Pitman, J. C. Kenner, M. E. Vaughn, R. A. Corbin, D. W. Dunaway, T. R. Lewis, D. E. Starner, S. A. Gulick, B. R. Beahm, D. L. Whitt, J. B. Lafferty, and G. A. Hareland. 2011. Registration of 'Snowglenn' Wheat. Journal of Plant Registrations 5: 6 pages. doi: 10.3198/jpr2010.03.0160crc. The winter durum wheat cultivar Snowglenn has moderate resistance to FHB with a four year average index of 21 and a DON level of 2.0 ppm. The most susceptible lines had an index of 67 and a DON level of 14 ppm.

The SRW wheat germplasm lines VA04W-433 (PI 657945) and VA04W-474 (PI 657946) were developed by the Virginia Agricultural Experiment Station and released in March 2009. VA04W-433 was derived from a three-way cross of 'Ning 7840' / Pioneer Brand '2684'// VA96-54-244. VA04W-474 is a doubled haploid line derived from the $F_1$ of the three-way cross 'Roane' // W14 / 'Coker 9134'. VA04W-433 has *Fhb*1 and VA04W-474 has the 5AS QTL. FHB incidence, severity, index, and DON levels of the two lines are similar to those of the resistant check cultivar Ernie.

The SRW winter wheat cultivar 12V51 was released in 2011. It has a similar level of FHB resistance as Jamestown with a three year mean index value of 8 versus 22 for USG 3592.
The SRW wheat cultivar Yorktown was released in 2012. Yorktown was derived from the cross '38158' (PI 19052) / VA99W-188 [(VA91-54-343 / 'Roane' (PI 612958) sib] // 'Tribute' (PI 632689). Yorktown is most similar to the moderately resistant check cultivar Ernie in reaction to fusarium head blight (*Fusarium graminearum*).

**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 grant. Please reference each item using an accepted journal format. If you need more space, continue the list on the next page.**

**Other Journal Publications**

Liu, S., C.A. Griffey, M.D. Hall, A.L. McKendry, J. Chen, W.S. Brooks, G. Brown-Guedira, D. Van Sanford, and D.G. Schmale. 2013. Molecular characterization of field resistance to Fusarium head blight in two U.S. soft red winter wheat cultivars. TAG. DOI 10.1007/s00122-013-2149-y

**Presentations**

Wright E., C. Griffey, S. Malla, D. Van Sanford, S. Harrison, J.P. Murphy, J. Costa, G. Milus, J. Johnson, A. McKendry, D. Schmale III, A. Clark, and N. McMaster. 2013. Mapping FHB Resistance QTL in Jamestown x LA97113UC-124 RIL Population. *In* Soft Wheat Quality Laboratory Research Review, Wooster, Ohio , USA.

Wright E., C. Griffey, S. Malla, S. Harrison, G. Milus, J. Johnson, D. Schmale III, N. McMaster, D. Van Sanford, P. Murphy, J. Costa, A. McKendry, and A. Clark. 2013. Mapping Fusarium Head Blight Resistance QTL in the Soft Red Winter Wheat Cultivar Jamestown and Roane. *In* Proc. Plant and Animal Genome XXI, San Diego, California, USA.

Wright E., C. Griffey, S. Malla, D. Van Sanford, S. Harrison, J.P. Murphy, J. Costa, G. Milus, J. Johnson, A. McKendry, D. Schmale III, A. Clark, and N. McMaster. 2012. Mapping of FHB Resistance in SRW Wheat Cultivar Jamestown. p. 108. *In* Proc. 2012 National Fusarium Head Blight, Orlando, Florida, USA.

Wright E., C. Griffey, S. Malla, D. Van Sanford, S. Harrison, J.P. Murphy, J. Costa, G. Milus, J. Johnson, A. McKendry, D. Schmale III, A. Clark, and N. McMaster. 2012. Mapping Fusarium Head Blight Resistance QTL in the Soft Wheat Cultivar Jamestown. *In* Proc. 2012 ASA, CSSA, and SSSA International Annual Meeting, Cincinnati, Ohio, USA.

Wright E., C. Griffey, S. Malla, D.S. Harrison, G. Milus, J. Johnson, D. Schmale III, and N. McMaster. 2012. Mapping Fusarium Head Blight Resistance QTL in the Soft Red Winter Wheat Cultivar Jamestown. p. 55. *In* Proc. 2012 Joint National Association of Plant Breeders/Plant Breeding Coordinating Committee Meeting. Indianapolis, IN, USA.