USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY09 Final Performance Report
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Cover Page

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Fiscal Year:	2009
USDA-ARS Agreement ID:	59-0206-9-084
USDA-ARS Agreement Title:	Evaluation, Breeding, and Genomics of FHB Resistance in Wheat and Barley.
FY09- USDA-ARS Award Amount:	$ 123,450

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Adjusted Award Amount
VDHR-SWW	Breeding and Genomics of FHB Resistance in Soft Red Winter Wheat.	$ 121,437
BAR-CP	Screening Hordeum Germplasm for Resistance to Fusarium Head Blight and DON Accumulation.	$ 2,013
	Total Award Amount	**$ 123,450**

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Principal Investigator Date

* 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 Winter Wheat Region
SWW – Southern Sinter Wheat Region

Project 1: *Breeding and Genomics of FHB Resistance in Soft Red Winter Wheat.*

1. **What major problem or issue is being resolved relevant to Fusarium head blight (scab) and how are you resolving it?**
   Accurate phenotyping and genotyping with the right target alleles are crucial to breeding and genomic studies of FHB resistance. We added two regional uniform tests (Gulf Atlantic and Mason-Dixon) in our 2009-10 scab nursery. This will provide FHB data on elite lines to cooperators which can be used in release decisions and selection of parents. In most years, FHB data was not available for these elite lines. During early May, it was dry and low temperatures resulted in slow and lower than normal FHB development in our irrigated scab nursery at Blacksburg. FHB infection was not adequate in some late-mature lines. On the other hand, FHB was severe in wheat and barley breeding populations and in a barley FHB-DON test in our scab nursery at Mt. Holly, VA.
   In addition to marker assisted selection (MAS) and breeding for FHB resistance, our research focuses on mapping and validating different types of FHB resistances in a few native sources addressing the following objectives:

   1) Scab resistant varieties derived from exotic FHB resistant parents have lower yields than those of widely grown commercial cultivars. Such lines have been crossed with superior elite lines and widely grown cultivars to enhance yields and other critical agronomic traits. FHB resistance is being integrated into elite lines having resistance to other diseases such as powdery mildew and leaf rust, as well as acceptable quality traits via MAS using available diagnostic markers to facilitate the development of FHB resistant wheat cultivars with high and stable yield and good end-use quality.
   2) Identification, validation and application of tightly linked markers for specific FHB resistance QTL in each unique source. We collaborated with USDA genotyping center in Raleigh, NC to use markers for 3BS QTL from Sumai 3 in MAS breeding. We saturated markers on the QTL regions of Ernie and used breeder friendly diagnostic markers in MAS of target FHB resistance QTL. QTL for FHB resistance were mapped in a native variety Massey. A RIL population of VA00W-38/Pioneer26R46 is being used to test if there are identical or different alleles for FHB resistance in VA00W-38 versus Ernie and Massey.

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>
   1) Cultivars having moderate scab resistance derived from native sources recently released by our program include ‘Jamestown’ in 2007, ‘SS 5205’ in 2008, and ‘SW049029104’ in 2009. In Virginia Tech’s inoculated, mist irrigated scab nursery, they have much better scab resistance than the susceptible controls.
   2) Based on field scab data from more than 4 environments in two years, significant molecular markers were identified for common QTL from Ernie and Massey and were used to screen advanced lines from our own breeding program, and in screening of lines in the uniform scab nurseries to identify new alleles or source of scab resistance.
   3) The Virginia Tech cultivar Tribute has resistance to scab and lower DON accumulation. A set of 28 double haploid lines from the cross Pioneer 26R46/Tribute have been

developed at CIMMYT and Dr. Paul Murphy's group is currently working to develop additional DH lines. Breeding programs in southern SRW region plan to collaborate in the characterization and mapping of genes governing scab resistance in this unique native source. An effort also has been proposed to use association mapping to analyze the scab resistance in Roane and its derivative, Jamestown.

4) Marker-assisted selection of parents for diverse FHB resistance QTL and other agronomic traits: Haplotyping elite lines with available diagnostic markers for FHB resistance in Ernie and Sumai-3 derivatives, as well as resistances to other diseases (powdery mildew, leaf rust, stripe rust), quality (1B.1R, 1A.1R and gluten), and dwarfing genes (*Rht1*, *Rht2*, and *Rht8*). A set of 61 elite SRW wheat lines, 16 FHB resistant SRW wheat lines, and 36 HRW wheat lines were screened for parental profiling at these loci.
5) Marker-assisted selection combined with phenotypic selection for FHB resistance in segregating breeding populations: a) F_4 top cross population VA02W-713 (Ning 7840 /Pioneer 2691//Roane) / Tribute // VA07W-120 (Ernie*2// Futai8944/Ernie/3/Ernie). Among 200 headrows, 3 were selected for scab observation test. b) More than 800 individual plants from five top cross populations with Ning7840 or Ernie derived FHB resistance were screened for markers linked to 3BS, 5AS, 6BS, 2B, 3BSc, 4B QTL. They were planted at Warsaw in headrows for evaluation and selction for disease resistance and other agronomic traits. c) 26 lines from the cross of Neuse/VA01W-476 and 196 lines derived from Ning 7840 x McCormick backcrosses and top crosses were screened in the scab nursery and in headrows at Warsaw in collaboration with USDA-ARS at Raleigh and University of Kentucky.
6) A set of 146 F_2 to F_6 segregating populations with various sources of FHB resistance were evaluated in 160 ft^2 inoculated plots at Mt Holly, VA. A set of 64 F_4 to F_6 were also planted in Blacksburg, VA for head and/or bulk selection under natural scab infection. Among the 146 populations, 32 were head selected to derive pure lines and 38 were advanced via bulk selection.
7) Nearly 118 single and 222 top crosses including scab resistant parents were made during spring 2010. Three top crosses including parents from VA, LA and NC were developed to deploy MAS enrichment for FHB resistance and other traits.
8) More than 1,000 wheat lines were tested in our Blacksburg scab nursery. These lines include entries in Virginia's official wheat variety trial, lines in FHB advance and preliminary tests, lines in southern, northern and preliminary northern uniform scab nurseries, entries in Gulf Atlantic and Mason Dixon regional nurseries, and other elite SRW, HRW, and durum lines.

Impact:

1) Cultivars having moderate scab resistance derived from native sources released from our program including 'Roane', 'Tribute', 'McCormick', 'USG 3342', 'Dominion', and 'MPV 57' have been grown by producers over a broad area. Seed of our latest cultivars Jamestown, SS 5205, and SW049029104 are available to seedsmen and/or producers.
2) Our QTL mapping indicated that there are some identical and unique QTL between Ernie and Massey. We identified diagnostic markers for FHB resistance QTL in Ernie and

shared the information with Gina Brown-Guedira who is using them for haplotyping at the USDA-ARS genotyping center.

3) Deployment of phenotypic selection combined with MAS using diagnostic markers for target FHB resistance QTL to select parents and progeny with target regions for resistance to FHB, powdery mildew, leaf rust, stripe rust, Hessian fly, dwarfing genes *Rht1*, *Rht2*, and *Rht8*, photoperiod sensitive genes, and quality traits enhances efforts to develop acceptable FHB resistant cultivars.

Project 2: *Screening Hordeum Germplasm for Resistance to Fusarium Head Blight and DON Accumulation.*

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

In comparison to wheat, fewer FHB resistance sources have been identified, genetically characterized, and mapped. We continue to collaborate with Brian Steffenson in the evaluation of winter barley accessions to validate their FHB resistance. In addition to feed, winter barley is positioned for use as a feedstock for ethanol production. Because the byproduct, distiller's dry grain solubles (DDGS) from ethanol production has potential for use in both food and feed markets, efforts have been enhanced to characterize and enhance FHB resistance in winter barley. FHB resistant germplasm, e.g. 'Chevron', Fredrickson', and elite malt barley lines have been used as parents in our breeding program to enhance FHB resistance in winter barley.

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:

Twenty-seven winter barley germplasm lines received from Brian Steffenson were evaluated in a replicate test in our scab nursery and FHB and DON data were sent to him. Twenty-six hulless and 37 hulled barley lines included in our state variety trial also were evaluated in replicated tests in our scab nursery for FHB and DON.

Single and top crosses were made among scab resistance sources and F_2 to F_4 segregating populations having scab resistant parents were evaluated and advanced at two locations in Virginia.

We conducted a test with two resistant, two moderately resistant, and two susceptible cultivars or advanced lines for each of hulless and hulled barley. Twelve lines were planted in a scab nursery at two locations with mist irrigation. The one in Blacksburg was inoculated via conidial spray suspension and spreading scabby corn seeds while the one in Mt. Holly only received scabby corn seeds. FHB incidence, severity, DON and FDK have or will be collected and analyzed for their effects on ethanol and DDGS production.

Impact:

FHB and DON data on winter barley germplasm lines with facilitate the selection and validation of effective and potentially unique resistance sources which can be used as parents in variety development and in mapping studies. FHB and DON data on entries in Virginia's official variety test will enhance breeding efforts and also will provide producers with information regarding resistant versus susceptible cultivars. The research on DON accumulation during the production of ethanol and the concentration in DDGS is very important to the biofuels industry relating to food and feed safety.

Include below a list 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.

The SRW wheat cultivar SW049029104 derived from the cross '38158' (PI 619052) / Pioneer Brand '2552' // 'Roane' and tested as VA04W-90 was released in 2009. The manuscript entitled "Registration of 'SW049029104' Wheat" was accepted on June 10, 2010 for publication in the Journal of Plant Registrations. In inoculated-irrigated experiments conducted in Virginia (2007 – 2009), SW049029104 had a mean FHB Index (Incidence x Severity / 100) value (0 – 100) of 7.0 and a DON concentration of 0.12 mg kg^{-1} (Table 1). In the 2009 Uniform Southern SRW Wheat Nursery (Table 3), SW049029104 had a mean FHB score (0 – 9) of 3.7 and a Fusarium Damaged Kernels (FDK) value of 9.1% versus respective values of 6.8 and 53.4% for the check cultivar Pioneer Brand 26R61 (PI 612153 PVPO). In the Southern Uniform Winter Wheat Scab Nursery (Table 4), SW049029104 had FHB Index (28), FDK (25%), ISK (0.3 x Incidence + 0.3 x Severity x 0.4 x FDK) Index (43), and DON (8 mg kg^{-1}) values similar to those of the resistant check cultivars Ernie (PI 584525), Bess, and Jamestown. FHB and ISK indices of SW049029104 were significantly ($P < 0.05$) lower than those of the susceptible check 'Coker 9835' (PI 548846 PVPO).

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.

Griffey, C.A., W.E. Thomason, R.M. Pitman, B.R. Beahm, J.J. Paling, J. Chen, J.K. Fanelli, J.C. Kenner, D.W. Dunaway, W.S. Brooks, M.E. Vaughn, E.G. Hokanson, H.D. Behl, R.A. Corbin, M.D. Hall, S. Liu, J. T. Custis, C.M. Waldenmaier, D.E. Starner, S.A. Gulick, S.R. Ashburn, D.L. Whitt, H.E. Bockelman, E.J. Souza, G.L. Brown-Guedira, J.A. Kolmer, D.L. Long, Y. Jin, X. Chen, and S.E. Cambron. 2010. Registration of 'Jamestown' Wheat. J. of Plant Registrations. 4:28-33.

Griffey, C.A. et al. 2010. Registration of 'Shirley' Wheat. J. of Plant Registrations. 4:38-43.

Griffey, C.A. et al. 2010. Registration of '3434' Wheat. J. of Plant Registrations. 4:44-49.

Griffey, C.A. et al. 2009. Registration of 'USG3555' Wheat. J. of Plant Registrations. 3: 273-278.

Griffey, C.A. et al. 2009. Registration of '5205' Wheat. J. of Plant Registrations. 3:283-288.

Liu S., M.D. Hall, C.A. Griffey, A.L. McKendry. 2009. Meta-analyses of Fusarium head blight resistance QTL in wheat. Crop Science 49:1955-1968.

Liu S.,, M.D. Hall, C.A. Griffey, A.L. McKendry, J. Chen, G. Brown-Guedira, J.P. Murphy and D. Van Sanford. 2009. Identification of diagnostic markers for scab resistance in US wheat cultivars. International Annual Meeting of ASA-CSSA-SSA. Pittsburg, PA. November, 1-5, 2009.

Liu S., G.L. Berger, M.D. Hall, W.S. Brooks, S. Chao, C.A. Griffey, G.J. Muehlbauer. Identification of molecular markers for important traits in winter barley using association mapping. The International Plant and Animal XVIII Conference. San Diego, CA USA. January 9-13, 2010.

Liu S., W.E. Thomason, C.A. Griffey, M.D. Hall. P.G. Gumdrum, W.S. Brooks, R. Pitman, M. Vaughn, T. Lewis. and D. Dunaway. Integrated Management of Scab in Wheat using Resistant Varieties and Fungicide. In: S. Canty, A. Clark, E. Walton, E. Ellis, J. Mundell, and D. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2009 December 7-9, Orlando, FL, USA. Lexington, KY: University of Kentucky p66.

Liu S., W.S. Brooks, S. Chao. C.A. Griffey, M.D. Hall, P.G. Gundrum, G.L. Berger, P.A. Khatibi, and D.G. Schmale. Association Analyses of SNP Markers with Scab Resistance in Winter Feed Barley. In: S. Canty, A. Clark, E. Walton, E. Ellis, J. Mundell, and D. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2009 December 7-9, Orlando, FL, USA. Lexington, KY: University of Kentucky p133.

Liu S., C.A. Griffey, A.L. McKendry. M.D. Hall and W.S. Brooks. Saturation Mapping of Scab Resistance QTL in Ernie and Identification of Diagnostic Markers for Breeding Scab Resistance. In: S. Canty, A. Clark, E. Walton, E. Ellis, J. Mundell, and D. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2009 December 7-9, Orlando, FL, USA. Lexington, KY: University of Kentucky p134.

Liu S., M.D. Hall, C. A. Griffey, A.L. McKendry, J. Chen, W.S. Brooks, G. Brown-Guand D. Van Sanford. Saturation Mapping QTL for Scab Resistance in a Virginia Wheat Cultivar Massey. In: S. Canty, A. Clark, E. Walton, E. Ellis, J. Mundell, and D. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2009 December 7-9, Orlando, FL, USA. Lexington, KY: University of Kentucky p135.