USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY11 Final Performance Report
July 13, 2012

Cover Page

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Fiscal Year:	FY11
USDA-ARS Agreement ID:	59-0206-9-084
USDA-ARS Agreement Title:	Evaluation, Breeding, and Genomics of FHB Resistance in Wheat and Barley.
FY11 USDA-ARS Award Amount:	$ 153,655

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
BAR-CP	Development of Winter Barley Cultivars with Enhanced Resistance to FHB and DON.	$ 29,268
VDHR-SWW	Improving FHB Resistance in SRW Wheat via Integrated Mapping, Phenotypic and MAS.	$ 124,387
	Total ARS Award Amount	**$ 153,655**

Carl A. Griffey

July 5, 2012

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 Soft Winter Wheat Region
SWW – Southern Soft Red Winter Wheat Region

Project 1: *Development of Winter Barley Cultivars with Enhanced 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?**

   FHB and DON contaminated grain pose serious threats to barley producers and consumers as FHB reduces yields and grain quality and relatively low DON concentrations, which are amplified in DDGS during ethanol production, can render them unacceptable to end users. Winter barley cultivars possessing FHB resistance and lower DON levels have been identified and confirmed in the Virginia Tech barley program. The resistant hulled barley cultivar Nomini had FHB Index = 12, FDK = 7%, DON = 2.7mg/kg, while the susceptible hulled cultivar Thoroughbred had FHB Index = 31.4, FDK = 19.5% and DON = 20.2mg/kg). The resistant hulless cultivar Eve had FHB Index = 13.8, FDK = 5.5% and DON = 2.5 mg/kg) while the susceptible cultivar Doyce had FHB index = 42.6, FDK = 31%, and DON = 29.8 mg/kg. Another susceptible hulless experimental line VA 07H-35WS had FHB Index= 34.3, FDK= 32.5% and DON= 31.4 mg/kg. Mapping populations including the FHB resistant hulled cultivar Nomini and hulless cultivar Eve are being developed and will be used to identify potential QTL conferring FHB resistance in Virginia Tech winter barley gremplasm.

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>
   In addition to identifying and confirming FHB resistance in winter barley, collaborative research has led to other significant accomplishments.
   1. Two *Fusarium* trichothecene 3-*O*-acetyltransferases (FgTRI101 and FfTRI201) were cloned and expressed in yeast (*Saccharomyces cerevisiae*) during a series of small-scale ethanol fermentations using barley (*Hordeum vulgare*). During the fermentation process, FgTRI101 converted 9.2% to 55.3% of the DON to 3ADON, resulting in DDGS with reductions in DON and increases in 3ADON in the Virginia winter barley cultivars Eve, Thoroughbred and Price, and the experimental line VA06H-25. Analysis of barley mashes prepared from the barley line VA04B-125 showed that yeast expressing FfTRI201 were more effective at acetylating DON than those expressing FgTRI101; DON conversion for FfTRI201 ranged from 26.1% to 28.3%, whereas DON conversion for FgTRI101 ranged from 18.3% to 21.8% in VA04B-125 mashes. Ethanol yields were highest with the industrial yeast strain Ethanol Red®, which also consumed galactose when present in the mash.
   2. 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:

Presence of FHB resistance in winter hulled and hulless barley cultivars has been confirmed and these adapted sources have and will continue to be used in the breeding program to enhance resistance in future cultivars. Collaborative research with David Schmale's lab at Virginia Tech and with Kevin Hicks' lab at the USDA-ARS Eastern Regional Research Center has demonstrated the potential of using yeast expressing a trichothecene 3-*O*-acetyltransferase to modify DON during commercial fuel ethanol fermentation.

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. Recombinant inbred lines derived from crosses including the FHB resistant SRW wheat cultivars Roane and Jamestown were obtained and a northern and southern set of lines were sent to relevant cooperators in AR, GA, KY, LA, MD, MO, NC, and VA for FHB phenotyping for the second year during fall 2011. Double haploid lines of Pioneer26R46/Tribute, developed at NCSU, were grown to increase seed and will be sent to potential cooperators in AR, GA, KY, LA, MD, MO, NC and VA for FHB phenotyping during fall 2012. 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 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 2010, FHB breeding materials evaluated in scab nursery and/or field tests included: 272 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:
   1. FHB resistance was mapped in VA00W-38/Pioneer26R46. Six consistent QTL were identified on chromosomes 1BL, 1D, 2B, 3BS, 6A and 6BS and explained 6.6% to 15.8% of the phenotypic variation. Eleven other suggested QTL were detected in one environment

and explained 7.8% to 20.2% of trait variation with favorable alleles in VA00W-38 associated with lower FHB and higher TKW.
2. Recombinant inbred lines derived from Jamestown/LA97113UC-124 were phenotyped in the field in AR, LA and VA in 2011. There were 51 suggestive QTLs detected on chromosomes 1A, 1B, 1D, 2A, 2B, 2D, 3A, 3B, 3D, 4A, 4B, 5A, 5B, 6A, 7A, and 7B with SNP markers for FHB incidence, severity, index, DON and NIV content. Out of 51 suggestive QTLs, 18 QTLs were consistent being associated with more than one FHB trait or the QTL for a given FHB trait was observed in more than one environment. The consistent QTL were located on chromosomes 1A, 1B, 2A, 2B, 3A, 3B, 4A, 4B, 5A, 5B, 6A, 7A, and 7B. There were eight, six, eleven, four and nine QTLs associated with FHB incidence, severity, index, DON and NIV content, respectively.

Impact:

1. The molecular markers associated with the QTL in VA00W-38 were Xgwm18 on chromosome 1BL, XwPt1682 on chromosome 3BS, XwPt0902 on chromosome 6A.These additional diagnostic markers can be used in marker-assisted selection to pyramid multiple QTL for scab resistance.
2. The QTLs identified in the Jamestown/LA97113UC-124 population in the first year will be verified with the second year of the phenotypic data. Also, diagnostic SSR markers will be run in the populations to identify whether these QTLs are similar or different from known QTLs. The markers associated with novel QTLs will be available for the enrichment of scab resistance in wheat breeding programs via marker assisted breeding.

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.**

Chen, J., C. A. Griffey, S. Liu, M. A. Saghai Maroof, J. Paul Murphy, R. A. Navarro, C. H. Sneller, G. L. Brown-Guedira, and E. J. Souza. 2012. **Registration of Fusarium head blight resistant soft red winter wheat germplasm VA04W-433 and VA04W-474.** Journal of Plant Registrations 6:111-116. **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.**

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 winter wheat line VA05W-251 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.

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, G. Brown-Guedira, D. Van Sanford, and D.G. Schmale. **Molecular characterization of field resistance to Fusarium head blight in two U.S. soft red winter wheat cultivars.** (In Review).

Liu, S., C.A. Griffey, M.D. Hall, J. Chen, W.S. Brooks, G. Brown-Guedira, A.L. McKendry, and D. Van Sanford. **Association of Fusarium head blight resistance with morphological traits in two U.S. soft red winter wheat cultivars.** (In Review).

Liu, S., M.D. Christopher, C.A. Griffey, M.D. Hall, P.G. Gundrum and W.S. Brooks. 2012. **Molecular characterization of resistance to Fusarium head blight in U.S. soft red winter wheat breeding line VA00W-38.** Crop Sci 52:1-10.

Kang, J., A. Clark, D. Van Sanford, C. Griffey, G. Brown-Guedira, Y. Dong, and J. Costa. 2011. **Exotic scab resistance quantitative trait loci (QTL) effects on soft red winter wheat.** Crop Sci. 51:924-933.

Khatibi, P., J. Montanti, N. Nghiem, K. Hicks, G. Berger, W. Brooks, C. Griffey, D. Schmale. 2011. **Conversion of deoxynivalenol to 3-acetyldeoxynivalenol in barley-derived fuel ethanol co-products with yeast expressing trichothecene 3-O-acetyltransferases.** Biotechnology for Biofuels. 4:26.

Khatibi, P. A., G. Berger, S. Liu, W. S. Brooks, C. Griffey, and D. G. Schmale, III. 2012. Resistance to Fusarium head blight and deoxynivalenol accumulation in Virginia barley. Plant Disease 96:279-284. http://apsjournals.apsnet.org/doi/abs/10.1094/PDIS-07-11-0551

Presentations

Berger, G., P. Khatibi, W. Brooks, S. Liu, M. Hall, A. Green, C. Griffey, and D. Schmale III. 2011. **Fusarium Head Blight Resistance and Deoxynivalenol Accumulation in Hulled and Hulless Winter Barley and Distiller's Dried Grain.** In: S. Canty, A. Clark, A. Anderson-Scully, D. Ellis and D. Van Sanford (Eds.), Proceedings of the 2011 National Fusarium Head Blight Forum; Dec 4-6, St. Louis, MO. ASAP Printing, Inc., Lansing, MI.

Khatibi, P.A., J. Montanti, N.P. Nghiem, K.B. Hicks, G. Berger, W.S. Brooks, C.A. Griffey and D.G. Schmale III. 2011. **Conversion of Deoxynivalenol to 3-Acetyldeoxynivalenol in Barley-Derived Fuel Ethanol Co-Products with Yeast Expressing Trichothecene 3-O-acetyltransferases.** In: S. Canty, A. Clark, A. Anderson-Scully, D. Ellis and D. Van Sanford (Eds.), Proceedings of the 2011 National Fusarium Head Blight Forum; Dec 4-6, St. Louis, MO. ASAP Printing, Inc., Lansing, MI.

Liu, S., M.D. Christopher, C.A. Griffey, M.D. Hall, P.G. Gundrum, and W.S. Brooks. 2011. **Characterization of Fusarium Head Blight Resistance in Soft Red Winter Wheat Line VA00W-38.** In: S. Canty, A. Clark, A. Anderson-Scully, D. Ellis and D. Van Sanford (Eds.), Proceedings of the 2011 National Fusarium Head Blight Forum; Dec 4-6, St. Louis, MO. ASAP Printing, Inc., Lansing, MI.

Liu, S., C.A. Griffey, M.D. Hall, A.L. McKendry, J. Chen, G. Brown-Guedira, D. Van Sanford, and D.G. Schmale. 2011. **Mapping Fusarium Head Blight Resistance in Wheat Cultivars Ernie and Massey.** In: S. Canty, A. Clark, A. Anderson-Scully, D. Ellis and D. Van Sanford (Eds.), Proceedings of the 2011 National Fusarium Head Blight Forum; Dec 4-6, St. Louis, MO. ASAP Printing, Inc., Lansing, MI.

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, and N. McMaster. 2011. **Family Based Mapping of Fusarium Head Blight Resistance in Soft Wheat Cultivars Roane and Jamestown.** In: S. Canty, A. Clark, A. Anderson-Scully, D. Ellis and D. Van Sanford (Eds.), Proceedings of the 2011 National Fusarium Head Blight Forum; Dec 4-6, St. Louis, MO. ASAP Printing, Inc., Lansing, MI.