USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY11 Final Performance Report
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Cover Page

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Fiscal Year:	FY11
USDA-ARS Agreement ID:	59-0206-9-077
USDA-ARS Agreement Title:	Fusarium Head Blight Research in Winter Wheat.
FY11 USDA-ARS Award Amount:	$ 78,422

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
VDHR-NWW	Accelerating the Development of Scab Resistant Soft Red Winter Wheat.	$ 51,213
VDHR-NWW	Coordinated Evaluation and Utilization of Marker Assisted Selection.	$ 7,805
VDHR-NWW	Improved Breeding for FHB Resistance by Advanced Genetic and Phenotypic Characterization of Soft Winter Wheat.	$ 10,879
VDHR-NWW	Coordinated Evaluation of FHB Resistance of Advanced Soft Winter Lines and Cultivars.	$ 8,525
	Total ARS Award Amount	**$ 78,422**

Anne L McKendry

07/06/12

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: *Accelerating the Development of Scab Resistant 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?**

   Fusarium head blight, in wheat continues to be an important problem in the north-central region of the United States. This ongoing project has focused largely on the exploiting the broadly based, effective, genetically different, native sources of resistance identified in Missouri wheat germplasm; an approach that has been shown to accelerate the development and release of FHB resistant cultivars for the soft red winter wheat region. In FY11 our major objectives were: (1) continue our history of designing crosses that include FHB-resistant parents with native and/or exotic sources of resistance; (2) systematically screen all lines developed at the University of Missouri from preliminary yield testing and verify FHB resistance through years of advanced yield testing; (3) enter lines that combine FHB resistance with excellent agronomic performance into the Northern and Preliminary Scab Nurseries and other relevant breeding nurseries; (4) continue development of recombinant inbred lines; Bess/MO 94-317 for validation of Truman markers (currently in the F5); (5) Continue to study the genetics of newly identified sources of resistance.

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):
   Resistance levels for a total of 250 advanced breeding lines were evaluated for verification of previously identified FHB resistance in both the field and greenhouse nurseries. 184 lines were retained with field index scores < 10% and < 10% FDK. DON values in these 184 lines ranged from 0.67 to 8.2 ppm in the 2011 scab nursery with 105 having DON levels < 2ppm. For comparative purposes, DON levels in Truman, Bess, MO 080104, Ernie, and our susceptible check, MO 94-317 were 1.2, 1.7, 1.1, 3.9, and 7.7, respectively. We are making significant progress selecting not only for low FHBI and FDK but also for low DON. In addition, 500 less advanced lines were evaluated for the first time in FY11 and 80% were retained for low FHBI values (<15%). This group reflects the normal levels of FHB resistance we now have in our program. We have the luxury of being able to select first for performance and then for FHB levels within good agronomic types. This, coupled with the fact that most of these lines contain 'native' sources of resistance, truly accelerates the development of FHB resistant varieties.

   Impact (1): Using sources of resistance that have been discovered in U.S. wheat (previously called 'native' resistance) has enabled us to have FHB resistance (including low FDK and low DON) in adapted and desirable genetic backgrounds. Coupling these factors with photoperiod insensitivity (a breeding goal for some of our material) will extend the range of these lines and when grown, immediately lessen the risk of FHB and mycotoxin contamination of the grain broadly across the soft red winter wheat region.

Accomplishment (2):

In 2011, we completed QTL identification in the resistant cultivar Truman. QTL were identified for all four components of resistance including: incidence, severity, FDK, and DON. Novel QTL were identified for each of these four parameters of resistance. Manuscripts have been written and are in the final stages of editing prior to submission to Crop Science. We then undertook an extension of this project under our breeding grant. The population was SNP'd using the 9K chip and a map is currently being constructed using the 2000+ polymorphic SNPs and the SSRs currently on our map. Although not all components of resistance have been analyzed, preliminary analysis for type II resistance has identified a new QTL on 2DL accounting for 15% of the variance in type II resistance. It was not identified using SSRs and DArTs. A SNP is associated with this QTL and maps at the QTL peak. Bracketing this SNP are two other SNPs and the distance between flanking markers is 1cM. These data are preliminary but indicate the increased quality of the QTL data when the map is more fully saturated. This work will be completed in 2012.

Impact (2):

The source of FHB resistance in Truman is a highly penetrant source of resistance for all 4 FHB resistance traits (greenhouse spread, field incidence, severity, FDK and DON). Having a more fully saturated map for our Truman population will result in better markers for marker-assisted-selection and SNPs offer the possibility of perfect markers – i.e. the gene. Dr. Gina Brown-Guedira is closely involved in this extension of our mapping effort and once either SSRs or SNPs are identified they are being made immediately available to the genotyping labs for use in F2 enrichment and or backcrossing efforts, thereby enabling breeders to pyramid genes for all four types of resistance in regional variety development efforts. Publication of these results in peer-reviewed journal(s) when complete will benefit the scientific community as a whole.

Project 2: *Coordinated Evaluation and Utilization of Marker Assisted Selection.*

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

The effectiveness of MAS for FHB resistance alleles at several QTL derived from Asian wheat lines has been demonstrated convincingly in spring wheat, where native resistance sources are scarce. However, in SWW, relatively few varieties have been released that are derived from Sumai 3 or other Asian resistance sources. In part, this stems from the difficulty in combining the QTL based resistance with superior agronomic performance and acceptable milling and baking quality. Further, there is an abundance of native resistance in SWW that has been deployed in a number of resistant varieties. Nonetheless, we hypothesize that the highest levels of resistance will come through combining native SWW resistance with that conferred by exotic QTL. The approaches used to address this problem are as follows:

1. Near isolines carrying (or not) known QTL will be allocated to regional nurseries according to likely adaptation (eg northern corn belt; southern corn belt) phenotyped in regional scab nurseries and grown in replicated yield trials in 2010-11 and 2011-12 and evaluated for milling and baking quality at the USDA regional quality lab in Wooster, OH. Phenotyping will include standard FHB traits such as incidence, severity, FDK and DON and will likely include evaluation in at least one cooperator's greenhouse.
2. Promising lines can be used as parents by all of the breeders in the CP, and lines that show regional adaptation may be candidates for joint release.

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 2011, we phenotyped a replicated test of 70 lines that were either homozygous for or null for known FHB QTL developed by breeders at 7 public breeding programs. Lines were phenotyped for incidence, severity, FDK and DON. In 2012, the second year of this cooperative trial will be phenotyped. Yield trials of these same lines were done at two locations, but not at Missouri.

Impact:

This trial will look at the efficacy of pyramiding genes from different exotic sources of resistance into soft red winter wheat backgrounds and will determine the impact of these genes on agronomic performance and on milling and baking quality. Results will enable breeders to determine whether or not exotic QTL will impact performance and thus will extend our knowledge on the utility of pyramiding exotic QTL with native sources of resistance to accelerate the development of highly FHB resistant soft red winter wheat. Additionally, cooperating breeders will have access to lines containing known QTL for their own pyramiding efforts.

Project 3: *Improved Breeding for FHB Resistance by Advanced Genetic and Phenotypic Characterization of Soft Winter Wheat.*

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

   There is moderate to strong resistance to FHB in Eastern US SWW. The FHB resistance includes Type I & II resistance as well as potentially resistance to kernel infection (RKI) and toxin accumulation (RTA). It is likely that a combination of all types of resistance is needed to reliably produce grain with low deoxynivalenol (DON). Genetics studies in SWW suggest that resistance is controlled by a few QTL with moderate effect and many QTL of small effect. Traditional mapping and MAS approaches may not be effective given the potentially large number of unique resistance sources and that most variation is likely controlled by genes with small effect. The evolving picture of FHB resistance in SWW currently suggests that recurrent selection is likely to be an effective breeding tool to accumulate favorable alleles. We propose to develop knowledge of the types of resistance, the genetics of this resistance, and efficient breeding methodologies and populations for improving FHB resistance in SWW. Our specific goals are:
   1. Elucidate the genetic structure of multiple mechanisms of FHB resistance in SWW
   2. Develop models to implement genomic selection (GS) for multiple FHB traits.
   3. Document RKI and RTA in SWW

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>

   We grew and evaluated a replicated panel of soft red winter wheat lines representing 7 FHB elite lines from each program and 100 additional sets of lines from pedigrees involving the 7 elite Missouri lines. Data for this year's nursery are not yet analyzed but preliminary data suggests good levels of resistance in many lines. Data has been collected for incidence, severity, FDK and seed will be sent for DON analysis.

   <u>Impact:</u>
   This analysis, once complete, will help identify QTL across entire populations that may be useful in marker-assisted selection using these sources of resistance. Once completed, markers will be made available to the genotyping lab and will be published through peer reviewed journals. Where pyramiding different sources of resistance into individual lines marked reduces the impact of FHB, this project should lead to a reduction in the impact of FHB on the wheat community.

Project 4: *Coordinated Evaluation of FHB Resistance of Advanced Soft Winter Lines and Cultivars.*

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

   Resistance in newly developed germplasm produced in all breeding programs where FHB resistance is an objective requires verification. The nursery systems including the Northern and Southern FHB nurseries as well as other cooperative performance nurseries including the Eastern Soft Red Winter Wheat Nursery and 5-State Advanced and Preliminary Nurseries provide an excellent opportunity to screen the most advanced soft red winter wheat varieties for FHB resistance. Coordinated evaluation of these nurseries accelerates the process of verification by providing breeders with a number of location years of data each year. This multi-location evaluation would be cost prohibitive in most breeding programs and thus, the cooperative nursery systems provide an opportunity to exchange this information among the breeding community and communicate new sources of resistance to all interested breeders. Evaluation of the Official Variety Trials, immediately transfers FHB resistance information to the growers and permits more informed decisions regarding variety selection.

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 FY11, we provided information to respective breeders on incidence, severity, the FHB index, FDK and greenhouse severity on the Northern, Preliminary, the Uniform Eastern Soft Red Winter Wheat Nursery the 5-State Advanced and Preliminary Nurseries. FHB resistance of Missouri lines was among the best evaluated. We also screened and the Official Variety Trial for Missouri which in FY11 was comprised of 87 entries. FHBI values in this commercial trial ranged from 6.4% to 57.6% (susceptible check = 72.67%). 7 commercial lines had FHBI scores equal to Truman and Bess (8.3 and 9.7% respectively), while an additional 19 lines had FHBI scores less than 15%. Most were brands and probably reflect the effort of public breeders in improving FHB resistance of lines that ultimately became proprietary. In addition, although we certainly cannot say for sure, many may have been developed with USWBSI funds. Of note, Pioneer 26R20 and 26R22 were the most susceptible lines in the trial. It is encouraging to know that when we post this information, growers will be better informed on the FHB resistance of commercial brands.

   Impact: This work helps validate sources of resistance from other breeding programs as well as from the Missouri program, thereby providing information on stability of resistance of newly developed germplasm evaluated in the Northern, Preliminary and Southern Scab Nursery. Evaluation of the Official Variety Trials will immediately provide growers with FHB resistance levels on all commercial cultivars, thereby enabling more informed grower choices of varieties to plant on their respective farms. Again, where growers select resistant material, the threat of FHB will be significantly lessened.

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.

None during FY2011 however, a breeder seed increase of MO 080104 was produced during the 2011-2012 crop season. This line has Truman level of resistance in a much better agronomic package including high yield, test weight, early maturity, short stature, photoperiod insensitivity, broad adaptation, and resistance to other relevant diseases. We are currently in discussions for the proprietary release of this line to a company with the infrastructure to market and make the variety broadly available throughout the region.

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.

Refereed Publications

Islam, Md. S., G. Brown-Guedira, H.Ohm, D. Van Sanford, **A.L. McKendry**. 2011. QTL associated with Fusarium head blight incidence and severity in Truman soft red winter wheat. Crop Sci. (in preparation).

Islam, Md. S., G. Brown-Guedira, H.Ohm, D. Van Sanford, Y. Dong, **A.L. McKendry**. 2011. QTL associated with kernel quality retention and DON in Truman soft red winter wheat. Crop Sci. (in preparation).

Islam, Md. S., G. Brown-Guedira, **A.L. McKendry**. 2011. QTL associated with type II Fusarium head blight resistance in Truman soft red winter wheat. Crop Sci. (final editing prior to submission)

Liu, S.Y., C.A. Griffey, M.D. Hall, J. Chen, W.S. Brooks, G. Brown-Guedira, **A.L. McKendry**, D. Van Sanford. Association of Fusarium head blight resistance with morphological traits in two U.S. soft red winter wheat cultivars. 2011. Plant Breeding (under review).

Liu, S.Y., C.A. Griffey, M.D. Hall, **A.L. McKendry**, J. Chen, G. Brown-Guedira, D. Van Sanford, and D.G. Schmale. 2011. Molecular characterization of field resistance to Fusarium head blight in two U.S. soft red winter wheat cultivars. Theor. Appl. Genet. (accepted – under revision)

Non-Refereed Publications

Islam, Md. S., G. Brown-Guedira, H.Ohm, D. Van Sanford, **A.L. McKendry**. 2011. QTL associated with Fusarium head blight incidence and severity in Truman soft red winter wheat. In: S. Canty, A. Clark, A. Anderson-Scully, and D. Van Sanford (Eds). Proceedings of the 2011 National Fusarium Head Blight Forum (Pp. 27). East Lansing, MI/Lexington KY: U.S. Wheat & Barley Scab Initiative.

Islam, Md. S., G. Brown-Guedira, H.Ohm, D. Van Sanford, Y. Dong, **A.L. McKendry**. 2011. QTL associated with kernel quality retention and DON in Truman soft red winter wheat. In: S. Canty, A. Clark, A. Anderson-Scully, and D. Van Sanford (Eds). Proceedings of the 2011

National Fusarium Head Blight Forum (Pp. 28). East Lansing, MI/Lexington KY: U.S. Wheat & Barley Scab Initiative.

Islam, Md. S., G. Brown-Guedira, **A.L. McKendry**. 2011. QTL associated with type II Fusarium head blight resistance in Truman soft red winter wheat. In: S. Canty, A. Clark, A. Anderson-Scully, and D. Van Sanford (Eds). Proceedings of the 2011 National Fusarium Head Blight Forum (Pp. 29). East Lansing, MI/Lexington KY: U.S. Wheat & Barley Scab Initiative.

Liu, S.Y., 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, and D. Van Sanford (Eds). Proceedings of the 2011 National Fusarium Head Blight Forum (Pp. 34). East Lansing, MI/Lexington KY: U.S. Wheat & Barley Scab Initiative.

Wright, E., C. Griffey, S. Malla, D. Van Sanford, S. Harrison, J.P. Murphy, J. Costa, G. Milus, J. Johnson, **A.L. McKendry**, D. Schmale, 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, and D. Van Sanford (Eds). Proceedings of the 2011 National Fusarium Head Blight Forum (Pp. 60). East Lansing, MI/Lexington KY: U.S. Wheat & Barley Scab Initiative.