USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY12 Final Performance Report
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Cover Page

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Fiscal Year:	FY12
USDA-ARS Agreement ID:	59-0206-9-077
USDA-ARS Agreement Title:	Fusarium Head Blight Research in Winter Wheat.
FY12 USDA-ARS Award Amount:	$ 95,816

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
VDHR-NWW	Accelerating the Development of Scab Resistant Soft Red Winter Wheat.	$ 79,351
VDHR-NWW	Coordinated Evaluation of FHB Resistance of Advanced Soft Winter Wheat Lines and Cultivars.	$ 8,515
VDHR-NWW	Improved Breeding for FHB Resistance by Advanced Genetic and Phenotypic Characterization of Soft Winter Wheat.	$ 5,220
VDHR-NWW	Coordinated Evaluation and Utilization of Marker Assisted Selection.	$ 2,047
VDHR-NWW	Male Sterile Facilitated Recurrent Selection for FHB Resistance (MPI-5).	$ 683
	Total ARS Award Amount	**$ 95,816**

Anne L McKendry 7/14/13
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 FY12 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 for FHB resistance; (3) enter lines that combine FHB resistance with excellent agronomic performance into the Northern and Preliminary Scab Nurseries and other relevant breeding nurseries; (4) collaborate with Dr. Paul Murphy to validate Truman markers in the doubled haploid population Bess/Neuse where Bess is a full sib of Truman, (5) continue development of recombinant inbred lines of Bess/MO 94-317 for validation of Truman markers (currently in the F5). Germplasm is shared with interested breeders through the FHB nursery system.

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.**

   Accomplishment: Resistance levels for a total of 500 advanced breeding lines were evaluated for FHB resistance in both the field and greenhouse nurseries. Resistance (FHBI) ranged from 0.8-46.2%. Of 500 lines, 439 had an FHBI less than 20% while 220 had an FHBI less than 10% compared with the susceptible check, MO 94-317 (FHBI 67.7%). DON values ranged from 0.04 to 6.9 compared with Truman (0.5 ppm), Bess (1.0) and the susceptible check MO 94-317 (20.0 ppm). 170 lines had DON levels less than 1.0 ppm which is significant progress over 105 lines with DON levels less than 2.0 ppm in 2011. Results from FY12 suggest that we are making significant progress selecting not only for low FHBI and FDK but also for low DON. As this data suggests, the level of resistance in the program is increasing annually which gives us 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. Progress is also being made in collaborative projects with Paul Murphy on replicated phenotyping of a Bess/Neuse population and on advancing a Bess/MO 94-317 RIL population, both of which will be used for validating Truman markers.

   Impact: 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.

Project 2: *Coordinated Evaluation of FHB Resistance of Advanced Soft Winter Wheat 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 and provide breeders with a number of location years of data each year. This multi-location testing would be cost prohibitive for most individual breeding programs. This cooperative effort also enables the exchange of information and germplasm throughout the participating breeding community. Finally, 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.**

   Accomplishment: In FY12, we entered 10 lines into either the Preliminary Northern or Northern FHB Winter Wheat Nurseries. We also phenotyped the replicated nursery for incidence, severity, FHBI, FDK and DON and provided this information to respective breeders by dissemination through the annual nursery report. For Missouri entries, all finished in the 'best group' in their respective nursery and are made available to other breeders for crossing through that nursery. Additionally, we phenotyped a nursery from DOW and the 2012 OVT from Missouri. Truman remained the most resistant variety (FHBI 2.8%) but 8 varieties had an FHBI of less than 10% while the FHBI of an additional 39 entries was less than 20%. Among the most susceptible were again, Pioneer lines XW10T, 26R20 and 26R22 with FHBI values of 43-60% compared to the susceptible check (67.7%). More lines in this nursery had higher levels of resistance and this bodes well for reducing the threat of FHB in Missouri. Most were brands and probably originated from breeding programs supported by USWBSI funds. Finally, we phenotyped the Uniform Eastern and Southern Nurseries, and the 5-State Advanced and Preliminary Nurseries sharing information with the respective breeders through routine nursery reporting mechanisms.

   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. Evaluation of official breeding nurseries gives those breeders in public institutions and private companies who participate, multi-location FHB data that will inform their selection of superior lines. Finally, 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 which should lessen the threat of FHB across the region.

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):**

   Accomplishment: During FY12 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 were collected for incidence, severity, FHBI, FDK and DON. We provided an individual head of each or the Missouri lines in the panel for genetic analyses. Analysis of the Missouri location suggested good levels of resistance in many lines.

   Impact: Once completed, this study 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 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 2012, 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. 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 5: *Male Sterile Facilitated Recurrent Selection for FHB Resistance (MPI-5).*

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

It is thought that combining genetically different sources of FHB resistance into individual cultivars may increase the level of resistance, maintain resistance over broad geographical areas, and/or enhance resistance levels under heavy epidemics in any one geographical area. The use of native sources of resistance that are in broadly adapted genetic backgrounds, should accelerate the development of FHB resistant lines that also possess the agronomic traits necessary for immediate adoption within areas where FHB is a serious problem. Because wheat is self-pollinated, combining several sources of resistance into individual cultivars is labor intensive, requiring hand emasculation and pollinations. The use of genetic male sterility should enable these genetic combinations to be produced more easily resulting in highly useful, cross-composites of several different sources of resistance. These populations can be easily recombined with locally adapted sources, thereby shifting adaptation to the target environment of the local breeding program. Subsequently these populations can be used for selection for FHB, grain yield and relevant agronomic traits and those populations may also be shared among breeders in the target region.

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: During the FY12 crop season, early and mid-season populations segregating for genetic male sterility were grown in Missouri. Each was surrounded with a composite of 7 elite Missouri lines that spanned the maturity of each male sterile population. Male sterile heads were identified, tagged, and intercrossed seed was harvested. Because of the lack of seed, screening for FHB has been postponed until several cycles of intercrossing were accomplished. Each year has resulted in more crossed seed being produced. The populations will be screened for FHB resistance in 2013/14 and where desired, a few grams of intercrossed seed will be shared with interested breeders.

Impact: This project is necessarily long term but has tremendous potential for impact by providing a mechanism to accumulate genes for FHB resistance from diverse sources in locally adapted backgrounds. These populations are simultaneously regional and local, providing both the opportunity for individual breeding programs to select genotypes with favorable local adaptation and the region-wide opportunity to recombine local selections into an improved regional pool. As a result of this project breeding programs in the eastern regions will have several pools of germplasm from which to extract breeding lines. The breeding lines extracted from these populations have the potential to have unique combinations of FHB resistance genes.

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.

MO 080104 is a soft red winter wheat, developed by the University of Missouri's Wheat Breeding Program. It was licensed in 2012 and will be available as a private brand. It is a broadly adapted, awnless variety carrying Ppd-D1a for photoperiod insensitivity. It is unique in that it has excellent yield and test weight and has Fusarium head blight (FHB) resistance for incidence, severity, Fusarium damaged kernels, and deoxynivalenol, at a level that is equal to or better than 'Truman' in a more desirable, earlier, shorter, agronomic background. Although MO 080104 is reasonably short in plant stature, it is also unusual in that it does not carry any of the common reduced height (Rht) molecular markers including Rht-B1b, Rht-D1b or Rht8. MO 080104 carries the Sbmv1 allele for resistance to soilborne mosaic virus, is moderately resistant to stripe rust, and has some tolerance to acid soils. MO 080104 carries Lr10 and Lr11 seedling rust resistance genes and postulated Lr14a, and 2a but is moderately susceptible to leaf rust in the adult plant. Although it carries no known stem rust genes and therefore is considered susceptible, it does appear moderately resistant in some field environments. Milling and baking quality of MO 080104 are both acceptable but not remarkable. It carries the 5+10 glutenin subunits at Glu-D1 and Ax2* at Glu-A1. Lactic acid is high. MO 080104 has been tested across the eastern United States in the Uniform Eastern Soft Red Winter Wheat Nursery (UESRWWN) in 2010 where it finished 2nd for grain yield (72.8 bu/a) and 3rd for test weight (59.1 lb/bu) across 21 Eastern U.S. locations. In 2011, MO 080104 was tested in the U.S. Uniform Southern Soft Red Winter Wheat Nursery where it finished 6th for grain yield (76.0 bu/acre) and 3rd for test weight (60.1 lb/bu) across 26 Southeastern U.S. locations. In 2012, it was named a check variety In the UESRWWN because of its broad adaptation, performance and excellent FHB resistance.

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.

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

McKendry, A.L. 2012. Is the Fusarium head blight resistance in Truman soft red winter wheat novel? In: S. Canty, A. Clark, A. Anderson-Scully and D. Van Sanford (Eds.), Proceedings of the 2012 National Fusarium Head Blight Forum (pp.68). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative. Abstract associated with Invited Talk

Maloney, P.V., S. Petersen, R.A. Navarro, D. Marshall, A.L. McKendry, J.M. Costa, J.P. Murphy. 2012. Comparison of visual and digital image analysis methods for estimation of

Fusarium damaged kernels in wheat. In: S. Canty, A. Clark, A. Anderson-Scully and D. Van Sanford (Eds.), Proceedings of the 2012 National Fusarium Head Blight Forum (pp.66). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.

Sneller, C.H., A. Cabrera, P. Paul, D. Van Sanford, A. Clark, A. McKendry, F. Kolb, H. Ohm, R. Freed and M.E. Sorrells. 2012. Phenotypic analysis of soft wheat populations that will be used for association analysis and genomic selection. In: S. Canty, A. Clark, A. Anderson-Scully and D. Van Sanford (Eds.), Proceedings of the 2012 National Fusarium Head Blight Forum (pp.99). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.

Van Sanford, D., F. Kolb, A. McKendry, H Ohm, C Sneller, M Sorrells, G. Brown-Guedira, J. Lewis, R, Freed and Lee Siler. 2012. Coordinated evaluation and utilization of marker-assisted selection for FHB resistance. In: S. Canty, A. Clark, A. Anderson-Scully and D. Van Sanford (Eds.), Proceedings of the 2012 National Fusarium Head Blight Forum (pp.107). 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. McKendry, D. Schmale III, A. Clark and N. McMaster. 2012. Mapping of FHB resistance in SRW wheat cultivar Jamestown. In: S. Canty, A. Clark, A. Anderson-Scully and D. Van Sanford (Eds.), Proceedings of the 2012 National Fusarium Head Blight Forum (pp.108). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.