USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY15 Final Performance Report
Due date: July 15, 2016

Cover Page

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Fiscal Year:	2015
USDA-ARS Agreement ID:	59-0206-4-025
USDA-ARS Agreement Title:	Fusarium Head Blight Research in Winter Wheat.
FY15 USDA-ARS Award Amount:	$ 91,159
Recipient Organization:	The Curators of the University of Missouri 310 Jesse Hall Columbia, MO 65211
DUNS Number:	153890272
EIN:	43-6003859
Recipient Identifying Number or Account Number:	39837
Project/Grant Reporting Period:	05/27/15-05/26/16
Reporting Period End Date:	05/26/16

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
VDHR-NWW	Accelerating the Development of Scab resistant Soft Red Winter Wheat.	$ 82,345
VDHR-NWW	Male Sterile Facilitated Recurrent Selection for FHB Resistance (MPI-5).	$ 680
VDHR-NWW	Coordinated Phenotyping of Uniform Nurseries and Official Variety Trials.	$ 8,134
	FY15 Total ARS Award Amount	**$ 91,159**

Principal Investigator Date

* MGMT – FHB Management
FST – Food Safety & Toxicology
GDER – Gene Discovery & Engineering Resistance
PBG – Pathogen Biology & Genetics
EC-HQ – Executive Committee-Headquarters
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 are the major goals and objectives of the project?**
   The focus on 'native' resistance in the Missouri program has accelerated the development Fusarium head blight (FHB) resistant varieties. Specific objectives of this project for FY15 included: (a) the continued design of crosses that combine FHB-resistant parents with native and/or exotic sources of resistance; (b) systematic screening of advanced breeding lines for all 4 types of FHB resistance and verification of resistance levels in lines with putative resistance identified in previous years of screening; (c) greenhouse and field screening of 300 F7 RILs of a mapping population developed from the cross Bess/MO 94-317 to validate Truman FHB markers as Bess is a full sib of Truman that has FHB resistance.

2. **What was accomplished under these goals?**
   1) Major activities: A crossing block was conducted and approximately 400 single, 3-way or 4-way crosses were made with FHB resistant parents that had been previously screened in greenhouse and field inoculated nurseries. All lines were evaluated for incidence, severity, Fusarium damaged kernels, and DON content. For screening in the field environment, lines were sprayed in an over-head mist irrigated, inoculated nursery at heading (by heading date of each individual line) with inoculum concentrated to 70,000 spores per mL of a macroconidial suspension of *Fusarium graminearum*, previously tested for agressivity on Missouri resistant breeding lines. Lines were then rated at 18 days post inoculation for incidence and severity and resistant lines were hand-harvested, threshed and hand-cleaned for FDK determination. Seed was then sent to the University of Minnesota for DON determination. In the greenhouse environment, lines were point-inoculated at first anthesis in a single, central, basal floret with 10 µL of a macroconidial suspension of *Fusarium graminearum*, concentrated to 50,000 spores per mL. Following inoculation, plants were removed from the greenhouse bench, misted for 72 hours and returned to the greenhouse bench where they remained until they were rated at 21-days post inoculation. Disease severity was then determined as the percentage of the inoculated head showing disease symptoms.

   2) Specific objectives: As an ongoing breeding project, the objectives and goals listed in section (one) above reflect a continued annual effort to design crosses that will enhance FHB resistance in soft red winter wheat; screen, in both the greenhouse and field FHB nursery environments, all advanced breeding lines in the Missouri breeding program for FHB resistance and eliminate from the breeding stream, those lines that do not meet a minimal threshold of 15% FHB severity; and phenotype for the second time, 300 recombinant lines of a Bess/MO 94-317 mapping population which will be used to validate Truman (a full sib of Bess) markers for FHB resistance.

   3) Significant results: Results continue to be encouraging. We are accumulating FHB resistance in most of our advanced lines and in our germplasm in general.

   Result 1: In FY15 we made approximately 400 different crosses in our breeding program. Approximately 96% of the crosses made were designed to enhance FHB resistance in the resulting populations. All contained at least one source of resistance in the parents while

approximately 80% contained two or more sources of resistance. All contained at least one native source of resistance while about 40% contained combined native sources with other sources including those from China, S. Korea, Brazil, Argentina, Romania, Hungary and CIMMYT.

Result 2: Our most advanced yield trial consisted of 81 entries selected not only for FHB resistance (FY14) but also for resistance to other diseases and more importantly, for yield and test weight. In this test, the average FHB index (incidence x severity) was 10% and only 7 lines (ranging from 11.1 to 24.3% FHBI) were more susceptible than the mean. Only 2 lines (16.0% and 24.3%) were above the 15% threshold for elimination from the breeding stream. These data validated those of FY14.

Result 3: 436 breeding lines, selected for agronomic performance (yield, test weight, height, maturity, disease resistances other than FHB and grain quality) were evaluated for FHB resistance for the first time in both the field and greenhouse FHB nurseries. The FHB index in these lines ranged from 0.2% to 54.2%. Of these 436 lines, 39 (9%) lines had an index greater than 15%. In other words, 91% of our lines that were advanced from preliminary yield trials to advanced yield testing had acceptable to high levels of resistance to FHB. This speaks to the high level of FHB resistance in our program and validates our objectives in the crossing program.

Result 4: One of the sources of native resistance we have been working with is that in the Missouri line MO 080104 which serves as a performance check in the Uniform Eastern Soft Red Winter Wheat Nursery. We have a number of lines in our program that have this as a parent and these lines are currently in their first year of advanced yield testing. One specific yield test (AYT6) had 100 lines with this line in the pedigree. The mean FHB index for the test was 4.8% and ranged from 0.1% - 16.5%. Only one line exceeded the threshold (15%) for acceptable FHB resistance which indicates that the resistance in MO 080104, which differs from that in Truman, is very highly penetrant and appears to have a reduced level of genetic background epistatic interaction that we see with many other sources of resistance.

Result 5: Low DON in our lines is a major objective of my program. In a year in which DON levels in farmer's fields ranged from 27-30 ppm due to natural infection, DON levels in 251 lines that were selected for low FHBI ranged from 0.64 to 10.9 ppm and averaged 3.8 ppm – the lowest we have had and lower than averages for the Northern (7.96 ppm) and Preliminary Northern (6.08) Scab Nurseries, respectively for the MU location.

4) Key outcomes or other achievements: We are achieving increasingly (over years) a higher proportion of resistant lines in our program and higher levels of resistance in those lines. In addition, DON levels in selected lines were at an all-time low. Levels in 251 selected lines averaged 3.8 ppm which is a record low for my program. In FY15, we licensed MO 110799 and MO 121317 for eastern soft red winter wheat seed production and sold a highly resistant grazing wheat (MO 100647). Along with MO 080104, MO 110799 and MO 121317 carry FBH resistance and will have the potential to be grown throughout the soft red winter wheat production region, thereby lessening the risk of losses associated with FHB.

3. What opportunities for training and professional development has the project provided?

No graduate students were directly funded on this grant. However, 2 MS students who were otherwise funded, participated in both greenhouse and field screening for FHB incidence,

severity, Fusarium damaged kernels, and the ISK (incidence, severity, kernel) index. They also learned of how DON evaluations were conducted at the University of Minnesota. Finally, they participated in selections for which FHB was a major selection criterion. One of these students (who has not yet graduated) is now working on screening these among other disease resistance traits at Monsanto. In addition, this project provided direct experience in FHB resistance screening and breeding for 5 undergraduate students in our Breeding, Biology, and Biotechnology emphasis are within the Division of Plant Sciences.

4. How have the results been disseminated to communities of interest?

All advanced lines screened in our breeding program will be candidates for inclusion in the Uniform Northern and Preliminary Northern Scab Nurseries. We have a combined 10 slots in these nurseries and upon entry and evaluation they are available as germplasm sources for any interested breeder. This is valuable germplasm in that it has been evaluated not only for FHB but also for agronomic performance prior to entry into these tests and therefore should accelerate the development of FHB resistant germplasm in other programs. The best lines will be entered into the 5-State Nurseries and the Uniform Eastern Nursery, where again, they are available upon request for interested breeders to include them in their crossing programs.

Project 2: *Male Sterile Facilitated Recurrent Selection for FHB Resistance (MPI-5).*

1. **What are the major goals and objectives of the project?**
   Each breeding program, including that in Missouri, has planted the male sterile facilitated recurrent selection (MSFRS) populations for several generations to facilitate the accumulation of native sources of resistance into local germplasm while maintaining the diversity within populations to enable selection for high levels of Fusarium head blight (FHB) resistance in locally adapted backgrounds with unique combinations of FHB resistance alleles.

2. **What was accomplished under these goals?**
   1) Major activities: The major objective of this project is to accumulate FHB resistance genes from a variety of native sources in an effort to enhance the resistance levels in soft red winter wheat. In FY14 we bulk harvested seed after 5 cycles of crossing with the MSFRS population. Each season we selected 7 or 8 of our best FHB resistant lines that were consistent with the maturity of the population. In FY15 we grew the bulk population (a 4-row, 200-ft strip) for line derivation.

   2) Specific objectives: Specific objective in FY15 was to begin the process of deriving lines from this mid-season population with enhanced FHB resistance.

   3) Significant results: The entire bulk was inoculated twice to provide disease pressure, and we visually noted good levels of resistance in the population. The population was not rated as it was segregating. It was harvested and sieved to remove Fusarium damaged kernels in an effort to mass select for kernel quality, with the assumption that these kernels were generated on resistant plants.

   4) Key outcomes or other achievements: This project has been long term. We will repeat procedures from FY15 in FY16 and derive lines that have high levels of resistance. These will be grown in head rows in FY17 and seed shared with interested breeders.

3. **What opportunities for training and professional development has the project provided?**

   No graduate students were directly funded on this grant. However, 2 MS students who were otherwise funded, participated in experimental design associated with this project, in selecting locally adapted FHB resistance lines for intercrossing with the MSFRS populations and in tagging male sterile plants that they ultimately harvested for crossed seed.

4. **How have the results been disseminated to communities of interest?**
   No seed has been disseminated to date as the project is ongoing and not yet completed, but once lines have been derived, evaluated and seed increased, seed will be shared for crossing or direct line development with interested breeders.

Project 3: *Coordinated Phenotyping of Uniform Nurseries and Official Variety Trials.*

1. **What are the major goals and objectives of the project?**
   Strong Fusarium head blight (FHB) resistance must be combined with high-yield to impact the Eastern US wheat industry. Regional uniform testing has stood the test of time as one of the best ways to evaluate and distribute new germplasm and to identify other agronomically desirable traits such as yield and test weight required for profitable wheat production within the target environments of individual breeding programs. The goal of the Missouri breeding program was to collaborate across the northern and southern FHB regions in screening the Uniform Northern, Preliminary Northern, and Southern FHB nurseries for incidence, severity, Fusarium damaged kernels and DON content of harvested grain. In addition, the Missouri breeding program screened the 5-State Nurseries (both advanced and preliminary), the Uniform Eastern Soft Red Winter Wheat Nursery, and the Official Variety Trial conducted by MU extension for these four types of resistance.

2. **What was accomplished under these goals?**
   1) Major activities: At MU, we screened several collaborative nurseries including: the Uniform Northern and Preliminary Northern FHB Nursery, the Southern FHB Nursery, the Advanced and Preliminary 5-State Performance Nurseries, the Uniform Eastern Soft Red Winter Wheat Nursery, and the Missouri Official Variety Trial of commercial varieties.

   2) Specific objectives: Provide greenhouse and field data for FHB resistance to breeders, and others entering lines into these nurseries, and to growers. Data included those for incidence, severity, the Fusarium head blight index (FHBI = incidence * severity), Fusarium damaged kernels (FDK), ISK (= 0.03 INC + 0.03 SEV = 0.04 FDK), and DON.

   3) Significant results:
   Result 1: The range of MU data for FHBI for the Northern Scab Nursery ranged from .07 to 58.3% and averaged 15.3% while DON values averaged 7.96 ppm. The Preliminary Northern Scab nursery had a similar FHBI range (1.3 – 57.1%) while the mean DON content of lines was somewhat better, averaging 6.08 ppm. This suggests some improvement in this important component across the northern region.
   Result 2: Data from the Southern Scab Nursery ranged from 1.3 to 60.3% disease (FHBI) and averaged 16.7%. Mean DON data for this nursery ranged from 0.8 – 17.2 ppm and averaged 6.9 ppm. These data suggest significant improvement in scab resistance in southern lines compared to past years.
   Result 3: Improvement in FHB resistance is apparent in the Uniform Eastern Soft Red Winter Wheat Nursery where DON values from our inoculated nursery ranged from 0.63 to 8.5 ppm and disease symptoms assessed as the FHBI ranged from 3.6 to 35.9% and averaged 13.5%.
   Result 4: MU data from the OVT suggests that these lines are making it into the marketplace. Growers in Missouri use the Official Variety Trials as the primary source of information for variety selection. Varieties in the OVT ranged in FHBI from 0.28-67.5% disease, but averaged 15.10% - which was a lower mean for the 116 entries than occurred in FY14 (25.1%)

4) Key outcomes or other achievements: The trend in these data from the various scab and breeding nurseries suggests that significant improvement is being made in breeders' lines throughout the soft red winter wheat region for both disease and DON levels in inoculated nurseries. Those lines are being entered into performance nurseries and are being released or licensed as evidenced by lower disease levels among entries in variety trials in Missouri. This should lessen the impact of FHB for wheat growers in Missouri and beyond.

3. What opportunities for training and professional development has the project provided?

No graduate students were directly funded on this grant. However, 2 MS students who were otherwise funded, participated in both greenhouse and field screening of cooperative nurseries and program advanced yield trials (AYTs) for FHB incidence, severity, Fusarium damaged kernels, and the ISK (incidence, severity, kernel) index. They also learned of how DON evaluations were conducted at the University of Minnesota. Finally, they participated in selections for which FHB was a major selection factor. One of these students is now working on screening these among other disease resistance traits at Monsanto. In addition, this project provided direct experience in FHB resistance screening and breeding for 5 undergraduate students in our Breeding, Biology, and Biotechnology emphasis are within the Division of Plant Sciences.

4. How have the results been disseminated to communities of interest?

Results of all cooperative nurseries have been delivered to the coordinators of those nurseries and subsequently provided to all breeders entering lines. OVT results have been delivered to coordinators of the Missouri OVT and been made available to growers through field days or through publications resulting from this nursery.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY15 award period. The term "support" below includes any level of benefit to the student, ranging from full stipend plus tuition to the situation where the student's stipend was paid from other funds, but who learned how to rate scab in a misted nursery paid for by the USWBSI, and anything in between.

1. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their MS degree during the FY15 award period?**
   NO
   If yes, how many?

2. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY15 award period?**
   NO
   If yes, how many?

3. **Have any post docs who worked for you during the FY15 award period and were supported by funding from your USWBSI grant taken faculty positions with universities?**
   NO
   If yes, how many?

4. **Have any post docs who worked for you during the FY15 award period and were supported by funding from your USWBSI grant gone on to take positions with private ag-related companies or federal agencies?**
   NO
   If yes, how many?

Release of Germplasm/Cultivars

Instructions: In the table below, list all germplasm and/or cultivars released with full or partial support through the USWBSI during the FY15 award period. All columns must be completed for each listed germplasm/cultivar. Use the key below the table for Grain Class abbreviations. *Leave blank if you have nothing to report or if your grant did NOT include any VDHR-related projects.*

Name of Germplasm/Cultivar	**Grain Class**	**FHB Resistance** (S, MS, MR, R, where R represents your most resistant check)	**FHB Rating** (0-9)	**Year Released**
MO 121317 (licensed)	SRW	MR/MS	4	2015
MO 110799 (licensed)	SRW	MR/R	2	2015
MO 100647 (sold)	Grazing; SWR	MR/R	2	2015

Add rows if needed.

NOTE: List the associated release notice or publication under the appropriate sub-section in the 'Publications' section of the FPR.

Abbreviations for Grain Classes

Barley - BAR
Durum - DUR
Hard Red Winter - HRW
Hard White Winter - HWW
Hard Red Spring - HRS
Soft Red Winter - SRW
Soft White Winter - SWW

Publications, Conference Papers, and Presentations

Refer to the FY15-FPR_Instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY15 grant. If you did not have any publications or presentations, state 'Nothing to Report' directly above the Journal publications section.

Journal publications.

Islam, Md. S., G. Brown-Guedira, H. Ohm, D. Van Sanford, A.L. McKendry. 2015. Novel QTL Associated with the Fusarium Head Blight Resistance in Truman Soft Red Winter Wheat. Euphytica DOI 10.107/s10681-015-1550-9.
Status: Published
Acknowledgement of Federal Support: Yes

Books or other non-periodical, one-time publications.

n/a

Other publications, conference papers and presentations.

Cabrera, A., J. Isidro, E. Olson, B. Brisco, F. Kolb, E Brucker, A. Krill, M.P. Arruda, M. Sorrells, D. Van Sanford, A. Clark, A. McKendry, C. Sneller. 2015. "Utilizing Genomic Selection to Accelerate the Pace of Developing Resistant Varieties." In: S. Canty, A. Clark, S. Vukasovich, and D. Van Sanford (Eds.) *Proceedings of the 2015 National Fusarium Head Blight Forum* (pp. 80). East Lansing, MI/Lexington, KY: U.S. Wheat and Barley Scab Initiative.
Status: Talk presented with associated published Abstract
Acknowledgement of Federal Support: No

Anne L. McKendry. 2015. UM16C_10_29_13 Invention Disclosure MO 121317 Soft Red Winter Wheat (2015).
Status: Completed
Acknowledgement of Federal Support: Yes

Anne L. McKendry. 2015. UM16C_10_29_13 Invention Disclosure MO 110799 Soft Red Winter Wheat.
Status: Completed
Acknowledgement of Federal Support: Yes