

**USDA-ARS/  
U.S. Wheat and Barley Scab Initiative  
FY14 Final Performance Report  
July 15, 2015**

**Cover Page**

<b>PI:</b>	Anne McKendry
<b>Institution:</b>	University of Missouri
<b>Address:</b>	Department of Plant Sciences 106 Curtis Hall Columbia, MO 65211
<b>E-mail:</b>	mckendrya@missouri.edu
<b>Phone:</b>	573-882-7708
<b>Fax:</b>	573-884-7850
<b>Fiscal Year:</b>	FY14
<b>USDA-ARS Agreement ID:</b>	59-0206-4-025
<b>USDA-ARS Agreement Title:</b>	Fusarium Head Blight Research in Winter Wheat.
<b>FY14 USDA-ARS Award Amount:</b>	\$ 91,248

**USWBSI Individual Project(s)**

<b>USWBSI Research Category*</b>	<b>Project Title</b>	<b>ARS Award Amount</b>
VDHR-NWW	Accelerating the Development of Scab resistant Soft Red Winter Wheat.	\$ 82,425
VDHR-NWW	Male Sterile Facilitated Recurrent Selection for FHB Resistance (MPI-5).	\$ 681
VDHR-NWW	Coordinated Phenotyping of Uniform Nurseries and Official Variety Trials.	\$ 8,142
	<b>FY14 Total ARS Award Amount</b>	<b>\$ 91,248</b>

Anne L. McKendry  
Principal Investigator

07/14/15  
Date

\* MGMT – FHB Management  
FSTU – Food Safety, Toxicology, & Utilization of Mycotoxin-contaminated Grain  
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  
WES-CP – Western 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?**

This ongoing project has focused largely on the exploiting the broadly based, effective, genetically different, native sources of Fusarium head blight resistance identified in Missouri wheat germplasm, particularly in Truman (and sibs), Ernie, and the MO 030291 family of lines (including MO 080104). This approach has proven effective in accelerating the development and release of FHB resistant cultivars for the soft red winter wheat region. Recent releases are moderately resistant to FHB coupled with better agronomic performance than Truman. We have, however, also used native resistances from Illinois, Purdue and Ohio as well as exotic sources from CIMMYT (Catbird), Brazil, Argentina, Japan, Asia and Europe (primarily: released cultivars from Romania, Hungary, and Italy and landraces from the former Yugoslavia). In FY14 and FY15, many of the breeding lines being evaluated have these more exotic sources combined with native sources in 3- and 4-way crosses. Our overarching goals in this project continue to be the improvement of FHB resistance, particularly DON levels, in agronomic backgrounds that are earlier, shorter, higher yielding, and with better end-use quality than the Truman background. In FY14 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) began initial FHB screening (greenhouse and field) of a Bess/MO 940317 RIL set for validation of Truman markers. Germplasm is shared with interested breeders through the FHB nursery system.

**2. List the most important accomplishments and their impact (i.e. how are they being used) to minimize the threat of Fusarium Head Blight or to reduce mycotoxins. Complete both sections; repeat sections for each major accomplishment:**

**Accomplishment:** Licensed MO 100172. MO 100172 has FHB resistance that is intermediate between Truman and Bess. In addition to its very good levels of FHB resistance, MO 100172 was licensed because it maintains this level of resistance in a high yield, high test weight, very early (1 day earlier than Ernie), widely adapted genetic background.

**Impact:** As a very early wheat, MO 100172 should be in high demand for double cropping areas within the soft red winter wheat production region. It is widely adapted, and is a day earlier than Ernie while yielding about 30% more than Ernie. It has frequently finished in the top yield group of cooperative tests in which it was included. The FHB resistance in MO 100172 is intermediate between Truman and Bess and therefore should have an immediate impact on FHB levels in areas in which it is grown. It was licensed rather than released as a public variety so that it could be grown over a wider geographic area than would be possible if the release was handled by the Univ. of Missouri.

**Accomplishment**

FHBI resistance was verified in 288 lines from 2014 that were retained because they had good agronomic performance [yield, test weight, maturity, height, lodging, resistance to BYDV, Septoria tritici blotch and Fusarium head blight (FHBI, FDK, DON)]. Data for FHBI in these lines ranged from 3.9 to 49.1%. 113 lines had FHBI values less than 10%; 75 additional lines had an FHBI greater than 10% and less than 15%; while 47 lines had a value greater than 15% but less than 20%. Of the 288 lines re-tested, 40% had resistance levels equal to Truman while 81.6% of lines had resistance levels equal to or better than Ernie which continues to be a very functional level of resistance in the marketplace. DON values in these lines ranged from 0.46 ppm to 15.7 ppm and averaged 3.1 ppm indicating that we continue to make progress improving all components of FHB resistance in our program. In 2014/2015, we screened an additional 480 advanced lines for the first time that had been previously selected for agronomic performance. 194 lines (40.4%) had field ratings of less than 10% FHBI or equal to Truman. We are currently in the process doing FDK on these lines after which they will be sent for DON analyses. These data will inform all selections we make in the breeding program in August, 2015. Ten of the best lines will be entered into the 2015/2016 scab nurseries for multi-location evaluation and can be freely crossed by breeders wishing to use Missouri germplasm.

**Impact:** Using sources of resistance that have been discovered in U.S. wheat 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:** *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?**

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 accomplishments and their impact (i.e. how are they 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 FY14 crop season, a mid-season population segregating for genetic male sterility was grown in Missouri. It was surrounded with a composite of Missouri elite lines that spanned the maturity of the population to try to get better synchrony and as such, more crossed seed. Male sterile heads were identified, tagged, and intercrossed seed was harvested. Each year has resulted in slightly more crossed seed being produced but seed quantities are still limited. Seed on sterile plants has been harvested will be bulked in 2015/16 and sprayed twice after which, resistant heads will be tagged and harvested. The bulk population will be harvested and if there is enough seed, will be shared with others who wish to have our germplasm. Plants that are fertile were also harvested and will be used in our traditional crossing program in the greenhouse.

**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. This population is 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.

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

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

Improving resistance in newly developed germplasm is an objective that requires verification by others. 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 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 accomplishments and their impact (i.e. how are they being used) to minimize the threat of Fusarium Head Blight or to reduce mycotoxins.**

**Accomplishment:**

In FY14, we again entered 10 lines into either the Preliminary Northern or Northern FHB Winter Wheat Nurseries. We endeavored to enter only those lines with good agronomic performance and intentionally kept back lines with poorer agronomic performance so that breeders who crossed with our material would not have as much negative linkage drag. We phenotyped these replicated nurseries for incidence, severity, FHBI, FDK and DON and provided this information to respective breeders by dissemination through the annual nursery report. Once again, no Missouri entries were susceptible while many were in the best group. In addition to phenotyping cooperative yield nurseries including the Uniform Eastern, 5-State Advanced and 5-State Preliminary Soft Red Winter Wheat Nurseries, we also phenotyped the Missouri Official Variety Trial (OVT) which had 121 entries. Average FHBI for the OVT was 25.1% disease (ranging from 0.3-67.5%). Most resistant was Merschman Barbie 11 (0.3%) while the most resistant public line was Bess (2.2%). Forty-three other lines had a resistance level under 10%. Among the most susceptible lines were Medoc Valley MVI-16, Armor ARX1415, ARX 1418, Armor Havoc, Armor ARX1413, Dixie Extreme, and USG EXP 3756, which had an FHBI greater than 30%. 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.

**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.

### **Training of Next Generation Scientists**

**Instructions:** Please answer the following questions as it pertains to the FY14 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 FY14 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 FY14 award period? No**

**If yes, how many?**

- 3. Have any post docs who worked for you during the FY14 award period and were supported by funding from your USWBSI grant taken faculty positions with universities? None**

**If yes, how many?**

- 4. Have any post docs who worked for you during the FY14 award period and were supported by funding from your USWBSI grant gone on to take positions with private ag-related companies or federal agencies? None**

**If yes, how many?**

**Include below a list of all germplasm or cultivars released with full or partial support of the USWBSI during the FY14 award period. List the release notice or publication. Briefly describe the level of FHB resistance. *If not applicable because your grant did NOT include any VDHR-related projects, enter N/A below.***

MO 100172 was licensed in 2014. It is a high yielding, extremely early (1 day earlier than Ernie) soft red winter wheat line with FHB resistance that is intermediate between Truman and Bess. Although there is no release notice or publication for this line (it was a proprietary license), a technical description is appended on the next pages.

**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 FY14 grant. Please reference each item using an accepted journal format. If you need more space, continue the list on the next page.**

Maloney, P.V., Petersen, S, Navarro, R.A. Marshall, D., McKendry, A.L., Costa, J.M., and J. Paul Murphy. 2014. Digital image analysis method for estimation of Fusarium-damaged kernels in wheat. *Crop Science* 54:2077-2083.

Islam, Md. S., G. Brown-Guedira, H.Ohm, D. Van Sanford, A.L. McKendry. 2014. Novel QTL Associated with the Fusarium Head Blight Resistance in Truman Soft Red Winter Wheat. *Euphytica*. (under revision).

Cabrera, A., Kolb, F., Brucker, E.A., Krill, A., Arruda, M.P., Sorrells, M. Van Sanford, D., Clark, A., McKendry, A and C. Sneller. 2014. Phenotypic analysis of FHB resistance in a soft wheat population for genome-wide analysis. In: S. Canty, A. Clark, N. Turcott and D. Van Sanford (Eds.), *Proceedings of the 2014 National Fusarium Head Blight Forum* ( pp. 75). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.

## APPENDIX

### **MO 100172 Technical Description**

MO 100172, developed in the University of Missouri's soft red winter wheat breeding program, resulted from the 1999 cross MO 960304/MO 960815. MO 960304 has the pedigree MO 11769/'Madison'. MO 11769 was from the cross 'Kawvale'/'Vigo'// 'Directeur Journee'/3/W7510/4/'NS 314'/'Stoddard' where W7510 is a full sib of 'Hart'. MO 960815 was from the cross 'NASW 85-94'/W11769. The cross was made for several reasons. MO 960304 had good yield and test weight and excellent combining ability for Fusarium head blight (FHB) but was segregating for maturity. Two released lines including 'Truman' a full season, FHB resistant cultivar and 'Bess', an early maturing, FHB resistant cultivar were both selected from MO 960304. Both Bess and Truman are widely grown in Missouri and surrounding states and both also serve as check varieties for yield and FHB resistance in several regional cooperative breeding nurseries. Several germplasm lines were also selected from this parent some of which (including MO 980725 which is early maturing and MO 980829 which is full season) have been used as parents in the Missouri breeding program and other soft red winter wheat breeding programs regionally. MO 960815 was a high yield, good test weight parent that carried the source of FHB resistance in Truman and Bess as well as other broad-based disease resistances. The F<sub>1</sub> of the cross was grown in the 2000 field season and advanced by bulk breeding to the F<sub>5</sub> generation when head selections were made. The parental population from which MO 100172 was re-selected was tested as M0 041687, an F<sub>5</sub> derived F<sub>6</sub> line that was very early and had high yield but was variable for height. MO 100172 is an F<sub>8</sub> derived F<sub>9</sub> re-selection of MO 041687 that was first grown in head row 09HR1434 in 2009. Ninety-two re-selections were made from MO 041687 and tested in preliminary yield nurseries (PYNs) in the Missouri breeding program in 2010. MO 100172 was the highest yielding of these selections, out-yielding others by as much as 15%. It was tested for yield and other qualitative traits as entry number 72 in PYN1 in 2010. From 2011 through 2014, it was repeatedly re-tested in advanced yield trials (AYTs) in the Missouri breeding program where it was consistently a day or two earlier than Ernie, and 10-25% higher in grain yield depending on the year. Concurrently, MO 100172 was tested in 2014 in the 5-State Advanced Cooperative Nursery near Columbia, MO (Bradford Research and Extension Center, University of Missouri), West Lafayette Indiana (Purdue University), Lexington KY (University of Kentucky), Urbana Illinois (University of Illinois) and Wooster OH (The Ohio State University) where it finished 4<sup>th</sup> for grain yield over 5 test locations that had a CV% less than 10%. At all locations, it was the earliest line in the test (25 advanced entries) and 3-4 days earlier than the test average.

MO 100172 is a white-chaffed, large seeded, two gene red (RR\_rr\_RR), soft red winter wheat with yellow anthers. It is awnless with very short apical awnlets. MO 100172 is of intermediate height, approximately 12.7 cm shorter than Truman, 2.5 cm taller than 'Ernie' and approximately equal to 'Milton' in the Missouri environment. It carries *Rht-B1b* and *Rht-D1a* reduced height markers.

MO 100172 is unique in that it is very early yet has excellent yield potential. MO 100172 is approximately 1 d earlier than Ernie, 3.5 d earlier than Bess and approximately 9-10 d earlier than Truman in the Missouri environment. It is homozygous for the marker *Ppd-A1a.1* for photoperiod insensitivity and has the *vrn-A1*, *vrn-B1*, and *vrn-D1* vernalization alleles. Despite its very early heading date, MO 100172 has excellent yield potential over the northern corn-belt states, finishing in the top yield group over 17 locations of testing in MO, IL, OH, KY, IN and TN in 2014. Of the 40 entries tested, heading date for MO 100172 was equal to or earlier than all other varieties in the top yield group. As such, this variety is ideally suited to double crop environments in which there is a desire to harvest wheat and follow that harvest with soybeans. Average test weight was above average and ranked 5<sup>th</sup> of the 25 lines tested in the 2014 5State Nursery.

Results from inoculated tests for FHB which have been conducted in the inoculated MU FHB greenhouse and field indicate that the level of FHB resistance for MO 100172 is roughly equivalent to Bess. Missouri data from an over-

head mist-irrigated spray-inoculated nursery conducted in 2014 indicated that the Fusarium head blight index of MO 100172 is 13.1% while those for Truman (8.5%) and Bess (18.3%) were lower and higher, respectively. Summary data from the 2014 Northern Winter Wheat Scab Nursery also indicated that MO 100172 is moderately resistant to FHB with low scores for FHB incidence, severity and their index (incidence x severity). It carries no known FHB markers but is expected to carry some of the Truman markers as MO 960304 is the source population from which Truman was derived. Although the canopy remains relatively clean of disease, it is considered moderately susceptible to leaf, stem, and stripe rust. It carries no known markers for these diseases. In the Missouri environment, it escapes most rust infection because of its early finish. MO 100172 is also moderately susceptible to barley yellow dwarf virus.

Milling (flour yield) and baking (cookie spread) quality are equal or superior to Truman and Bess but poorer than 'Milton', the latter being one of the best milling and baking soft red winter wheat cultivars in the market. It has the 5+10 sub units for the *Glu-D1* allele, is *Ax1* or *null* for the *Glu-A1* allele and does not carry *Bx7oe* for the *Glu-B1* allele. It does not carry either the 1BL.1RS or 1AL.1RS wheat-rye translocation.