USDA-ARS
U.S. Wheat and Barley Scab Initiative
FY17 Preliminary Final Performance Report
Due date: July 31, 2018

Cover Page

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USDA-ARS Agreement ID:	59-0206-4-025
USDA-ARS Agreement Title:	Fusarium Head Blight Research in Winter Wheat.
FY17 USDA-ARS Award Amount:	$ 93,968
Recipient Organization:	The Curators of the University of Missouri 115 Buisness Loop 70 W Mizzou North, Rm 501 Columbia, MO 65211-0001
DUNS Number:	153890272
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Project/Grant Reporting Period:	5/27/17 - 5/26/18
Reporting Period End Date:	5/26/2018

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
VDHR-NWW	Accelerating the Development of Scab Resistant Soft Red Winter Wheat.	$ 84,569
VDHR-NWW	Male Sterile Facilitated Recurrent Selection for FHB Resistance.	$ 678
VDHR-NWW	Coordinated Phenotyping of Uniform Nurseries and Official Variety Trials.	$ 8,721
	FY17 Total ARS Award Amount	$ 93,968

Anne L McKendry

07/30/18

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 breeding program has accelerated the development of Fusarium head blight (FHB) resistant varieties. The specific goals of this project are to develop and release to the soft red winter wheat community, varieties of wheat that have enhanced levels of FHB resistance and to accelerate this process by building on sources of FHB resistance that are native to US soft red winter wheat. The ultimate goal is to combine these sources of resistance with other more exotic resistance to both increase resistance levels in our varieties and make them more durable under heavy disease pressure. The main thrust of our effort is combine Missouri sources that differ by pedigree with resistant sources from other northern breeding programs. We then further combine these native resistances with sources from CIMMYT, Brazil, Japan, China and Europe (primarily Romania). This project in FY17 had 3 specific objectives: (1) the continued design of crosses that combine FHB-resistant parents with native and/or exotic sources of resistance; (2) 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; (3) Field and greenhouse screening of 300 doubled haploid lines acquired from Dr. Van Sanford, that contain FHB QTL including those on 3BS (Fhb1), 2DL, 5A that had been introgressed into adapted soft red winter wheat backgrounds. Backgrounds include lines from Kentucky, Syngenta and Virginia.

2. **What was accomplished under these goals?** *Address items 1-3) below for each goal or objective.*

   <u>Objective 1</u> "*the continued design of crosses that combine FHB-resistant parents with native and/or exotic sources of resistance*"

   1) <u>Major activities</u>: A crossing block was conducted and approximately 350 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 crosses were designed to enhance FHB resistance in the resulting populations by selecting parents with FHB resistance levels that had an FHB index less than 15%, coupled with low DON and Fusarium damaged kernels. To accelerate the development of FHB resistant cultivars, parental choice was also informed by good yield and test weight, soft red winter wheat quality, resistance to stripe rust, leaf rust, soilborne mosaic virus resistance, maturity and height. We have used this approach for many years and outcomes from advanced yield testing that are listed below reflect results of this approach.

   2) <u>Significant results</u>: All crosses contained at least one source of native resistance. Of these, 95% contained 2 sources of native resistance that differed based on pedigree for the genetic source. Where exotic material was included in the cross (25% of crosses), 3 or 4-way crosses were made with one exotic source combined with 2 or 3 native US sources. Achievements are described in objective 2.

3) Key outcomes or other achievements: - Beyond actually making the crosses, outcomes and achievements are necessarily long term. We have had this objective for many years and the outcomes and achievements are described below under objective 2.

Objective 2: ***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***

1) Major activities: In the Missouri program, lines in head row (generally 20,000 to 30,000 annually) are selected based on agronomic traits. Where there is natural infection of FHB, susceptible lines are eliminated from the breeding stream prior to initial yield testing. The first inoculated FHB screen occurs after preliminary yield trials (single plot testing) on lines that have been selected for grain yield, test weight, height, maturity, and prevalent diseases in the year of testing. In 2016/17, 28,000 head rows were evaluated and 2500 were entered into 2017/18 preliminary yield testing where agronomic traits including yield, and test weight were evaluated. Although all data are still being analyzed, approximately 500 new lines will be selected for continued testing based on the traits listed above. These will be evaluated for the first time in the FHB nursery during the 2018/19. Three hundred advanced breeding lines were evaluated in the 2017/18 FHB nursery. 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. During the winter of 2017/2018, all lines evaluated in the field, were also evaluated in the greenhouse for severity using point-inoculation. Inoculation was at first anthesis in a single basal floret of a central spikelet. Spore concentration was 50,000 spores per mL with subsequent protocols developed and used over the past 15 years at Missouri.

2) Significant results: To date all data except FDK and DON have been taken and include incidence, severity, field FHBI and greenhouse severity. Checks included Truman, Ernie, MO 080104 and MO 94-317 which is our susceptible check. Greenhouse data suggested that these lines continue to have good FHB resistance.

- All advanced yield trial lines (100 lines) were validated in the greenhouse (GH) and field. GH data were very good with severity data ranging from 5.6% to 29.3%.
- 95 lines were better than Ernie (20% severity) and 27 lines were better than Truman (8.63% severity).
- For 200 lines screened for the first time, 53 lines were better than Truman (8% severity) while 192 lines were better than Ernie (20% severity).
- Field data on these lines are complete except for FDK and DON and look equally good, however at the time of this preliminary report, data have not yet been completely analyzed and thus are not presented in this report.
- With the writing of the 2016 report for the 2016/17 field season in July of 2017, data for DON were not available. We received data back in December of 2016. 302 selected lines were sent off for DON analyses, and data were low, ranging from 0.05ppm to 0.89 ppm. Data for the resistant checks were also low ranging from 0.06ppm (Truman) to

0.45 ppm (Ernie) and 0.53ppm (MO 080104). These lines were re-screened in FY17 and will be analyzed again for DON 2017/18 to ensure accuracy of the data.

3) Key outcomes or other achievements: -

- Ten lines were entered into the 2017 Northern (4 lines) and Preliminary Northern (6 lines) FHB nurseries. 9 of 10 lines were low for all traits evaluated including FDK and DON. Validation by other programs and our own scab nurseries continue to show that our objectives for developing lines for release with enhanced FHB resistance are being met. By entry into these nurseries we disseminated the best of these lines to other interested breeders who will be free to cross with this material if they wish.
- Our progress in this overall objective is evidenced by the licensing of MO 080104 (2012-13), MO 100172 (2014), MO 110799 and MO 121317 (2015) and a grazing wheat MO 100647 (2015) that range in FHBI from 7-9% for MO 080104 to 11-13% for MO 100172, 110799 and 100647 to a high of 20.3% for MO 121317. Four of the five lines released had DON values under 2ppm while that for MO 121317 was 4.7%. In 2016-17, MO 121058 (FHBI = 15-18%) and MO 120187 (FHBI = 14.0%) were also licensed.

Objective 3: ***To add the 3BS (Fhb1), 2DL, 5A QTL to our program from additional soft red winter wheat backgrounds.***

1) Major activities: To add further genetic diversity to our program we acquired 300 doubled haploid lines from Dr. Van Sanford, that contained FHB QTL including those on 3BS (Fhb1), 2DL, and 5A that had been introgressed into adapted soft red winter wheat backgrounds which differed from the genetic backgrounds currently in my program. Backgrounds include lines from Kentucky, Syngenta and Virginia. In 2017, we increased seed of all 300 lines in the greenhouse and also grew a single 3-ft head row in the field. Field grown lines were evaluated for agronomic traits (including: height, maturity, resistance to prevalent diseases other than FHB, etc.) but were not inoculated in 2017 so that good quality seed could be generated.

2) Significant results: Of the 300 lines evaluated, there was segregation for height genes. Several were double dwarfs while others were tall. Upon harvest, we noted that the seed was shriveled in many of the lines. 90 lines that appeared to be adapted to the Missouri environment, were selected and were grown in a yield trial in 2018 against Missouri check varieties to determine yield and test weight. In the 2017/18 greenhouse, all 300 lines were evaluated for greenhouse FHB severity which ranged from 1.18 – 51.3% disease. 254 lines had a greenhouse severity less than or equal to Ernie (20%) while 100 lines had a severity less than or equal to Truman (8%). These data show high levels of resistance in most of these lines. Concurrently, all 300 lines were grown in our field nursery and inoculated for FHB using Missouri protocols. Data have been collected but analyses are not yet complete.

3) Key outcomes or other achievements: - Lines with low FHB will be used in our crossing program during the fall of 2018. Once data analyses on both the yield test and FHB field

tests are completed, data will be communicated to those sharing the lines from Dr. Van Sanford and lines showing potential will be retested and crossed into Missouri backgrounds.

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

In 2017, 4 undergraduate students completed their undergraduate internships in my breeding program, learning crossing techniques for combining adapted and unadapted sources of resistance. They learned sterile technique and how to produce FHB inoculum for FHB screening; how to inoculate in both the greenhouse and field environments; how to rate FHB in both environments; data entry and analysis. In addition, they learned about doubled haploid production in wheat and the impact it has on the rapid production of uniform lines. Finally – each student participated in all aspects of the wheat breeding program. Each of these students received academic credit for their capstone undergraduate internship through their participation in this project.

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

- Advanced lines were disseminated to other interested breeders through the Northern and Preliminary Northern FHB nurseries as well as the 5-State Nurseries. One line was advanced for consideration for licensing in our private partnership.
- Lines released/licensed over the course of this project are all in production in the soft red winter wheat region.
- Doubled haploid results have not yet been communicated as they are not complete at the generation of this report.

Project 2: *Male Sterile Facilitated Recurrent Selection for FHB Resistance.*

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?** *Address items 1-3) below for each goal or objective.*

   Specific objective: ***To evaluate FHB resistance in 500 derived lines from selections made in a population resulting from 6 cycles of dominant male sterile facilitated recurrent selection.***

   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. Each season we selected 7 or 8 of our best FHB resistant lines that were consistent with the maturity of the population. In FY16, we grew a bulk population (2 4-row, 200-strips) for line derivation. The population was inoculated twice in 2017 and at harvest, 500 heads were selected for agronomic potential and low FHB systems. Heads were individually threshed and grown as head rows in the FHB inoculated nursery in the 2017/2018 season. In FY17 head rows were inoculated and rated for FHB response. Selections were made based on FHB response following inoculation.

   2) Significant results;
   Head rows with FHB ratings less than or equal to Truman (8% FHBI) were selected and hand harvested. Sixty-five rows were selected. Each will be re-evaluated in FY18 to validate FHB ratings.

   3) Key outcomes or other achievements:
   Results of this study suggested that recurrent selection using a dominant male sterile gene resulted in lines with an FHB response that was equal to or better than Truman in one year of evaluation. Lines will be validated in 2019 and pure-lined. Once data are confirmed and lines are sufficiently pure, lines will be shared through the FHB nursery system with breeders interested in using this material in their crossing programs. Validated pure-lines will be evaluated for agronomic performance at Missouri in and following sufficient testing, will be considered for release.

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

In 2017, 4 undergraduate students completed their undergraduate internships in my breeding program. Through this project, they learned about the use of male sterility (particularly dominant male sterility) by participating in all aspects of the field work associated with this project. They also learned about the use of male sterility by participating in the use of these lines in greenhouse crossing.

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

Nothing to report. I anticipate that populations from which lines were derived will be made available to interested breeders within the USWBSI in 2019.

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 screens 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? *Address items 1-3) below for each goal or objective.*

Specific Objectives: ***to provide greenhouse and field data for FHB resistance to breeders, and others entering lines into cooperative nurseries. Data will be collected 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.***

1) Major activities In FY17 we screened 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. To date, data from all nurseries are complete for incidence, severity, and FHBI. For the first time, data were presented on a 0-9 scale. All lines have been harvested and data for FDK and ISK are currently being taken. Samples will then be sent to Minnesota for DON analyses.

2) Significant results:

- MU data for FHBI for the Northern Scab Nursery (55 entries) ranged from 1.4 to 5.6 on a 0-9 scale reflecting FHBI in 10% increments. The test average was 2.7. No lines were better than Truman (1.4) at the Missouri location but 22 lines were equal to or better than Ernie (2.3). FDK are being taken and DON data will follow.
- The Preliminary Northern Scab Nursery (47 entries) ranged from 1.1 to 7.1 on the 0-9 scale. The test average was 2.8. Again, no lines were significantly better than Truman (1.2) but 30 lines were equal to or better than Ernie (3.0). FDK are being taken and DON data will follow.
- The Southern Scab Nursery (49 entries) ranged from from 0.9-7.2 (mean of 2.9%), with 12 entries better than or equal to Bess and 17 better than or equal to Ernie, the

two resistant check varieties in this nursery. These data from MU suggest continued improvement for FHB resistance in this region.

- Cooperative breeding nurseries including the 5-State Nurseries and the Eastern Nursery were evaluated and where the best of these entries go into the marketplace they should improve resistance available to growers. Analysis of these data is currently ongoing.
- MU data from the 99 varieties in the 2018 OVT have not yet been analyzed for this preliminary report but review of raw field data suggest they lag in resistance levels compared to breeding nurseries.

3) Key outcomes or other achievements:

This is an important component of our FHB research as validation is best if conducted by other programs. Data from the preliminary and northern nurseries indicate good progress in breeding for FHB resistance with more lines each year performing at a level equal to Truman and better than the resistant check Ernie. Where lines are also agronomically good, the release of these lines to the public will lessen the impact of FHB on soft red winter wheat.

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

In 2017, 4 undergraduate students completed their undergraduate internships in my breeding program. They learned about the value of collaborative nurseries both to my program and to other programs across the region. The learned about the impact of environment on FHB. In addition, by participating in the greenhouse and field evaluation of these nurseries, they learned about all aspects of the culture, inoculation and rating of FHB in both the greenhouse and field environments.

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

Preliminary data for the Northern, Preliminary Northern and Southern Nurseries are being sent out. Other data will be sent to nursery coordinators or breeders entering the nurseries will be disseminated as soon as analyses are completed.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY17 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 FY17 award period?**

   Yes

   If yes, how many?

   One MS student who was supported by other funds but who learned FHB techniques during this grant period graduated.

2. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY17 award period?**

   No

   If yes, how many?

3. **Have any post docs who worked for you during the FY17 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 FY17 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 Post-doctoral Fellows, however one MS student (listed above) currently works for Monsanto

   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 FY17 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**
Nothing to report in 2017				

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

Instructions: Refer to the FY17-FPR_Instructions for detailed instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY17 grant. Only include citations for publications submitted or presentations given during your award period (5/27/17 - 5/26/18). If you did not have any publications or presentations, state 'Nothing to Report' directly above the Journal publications section.

NOTE: Directly below each reference/citation, you must indicate the Status (i.e. published, submitted, etc.) and whether acknowledgement of Federal support was indicated in publication/ presentation.

Journal publications.

Petersen, S., J.H. Lyerly, A.L. McKendry, M.S. Islam, G. Brown-Guedira, C. Cowger, Y. Dong, and J.P. Murphy. 2017. Validation of Fusarium Head Blight Resistance in US Winter Wheat. Crop Sci. 57:1-12.
Status: published
Acknowledgement of Federal Support: Yes

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

n/a

Other publications, conference papers and presentations.

n/a