

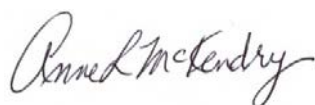
USDA-ARS
U.S. Wheat and Barley Scab Initiative
FY18 Performance Report
Due date: July 12, 2019

Cover Page

Principle Investigator (PI):	Anne McKendry
Institution:	University of Missouri
E-mail:	mckendrya@missouri.edu
Phone:	573-882-7560
Fiscal Year:	2018
USDA-ARS Agreement ID:	59-0206-8-204
USDA-ARS Agreement Title:	Fusarium Head Blight Research in Soft Red Winter Wheat
FY18 USDA-ARS Award Amount:	\$ 102,133
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:	00063970
Project/Grant Reporting Period:	5/27/18 - 5/26/19
Reporting Period End Date:	05/26/19

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
VDHR-NWW	Accelerating the Development of Scab Resistant Soft Red Winter Wheat.	\$ 91,470
VDHR-NWW	Male Sterile Facilitated Recurrent Selection for FHB Resistance.	\$ 1,163
VDHR-NWW	Coordinated Phenotyping of Uniform Nurseries and Official Variety Trials.	\$ 9,500
	FY18 Total ARS Award Amount	\$ 102,133



Principal Investigator

7/9/19

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 resistances to both increase resistance levels in our varieties and make them more durable under heavy disease pressure. The main thrust of our effort is to 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 FY18 had 4 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) introgression of FHB resistance from five of the 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, (4) Phenotyping one location of a panel of 300 lines (2 reps = 600 plots) of a hard wheat test for a graduate student of Dr. S. Baenziger, University of Nebraska.

2. What was accomplished under these goals?

1) **Objective 1:** the continued design of crosses that combine FHB-resistant parents with native and/or exotic sources of resistance

2) **Major activities:** A crossing block has been an ongoing part of this project for 20 years. Our goal annually has been to make approximately 350-450 single, 3-way or 4-way crosses with FHB resistant parents that have been previously screened in greenhouse and field inoculated nurseries in Missouri and other states within the USWBSI. 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, height, maturity and resistance to stripe rust, leaf rust, soilborne mosaic virus resistance. We have used this approach for many years and outcomes from advanced yield testing over the past 5 years of this project indicate our approach has enhanced the overall levels of FHB resistance across our program.

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3) Significant results: Over the years, as better sources of resistance were available, the number of parents with FHB resistance and the levels of that resistance have increased. Our approach has been to use single or three-way crosses only when parents contain native resistance. As the level of adaptation in parents from outside of our program decreases, the complexity of the cross increases. Where exotic material is used, a minimum of a 4-way cross is used with a minimum of three parents that are well adapted and contain native sources of resistance. Over this project, all crosses have 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.

4) Key outcomes or other achievements: - Beyond actually making the crosses, outcomes and achievements are necessarily long term. As the number of FHB resistant parents has increased, our crossing schemes have evolved as described above. The outcomes and achievements are described below under objective 2.

1) **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

2) 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 2018/19 **364 new** lines were evaluated for the first time in the FHB nursery along with **64 advanced lines** being validated from the 2018 FHB nursery. Therefore a total of 428 advanced lines were tested. 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 aggressivity on Missouri resistant breeding lines. During the winter of 2018/2019, 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.

3) Significant results:

- Advanced yield trial lines (64 lines) were validated in the greenhouse (GH) and field. 2019 data were very good with mean severity ranging from 2.5% to 29.3%.
- 43 advanced lines were better than Ernie (20% severity) and 10 lines were better than Truman (4.9% severity).
- 364 new lines were screened averaging 15.9% severity. Of these lines 127 lines were better than Truman (8.1% severity) while 270 lines were better than Ernie (18.5% severity).

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- At the time of this report, field data for FHBI, FDK and DON data are not yet available for the 2019 season.

4) Key outcomes or other achievements: -

- Ten lines were entered into the 2019 Northern (5 lines) and Preliminary Northern (5 lines) FHB nurseries. Missouri data suggests that these lines are again extremely competitive or better than most lines in these nurseries.
- Across all Missouri lines in our breeding program, severity averaged 16.8% with 137 lines better than or equal to Truman and 313 lines better than or equal to Ernie
- These are among the best FHB data we've had across the entire breeding program.
- Our new line, MO 151062 (B980582/Brazil8) continues to have Truman level resistance and where justified by performance in the Eastern Nursery, will be released.

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

2) 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 included 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 so that good quality seed could be generated. In 2018, we grew a small yield test of 90 of the best of the 300 lines that appeared to be adapted to Missouri and evaluated all 300 lines in our FHB nursery.

3) 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. All 300 lines were evaluated for greenhouse FHB severity which ranged from 1.18 – 51.3% disease. FDK from the field data averaged 23%. 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%). Although yield trials didn't indicate that any lines performed better than our check varieties, five diverse lines were identified for crossing to Introgress the FHB resistance into Missouri backgrounds.

4) Key outcomes or other achievements: - Five lines with low FHB were entered into our 2018/2019 crossing nursery.

1) **Objective 4:** Phenotyping one location of a panel of 300 lines (2 reps = 600 plots) of a hard wheat test for a graduate student of Dr. S. Baenziger, University of Nebraska.

2) Major activities: We have screened 300 lines (600 plots; 2-rep randomized complete block design with multiple replications of 5 checks within each block) in the field nursery. Data collected to date include incidence, severity and the Fusarium head blight

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index. All plots will be harvested and the percentage of Fusarium damaged kernels will be estimated and seed will be sent off for DON analysis.

- 3) Significant results: Data are currently being entered but have not yet been analyzed.
- 4) Key outcomes or other achievements: This is a graduate student project for a student at the University of Nebraska. There will be no other outcomes for my project. It does represent key collaboration between the hard and soft research groups and should lead to wider use of FHB resistant germplasm across the two regions.

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

In 2018/2019, one undergraduate student (Asa McCurdy) is working on his undergraduate internship in my breeding program, learning crossing techniques for combining adapted and unadapted sources of resistance. He has 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. He is also in charge of the Baenziger project, inoculating, rating, entering data, collecting weather information, and assisting with report writing. Finally – he is participating in all aspects of the wheat breeding program. Asa will learn about the rigors of doing research and will gain academic credit for his capstone undergraduate internship experience through his participation in this project.

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

- Advanced lines will be disseminated to other interested breeders through the Northern and Preliminary Northern FHB nurseries as well as the 6-State Nurseries.
- One line currently in the Eastern Soft Red Winter Wheat Nursery [MO 151062 (B980582/Brazil8)] which has very good (Truman level) FHB resistance coupled with yield, test weight and a good agronomic package is being advanced in Missouri for consideration for licensing. Based on Eastern data from 2019, a decision will be made as to whether this line will also be released more broadly across the eastern soft red winter wheat region.

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?

- 1) Major activities: In 2018/2019 we are validating FHB resistance in 65 lines from our location of this project and 80 lines acquired from Fred Kolb's location of the project. Selections will be made in both sets of lines based on agronomic potential and FHB resistance evaluated as incidence, severity, FDK and DON levels.
- 2) Specific objective: To evaluate FHB resistance in 65 lines selected in the 2017/2018 field season from preliminary screening of 500 lines selected from a population derived from 6 cycles of dominant male sterile facilitated recurrent selection.
- 3) Significant results: the 2019 crop season was very wet and soil saturation had a significant impact on performance. In addition, significant winter kill impacted the rows. Although data are not yet analyzed, and lines are not yet harvested, I anticipate approximately 20% of these lines will be harvested and re-evaluated in the 2020 crop year.
- 4) Key outcomes or other achievements: Results of this study suggest that recurrent selection using a dominant male sterile gene could result in lines with improved FHB resistance. Lines that have good validated levels of resistance and good agronomic performance will be pure-lined and where appropriate, made available to participating breeders.

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

As indicated above, one undergraduate student is doing an undergraduate capstone internship in my breeding program. Through this project, he had hands-on experience with the use of male sterility (particularly dominant male sterility) by participating in all aspects of the field work associated with this project.

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

Results have not yet been disseminated as this is a long term project. I anticipate that populations from which lines were derived or the lines themselves as seed levels permit, will be made available to 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 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?

- 1) Major activities: In 2018/2019 we screened, in both greenhouse and field nurseries, collaborative nurseries including: the Uniform Northern and Preliminary Northern FHB Nursery, the Southern FHB Nursery, the Advanced and Preliminary 6-State Performance Nurseries, the Uniform Eastern Soft Red Winter Wheat Nursery, and the Missouri Official Variety Trial of commercial varieties. Following harvest, data for FDK and ISK will be taken and seed samples will then be sent to Minnesota for DON analyses.
- 2) Specific Objective: 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 ($FHBI = \text{incidence} * \text{severity}$), Fusarium damaged kernels (FDK), $ISK (= 0.03 \text{ INC} + 0.03 \text{ SEV} = 0.04 \text{ FDK})$, and DON.
- 3) Significant Results: Preliminary Missouri data suggests that progress continues to be made in enhancing FHB resistance in soft wheat.
 - MU severity data for the Northern Scab Nursery (58 entries) ranged from 4.8 to 63.5%, averaging 23% infection. Seven lines had Truman level resistance (7.8%). For the Preliminary Northern Scab Nursery (46 entries), severity ranged from 5.7% to 85.1% and averaged 26%. 4 lines had Truman level resistance and 22 lines had resistance better than Ernie (18.6%).
 - Lines in the Southern Scab Nursery (50 entries) still lag a bit but FHB resistance is improving. Data ranged from 4.3 to 93.1% with 5 lines being better than Bess (7.3%; the resistant check) while 20 lines were better than Ernie (17.7%).
 - Data from the 6-State Nurseries and the Uniform Eastern Soft Red Winter Wheat Nursery (all of which are performance nurseries) have also improved with severity from the 6-State Advanced Nursery averaging 33.4% and from the 6-State

Preliminary Nursery averaging 28.1% . Severity in the Eastern nursery averaged 32.3%.

- The Missouri Official Variety Trial still lags but the average severity in the nursery continues to improve. 103 entries were evaluated in the 2019 field nursery. Data ranged from 2.8% to 98% severity but averaged 35.4% so this is an improvement. Many of the best entries in this nursery continue to be those either licensed from Missouri or experimental lines from Missouri, however, KWS, Pioneer, Dyna-Grow, AgriMaxx, Armor and Dixie have resistant lines in the 2019 OVT.
- 4) 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 continued 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 but more work is required to make these lines broadly available to growers and to develop lines that contain both good FHB resistance and yield. Fusarium severity in the OVT, which contains lines that are available for growers to produce, has improved over the years but we still need to work harder to educate growers about the need to look beyond yield to FHB resistance, particularly FHB resistance that has been evaluated in more than one year.

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

As indicated above, one undergraduate student is doing an undergraduate capstone internship in my breeding program. Through this project, he has had hands-on experience learning about the role of cooperative nurseries and evaluating lines within each nursery for their FHB resistance.

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

Data from all cooperative nurseries will be returned to nursery coordinators once the season is complete. Missouri OVT data combined for those entries tested in 2018 and 2019 will be reported to wheat growers at annual meetings. We began this approach in 2018 and it worked well, was well received, and drew their attention to these data as a selection tool in their choice of varieties for production.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY18 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 FY18 award period?**

None during this period. Since I am retiring, I haven’t taken graduate students for the past 3 years

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 FY18 award period?**

None during this period.

If yes, how many?

- 3. Have any post docs who worked for you during the FY18 award period and were supported by funding from your USWBSI grant taken faculty positions with universities?**

None during this period.

If yes, how many?

- 4. Have any post docs who worked for you during the FY18 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 during this period.

If yes, how many?

Undergraduate Training: 1 undergraduate student in the breeding emphasis area was supported by funding during this period for his undergraduate, capstone experience. He 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, he learned about the use of dominant genetic male sterility as a pollination control system in wheat. Finally, he participated in all aspects of the wheat breeding program. He will receive academic credit for his capstone undergraduate internship through their participation in this project.

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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 FY18 award period. All columns must be completed for each listed germplasm/cultivar. Use the key below the table for Grain Class abbreviations.

NOTE: 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 151062 (B980582/Brazil8) – being increased	SRW	R	5.3%	Not yet

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

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Publications, Conference Papers, and Presentations

Instructions: Refer to the FY18-FPR_Instructions for detailed instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY18 grant. Only include citations for publications submitted or presentations given during your award period (5/27/18 - 5/26/19). 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. See example below for a poster presentation with an abstract:

Conley, E.J., and J.A. Anderson. 2018. Accuracy of Genome-Wide Prediction for Fusarium Head Blight Associated Traits in a Spring Wheat Breeding Program. In: Proceedings of the XXIV International Plant & Animal Genome Conference, San Diego, CA.

Status: Abstract Published and Poster Presented

Acknowledgement of Federal Support: YES (poster), NO (abstract)

Journal publications.

None during this period

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

None during this period

Other publications, conference papers and presentations.

Presentation: McKendry, A.L. 2018. FHB Resistance Breeding in Missouri; Presentation to Wheat Growers in Missouri; Marriott Hotel, Columbia MO, August 16, 2018.

Status: Presented.

Acknowledgement of Federal Support: YES