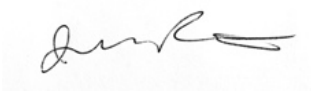
USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY19 Final Performance Progress Report
Due date: August 31, 2021

Cover Page

Principle Investigator (PI):	Jessica Rutkoski
Institution:	University of Illinois
E-mail:	jrut@illinois.edu
Phone:	217-300-6970
Fiscal Year:	2019
USDA-ARS Agreement ID:	59-0206-8-205
USDA-ARS Agreement Title:	Scab Research Projects and Development of Scab Resistant Soft Red Winter Wheat Varieties at the University of Illinois
FY19 USDA-ARS Award Amount:	$ 126,267
Recipient Organization:	The Board of Trustees of the University of Illinois Grants & Contracts Office 1901 S. First Street, Suite A Champaign, IL 61820
DUNS Number:	41544081
EIN:	37-6000511
Recipient Identifying Number or Account Number:	AF392
Project/Grant Reporting Period:	6/8/19 - 6/7/21
Reporting Period End Date:	6/7/2021

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
VDHR-NWW	Development of Scab Resistant Soft Red Winter Wheat Varieties	$ 108,027
VDHR-NWW	Male Sterile Facilitated Recurrent Selection for FHB Resistance	$ 1,163
VDHR-NWW	Coordinated Phenotyping of Uniform Nurseries and Official Variety Trials	$ 17,077
	FY19 Total ARS Award Amount	**$ 126,267**



August 31, 2021

Principal Investigator Date

* MGMT – FHB Management
FST – Food Safety & Toxicology
R – Research
S – Service (DON Testing Lab)
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: *Development of Scab Resistant Soft Red Winter Wheat Varieties*

1. **What are the major goals and objectives of the research project?**
   The major goals of this research project are to:

   1) Develop and release soft red winter wheat varieties that are resistant to FHB and competitive with other commercial varieties in terms of yield and all other traits of interest to farmers in the region,
   2) Introgress FHB resistance into breeding germplasm, and
   3) Develop and map markers for sources of FHB resistance.

2. **What was accomplished under these goals or objectives?** *(For each major goal/objective, address these three items below.)*

   a) **What were the major activities?**
   For the first major objective, the major activities included making crosses involving FHB resistant parents, advancing segregating populations to develop stable lines, testing lines for FHB resistance as well as other traits that are critical for variety adoption including grain yield, days to heading, test weight, and height. Other major activities include analyzing data across multiple locations and years, making selection decisions and designing new trials.

   For the second major objective, the major activities included making crosses involving non-Illinois lines with high levels of FHB resistance, deriving lines from these populations, and evaluating their progeny for FHB resistance and all other important traits.

   For the third major objective, the major activities have shifted away from identifying molecular markers linked to FHB resistance genes in favor of using molecular markers to predict FHB resistance in Genomic Selection (GS) models. These activities included genotyping at least 1000 breeding lines per year with genome-wide markers and validating genomic selection models.

   b) **What were the significant results?**
   One significant result of this work is that we see improved levels of FHB resistance in the breeding germplasm over time in combination with improved yields, and earlier maturity. We also find that Illinois derived wheat varieties tend to have higher levels of FHB resistance non-Illinois derived wheat lines in our region. However, some our scab resistant lines were developed using parental lines from other breeding programs in the region, especially from Missouri and Purdue. This germplasm exchange was made possible by cooperative nurseries, including the Northern Uniform Scab Nursery and Preliminary Northern Uniform Scab Nursery.

c) List key outcomes or other achievements.

A key outcome of this objective is that during FY19 and FY20, more than 15 wheat lines with at least moderate resistance to FHB has been licensed to a seed company for marketing. Foundation seed is being produced for 5 of these lines and we expect that at least 3 lines will be in commercial production in 2022. Another key outcome is that we developed GS models that can predict Deoxynivalenols and Fusarium damaged kernels with an accuracy of 0.64 and 0.82 respectively with will greatly improve our ability to improve FHB resistance in the future in an efficient manner.

3. Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns and/or restrictions, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.

This research has been impacted by COVID-19 significantly because 1) genotyping labs are not allowed to operate at full capacity and genome-wide-marker data that we use for genomic selection are arriving at least 6 months after their scheduled arrival date, 2) the PI of this project did not have childcare for three months' and is behind on hiring students, writing papers, and releasing varieties, 3) COVID-19 caused delays in hiring support staff which has slowed the pace of the breeding methods research component of this project.

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

This project has contributed to providing University of Illinois and Parkland college students with summer internships where they have learned about wheat breeding and FHB resistance and we have trained them on different technical aspects of plant breeding and on phenotyping procedures. The student interns have been instrumental in the FHB resistance phenotyping process.

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

Data on FHB resistance of wheat varieties for sale in Illinois has been disseminated on the Illinois state variety testing website and on ScabSmart. The PI has also communicated to Illinois wheat growers about this research and its outcomes at the 1) Illinois Wheat Association Summer Wheat Forum, Okawville Community Center August 21, 2019, and 2) The 66th Soft Wheat Quality Laboratory Annual Research Review Meetings, March 16-17, 2021.

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

1. **What are the major goals and objectives of the research project?**

   The goal of this project is to develop several breeding populations adapted to the eastern U.S. with genes for FHB resistance derived from multiple sources

2. **What was accomplished under these goals or objectives?** *(For each major goal/objective, address these three items below.)*

   a) **What were the major activities?**
   The major activities of this project include planting male sterile populations in the field along with elite male pollinators, selecting male sterile plants prior to or at anthesis, culling scab-susceptible plants just prior to maturity, selection and harvest of fertile spikes, and selection of a new set of male pollinators prior to planting. Seed from each of the fertile spikes as is planted as headrows, the best headrows are advanced to Stage-1 testing. The lines that enter Stage-1 testing then advance to Stages 2 and 3 if they are among the best in their cohort. The exact details of how the activities are performed vary by cooperator.

   b) **What were the significant results?**
   At the University of Illinois, one of the lines derived from the Illinois male-sterile population is among the best performers in terms of both resistance to FHB and grain yield across multiple locations. This line, as well as other male-sterile population derived lines will be tested again next year to evaluate their potential as varieties.

   At Cornell university, 19 lines derived from the Cornell male-sterile population were found to have higher levels of resistance than a FHB resistant check from Illinois, and 59 were found be more resistant than the most resistant experimental line originating from the conventional breeding program at Cornell.

   c) **List key outcomes or other achievements.**
   Male sterility in the populations is successfully being maintained through careful selection. We have also been successful in developing lines derived from the male-sterile population which have short stature and average maturity, which is one of the main challenges to using a male-sterile recombination system.

   One of our top performing lines for yield and FHB resistance originates from the male-sterile population supported by this project

3. **Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns and/or restrictions, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.**

   No, this research was not impacted by COVID-19

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

   Undergraduate students have learned to identify male sterile wheat heads and have gained experience in selection of male sterile heads.

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

   Seed from the IL male sterile population have been shared with other breeders. Male sterile derived lines currently in stage 2 testing will be made available to private seed companies for licensing within the next 2 years.

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

1. **What are the major goals and objectives of the research project?**

Objectives: 1) Phenotype advanced breeding lines that are candidates for release; 2) place FHB and other agronomic, disease resistance, and quality data in database; and 3) provide FHB resistance data for lines and varieties in the OVT to producers and seedsmen.

Data on FHB resistance collected from the OVT entries provide information to seedsmen and producers that can be used in making decisions about which wheat varieties to produce. These data are important because they allow seedsmen and producers to use FHB resistance as one criterion in their variety selection decisions.

Coordinated evaluation of breeding lines among the programs in the NWW provides all breeding programs in the CP with FHB resistance data from multiple locations in a single season. This coordinated evaluation of breeding material plays an important role in the identification of breeding lines with high levels of FHB resistance. Our objective is to cooperatively obtain information on breeding lines from various programs within the CP and the SWW CP to allow the breeders involved to make better decisions about which breeding lines to advance and release.

2. **What was accomplished under these goals or objectives?** *(For each major goal/objective, address these three items below.)*

a) What were the major activities?

In 2019, 2020, and 2021 field seasons an inoculated and mist irrigated field evaluation nursery at Urbana, IL was used to evaluate the Fusarium Head Blight resistance of entries from the following trials by collecting data on % incidence, % severity, % Fusarium damaged kernels (FDK) and deoxynivalenol (DON) level.

2020 Experiments:
- 86 entries in the Illinois Variety Trial
- 29 entries in the Uniform Eastern Soft Red Winter Wheat Nursery
- 25 entries in the Advanced Five State Nursery
- 25 entries in the Preliminary Six State Nursery
- 61 entries in the Northern Uniform Winter Wheat Scab Nursery
- 50 entries in the Preliminary Northern Uniform Winter Wheat Nursery
- 48 entries in the Southern Uniform Winter Wheat Scab Nursery

2021 Experiments:
- 80 entries in the Illinois Variety Trial
- 34 entries in the Uniform Eastern Soft Red Winter Wheat Nursery
- 25 entries in the Advanced Five State Nursery

- 25 entries in the Preliminary Six State Nursery
- 54 entries in the Northern Uniform Winter Wheat Scab Nursery
- 43 entries in the Preliminary Northern Uniform Winter Wheat Nursery
- 60 entries in the Southern Uniform Winter Wheat Scab Nursery

b) What were the significant results?

Data from the 2019, 2020, and 2021 Illinois Variety Trial were summarized and distributed. The results are available online.

Data collected on cooperative nurseries has been made available to cooperators in each nursery to facilitate selection of FHB resistant breeding lines.

Lines from the University of Illinois program were submitted for all of the cooperative nurseries, thus, breeding lines with FHB resistance were made available to other breeding programs for use as germplasm. Lines submitted from University of Illinois showed high levels of resistance both in 2019 and in 2020. Several breeders requested permission to cross with our breeding lines.

c) List key outcomes or other achievements.

- FHB resistance data collected from the Illinois Variety Trial were made available to producers and seedsmen.
- Data collected on cooperative nurseries will be made available to cooperators in each nursery to facilitate selection of FHB resistant breeding lines.

3. Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns and/or restrictions, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.

No

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

Undergraduate students have gained experience evaluating FHB resistance

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

FHB resistance data collected from the Illinois Variety Trial were summarized and the data made available in the annual Variety Trial Report and on the Illinois Variety Trial website (http://vt.cropsci.illinois.edu/wheat.html). These results are also reported on the ScabSmart website. Cooperative testing data has been made available to cooperators over email and also through the T3 database which is open access.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the **FY19 award period (6/8/19 - 6/7/21)**. 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 FY19 award period?**
   ☐Yes ☒No ☐ Not Applicable
   If yes, how many? Click to enter number here.

2. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY19 award period?**
   ☐Yes ☒No ☐ Not Applicable
   If yes, how many? Click to enter number here.

3. **Have any post docs who worked for you during the FY19 award period and were supported by funding from your USWBSI grant taken faculty positions with universities?**
   ☐Yes ☒No ☐ Not Applicable
   If yes, how many? Click to enter number here.

4. **Have any post docs who worked for you during the FY19 award period and were supported by funding from your USWBSI grant gone on to take positions with private ag-related companies or federal agencies?**
   ☐Yes ☒No ☐ Not Applicable
   If yes, how many? Click to enter number here.

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 **FY19 award period (6/8/19 - 6/7/21)**. 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	FHB Rating (0-9)	Year Released
IL14-28444	SRW - Soft Red Winter	MR - Moderately Resistant	4	2019
IL14-28468	SRW - Soft Red Winter	R - Resistant	2	2019
IL14-28307	SRW - Soft Red Winter	MR - Moderately Resistant	4	2019
IL15-4957	SRW - Soft Red Winter	MR - Moderately Resistant	3	2019
IL16-23972	SRW - Soft Red Winter	MR - Moderately Resistant	3	2020
IL16-IL-061-029	SRW - Soft Red Winter	MR - Moderately Resistant	2	2020
IL16-8048	SRW - Soft Red Winter	R - Resistant	1	2020
IL16-8737	SRW - Soft Red Winter	R - Resistant	1	2020
IL13-1910	SRW - Soft Red Winter	MS - Moderately Susceptible	5	2020
IL16-1922	SRW - Soft Red Winter	MR - Moderately Resistant	3	2020
IL17-17739	SRW - Soft Red Winter	R - Resistant	1	2021
IL17-23874	SRW - Soft Red Winter	MS - Moderately Susceptible	5	2021
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year

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

Publications, Conference Papers, and Presentations

Instructions: Refer to the FPR_Instructions for detailed more instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY19 grant award. Only citations for publications published (submitted or accepted) or presentations presented during the **award period (6/8/19 - 6/7/21**) should be included. If you did not publish/submit or present anything, state 'Nothing to Report' directly above the Journal publications section.

NOTE: Directly below each citation, you **must** indicate the Status (i.e. published, submitted, etc.) and whether acknowledgement of Federal support was indicated in the publication/ presentation. See example below for a poster presentation with an abstract:

Z.J. Winn, R. Acharya, J. Lyerly, G. Brown-Guedira, C. Cowger, C. Griffey, J. Fitzgerald, R.E. Mason and J.P. Murphy. 2020. "Mapping of Fusarium Head Blight Resistance in NC13-20076 Soft Red Winter Wheat." In: S. Canty, A. Hoffstetter, and R. Dill-Macky (Eds.), *Proceedings of the 2020 National Fusarium Head Blight Forum (*p. 12.), Virtual; December 7-11. Online: https://scabusa.org/pdfs/NFHBF20_Proceedings.pdf.
Status: Abstract Published and Poster Presented
Acknowledgement of Federal Support: YES (Abstract and Poster)

Journal publications.

Gaire, Dr. R., Sneller, Prof. C., Brown-Guedira, Dr. G., Sanford, Dr. D. A. van, Mohammadi, Dr. M., Kolb, Dr. F. L., Olson, Dr. E., Sorrells, Dr. M., & Rutkoski, Dr. J. (2021). Genetic trends in Fusarium head blight resistance due to 20 years of winter wheat breeding and cooperative testing in the Northern US. *Https://Doi.Org/10.1094/PDIS-04-21-0891-SR*. https://doi.org/10.1094/PDIS-04-21-0891-SR
Status: published
Acknowledgement of Federal Support: YES

Gaire, Dr. R., Arruda, Dr. M., Mohammadi, Dr. M., Brown-Guedira, Dr. G., Kolb, Dr. F., Rutkoski, Dr. J., (2021). Multi-trait Genomic Selection Can Increase Selection Accuracy for Deoxynivalenol Accumulation due to Fusarium Head Blight in Wheat
Status: In-press
Acknowledgement of Federal Support: YES

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

None

Other publications, conference papers and presentations.

None.