USDA-ARS
U.S. Wheat and Barley Scab Initiative
FY20 Annual Performance Progress Report
Due date: August 31, 2021

Cover Page

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Fiscal Year:	2020
USDA-ARS Agreement ID:	59-0206-0-143
USDA-ARS Agreement Title:	Scab Research Projects and Development of Scab Resistant Soft Red Winter Wheat Varieties at the University of Illinois
FY20 USDA-ARS Award Amount:	$ 228,912
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:	AG027
Project/Grant Reporting Period:	6/8/20 - 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	$ 143,057
VDHR-NWW	Fast, Efficient Phenotyping Methods for FHB Resistance using Imagery and Imputation	$ 67,781
VDHR-NWW	Coordinated Phenotypes of Soft Wheat Germplasm for the Midwest	$ 18,074
	FY20 Total ARS Award Amount	**$ 228,912**

August 31, 2021

Principal Investigator Date

* MGMT – FHB Management
FST – Food Safety & Toxicology
R- Research
S – Service (DON Testing Labs)
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 project are to:

1) Increase and document the number of varieties with improved FHB resistance and high grain yield and grain quality that are tested in statewide variety trials and available to farmers; and
2) Implement new and underutilized breeding techniques/technologies to further enhance short term and long-term improvement of both FHB resistance and grain yield.

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 are:

1) development of new breeding populations and lines,
2) phenotyping for FHB resistance and agronomic traits including yield,
3) data analysis and selection using a selection index, and
4) implementation of male-sterile facilitated recurrent selection with FHB resistant parents.

b) What were the significant results?

1200 new breeding lines were developed, genotyped, and phenotyped in stage-1 trials. Of these 315 were identified for advancement and will be evaluated in multiple locations in 2022. Phenotypic data on scab resistance was collected on over 3,000 plots, representing over 1,000 entries. In all trials, the reliability of the data was more than 0.65, indicating that the evaluation was successful. Several lines were identified as superior to checks based on a selection index combining data on scab resistance, test weight, yield, and days to heading. One of the best lines that we identified originates from the male-sterile recurrent selection population supported by this project.

c) List key outcomes or other achievements.

- 16 new lines were licensed to a private seed company for potential commercialization, and of these six were selected for further testing and seed production. Of these six, three are more resistant to FHB than our most resistant commercial check.
- FHB resistance data on the Illinois state variety trial was collected, analyzed, and published on the state variety trial website and on scab smart.

- Computer code for the analysis and selection procedures implemented have been made available on github https://github.com/jrutUIUC
- All breeding data has been migrated to T3/Breedbase which is being used extensively for breeding trial and data management.

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.

The COVID-19 pandemic has caused delays in hiring and a shortage of qualified applicants. As a result, we are behind on hiring research support personnel. We have focused our efforts keeping the breeding activities at full capacity, meanwhile scaling back on methods research. As a result, we have published fewer research papers than expected.

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

This project has given graduate students and undergraduates the opportunity to gain experience evaluating and identifying symptoms of FHB resistance. Undergraduate students have learned about the technical processes of plant breeding and have gained exposure to agriculture and agricultural research.

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

We have presented our breeding work supported by this project at the 66th Soft Wheat Quality Laboratory Annual Research Review Meetings, March 16-17, 2021

Results of FHB resistance evaluation on varieties in the Illinois State Variety trial have been published on the variety testing website: http://vt.cropsci.illinois.edu/wheat.html and on scab smart https://scabsmart.org/

We published the results of 20 year of breeding for FHB resistance in our region in the journal *Plant Disease.* The citation for this article is: 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

Project 2: *Fast, Efficient Phenotyping Methods for FHB Resistance using Imagery and Imputation*

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

   The objective of this project is to develop faster and more efficient phenotyping and selection methods for FHB resistance so that breeding programs can select for FHB resistance, including DON levels, on a larger scale, in a timely manner, with greater accuracy, and at a lower cost.

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 include

   - Collection of images of FHB infected plots and grain samples
   - Image analysis and training deep-learning models
   - Evaluation prediction methods and phenotyping strategies that can reduce the amount total phenotyping that is required.

   b) **What were the significant results?**

   - A deep learning model for phenotyping *Fusarium* damaged kernels (FDK) has been trained. This model is able to identify FDK from cell-phone images with 77% accuracy.
   - We determined that if breeding candidates have been genotyped and a model-training dataset is available with both FDK and deoxynivalenol (DON), including phenotypic data on incidence and severity does not improve selection accuracy for FHB resistance. To improve efficiency, it's likely that breeding programs no longer need to phenotype incidence and severity if they are implementing genomic selection.

   c) **List key outcomes or other achievements.**

   Our research article showing that FDK and DON may be the only traits needed for phenotyping FHB resistance has been accepted for publication in *The Plant Genome Journal*.

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?

The postdoctoral fellow funded by this project attended the 2020 National FHB Forum and gave a presentation.

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

These results have been presented at 1) the 2020 National FHB Forum, December 7-11, 2020, 2) The National Association of Plant Breeders (NAPB) meeting, Cornell University August 15-19, 2021.

Our research article showing that FDK and DON may be the only traits needed for phenotyping FHB resistance has been accepted for publication in *The Plant Genome Journal*.

Project 3: *Coordinated Phenotypes of Soft Wheat Germplasm for the Midwest*

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: 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 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 website, which is open access.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY20 award period (6/8/20 - 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? 1

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 FY20 award period (6/8/20 - 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
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
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
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 PR_Instructions for detailed more instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY20 grant award. Only citations for publications published (submitted or accepted) or presentations presented during the **award period (6/8/20 - 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:

> Winn, Z.J., Acharya, R., Lyerly, J., Brown-Guedira, G., Cowger, C., Griffey, C., Fitzgerald, J., Mason R.E., and Murphy, J.P. (2020, Dec 7-11). Mapping of Fusarium Head Blight Resistance in NC13-20076 Soft Red Winter Wheat (p. 12). In: Canty, S., Hoffstetter, A. and Dill-Macky, R. (Eds.), *Proceedings of the 2020 National Fusarium Head Blight Forum*. 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.

Nothing to report.