USDA-ARS | U.S. Wheat and Barley Scab Initiative

FY21 Performance Progress Report

Due date: July 26, 2022

Cover Page

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Fiscal Year:	2021
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:	$199,791
Recipient Organization:	University of Illinois Department of Crop Sciences 1102 S. Goodwin Ave., Urbana, IL 60801
DUNS Number:	41544081
EIN:	37-6000511
Recipient Identifying Number or Account Number, if any:	AG027
Project/Grant Period:	6/8/21 - 6/7/23
Reporting Period End Date:	6/7/2022

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
VDHR-NWW	Development of Scab Resistant Soft Red Winter Wheat Varieties	$114,671
VDHR-NWW	Fast, Efficient Phenotyping Methods for FHB Resistance using Imagery and Imputation	$67,157
VDHR-NWW	Coordinated Phenotypes of Soft Wheat Germplasm for the Midwest	$17,963
	FY21 Total ARS Award Amount	$199,791

I am submitting this report as an: ☒ Annual Report ☐ Final Report

I certify to the best of my knowledge and belief that this report is correct and complete for performance of activities for the purposes set forth in the award documents.

Principal Investigator Signature — July, 22, 2022 — Date Report Submitted

‡ BAR-CP – Barley Coordinated Project
DUR-CP – Durum Coordinated Project
EC-HQ – Executive Committee-Headquarters
FST-R – Food Safety & Toxicology (Research)
FST-S – Food Safety & Toxicology (Service)
GDER – Gene Discovery & Engineering Resistance
HWW-CP – Hard Winter Wheat Coordinated Project
MGMT – FHB Management
MGMT-IM – FHB Management – Integrated Management Coordinated Project
PBG – Pathogen Biology & Genetics
TSCI – Transformational Science
VDHR – Variety Development & Uniform Nurseries
NWW –Northern Soft Winter Wheat Region
SPR – Spring Wheat Region
SWW – Southern Soft Red Winter Wheat Region

Project 1: Development of Scab Resistant Soft Red Winter Wheat Varieties

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1. **What are the major goals and objectives of the research project?**
   The major goals and objectives of this project are to 1) increase and document the number wheat varieties with FHB resistance and high grain yield, and 2) implement new and underutilized breeding techniques to enhance short and long-term improvement of 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?**
   To address our two main goals, we executed a breeding strategy aimed at improving both FHB resistance and yield, and we evaluated the Illinois official variety trial for FHB resistance in our inoculated and misted nursery.

   b) **What were the significant results?**
   During FY21, we developed 1200 new lines which we genotyped and phenotyped in stage-1 yield trials. We also evaluated 480 preliminary and advanced lines for FHB resistance in our inoculated and misted nursery and used the FHB resistance data for selection for further evaluation and breeding. We also identified 28 released varieties present in the Illinois official variety trial with at least moderate resistance to FHB.

   c) **List key outcomes or other achievements.**
   Out of our most advanced lines, we licensed 9 to a private seed company for further testing and increasing. Six of the 9 lines are have excellent scab resistance. The results on FHB resistance among released varieties have been published on the Illinois Official Variety Trial website: http://vt.cropsci.illinois.edu/wheat.html

3. **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. Several of our undergraduate students have used their work experience with our research group to help them gain acceptance to graduate or medical school.

4. **How have the results been disseminated to communities of interest?**
   Results of the breeding program, in the form of germplasm, has been shared with private seed companies for licensing.
   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/

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

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1. **What are the major goals and objectives of the research project?**
   This research project aims to improve the efficiency and accuracy of FHB resistance evaluation using imagery and statistical techniques.

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?**
   During FY21 we collected images of FHB infected plots and on grain samples, we analyzed aerial image data collected on plots during 2020, we trained a deep-learning model to evaluate Fusarium Damaged Kernels, and we evaluated the genomic prediction accuracy of models that used FDK estimated using deep learning with that of models that used FDK estimated using human ratings. Our previous work showed that FDK is more important than incidence or severity for training genomic prediction models, thus in FY21 we focused primarily on using imagery for FDK phenotyping.

   b) **What were the significant results?**
   We determined that including FDK estimated using deep learning as a secondary trait in a genomic prediction model improved accuracy for Deoxynivalenol by more than 150% relative to a single-trait model. However, using human-rated FDK phenotypes improved genomic prediction model accuracy by more than 300%.

   c) **List key outcomes or other achievements.**
   A deep learning model capable of evaluating FDK has been trained, and it will continue to be updated to further improve its accuracy.

3. **What opportunities for training and professional development has the project provided?**
   The postdoctoral researcher funded by this project learned how to use multi-trait genomic selection models and is now working as a Senior Researcher at Bayer.

4. **How have the results been disseminated to communities of interest?**
   Our work showing that FDK can improve genomic prediction accuracy for Deoxynivalenol was published in The Plant Genome Journal on January 19, 2022. Computer code for multi-trait genomic selection has been made available on github https://github.com/jrutUIUC

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

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1. **What are the major goals and objectives of the research project?**
   This research project aims to 1) gather robust, multi-location data on scab resistance among advanced breeding lines that are candidates for variety release, 2) make data available in a centralized database, and 3) provide FHB resistance data on candidate varieties to seedsmen to help promote the release of more FHB-resistant varieties.

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?**
   Cooperative nurseries were evaluated for FHB resistance our inoculated and misted nursery. On each plot we evaluated Days to Heading, Incidence, Severity, Fusarium Damaged Kernels, and Deoxynivalenol. Deoxynivalenol analysis was provided by the University of Minnesota. During the 2021 field season we evaluated the following nurseries:
   - Northern Uniform- 171 plots with 54 entries and 3 checks
   - Preliminary Northern Uniform- 138 plots with 43 entries and 3 checks
   - Uniform Eastern- 111 plots with 34 entries and 3 checks
   - Southern Uniform -189 plots with 60 entries and 3 checks
   - Advanced 5-state- 84 plots with 25 entries and 3 checks
   - Preliminary 5-state- 84 plots with 25 entries and 3 checks

   After data were collected, we uploaded them to the T3 database, analyzed the data, and sent raw and analyzed data to cooperators.

   b) **What were the significant results?**
   We obtained a high level of disease pressure in the FHB nursery and data reliability were high.

   c) **List key outcomes or other achievements.**
   Data collected on cooperative nurseries were made available to cooperators in each nursery to facilitate selection of FHB resistant breeding lines. This data is being used to facilitate variety release decisions.

3. **What opportunities for training and professional development has the project provided?**
   Undergraduate students have gained experience evaluating FHB resistance.

4. **How have the results been disseminated to communities of interest?**
   Data have been made publicly available on the T3 database, and data have been shared with collaborators over email.

Publications, Conference Papers, and Presentations

Please include a listing of all your publications/presentations about your FHB work that were a result of funding from your FY21 grant award. Only citations for publications published (submitted or accepted) or presentations presented during the **award period** should be included.

Did you publish/submit or present anything during this award period?

☒ Yes, I've included the citation reference in listing(s) below.

☐ No, I have nothing to report.

Journal publications as a result of FY21 grant award

List peer-reviewed articles or papers appearing in scientific, technical, or professional journals. Include any peer-reviewed publication in the periodically published proceedings of a scientific society, a conference, or the like.

Identify for each publication: Author(s); title; journal; volume: year; page numbers; status of publication (published [include DOI#]; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).

Gaire, Dr. R., Arruda, Dr. M., Mohammadi, Dr. M., Brown-Guedira, Dr. G., Kolb, Dr. F., Rutkoski, Dr. J., (2022). Multi-trait Genomic Selection Can Increase Selection Accuracy for Deoxynivalenol Accumulation due to Fusarium Head Blight in Wheat. *The Plant Genome* 15.1 (2022): e20188. https://doi.org/10.1002/tpg2.20188; acknowledgment of federal funding - yes.

Books or other non-periodical, one-time publications as a result of FY21 grant award

Report any book, monograph, dissertation, abstract, or the like published as or in a separate publication, rather than a periodical or series. Include any significant publication in the proceedings of a one-time conference or in the report of a one-time study, commission, or the like.

Identify for each one-time publication: Author(s); title; editor; title of collection, if applicable; bibliographic information; year; type of publication (book, thesis or dissertation, other); status of publication (published; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).

Other publications, conference papers and presentations as a result of FY21 grant award

Identify any other publications, conference papers and/or presentations not reported above. Specify the status of the publication.