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:	59-0206-0-142
USDA-ARS Agreement Title:	Genetic Improvement of Grain Yield and Disease Resistance in Wheat
FY20 USDA-ARS Award Amount:	$ 102,798
Recipient Organization:	Purdue University AG Spnsored Program Services 615 W. State Street West Lafauette, IN 47907
DUNS Number:	07-205-1394
EIN:	35-6002041
Recipient Identifying Number or Account Number:	17000699
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	Genetics of, and Breeding for, Fusarium Head Blight Disease Resistance in Wheat	$ 72,449
VDHR-NWW	Coordinated Phenotypes of Soft Wheat Germplasm for the Midwest	$ 2,028
VDHR-NWW	FHB Mining: From Genebank to Growers Fields	$ 28,321
	FY20 Total ARS Award Amount	**$ 102,798**

M. Mohammadi 8/31/21

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: *Genetics of, and Breeding for, Fusarium Head Blight Disease Resistance in Wheat*

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

The overall goal of this research was to mitigate the adverse effect of FHB by breeding for resistance in soft red winter wheat. We aimed to achieve this goal by using traditional plant breeding techniques such as breeding crosses, advancing segregating populations, and evaluation and selection from headrow nurseries, and conducting preliminary and advanced yield trials, in Indiana as well as neighboring states. Specifically, the objectives were:

1) continue developing new genetic variation by crossing high-yielding experimental lines with FHB moderately resistant lines, and advancing segregating progeny for line development;
2) field-based screening advanced lines for FHB resistance; and
3) preliminary and advanced yield trials for assessment of lines in different stages of breeding program.

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?

1) During January-April 2021, we completed artificial hybridization of > high-yielding and FHB moderately resistant germplasm. We collected the FHB moderately resistant germplasm by using the recent P+N scab nursery data. In addition, the F1 generation (n > 200) of the previous crossing block were advanced in the greenhouse to obtain seed for F2 generation that will be planted in Oct 2021 in the field.
2) During June-August 2020, we selected and harvested new lines from F7 generations and selected superior heads from more advanced plots that did not look completely pure. We planted these materials in headrows in Oct 2020. Selection was performed in June 2021 and the selected materials were sickle harvested in July 2021. In total, we hand harvested 930 headrows, which will be used for stage-1 line testing in the following year.
3) The headrows that were harvested from 2020 were divided into 8 trials, each accommodating 70-80 entries. These trials were named Y1-1, Y1-2, Y1-3, Y1-4, Y1-5, SPY1-KY, SPY1-OH, and SPY1-IL. These trials were the first stage-1 testing of lines that were produced by Dr. Mohammadi since joining Purdue University.
4) In FY20 a consortium was created by collaboration of KY, IL, IN, and OH, which was then augmented to also include MI and NY. The goal of this consortium was to implement genomic selection in our breeding programs. This consortium resulted in slight modifications to our line testing. For example, for the case of Indiana, the SPY1-KY stage-1 testing trial that were planted in West Lafayette was also planted

in KY. Same pattern was conducted for the SPY1-OH and SPY1-IL trials. Similarly, each breeder reciprocated this scheme so we had the opportunity to test our lines in other states and evaluated other states' lines in our location very early in the breeding process.

b) What were the significant results?

1) The significant result is the creation of novel progeny that will be advanced and tested in the following years.
2) 930 pure lines (new and purified from older materials) were created.
3) We recorded grain yield and test weight and were able to selected the best performing lines from these trials for advancement.
4) The significant result was that we could observe the performance of at least a fraction of our new lines in stage-1 in a wider geographical areas.

c) List key outcomes or other achievements.

1) The outcome of producing novel genetic variation is that we can combine the best phenotypes of parents in the genetic composition of progeny.
2) The outcome is that these 930 lines will be tested for yield performance in the following year.
3) Three more advanced trials were created based on the results of The outcome of producing novel genetic variation is that we can combine the best phenotypes of parents in the genetic composition of progeny.
4) These testing schemes allowed my program to identify several high yielding Purdue lines that yielded up to 130 bu/acre in KY.

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.

Staffing has become a little bit difficult but overall no impact.

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

One undergraduate student was trained with various aspects of wheat breeding.

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

During 6/8/20 - 6/7/21, we have shared the breeding and scab data of 2020 season with other breeders. For the plants we harvested in 2021, the reporting activity was after FY20 period.

Project 2: *Coordinated Phenotypes of Soft Wheat Germplasm for the Midwest*

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

   High yielding wheat varieties must also show scab resistance for the eastern region of US. Each year multiple breeding programs generate breeding lines that are in the advanced stages of development. Due to low to moderate heritability of scab resistance, multi-location testing is needed to produce a good estimate of scab resistance based on responses in multiple environments. Determination of yield performance in wide geographical areas is also needed. The collaborating breeders in this project use coordinated nurseries to test advanced lines for scab resistance and yield in neighboring states. The data will help them to select and advance germplasm for variety release. Specific goals of my program were conducting:

   1) Preliminary Northern and Northern Winter Wheat Scab Nursery (P+NUWWSN).
   2) Five-State preliminary and advanced nurseries
   3) Uniform Eastern and Southern Regional Winter Wheat Nurseries (UESRWWN)

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?

   A total of 43 entries for PNUWWSN and 54 entries for NUWWSN were planted in three replicates of randomized head rows in October 2020. FHB incidence and severity were measured on all three replicates. Measurement of FDK is being conducted now. DON analysis will be conducted after FDK measurements.

   25 entries, five from each of IN, KY, MI, IL, and OH states, were planted in randomized complete block design experiments in three replicates under preliminary 5-state trial in West Lafayette. Similar design was used to plant another trial with a second set of 25 entries under advanced 5-state trial. The goal of these tests was to estimate yield performance of lines in wide environments that can be used by multiple breeding programs for advancement decisions.

   34 entries from multiple breeding programs in the eastern region were planted under UESRWWN nursery and evaluated.

   b) What were the significant results?

   INC was recorded with min 13% and max 57%, averaging 30%. SEV was recorded with min 10% and max 77%, averaging 28%. In the PNUWWSN nursery, example lines with lower INC were 17VDH-SRW03-143 (13.3%) Truman (16.7%), , KWS347 (16.7%), and

09169A1-2-1 (16.7%). The example lines with lower amount of SEV were 17VDH-SRW03-143 (10.0%), OH17-21-11 (10.0%), and KWS342 (16.7%). In the NUWWSN nursery, example lines with lower INC were OH16-184-77 (13.3%), IL16-22039 (13.3%), and LES19-7384 (16.7%). The example lines with lower amount of SEV were 15VDH-FHB-MAS31-30 (10.0%), IL16-8605 (10.0%), 10535A1-15-6 (10.0%) and 10538B1-4-14 (10.0%).

For 5-state trials, the number of days to heading, grain yield, and test weight were recorded. The highest yielding of the advanced 5-state trial were IL07-19334 (121 bu/acre), OH15-191-52 (120 bu/acre), and KY07C-1145-94-12-5 (119 bu/acre). The highest yielding of the preliminary 5-state trial were MI16R0898 (103.9 bu/acre), IL07-19334 (103.8 bu/acre), and IL17-23904 (102.0 bu/acre).

For the UESRWWN trial, the number of days to heading, grain yield, and test weight were recorded. The highest yielding of the advanced 5-state trial were IL07-19334 (121 bu/acre), OH15-191-52 (120 bu/acre), and KY07C-1145-94-12-5 (119 bu/acre). The highest yielding of the preliminary 5-state trial were MI16R0898 (103.9 bu/acre), IL07-19334 (103.8 bu/acre), and IL17-23904 (102.0 bu/acre).

c) List key outcomes or other achievements.

The data of these collaborative trials were sent to the corresponding coordinators. These data will be used for decision making of line advancement, variety release, or entering lines as parents in the crossing nurseries.

Project 3: *FHB Mining: From Genebank to Growers Fields*

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

   Fusarium head blight (FHB) is the most devastating disease of wheat and barley in the United states.There are several ways to control the disease including crop rotation, application of fungicides, and use of the resistant cultivars. The use of resistant varieties is environmentally friendly and the most economical way to manage the disease. However, breeding resistant varieties to any diseases requires the availability of resistance and effective genes in the breeding nurseries. To date, the sources of resistance can be attributed to only few plant introduction e.g., Sumai 3 and native germplasm e.g., Truman, Ernie and Freedom. These handful of sources of variations are being used by the soft red winter wheat breeding programs to develop varieties. Continuous use of same varieties will lead to the loss of genetic diversity, which then results in diminishing genetic gains. We aimed to make use of the existing wealth of genetic resources at the US National Small Grains Collection (NSGC) by sourcing, field testing, and FHB testing of selected worldwide (mainly Europe) winter wheat germplasm in the Agronomy Center for Research and Education (ACRE) in West Lafayette, IN.

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?**

   These 2,850 were visually evaluated for winter survival, crop stand, spike appearance and grain set, natural levels of infection to scab disease (as they were close to the scab nursery). A total of n= 190 accessions were hand harvested by sickle, threshed, and cleaned.

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

   These 190 accessions will be advanced for scab evaluation of next year. A subset of ~80 accessions will also be planted in yield trials next year.

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

   This is a research in progress. The hope is that lines with FHB resistance and/or yield traits are identified in the future from this collection.

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.**

   Staffing of undergrad researchers has become a little bit difficult but overall no impact.

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

One undergraduate student was educated in different aspects of the project.

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

During 6/8/20 - 6/7/21, we have shared the breeding and scab data of 2020 season with other breeders. For the plants we harvested in 2021, the date of data sharing is after the reporting period.

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? 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 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
Nothing to report.	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
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
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:

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 R, Brown-Guedira G, Dong Y, Ohm O, and Mohammadi M. 2021. Genome-wide association studies for Fusarium head blight resistance and it's trade-off with grain yield in soft red winter wheat. **Plant Disease**. https://doi.org/10.1094/PDIS-06-20-1361-RE.
Status: Published
Acknowledgement of Federal Support: YES

Gaire R, Sneller C, Brown-Guedira G, Van Sanford D, Mohammadi M, Kolb F, Olson E, Sorrells M, and Rutkoski J. 2021. Genetic trends in Fusarium head blight resistance due to 20 years of winter wheat breeding and cooperative testing in the Northern US. **Plant Disease**. https://doi.org/10.1094/PDIS-04-21-0891-SR.
Status: Published
Acknowledgement of Federal Support: YES

Gaire R, Arruda M, Mohammadi M, Brown-Guedira G, Kolb F, and Rutkoski J. 2021. Multi-trait genomic selection can increase selection accuracy for deoxynivalenol accumulation due to Fusarium head blight in wheat. **Submitted to The Plant Genome**.
Status: Submitted
Acknowledgement of Federal Support: YES

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

Nothing to report.

Other publications, conference papers and presentations.

Gaire, Rupesh, Arrudo, Marcio P., Mohammadi, Mohsen, Kolb, Frederic K. and Rutkoski, Jessica. 2020. "Multivariate Genomic Prediction for Fusarium Head Blight Resistance in Soft Red Winter Wheat." In: S. Canty, A. Hoffstetter, and R. Dill-Macky (Eds.), *Proceedings of the 2020 National Fusarium Head Blight Forum (*p. 103.), Virtual; December 7-11. Online: https://scabusa.org/pdfs/NFHBF20_Proceedings.pdf.
Status: Published
Acknowledgement of Federal Support: Yes (Abstract and Poster)