FY21 FINAL Performance Progress Report

Due date: July 26, 2023

Cover Page

USDA-ARS Agreement ID:	59-0206-0-149
USDA-ARS Agreement Title:	Improving SRWW Resistance to FHB using Traditional and Molecular Breeding
Principle Investigator (PI):	Clay Sneller
Institution:	The Ohio State University
Institution UEI:	DLWBSLWAJWR1
Fiscal Year:	2021
FY21 USDA-ARS Award Amount:	$261,797
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Period of Performance:	6/6/21 - 6/5/23
Reporting Period End Date:	6/5/2023

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
HWW-CP	Innovated Selection Plan to Improve the FHB Resistance of Hard Winter Wheat	$16,576
VDHR-NWW	Discovering, Understanding, and Utilizing Wheat Genes for FHB Resistance in Ohio	$63,212
VDHR-NWW	Coordinated Phenotypes of Soft Wheat Germplasm for the Midwest	$18,024
VDHR-NWW	Implementing Genomic Selection within the NWW Coordinated Project	$135,664
VDHR-NWW	Assessing FDK, DON, and Fusarium graminearum Biomass in Soft Winter Wheat Grain	$28,321
	FY21 Total ARS Award Amount	$261,797

I am submitting this report as a: ☒ 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.

_____   July 28th, 2023 _____
Principal Investigator Signature   Date Report Submitted

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‡ 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: Innovated Selection Plan to Improve the FHB Resistance of Hard Winter Wheat

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

   The incidence and severity of FHB in the Great Plains can be variable and low even in FHB nurseries due to low humidity and wind. Our goal was to assess the effectiveness of assessing FH of HRW in Ohio and using the Ohio data to predict the FHB resistance of lines in NE and SD.

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?**

      We assessed the FHB reaction of 768 HRW lines from the NE and SD programs. All lines were genotyped and also phenotyped in NE and SD.

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

We had strong disease pressure in both years of the study. We noted HRW lines with good resistance to FHB when assessed under strong disease pressure in Ohio (Fig. 1). About 35% of the HRW had an FHB index less that that of the MR check Freedom: this value approaches 80% in SRWW. The analyses are not completed. The correlation of the phenotypes estimated in OH and the great plains has been moderate to low, and SD experienced strong FHB pressure in their nursery in 2021.
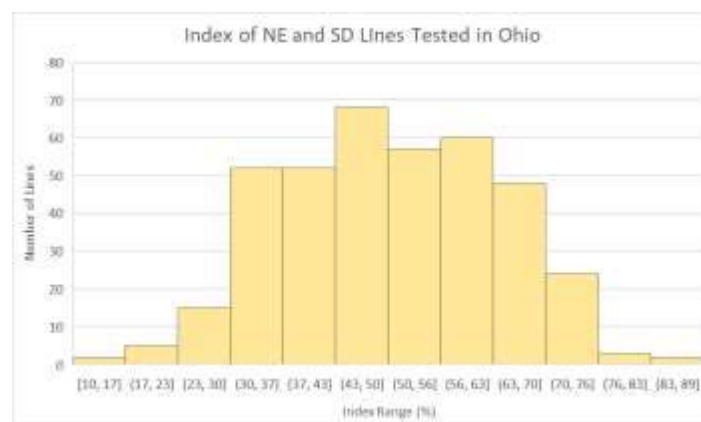

Figure 1. Distribution of FHB index of NE and SD HRW lines phenotyped in Ohio.

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

      We are still assessing the effectiveness of GS. The NE and SD have been genotyped separately and leadership in NE has changed. We are still gathering the needed genotype and phenotype files from NE and SD. Our preliminary analysis suggests that the phenotyping in Ohio can predict FHB in NE and SD, but it does not appear to be better than assessments using FHB phenotypes generated in those states.

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

One PhD student worked on this project

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

Results have been communicated to the breeders in NE and SD

Project 2: Discovering, Understanding, and Utilizing Wheat Genes for FHB Resistance in Ohio

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

   The major goals are 1) to develop new SRWW cultivars with strong FHB resistance and 2) to improve the efficiency of the 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?**

Our major activity is screening OSU wheat breeding lines for FHB resistance as well as high yield and test weight. We have assessed the FHB resistance or 2,982 OSU breeding lines over the past 3 years (Table 1). This total includes 1,768 new lines. We note that about 30% of lower index than that of the most resistant line (Truman) and 75% have better FHB resistance than the the MR check (Freedom).

Table 1. Number of OSU breeding lines screened for FHB resistance in 2021, 2022, and 2023.

	Stage-1	Stage-2	Stage-3	Stage-4
2021	670	300	70	25
2022	560	420	100	25
2023	538	195	54	25
Total	1768	915	224	75

Marker assisted selection is used to track the resistant allele at Fhb1 in out population. The frequency of R at FHB1 in OSU lines has increased from 0.15 to 0.43 in 2023.

All of the 2,982 OSU lines have been genotyped and the data used to make predictions using genomic selection. The predicted value for yield, test weight, and FHB are used in advancing lines to the next stage of testing and in parent selection.

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

We are continuing our progress in combining high yield with FHB resistance. Our analysis within the OSU suggest that yield is increasing at a rate of 0.85 bu/acre/year and that FHB index is declining at a rate of 1.09% per year. Increasing the probability of high yield and good FHB increases the probability of finding lines that are good for both.

c) List key outcomes or other achievements.

The level of yield and FHB resistance in the OSU wheat breeding program is increasing. This enables us to release now cultivars. To that end, the OSU program has released five new cultivars in the past three years (Table 2). In addition, we have increased seed and will propose the release of a new public cultivar that has high yield, TW and Truman-like FHB resistance.

Table 2. Performance of OSU breeding lines complied over 2020, 2021, and 2022.

NAME	YLD (bu/ac)	HD (days)	HGT (inches)	FHBN (%)	*Fhb1*	Released
OH15-191-52	94.0	146.5	38.5	30.3	Yes	Licensed
OH09-207-68	90.1	146.0	41.0	40.0		Licensed
OH13-88-61	89.9	145.5	38.0	37.0		Licensed
OH15-131-31	87.2	143.7	37.0	19.8	Yes	Licensed
OH14-222-49	87.1	144.0	38.0	28.1		Licensed
KOKOSING	84.3	144.0	40.0	46.0		Public
TRUMAN {R}	.	147.0	.	21.1		
FREEDOM (MR)	.	147.0	.	46.4		
PIONEER2545 (S)	.	146.0	.	85.3		

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

All students at the OSU program work on this project. That includes 4 PhD students, 2 visiting scholars, and perhaps 10 different undergraduate students.

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

The results have been communicated to Ohio Seed Improvement Association, Ohio Foundation Seeds, Ohio Corn and Wheat, and Ohio wheat growers through field days.

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?**

   The goal of this project is to coordinate the uniform testing of SRWW across environments relevant to the breeders and growers of the NWW-CP region.

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 screening germplasm from nine different breeding programs. The lines are evaluated in inoculated misted nurseries. The data is compiled, and a report prepared and distributed to all participants. The lines are all genotyped for key markers for disease resistance, growth habits, photoperiod and vernalization, and quality genes.

      The OSU program assesses the FHB resistance of all commercial entries in the Ohio Wheat Performance Trial (OWPT).

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

      The project has assessed the FHB resistance of 274 lines in 8-10 trials per year over the past three years. An analysis of trait changes over the past 18 years revealed significant increases in FHB resistance and a decrease of DON levels. In addition, resistance at FHB1 had increased.

      The results of the FHB screening of the OWPT are included in the OSU extension report. The project has assessed the FHB resistance of 298 entries in the past three years. This report is widely used by Ohio growers to select cultivars.

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

      The data is used to support the release of new cultivars from the 6 NWW-CP programs. We estimate that the data has supported the release of 20 new cultivars, including lines from three programs that are not part of the NWW-CP (NE, VA, KWS)

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

    All students at the OSU program work on this project. That includes 4 PhD students, 2 visiting scholars, and perhaps 10 different undergraduate students.

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

    The results of the OWPT are distributed to Ohio wheat growers through the OSU Extension service which employs a website, printed report, grower meetings, and various social media platforms.

    The results of the Uniform FHB nurseries are complied in a report and distribuend to all participants and are available to all via the USWNSI website.

Project 4: Implementing Genomic Selection within the NWW Coordinated Project

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

   This project is designed to facilitate the coordinated use of genomic selection among the six NWW-CP breeding programs.

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 are 1) joint genotyping of breeding lines across all six programs, 2) using genomic selection to predict the value of all breeding lines from all programs, 3) availability of a coordinator to execute advanced analyses and assist in advancing genotyping technologies.

   b) **What were the significant results?**
      The project has called SNPs on 32,197 samples, including 15,460 breeding lines over the past three years. The 15,460 lines have all been field tested for FHB, yield, and test weight. The genotyping data has been combined with phenotypic data from each program to predict the value of breeding lines and make advancements.

      The coordinator has also made significant contributions to the development of an Allegro genotyping platform designed for SRWW. This platform will combine markers for MAS and GS into one genotyping operation, produce repeatable markers across years and samples sets, and greatly reduce the bioinformatics resources (time, CPU, storage) required by the current GBS system.

   c) **List key outcomes or other achievements.**
      In the past three year, 15,460 lines have been genotyped and their data used to advance the best lines through the stages of testing. This has enhanced the accuracy of selection by complementing phenotypic selection with predictions based on large data sets.

      An Allegro platform has been developed consisting of ~2,500 markers suitable for MAS and GS. The utility of the platform for GS is being validated on sets of lines that have been genotyped with GBS and have been phenotyped.

3. **What opportunities for training and professional development has the project provided?**
   The genotypic data is being used by students at all six programs in their variety development activities and in some cases in their individual dissertations or theses.

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

   The marker data is distributed to all programs and the phenotypic data is compiled on the T3 server.

Project 5: Assessing FDK, DON, and Fusarium graminearum Biomass in Soft Winter Wheat Grain

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

To determine the relationship between IND, FDK, DON and fungal biomass (Fg) and assess if there are SRWW lines that produce less DON than predicted based on Fg. This would be an indication that the line somehow inhibits DON production despite infection by *Fusarium graminearum*.

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?

We have collected data on IND, DFDK, DON and Fg from 886 samples including multiple samples from the same lines collected over time and space.

b) What were the significant results?

We are in the process of doing the analyses. The correlation of DON with IND ranged from 0.22 to 0.62 in different sets of samples while the correlation of FDK with DON ranged from 0/59 to 0.78 in the same sets. The correlation of DON with Fg ranged from 0.21 to 0.30.

c) List key outcomes or other achievements.

There was a significant effect of genotype on all FHB traits including Fg. The DON concentration varied considerably within a particular level of Fg. When regressing DON onto Fg, some lines repeatedly had less DON than expected based on Fg, suggesting these lines resist DON accumulation despite fungal infection. The most resistant line had an average residual of -4.15 indicating it accumulated 4.15 ppm less DON than expect while the worst lines accumulated 5.84 ppm more DON than expected.
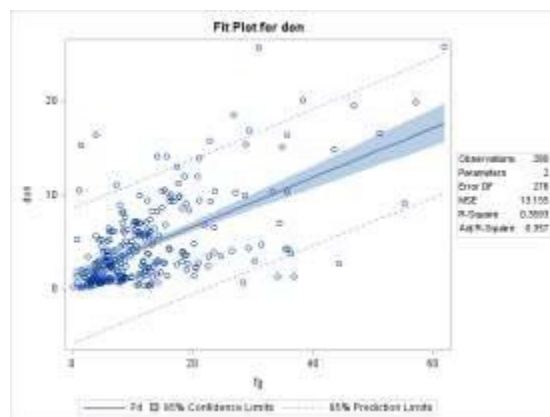

Figure 2. Regression of DON onto fungal biomass (Fg)

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

One PhD student is being trained through this project.

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

The results are preliminary and have not been distributed.

Publications, Conference Papers, and Presentations

Please include a listing of all your publications/presentations about your <u>FHB work</u> that were a result of funding from your FY21 grant award. Only citations for publications <u>published</u> (submitted or accepted) or presentations <u>presented</u> 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 award

> 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).

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.

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

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