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

FY22 Performance Progress Report

Due date: July 26, 2023

Cover Page

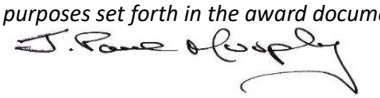
USDA-ARS Agreement ID:	59-0206-2-136
USDA-ARS Agreement Title:	Fusarium Head Blight Breeding Research at North Carolina State University
Principle Investigator (PI):	J. Paul Murphy
Institution:	North Carolina State University
Institution UEI:	U3NVH931QJJ3
Fiscal Year:	2022
FY22 USDA-ARS Award Amount:	$127,638
PI Mailing Address:	North Carolina State University, Department of Crop Science Box 7629, 840 Method Rd, Unit 3 Raleigh, NC 27695
PI E-mail:	paul_murphy@ncsu.edu
PI Phone:	919-610-0100
Period of Performance:	May 1, 2022 – April 30, 2024
Reporting Period End Date:	April 30, 2023

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
VDHR-SWW	Enhancement of Fusarium Head Blight Resistance in the Southeastern U.S. Germplasm	$111,434
VDHR-SWW	A Double Haploid Initiative to Speed Development of FHB Resistant Soft Winter Wheat.	$16,204
	FY22 Total ARS Award Amount	$127,638

I am submitting this report as an: ☒ Annual 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

7/12/2023
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: Enhancement of Fusarium Head Blight Resistance in the Southeastern U.S. Germplasm

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

1) Increase the number of varieties with improved FHB resistance and other important traits to reduce DON in the US grain supply, 2) increase efficiency of Coordinated Project breeding programs by enhancing cooperation and coordination of research, and 3) evaluate and implement modern breeding technologies to further enhance short term and long-term improvement of FHB resistance.

2. What was accomplished under these goals or objectives?

Objective 1) Increase the number of varieties with improved FHB resistance and other important traits to reduce DON in the US grain supply.

a) What were the major activities?

Over 200 F_2 and F_3 bulks (combined) advanced utilizing mass selection. Almost all crosses contained one or more parents exhibiting moderate FHB resistance. Over 4,000 head rows in the F_5 and F_6 generations (combined) underwent selection using the pedigree method. We evaluated approximately 500 advanced lines ($F_{5:7}$ or greater) at two locations. Entered advanced lines in two uniform nurseries (Uniform Southern and Uniform Scab).The misted and inoculated nursery evaluated five cooperative uniform nurseries (USFHBN, GAWN) and the NC Official Variety Test.

b) What were the significant results?

NC18-16900 (*Fhb1, Fhb1BJ, FHB 4AN, Lr18, Pm1a, H13)* was among the highest yielding lines in the state Official Commercial Variety Test. It contains a stack of three scab resistance genes plus leaf rust, powdery mildew and Hessian fly genes). It will go to NC Foundation Seed this fall for increase prior to release. Five of the seven highest yielding lines in the state Official Experimental Variety test were NC State bred with moderate scab resistance and overall good agronomic performance.

c) List key outcomes or other achievements.

Enough data has been assembled to write up a release package for NC18-16900. Breeders seed of two more lines (NC13217-211 and NC1530-747) that performed well in state or regional tests has been produced.

Objective 2) Increase efficiency of Coordinated Project breeding programs by enhancing cooperation and coordination of research,

a) What were the major activities?

We coordinated the annual Southern Uniform Scab Nursery for seven public and one private breeding programs. There were 60 experimental entries and six checks. I collated and summarized data and published a report on the USWBSI website. I participated in coordinated breeding activities with the seven-university SUNGRAINS cooperative breeding

program. Jeanette Lyerly, a Research Associate on my project, ran the Genomic Selection activities in the CP.

b) What were the significant results?

The annual Uniform Nursery report was published online at https://scabusa.org/pdfs_dbupload/suwwsn22_report.pdf. This report contained a diverse set of information for breeding programs that included not only multi-state disease resistance evaluation but, in addition, updates on the effectiveness of the training population used for genomic selection, QTL content of entries and advice on the optimum cross combinations to make in developing future breeding populations. I also included some historical information related to the first Uniform Scab Nursery in 2000. The quantification of scab resistance of entries in the SUNGRAINS nurseries influenced the advancement decisions of seven university breeding programs. Genomic predictions for scab resistance in addition to yield, test weight, powdery mildew, leaf and stripe rust resistances for over 5,000 advanced lines were distributed to breeders in March of each year prior to field selection.

c) List key outcomes or other achievements.

The Southern Uniform Scab Nursery provides public and private sector breeders with multi-environment evaluations of FHB resistance in advanced generation breeding lines compared with the resistant check varieties. The report contains a large set of information to assist in breeding for scab resistance. Correlations between predicted and observed measures for scab resistance consistently ranged over 0.50. Our seven years of applied experience with genomic predictions for scab resistance and yield strongly suggest that the initial selection for both these key traits can be made based on genomic predictions rather than field evaluations without detrimental impact on a program.

Objective 3) Evaluate and implement modern breeding technologies to further enhance short term and long-term improvement of FHB resistance.

a) What were the major activities?

The improvement of genomic predictions for Fusarium Damaged Kernels (FDK) and DON was investigated from Uniform Scab Nursery historic data tracing back to 2012. Emphasis was placed on check line performance in each environment.

b) What were the significant results?

The best clusters of environments to use for a training population included higher heritability environments, but also those with clear separation of susceptible and resistant check means. Different clusters of environments gave the highest response for DON and FDK.

c) List key outcomes or other achievements.

The data from the Southern Uniform Winter Wheat Nursery may be used for genomic prediction. Creating training populations based on similar check performance improves forward genomic predictive accuracies. Filtering out locations with low genomic, per-plot, and narrow-sense heritability may improve predictive accuracies.

3. **What opportunities for training and professional development has the project provided?**
   Three undergraduate students worked in scab nurseries and on post-harvest processing of materials harvested from the scab nurseries. They worked with the project leader and PhD graduate student on these activities. Zachary Winn (PhD student) organized and conducted the NC Uniform Scab Nursery

4. **How have the results been disseminated to communities of interest?**
   The Southern Scab Nursery report can be found at can be found at this website: https://scabusa.org/pdfs_dbupload/suwwsn22_report.pdf. Presentations made at NC producers meetings and field days in August 2022 and January 2023. Presentations at Scab Forum (Dec 22) and Plant and Animal Genome Conference (Jan. 23). Three published manuscripts (see below).

Project 2: A Double Haploid Initiative to Speed Development of FHB Resistant Soft Winter Wheat.

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1. **What are the major goals and objectives of the research project?**
   The goal of this proposal is to expand the regional Double Haploid (DH) initiative to more quickly develop and release high-yielding varieties that contain an effective FHB resistance pyramid.

2. **What was accomplished under these goals or objectives?**
   a) **What were the major activities?**
   Between 22 and 57 percent of advanced generation lines in field testing are doubled haploids. Three of five of the best advanced lines in state Official Varity Trials are of double haploid origin. They are present in those trials at a far greater rate than is warranted based on the number of crosses involved in their generation.

   F1 seed of three crosses were sent to Heartland Plant Innovations in spring 2022 for DH production. Unfortunately, DH seed of those lines has not been received from at this time. I am hopeful they will be here for fall planting. The pedigrees were:

   16VDH-SRW03-018 / GA151313-LDH-192-20E48
   LANC11558-33 / AR15V25-19-2174N
   LANC11558-33 / GA151313-LDH-192-20E48
   The request was for 125 DH's per cross, or a total of 375.

   b) **What were the significant results?**
   Twenty four of the DHs evaluated in head rows were advanced to first year yield testing in 2023. Of the 468 lines in the F_7 and later generation yield trials in 2023, 20% will be doubled haploids.

   c) **List key outcomes or other achievements.**
   Materials are successfully moving through the variety development pipeline with savings of three to four years. The value of this effort is seen by the overrepresentation of DH's in advanced generation yield trials.

3. **What opportunities for training and professional development has the project provided?**
   Three undergraduate students worked in the DH nursery at harvest and on post-harvest processing of materials in preparation for fall planting. They worked with the project leader and PhD graduate student on these activities.

4. **How have the results been disseminated to communities of interest?**
   The materials are shared with other members of the CP

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 FY22 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 May 1, 2022 – April 30, 2023?

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

☐ No, I have nothing to report.

Journal publications as a result of FY22 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).

Winn, Z. J., J. Lyerly, B. Ward, G. Brown-Guedira, R. E. Boyles, M. Mergoum, J. Johnson, S. Harrison, A. Babar, R. E. Mason, R. Sutton, J. P. Murphy. 2022. Profiling of Fusarium Head Blight Resistance QTL Haplotypes Through Molecular Markers, Genotyping-by-Sequencing, and Machine Learning. TAG: 135: 3177-94. doi: 10.1007/s00122-022-04178-w. Federal support -- Yes

Winn, Z. J., J. Lyerly, G Brown-Guedira, J. P. Murphy and R. E. Mason. 2023. Utilization of a publicly available diversity panel in genomic prediction of Fusarium head blight resistance traits in wheat. The Plant Genome. DOI:10.1002/tpg2.20353. Federal support -- Yes

Ackerman, A. J., R. Holmes, E. Gaskins, K. E. Jordan, D. S. Hicks, J. Fitzgerald, C. A. Griffey, R. E. Mason, S. A. Harrison, J. P. Murphy, C. Cowger, and R. E. Boyles. 2022. Evaluation of Methods for Measuring Fusarium-Damaged Kernels of Wheat. Agronomy 12, no. 2: 532. https://doi.org/10.3390/agronomy12020532

Books or other non-periodical, one-time publications as a result of FY22 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 FY22 award

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

Winn, Z. J., J. Lyerly, G Brown-Guedira, and J. P. Murphy. (2022). Utilization of a Historical Diversity Panel in Genomic Prediction of Fusarium Head Blight of Wheat. Proceedings of the 2022 National Fusarium Head Blight Forum; Tampa, FL. December 4-6, 2022. Retrieved from: https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf

Winn, Z. J., J. Lyerly, B. Ward, G. Brown-Guedira, R. E. Boyles, M. Mergoum, J. Johnson, S. Harrison, A. Babar, R. E. Mason, R. Sutton, J. P. Murphy. "Leveraging Historical Genomic Information to Profile Major Effect QTL in Early Development Germplasm Via Machine Learning", Plant and Animal Genomics (PAG), 2023.