

## FY21 Performance Progress Report

**Due date:** July 26, 2022

### Cover Page

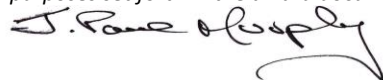
<b>Principle Investigator (PI):</b>	J. Paul Murphy
<b>Institution:</b>	North Carolina State University
<b>E-mail:</b>	paul_murphy@ncsu.edu
<b>Phone:</b>	919-610-0100
<b>Fiscal Year:</b>	2021
<b>USDA-ARS Agreement ID:</b>	59-0206-0-145
<b>USDA-ARS Agreement Title:</b>	Enhancement of Fusarium Head Blight Resistance in the Southeastern U.S. Germplasm
<b>FY20 USDA-ARS Award Amount:</b>	\$127,074
<b>Recipient Organization:</b>	North Carolina State University Department of Crop Science Box 7629, 840 Method Rd, Unit 3 Raleigh, NC 27695
<b>DUNS Number:</b>	04-209-2122
<b>EIN:</b>	56-6000756
<b>Recipient Identifying Number or Account Number, if any:</b>	567134
<b>Project/Grant Period:</b>	6/16/21 - 6/15/23
<b>Reporting Period End Date:</b>	6/15/2022

### 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. Wheat Breeding Programs	\$112,686
VDHR-SWW	Double Haploids to Expedite Development of FHB Resistant Soft Winter Wheat Varieties	\$14,388
<b>FY21 Total ARS Award Amount</b>		<b>\$127,074</b>

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 18, 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:** Enhancement of Fusarium Head Blight Resistance in the Southeastern U.S. Wheat Breeding Programs

---

**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.

**What was accomplished under these goals or objectives?** *(For each major goal/objective, address these three items below.)*

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 400 F<sub>2</sub> and F<sub>3</sub> bulks (combined) were advanced utilizing mass selection. Almost all crosses contained one or more parents exhibiting moderate FHB resistance. Over 18,000 head rows in the F<sub>4</sub>, F<sub>5</sub> and F<sub>6</sub> generations (combined) underwent selection using the pedigree method. Approximately 900 doubled haploids shared among breeding programs in the CP were evaluated in head rows at the Kinston Research station. The misted and inoculated nursery evaluated five cooperative uniform nurseries (USFHBN, GAWN, SPE, SPL and SUNWHEAT) and the NC Official Variety Test.

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

Eight of the highest yielding lines in the NC Official Variety Test 2022 were NC State bred with moderate scab resistance and overall good agronomic performance. All of these NCSU entries in the NC Official Variety Test 2022 had moderate levels of scab resistance plus overall good agronomic performance. Eighty three percent of lines in the Wheat Advanced test had ratings of 3 or lower FHB rating (0 – 9) and 61 percent of lines in the Wheat Preliminary Test were rated as moderately resistant to scab.

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

Announcements regarding the release of NC11546-14 have been sent out by NC State. Breeders Seed of three competitive lines with moderate FHB resistance, NC18-16901, NC13211-9 and NC15V25-20 was produced for possible release in 2022 / 23.

2) Increase the 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 five public and one private breeding programs. There were 54 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://www.scabusa.org/pdfs\\_dbupload/suwwsn21\\_report.pdf](https://www.scabusa.org/pdfs_dbupload/suwwsn21_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. 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. Investigated machine learning models to predict scab resistance QTL haplotypes in a large SunGrains data base using sequence data alone and examined their effects in the SUWWN. Finished validation of important QTL for scab resistance identified in NC13-20076 and estimated their frequencies in the southern breeding germplasm using hierarchical clustering of GBS data.. Correlations between predicted and observed measures for scab resistance consistently ranged over 0.50. Our six 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.

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?**

Investigated machine learning models to predict scab resistance QTL haplotypes in a large SunGrains data base using sequence data alone and examined their effects in the SUWWSN. Finished validation of important QTL for scab resistance identified in NC13-20076 and estimated their frequencies in the southern breeding germplasm using hierarchical clustering of GBS data.

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

For all models trained, the predicted *Fhb1*, *Qfhb.vt-1B*, *Qfhb.nc-1A*, and *Qfhb.nc-4A* haplotype estimated effects for SEV, FDK, DON, plant height, and heading date were

not significantly different from their observed KASP call effects. Initial results indicated that a QTL on 1D in NC13-20076 has a significant verified effect and hierarchical clustering of GBS data indicate it is only present in 17 percent of southern germplasm.

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

The machine learning results indicated that this protocol can be utilized in breeding programs to accurately impute QTL haplotypes in earlier generations via a GBS and KASP genotyped training population. It was successfully utilized in spring 2022 on over 5,000 SunGrains lines to provide probable QTL content from GBS data two years before routine KASP assays. This is a huge boost in efficiency through savings in time and labor. The use of hierarchical clustering also enhanced standard QTL studies to actually find the frequencies of the QTL in breeding germplasm, and verify their effects in a relevant broad germplasm database.

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

Six 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) attended the virtual Scab Forum in 2021. Zachary Winn organized and conducted the NC Uniform Scab Nursery

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

The Southern Scab Nursery reports for both years can be found at can be found at this website: [https://www.scabusa.org/pdfs\\_dbupload/suwwsn21\\_report.pdf](https://www.scabusa.org/pdfs_dbupload/suwwsn21_report.pdf).

Presentations were made at NC producers meetings and field days in August 2021 and January 2022. Manuscript on QTL mapping has been submitted to the Journal Cop Science.



**Project 2:** Double Haploids to Expedite Development of FHB Resistant Soft Winter Wheat Varieties

---

**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?**

Two hundred sixty seven DHs were evaluated in head rows at Kinston, NC for overall agronomic quality. They consisted of 102 from NCSU, 62 from LSU, 70 from UGA and 33 from VA Tech. Of the 616 lines in the F<sub>7</sub> and later generation yield trials, 31% were doubled haploids. 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. They 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<sub>7</sub> 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?**

Six 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 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).

Winn, Z. J., R. Acharya, J. Lyerly, G. Brown-Guedira, C. Cowger, C. Griffey, J. Fitzgerald, R. E. Mason, and J. P. Murphy. 2022. Mapping of *Fusarium* Head Blight Resistance QTL in Soft Red Winter Wheat and Estimation of Their Effects in Regional Germplasm. *Crop Sci.* (Accepted); acknowledgement of federal support - yes.

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. Profiling of *Fusarium* Head Blight Resistance QTL Haplotypes through Molecular Markers, Genotyping-by-Sequencing, and Machine Learning. (TAAG-D-22-00108R1) (Accepted); acknowledgement of federal support - 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).

None

### 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.

J. P. Murphy, J. H. Lyerly, J. Page, Z. Winn and G. Brown-Guedira. 2021. The 2021 Uniform Southern Soft Red Winter wheat Scab Nursery Report. Also available at [https://scabusa.org/pdfs\\_dbupload/suwwsn21\\_report.pdf](https://scabusa.org/pdfs_dbupload/suwwsn21_report.pdf)