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

FY22 Performance Progress Report

Due date: July 26, 2023

Cover Page

USDA-ARS Agreement ID:	59-0206-2-092
USDA-ARS Agreement Title:	Breeding for Fusarium Head Blight (FHB) Resistance in Spring Wheat
Principle Investigator (PI):	James Anderson
Institution:	University of Minnesota
Institution UEI:	KABJZBBJ4B54
Fiscal Year:	2022
FY22 USDA-ARS Award Amount:	$155,283
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Period of Performance:	May 1, 2022 – April 30, 2026
Reporting Period End Date:	April 30, 2023

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
VDHR-SPR	Breeding and Genomic Selection for Fusarium Head Blight Resistance in Spring Wheat	$155,283
	FY22 Total ARS Award Amount	$155,283

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.

James A. Anderson _____ _____ July 21, 2023

Principal Investigator Signature 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: Breeding and Genomic Selection for Fusarium Head Blight Resistance in Spring Wheat

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

Objective 1) Develop Fusarium head blight resistant wheat germplasm and varieties adapted for commercial production in Minnesota and the surrounding region
Objective 2) Characterize the level of FHB resistance of all wheat varieties grown in the region
Objective 3) Use DNA markers to characterize potential parental lines and utilize MAS and genomic selection to increase frequency of FHB QTLs in advanced lines

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?

Objectives 1-2: Scab nurseries were established at two field sites, Crookston and St. Paul, in 2022. A total of 1,336 genotypes + checks were evaluated in 1 to 3 replications for a total of 3,924 single row plots across the two locations. We evaluated the FHB reaction of external germplasm from the 2022 Uniform Regional Scab Nursery (27 lines) and 2022 Regional Performance Nursery (27 lines) and 45 named varieties in our statewide performance trials. We completed Visual Scabby Kernel (VSK) assessment of all materials from these nurseries and received DON data from select materials, predominantly the most advanced nurseries. FHB ratings (1-9 scale) were assigned to all the named varieties.

Objective 3: We obtained GBS data from 3251 of 3268 F_5 lines using GBS. Genomic predictions were formulated from a training population of a subset of 265 lines and parents that were phenotyped for FHB field disease severity, VSK and test weight. Marker-assisted selection was also used to characterize parental lines (done in-house) and the F_5 lines (in cooperation with the USDA-ARS Small Grains Genotyping Center in Fargo). We routinely use DNA markers to screen for genes that provide resistance to Fusarium head blight, leaf rust, Ug99 stem rust resistance, semi-dwarfing, and high molecular weight glutenins that are necessary for good baking quality. The Fargo Genotyping Center provided data on 14 gene-specific markers on 3306 F_5 lines and 55 parents of F_5 materials, generating 46,284 marker data points. We used the MAS data from the 14 markers, genomic predictions for FHB, and observations from our winter nursery in New Zealand, including seed size measurements to select a set of 360 lines for entry into preliminary yield trials in spring 2023. In addition, since Fall 2022 we screened 1524 individual F_1 plants from topcrosses and backcrosses and 55 parents from Fall 2022 and Spring 2023 crossing blocks for as many as 74 markers in-house, generating a total of 15,633 datapoints.

b) What were the significant results?

- Our Crookston and St. Paul FHB screening nurseries provided good data in 2022. Disease index in the AY1 (with named varieties) was excellent, providing highly discriminatory data.

Across the two locations, disease index averaged 31.2% (range 11-81%), VSK 15.5% (6-73%). The Crookston nursery produced high DON levels, averaging 11.2 ppm (range 3.7-33) while St. Paul was unexpectedly low, averaging 4.5 ppm (0.5-12.5). From the 2022 FHB nursery data and results from previous years, the FHB resistance of 36 spring wheat cultivars was assessed and reported.

- We used genomic selection at the F_5 stage for FHB to help select lines to advance to preliminary yield trials. Fortunately, in-person travel to our New Zealand winter nursery was allowed so that phenotypic assessment and predictions could both be used to select lines to advance to our 2023 preliminary yield trials.
- 'MN-Torgy', released in 2020 was the most popular wheat in Minnesota in 2022, according to a variety survey conducted by the MN Assoc. of Wheat Growers. MN-Torgy was grown on 21.7% of the state's 1.25 million acres.

c) List key outcomes or other achievements.

High yielding wheat varieties with high grain protein content, good straw strength and good scab resistance are in demand by wheat growers because they greatly influence the profitability of wheat production in Minnesota. Recent releases include 'Linkert' (2013), 'Bolles' (2015), 'Shelly' (2016), 'Lang-MN' (2017), 'MN-Washburn' (2019), 'MN-Torgy' (2020), and 'MN-Rothsay' (2022). University of Minnesota developed spring wheat varieties accounted for an estimated 34.5% of Minnesota's 1.25 million spring wheat acres in 2022 and MN-Torgy, released in 2020, was the no. 1 wheat variety in Minnesota in 2022, grown on 21.7% of the state's wheat acres. UMN-developed varieties were also grown on more than 10% of North Dakota's 5.4 million spring wheat acres. Germplasm from our breeding program is being used as parents by private and public breeding programs in the region. We also coordinate the testing and reporting of performance testing of ~40 public and private released hard spring wheat varieties per year in statewide trials to assess their performance in yield nurseries, end-use quality, and reactions to important diseases. This information is critical for growers to make informed choices among varieties.

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

All members of my project, regardless of what species they work on (wheat, intermediate wheatgrass, or field pennycress) help with inoculation and scoring of our FHB nurseries. This provides them with knowledge of the importance of this disease and our screening methodologies.

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

Wheat cultivar performance, including FHB reaction, of 38 spring wheat cultivars was assessed and reported to growers via print media, web-accessible publications, winter meetings, and field day presentations. We routinely enter five lines in the regional FHB nursery and a variety candidate performance nursery. The data of these nurseries is publicly available and other participants in the nursery have access to cross with this germplasm.

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?

x 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).

Adeyemo, E., E. Conley, R. Bernardo, P. Bajgain, and J.A. Anderson. 2023. Combining Datasets to Routinely Predict Fusarium Head Blight Resistance in a Wheat Breeding Program. Crop Sci. DOI: 10.1002/csc2.20929. Acknowledgment of federal support: yes

Hay, W.T., J.A. Anderson, S.P. McCormick, M.P. Hojilla-Evangelista, G.W. Selling, K.D. Utt, M.J. Bowman, K.M. Doll, K.L. Ascher, M.A. Berhow, and M.M. Vaughan. 2022. Fusarium head blight resistance exacerbates nutritional loss of wheat grain at elevated CO2. Scientific Reports https://doi-org.ezp3.lib.umn.edu/10.1038/s41598-021-03890-9. Acknowledgment of federal support: no

Zhang, J. A. Min, B.J. Steffenson, W.-H. Su, C.D. Hirsch, J. Anderson, J. Wei, Q. Ma, and C. Yang. 2022. Wheat-Net: An Automatic Dense Wheat Spike Segmentation Method Based on an Optimized Hybrid Task Cascade Model. Front. Plant Sci. https://doi.org/10.3389/fpls.2022.834938 Acknowledgment of federal support: yes

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.