

FY21 Performance Progress Report

Due date: July 26, 2022

Cover Page

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| Phone: | 330-263-3876 |
| Fiscal Year: | 2021 |
| USDA-ARS Agreement ID: | 59-0206-0-174 |
| USDA-ARS Agreement Title: | DON Accumulation and Fusarium Head Blight Resistance in Winter Barley |
| FY20 USDA-ARS Award Amount: | \$59,961 |
| Recipient Organization: | The Ohio State University Department of Horticulture and Crop Science OARDC, 1680 Madison Ave Wooster, OH 44691 |
| DUNS Number: | 07-165-0709 |
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| Recipient Identifying Number or Account Number, if any: | GRT00060260 |
| Project/Grant Period: | 5/15/21 - 5/14/23 |
| Reporting Period End Date: | 5/14/2022 |

USWBSI Individual Project(s)

| USWBSI Research Category* | Project Title | ARS Award Amount |
|------------------------------------|---|------------------|
| BAR-CP | Establishing a Winter Barley Fusarium Head Blight Screening Nursery in Ohio | \$59,961 |
| FY21 Total ARS Award Amount | | \$59,961 |

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.

July 26, 2022

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: Establishing a Winter Barley Fusarium Head Blight Screening Nursery in Ohio

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

The overall project goal was to:

Identify winter barley lines possessing resistance to *Fusarium graminearum* toxin accumulation and incorporate that genetic resistance into modern elite two-row winter malting barley cultivars.

The specific objectives for this project were to:

- 1) Assess lines in the Ohio Winter Malting Barley Breeding Program for resistances to FHB and fungal toxin accumulation
- 2) Assess a mapping population derived from a FHB-resistant parent for resistances to FHB and fungal toxin accumulation.
- 3) Establish a uniform winter barley scab nursery consisting of a core set of 20–30 lines, and test this set for resistances to Fusarium Head Blight (FHB) and fungal toxin accumulation.

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 planted the Ohio winter barley scab nursery October 12, 2021. This was the 2nd year we planted a winter barley scab nursery in Ohio. Each line was planted in three reps. For Objective 1 we assessed a population of ~380 highly-diverse two-row winter barley lines associated with the Ohio breeding program. For Objective 2 we assessed a population of 82 recombinant lines from the 95SR316A × Charles cross, a population we refer to as the “Bregitzer population” in recognition of its developer, who had preliminary data indicating the population is segregating for FHB resistance. For Objective 3 we planted 45 lines that comprise the winter North American Barley Scab Evaluation Nursery (NABSEN), a set of lines being tested in scab nurseries across North America. Included in the latter are four two-row and four six-row controls, selected as being the best to represent the susceptible to resistant spectrum for both visual and DON level resistance level differences by the eight participants planting the NABSEN. Six North American winter barley breeders submitted their lines for testing in the 2021–22 NABSEN. We are also the coordinator of the NABSEN. Combined, we are testing approximately 500 different barley lines in Ohio the 2021–22 season.

An overhead irrigation system was put in place prior to heading. Early in canopy development (April 22, 2022) the nursery was inoculated with multiple race isolates of Ohio *F. graminearum* using corn cob "spawn" placed in nursery rows. Heading date of each line was recorded. At the first sign of head emergence (Zadoks 51-53) and prior to pollen dehiscence, heads were spray-inoculated using a backpack sprayer at two-day intervals with asexual spores, also derived from multiple Ohio pathogenic races. The field was overhead irrigated intermittently for 5 minutes every

20 minutes between 5:00 AM and 10:00 AM, and again between 5:00 PM and 10:00 PM throughout anthesis, and for seven days following the latest line completing anthesis.

To obtain an index of disease severity, each rep of every line was independently rated by three individuals for visual symptoms using a 1-10 scale. The three independent disease severity scores were then compiled to obtain a mean index rating for each line. Mean indexes of the 2021–22 scab nursery were then compared to the mean indexes of the 2020–21 scab nursery.

At maturity, the reps were hand-harvested and bulked to create a composite. The composite was then threshed in a stationary lab thresher to obtain clean seed. This material is currently being ground using coffee grinders. Once all samples are ground they will be sent to the lab of Yanhong Dong, Department of Plant Pathology, University of Minnesota for DON analyses.

The Ohio 2020–21 scab nursery DON measurements were made in the lab of Yanhong Dong, University of Minnesota. Each sample analyzed was the composite of two replicates grown in an inoculated and misted nursery. Receipt of that DON data occurred January 2022. Following the receipt of the DON data, crosses were made using low DON accumulating lines as parents.

A subset of the lines were genotyped using the Barley 50k iSelect SNP Array.

b) What were the significant results?

2020–21 Ohio scab nursery DON levels

DON values for the OH set, excluding the checks, ranged from 21.1 (Wong) to 124.7 ppm ('Mercer'). The Ohio set was planted September 28, 2020.

DON values for the Bregitzer population ranged from 46.5 ppm (95SR316A) to 123.0 ppm DON (12ID60). The Bregitzer population set was planted October 15, 2020.

Within the Ohio set, MO B2549 exhibited values (22.1 ppm) nearly identical to that of 'Wong' (21.1 ppm) and very similar to 'Carstens' (36.8), which are the parents of MO B2549. Ohio selection 2011-725-02, which is the offspring of 'Endeavor' × MO B2549, exhibited intermediate values (43.9 ppm), while 'Endeavor' was substantially higher (58.3 ppm), which was just under the mean of 60.5 ppm for the ~170 highly-diverse two-row winter barley lines tested in the Ohio set. These data suggest the possibility of a genetic basis for resistance, but the data are too preliminary at this stage to draw a conclusion. The relatively high value exhibited by 'Endeavor' was also a bit unexpected, as 'Endeavor' was selected by participants of the winter NABSEN for its high levels of resistance to *F. graminearum*, both in terms of visual disease indexes and DON accumulation levels.

Within the Bregitzer population set, 95SR316A exhibited the lowest value (46.5 ppm), 12ID60 the highest value (123.0 ppm), and 'Charles' an intermediate value (64.4 ppm). While the low value of 95SR316A is consistent with it being the hypothesized source of resistance in the population (P.B., personal communication), 'Secretariate' and 'Atlantic', exhibited DON levels lower than 95SR316A (24.3 ppm and 29.9, ppm, respectively). This latter result was unexpected because 'Secretariate' and 'Atlantic' were previously found to exhibit intermediate levels of susceptibility (Wynse Brooks, personal communication).

One very unexpected result was that the values detected in the Ohio scab nursery were an order of magnitude greater than the values recorded by others in their nurseries (Cowger, C., Arellano, C., Marshall, D. and Fitzgerald, J.; Managing Fusarium head blight in winter barley with cultivar resistance and fungicide; Plant Disease, 103: 2019; 1858-1864; published [10.1094/PDIS-09-18-1582-RE]).

Nonetheless, despite the exceedingly high values there was good concordance between each of the two reps of 'Charles' in the Ohio set (64.4 ppm and 65.9 ppm) and with 'Charles' in the Bregitzer population set (64.4). The planting dates of these two nurseries were separated by 17 days.

While the DON data must be considered preliminary, the data suggest there might be resistance segregating in the ID population and that many of the lines in the Ohio set may possess resistance. It will be critical to assess DON data for the 2021-22 set.

Presently we do not have an explanation for why the susceptible check varieties supplied by Virginia Tech (VT) exhibited DON values at the lowest end of the spectrum. One possibility is that the very low DON values observed with the VT lines is related to their very early maturity, relative to the Ohio lines.

Again, the data are too preliminary to draw a conclusion at this time, particularly with regard to the exceedingly high DON values detected for all lines in the Ohio nursery and the unexpectedly low values of the VT susceptible lines.

2021–22 Ohio scab nursery disease index ratings relative to the 2020–21 nursery

Comparison of the mean disease index ratings of the 2021–22 nursery to the 2020–21 indicated a general trend of lower values for the 2021–22 season. This trend was observed for the sets of Ohio lines entered into the Ohio scab nursery and tested both years, the check lines supplied by VT, and the check lines used in the NABSEN. The average rating of a subset of the Ohio lines indicated about a 16% lower incidence index overall. Nonetheless, some lines were given disease incidence index scores much lower than this 16%, while a few lines exhibited much higher disease index scores relative to the 2020–21 season.

In the instance of the check lines provided by VT, despite the trend towards lower overall mean disease index scores, the range between the highest and lowest values assigned was about the same as the 2020–21 season (Table 1).

In the instance of the check lines used for the NABSEN, the means were much lower (Table 1).

Table 1. Disease index ratings of the check lines tested 2021–22 and 2020–21.

| | | Mean | | Lowest | | Highest | |
|----------------------|--------------|------|------|--------|------|---------|------|
| | | 2021 | 2022 | 2021 | 2022 | 2021 | 2022 |
| Virginia Controls | Line | | | | | | |
| | VA15H-73 | 28 | 31 | 15 | 13 | 48 | 34 |
| | SB255 | 77 | - | 66 | - | 92 | - |
| | Secretariat | 83 | 80 | 78 | 66 | 92 | 88 |
| NASBAN | Atlantic | 90 | 79 | 84 | 67 | 94 | 86 |
| | Endeavor | 71 | 31 | - | 19 | - | 42 |
| | Calypso | 52 | 36 | - | 22 | - | 43 |
| | Wintmalt | 81 | 40 | - | 25 | - | 51 |
| | Thoroughbred | 92 | 61 | - | 48 | - | 71 |

c) List key outcomes or other achievements.

A winter barley scab nursery has been established in Ohio, an environment ideal to screen for FHB resistance because high disease pressure is high enough each year to produce solid reactions that enable distinguishing resistant lines from susceptible lines, and winter temperatures are not so cold so as to kill the overwintering plants, yet they are cold enough to effect flowering through vernalization. Our experience the first season guided substantial improvements in the design of the scab nursery we used the second season, which maximizes data quality and minimizes experimental error. Together, the environmental factors and the nursery redesign have enabled us to screen highly diverse sets of winter barley lines for FHB resistance. Given the predicted large increases in acreages on which winter malting barley will be grown in the region, identifying resistance in germplasm that is well adapted to the region is of vital importance to the industry. The finding that many of the winter barley lines within the Ohio breeding program and those comprising foundation parents and ancestral lines of the breeding program accumulate very low levels of DON suggests resistance is heritable and is segregating in our germplasm. While the DON data result from only one season of testing, they are nonetheless encouraging. With additional location and trial years of testing, alongside genetic fingerprinting of the lines in the Ohio program it should be possible to predict and breed for resistance.

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

This project provided tremendous opportunities for learning and professional development for a technician and three undergraduate summer student researchers. The technician in

particular made significant advances in redesigning the scab nursery after the first season. These changes minimize errors and maximize data quality. All changes were initiated by the technician. The changes include: (1) use of wheat as a spacer between rows of barley to reduce or altogether eliminate tangling of different barley lines as a consequence of lodging, (2) the spatial separation of barley lines in which lodging susceptible lines were grouped together and separated spatially, from lodging-resistant lines. This change minimized lodging of lodging-resistant lines caused by a lodging-susceptible line falling into the plot of the lodging-resistant line, and (3) taller irrigation risers that lessened the direct horizontal impact to standing plants. In this way we were better able to screen a wide and diverse collection of barley germplasm without compromising the data quality.

The project also provided the lead technician with the opportunity to lead and manage a team, and to directly interact with the public. This latter opportunity was impromptu and happened because the derecho storm that caused widespread destruction and left roads impassable in the PI's residential area the night before the small grains field day. For the undergraduate summer student research helpers this project has provided their first employment opportunity. The project has allowed them to experience firsthand what it is like to work as a team in an academic research and teaching environment.

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

The results of the 2020–21 scab nursery were presented at the 2021 National Fusarium Head Blight Forum, Virtual Meeting. December 6–7, 2021. Workings of the Ohio scab nursery were presented to the Ohio wheat, corn, and small grains farmer group attending the Wooster small grains field day, June 14, 2022.

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).

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).

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.

Eggers, B, and Stockinger, E.J. DON accumulation and Fusarium Head Blight resistance in winter barley. Proceedings of the 2021 National Fusarium Head Blight Forum; Virtual. December 6-7, 2021. Retrieved from: <https://scabusa.org/forum/2021/2021NFHBFForumProceedings.pdf>