USDA-ARS
U.S. Wheat and Barley Scab Initiative
FY20 Annual Performance Progress Report
Due date: August 31, 2021

Cover Page

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Fiscal Year:	2020
USDA-ARS Agreement ID:	59-0206-0-146
USDA-ARS Agreement Title:	Improving FHB Resistance in Barley and Wheat using Breeding and Genomics Methods
FY20 USDA-ARS Award Amount:	$ 190,670
Recipient Organization:	Virginia Polytechnic Institute and State University 1880 Pratt Drive, Suite 2006 Blacksburg, VA 24060
DUNS Number:	003137015
EIN:	54-6001805
Recipient Identifying Number or Account Number:	423543
Project/Grant Reporting Period:	6/17/20 - 6/16/21
Reporting Period End Date:	6/16/2021

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
BAR-CP	Cultivar Development, and Mapping of FHB Resistance QTL in Native Cultivars Nomini and Eve	$ 59,202
VDHR-SWW	Improving FHB Resistance in Winter Wheat via Traditional, GS, MAS and DH Methods	$ 118,217
VDHR-SWW	Double Haploids to Expedite Development of FHB Resistant Soft Winter Wheat Varieties	$ 13,251
	FY20 Total ARS Award Amount	**$ 190,670**

Nicholos Santantonio 8/31/2021

Principal Investigator Date

* MGMT – FHB Management
FST – Food Safety & Toxicology
R- Research
S – Service (DON Testing Labs)
GDER – Gene Discovery & Engineering Resistance
PBG – Pathogen Biology & Genetics
EC-HQ – Executive Committee-Headquarters
BAR-CP – Barley Coordinated Project
DUR-CP – Durum Coordinated Project
HWW-CP – Hard Winter Wheat Coordinated Project
VDHR – Variety Development & Uniform Nurseries – Sub categories are below:
SPR – Spring Wheat Region
NWW – Northern Soft Winter Wheat Region
SWW – Southern Soft Red Winter Wheat Region

Project 1: *Cultivar Development, and Mapping of FHB Resistance QTL in Native Cultivars Nomini and Eve*

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

The specific objectives of this project are: 1) evaluate available barley germplasm for novel sources of FHB resistance; 2) develop barley cultivars with enhanced resistance to FHB and lower DON and; 3) map and validate QTL for FHB resistance in our native winter barley sources

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?

In 2020-21, 1,450 elite barley lines (hulled, hulless and malt) from the VT program, uniform FHB nurseries, regional trials, and other USWBSI collaborators were evaluated for FHB resistance in an inoculated, misted nursery at EVAREC in Warsaw, VA. Additionally, breeding populations derived from crosses made with FHB resistance sources (Island, AC Alberte, Atahulpa, Quest, MN Brite, FEG-4-98, and Fredrickson) are in advanced generations. This season (2020-21), pure lines were evaluated and selected from 1,440 hulled and hulless and 2,640 malt FHB headrows at the Eastern Virginia AREC in Warsaw, VA. Fifty three segregating barley populations for FHB resistance in our scab nursery were evaluated and advanced in the program. Two Nomini mapping populations (Thoroughbred x Nomini (RIL) and Nomini x Violetta (DH)) were evaluated for FHB, morphological traits and DON in Warsaw VA and Kinston, NC location. Including previous years of evaluation, the Thoroughbred x Nomini and Violetta x Nomini populations have been observed in six and three inoculated and misted environments, respectively.

b) What were the significant results?

In spring of 2021, most of the barley crosses (350) included at least one FHB resistant parent (ARS15B12, VA13B-25 LA, VA16BFHB-268 NA, and 12ID2). A total of 75 new FHB crosses were made, and 53 barley breeding populations were evaluated in an inoculated, mist irrigated scab nursery. Individual heads were selected from these families and will be planted in fall of 2021, representing approximately 800 headrows.

An awnless line, VA16BFHB-268 NA, with superior performance to Nomini as a forage barley was developed as part of this project and released in 2021. The newly released awnless cultivar expresses moderate resistance to FHB and lower DON accumulation similar to cultivar ‘Nomini’ and better than cultivars ‘Secretariat’ and ‘Thoroughbred’.

Mapping populations of Thoroughbred / Nomini (RIL) and Nomini / Violetta (DH) were evaluated in an inoculated mist irrigation nursery in Kinston, NC in 2020, where FHB ratings (0-10) in each population averaged 4.8 and 4.2, respectively. Overall, this location provided the only reliable data in 2020 as very cold conditions in Virginia and freezing temperatures in Kentucky severely damaged the barley crop. As we continue to process the FDK and DON samples from each population, the FDK (%) data from Nomini / Violetta averaged 20.9% from the Kinston location. Preliminary linkage analysis has identified several QTL regions in the Thoroughbred / Nomini RIL population along chromosome 2H (Figure 1). Similarly, in the Nomini / Violetta DH population QTL regions were identified on chromosomes 2H and 7H. However, significant correlations differentiating row-types, plant height, and flowering dates with FHB traits were seen in this population across 2018 and 2019 in the Virginia FHB site, as previously reported by others. Investigation into relationships between morphological and phenological traits, and FHB resistance loci is currently being conducted to ensure that identified QTL are not the result of pleiotropic effects. Lines from both populations exhibiting FHB and DON values lower than the parents and checks across 2018-2019 with acceptable agronomic traits were advanced into observation tests in 2020-2021.

c) List key outcomes or other achievements.

Pure lines derived from crosses between FHB resistant spring barley lines and adapted winter barley lines are being developed and evaluated for FHB resistance and agronomic performance. Several candidate regions have been identified as targets for marker assisted selection for FHB resistance, however it is currently unclear if these methods will be as effective as they have been demonstrated to be in winter wheat.

Ongoing research aims to use whole genome information for genomic prediction and selection of FHB traits. Towards this end, all barley lines advanced to yield trials will be genotyped with a high density marker panel to facilitate model development for genomic prediction of FHB traits.

The newly released line, VA16BFHB-268 NA, provides producers in the eastern US, with a better option to cultivar Nomini having good to moderate resistance to prevalent diseases including FHB and low DON accumulation.

3. Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns and/or restrictions, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.

This research was impacted by the COVID-19 pandemic in multiple ways, including setbacks due to mandatory quarantine periods for personnel both in the breeding program and at the experiment station (due to expected exposure), increased costs of

transportation (1 car per person) and accommodations (one room per person) when traveling to the experiment station in Warsaw VA. Contractual services were greatly impeded by supply chain issues and limited working hours, which delayed DON samples processing among other services. Despite these challenges, most of the field, greenhouse and lab operations were completed successfully.

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

This project has provided training for FHB evaluation and screening to employees at the Eastern Virginia AREC including current and new research specialists and undergraduate students. The annual USWBSI meeting has contributed to the professional development of the research lead, Dr. Joshua Fitzgerald, through participation in multiple coordinated projects.

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

Data on FHB index, FDK, ISK, and DON obtained from the Virginia's state barley variety trial are reported at field days and online (https://resources.ext.vt.edu/contentdetail?contentid=3239&contentname=Small%20Grains%20in%202021) to promote selection and production of FHB resistant cultivars.

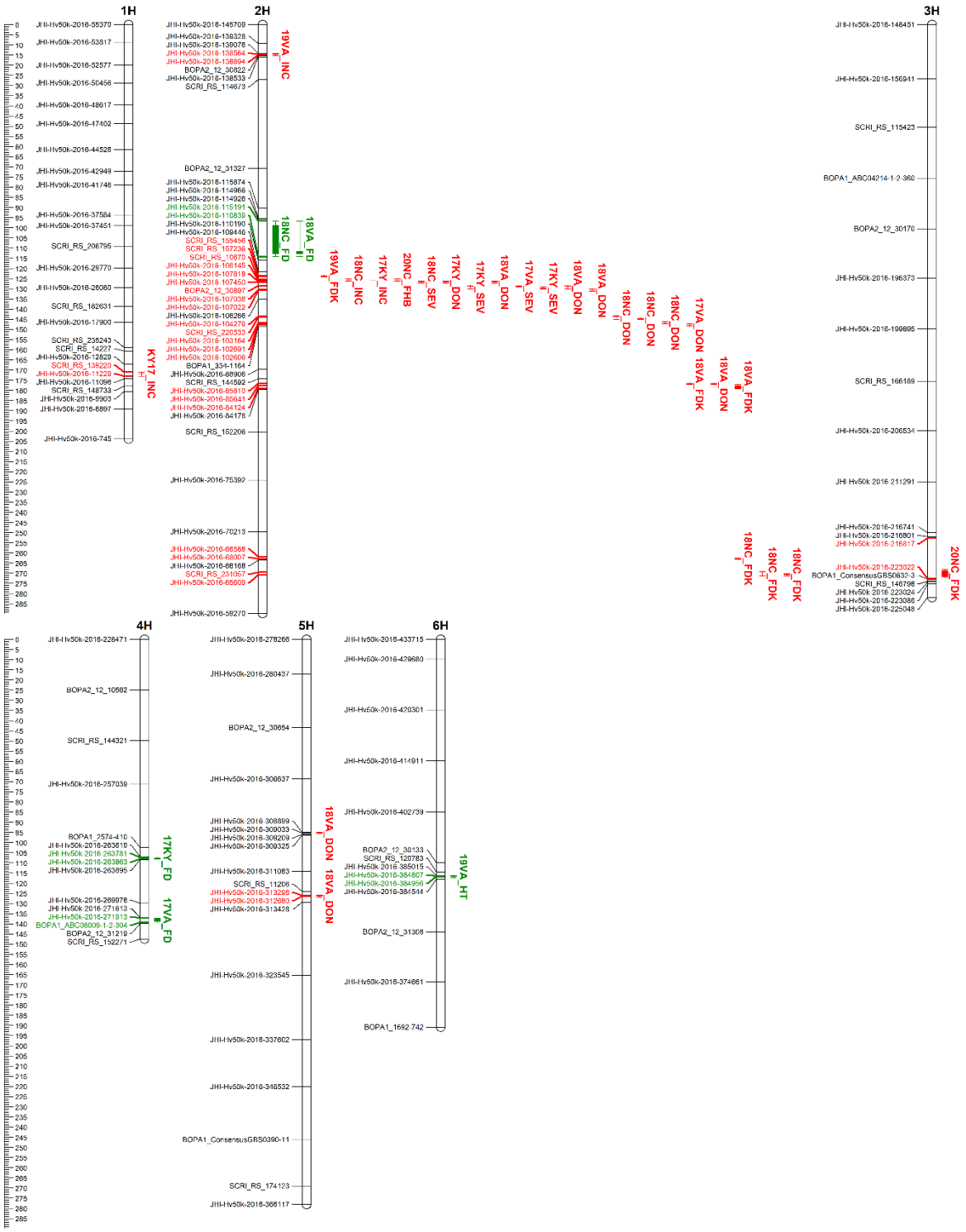

Figure 1: Map of barley chromosome 1H-6H harboring both morphological (green) and FHB (red) QTLs in the THoroughbred x Nomini RIL population evaluated in 6 environments over 2017-2020. Three significant FHB related QTL regions were identified on chromosome 2H spanning 125-132 cM, 145-148 cM, and 264-271 cM, respectively.

Project 2: *Improving FHB Resistance in Winter Wheat via Traditional, GS, MAS and DH Methods*

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

The specific objectives of this research are to: 1) incorporate and combine resistance genes from newly improved scab resistant germplasm and/or scab-tolerant native wheat lines to develop and release commercially viable cultivars and; 2) accelerate the release of scab resistant cultivars and/or germplasm using marker assisted breeding, genomic selection and doubled haploid methods.

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?

Marker haplotypes linked to 9 scab resistance genes located on wheat chromosomes 2D, 3B (*Fhb1*), and 5A of Ning 7840, 1B of Jamestown, 2B and 3B of Bess, 3B of Massey, and 1A, and 6A of Neuse were used to screen, characterize and select parents and their progeny for FHB resistance genes. Marker haplotypes linked to 44 disease resistance, phenological or morphological traits were also screened to select parents with other important agronomic loci. One hundred and four parents were selected based on observed phenotypic scab resistance, FHB marker genotypes and agronomic performance. Of these, 24 lines had positive marker scores for *Fhb1*.

Previous use of genomic estimated breeding values for scab resistance in the program were limited to considerations of GEBVs as a separate trait. In preparation to transition from a marker-assisted and phenotypic selection approach, to one that includes genome-wide information to predict breeding values that are selected upon *per se* (i.e. genomic selection), all Virginia Tech soft winter wheat breeding lines were genotyped using genotyping by sequencing (GBS) at the USDA wheat genotyping lab at North Carolina State University. This includes all lines evaluated in yield trials starting in 2019 through the foreseeable future. We are currently working to build the foundational capacities to collect (digital data collection: Fieldbook), store (breeding database: BreeDBase) and effectively utilize genomic information for decision making (custom genomic prediction and selection algorithms).

Segregation populations (395 F2, 87 F3, 42 F4, 2 F5 populations) of FHB crosses were evaluated in the inoculated scab nursery. However, due to a limited water supply at a new location, mist was not applied to these populations to save water for application to pure line trials (e.g. regional nursery entries). Heads were selected from 10 F4 and F5 families to derive approximately 150-200 pure lines per family for the following field season.

A total of 4,400 FHB SRW headrows were evaluated for agronomic traits and 177 were advanced to observational yield trials for the 2021-2022 season. These lines will be genotyped in the fall of 2021. It is expected that selection based on GEBVs for FHB traits will be conducted at this stage in future years.

Materials from the Gulf Atlantic (56 lines) and Mason Dixon (76 lines) regional cooperative nurseries were evaluated in a misted and inoculated (cultured corn kernels) *Fusarium* (scab) nursery. All entries from the NUWWSN, PNUWWSN and SUWWSN (170 lines) were evaluated in the scab nursery and included in a single replicate observational yield trial for evaluation of other disease and agronomic traits, with samples subsequently sent to the Soft Wheat Quality Lab for milling and baking quality analysis.

b) What were the significant results?

A combined total of 447 successful crosses out of 534 crosses made were accomplished in March and April of 2021. Of these, 32 (7.2%) had one FHB QTL, 87 (19.5%) had 2 FHB QTL, 129 (28.9%) had 3 FHB QTL, 106 (27.3%) had 4 FHB QTL, 66(14.8%) had 5 FHB QTL, 25(5.6%) had 6 FHB QTL, and 2 had 8 FHB QTL (0.4%) expected in the F1 hybrid. Extra emphasis was directed to crosses containing at least one parent with *Fhb1*, resulting in a total of 252 crosses with the *Fhb1* resistance allele, representing 56.4% of the crosses made. Of these, 35 crosses were made between parents that each contained *Fhb1*, and thus all lines derived from these crosses should contain *Fhb1*.

FHB infection and disease progression in the scab nursery was low, mirroring the disease progression of other pathogens in 2021, including leaf rust and powdery mildew. Known susceptible checks did exhibit FHB and DON scores higher than known resistant materials, but many DON levels were undetectable, indicating poor infection rates. To encourage better infection and disease progression, fresh isolates will be used to inoculate corn kernels, as well as daily spray applications of inoculum during flowering for the 2021-2022 growing season.

A significant yield reduction is often observed in crosses made with parents containing *Fhb1*, however we are seeing evidence that this is due to linkage or negative epistasis, as opposed to pleiotropy. Several lines in the program containing *Fhb1* have been shown to demonstrate excellent agronomic performance as well as scab resistance, suggesting that linkage drag has been reduced through recombination. This has led to interest from private seed companies looking to license lines developed at Virginia Tech with *Fhb1* and high yield and quality.

c) List key outcomes or other achievements.

Through many years of work, Dr. Carl Griffey developed lines through marker assisted selection for FHB QTL that now populate each stage of the breeding program. The 2020-2021 field season highlighted five lines, 15VDH-FHB-MAS25-15, 15VDH-FHB-MAS33-13, 15VDH-FHB-MAS38-01, 17VDH-SRW01-077 and VA17W-75, that have superior scab resistance and good agronomic performance. These lines are candidates for release in spring of 2022, with private seed companies expected to bid on exclusive licenses for several of these lines. A public release of a highly scab resistant line with excellent agronomic performance is anticipated within the next year or two.

3. Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns and/or restrictions, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.

This research was impacted by the COVID-19 pandemic in multiple ways, including setbacks due to mandatory quarantine periods for personnel both in the breeding program and at the experiment station (due to expected exposure), increased costs of transportation (1 car per person) and accommodations (one room per person) when traveling to the experiment station in Warsaw VA. Contractual services were greatly impeded by supply chain issues and limited working hours. Despite these challenges, most of the field, greenhouse and lab operations were completed successfully.

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

The scab nursery has been largely run and managed by a former Postdoc and current Research Associate, Dr. Joshua Fitzgerald, allowing him experience in managing field trials and collaborations. His work as the scab breeder at Virginia Tech funded almost entirely by the USWBSI has prepared him to run his own breeding program.

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

Results from all collaborative nurseries are being compiled and distributed to all collaborators as DON data becomes available. We are currently working to incorporate FHB results into a format for submission to T3 (The Triticeae Toolbox), anticipated to be completed by 2022. Data on agronomic performance, FHB index, FDK, ISK, and DON obtained from the Virginia's state wheat variety trial are reported at field days and in the Virginia Tech Small Grains Variety Test publication: https://resources.ext.vt.edu/contentdetail?contentid=3239&contentname=Small%20Grains%20in%202021

Project 3: *Double Haploids to Expedite Development of FHB Resistant Soft Winter Wheat Varieties*

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

Objectives are to: (1) Increase the number of FHB resistant varieties available to farmers to reduce DON in the US grain supply by utilizing doubled haploid (DH) technology to decrease the breeding cycle leading to release of FHB resistant varieties at a faster rate with improved efficiency. A greater choice of FHB resistant varieties in the seed market is key to reducing DON presence within the national wheat supply chain. 2) Increase efficiency of coordinated project breeding programs to develop and release FHB resistant varieties. This will be accomplished by a unique sharing of selected DHs among all VDHR-SWW breeders, leading to a much larger number of FHB resistant DHs in regional yield trials in a decreased time frame.

This will practically ensure that no line goes unnoticed and robust, multi-location data for individual lines will provide appropriate information needed to justify release and licensing to companies for marketing to growers. (3) Implement breeding technologies to enhance short term and long-term improvement of FHB resistance and to efficiently introgress effective resistance genes into breeding germplasm. Prior to selection of crosses for DH production, enrichment of FHB QTL and other important QTL using established markers and the USDA ARS Eastern Regional Small Grains Genotyping Lab.

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?

F1 seed (VA13W-174 / Pioneer W050216N2) developed in 2018 was top-crossed to parents 13VTK59-55 and 15VDH-FHB-MAS25-08 with complementary FHB alleles in spring of 2019, and sent to Heartland for Doubled Haploid (DH) production. A total of 443 DH top-cross progeny headrows were planted in the fall of 2020 and evaluated for agronomic performance and disease resistance in the spring of 2021. Of these, 36 lines were selected for evaluation in observational yield tests for the 2021-2022 field season in two of three locations in Blacksburg VA, Warsaw VA, and Urbana-Champaign, Illinois in a sparse testing design. Thirty three of these lines contained sufficient remnant seed to send 10 grams of seed to each VDHR cooperator for headrow evaluation in 2021-2022 field season. An additional 26 lines developed through this project at North Carolina State were selected from headrows grown in Virginia and advanced to observational yield trials.

Similarly, plants from three top-cross families with pedigrees CROPLAN 8550 / USG 3118 // 15VDH-FHB-MAS33-13, NC14-23372 / GA061471-15LE38 // 15VDH-FHB-

MAS33-13, and CROPLAN 8550 / 13VTK434-89// 16VDH-SRW07-067 were sent for DH production in 2020 and at least 224 DH lines planted in headrows will for selection in spring of 2022. The reduced number of lines is due to the increase in cost from an expected $30 per line to $45 per line.

In a typical year of this research project, top-crosses with F1 hybrids are made to pyramid known FHB QTL in elite materials. However, in April of 2020, all the crossed parent plants in the greenhouse were mistakenly sprayed with a sprayer containing new insecticide, and sufficient residual herbicide from a previous spraying event to effectively kill all parent plants before viable F1 seed was produced. A decision was therefore made to abandon top-crosses for the year, and instead put additional focus on single crosses for FHB QTL for DH production in the 2021 crossing season, with top-crosses for DH production to resume in 2022

b) What were the significant results?

Table 1: Single crosses made in 2021 selected for DH production for the 2022-2023 field season. The number of unique FHB QTL segregating in the population is indicated.

Cross	Number of FHB QTL	Has *Fhb1**
VA20W-171 / 17VTK19-15	**5**	**0**
DH15SRW67-151 / VA19W-89	**6**	**1**
17VTK4-29 / VA20W-171	**5**	**1**
18VDH-FHB-MAS07-173-03 / 18VDH-FHB-MAS07-164-08	**5**	**1**
VA19W-89 / Liberty 5658	**8**	**1**

* 0 indicates that neither parent has *Fhb1*, 1 indicates that one parent contains *Fhb1*, and a 2 indicates both parents contain *Fhb1*.

Five single crosses made in spring of 2021 were selected for DH production at Heartland based on a simple selection index calculated with expected family yield performance with a weight of 5, and FHB QTL weighted as 1 for each QTL, with the exception of Fhb1, which was assigned a weight of 2 (Table 1). Lines designated with "VDH-FHB-MAS" were developed through this project in previous years.

Twenty five lines developed through the project were evaluated in advanced yield nurseries in the 2020-2021 harvest season. Five of these lines were tested in regional yield trials and demonstrated excellent (3) to average (2) agronomic performance while exhibiting excellent scab resistance. The remaining 20 lines were evaluated in two locations in Virginia, and exhibited an average FHB rating of 1.7 compared to an average FHB rating of 5.7 for susceptible checks. Seven of these lines were advanced to regional nurseries for the 2021-2022 growing season.

c) List key outcomes or other achievements.

Led by Dr. Carl Griffey, marker assisted top-crossing for FHB QTL with DH production to reduce time to release, has resulted in superior materials in late stage testing. Lines 15VDH-FHB-MAS25-15, 15VDH-FHB-MAS33-13, and 15VDH-FHB-MAS38-01, were all developed through this project and are current candidates for release in spring of 2022. All three lines contain *Fhb1*, are highly scab resistant and exhibit excellent agronomic performance. Private seed companies are expected to bid on exclusive licenses for one or more these lines. One of these lines will likely be released as a public variety in the next year.

Additionally, the top-cross project and the sharing of DH lines across collaborators has populated several stages of all the breeding programs, providing valuable elite germplasm for crossing and potential release.

3. Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns and/or restrictions, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.

This research was impacted by the COVID-19 pandemic in multiple ways, including setbacks due to mandatory quarantine periods for personnel both in the breeding program and at the experiment station (due to expected exposure), increased costs of transportation (1 car per person) and accommodations (one room per person) when traveling to the experiment station in Warsaw VA. Contractual services were greatly impeded by supply chain issues and limited working hours. Despite these challenges, most of the field, greenhouse and lab operations were completed successfully.

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

The project has provided training and experience for a graduate student, Cameron Hoyt, in the selection and crossing of parents for pyramiding QTL, as well as considerations related to other agronomic traits when considering parent pairs.

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

FHB DH lines have been distributed to collaborators, and advanced FHB DH lines have been evaluated in regional nurseries. Data on agronomic performance, FHB index, FDK, ISK, and DON obtained from the Virginia's state wheat variety trial are reported at field days and in the Virginia Tech Small Grains Variety Test publication: https://resources.ext.vt.edu/contentdetail?contentid=3239&contentname=Small%20Grains%20in%202021

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY20 award period (6/17/20 - 6/16/21). The term "support" below includes any level of benefit to the student, ranging from full stipend plus tuition to the situation where the student's stipend was paid from other funds, but who learned how to rate scab in a misted nursery paid for by the USWBSI, and anything in between.

1. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their MS degree during the FY20 award period?**
   ☐Yes ☒No ☐ Not Applicable
   If yes, how many? Click to enter number here.

2. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY20 award period?**
   ☐Yes ☒No ☐ Not Applicable
   If yes, how many? Click to enter number here.

3. **Have any post docs who worked for you during the FY19 award period and were supported by funding from your USWBSI grant taken faculty positions with universities?**
   ☐Yes ☒No ☐ Not Applicable
   If yes, how many? Click to enter number here.

4. **Have any post docs who worked for you during the FY20 award period and were supported by funding from your USWBSI grant gone on to take positions with private ag-related companies or federal agencies?**
   ☐Yes ☒No ☐ Not Applicable
   If yes, how many? Click to enter number here.

Release of Germplasm/Cultivars

Instructions: In the table below, list all germplasm and/or cultivars released with full or partial support through the USWBSI during the FY20 award period (6/17/20 - 6/16/21). All columns must be completed for each listed germplasm/cultivar. Use the key below the table for Grain Class abbreviations.

NOTE: Leave blank if you have nothing to report or if your grant did NOT include any VDHR-related projects.

Name of Germplasm/Cultivar	Grain Class	FHB Resistance	FHB Rating (0-9)	Year Released
VA16BFHB-268 NA	BAR - Barley	MR - Moderately Resistant	3.5	2021
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
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Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year

NOTE: List the associated release notice or publication under the appropriate sub-section in the 'Publications' section of the FPR.

Publications, Conference Papers, and Presentations

Instructions: Refer to the PR_Instructions for detailed more instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY20 grant award. Only citations for publications published (submitted or accepted) or presentations presented during the **award period (6/17/20 - 6/16/21**) should be included. If you did not publish/submit or present anything, state 'Nothing to Report' directly above the Journal publications section.

NOTE: Directly below each citation, you **must** indicate the Status (i.e. published, submitted, etc.) and whether acknowledgement of Federal support was indicated in the publication/ presentation. See example below for a poster presentation with an abstract:

> Winn, Z.J., Acharya, R., Lyerly, J., Brown-Guedira, G., Cowger, C., Griffey, C., Fitzgerald, J., Mason R.E., and Murphy, J.P. (2020, Dec 7-11). Mapping of Fusarium Head Blight Resistance in NC13-20076 Soft Red Winter Wheat (p. 12). In: Canty, S., Hoffstetter, A. and Dill-Macky, R. (Eds.), *Proceedings of the 2020 National Fusarium Head Blight Forum*. https://scabusa.org/pdfs/NFHBF20_Proceedings.pdf.
> Status: Abstract Published and Poster Presented
> Acknowledgement of Federal Support: YES (Abstract and Poster)

Journal publications.

Brooks, W., Griffey, C.A., Vaughn, M., Seago, J., Thomason, W., Fitzgerald, J., Christopher, A., Pitman, R., Dunaway, D., Light, J., Rucker, E., Behl, H., Beahm, B., Browning, P., McMaster, N., Schmale, D., Hardiman, T., Custis, J.T., Gulick, S., Ashburn, S.B., Jones, N., Marshal, D., Fountain, M., and Oakes, J. (2021). Registration of 'SB255'winter barley. *Journal of Plant Registrations*, *15*(2), 236-243.
Status: Published
Acknowledgement of Federal Support: YES

Books or other non-periodical, one-time publications.

Nothing to report.

Other publications, conference papers and presentations.

Nothing to report.