USDA-ARS
U.S. Wheat and Barley Scab Initiative
FY18 Performance Report
Due date: July 12, 2019

Cover Page

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Fiscal Year:	2018
USDA-ARS Agreement ID:	59-0206-8-191
USDA-ARS Agreement Title:	Improving FHB Resistance in Barley and Wheat using Breeding and Genomics Methods.
FY18 USDA-ARS Award Amount:	$ 182,865
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:	422671
Project/Grant Reporting Period:	6/17/18 - 6/16/19
Reporting Period End Date:	06/16/19

USWBSI Individual Project(s)

USWBSI Research Category*	**Project Title**	**ARS Award Amount**
BAR-CP	Variety Development, Selection and Mapping of Resistance to FHB and DON in Barley.	$ 52,602
VDHR-SWW	Improving FHB Resistance in Winter Wheat via Traditional, GS, MAS and DH Methods.	$ 120,000
VDHR-SWW	Developing Doubled Haploids to Expedite Variety Development in Soft Red Winter Wheat.	$ 10,263
	FY18 Total ARS Award Amount	$ 182,865

Carl A. Griffey

Principal Investigator — Date: 7/11/2019

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* MGMT – FHB Management
FST – Food Safety & Toxicology
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

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Project 1: *Variety Development, Selection and Mapping of Resistance to FHB and DON in Barley.*

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

The primary goal of the project is to evaluate and enhance FHB resistance in commercially viable winter barley cultivars by identifying, mapping, and incorporating unique and/or complementary FHB resistance QTL from different sources using MAS and conventional breeding methods.

2. What was accomplished under these goals? *Address items 1-4) below for each goal or objective.*

1) major activities

The program continues to develop and advance populations and pure lines derived from crosses between superior winter barley cultivars and lines with FHB resistant varieties from our program and spring barley lines. The program is conducting research to characterize and validate QTL and to identify diagnostic markers for FHB resistance in barley cultivars Eve, Nomini, and Violetta. Current diagnostic markers for FHB resistance (ten SSR markers each for QTL on chromosomes 2H and 6H) from spring barley, along with markers for other diseases (three SNP markers for leaf rust, three SNP markers for powdery mildew, eleven markers for net blotch, and three SSR markers for spot blotch), yield (one SNP marker) and quality (one SNP marker), are being used to characterize parents and for MAS in the Virginia Tech barley program.

Breeding populations derived from crosses made with FHB resistance sources (Island, AC Alberte, Atahulpa, Quest, MN Brite, FEG-4-98, Chevron and Fredrickson) are in advanced generations. This season (2017-18), we evaluated and selected pure lines from nearly 600 hulled and hulless FHB headrows at the Eastern Virginia AREC in Warsaw, VA. We also evaluated 104 FHB resistant lines in an observation yield trial, and 58 populations were evaluated for FHB resistance in our scab nursery and advanced in the program.

2) specific objectives

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 adapted winter barley sources.

3) significant results

The release of one elite feed barley line VA11B-141 LA this spring (2019), which had three year (2016, 2017 and 2018) average DON values that were 3 to 6 ppm lower than those of current cultivars Atlantic, Secretariat, and Thoroughbred. Breeding efforts continue expanding to develop adapted winter malt barley varieties having high yields, good quality and resistance to diseases including FHB. This season (2018-19), three advanced winter malt barley lines from our program were grown in increase blocks and seed samples from these lines will be submitted to AMBA's Pilot Malting Trial.

Two mapping populations (Thoroughbred/Nomini RIL and Violetta/Nomini DH populations) were evaluated for FHB resistance in 2018-19 at Mt. Holly, VA (Table 1) and Lexington, KY misted nurseries. Unfortunately, severe water-logging and flood damage occurred in Kinston, KY once again, as in 2017; therefore, both populations will be grown again in 2019-20 at this location. Currently, phenotypic data has been collected over the course of three years and various locations for Thoroughbred/Nomini and a second year of data from Violetta/Nomini will be obtained in 2019-20 (see Tables 2 and 3). Genotypic data from the 50K SNP genotypic platform have been obtained where linkage maps are being estimated for Thoroughbred/Nomini and SNP calling for Violetta/Nomini is in progress. Preliminary mapping results from both populations will be presented at the 2019 FHB Forum in Milwaukee, WI.

4) key outcomes or other achievements

Pure lines derived from crosses between known FHB resistant spring barley lines and adapted winter barley lines are being developed and evaluated for FHB resistance and agronomic performance. New SNP markers tightly linked to the FHB resistance QTL in Eve on chromosome 6H were identified and can be used to incorporate and pyramid FHB resistance genes into adapted cultivars via MAS breeding. In 2019, a seed increase was made of a two-row hulless barley line VA15H-73 having lower FHB Index (0-100), FDK (%), ISK Index (0-100), and DON (ppm) values than the moderately resistant cultivar Eve (8.6 vs 30.2; 15% vs 30%; 29 vs 48; and 7.5 vs 11.3 ppm), respectively.

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

This project has provided training to employees at the Eastern VA AREC as well as those working for the program on the Virginia Tech campus. These including current and new research specialists, undergraduate students (2 student interns working at EVAREC and 4 student interns on campus). Also. the project provided professional development by allowing a post-doc research associate to attend the annual USWBSI meeting and participate in poster presentation sessions.

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

Data on FHB index, FDK, ISK, and DON obtained from the Virginia's state wheat variety trial are reported at field days, online (https://pubs.ext.vt.edu/SPES/SPES-46/SPES-46.html) and in the extension bulletin VCE Publications / SPES / SPES-46 "Small Grains in 2018" to promote selection and production of FHB resistant cultivars. The results on FHB resistant QTL mapping were disseminated through USWBSI annual meetings.

Table 1. Distribution of FHB traits in both the Thoroughbred/Nomini RIL and Nomini/Violetta DH populations in 2019, respectively.

	Mt. Holly, VA (2019)				
Parent/Population	**Flowering Date (Julian)**	**FHB Incidence (%)**	**FHB Severity (%)**	**FHB Index (0-100)**	**Height (In)**
Nomini	106.8	40	8.2	3.5	31.5
Thoroughbred	111	55	21.5	12	30
Thoroughbred/Nomini	111	57.8	19.3	12.4	30.9
Nomini	106.8	43.3	7.6	3.3	34
Violetta	113.8	58.8	9.5	5.8	24.5
Nomini/Violetta	110.5	63.1	18.4	18.4	28.7

Table 2. Distribution of FHB traits in both the Thoroughbred/Nomini RIL and Nomini/Violetta DH populations in 2018, respectively.

	Mt. Holly, VA (2018)						
Parent/Population	**Flowering Date (Julian)**	**FHB Incidence (%)**	**FHB Severity (%)**	**FHB Index (0-100)**	**FDK (%)**	**ISK Index (0-100)**	**DON (ppm)**
Nomini	118.0	100.0	62.9	62.9	3.5	48.9	.
Thoroughbred	123.5	100.0	57.9	57.9	40.0	47.5	.
Thoroughbred/Nomini	121.6	99.8	61.9	61.9	21.1	48.6	.
Nomini	114.5	100.0	73.3	73.3	10.5	52.0	11.0
Violetta	119.0	100.0	44.4	44.4	18.0	43.4	52.1
Nomini/Violetta	120.4	98.6	55.1	54.6	20.7	46.2	27.5

	Kinston, NC (2018)						
Parent/Population	**Flowering Date (Julian)**	**FHB Incidence (%)**	**FHB Severity (%)**	**FHB Index (0-100)**	**FDK (%)**	**ISK Index (0-100)**	**DON (ppm)**
Nomini	105.0	95.0	35.3	33.4	12.0	39.1	.
Thoroughbred	112.5	65.0	22.7	15.6	32.0	26.4	.
Thoroughbred/Nomini	110.2	81.3	32.4	28.0	17.6	34.2	.

Table 3. Distribution of FHB traits in the Thoroughbred/Nomini RIL population in 2017 from the Mt. Holly, VA and Lexington, KY locations.

	Mt. Holly, VA (2017)						
Parent/Population	**Flowering Date (Julian)**	**FHB Incidence (%)**	**FHB Severity (%)**	**FHB Index (0-100)**	**FDK (%)**	**ISK Index (0-100)**	**DON (ppm)**
Nomini	95.0	66.3	8.3	5.6	18.5	22.4	1.6
Thoroughbred	104.0	77.5	16.7	12.9	60.0	28.5	3.6
Thoroughbred/Nomini	102.7	85.2	20.6	18.1	32.2	32.0	3.2

	Lexington, KY (2017)						
Parent/Population	**Flowering Date (Julian)**	**FHB Incidence (%)**	**FHB Severity (%)**	**FHB Index (0-100)**	**FDK (%)**	**ISK Index (0-100)**	**DON (ppm)**
Nomini	112.5	60.0	8.0	5.3	13.5	20.5	46.2
Thoroughbred	114.5	95.0	10.0	9.7	38.0	31.7	56.8
Thoroughbred/Nomini	115.1	77.1	12.1	10.0	25.4	26.9	36.7

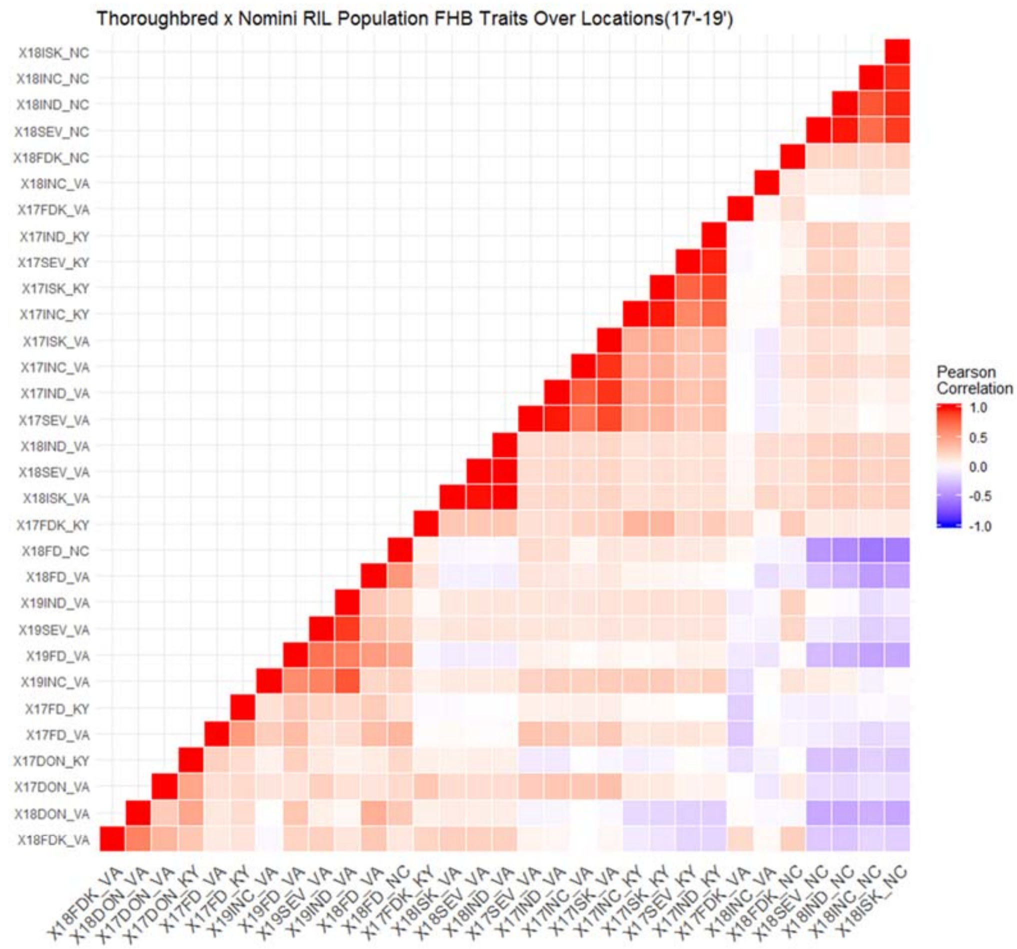

Figure 1. Correlation plot of Fusarium head blight (FHB) traits for each of the RILs in the Thoroughbred/Nomini mapping population across all current locations (VA,KY and NC) in the 2017, 2018 and 2019 growing seasons. Flowering Date (FD) was recorded in Julian. FHB incidence (INC; % of infected barley heads per plot). FHB severity (SEV; % of infected spikelets). Fusarium damaged kernels (FDK) is the percentage of infected kernels per harvested sample. Deoxynivalenol (DON) content in ppm from harvested samples. Significant correlations are indicated by color: red indicates positive correlation (value of 1.0) and blue indicates a negative correlation (value of -1.0).

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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 project?**

The ultimate goal of the proposed research is to incorporate unique FHB resistance QTL from complementary types and sources of resistance into commercially viable cultivars using Genomic prediction, Marker Assisted Selection (MAS) and Doubled Haploid (DH) technologies in conjunction with conventional breeding methods. The project addresses CP milestones 1 and 2 by selecting and crossing FHB resistant parents on the basis of agronomic performance, FHB resistance, and marker haplotypes of parents for known and validated QTL for traits of interest. The program is implementing marker assisted selection (MAS) to pyramid *Fhb1* and other QTL into our germplasm. We evaluated 128 lines for scab resistance in a Genomic Selection training population in 2018, which will be evaluated again along with some new FHB resistant lines (156 entries) in 2019.

2. **What was accomplished under these goals?** *Address items 1-4) below for each goal or objective.*

1) major activities

Breeding populations (247) were evaluated and selections made in an irrigated and grain spawn inoculated scab nursery at Mt. Holly, VA in 2018-19. Pure lines evaluated and selected in headrows at Warsaw, VA in 2018 will be tested in observation yield trials in 2019 and includes 25 FHB-MAS derived lines and 45 FHB-MAS-DH lines. Wheat lines (337 SRW, 146 HRW, and 65 Durum) in preliminary, advance, and state yield trials were evaluated for agronomic performance at two to seven locations and for FHB resistance in a scab nursery at Mt. Holly, VA. Elite lines in regional (52 entries in the Gulf Atlantic, 70 entries in Mason Dixon, and 46 entries in the Uniform Bread Wheat trials), and uniform scab nurseries (49 entries in southern, 55 entries in northern, and 47 entries in preliminary northern scab nurseries) were evaluated in yield test plots and in a scab nursery at Mt. Holly. Our program also evaluates lines in these uniform nurseries for seedling resistance to two races of leaf rust in greenhouse trials. Agronomic and disease data are provided to all cooperators and grain samples of entries in the three uniform scab nurseries are sent to the Soft Wheat Quality Lab for quality analyses each year. Lines included in these tests currently are being analyzed for DON content.

Molecular markers linked to 15 scab resistance genes located on wheat chromosomes 2D, 3B (Fhb1), and 5A of Ning 7840, 1B and 6A of Jamestown, 1A and 2A of Tribute, 3B and 4B of Ernie, 2B and 3B of Bess, 3B of Massey, and 1A, 4A, and 6A of Neuse are being used to screen parental lines of crosses and in marker-assisted selection to pyramid different FHB resistance genes. MAS enrichment was applied in 13 SRW-FHB populations in 2016 (Table 3) and 14 SRW-FHB populations in 2017 (Table 4). During

2018-19, FHB breeding materials evaluated in scab nursery and/or field tests included: 247 populations, 4,400 headrows, and more than 800 pure lines.

2) specific objectives

The specific objectives were: 1) to screen, characterize, and identify adapted wheat varieties having resistance to FHB and other prevalent diseases; 2) to identify and deploy unique FHB-QTL and diagnostic markers in MAS and DH breeding that is critical for accelerating progress and improving selection efficiency in enhancing FHB resistance via gene pyramiding in wheat cultivars.

3) significant results

Five FHB resistant lines, having *Fhb1* in the pedigree, have been developed from our Marker-assisted breeding program with above average yield and improved scab resistance which performed well in the 2018 preliminary test and have been entered into the Virginia State Wheat test in 2019. Two sister lines, 15VDH-FHB-MAS22-15 and 15VDH-FHB-MAS22-14 yielded 15 and 6 percent above the test average, respectively and 15VDH-FHB-MAS22-14 exhibited exceptional test weight of 60.5 lb/bu across all locations. A summary of other scab resistant breeding stocks and lines developed and evaluated in our program from 2012 to 2019 is presented in Table 1.

4) key outcomes or other achievements

A large number of superior lines are being obtained from our FHB-MAS-DH project where the primary goal is to pyramid gene *Fhb1* with multiple other QTL for FHB resistance. More than 50% of the entries in our 2019 FHB Wheat Observation Test were developed using DH and/or MAS breeding techniques. Two SRW wheat lines (VA13W-38 and DH12SRW056-058) having moderate resistance to FHB were approved for released in spring 2019.

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

This project has provided training to employees at the Eastern VA AREC as well as those working for the program on the Virginia Tech campus. These including current and new research specialists, undergraduate students (2 student interns working at EVAREC and 4 student interns on campus). Also, the project provided professional development by allowing a post-doc research associate to attend the annual USWBSI meeting and participate in poster presentation sessions.

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

Data on FHB index, FDK, ISK, and DON obtained from the Virginia's state wheat variety trial are reported online (https://pubs.ext.vt.edu/SPES/SPES-46/SPES-46.html) and in the extension bulletin VCE Publications / SPES / SPES-46 "Small Grains in 2018" to promote selection and production of FHB resistant cultivars. Information on FHB resistance of cultivars and the FHB disease forecasting website are also shared with producers at annual field days. Data on seedling resistance to leaf rust, resistance to FHB and other prevalent diseases as well as agronomic traits (e.g. heading date, height, lodging tolerance, yield, and test weight) and quality (samples provided to Soft Wheat Quality Lab) are collected and provided to cooperators in three uniform scab nurseries (SUWWSN, NUWWSN, and PNUWWSN).

Table 1. Scab resistant breeding stocks developed and evaluated by the Virginia Tech wheat breeding program from 2013 to 2019.

Breeding Nursery / Test	2013	2014	2015	2016	2017	2018	2019
Populations	140	386	265	233	140	176	247
SRW, MAS, and DH Headrows	1300	2800	2160	8000	3400	4400	2700
Preliminary yield test	40	10	15	7	20	20	28
Advance yield test	38	5	3	6	13	13	9
VA state yield test	2	5	7	5	12	18	21
Southern FHB uniform test	6	6	8	8	8	8	9
Northern FHB uniform test	4	4	5	4	5	5	5
Preliminary northern FHB test	6	6	5	5	5	5	5

Table 2. Soft red winter wheat (SRW) scab top cross populations enriched via MAS in 2016 and evaluated in F_4 headrows in 2018 and in F_5 headrows in 2019 at Warsaw, VA.

Pop no.	Short Pedigree	Traits for MAS	F_5 Rows Tested in 2019
1	MD08-26-H2-7-12-9/Jamestown//VA09W-73	**Fhb1 het, Fhb1B-Jtwn**, Lr9, Sbm1 het, vrn-A1 het, Rht2, Ppd-A1a.1, Ppd-D1a het	24
2	VA11W-95// MD08-26-H2-7-12-9/12V51	**FHB2Dl het, FHB3BL het, FHB1B-Jtwn**, Yr17/Lr37/Sr38 het, Sr24/Lr24, Lr9, Sbm1, Rht2, Ppd-A1a.1, Ppd-D1a	8
3	MD08-26-H2-7-12-9/VA09W-73//Hilliard	**Fhb1 het, FHB1B-Jtwn het**, Yr17/Lr37/Sr38 het, Sbm1, Pht2, Ppd-A1a.1, Ppd-D1a	8
4	MD08-26-H2-7-12-9/VA09W-73//VA12W-150	**Fhb1 het, FHB2DL het, FHB5A het, FHb1B-Jtwn het**, Sbm1, Rht2, Ppd-A1a.1, Ppd-D1a	4
5	MD08-26-H2-7-12-9/VA11W-278//VA12W-150	**Fhb1 het, FHB2DL het**, Yr17/Lr37/Sr38 het, Sr24/Lr24, Sbm1, Rht2, Ppd-A1a.1 het, Ppd-B1a_S64, Ppd-D1a	8
6	MD08-26-H2-7-12-9/ Hilliard//VA09W-73	**Fhb1 het, FHB1B-Jtwn het**, Yr17/Lr37/Sr38 het, Sbm1, Pht2, Ppd-A1a.1, Ppd-D1a	8
7	MD08-26-H2-7-12-9/USG3555//VA12W-150	**FHB2DL het, FHb 3BL het**, Yr17/Lr37/Sr38 het, Sr36, Sbm1, 1RS:1BL het, TaSus-2B, Rht2, Ppd-A1a.1 het, Ppd-D1a	4
8	MD08-26-H2-7-12-24/HILLIARD//SS8412	**Fhb1 het, FHB2DL het, FHB1B-Jtwn het**, Yr17/Lr37/Sr38 het, Sr24/Lr24, Sbm1, Rht2, Ppd-A1a.1 het, Ppd-A1a.1 het, Ppd-D1a het	8

Table 3. Soft red winter wheat scab top cross populations enriched via MAS in 2016 and grown out in 2018 for evaluation in F_3 headrows in 2019 in Warsaw, VA.

Pop No.	Cross Pedigree	Max# FHB QTLs	Marker Traits	No. F_3 Rows
1	NC8248-14 / Jamestown // MDC07026-F2-19-13-1	6	**Fhb1, FHB1B_Jtw, FHB3B_Bes, FHB1A_Nse, FHB4A_Nse, FHB6A_Nse**, Sbm1, Lr37, Lr/Sr24, Sr36	104
2	NC8248-14 / Featherstone 73 // MDC07026-F2-19-13-1	5	**Fhb1, FHB1B_Jtw, FHB3B_Bes, FHB4A_Nse, FHB6A_Nse**, Sbm1, Lr37, Lr9, Lr/Sr24, Sr36	39
3	NC8248-14 / Hilliard // MDC07026-F2-19-13-1	5	**Fhb1, FHB1B_Jtw, FHB3B_Bes, FHB1A_Nse, FHB6A_Nse**, Sbm1, Lr37, Lr/Sr24, Sr36	112
4	NC8248-14 / GA03564-12E6 // MDC07026-F2-19-13-4	5	**Fhb1, FHB1B_Jtw, FHB3B_Bes, FHB4A_Nse, FHB6A_Nse**, Sbm1, Lr37, Lr/Sr24, Sr36, 1A.1R	48
5	NC8248-14 / VA12W-54 // MDC07026-F2-19-13-1	5	**Fhb1, FHB1B_Jtw, FHB3B_Bes, FHB4A_Nse, FHB6A_Nse**, Sbm1, Lr37, Lr/Sr24, Sr36, Lr46, H13	40
6	NC8248-14 / VA12W-72 // MDC07026-F2-19-13-4	6	**Fhb1, FHB1B_Jtw, FHB3B_Bes, FHB3B_Msy, FHB4A_Nse, FHB6A_Nse**, Sbm1, Lr37, Lr/Sr24, Sr36	24
7	NC8248-14 / MDC07026-F2-19-13-4 // VA11W-108PA	5	**Fhb1, FHB1B_Jtw, FHB3B_Bes, FHB4A_Nse, FHB6A_Nse**, Sbm1, Lr37, Lr/Sr24, Sr36	24
8	NC8248-14 / MDC07026-F2-19-13-4 // VA11W-279	6	**Fhb1, FHB1B_Jtw, FHB3B_Msy, FHB4A_Nse, FHB1A_Nse, FHB6A_Nse**, Sbm1, Lr37, Lr/Sr24, Sr36, H13	8
9	NC8248-14 / MDC07026-F2-19-13-4 // VA12W-72	5	**Fhb1 or FHB3B_Bes, FHB1B_Jtw, FHB3B_Msy, FHB4A_Nse, FHB6A_Nse**, Sbm1, Lr37, Lr/Sr24, Sr36, Lr46, H13	60
10	NC8248-14 / MDC07026-F2-19-13-4 // TXGA06343-17-3-5-EL2	4	**Fhb1, FHB1B_Jtw, FHB3B_Bes, FHB4A_Nse, FHB6A_Nse**, Sbm1, Lr37, Lr/Sr24, Sr36	8
11	NC8248-14 / MDC07026-F2-19-13-4 // VA14FHB-28	5	**Fhb1, FHB1B_Jtw, FHB3B_Bes, FHB4A_Nse, FHB6A_Nse**, Sbm1_het, Lr37, Lr/Sr24, Sr36	8
12	NC8248-14 / MDC07026-F2-19-13-4 // VA07MAS3-7304-3-2-4-3	5	**Fhb1, FHB1B_Jtw, FHB3B_Bes, FHB4A_Nse, FHB6A_Nse**, Sbm1_het, Lr37, Lr/Sr24, Sr36	8
13	NC8248-14 / MDC07026-F2-19-13-4 // VA09MAS6-122-7-1	4	**Fhb1, FHB1B_Jtw, FHB3B_Bes, FHB4A_Nse, FHB6A_Nse**, Sbm1_het, Lr37, Lr/Sr24, Sr36	12

Table 4. SRW top cross populations enriched via MAS in 2017 and grown in F_2 headrows in 2019 in Warsaw.

Pop No.	Cross Pedigree	Max# FHB QTLs	Marker Traits	No. F_2 Plants
1	VA12W-68 / MDC07026-F2-19-13-4 // HILLIARD	3	**Fhb1_het, FHB1B-Jtw_het**, Yr17/Lr37/Sr38_het, Sr24/Lr24, Sbm1, Lr46_het	20
2	VA12W-68 / MDC07026-F2-19-13-4 // TXGA06343-17-3-5-EL2	3	**Fhb1_het, H13_het**, Yr17/Lr37/Sr38, Sbm1, Lr46_het	20
3	VA12W-68 / TXGA06343-17-3-5-EL2 // MDC07026-F2-19-13-1	2	**Fhb1_het, FHB6A-Nse_het**, H13_het, Yr17/Lr37/Sr38, Sr24/Lr24, Sbm1, Lr46_het	20
4	TXGA06343-17-3-5-EL2 / MDC07026-F2-19-13-1 // VA12W-68	2	**Fhb1_het, FHB6A-Nse_het, FHB3B-Msy_het,** H13_het, Yr17/Lr37/Sr38, Sbm1	20
5	TXGA06343-17-3-5-EL2 / MDC07026-F2-19-13-1 // VA11W-108PA	3	**Fhb1_het, FHB1B-Jtw_het**, Yr17/Lr37/Sr38_het, Sr24/Lr24, Sbm1	22
6	TXGA06343-17-3-5-EL2 / MDC07026-F2-19-13-1 // VA11W-279	4	**FHB1A-Nse_het, FHB4A-Nse_het, FHB6A-Nse_het, FHB3B-Msy_het, FHB1AL-Trib**, H13_het, Yr17/Lr37/Sr38, Sr36/Pm6_het, Sbm1	12
7	TXGA06343-17-3-5-EL2 / Jamestown // 15MW-133 (MDC07026-F2-19-13-3)	5	**Fhb1_het, FHB1A-Nse_het, FHB6A-Nse_het, FHB6A-Jtw_het, FHB1AL-Trib_het**, Yr17/Lr37/Sr38, Sr24/Lr24, Sbm1	20
8	KY-X08C-1299-42-18-3 / VA11W-279 // MDC07026-F2-19-13-1	5	**Fhb1_het, FHB1A-Nse_het, FHB4A-Nse_het, FHB6A-Nse_het, FHB3B-Msy_het, FHB1AL-Trib_het**, Yr17/Lr37/Sr38, Sr24/Lr24, Sr36/Pm6_het, Sbm1_het	12
9	KY06C-1178-16-10-3 / USG 3895 // GAJT 141-14E45	4	**Fhb1, FHB1A-Nse_het, FHB1B-Jtw_het, FHB6A-Jtw_het**, H13_het, Yr17/Lr37/Sr38_het, Sbm1, 2+12, vrn-A1_short_het,	14
10	VA11W-108PA / VA07MAS3-7304-3-2-4-3 // L11541 (MDC07026-F2-19-13-4)	4	**Fhb1_het, FHB4A-Nse_het, FHB6A-Nse_het, FHB1B-Jtw_het**, Yr17/Lr37/Sr38_het, Sr24/Lr24, Sbm1, 2+12, vrn-A1	22
11	L11541 (MDC07026-F2-19-13-4) / VA07MAS3-7304-3-2-4-3 // HILLIARD	4	**Fhb1_het, FHB4A-Nse_het, FHB6A-Nse_het, FHB1B-Jtw_het**, Yr17/Lr37/Sr38_het, Sbm1, 1RS:1BL_het, 2+12, vrn-A1	16
12	AR11LE24 / VA12W-72 // L11541 (MDC07026-F2-19-13-4)	3	**Fhb1_het, FHB1A-Nse_het, FHB6A-Nse_het, FHB3B-Msy_het**, H13_het, Yr17/Lr37/Sr38, Sr24/Lr24, Sbm1, 2+12	8
13	USG 3895 / VA12W-72 // 15MW-133 (MDC07026-F2-19-13-3)	3	**Fhb1_het, FHB6A-Nse_het, FHB3B-Msy_het, FHB1AL-Trib_het**, Yr17/Lr37/Sr38, Sr24/Lr24, Sbm1, 2+12	20
14	USG 3895 / MD272-8-4-14-6 // VA11W-279	5	**Fhb1_het, FHB1A-Nse_het, FHB4A-Nse_het, FHB3B-Msy_het, FHB1AL-Trib_het, FHB3BSc-Trib_het**, H13_het, Yr17/Lr37/Sr38, Sr36/Pm6_het, Sbm1, 1RS:1BL_het, 2+12	26

FY18 Performance Report
PI: Griffey, Carl
USDA-ARS Agreement #: 59-0206-8-191
Reporting Period: 6/17/18 - 6/16/19

Project 3: *Developing Doubled Haploids to Expedite Variety Development in Soft Red Winter Wheat.*

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

One of the main objectives of the VDHR research area is to increase the efficiency of coordinated project breeding programs in developing and releasing FHB-resistant varieties. Doubled haploids (DH) shorten variety development time in fall-sown small grains by approximately three years.

2. What was accomplished under these goals? *Address items 1-4) below for each goal or objective.*

1) major activities

Research is focused on shortening breeding cycles through the development of doubled haploid populations and enhancing FHB resistance via MAS breeding efforts in selection of parents, designing crosses, gene introgression and pyramiding, population enrichment, and selection of pure lines. Marker haplotypes of parents for validated FHB resistance QTL and other traits of importance such as dwarfing genes, disease and insect resistance, rye translocations, and quality are being assessed and utilized to enhance breeding efficiency. Molecular markers linked to 15 scab resistance genes located on wheat chromosomes 2D, 3B (Fhb1), and 5A of Ning 7840, 1B and 6A of Jamestown, 1A and 2A of Tribute, 3B and 4B of Ernie, 2B and 3B of Bess, 3B of Massey, and 1A, 4A, and 6A of Neuse are being used to screen parental lines of crosses and in marker-assisted selection to pyramid different FHB resistance genes. Marker assisted selection (MAS) was applied in 13 SRW-FHB top cross populations in 2016 and 2017 (See Tables 3 and 4 above). In 2016 and 2017, individual plants having multiple FHB resistance QTL and other traits of interest were delivered to Heartland Plant Innovations to develop DH lines for breeding programs in VA, AR, GA, LA, NC and KY. Other MAS plants were grown out in the greenhouse and are being advance in our breeding program using the Pedigree method. Lines selected from DH populations also have be shared with and evaluated in the aforementioned breeding programs.

2) specific objectives

The specific objective is to shorten variety development time and enhance FHB resistance and other critical traits in SRW wheat cultivars by deploying a combination of MAS and DH breeding methods.

3) significant results

The VT program has developed 10 or more top cross populations (~100 seed / cross) over the past three years, from which individual seedlings have been screened via MAS to identify genotypes having multiple genes/QTL for FHB resistance. This data and selected DH lines have been shared with southern breeders who cooperate in the DH project. During the past two years, breeders in AR, GA, LA, NC, and KY have selected plants from which DH lines were developed by Heartland for their programs. In 2018-19, 705 DH lines (Table 5) developed via MAS through Heartland Plant Innovations (HPI) were evaluated in Warsaw, VA and superior lines will be advanced into observation tests in 2019. Additionally, 304 DH lines developed by University of Arkansas-Virginia Tech were also evaluated as headrows in 2018-19 (Table 6).

4) key outcomes or other achievements

Concurrent deployment of MAS and DH breeding methods has greatly accelerated the rate at which superior wheat lines having multiple QTL for FHB resistance, including gene *Fhb1*, are being developed and tested in the southern region. The proportion of wheat lines having enhanced FHB resistance has increased significant as a result of this regional project.

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

This project has greatly enhanced collaborative breeding efforts between breeding programs in the southern and mid-Atlantic regions. It also has provided novel training to small grains employees located on campus and at the Eastern VA AREC including research associates, research specialists, graduate and undergraduate students.

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

Genotypic and phenotypic data, MAS selected top-cross progeny, and selected DH lines have been shared with southern breeders who cooperate in the DH project. Information and progress garnered from the project also has been showcased and shared with producers at field days and annual grower meetings.

Table 5. FHB doubled haploid (DH) lines developed from MAS enriched F_2 grow-outs by Heartland Plant Innovation in spring of 2018 to be evaluated in 2019 headrows.

Pop no.	Short Pedigree	DH Rows Tested in 2019
1	TXGA06343-17-3-5-EL2/ MDC07026-F2-19-13-1//VA11W-108PA	110
2	TXGA06343-17-3-5-EL2/ MDC07026-F2-19-13-1//VA11W-279	32
3	TXGA06343-17-3-5-EL2/ Jamestown//15MW-133	92
4	KY-X08C-1299-18-3/VA11W-279 //MDC07026-F2-19-13-1	60
5	KY06C-1178-16-10-3/ USG3895//GAJT141-14E45	152
6	VA11W-108PA/VA07MAS3-7304-3-2-4-3//MDC07026-F2-19-13-4	118
7	MDC07026-F2-19-13-4/ VA07MAS3-7304-3-2-4-3// HILLIARD	45
8	USG 3895/MD272-8-4-14-6// VA11W-279	96

Table 6. FHB doubled haploid (DH) lines developed jointly by the University of Arkansas-Virginia Tech via Heartland Plant Innovations for evaluation as headrows in the 2018-19 growing season in Warsaw, VA.

Pop no.	Short Pedigree	DH Rows Tested in 2019
1	MDC07026-F2-19-13-3/VA11W-106 (Hilliard "S")	164
2	NC8248-14/Hilliard//MDC07026-F2-19-13-4	84
3	NC8248-14/VA12W-54//MDC07026-F2-19-13-4	56

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY18 award period. 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 FY18 award period?**

   If yes, how many?

   No.

2. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY18 award period?**

   If yes, how many?

   No.

3. **Have any post docs who worked for you during the FY18 award period and were supported by funding from your USWBSI grant taken faculty positions with universities?**

   If yes, how many?

   No.

4. **Have any post docs who worked for you during the FY18 award period and were supported by funding from your USWBSI grant gone on to take positions with private ag-related companies or federal agencies?**

   If yes, how many?

   No.

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 FY18 award period. 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** (S, MS, MR, R, where R represents your most resistant check)	**FHB Rating** (0-9)	**Year Released**
VA11B-141	BAR	MR	1.2	2019
VA12W-68 (SR8483)	SRW	MR	2.6	2018
VA13W-38	SRW	R	0.4	2019
DH12SRW056-058	SRW	MR	2.3	2019
VA14HRW-25	HRW	MR	2.7	2019

Add rows if needed.

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

Abbreviations for Grain Classes

Barley - BAR
Durum - DUR
Hard Red Winter - HRW
Hard White Winter - HWW
Hard Red Spring - HRS
Soft Red Winter - SRW
Soft White Winter - SWW

Publications, Conference Papers, and Presentations

Instructions: Refer to the FY18-FPR_Instructions for detailed instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY18 grant. Only include citations for publications submitted or presentations given during your award period (6/17/18 - 6/16/19). If you did not have any publications or presentations, state 'Nothing to Report' directly above the Journal publications section.

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

> Conley, E.J., and J.A. Anderson. 2018. Accuracy of Genome-Wide Prediction for Fusarium Head Blight Associated Traits in a Spring Wheat Breeding Program. In: Proceedings of the XXIV International Plant & Animal Genome Conference, San Diego, CA.
> Status: Abstract Published and Poster Presented
> Acknowledgement of Federal Support: YES (poster), NO (abstract)

Journal publications.

Cowger, C., Arellano, C., Marshall, D., and **Fitzgerald, J.** (2019). Managing Fusarium head blight in winter barley with cultivar resistance and fungicide. Plant Disease. February 11, 2019.
Status: Published
Acknowledgement of Federal Support: YES

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

Other publications, conference papers and presentations.

"Breeding for FHB Resistance in Virginia Small Grains", February 21, 2019. **Fitzgerald, J.** 2019 Virginia Seed Conference, Richmond, VA.
Status: Presented
Acknowledgement of Federal Support: YES

"Breeding for FHB Resistance in Virginia Small Grains and FHB Research Update", March 21, 2019. Fitzgerald**, J.** Northumberland Young Farmers Association, Heathsville, VA.
Status: Presented
Acknowledgement of Federal Support: YES