

Virginia Small Grains Board Progress Report 2023

Soft Red Winter Wheat Cultivar Development

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PROGRESS REPORT

The soft wheat breeding program at Virginia Tech has continued to use marker assisted selection for determining mate pairs for crossing. However, a new genomic prediction algorithm is now being used to predict genome-wide performance for quantitative traits, such as yield and test weight, in addition to markers that track single gene traits, such as rust resistance.

Breeding activities related to SRW are listed in Table 2. Parent selection included 98 inbreds, with 25 elite lines (3+ years of yield evaluation), preliminary lines (2 years of yield evaluation) and 50 observational lines (1 year of yield evaluation), as well as 48 F_1 parents developed in the previous year (2023). All inbred parents were genotyped with 7,225 genome-wide markers using genotyping by sequencing, as well as with KASP and SSR markers designed to track 51 specific known loci for various traits (Table 1). F_1 lines were genotyped *in silico* using parental genotypes. To reduce the cycle time, genomic prediction was used to predict the genetic merit of lines with only a single year of yield evaluation, where observational lines were only observed in one or two of three environments in a sparse testing design. Environments included Blacksburg VA, Warsaw, VA and Urbana IL in collaboration with the University of Illinois. Plans to include a fourth environment in South Carolina with a Clemson University collaborator are in development.

A total of 348 single crosses and 106 top-crosses (F_1 by elite) were made, as well as three double crosses (F_1 by F_1) of specific interest in spring of 2023. Each day, a list of females and males that were ready for crossing was used to create all pairwise crosses *in silico*. A training dataset consisting of data from 2019 to 2022 was used to train the genomic prediction model. Genomic prediction was then used to assign a genetic merit to each potential cross for multiple traits, including yield, test weight and various diseases resistances such as Fusarium Head Blight (FHB), Leaf rust and powdery mildew. Marker information on known loci were also included for each cross and were considered alongside the genomic predictions. Seed from 12 crosses with complementary disease resistance alleles were selected for DH line development in collaboration with KWS. A set of 99 backcrosses were also made to introgress a dominant male sterility gene from New York germplasm into a Virginia germplasm background for the second cycle of backcrossing to facilitate crossing in a future rapid cycling breeding scheme.

During the past year, the breeding program has continued efforts to facilitate development of superior SRW wheat varieties that are widely adapted, high yielding, resistant to disease and insect pests, and meet both local and export market demands. SRW breeding populations (612) were grown in Blacksburg and Warsaw, and will be selected with a bulk approach to select on family mean yield for the F_2 - F_4 generation. Progeny rows derived from SRW (7,680), FHB (8,960), and Doubled Haploid (DH; 945) populations were evaluated in the field at Warsaw, VA in 2023, of which approximately 1,000 lines have been selected for first-year yield trials for 2023. Experimental and elite lines derived from SRW, FHB, MAS, and DH populations were evaluated in yield tests in 2022 (1247) and 2023 (1318), and results for superior lines evaluated in 2022 are presented in Tables 3 and 4. The advanced nursery (year 3+) was combined with the preliminary (year 2) to allow for direct comparisons of breeding values between year 2 and more advanced materials.

Table 3: Public Soft Wheat Varieties released since 2000*.

Experimental Name	Variety Name	Year of Release
VA96W-250	Sisson	2000
VA98W-591	McCormick	2002
MD11-52	Choptank	2004
MV5-46	Chesapeake	2005
VA02W-370	Jamestown	2007
VA03W-412	Merl	2009
VA11W-108	Hilliard	2015
DH12SRW056-058	Liberty 5658	2019
15VDH-FHB-MAS25-15	TBD	2023

* Lines in bold released since Dr. Santantonio's arrival in August 2020

Table 4: Exclusive Soft Wheat Released since 2015*.

Experimental Name	Variety Name	Year of Release
VA10W-21	AgriMAXX 462	2015
VA10W-96	16162660	2016
VA10W-119	SH 7200	2016
VA11W-106	L11550	2016
VA11W-108PA	Dyna-Gro 9811	2017
VA11W-279	USG 3118	2017
VA12W-72	Progeny 16162692	2017
VA12W-31	Featherstone 31	2018
VA12W-68	SR8483	2018
VA09MAS2-131-6-2	Laverne	2019
VA09MAS1-12-5-1-1	Featherstone 125	2019
13VTK429-3	SH 7222	2020
VA16W-202	Croplan 8118	2020
DH12SRW057-006	SSI30-06	2020
DH13SRW023-201	<i>Not Marketed</i>	2020
VA17W-75	16162746 (EPIX 1375)	2022
15VDH-FHB-MAS33-13	16162747 (SH 5123, USG 3673)	2022
15VDH-FHB-MAS38-01	TBD	2022

* Lines in bold released since Dr. Santantonio's arrival in August 2020

Table 1: Table of SRW breeding activities.

Germplasm Type	2021	2022	2023
SRW Single Crosses made	535	352	348
SRW Top- or Double-Crosses made	0	284	109
SRW Single Cross F_1 rows evaluated	13 ^a	361	348
SRW Top Cross F_1 rows evaluated	0	0	255
Scab-MAS Crosses Made for DH Line development	8	8	11
SRW Crosses to KWS for DH Line development	12	14	12
SRW Breeding Populations evaluated	526	655	612
SRW Wheat Progeny Rows evaluated	3618	10560	7680
Scab Progeny Rows and FHB-MAS-DH Rows evaluated	2798	1497	8960
SRW Wheat Doubled Haploid Headrows evaluated	4044	625	945
SRW, Scab, MAS, and DH Lines in Observation Yield Tests	352	924	988
SRW, Scab, MAS, and DH Lines in Preliminary Yield Tests	131	161	278
SRW, Scab, MAS, and DH Lines in Virginia's State Wheat Test	33	40	42
SRW Wheat Varieties Released	0	3	1 ^b

^a In April of 2020, before the arrival of the new PI, a technician failed to dump and clean a sprayer that had been left half full of glyphosate solution, believing it instead contained an insecticide to control for aphids. This solution was sprayed on the plants developing F_1 and top cross seed. The herbicide application killed the plants and subsequently all developing seed. Only a handful (13) of F_1 lines were observed to have survived.

^b Only a single public release was completed in the spring of 2023. The PI is working with industry and CALS to streamline release of new lines for commercial license in the summer of 2023 shortly after performance is evaluated.

One SRW line, 15VDH-FHB-MAS25-15, was selected for public release in 2023. Line 15VDH-FHB-MAS25-15 is a sister line to 15VDH-FHB-MAS33-13, which was released and privately licensed in 2022. Line 15VDH-FHB-MAS25-15 contains the *Fhb1* locus, known to limit the spread of scab within the grain head, and is resistant to scab and leaf rust, and is moderately resistant to powder mildew. Across three years in the Virginia Tech Official Variety Test, 15VDH-FHB-MAS25-15 ranked 17th in mean grain yield (86.7 bu/ac) across three years, 2020 to 2022, only significantly less than the two highest yielding line 'MAS #143' (90.3 bu/ac) and Dyna-Gro 9172 (90.1 bu/ac; data not shown). This line also exhibited average or above average yield performance in the 221 Gulf Atlantic Nursery in VA, SC, NC, AR and GA. Detailed release documents can be found at github.com/nsantantonio/releases2023.

While the spring (March) timeline for release is suitable for public varieties, this does not work as well for licensing. Industry customers are interested in negotiating licensing shortly after harvest data has been summarized in mid to late summer. The PI is working with CALS and industry partners to streamline release of new lines for commercial license in the summer of 2023 shortly after performance is evaluated.

Table 2: Single gene traits and the loci indicated by DNA markers.

Trait	Locus
Plant Height	RHT1
Plant Height	RHT2
Photoperiod Sensitivity	PpdA1
Photoperiod Sensitivity	Ppd-D1
Vernalization	VrnA1
Vernalization	VrnB1
Vernalization	VrnD1
Fusarium Head Blight	FHB1-3BS
Fusarium Head Blight	FHB 2DL
Fusarium Head Blight	FHB5AS
Fusarium Head Blight	FHB1BJtw
Fusarium Head Blight	FHB2BBess
Fusarium Head Blight	FHB3BBess
Fusarium Head Blight	FHB3BL
Fusarium Head Blight	FHB1ANeusse
Fusarium Head Blight	FHB6ANeusse
Powdery Mildew	Pm1a
Stem Rust / Powdery Mildew	Sr36/Pm6
Stem Rust	Sr26
Stem Rust	Sr22
Stem Rust	Sr24
Stem Rust	Sr2
Leaf/Stripe/Stem Rust	Lr37Yr17Sr38
Leaf Rust	Lr9
Leaf Rust	Lr18
Leaf Rust	Lr19/Sr25
Leaf Rust	Lr19
Leaf Rust	Lr21
Leaf Rust	Lr34/Yr18 CS
Leaf Rust	Lr34Yr18 Jagger
Leaf Rust	Lr46/Yr29
Leaf Rust	Lr1B
Stripe Rust	Yr5
Stripe Rust	Yr4BL
Stripe Rust	QYR.vt-6A
Hessian Fly	H9
Hessian Fly	H13
Barley Yellow Dwarf Virus	BYDV2
Soil Borne Mosaic Virus	SbmP
Tan-spot, Septoria	Tsn1
Rye translocation	1R TRANS
HMW Glutenin	GluA1 Umn19
HMW Glutenin	GludD1
Over-expressed Glutenin	Bx7Oe

Trait	Locus
Milling Quality	SusSynth2B
Flour Yield	FY3AJtown
Kernel Color	KASP_Tamyb10-A1
Kernel Color	KASP_Tamyb10-Nor17
Kernel Color	KASP_Tamyb10-B1
Grain Hardness	pina-D1a Kaspar
Grain Hardness	pinb-wild Kaspar

Table 3: Performance of varieties and breeding lines in the Virginia State Official Variety Test in 2022, comprised of 5 locations across Virginia.

Line	Grain Yield Bu/a (5)	Test Weight Lb/bu (5)	Date Headed Julian (2)	Mature Height In (2)	Powdery Mildew 0-9 (1)
VA19FHB-36	90.7+	57.4	119-	35+	2.5
17VTK4-29	90.2+	57.1	119-	32	0.0-
Dyna-Gro WX21793	87.9+	57.0	122+	34	0.5-
SH 7222 (13VTK429-3)	87.3+	58.2+	120	34	0.0-
VA19W-29	87.0+	57.0	119-	33	2.5
Dyna-Gro WX21741	87.0+	57.3	121	34+	3.0
Dyna-Gro Laverne	86.9+	56.9	117-	30-	5.0+
15VTK-1-101	86.7+	56.4-	120	30-	0.5-
VA19W-02	86.3+	57.1	119-	33	3.0
Dyna-Gro WX22741	86.3+	54.5-	122+	34	1.5
Dyna-Gro Shirley	85.9+	55.2-	123+	33	0.0-
USG 3451	85.5+	57.5	119-	31	3.0
USG 3472	85.4+	56.5	123+	32	1.0-
AgriMAXX 503	85.3+	57.1	123+	34	2.5
17VDH-SRW05-169	85.2+	56.4-	117-	30-	0.0-
Dyna-Gro 9172	85.2+	56.4-	123+	32	3.5+
MAS #86	85.1+	56.0-	122+	34+	4.0+
VA20W-142	85.1+	57.3	122	34+	2.5
VA20FHB-20	84.8	58.4+	118-	33	1.0-
17VDH-SRW01-077	84.6	57.7+	118-	34	0.0-
VA17W-75	84.6	58.0+	117-	32	0.0-
Progeny 20-2	84.6	58.3+	121	34	0.0-
MAS #155	84.6	56.7	122+	34	1.5
KWS394	84.6	55.7-	123+	32	2.0
SY Viper	84.4	57.6+	118-	34+	0.5-
KWS415	84.3	55.4-	124+	33	0.0-
VA19W-24	84.2	57.6+	121	31-	2.0
MAS # 86 PS+	83.7	56.7	123+	35+	4.0+
Featherstone 125	83.6	58.8+	120-	33	1.5
17VDH-SRW05-052	83.6	57.1	117-	30-	1.5
Revere 2148	83.6	57.4	124+	34	2.5
USG 3352	83.4	57.0	124+	34	2.5
CPX91221	83.3	58.6+	124+	32	3.5+
mean	79.8	57.0	121	33	2.2
LSD	5.1	0.6	1	2	1.1
CV	10.1	1.8	1	3	24.5

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A plus or minus sign indicates a performance significantly above or below the test average. The 0-9 ratings indicate a genotype's response to disease or lodging where 0 = highly resistant and 9 = highly susceptible.

Parentheses below column headings indicate the number of site-years in which data were collected.

Line	Grain Yield	Test Weight	Date Headed	Mature Height	Powdery Mildew
CP8045	83.2	56.5	122+	33	3.0
18VDH-FHB-MAS07-164-08	83.1	56.6	116-	32	0.0-
Vision 45	83.0	57.4	124+	38+	0.0-
15VDH-FHB-MAS38-01	82.9	56.4-	115-	30-	0.0-
Pioneer 26R45	82.9	55.8-	122	33	4.0+
AgriMAXX 513	82.9	57.2	121	32	3.0
18VDH-FHB-MAS07-164-01	82.9	57.1	117-	33	1.0-
15VDH-FHB-MAS33-13	82.9	57.2	121	31	4.0+
MAS #143	82.8	56.4-	123+	32	0.0-
Progeny 19-12	82.8	56.2-	122	33	3.0
Progeny #Bullet	82.7	56.6	123+	34	2.5
15VDH-FHB-MAS25-15	82.6	58.0+	118-	31-	2.5
VA19W-43	82.5	58.0+	118-	31-	0.5-
16VDH-SRW03-018	82.5	57.8+	119-	33	2.5
16VDH-SRW03-023	82.4	56.8	120	33	4.0+
Liberty 5658	82.3	57.4	118-	34	3.0
16VDH-FHB-MAS60-7-03	82.3	57.7+	119-	32	0.0-
USG 3363	82.2	57.7+	123+	34	3.0
Progeny #Buster	82.2	57.8+	119-	34	5.5+
DH17SRW136-066	82.2	56.0-	121	33	0.0-
17VDH-SRW03-143	82.2	58.3+	119-	33	0.0-
DH16-SRW120-064	82.1	58.3+	120	30-	0.0-
Dyna-Gro 9151	82.1	58.2+	123+	34	3.0
AgriMAXX 502	82.1	56.3-	121	31	0.0-
MBX 127	81.9	57.0	122+	32	4.0+
SH 4222	81.8	57.5	122+	34	1.5
Dyna-Gro WX20738	81.8	56.8	119-	32	5.0+
Revere 2169	81.8	56.5	123+	32	1.5
Pioneer 26R59	81.7	56.3-	121	30-	0.5-
14VDH-SRW14-150	81.7	56.5	118-	33	1.0-
Progeny #Chad	81.5	56.3-	118-	30-	3.5+
MBX 176	81.5	56.1-	122+	32	3.5+
VA19MAS7-519-1WS-R110	81.5	58.0+	124+	34	1.5
AgriMAXX 505	81.4	57.9+	122+	32	4.0+
VA19FHB-05	81.4	57.4	118-	32	2.5
MAS1407-056-6-3	81.4	58.2+	124+	32	5.0+
Featherstone 3000	81.4	57.6	123+	33	3.0
Revere 2277	81.3	57.9+	126+	33	1.0-
mean	79.8	57.0	121	33	2.2
LSD	5.1	0.6	1	2	1.1
CV	10.1	1.8	1	3	24.5

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A plus or minus sign indicates a performance significantly above or below the test average. The 0-9 ratings indicate a genotype's response to disease or lodging where 0 = highly resistant and 9 = highly susceptible. Parentheses below column headings indicate the number of site-years in which data were collected.

Line	Grain Yield	Test Weight	Date Headed	Mature Height	Powdery Mildew
AgriMAXX 514	81.2	56.5	122+	33	3.0
KWS398	81.2	56.3-	124+	32	0.0-
USG 3463	81.1	56.6	120	33	4.5+
Dyna-Gro 9393	81.0	57.2	122+	32	0.0-
MAS # 133 PS+	81.0	55.3-	123+	32	1.7
Dyna-Gro 9120	81.0	58.2+	120	32	3.5+
Dyna-Gro 9002	81.0	56.3-	120	32	3.5+
Dyna-Gro 9352	80.9	55.9-	122	33	3.0
AgriMAXX EXP 2110	80.8	57.5	124+	32	3.0
USG 3118	80.8	57.2	117-	32	0.0-
15VDH-FHB-MAS31-30	80.7	57.7+	121	32	2.0
16VDH-SRW09-025	80.7	57.0	119-	33	2.0
USG 3661	80.4	57.9+	122+	31-	3.0
KWS414	80.4	55.5-	125+	33	3.5+
HILLIARD	80.3	56.6	119-	34	3.0
MAS #316 PS+	80.1	56.5	123+	36+	3.0
SY 547	80.1	57.1	120	36+	4.0+
CP8118	80.1	56.2-	118-	30-	3.0
AgriMAXX 516	80.0	56.2-	123+	32	3.0
AgriMAXX EXP 2105	80.0	56.9	124+	33	3.5+
VA20W-171	79.8	55.6-	118-	33	3.0
SY 100	79.7	54.5-	122+	31	3.5+
MBX 223	79.6	56.6	121	32	3.5+
MAS # 134	79.4	57.3	122+	31-	3.0
17VTK6-61	79.2	58.1+	118-	30-	0.0-
SH 9520	79.2	57.0	125+	32	4.0+
AgriMAXX EXP 2222	79.1	58.0+	122+	32	3.0
USG 3783	79.0	57.3	123+	32	1.5
NC15V25-20	78.5	57.8+	120	32	4.0+
NC18-16913	78.5	57.7+	119-	35+	1.0-
SY Richie	78.5	56.6	116-	32	3.0
17VTK19-15	78.4	57.2	121	34	3.5+
Pioneer 26R36	78.2	56.8	123+	32	1.5
NC11546-14	78.2	58.1+	118-	36+	3.5+
SY 007	78.2	57.1	117-	33	2.5
16VTK19-201	77.9	58.0+	117-	34	2.5
FS 743	77.7	56.9	122+	34	3.5+
MAS #67	77.6	55.5-	121	32	2.0
mean	79.8	57.0	121	33	2.2
LSD	5.1	0.6	1	2	1.1
CV	10.1	1.8	1	3	24.5

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A plus or minus sign indicates a performance significantly above or below the test average. The 0-9 ratings indicate a genotype's response to disease or lodging where 0 = highly resistant and 9 = highly susceptible.

Parentheses below column headings indicate the number of site-years in which data were collected.

Line	Grain Yield	Test Weight	Date Headed	Mature Height	Powdery Mildew
GA 11052-19LE15	77.6	57.9+	119-	33	1.5
FS 875	77.3	57.2	121	32	3.0
VA20W-69	77.1	56.0-	118-	32	3.5+
MBX 2261	77.1	56.4	121	33	1.5
MAS #139	77.0	55.8-	123+	32	3.5+
FS 745	76.7	56.4-	122+	32	3.0
MAS #133	76.6	55.2-	122+	32	3.0
GP 463	76.2	56.2-	120	32	0.5-
FS 597	76.2	56.8	119-	31-	2.0
VA19FHB-22	76.0	57.3	119-	34+	4.5+
Revere 2266	75.9	56.1-	123+	32	3.0
NC13211-9	75.8	58.2+	121	33	3.5+
USG 3563	75.6	57.1	124+	34	2.0
VA19W-31	74.9	56.9	118-	32	2.0
GP 381	74.7	55.7-	120	31	1.5
MAS #2	74.7-	58.1+	124+	39+	3.5+
KWS405	74.4	57.4	121	33	3.5+
GA 151313-LDH224-19E38	74.3-	58.0+	121	32	0.0-
GP 348	74.1-	58.6+	114-	32	1.0-
SY 576	73.1-	56.1-	127+	34	3.0
SH 7200	72.4-	57.2	117-	34	2.5
VA18HRW-57	72.1-	57.1	125+	34+	3.5+
FL16045LDH-25	71.6-	59.3+	118-	34	4.0+
MAS # 316	71.2-	56.9	123+	35+	3.0
MASSEY	71.2-	56.9	118-	39+	1.0-
FS 891	71.1-	57.3	123+	33	2.0
18VDH-FHB-MAS06-152-03	70.8-	56.3-	119-	32	5.5+
VA18HRW-96	70.8-	57.1	124+	35+	1.0-
VA18HRW-58	70.4-	58.5+	125+	35+	2.0
MAS # 189	70.3-	57.5	115-	34	1.0-
MAS #106	69.7-	56.4-	116-	31-	2.5
15VDH-HRW15-062	69.6-	56.8	124+	31-	1.0-
NC13955-G125	68.9-	56.6	119-	34	2.5
GA 121012-19LE8	68.9-	57.7+	124+	38+	0.0-
HR 5210	68.2-	56.0-	124+	31-	1.5
FL16009LDH-16	68.2-	54.9-	119-	33	2.0
FL15105-LDH039	67.8-	58.6+	116-	34	2.5
GA 111055-19LE12	67.4-	57.3	119-	33	2.0
mean	79.8	57.0	121	33	2.2
LSD	5.1	0.6	1	2	1.1
CV	10.1	1.8	1	3	24.5

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A plus or minus sign indicates a performance significantly above or below the test average. The 0-9 ratings indicate a genotype's response to disease or lodging where 0 = highly resistant and 9 = highly susceptible.

Parentheses below column headings indicate the number of site-years in which data were collected.

Line	Grain Yield	Test Weight	Date Headed	Mature Height	Powdery Mildew
Hardy 2519	53.9-	56.2-	122+	30-	3.5+
mean	79.8	57.0	121	33	2.2
LSD	5.1	0.6	1	2	1.1
CV	10.1	1.8	1	3	24.5

A plus or minus sign indicates a performance significantly above or below the test average. The 0-9 ratings indicate a genotype's response to disease or lodging where 0 = highly resistant and 9 = highly susceptible. Parentheses below column headings indicate the number of site-years in which data were collected.

Table 4: Performance of breeding lines in the 2022 SRW Preliminary Yield Trial across two locations, Blackburg VA and Warsaw VA.

Line	Grain Yield bu/ac	Test Weight lb/bu	Heading Date Julian	Height in	Lodging 0-9	Powdery Mildew 0-9
17VDH-SRW02-125	108.3+	60.5+	123+	34	0.3	0.0-
VA20FHB-18	106.6+	60.0	116-	35	0.3	3.5+
18VTK10-77	105.6	59.6	116-	33	0.3	3.5+
SY-VIPER	105.6	60.2	116-	37+	0.3	3.0
18VTK5-95	105.5	60.6+	120	34	0.3	2.0
18VTK6-3	105.1	60.1	121+	34	0.3	2.0
VA19W-87	104.7	59.5	120	36+	1.3+	0.0-
VA17W-74	104.1	61.0+	116-	34	0.3	0.0-
VA21W-59	103.4	58.6	121+	33	0.3	3.0
AGRIMAXX502	103.2	58.1	120	35	0.3	3.0
17VDH-SRW03-204	102.6	59.7	119	36+	0.3	0.5-
18VTK15-27	102.6	56.0-	116-	36+	0.5	0.0-
DH13SRW022-216	102.5	60.1	119	34	0.3	0.0-
MAS#143	102.4	58.1	122+	34	0.3	3.5+
VA20FHB-21	102.2	60.2	118	36+	0.3	3.0
L11541	102.1	60.1	121+	33	0.3	0.0-
18VTK10-188	101.8	59.7	118	34	0.3	3.5+
HILLIARD	101.4	58.6	118	34	0.3	3.0
VA21W-170	101.4	58.6	121+	34	0.3	0.5-
18VTK10-23	101.1	61.1+	116-	33	0.3	2.0
VA21W-76	101.1	57.8-	120+	33	0.3	0.0-
PIONEER26R59	101.0	58.4	119	30-	0.3	3.0
18VTK10-110	100.9	60.8+	122+	33	0.3	2.5
18VTK12-111	100.7	60.8+	123+	34	0.3	0.5-
18VTK12-60	100.6	57.2-	116-	34	0.5	3.5+
VA21W-75	100.4	58.7	117	34	0.3	2.0
17VTK18-13	100.3	58.4	121+	35	0.3	2.5
VA21W-39	100.2	58.5	118	35	0.3	0.5-
18VTK10-5	100.2	60.7+	120+	33	0.3	2.5
VA21W-113	100.0	57.3-	118	32	0.3	3.0
VA21W-165	99.7	59.0	118	34	0.3	0.0-
18VTK10-147	99.6	60.9+	118	35	0.3	2.5
VA21W-112	99.5	57.4-	118	33	0.3	0.5-
17VDH-SRW05-170	99.4	58.4	122+	33	0.3	2.5
mean	94.2	59.1	118	34	0.4	2.3
LSD	11.5	1.2	1	2	0.8	1.2
CV	8.8	1.4	1	4	128.3	26.9

continued ...

A plus or minus sign indicates a performance significantly above or below the test average.
The 0-9 ratings indicate a genotype's response to disease or lodging where 0 = highly resistant and 9 = highly susceptible.
Parentheses below column headings indicate the number of site-years in which data were collected.

Line	Grain Yield	Test Weight	Heading Date	Height	Lodging	Powdery Mildew
VA19W-79	99.1	59.4	117	36	0.3	3.5+
SHIRLEY	99.0	58.0	122+	32	0.3	0.0-
VA20W-5	98.9	60.9+	118	33	0.3	3.0
18VTK10-40	98.9	60.6+	120+	36+	0.3	0.5-
18VDH-FHB-MAS15-367-12	98.8	58.6	118	31-	0.3	1.0-
18VTK9-6	98.8	59.4	116-	32	0.6	3.5+
13VTK59-55	98.8	61.1+	119	32	0.3	3.0
VA21W-57	98.7	59.2	121+	34	0.3	0.5-
VA21W-164	98.4	58.4	118	32	0.3	0.0-
18VTK12-25	98.3	60.5+	118	34	1.3+	3.0
18VTK9-68	98.3	59.0	116-	32	0.6	3.0
18VTK10-133	98.3	61.4+	117-	33	0.3	2.5
VA21W-18	98.2	60.1	114-	31-	0.3	1.5
18VTK18-112	98.2	60.3+	118	35	0.3	3.5+
VA21W-53	98.0	58.3	120+	36+	0.3	3.0
VA21W-52	97.9	58.7	117	33	0.3	1.5
18VTK5-149	97.8	60.0	117	31-	0.3	1.5
VA21W-124	97.2	57.1-	120+	34	0.3	3.0
VA21FHB-24	97.0	57.1-	116-	38+	0.5	0.0-
18VTK15-79	96.9	57.2-	119	34	0.3	2.0
VA20W-191	96.9	59.1	122+	36+	0.3	2.5
19VT1FHB_DH-147	96.6	58.6	122+	37+	0.3	0.5-
VA21W-111	96.5	56.8-	118	32-	0.3	4.5+
DH15SRW65-53	96.3	59.7	121+	31-	0.3	2.5
VA21W-126	96.0	59.5	118	34	0.6	1.0-
VA21W-188	95.7	60.1	117-	36+	1.0	3.0
VA21W-178	95.6	60.4+	117	35	0.3	3.5+
VA21W-77	95.5	61.2+	120	33	0.3	0.5-
18VTK12-90	95.5	60.5+	124+	32	0.3	0.5-
18VTK17-33	95.4	58.8	120	34	0.3	2.0
VA19W-89	95.4	57.9-	120+	35	0.3	0.5-
18VTK17-15	95.3	58.3	116-	34	0.3	0.0-
VA21W-14	95.3	59.0	116-	34	0.3	3.5+
18VTK18-79	95.3	59.5	122+	36+	0.3	4.5+
17VDH-SRW05-223	95.2	59.0	121+	34	0.3	3.0
VA19W-46	95.1	60.2	118	35	0.3	2.5
DH17SRW136-026	95.1	59.0	116-	33	0.3	0.0-
VA21W-60	95.1	59.9	119	29-	0.3	0.0-
mean	94.2	59.1	118	34	0.4	2.3
LSD	11.5	1.2	1	2	0.8	1.2
CV	8.8	1.4	1	4	128.3	26.9

continued . . .

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The 0-9 ratings indicate a genotype's response to disease or lodging where 0 = highly resistant and 9 = highly susceptible.

Parentheses below column headings indicate the number of site-years in which data were collected.

Line	Grain Yield	Test Weight	Heading Date	Height	Lodging	Powdery Mildew
18VTK7-14	94.9	60.1	121+	33	0.3	3.0
19VT1FHB_DH-77	94.9	58.9	120	37+	0.3	2.5
18VDH-FHB-MAS06-141-27	94.9	57.7-	121+	33	0.3	1.0-
18VTK18-114	94.9	59.7	118	33	0.3	2.0
DH16-SRW123-029	94.8	60.1	120+	36+	0.3	2.0
18VTK13-112	94.8	57.6-	118	35	0.5	3.0
18VDH-FHB-MAS15-367-09	94.7	59.7	116-	30-	0.3	3.0
VA21W-177	94.7	60.4+	118	36+	0.3	1.5
19VT1FHB_DH-210	94.6	58.2	119	35	0.3	1.5
19VT1FHB_DH-241	94.5	59.5	118	36+	0.3	2.5
18VTK17-106	94.5	59.7	116-	34	0.3	0.5-
16VDH-FHB-MAS60-7-03	94.5	59.5	118	31-	0.3	0.0-
18VTK17-123	94.4	59.9	117	35	0.6	1.0-
19VT1FHB_DH-74	94.2	60.3+	121+	36+	0.3	2.0
18VTK18-49	94.1	61.5+	117	31-	0.3	3.0
18VTK18-159	94.0	60.1	116-	33	0.3	2.0
VA20W-193	94.0	58.6	119	34	0.3	4.0+
VA21W-84	93.9	57.2-	118	36	1.6+	2.0
18VTK5-147	93.8	60.9+	122+	33	0.3	0.0-
VA21W-182	93.7	58.4	120+	31-	0.3	3.5+
VA21W-116	93.6	57.9-	117	30-	0.3	1.5
VA21W-56	93.5	59.5	120	33	0.3	3.0
18VTK12-91	93.5	58.8	121+	36	0.3	0.5-
VA21W-15	93.4	60.0	117-	36	0.3	3.0
19VT3FHB_DH-25	93.3	58.9	120+	35	0.3	0.5-
USG3316	93.3	58.4	122+	35	0.3	5.0+
19VT1FHB_DH-21	93.2	58.8	120	34	0.3	1.5
19VT1FHB_DH-170	93.1	60.7+	116-	36+	0.8	2.0
USG3118	93.1	60.0	116-	31-	0.3	0.0-
VA21W-194	93.0	60.1	117-	36+	0.5	2.0
VA21FHB-8	93.0	59.8	121+	34	0.5	2.0
18VDH-FHB-MAS06-141-31	93.0	57.2-	121+	36+	0.6	1.5
18VTK16-192	92.8	55.9-	119	33	0.3	2.0
VA21W-28	92.7	60.5+	116-	36+	0.3	0.5-
18VTK18-81	92.6	59.9	116-	32-	0.3	2.0
17VTK20-2	92.6	60.1	123+	34	0.3	3.5+
VA21W-181	92.6	60.1	118	34	0.3	3.0
VA21W-176	92.3	58.8	118	33	0.3	1.0-
mean	94.2	59.1	118	34	0.4	2.3
LSD	11.5	1.2	1	2	0.8	1.2
CV	8.8	1.4	1	4	128.3	26.9

continued ...

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The 0-9 ratings indicate a genotype's response to disease or lodging where 0 = highly resistant and 9 = highly susceptible.

Parentheses below column headings indicate the number of site-years in which data were collected.

Line	Grain Yield	Test Weight	Heading Date	Height	Lodging	Powdery Mildew
19VT1FHB_DH-139	92.3	60.5+	120+	34	0.3	0.5-
19VT1FHB_DH-163	92.0	58.4	116-	35	0.3	2.0
16VT07-5-4-3	91.6	60.1	122+	34	0.3	0.0-
18VTK18-65	91.6	60.2	118	36+	0.3	1.0-
VA21FHB-25	91.4	57.0-	123+	34	0.3	2.5
VA21W-48	91.4	57.9-	116-	33	0.3	2.5
VA21W-17	91.3	59.2	114-	32	0.3	0.0-
VA21W-12	91.2	58.5	122+	36+	0.3	4.0+
VA21W-196	90.8	58.8	115-	34	0.3	0.0-
VA21FHB-11	90.8	58.0	118	36+	0.8	2.0
17VDH-SRW03-266	90.7	58.0	122+	34	0.3	2.5
VA21W-47	90.5	57.8-	118	36+	0.3	2.0
COKER9835	90.4	57.3-	118	31-	0.3	2.0
17VTK18-18	89.9	59.5	116-	34	0.3	3.5+
17VTK4-92	89.9	59.9	116-	35	1.2+	4.0+
17VTK6-54	89.8	60.8+	117-	31-	0.3	3.5+
VA21FHB-12	89.8	57.6-	118	35	0.5	3.0
18VTK5-186	89.4	58.4	122+	32	0.3	2.5
VA21FHB-13	89.3	59.2	115-	35	0.3	7.0+
17VTK2-25	89.0	60.1	116-	36+	0.6	0.0-
16YR0106-5-2	89.0	58.2	116-	30-	0.3	1.0-
18VTK13-52	88.8	59.0	117	34	0.3	2.5
16VT51-4-7-2	88.7	58.1	121+	33	0.3	1.5
VA21FHB-22	88.7	56.2-	118	32	0.3	4.0+
VA21W-51	88.5	58.1	117	31-	0.3	4.5+
17VDH-SRW01-112	87.8	59.8	125+	33	0.3	5.5+
PIONEER26R46	87.7	58.0	117-	34	0.3	3.0
VA21W-71	87.5	60.4+	115-	33	0.3	4.0+
VA21W-69	87.0	59.2	116-	32-	0.3	4.0+
VA21W-175	86.7	59.5	118	35	0.3	6.0+
VA21W-174	86.5	58.5	118	35	0.3	5.0+
18VTK16-57	86.3	59.8	118	33	0.8	2.5
18VTK17-163	86.0	54.9-	116-	31-	0.3	2.0
VA21W-16	85.9	59.5	116-	34	0.3	5.0+
VA21W-49	85.3	58.6	116-	32-	0.3	1.5
DH17SRW136-025	85.2	57.5-	116-	30-	0.3	1.5
19VT1FHB_DH-62	85.1	58.5	123+	35	1.1	0.0-
19VT1FHB_DH-80	85.1	57.7-	117	32	0.3	2.0
mean	94.2	59.1	118	34	0.4	2.3
LSD	11.5	1.2	1	2	0.8	1.2
CV	8.8	1.4	1	4	128.3	26.9

continued . . .

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The 0-9 ratings indicate a genotype's response to disease or lodging where 0 = highly resistant and 9 = highly susceptible.
Parentheses below column headings indicate the number of site-years in which data were collected.

Line	Grain Yield	Test Weight	Heading Date	Height	Lodging	Powdery Mildew
JAMESTOWN	85.0	59.6	116-	32-	0.3	8.0+
18VTK5-133	84.2	59.0	120	30-	0.3	3.0
VA20W-172	84.0	56.9-	118	32-	0.3	5.0+
18VTK13-4	83.6	58.0	121+	34	0.3	4.5+
DH16-SRW120-019	82.5-	59.6	121+	32-	0.3	6.5+
VA21W-61	81.8-	58.9	118	32-	0.3	2.5
19VT1FHB_DH-76	81.3-	60.3+	118	37+	0.3	3.5+
18VTK18-123	81.3-	60.7+	115-	33	0.3	6.5+
VA21W-198	81.0-	60.1	116-	36+	0.3	2.0
VA21W-50	80.9-	58.8	116-	32-	0.3	0.5-
VA21W-121	80.7-	58.3	117	35	0.3	2.0
VA21W-123	80.3-	57.9-	116-	34	0.3	7.0+
18VTK13-26	69.7-	58.2	117-	34	3.0+	5.0+
mean	94.2	59.1	118	34	0.4	2.3
LSD	11.5	1.2	1	2	0.8	1.2
CV	8.8	1.4	1	4	128.3	26.9

A plus or minus sign indicates a performance significantly above or below the test average.

The 0-9 ratings indicate a genotype's response to disease or lodging where 0 = highly resistant and 9 = highly susceptible.

Parentheses below column headings indicate the number of site-years in which data were collected.

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