

Report of the 2022 Uniform Regional Scab Nursery for Spring Wheat Parents

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The Uniform Regional Scab Nursery for Spring Wheat Parents (URSN) was grown for the 28th year in 2022. Five locations (St. Paul, MN, Crookston, MN, Brookings, SD, Prosper, ND, and Langdon, ND) reported results.

A total of 20 entries was included in the 2022 URSN, in addition to the resistant checks ND2710, BacUp, and Rollag, the susceptible checks Wheaton, Oslo, and Norm, and N10, a Norm near-isoline containing *Fhb1*. The entries were contributed by four university wheat breeding programs.

The core set of traits evaluated at the nursery locations varied, but most included Fusarium head blight (FHB) incidence, FHB severity, and disease index. In addition, visual scabby kernel ratings (VSK/tombstone/FDK) were provided for locations. Additional agronomic trait data are presented in individual location summary tables for locations where they were measured. Adult plant and seedling stem rust reactions are also presented. Molecular marker genotypes for a set of FHB resistance QTLs and other traits are provided for entries.

The data of genotype means for locations (Tables 2-6) will be available online on the Triticeae Toolbox under T3/Wheat.

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St. Paul, MN
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Cooperators for the 2022 Uniform Regional Scab Nursery for Spring Wheat Parents

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University of Minnesota (St. Paul, Crookston):

Jim Anderson and Ruth Dill-Macky

North Dakota State University (Prosper, Langdon):

Andrew Green

USDA-ARS, Cereal Crops Research Unit (Fargo, ND):

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USDA-ARS, Cereal Disease Laboratory (St. Paul, MN):

Jim Kolmer and Yue Jin

Figure 1. Map of Uniform Regional Scab Nursery Locations, 2022



Table 1. Entries for the 2022 Uniform Regional Scab Nursery Parents.

Entry	Line	Pedigree	1st Year in URSN	Submitter	Organization
1	Bacup	CHECK			
2	ND2710	CHECK			
3	Rollag	CHECK			
4	Oslo	CHECK			
5	Wheaton	CHECK			
6	Norm	CHECK			
7	N10	CHECK (Norm <i>Fhb1</i> NIL)			
8	MN17065-2	Shelly/MN11268-1	2022	J. Anderson	UMN
9	MN18081-5	MN12069-1/Linkert//Shelly	2022	J. Anderson	UMN
10	MN18163-5	MN12193-6/Lang-MN MN11268-1/MN111116-	2022	J. Anderson	UMN
11	MN18179-4	3//Prosper	2022	J. Anderson	UMN
12	MN18292-3	MN12515-1/MN12281-2//Bolles	2022	J. Anderson	UMN
13	SD4893	SD4383/FOREFRONT	2022	K. Glover	SDSU
14	SD4924	SD4576/SD4607	2022	K. Glover	SDSU
15	SD5030	SY-VALDA/SD4631	2022	K. Glover	SDSU
16	SD5038	SD4539/MN13398-2	2022	K. Glover	SDSU
17	SD5051	SY-VALDA/FOCUS	2022	K. Glover	SDSU
18	NDHRS13-0177-0001	ND823/LANGMN	2021	A. Green	NDSU
19	NDHRS13-0156-C04	ALSEN/FOREFRONT	2021	A. Green	NDSU
20	NDHRS13-0309-B03	LANGMN/SYSOREN	2021	A. Green	NDSU
21	NDHRS17-0596-B28	ND834/LINKERT//SYROWYN	2021	A. Green	NDSU
22	MT21076		2022	J. Cook	MSU
23	MT21082		2022	J. Cook	MSU
24	MT21089		2022	J. Cook	MSU
25	MT21091		2022	J. Cook	MSU
26	MT21102		2022	J. Cook	MSU
27	MT21111		2022	J. Cook	MSU

Table 2. 2022 Uniform Regional Scab Nursery for Spring Wheat Parents, St. Paul, MN.

Entry	Line	Incidence %	Severity %	Disease Index	VSK %	Heading d from 6-1	micro TWT ¹ g	DON ppm
1	Bacup	83.3	11.0	9.2	10.0	27.0	11.1	1.8
2	ND2710	70.0	9.8	7.2	6.0	29.0	11.2	1.7
3	Rollag	93.3	19.2	17.9	10.0	28.0	10.9	2.0
4	Oslo	96.7	45.3	44.2	22.5	27.0	9.7	3.4
5	Wheaton	96.7	91.3	88.3	67.5	30.3	9.3	5.1
6	Norm	100.0	63.4	63.4	57.5	32.3	10.0	4.6
7	N10	90.0	47.2	45.4	42.5	31.7	10.2	2.2
8	MN17065-2	78.3	26.2	20.7	6.0	31.0	10.6	2.4
9	MN18081-5	76.7	33.9	29.4	9.0	31.0	11.3	2.5
10	MN18163-5	73.3	23.6	20.2	7.0	30.3	10.9	0.7
11	MN18179-4	81.7	40.7	36.0	9.0	32.3	11.3	2.7
12	MN18292-3	100.0	41.7	41.7	9.0	33.7	10.9	3.9
13	SD4893	85.0	26.0	24.8	11.5	27.0	10.7	2.1
14	SD4924	100.0	55.9	55.9	11.0	27.0	11.3	3.3
15	SD5030	88.3	18.5	16.9	11.5	27.0	10.8	1.8
16	SD5038	76.7	18.9	14.7	11.5	29.0	10.6	2.4
17	SD5051	96.7	20.6	20.0	13.5	27.0	10.7	2.7
18	NDHRS13-0177-0001	93.3	25.9	24.3	8.0	27.0	11.2	3.0
19	NDHRS13-0156-C04	85.0	21.3	18.8	15.0	27.0	10.3	1.9
20	NDHRS13-0309-B03	58.3	12.7	7.3	8.0	30.0	10.9	1.6
21	NDHRS17-0596-B28	80.0	33.0	26.8	10.0	30.7	10.7	0.8
22	MT21076	98.3	38.5	38.0	12.0	32.3	10.9	3.0
23	MT21082	80.0	28.5	25.2	20.0	29.7	10.5	3.8
24	MT21089	98.3	43.1	42.4	6.0	33.7	10.1	2.1
25	MT21091	78.3	45.4	42.2	11.5	32.3	10.5	3.2
26	MT21102	96.7	53.0	51.7	12.0	30.7	10.8	7.2
27	MT21111	96.7	43.6	42.5	17.5	27.0	10.4	5.4
*	Alsen	91.7	17.1	15.7	9.0	28.0	10.7	1.9
*	Roblin	100.0	81.2	81.2	27.5	27.0	10.7	3.1
*	MN00269	91.7	57.6	54.2	70.0	31.0	9.0	1.3
Mean		87.8	36.5	34.2	18.1	29.6	10.6	2.8
LSD		25.3	24.0	26.4	12.0	2.4	0.6	–
CV		17.2	39.4	46.1	32.4	5.0	2.8	–

¹ Weight of the VSK sample that fits in a 15.7 mL copper vessel measuring 20 mm in diameter and 50 mm in height

* Extra entries

Table 3. 2022 Uniform Regional Scab Nursery for Spring Wheat Parents, Crookston, MN.

Entry	Line	Incidence %	Severity %	Disease Index	VSK ¹ %	Heading d from 6-1	micro TWT ² g	DON ppm
1	Bacup	67.5	13.1	8.8	12.5	35.7	11.2	14.8
2	ND2710	97.5	17.3	17.1	10.5	38.0	11.3	12.3
3	Rollag	100	31.2	31.2	15.5	38.3	11.5	6.5
4	Oslo	100	82.7	82.7	40.0	37.0	10.2	29.4
5	Wheaton	100	66.3	66.3	25.0	42.0	11.0	44.1
6	Norm	100	58.2	58.2	36.5	41.7	10.4	37.6
7	N10	100	41.7	41.7	42.5	40.0	9.8	25.1
8	MN17065-2	100	22.2	22.2	19.0	41.0	11.0	12.6
9	MN18081-5	97.5	22.2	21.5	16.0	39.7	10.7	14.3
10	MN18163-5	97.5	15.9	15.4	13.0	40.7	11.1	5.9
11	MN18179-4	100	17.5	17.5	12.5	42.0	11.0	13.2
12	MN18292-3	100	19.5	19.5	42.5	42.3	9.7	9.5
13	SD4893	95	19.9	19.5	9.0	36.7	11.8	9.1
14	SD4924	95	19.8	19.4	21.0	35.0	10.0	5.0
15	SD5030	100	31.1	31.1	25.0	37.7	10.7	7.3
16	SD5038	100	38.4	38.4	20.0	39.3	10.8	18.4
17	SD5051	100	31.4	31.4	14.0	36.3	11.5	9.3
18	NDHRS13-0177-0001	100	22.6	22.6	20.0	39.7	10.7	19.8
19	NDHRS13-0156-C04	90	20.0	19.1	11.0	38.0	11.9	11.3
20	NDHRS13-0309-B03	100	18.8	18.8	15.0	43.7	11.2	14.0
21	NDHRS17-0596-B28	97.5	28.9	28.0	24.0	39.3	10.6	10.7
22	MT21076	97.5	43.7	42.9	50.0	42.3	10.4	22.0
23	MT21082	100	72.4	72.4	14.0	37.3	10.8	21.1
24	MT21089	100	59.7	59.7	28.0	39.0	10.9	27.7
25	MT21091	100	40.8	40.8	14.0	39.7	11.4	17.6
26	MT21102	100	45.9	45.9	37.5	41.7	10.5	29.3
27	MT21111	100	39.1	39.1	9.0	36.7	11.8	21.9
*	Alsen	97.5	17.8	17.4	14.0	39.3	11.7	9.4
*	Roblin	100	84.9	84.9	14.5	36.3	11.3	19.6
*	MN00269	100	54.6	54.6	15.0	45.0	11.0	22.3
Mean		97.8	36.6	36.2	21.4	39.4	10.9	17.4
LSD		7.4	20.4	20.7	38.5	2.1	2.2	–
CV		4.1	27.3	29.5	104.1	4.3	10.1	–

¹ VSK samples had a very high CV with some susceptible checks, e.g. Roblin and Wheaton, much lower than expected

² Weight of the VSK sample that fits in a 15.7 mL copper vessel measuring 20 mm in diameter and 50 mm in height

* Extra entries

Table 4. 2022 Uniform Regional Scab Nursery for Spring Wheat Parents, Brookings, SD.

Entry	Line	Incidence %	Severity %	Disease %	Tombstone %
1	Bacup	100.0	23.7	23.7	26.7
2	ND2710	100.0	17.5	17.5	20.0
3	Rollag	100.0	25.3	25.3	21.7
4	Oslo	100.0	31.2	31.2	36.7
5	Wheaton	100.0	35.3	35.3	35.0
6	Norm	100.0	29.8	29.8	33.3
7	N10	100.0	28.3	28.3	23.3
8	MN17065-2	100.0	21.3	21.3	13.3
9	MN18081-5	100.0	22.0	22.0	23.3
10	MN18163-5	100.0	24.0	24.0	18.3
11	MN18179-4	100.0	16.8	16.8	20.0
12	MN18292-3	100.0	23.7	23.7	15.0
13	SD4893	100.0	21.5	21.5	20.0
14	SD4924	100.0	29.7	29.7	31.7
15	SD5030	100.0	24.8	24.8	21.7
16	SD5038	100.0	24.8	24.8	26.7
17	SD5051	100.0	22.7	22.7	23.3
18	NDHRS13-0177-0001	100.0	22.3	22.3	23.3
19	NDHRS13-0156-C04	100.0	26.8	26.8	28.3
20	NDHRS13-0309-B03	100.0	17.3	17.3	21.7
21	NDHRS17-0596-B28	100.0	21.5	21.5	23.3
22	MT21076	100.0	20.8	20.8	18.3
23	MT21082	100.0	32.7	32.7	30.0
24	MT21089	100.0	22.5	22.5	23.3
25	MT21091	100.0	21.7	21.7	20.0
26	MT21102	100.0	25.2	25.2	23.3
27	MT21111	100.0	27.3	27.3	21.7
Mean			24.46	24.46	23.62
LSD 0.05			5.98	5.98	5.41
CV			14.96	14.96	14.01

Table 5. 2022 Uniform Regional Scab Nursery for Spring Wheat Parents, Prosper, ND.

Entry	Line	FDK %	VIBE FDK * %	FHB (1-9)
1	Bacup	62.6	92.8	4.6
2	ND2710	30.5	68.2	3.7
3	Rollag	52.4	76.5	4.8
4	Oslo	48.1	55.5	4.1
5	Wheaton	62.7	79.0	4.4
6	Norm	75.1	96.1	6.8
7	N10	66.0	100.0	4.3
8	MN17065-2	53.7	67.4	4.1
9	MN18081-5	53.5	85.7	4.7
10	MN18163-5	34.6	67.4	3.2
11	MN18179-4	44.0	38.2	2.3
12	MN18292-3	40.3	54.1	3.5
13	SD4893	46.2	71.2	4.1
14	SD4924	55.7	80.9	5.7
15	SD5030	60.4	83.3	4.1
16	SD5038	65.0	100.0	5.3
17	SD5051	52.8	80.4	4.4
18	NDHRS13-0177-0001	49.6	78.1	3.5
19	NDHRS13-0156-C04	49.6	77.4	4.6
20	NDHRS13-0309-B03	39.0	69.9	3.6
21	NDHRS17-0596-B28	45.4	74.5	2.7
22	MT21076	65.7	74.5	4.4
23	MT21082	54.3	81.8	5.3
24	MT21089	59.3	64.5	4.0
25	MT21091	55.6	64.8	3.6
26	MT21102	64.3	81.6	4.9
27	MT21111	59.8	80.4	4.7
Mean		53.6	75.8	4.3
LSD 0.05		6.2	6.7	0.8
CV		11.6	11.9	11.3

* Fusarium Damaged Kernels calculated from RGB image of plot grain sample using algorithm from VIBE seed analyzer

Table 6. 2022 Uniform Regional Scab Nursery for Spring Wheat Parents, Langdon, ND.

Entry	Line	FDK %	FHB (1-9)
1	Bacup	38.3	6.0
2	ND2710	27.5	4.5
3	Rollag	30.0	7.5
4	Oslo	41.7	6.2
5	Wheaton	45.0	6.0
6	Norm	45.0	6.7
7	N10	63.3	5.7
8	MN17065-2	33.3	4.0
9	MN18081-5	35.0	4.5
10	MN18163-5	30.0	3.3
11	MN18179-4	32.5	3.0
12	MN18292-3	41.7	3.2
13	SD4893	18.3	5.5
14	SD4924	50.0	8.3
15	SD5030	48.3	5.8
16	SD5038	47.5	5.5
17	SD5051	45.0	5.3
18	NDHRS13-0177-0001	21.7	3.7
19	NDHRS13-0156-C04	41.7	6.5
20	NDHRS13-0309-B03	31.7	4.2
21	NDHRS17-0596-B28	30.0	3.8
22	MT21076	70.0	5.8
23	MT21082	45.0	5.8
24	MT21089	43.3	3.7
25	MT21091	41.7	4.8
26	MT21102	40.0	7.5
27	MT21111	36.7	7.0
Mean		39.8	5.3
LSD 0.05		17.3	1.4
CV		26.6	16.6

Table 7. 2022 Uniform Regional Scab Nursery for Spring Wheat Parents - Summary of Means.

Line	Incidence		Severity		Disease		VSK ¹		
	No. of Locations >	%	Rank	%	Rank	Index	Rank	%	Rank
	3			3		3		5	
Bacup		83.6	1	15.9	2	13.9	1	30.0	16
ND2710		89.2	3	14.9	1	13.9	2	18.9	1
Rollag		97.8	16	25.2	12	24.8	13	25.9	8
Oslo		98.9	20	53.1	26	52.7	26	37.8	23
Wheaton		98.9	20	64.3	27	63.3	27	47.0	25
Norm		100.0	26	50.5	25	50.5	25	49.5	27
N10		96.7	15	39.1	21	38.5	21	47.5	26
MN17065-2		92.8	9	23.2	7	21.4	5	25.1	7
MN18081-5		91.4	5	26.0	13	24.3	11	27.4	10
MN18163-5		90.3	4	21.2	4	19.9	4	20.6	2
MN18179-4		93.9	13	25.0	11	23.4	9	23.6	5
MN18292-3		100.0	26	28.3	16	28.3	16	29.7	14
SD4893		93.3	11	22.5	5	21.9	7	21.0	3
SD4924		98.3	18	35.1	18	35.0	19	33.9	20
SD5030		96.1	14	24.8	9	24.3	10	33.4	19
SD5038		92.2	7	27.3	14	26.0	15	34.1	21
SD5051		98.9	20	24.9	10	24.7	12	29.7	15
NDHRS13-0177-0001		97.8	16	23.6	8	23.1	8	24.5	6
NDHRS13-0156-C04		91.7	6	22.7	6	21.6	6	29.1	13
NDHRS13-0309-B03		86.1	2	16.3	3	14.5	3	23.1	4
NDHRS17-0596-B28		92.5	8	27.8	15	25.4	14	26.5	9
MT21076		98.6	19	34.3	17	33.9	17	43.2	24
MT21082		93.3	11	44.5	24	43.4	24	32.7	18
MT21089		99.4	25	41.8	23	41.5	23	32.0	17
MT21091		92.8	9	35.9	19	34.9	18	28.5	11
MT21102		98.9	20	41.4	22	40.9	22	35.4	22
MT21111		98.9	20	36.7	20	36.3	20	28.9	12

¹ FDK and Tombstone ratings are included, these terminologies are interchangeable

Table 8. Correlation Coefficients Between Traits, by Location.

Correlation Between	St. Paul	Crookston	Brookings
Incidence & Severity	0.583	0.353	*
Incidence & Disease Index	0.643	0.390	*
Incidence & Tombstone/VSK/FDK	0.361	0.245	*
Incidence & DON	0.559	0.184	
Severity & Disease Index	0.996	0.999	1.000
Severity & Tombstone/VSK/FDK	0.726	0.459	0.754
Severity & DON	0.668	0.777	
Disease Index & Tombstone/VSK/FDK	0.723	0.459	0.754
Disease Index & DON	0.687	0.772	
Tombstone/VSK/FDK & DON	0.427	0.471	

* No value since incidence was 100% for all entries.

Table 9. Correlation coefficients among traits, using means across locations.

	Incidence	Severity	Disease Index
Severity	0.233		
Disease Index	0.317	0.995	
Tombstone/VSK/FDK	0.405	0.495	0.519

Calculated using 3 locations: St. Paul, Crookston and Brookings

**Table 10. 2022 Uniform Regional Scab Nursery for Spring Wheat Parents, St. Paul, MN.
Seedling stem rust reactions (Y. Jin, USDA-ARS).**

Entry	Line	Race					Foreign stem rust races ¹						Field stem rust response ²	Notes
		QFCSC 06ND76C	QTHJC 75ND717C	RTQQC 04MN74-1	TPMKC 74MN1409	TTTTF 01MN84A-1-2	TKSK 04KEN156/0 4	TKTT 14KEN58-1	TKTTF 13ETH18-1	TTRTF 14GEO189-1	TKKTP 13GER16-4			
1	Bacup	;1-	2-	2	;1-	3+	3	3	3	3-	23-/;1	15RMR		
2	ND2710	0	2-	2-	2-	0;1	3-	3	;	3	2-	15RMR		
3	Rollag	0	2-	2	2-	;1	3+	3	;1	3-	3	15MRR		
4	Oslo	;	2-	;1-	2-	3	3	3	2-	3+	2-	15MRR		
5	Wheaton	0	2-	;	2-	1;	3	3	0	3	;	5RMR		
6	Norm	0	2-	0;	2-	;1	3	3	0	3-	;	5RMR		
7	N10	0	2-	0;	2-	;1	3+	3	0	3	;	10RMR		
8	MN17065-2	0	2-	2	2-	4	3+	3+	2-	3	2-	20MRR		
9	MN18081-5	;2-	2	22+	2-	4	3-	3	3	3-	3-	20RMR		
10	MN18163-5	0	2-	2-	2-;	;2-	2-	3	0	;2-	2	10RMR	Sr24	
11	MN18179-4	0;	2-2	2-2	2	11+;	3	3+	;1	3	2+3	25MR		
12	MN18292-3	0	2	2-	2-	2-	;1	3	0	0/3	2-	5RMR	Sr24	
13	SD4893	0	2-2	2	2	;1	3-	3	0	3-	1+3-	30MRMS		
14	SD4924	;	2-	2	1-;	11+;	3	3+	1;	3	2+3	30MR		
15	SD5030	;	2-	2	2-	1;	3+	3+	11+;	3+	2+	25MR		
16	SD5038	;	2	2	2-	;1	3+	3+	;1	3	2	25MRR		
17	SD5051	;	2-	2-	2-	0;1	3+	3+	;1	3	2-	15RMR		
18	NDHRS13-0177-0001	;	2-	;1	2/1;	1+1;	3	3+	;1	3	2	20RMR		
19	NDHRS13-0156-C04	0;	2-	2-	2-	0;1-	3+	3+	0	3-	;1	20MRMS		
20	NDHRS13-0309-B03	0;	2-	;1-	2-	;1	3+	3+	;1	3-	2	20RMR		
21	NDHRS17-0596-B28	0;/;2-	2	2	2-	;1	3+	3+	1;	3	22+	30MRMS		
22	MT21076	;	2	2	2	11+;	3+	3+	11+;	3	2+	25MR		
23	MT21082	0;	2-C	1;	2-	0;1	3	3	;1	3+	23	20MRR		
24	MT21089	0;	2-	2-	2-	0;1	3	3	;1	3	3	10RMR		
25	MT21091	0	2-2	;1	2-	;1	3+	3+	;1	3+	22+	5RMR		
26	MT21102	2	2/1	2/;1-	12-/2	3+	3	3+	3+	3+	3+	35MRMS		
27	MT21111	0	2-	;1	2-	0;1	3	3	;1	3+	3-	15RMR		
*	Line E	4	4	4	4	4	4	4	3+	3+	3+	100S		
*	LMPG-6	2+	2+	3+	3+	3+	3+	3+	3+	2-	3	80S		
*	NA101/MqSr7a	11+;	3	1;	3+	;1	3+	3+	1+	3-	2+3	40MRMS		

¹ Recorded in January 2023

² Recorded on July 15th

* checks

Explanatory notes on next page

Table 10 continued, Explanatory notes.

A. Races used in seedling evaluations:

Race	Origin	Virulence on differential genes
QFCSC	USA	5 8a 9a 9d 9g 10 17 21 McN
QTHJC	USA	5 6 8a 9b 9d 9g 10 11 17 21 McN
RTQQC	USA	5 6 7b 8a 9a 9b 9d 9g 11 21 36 McN
TPMKC	USA	5 7b 8a 9d 9e 9g 10 11 17 21 36 Tmp McN
TTTTF	USA	5 6 7b 8a 9a 9b 9d 9e 9g 10 11 17 21 30 36 38 Tmp McN

Foreign stem rust races used, testing is done in Dec-Feb.

TTKSK	Kenya	5 6 7b 8a 9a 9b 9d 9e 9g 10 11 17 21 30 31 38 McN
TTKTT	Kenya	5 6 7b 8a 9a 9b 9d 9e 9g 10 11 17 21 24 30 31 38 McN Tmp
TKTTF	Ethiopia	5 6 7b 8a 9a 9b 9d 9e 9g 10 17 21 30 36 38 McN Tmp
TTRTF	Georgia	5 6 7b 8a 9a 9b 9d 9e 9g 10 11 17 21 36 38 McN Tmp
TKKTP	Germany	5 6 7b 8a 9a 9b 9d 9e 9g 10 17 21 24 30 38 McN Tmp

* **Red font** represents unique and/or significant virulence or combination of virulences to resistance genes that are important in spring wheat

B. Seedling rating scale:

0 to 4 infection type scale of Stakmen et al., 3 or 4 are considered susceptible

"/" denotes heterogeneous, the predominant type given first.

"LIF" denotes low infection frequency, or fewer number of pustules.

"C" stands for excessive chlorosis

"N" stands for excessive necrosis

"Sr2M" referred to seedling chlorosis, similar to Sr2 expression in seedling under certain environments

C. Please direct any questions to yue.jin@usda.gov and sam.gale@usda.gov

Table 11. Markers Associated With Selected Traits/Genes (R. Nandety and J. Fiedler, USDA-ARS).

Trait	Marker	StemRust 3B	StemRust 3B	StemRust 6A	Stem Rust 7D	Fhb 3B	Fhb 3B	Fhb 5A	Fhb 5A	Fhb 6B	LeafRust 1D	LeafRust 2B	LeafRust 2B	LeafRust 7D	YellowRust 2B	TanSpot 5B	Glutenin 1A	Glutenins 1D	GrainProt. 6B	Photoper. 2B	Photoper. 2D	Dwarfing 4B	Dwarfing 4D	StemRust 2D	StemRust 4B	StemRust 4B	StemRust 4B	StemRust 4B	StemRust 6B
		Sr12	Sr2	Sr8-kwh53	Sr25	Fhb1-FM227	Fhb1-TaHRC	barc180-GENE3371	barc186-80018	gwm644	Lr21	Lr16-kwm849	Lr23-sun16	Lr34	Yr7D	Tsn1-1Ka	umh19	GluD1	GPC	PpdB1	PpdD1	RhtB1	RhtD1	Sr6-IWA2415	Sr7a-IWB68386	Sr7a-IWB12146	Sr7a-IWB47019	Sr11-IWB10724	

Entry	Line	Sr12	Sr2	Sr8-kwh53	Sr25	Fhb1-FM227	Fhb1-TaHRC	barc180-GENE3371	barc186-80018	gwm644	Lr21	Lr16-kwm849	Lr23-sun16	Lr34	Yr7D	Tsn1-1Ka	umh19	GluD1	GPC	PpdB1	PpdD1	RhtB1	RhtD1	Sr6-IWA2415	Sr7a-IWB68386	Sr7a-IWB12146	Sr7a-IWB47019	Sr11-IWB10724
1	Bacup	R	S	S	R	S	S	R	R	R	S	S	S	R	S	S	1	G	N	I	I	W	W	R	R	R	R	S
2	ND2710	R	S	S	S	R	R	R	R	S	S	S	R	R	R	S	1	G	N	S	S	W	W	S	R	R	R	R
3	Rollag	R	S	S	R	R	R	S	R	S	S	R	R	R	S	2	G	N	S	S	W	D	S	R	R	R	R	S
4	Oslo	R	S	R	S	S	S	S	S	S	S	S	S	R	R	1	P	N	S	I	D	W	S	R	S	S	R	R
5	Wheaton	R	S	S	S	S	S	S	S	S	S	R	R	R	R	2	G	N	S	S	I	W	D	S	R	R	R	R
6	Norm	R	S	S	S	S	S	S	S	S	S	R	R	R	R	2	G	N	S	S	W	D	S	R	R	R	R	R
7	N10	R	S	S	S	R	R	S	S	S	S	R	R	R	R	1	P	N	S	S	W	D	S	R	R	R	R	R
8	MN17065-2	R	--	S	R	R	R	S	S	S	R	R	R	S	R	2	G	N	S	S	D	W	S	R	S	S	R	R
9	MN18081-5	R	--	S	R	R	R	S	S	S	R	R	R	R	R	2	G	N	I	I	D	W	S	R	S	S	S	S
10	MN18163-5	R	--	S	R	R	R	S	S	S	R	R	R	S	R	2	G	N	S	S	D	W	R	R	R	R	R	S
11	MN18179-4	R	--	S	S	R	R	S	S	S	R	R	R	R	R	2	G	N	S	S	D	W	S	R	S	S	R	S
12	MN18292-3	R	--	S	R	R	R	S	S	S	R	R	R	S	R	2	G	N	S	S	D	W	S	R	S	S	R	R
13	SD4893	R	S	R	S	S	S	S	S	S	S	R	R	R	R	2	G	N	I	I	W	W	S	R	R	R	R	R
14	SD4924	S	S	S	S	S	S	S	S	S	S	R	R	S	R	2	G	N	S	S	W	W	R	R	R	R	R	S
15	SD5030	R	--	S	S	R	R	R	R	R	S	R	R	S	R	2	G	N	S	S	W	D	S	R	R	R	R	S
16	SD5038	S	S	S	S	S	S	S	S	S	S	R	R	R	R	2	G	N	S	S	W	W	S	R	R	R	R	R
17	SD5051	S	--	S	S	R	R	S	S	S	R	R	R	S	R	2	G	N	S	I	W	D	S	R	R	R	R	S
18	NDHRS13-0177-0001	S	--	S	S	R	R	S	S	R	U	S	R	H	R	1	G	N	S	S	W	W	S	R	R	R	R	R
19	NDHRS13-0156-C04	R	S	S	R	S	S	S	S	R	S	R	R	R	S	2	G	N	S	S	W	W	S	R	R	R	R	R
20	NDHRS13-0309-B03	R	--	S	S	R	R	S	S	S	R	R	R	R	S	1	G	N	S	S	W	W	S	R	R	R	R	S
21	NDHRS17-0596-B28	R	--	S	S	S	S	R	R	R	S	R	R	R	R	2	G	N	S	I	W	D	S	R	R	R	R	R
22	MT21076	R	--	S	R	R	R	S	S	S	S	R	R	S	R	1	G	N	S	S	D	W	S	R	R	R	R	R
23	MT21082	R	--	S	S	R	R	S	S	S	R	R	R	S	R	2	G	N	S	S	D	W	S	R	S	S	S	S
24	MT21089	S	--	S	S	R	R	S	S	S	R	R	R	S	R	2	G	N	I	S	D	W	S	R	S	S	S	S
25	MT21091	R	--	S	S	R	S	S	S	S	R	R	R	S	R	2	G	N	S	S	D	W	S	R	S	S	S	S
26	MT21102	S	S	S	S	S	S	S	S	R	S	S	S	U	S	1	G	N	S	S	W	D	S	R	S	S	S	R
27	MT21111	R	--	S	S	R	R	S	S	R	S	R	S	H	R	1	G	N	S	S	D	W	S	R	S	S	S	S

Information about markers on next page

Allele Code	Meaning
R = Resistant	S = Susceptible
R = Resistant (Hope allele)	S = Susceptible
R = Resistant (Harvest allele)	S = Susceptible
R = Resistant (200 bp present)	S = Susceptible (no 200 bp)
R = Resistant	S = Susceptible
R = Resistant	S = Susceptible
R = Resistant	S = Susceptible
R = Resistant	S = Susceptible
R = Resistant (161 bp present)	S = Susceptible (no 161 bp)
R = Resistant	S = Susceptible
R = Resistant	S = Susceptible
R = Resistant	S = Susceptible
R = Resistant	S = Susceptible
R = Resistant (Thatcher allele)	S = Susceptible
R = Resistant	S = Susceptible
1=359bp = Ax1 or Ax-null	2 = 341bp = Ax2
G = Good (5+10)	P = Poor (2+12)
I = Increased	N = Normal
I = Insensitive	S = Sensitive
I = Insensitive	S = Sensitive
D = Dwarfing = Rht-B1b	W = Wild Type = Rht-B1a
D = Dwarfing = Rht-B1b	W = Wild Type = Rht-B1a
R = Resistant/Presence (Sr6 allele)	S = Susceptible/Absence
R = Resistant/Presence (Sr7a allele)	S = Susceptible/Absence
R = Resistant/Presence (Sr7a allele)	S = Susceptible/Absence
R = Resistant/Presence (Sr7a allele)	S = Susceptible/Absence
R = Resistant/Presence (Sr11 allele)	S = Susceptible/Absence

U = No Call or Unknown = Indeterminant designation

Het = Heterozygous call

Table 11 continued, Marker information

Name	Chromosome	Alternate Name	Comment	Manuscript
Sr2			Null allele	https://doi.org/10.1007/s00122-010-1482-7
Sr8		kwh53		https://doi.org/10.1094/PHYTO-05-16-0186-R
Sr12		NBLRR3		https://doi.org/10.1371/journal.pone.0157029
Sr25			SSR	Chao, unpublished
Lr13		IWB1575		https://doi.org/10.1094/PHYTO-03-20-0074-R
Lr16		kwm849		https://doi.org/10.1186/s12870-017-0993-7
Lr21				https://doi.org/10.1007/s11032-012-9773-0
Lr23		sunKASP_16 FJ436983-		https://doi.org/10.1007/s11032-017-0628-6
Lr34		T67957A		https://doi.org/10.1126/science.1166453
Yr7		Yr7D		https://doi.org/10.1038/s41477-018-0236-4
Tsn		Tsn1-1Ka	SNP flanking deletion	Faris Lab unpublished
Fhb1		FM227		https://doi.org/10.1007/s00122-016-2727-x
TaHRC				https://doi.org/10.1007/s00122-018-3159-6
barc180		GENE-3371_56	equivalent to SSR	https://doi.org/10.1007/s00122-011-1573-0
barc186		IWA6412	equivalent to SSR	Chao, unpublished
gwm644			SSR	https://doi.org/10.1093/genetics/149.4.2007
GPC		GPC-B1_DUP		https://doi.org/10.1111/j.1469-8137.2005.01627.x
GluD1				https://doi.org/10.1270/jsbbs.57.243
umn19			SSR	https://doi.org/10.1007/s00122-008-0886-0
RhtB1				https://doi.org/10.1007/s00122-002-1048-4
RhtD1				https://doi.org/10.1007/s00122-002-1048-4
PpdB1				https://doi.org/10.1371/journal.pone.0079459
PpdD1				https://doi.org/10.1007/s11032-012-9765-0
Sr6	2D	IWA2415		https://doi.org/10.3389/fpls.2018.00052
Sr7a	4B	IW68386		https://doi.org/10.1186/s12870-015-0628-9 ; https://doi.org/10.1111/ppa.13530
Sr7a	4B	IWB12146		https://doi.org/10.1186/s12870-015-0628-9 ; https://doi.org/10.1111/ppa.13530
Sr7a	4B	IWB47019		https://doi.org/10.1186/s12870-015-0628-9 ; https://doi.org/10.1111/ppa.13530
Sr11	6BL	IWB10724		https://doi.org/10.1094/PHYTO-04-16-0165-R