Report of the 2016 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 21st year in 2016. Five locations (Brookings, SD, St. Paul and Crookston, MN, Prosper, ND, and Morden, Canada) reported results.

A total of 33 entries was included in the 2016 URSN, in addition to the resistant checks 2375, BacUp, and ND2710, the susceptible checks Wheaton , Oslo, and Norm, and N10, a Norm near-isoline containing the resistance gene *Fhb1*. The entries were contributed by five university and two industry wheat breeding programs.

A core set of traits evaluated at the nursery locations included Fusarium head blight (FHB) incidence, FHB severity, and disease index (incidence x severity). In addition, visual scabby kernel ratings (VSK ≅ tombstone) and grain deoxynivalenol content were provided from two or more locations. Additional agronomic trait data are presented in individual location summary tables for locations where they were measured. Overall means for traits over locations are presented, as are relative rankings for incidence, severity, disease index, and VSK. Correlation coefficients are provided between incidence, severity, disease index, and VSK. Molecular marker genotypes for a set of FHB resistance QTLs and other traits are provided for entries. Adult plant leaf and stem rust reactions are also presented.

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St. Paul, MN
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Cooperators for the 2016 Uniform Regional Scab Nursery for Spring Wheat Parents

South Dakota State University (Brookings):
Karl Glover

University of Minnesota (St. Paul, Crookston):
Jim Anderson and Ruth Dill-Macky

North Dakota State University (Prosper):
Andrew Green

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

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Jim Kolmer, Yue Jin

Table 1. Entries for the Uniform Regional Scab Nursery for Spring Wheat Parents, 2016.

Entry No.	Name	Pedigree	Year First Entered	Source	Organization
1	2375		Check		
2	Wheaton		Check		
3	Bacup		Check		
4	Oslo		Check		
5	ND2710		Check		
6	Norm		Check		
7	N10	Norm BC4 near-isoline with Fhb1	Check		
8	MN10261-1	Glenn/Sabin	2016	J. Anderson	UMN
9	MN11394-6	MN00209-3-1/MN05209	2016	J. Anderson	UMN
10	MN13056-7	Albany/MN07069	2016	J. Anderson	UMN
11	MN13064-2	MN06018/Faller	2016	J. Anderson	UMN
12	MN13515-8	MN00209-3-1/Albany//Rollag	2016	J. Anderson	UMN
13	SD4587	SD3997/SD4181	2016	K. Glover	SDSU
14	SD4589	SD3997/SD4181	2016	K. Glover	SDSU
15	SD4621	SD4078/SD4165	2016	K. Glover	SDSU
16	SD4645	SD4181/SD4165	2016	K. Glover	SDSU
17	SD4675	GLENN/SD4346	2016	K. Glover	SDSU
18	ND820	SD8119/2*ND721	2015	R. Horsley	NDSU
19	ND822	Dapps/Parshall	2015	R. Horsley	NDSU
20	ND824	ND729/ND725	2016	R. Horsley	NDSU
21	ND825	ND2849/ND721//ND735/3/Glenn	2016	R. Horsley	NDSU
22	ND828	Goldfield/2*Alsen//Steele-ND	2016	R. Horsley	NDSU
23	MT1316	Glenn/MT0747	2015	L. Talbert	MSU
24	MT1348	MT0852/MT0858	2016	L. Talbert	MSU
25	MT1401	Vida/MT0827	2016	L. Talbert	MSU
26	UI Stone	Pomerelle*2/Tui	2016	J. Chen	U Idaho
27	IDO1601S	JFSN*4/IDO584 (70-5) // Lassik	2016	J. Chen	U Idaho
28	IDO1603S	JFSN*4/IDO584 (70-5) // Lassik	2016	J. Chen	U Idaho
29	IDO1403S	Yr5/6*Avocet//2*IDO645	2016	J. Chen	U Idaho
30	IDO1405S	IDO495/P29//Treasure/3/IDO624	2016	J. Chen	U Idaho
31	09S0018-2	Breaker/KELBY	2016	J. Davies	Syngenta
32	09S0054-5	03S0352-22/01S0236-6	2016	J. Davies	Syngenta
33	09S0055-1	03S0352-22/03S0032-5	2016	J. Davies	Syngenta
34	09S0084-14	04S0284-4/FALLER	2016	J. Davies	Syngenta
35	09S0118-10	SD4059/SY SOREN	2016	J. Davies	Syngenta
36	LNR14-0677	CARBERRY / RB07	2016	B. Cooper	Limagrain
37	LNR14-0679	CARBERRY / RB07	2016	B. Cooper	Limagrain
38	LNR14-0747	LNR10-0146 / SNOWBIRD	2016	B. Cooper	Limagrain
39	LNR14-1868	FALLER / RB07	2016	B. Cooper	Limagrain
40	LNR14-1774	SP05 / RB07	2016	B. Cooper	Limagrain

Table 2. 2016 Uniform Regional Scab Nursery for Spring Wheat Parents, Crookston, MN.

Line	Incidence %	Severity %	Disease Index	VSK %	DON ppm	Heading d from 6-1
2375	97.5	33.5	32.9	17.5	10.1	33
Wheaton	100.0	84.6	84.6	-	30.5	34
Bacup	100.0	19.3	19.3	14.5	8.3	29
Oslo	100.0	89.6	89.6	-	4.5	32
ND2710	92.5	11.8	10.8	8.0	9.1	32
Norm	100.0	62.2	62.2	30.0	16.9	35
N10	100.0	51.6	51.6	30.0	7.6	35
MN10261-1	100.0	16.9	16.9	12.5	8.7	35
MN11394-6	87.5	11.1	9.8	7.0	5.4	35
MN13056-7	95.0	14.1	13.4	9.0	4.2	29
MN13064-2	92.5	20.0	18.6	7.0	8.4	32
MN13515-8	90.0	13.5	12.1	8.0	3.8	30
SD4587	82.5	12.3	9.9	9.0	8.8	30
SD4589	92.5	17.9	16.7	15.0	2.6	31
SD4621	92.5	24.2	22.1	7.0	5.6	32
SD4645	90.0	21.7	19.5	11.0	6.4	31
SD4675	87.5	14.6	12.7	6.0	5.9	37
ND820	100.0	23.3	23.3	11.0	8.6	30
ND822	100.0	37.1	37.1	18.5	14.3	30
ND824	85.0	11.1	9.3	8.0	7.1	31
ND825	92.5	16.9	16.2	7.0	10.1	32
ND828	100.0	18.6	18.6	6.0	7.1	36
MT1316	87.5	23.9	20.9	11.5	12.8	37
MT1348	100.0	63.4	63.4	25.0	19.9	35
MT1401	97.5	41.6	41.0	-	9.3	36
UI Stone	97.5	48.1	47.8	15.0	16.8	32
IDO1601S	100.0	78.4	78.4	15.0	3.7	33
IDO1603S	100.0	78.3	78.3	-	8.2	33
IDO1403S	100.0	61.2	61.2	-	27.9	36
IDO1405S	100.0	95.0	95.0	32.5	10.3	32
09S0018-2	92.5	16.6	15.5	9.0	13.1	35
09S0054-5	87.5	24.9	21.5	11.0	11.5	32
09S0055-1	97.5	14.6	14.3	10.0	7.4	33
09S0084-14	92.5	22.7	20.8	10.0	9.8	38
09S0118-10	92.5	21.9	20.8	14.5	15.5	36
LNR14-0677	85.0	13.9	11.8	8.0	4.0	30
LNR14-0679	95.0	14.0	13.3	8.0	5.8	33
LNR14-0747	65.0	12.9	8.2	8.0	5.3	35
LNR14-1868	85.0	15.2	13.0	7.0	4.7	33
LNR14-1774	95.0	24.4	22.9	14.5	5.9	33
Alsen*	100.0	23.2	23.2	7.0	6.6	33
MN00269*	100.0	68.8	68.8	25	7	38
Roblin*	100.0	74.3	74.3	35.0	8.3	28
Mean	94.1	31.7	30.7	13.4	9.5	33.1
LSD	13.2	25.3	24.5	9.4	–	6.6
CV	7.1	40.1	40.1	35.2	–	12.2

*extra entries

Table 3. 2016 Uniform Regional Scab Nursery for Spring Wheat Parents, St. Paul, MN.

Line	Incidence %	Severity %	Disease Index	VSK %	DON ppm	Heading d from 6-1	30 SSW[1] g	micro TWT[2] g
2375	70.0	35.2	25.1	5.0	1.1	23	21.4	11.5
Wheaton	96.7	52.0	50.5	50.0	8.5	30	9.4	-
Bacup	45.0	21.2	8.5	5.0	1.6	23	9.2	-
Oslo	90.0	44.3	40.4	21.0	2.7	23	18.6	10.7
ND2710	78.3	31.6	24.9	6.0	2.1	27	22.7	11.6
Norm	91.7	48.9	44.8	25.0	9.6	27	13.1	9.8
N10	88.3	34.4	30.5	9.0	7.0	28	12.6	9.5
MN10261-1	71.7	18.7	13.4	6.0	2.2	27	19.0	10.8
MN11394-6	75.0	16.6	13.6	4.0	1.0	27	23.1	11.1
MN13056-7	65.0	25.6	19.8	6.0	1.2	23	16.6	11.7
MN13064-2	86.7	22.4	20.3	7.0	2.2	24	24.7	11.6
MN13515-8	50.0	10.6	5.3	8.0	1.7	23	18.3	11.4
SD4587	38.3	21.2	8.2	5.0	1.8	23	22.6	11.3
SD4589	68.3	20.8	13.9	8.0	0.8	23	23.1	11.3
SD4621	43.3	11.7	5.1	5.0	1.6	23	19.1	11.9
SD4645	71.7	28.9	22.4	8.0	2.0	23	22.1	11.7
SD4675	63.3	30.3	18.3	7.0	2.6	27	14.7	10.9
ND820	76.7	31.9	24.5	9.0	2.4	23	15.1	11.6
ND822	56.7	14.1	8.0	8.0	1.7	23	25.5	11.2
ND824	61.7	13.6	8.8	6.0	1.4	23	19.1	11.5
ND825	75.0	20.3	15.5	7.0	4.8	23	17.2	11.2
ND828	63.3	22.2	14.2	5.0	2.8	27	21.3	11.6
MT1316	88.3	33.1	30.8	12.5	5.1	27	12.0	10.4
MT1348	98.3	64.1	62.9	28.5	5.7	26	16.2	10.0
MT1401	86.7	29.0	25.3	7.0	1.4	28	14.9	11.2
UI Stone	98.3	53.6	53.0	9.0	4.5	26	15.5	10.4
IDO1601S	88.3	41.0	36.4	30.0	5.9	23	13.0	10.8
IDO1603S	98.3	62.0	61.3	40.0	10.1	26	9.7	8.7
IDO1403S	91.7	55.1	50.8	14.0	6.0	28	13.3	9.8
IDO1405S	90.0	44.3	41.5	11.0	3.7	26	21.8	10.6
09S0018-2	78.3	29.6	23.7	7.0	3.8	27	13.0	9.8
09S0054-5	73.3	22.4	16.6	10.0	3.1	24	18.7	10.5
09S0055-1	96.7	33.4	32.3	10.5	3.1	27	14.5	10.3
09S0084-14	88.3	26.9	23.8	7.0	3.2	28	14.2	10.5
09S0118-10	80.0	24.7	19.6	17.5	4.5	28	20.3	11.0
LNR14-0677	68.3	29.4	22.0	7.0	0.8	24	17.1	11.6
LNR14-0679	66.7	30.3	22.4	13.5	3.4	26	13.5	10.7
LNR14-0747	60.0	19.2	12.1	5.0	0.9	24	22.0	11.2
LNR14-1868	81.7	19.0	16.0	5.0	1.5	27	18.3	11.1
LNR14-1774	61.7	24.8	16.0	9.0	1.3	23	18.1	10.8
Alsen*	76.7	21.6	16.5	6.0	1.5	24	15.0	11.4
MN00269*	98.3	54.8	54.0	40.0	3.6	30	10.0	8.2
Roblin*	100.0	68.9	68.9	47.5	8.8	23	9.9	8.8
Mean	76.7	31.7	26.6	13.0	3.4	25.3	16.9	10.8
LSD	19.9	20.6	21.2	18.3	–	2.3	5.9	0.7
CV	13.0	32.7	40.1	70.7	–	5.6	17.6	3.4

[1] 30 SSW = 30 spike seed weight. This is the sample used to determine VSK.

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

* extra entries

Table 4. 2016 Uniform Regional Scab Nursery for Spring Wheat Parents, Brookings, SD.

Line	Incidence %	Severity %	Disease Index	Tombstone %
2375	94.2	24.7	23.9	30.0
Wheaton	98.3	44.3	43.9	45.8
Bacup	97.5	27.0	26.5	31.7
Oslo	99.2	29.3	29.2	42.5
ND2710	90.8	20.0	19.0	20.5
Norm	95.8	32.6	31.8	35.8
N10	100.0	27.8	27.8	31.7
MN10261-1	90.0	22.8	21.5	18.3
MN11394-6	88.3	17.2	16.0	16.5
MN13056-7	87.5	15.2	13.9	12.0
MN13064-2	95.0	20.1	19.5	22.5
MN13515-8	95.8	17.2	16.5	17.5
SD4587	92.5	15.5	14.6	13.0
SD4589	93.3	18.6	17.7	17.2
SD4621	95.0	16.5	15.9	13.5
SD4645	97.5	18.6	18.1	15.3
SD4675	97.5	22.1	21.7	14.7
ND820	90.8	21.6	20.3	18.3
ND822	96.7	18.9	18.3	16.3
ND824	94.2	18.8	18.0	14.2
ND825	93.3	18.8	18.0	18.0
ND828	90.8	19.2	18.1	12.8
MT1316*				
MT1348*				
MT1401*				
UI Stone	98.3	33.8	33.2	26.7
IDO1601S	99.2	34.5	34.4	33.3
IDO1603S	100.0	39.3	39.3	41.7
IDO1403S	100.0	40.1	40.1	40.8
IDO1405S	100.0	37.8	37.8	39.2
09S0018-2	94.2	20.3	19.5	20.0
09S0054-5	96.7	22.8	22.3	16.8
09S0055-1	92.5	22.6	21.6	17.7
09S0084-14	94.2	30.2	29.0	23.3
09S0118-10	95.0	23.8	23.0	25.0
LNR14-0677	95.8	19.7	19.1	18.8
LNR14-0679	98.3	26.4	26.2	20.2
LNR14-0747	94.2	20.4	19.7	23.2
LNR14-1868	93.3	20.0	19.2	21.5
LNR14-1774	95.0	22.8	21.9	26.7
MEAN	95.16	24.36	23.69	23.59
LSD (0.05)	5.86	5.94	6.24	5.39
CV %	3.48	30.90	32.79	40.38

* not evaluated

Table 5. 2016 Uniform Regional Scab Nursery for Spring Wheat Parents, Prosper, ND.

Line	Incidence %	Severity %	Disease Index
2375	100.0	79.8	79.8
Wheaton	100.0	43.9	43.9
Bacup	100.0	67.8	67.8
Oslo	100.0	66.0	66.0
ND2710	100.0	56.6	56.6
Norm	100.0	67.2	67.2
N10	100.0	52.4	52.4
MN10261-1	100.0	89.3	89.3
MN11394-6	100.0	83.4	83.4
MN13056-7	100.0	91.6	91.6
MN13064-2	100.0	94.4	94.4
MN13515-8	100.0	40.0	40.0
SD4587	100.0	57.6	57.6
SD4589	100.0	50.9	50.9
SD4621	100.0	79.9	79.9
SD4645	100.0	53.8	53.8
SD4675	100.0	52.2	52.2
ND820	100.0	35.5	35.5
ND822	100.0	27.2	27.2
ND824	100.0	61.1	61.1
ND825	100.0	30.7	30.7
ND828	100.0	67.7	67.7
MT1316	100.0	77.2	77.2
MT1348	100.0	81.1	81.1
MT1401	100.0	78.0	78.0
UI Stone	98.0	49.1	48.7
IDO1601S	100.0	65.1	65.1
IDO1603S	100.0	52.7	52.7
IDO1403S	100.0	63.8	63.8
IDO1405S	100.0	46.0	46.0
09S0018-2	100.0	39.3	39.3
09S0054-5	100.0	91.8	91.8
09S0055-1	100.0	68.9	68.9
09S0084-14	97.8	24.1	23.7
09S0118-10	100.0	31.6	31.6
LNR14-0677	100.0	62.1	62.1
LNR14-0679	100.0	25.2	25.2
LNR14-0747	100.0	34.9	34.9
LNR14-1868	100.0	84.1	84.1
LNR14-1774	100.0	88.1	88.1
Mean	100	60.3	60.3
LSD (0.05)			17
CV			18.1

Table 6. 2016 Uniform Regional Scab Nursery for Spring Wheat Parents, Morden, Canada.

Line	Anthesis July date	Incidence[#]	Severity[#]	VRI[#]
2375	13	8.5	6.5	55.3
Wheaton	18	7.7	7.0	53.7
Bacup	6	8.8	4.7	41.2
Oslo	11	8.8	8.0	70.7
ND2710	13	5.8	1.3	7.8
Norm	14	7.7	7.5	57.5
N10	12	8.8	5.2	45.6
MN10261-1	13	7.5	1.8	13.8
MN11394-6	12	5.7	1.0	5.7
MN13056-7	6	8.3	2.8	23.6
MN13064-2	10	9.2	3.3	30.6
MN13515-8	10	8.0	2.5	20.0
SD4587*				
SD4589*				
SD4621*				
SD4645*				
SD4675*				
ND820	9	9.0	5.2	46.5
ND822	11	7.3	3.5	25.7
ND824	10	8.0	2.3	18.7
ND825	10	8.8	3.5	30.9
ND828	12	7.8	2.3	18.3
MT1316*				
MT1348*				
MT1401*				
UI Stone*				
IDO1601S*				
IDO1603S *				
IDO1403S*				
IDO1405S *				
09S0018-2*				
09S0054-5*				
09S0055-1*				
09S0084-14*				
09S0118-10*				
LNR14-0677	11	8.7	4.3	37.6
LNR14-0679	11	7.3	3.7	26.9
LNR14-0747	11	6.0	2.7	16.0
LNR14-1868	13	8.0	4.0	32.0
LNR14-1774	12	6.5	3.8	24.9

* not evaluated

Based on a 0-10 rating scale. VRI = incidence x severity.

Table 7. 2016 Uniform Regional Scab Nursery for Spring Wheat Parents - Summary of Means.

	Incidence		Severity		Disease		Tombstone	
	%	Rank	%	Rank	Index	Rank	%	Rank
No. Locations	4		4		4		3	
Line								
2375	90.4	22	43.3	29	40.4	28	17.5	30
Wheaton	98.7	38	56.2	37	55.7	37	47.9	40
Bacup	85.6	6	33.8	20	30.5	18	17.1	29
Oslo	97.3	34	57.3	38	56.3	38	31.8	38
ND2710	90.4	20	30.0	14	27.8	14	11.5	14
Norm	96.9	31	52.7	33	51.5	33	30.3	37
N10	97.1	33	41.6	28	40.6	29	23.6	32
MN10261-1	90.4	21	36.9	24	35.3	24	12.3	19
MN11394-6	87.7	10	32.1	18	30.7	19	9.2	6
MN13056-7	86.9	7	36.6	23	34.6	23	9.0	5
MN13064-2	93.5	28	39.2	25	38.2	27	12.2	18
MN13515-8	84.0	4	20.3	1	18.5	1	11.2	10
SD4587	78.3	1	26.6	10	22.6	5	9.0	4
SD4589	88.5	13	27.0	11	24.8	11	13.4	23
SD4621	82.7	3	33.1	19	30.7	20	8.5	3
SD4645	89.8	16	30.7	15	28.4	15	11.4	13
SD4675	87.1	8	29.8	13	26.2	13	9.2	7
ND820	91.9	24	28.1	12	25.9	12	12.8	22
ND822	88.3	12	24.3	5	22.6	6	14.3	26
ND824	85.2	5	26.1	8	24.3	8	9.4	8
ND825	90.2	19	21.7	2	20.1	3	10.7	9
ND828	88.5	14	31.9	17	29.6	17	7.9	2
MT1316*	91.9	26	44.7	30	43.0	30	12.0	16
MT1348*	99.4	39	69.5	40	69.1	40	26.8	34
MT1401*	94.7	29	49.5	32	48.1	32	7.0	1
UI Stone	98.1	37	46.1	31	45.7	31	16.9	28
IDO1601S	96.9	32	54.8	34	53.6	34	26.1	33
IDO1603S	99.6	40	58.1	39	57.9	39	40.8	39
IDO1403S	97.9	36	55.0	35	54.0	35	27.4	35
IDO1405S	97.5	35	55.8	36	55.1	36	27.6	36
09S0018-2	91.3	23	26.4	9	24.5	10	12.0	15
09S0054-5	89.4	15	40.5	27	38.0	26	12.6	20
09S0055-1	96.7	30	34.9	22	34.3	22	12.7	21
09S0084-14	93.2	27	26.0	7	24.3	9	13.4	24
09S0118-10	91.9	25	25.5	6	23.7	7	19.0	31
LNR14-0677	87.3	9	31.3	16	28.7	16	11.3	12
LNR14-0679	90.0	17	24.0	4	21.8	4	13.9	25
LNR14-0747	79.8	2	21.9	3	18.7	2	12.1	17
LNR14-1868	90.0	18	34.6	21	33.1	21	11.2	11
LNR14-1774	87.9	11	40.0	26	37.2	25	16.7	27

* Montana entry means based on one fewer location than other entries

Table 8. Correlation Coefficients Between Traits, by Location.

Correlation Between	Crookston	St. Paul	Brookings	Prosper
Incidence & Severity	0.57	0.77	0.68	0.28
Incidence & Disease Index	0.60	0.84	0.71	0.28
Incidence & Tombstone/VSK	0.51	0.61	0.66	
Incidence & DON	0.30	0.65		
Severity & Disease Index	1.00	0.99	1.00	1.00
Severity & Tombstone/VSK	0.87	0.79	0.90	
Severity & DON	0.40	0.76		
Disease Index & Tombstone/VSK	0.87	0.80	0.90	
Disease Index & DON	0.40	0.77		
Tombstone/VSK & DON	0.40	0.77		

Morden not included since the majority of entries were not evaluated

Table 9. Correlation Coefficients Among Traits, Using Means Across Locations.

	Incidence	Severity	Disease Index
Severity	0.76		
Disease Index	0.78	1.00	
Tombstone/VSK	0.70	0.73	0.74

Table 10. 2016 Uniform Regional Scab Nursery for Spring Wheat Parents, Adult Plant Leaf Rust Reactions, St. Paul, MN (J. Kolmer, USDA-ARS).

Line	Leaf Rust
2375	10MR
Wheaton	40MRMS
Bacup	--
Oslo	--
ND2710	50S
Norm	50MRMS
N10	60MS
MN10261-1	10R
MN11394-6	40MS
MN13056-7	10R
MN13064-2	50S
MN13515-8	40MRMS
SD4587	5R
SD4589	--
SD4621	10MR
SD4645	10MRMS
SD4675	10MR
ND820	40MS
ND822	40MRMS
ND824	10RMR
ND825	40MS
ND828	50S
MT1316	50S
MT1348	50MSS
MT1401	70S
UI Stone	--
IDO1601S	--
IDO1603S	--
IDO1403S	50S
IDO1405S	70S
09S0018-2	20MRMS
09S0054-5	20MS
09S0055-1	10R
09S0084-14	30MS
09S0118-10	40MRMS
LNR14-0677	50MSS
LNR14-0679	60S
LNR14-0747	40MS
LNR14-1868	70S
LNR14-1774	60MS

Data from inoculated trials using a mixture of races.

Table 11. 2016 Uniform Regional Scab Nursery for Spring Wheat Parents, Seedling and Adult Plant Stem Rust Ratings, St. Paul, MN (Y. Jin, USDA-ARS).

	Race-specific Seedling Reactions														Adult Plant
Line	QFCSC	QTHJC	MCCFC	RCRSC	RKRQC	TPMKC	TTTTF	GFMNC	QCCSM	TTKSK	TKTTF	TRTTF	TKTTF	TKKTP	Rating
2375	0	2	0;	;	2	;1	;1/1;	0;	;1-/1;	3+	;	3	3+	3/;	10R
Wheaton	;	2-	0;	;	;2-	2-	12-;	;	;	3	0	3	;1	;2-/2-	TR
Bacup	0;	2	0;	2-	22+	;1-	3	;	;1-/1;	3	3+	3	3+	3/2-	40RMR
Oslo	;	2	1-	1-;	;	2	4	;1-	;	3+	2-	2-	;1	1;	30RMR
ND2710	0;	2-	;1-	0;	2-	2-/;1-	1;	;	;/;1-	3+	0	3-	;	1-;	10R
Norm	0;	2-	0;	0;	-	2-;	1;	;	;	3	0	3-	;	1-;	TR
N10	0	2-	;	0;	;2-	2-	13-;	0;	;	3+	0;	3	-	1-;	TR
MN10261-1	0	2-	0;	;	2	;2-	13-;	0;	;	3+	;	3+	3+	3-	10R
MN11394-6	0	0	0;	0	;1-	2-	1;	0;	;1-	3+	;1	3	3+	3-	0
MN13056-7	0;/1-;	2-	;	0;	;2-	2-	13-;	;1-	0;	3+	0;	3	;	;2-	10R
MN13064-2	;	2-	2-;	;2-	2	2-	31;	;2-	2-	3+	3-;	3	3+	3	10R
MN13515-8	;	33-	;1-N	;1-	2	2;	0;/;1	;1-	2-	3+	0	3	3+	3	30RMR
SD4587	;	3/2-	;1-	0	1+	2;	;1	1	;/2-;	3+	0	2	3	3	50MS
SD4589	;1-	3c	;1-	;1-	1+2	2	;11+	12-	2-;	3+	0	22+	3+	3	50MS
SD4621	0	1-;	;	;	2	2	;	;	;1-	3+	;1	3	3	3	20R
SD4645	;1-	1c	;1-	;1-	2	2	;11+	2-;	2-	3+	;11+	3+	3+	3	20MR
SD4675	;1-/13-	-	;/1	;1	22+	2/;	3-	;	2c/;	3+	0	3	3+	3	10R/50S
ND820	;	1c	;1-	;1-	2	2-	;13-	;	;1-	3+	;1	3	3	3-	10R
ND822	0	1c	;	0;	;1-	1;	;13-	0;	;	3+	-	3-	0	1	10R
ND824	0;/;	13-	;	;1	2	2-	3-1;	;	1-;	3+	0	3	3	3	20R
ND825	0;/;	11-	;	0;	2-	1;	;1	;	;1-	3	0	3-	0/3	1	10R
ND828	-	13-	-	0;	;	2-	;13-	0;	-	3+	0	3	0	;1-	TR
MT1316	;	1c	;1-	;1-	22+	2-	;11+	;1-	1-;	3+	;1	3+	2+3	3	TR
MT1348	0;	1-1	;	;1-	2-;	1	;1	;	2-;	3+	0	2+3	3+	2+3	10R
MT1401	2-	21	2-	;1	2	2	3/1;	2-	2-	3+	;1	3	3+	2+	30R
UI Stone	;/3;	3	33-	2-;	;1-/3	3+/2	3	3/2-	;/4	3+	;/3+	3+	;2-	2/3+	70S
IDO1601S	0;	;/;1	0;	;	;1-	;1	;1	0;	;	3	0;	22+	;1	2	10MR
IDO1603S	0;	;	0	11-;	;1-/;1	;	;11+	0;	;	3+	3+	3	0	2	5R
IDO1403S	33-	3	3/2-	3	3	3;	3	;1LIF	3	3+	3+	2/3+	3+	3+	80S
IDO1405S	0;	2/3	;1-	;2-/3	;1-	22+	3+	-	;	3+	;1	2	2-	2-/3+	40MR
09S0018-2	0;	;1-	0;	;	;1-	1;	3+	0	0;/2-	3+	;1	3	0;	;1	TR
09S0054-5	0;	1c	0;	;1-	2	2-	;1	-	;2-	3	0	3-	0	23-	0
09S0055-1	;	1c	;1-	;	21	2	;1	;1-	;2-	3+	0	2	3/;	23-	10R
09S0084-14	0;	2-c	;	;1-	21	2	;1	;	;	3+	0	3	3+	3-	0
09S0118-10	0;	13-c	0;	;/;13	3	2	;11+	0	;	3+	0	;1	3	3-	30MRMS
LNR14-0677	0;	2	1;	;2-	2-	2-	;13-	;1-	1-	3+	0	3	3-	2-/3	10R
LNR14-0679	0;	2	;	0;	;2-	2-	;11+	;	;	3+	0/2-	3	2-	2-	10R
LNR14-0747	;1-	2-2	;1-	2-	2	2-	;11+	;1-	;2-	3+	;/3	3	3	3-	5R
LNR14-1868	2-	2-	1-;	2-	2	2-	3	2-	2-;	3	3+	3	3+	3+	5R
LNR14-1774	;	2	1-;	2-	2	2	31;	2-;	2-;	3+	;1	3	3	3	10R
LMPG-6*	3	3	3	3	3	3	3	3	3	3+	3	3	3	3+	80S

* check variety

Table 11, continued. Explanatory notes.

A. Races used in seedling evaluations:

Race	Origin	Virulence on differential genes
MCCFC	USA	5 7b 9a 9g 10 17 Tmp McN
QCCSM	USA	5 9a 9d 9g 10 17 21 **24** McN
QFCSC	USA	5 8a 9a 9d 9g 10 17 21 McN
QTHJC	USA	5 6 8a 9b 9d 9g 10 11 17 21 38 McN
RCRSC	USA	5 7b 9a 9b 9d 9g 10 17 21 38 McN
RKRQC	USA	5 6 7b 8a 9a 9b 9d 9g 17 21 McN
TPMKC	USA	5 7b 8a 9a 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** McN
TTKSK	Kenya	5 6 7b 8a 9a 9b 9d 9e 9g 10 11 17 21 30 **31 38** McN
TRTTF	Yemen	5 6 7b 9b 9d 9g 10 11 17 21 30 36 **38** Tmp McN (and **Sr13, 1A.1R)**
TKTTF	Ethiopia	5 6 7b 8a 9b 9d 9e 9g 10 17 21 30 36 **38 Tmp** McN (*avirulent on Sr7a)
TKTTF	Germany	5 6 7b 8a 9b 9d 9e 9g 10 17 21 30 36 **38 Tmp** McN (and **Sr7a**)
TKKTP	Germany	5 6 7b 8a 9b 9d 9e 9g 10 17 21 **24** 30 **38** McN (and **1A.1R**)

* **Red font** represents unique and/or significant virulence or combination of virulences

References for description of significant races used in the screening:
TTKST: Jin et al. (2008) *Plant Dis* 92:923-926;
TTTSK: Jin et al. (2009) *Plant Dis* 93:367-370.
TTKTT: Newcomb et al. (2016) *Phytopathology* 106:729-736.
TRTTF: Olivera et al. (2012) *Plant Dis* 96:623-628.
TKTTF: Olivera et al. (2015) *Phytopathology* 105:917-928..

B. Seedling rating scale:

0 to 4 infection type scale of Stakmen et al., 3 or 4 are considered susceptible
"/" denotes hetergeneous, 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. Entries repeated with additional races:

Entries had low infection types to TTKSK, missing data or mixed plants to this race, was repeated.

D. Field stem rust nursery evaluations:

Entries were planted in 1-m row plots perpendicular to mixed susceptible spreader rows
Nurseries were inoculated by needle injection of spreader rows, and by spray inoculations
A composite of races QFCSC, QTHJC, RCRSC, RKQQC, and TPMKC used as inoculum
Disease severity and infection responses (R, MR, MS, S and combinations) rated 7/9/2016 (soft dough stage)

Table 12. Allele Sizes of Molecular Markers Associated With Selected Traits/Genes (S. Chao, USDA-ARS).

Trait	Glutenins 1A	Glutenins 1D	Grain Protein	Leaf Rust 1D	Leaf Rust 7D	Tan Spot 5B	Fhb 3B	Fhb 5A	Photo-period	Dwarfing	Dwarfing	Stem Rust 3B	Stem Rust 7D				
Marker	umn19	GluD1	GPC-B1	Lr21	l4	tsn1	Fhb1	barc186	Ppd	Rht-B1	Rht-D1	Sr2	Sr25				
Line																	
2375	341	C	A	T	T	G	C	C/A	T/C	C	C	C	183		206	211	
Wheaton	341	C	A	T	T	--	C	C	C	C	A	C	183		206	211	
Bacup	359	C	A	T	T	G	C	A	C	C	C	C	183	200	206		
Oslo	359	G	A	T	A	G	C	C	C	T	C	C	183		206	211	
ND2710	359	C	A	T	T	G	T	C/A	T	C	C	C	183		206	211	
Norm	341	C	A	--	T	G	--	C	T	C	C	C	183		206	211	
N10	359	G	A	T	T	--	T	C	T	C	A	C	183		206	211	
MN10261-1	341	C	A	C	T	G	T	C	C	C	C	--	183	200	206		
MN11394-6		C	A	T	T	G	T	A	T	C	A	C	183		206	211	
MN13056-7	341	C	A	C	A	G	T	C	T	T	C	--	183		206	211	
MN13064-2	341	C	A	T	A	G	T	A	C	T	C	--	183		206	211	
MN13515-8	341	C	A	T	T	--	T	A	T	C	A	--	183	200	206		
SD4587	341	C	A	T	T	G	T	C	T	C	C	C	183		206	211	
SD4589	341	C	A	T	A/T	G	C/T	C	T	C	C	C	183		206	211	
SD4621	341	C	A	C	A	G	C	C	T	C	C	--	183		206	211	
SD4621	341	C	A	C	A	G	C	C	T	C	C	--	183		206	211	
SD4675		C	A	T	A	G	C	C	T	C	C	C	183		206	211	
ND820	341	C	A	C	A	G	C	C	T	T	C	--	183		206	211	
ND822	341	C	A	C	A	G	C	C	T	C	C	--	183	200	206		
ND824	341	C	A	C	A	--	C	A	T	T	C	--					
ND825	341	C	A	C	T	G	C	C	T	T	C	--	183		206	211	
ND828	341	C	A	C	T	G	T	A	T	T	C	--	183		206	211	
MT1316	359	C	A	C	A	--	C	C	T	T	C	--	183		206	211	231
MT1348	359	C	A	C	T	G	C	C	T	T	C	--			206	211	231
MT1401	341	C	A	C	A	G	C	C	T	C/T	C/A	C	183		206	211	
UI Stone	359	G	A	T	A	--	C	C	C	T	C	--	183	200	206		
IDO1601S	359	C	T	T	A	G	T	C	C	T	C	--	183	200	206	211	
IDO1603S	341	C	A/T	T	A	--	T	C	C	T	C	--	183	200	206		
IDO1403S	359	G	A	T	A	G	T	C	C	T	C	--	183	200	206		
IDO1405S	359	G	A	T	A	--	C	C	C	T	C	C	183		206	211	
09S0018-2	341	C	A	T	T	G	T	C	T	T	C	--	183		206	211	
09S005405	341	C	A	T	T	--	C	C	T	C	A	--	183		206	211	
09S0055-1		C	A	T/C	T	--	C	C	T	C	A	--	183				
09S0084-14	341	C	A	C	T	--	T	C	T	C	A	--	183		206	211	231
09S0118-10	1 and 3	C	A	T	T	G	C	A	T	T	C	C			206	211	231
LNR14-0677	1 and 3	C	A	--	A	G	C	C/A	T	T	C	C	183	200	206		
LRN14-0679	341	C	A	T	A	G	C/T	C/A	T	--	C	--	183		206	211	
LNR14-0747	341	C	A	C	A	G	C/T	A	T	T	C	--	183		206	211	
LRN14-1868	341	C	A	C	A	--	T	A	T	T	C	--	183		206	211	
LNR14-1774	341	G/C	A	T/C	A	G	C/T	C/A	C	T	C	C	183		206	211	

Table 12 continued, Key to Traits.

Trait	Marker	Gene	Chromosome	Size (base)
HMW Glutenins	umn19	Glu-1A	1A	Ax2*=341, Ax1=359
HMW Glutenins	Glu-1D	Glu-1D	1D	G=Poor, C=Good
Grain protein content	Gpc-B1	GPC	6B	T=High, A=Low
Leaf rust	Lr21	Lr21	1D	T=Susceptible, C=Resistance
Leaf rust	I4	Lr34	7D	T=Resistance, A=Susceptible
Tan Spot	tsn1	tsn1	5B	G=Susceptible, -- =Resistance
Scab	Fhb1	Fhb1	3B	T=Resistance, C=Susceptible
Scab	barc186	Fhb 5A	5A	C = Susceptible, A = Resistant
Photoperiod	Ppd	PpdD1_D2	2D	T=Sensitive, C=Insensitive
Plant height	Rht-B1	Rht-B1	4B	C=wild type, T=dwarf
Plant height	Rht-D1	Rht-D1	4D	C=wild type, A=dwarf
Stem rust	Sr2	Sr2	3B	C=Susceptible, T=Resistance (Hope allele)
Stem rust	Sr25	Sr25	7D	200=Resistance