Overview of Breeding for FHB Resistance in Wheat – Where We've Come From and Where We Are

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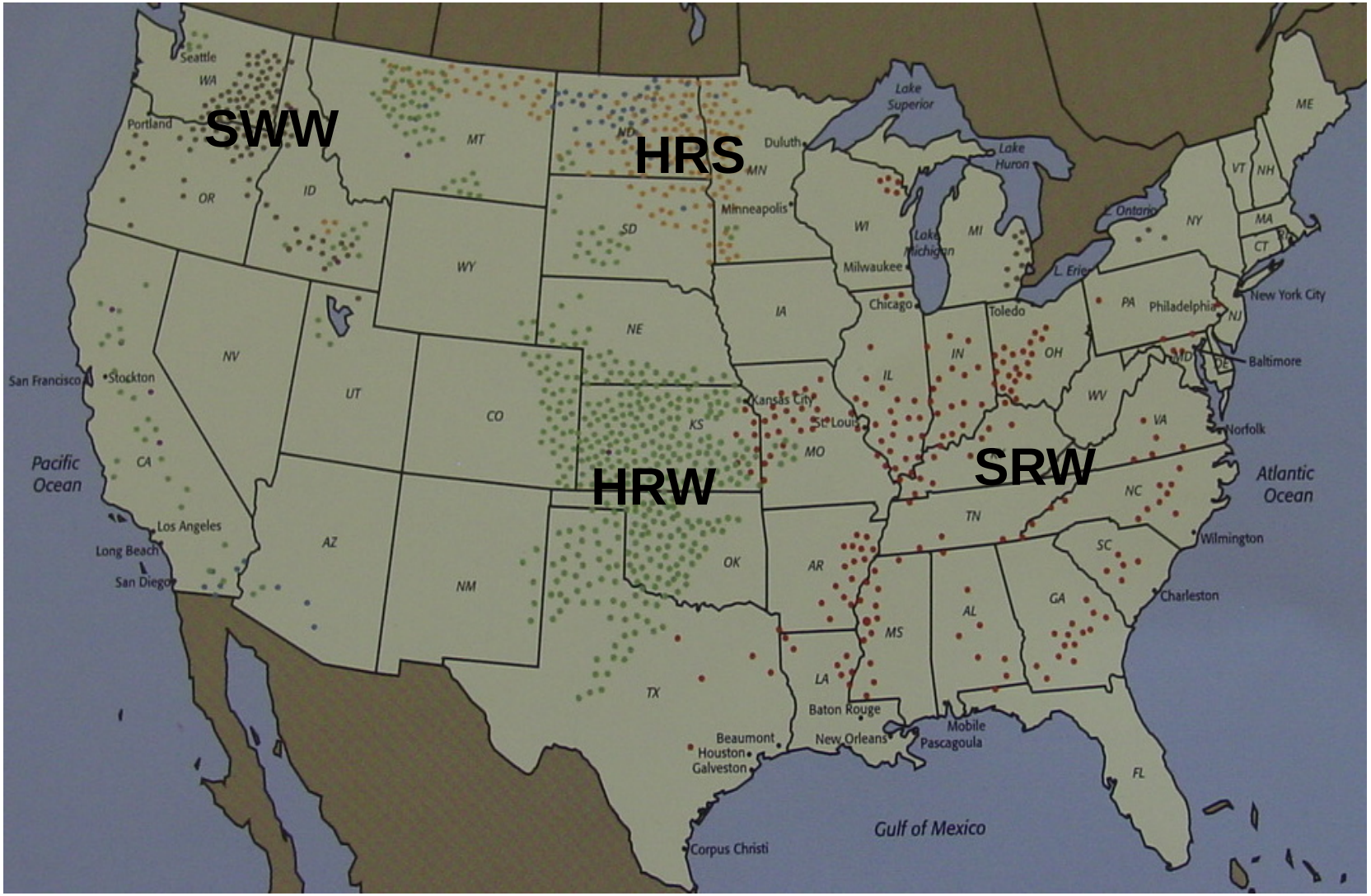
U.S. Wheat Production Regions




UNIVERSITY OF MINNESOTA
Robert Busch
Research Range

Wheat Breeding Priorities

Agronomic Characteristics

1. Yield
2. Lodging resistance
3. Test Weight
4. Shattering
5. Kernel color
6. Pre-harvest sprouting resistance

Diseases

1. Fusarium head blight (scab)
2. Leaf rust
3. Stem rust
4. Leaf Spotting (Tan Spot, Septoria's)
5. Bacterial leaf streak
6. Barley yellow dwarf virus

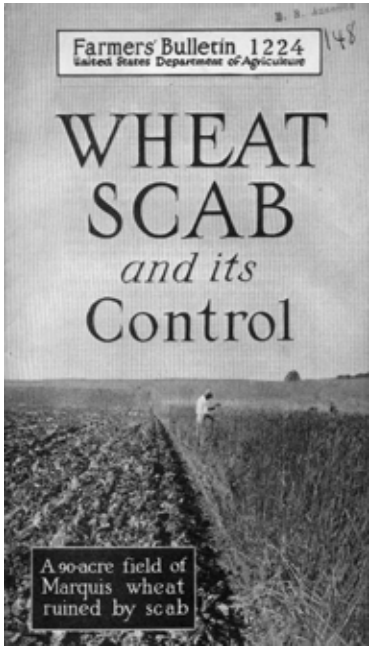
Bread-Making Quality Characteristics

1. % protein
2. Mixing Properties
3. Loaf Volume
4. Flour Water Absorption
5. Kernel Hardness
6. Milling Yield
7. Percent Flour Ash

Fusarium Head Blight in the U.S.

- **Periodic, under-appreciated/reported disease until 1993**

1921



- **Since 1993, regular occurrence of epidemics due to higher rainfall/humidity near flowering time and more residue on soil surface**

Resistance to FHB

(Mesterhazy, 1995)

- **Type I: initial infection (incidence)**
- **Type II: spread of infection (severity)**
- **Kernel infection**
- **Tolerance**
- **Decomposing toxins (DON)**

Type I resistance

Type II resistance

Kernel infection resistance

US Wheat and Barley Scab Initiative

About USWBSI
Mission
What's Scab?
Annual Research Plan
Committees
Browse Funding Data
News Center
Contact Us

USWBSI Services
FHB Listserv
Calendar of Events
What's New? *(RSS Feed)*
FHB-related Links
Site Info/Submit Feedback

Application Menu
Application Overview
Discussion Board
Scab Blog
Photo Library

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WHAT'S HOT!

2012 National Fusarium Head Blight Forum *(Updated: 10/11/12)*

- General Information
- Online-Registration
- Forum Program *(Updated: 10/11/12)*
- Call for Papers

On-line Article: Fusarium Head Blight a Minimal Issue in 2012 *(Posted: 10-9-12)*

Attention Growers: Important Tools for FHB

- Sign up for FHB Alerts
- Scab Smart
- FHB Risk Assessment Tool
- FHB Prediction Center (Wheat)
- Links to Regional FHB Management Sites
- Grain Sampling for DON analysis

Plant Scientists Fight Hunger Through Genetics *(Posted: 10/21/10)*
Read article and watch video!

USWBSI's Action Plan

DON Testing Information including Sample Submission Instructions. *Updated: 5/21/12*

FHB Bibliography Database *Maintained by USDA-ARS-CDL*

US Wheat, Barley and Durum Variety Scab Resistance Data *Interactive Map*

Protocols, Tips and Tricks

RESEARCH UPDATES/REPORTS/PUBLICATIONS

- FY11 Final Performance Reports *Posted: 7/16/12*

FHB Resistant Germplasm Development Timeline

- **Late 1980's screening nursery established, crosses with MR source Sumai 3 (Chinese)**
- **1993-1997 major epidemics, breeding germplasm devastated; massive screening effort to identify resistance sources**
  - **China, Native, South America, Europe**
- **1996 'BacUp' (Nyu Bai/2375//Marshall) released**
  - **MR level of resistance, still used as a check**
  - **Agronomically very poor (25% Chinese)**
- **2000 'Alsen' (ND674//ND2710/ND688)**
  - **MR from ND2710 (Sumai 3/Wheaton//Grandin)**
  - **Was widely grown in the region (6.25% Chinese)**

FHB Rating of popular varieties from 1980's to present

- the few MR cultivars released prior to 2000 were agronomically poor

- now, more than half of available cultivars are MR or better

- *Fhb1*, a major QTL for FHB resistance, is present in the majority of new cultivars

2011 →

2000 →

1986 →

Cultivar[1]	Origin	FBH Rating (1-9)[2]	*Fhb1*
Rollag	2011 MN	3	yes
Select	2011 SDSU	4	no
Prosper	2011 NDSU	5	yes
Brick	2009 SDSU	3	yes
Barlow	2009 NDSU	4	yes
Sabin	2009 MN	4	yes
Albany	2009 Limagrain Cereal Seeds	4	no
Brogan	2009 Westbred	6	no
Brennan	2009 AgriPro	7	yes
Jenna	2009 AgriPro	7	yes
Pivot	2009 Westbred	8	no
Breaker	2008 WestBred	4	yes
Tom	2008 MN	4	no
Blade	2007 WestBred	4	yes
Cromwell	2007 Thunder Seed	4	no
Faller	2007 NDSU	4	yes
RB07	2007 MN	4	no
Vantage	2007 WestBred	5	no
Kuntz	2007 AgriPro	6	yes
Samson	2007 WestBred	8	no
Traverse	2006 SDSU	5	no
Kelby	2006 AgriPro	5	yes
Howard	2006 NDSU	6	no
Ada	2006 MN	6	no
Glenn	2005 NDSU	3	no
Freyr	2004 AgriPro	4	yes
Granger	2004 SDSU	5	no
Steele-ND	2004 NDSU	6	no
Oklee	2003 MN	5	no
Hanna	2002 AgriPro	4	no
Briggs	2002 SDSU	5	no
Granite	2002 WestBred	6	no
Walworth	2001 SDSU	5	no
Knudson	2001 AgriPro	6	no
Alsen	2000 NDSU	4	yes
Parshall	1999 NDSU	5	no
Reeder	1999 NDSU	7	no
NorPro	1999 AgriPro	7	no
Mercury	1999 N. Star Genetics	9	no
Ingot	1998 SDSU	5	no
Forge	1997 SDSU	5	no
Gunner	1996 AgriPro	5	no
Russ	1995 SDSU	6	no
Oxen	1995 SDSU	8	no
2375	1988 Pioneer	5	no
Butte 86	1986 NDSU	6	no

[1] Cultivars are listed in reverse chronological order.

[2] Moderately resistant cultivars (4 or lower rating) are highlighted in green; moderately susceptible and susceptible cultivars (6 or higher rating) are highlighted in red

MR

M/MS

S

Growers are Choosing MR Varieties

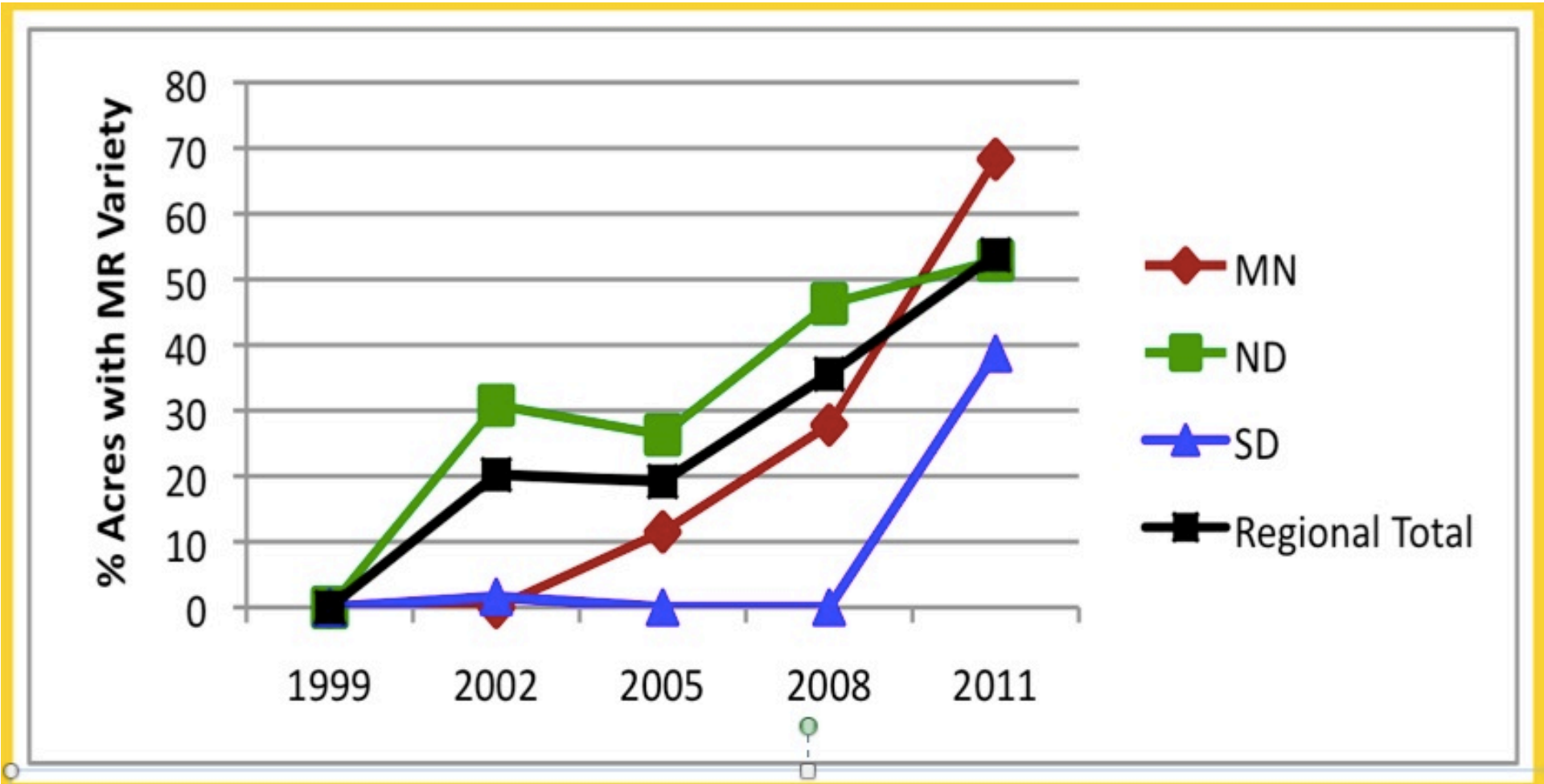

Figure 2: Percent of wheat acres in the Northern Great Plains seeded to cultivars with a moderately resistant (4 or better) rating for FHB resistance.

Variety	Scab	SEV	DON
Brick	3	18	6.7
Forefront	3		
Glenn	3		
Rollag	3		
Barlow	4		
Breaker	4		
Cromwell	4		
Faller	4		
LCS Albany	4		
RB07	4	22	7.1
Sabin	4		
Select	4		
SY-Soren	4		
Briggs	5		
LCS Breakaway	5		
LCS Powerplay	5		
Norden	5	39	9.7
Prosper	5		
Vantage	5		
Knudson	6		
Brennan	7		
Jenna	7		
Marshall	7		
Velva	7		
WB-Digger	7		
WB-Mayville	7		
Samson	8	57	17.8

Variety Rating (1-9 scale)

- Rating assigned following 6+ discriminatory environments
- Other breeders agree with most 3-4 and 7-8 ratings; 5-6 have less agreement

Evolution of FHB Phenotyping

Year(s)	Greenhouse	Field	
		No. Locs	Rows
1993-2000	Pre-yield trial screening 1,000 x 4 plants each	1-2	1,500
2001-2003	Characterize resistant lines & genetic studies	3	5,000
2004-2010	Genetic studies only	3	9,000
2011-p	Genetic studies only	2	10,000

Greenhouse Point-Inoculation Resistance Screening

Inoculated at anthesis with macroconidia

Or Ziploc bag for 48 h

Evaluated 21 d post inoculation

Scab Ratings

Conidia spray

Grain spawn

Kornservice seed cleaner

Thresh 30 spikes or ~0.5 m of row

Micro
Test weight

30 spike wt.
VSK
DON

2009-2011 (6 env.) FHB data

Name	DIS	30 Hd Wt	Micro TWT	DON	VSK	2XDON+VSK+1/4DIS
Alsen	19.5	12.5		6.6	8.6	26.7
Rollag	20.8	18.7	11.0	6.7	8.3	26.8
Brick	18.3	19.6	10.8	6.7	8.9	26.9
Bacup (MR ck)	15.1	17.9	10.8	7.0	10.2	27.9
Glenn	14.8	17.3	11.3	7.9	9.3	28.7
Select	19.6	20.6	10.6	6.2	12.0	29.4
Sabin	24.7	18.2	10.6	7.7	9.3	30.9
RB07	22.5	17.7	10.6	7.1	12.2	32.0
Barlow	29.2	17.2		7.8	9.6	32.6
Albany	32.8	15.9	10.9	7.4	10.0	33.1
Faller	21.4	21.0	10.8	9.3	10.0	33.9
Tom	24.2	19.2	10.5	8.6	12.3	35.5
Cromwell	37.7	15.6	10.5	7.9	11.1	36.4
Briggs	34.9	18.0	10.4	6.8	15.7	38.1
Vantage	31.8	17.4	11.1	10.0	11.0	39.0
Norden	39.8	16.5	10.8	9.7	10.5	39.9
Kelby	36.4	16.4	10.2	8.1	18.7	44.0
Oklee	39.1	20.4	10.4	9.7	18.5	47.6
Ada	36.5	15.4	10.4	12.1	18.5	51.8
Knudson	28.7	17.8	10.4	11.3	22.1	51.9
Marshall	48.7	10.7		15.2	18.3	60.9
Brennan	55.7	14.4	9.9	13.8	25.9	67.4
Jenna	58.3	14.0	10.0	13.7	30.3	72.3
MN00269 (S ck)	80.2	5.9		14.9	35.6	85.4
Samson	57.2	14.7	9.9	17.8	39.6	89.6
Roblin (S ck)	79.4	10.1		12.6	56.3	101.4
Wheaton (S ck)	84.0	6.5		18.3	62.5	120.1

Resistance Traits Assessed

Field Incidence = Type I

Field Severity = Type II

Thirty Head Weight

Test Weight = Grain volume weight

Visually scabby kernels

Deoxynivalenol accumulation

Greenhouse Severity = Type II

Heading date

Height

Resource Allocation and Cultivar Stability in Breeding for Fusarium Head Blight Resistance in Spring Wheat

R. G. Fuentes, H. R. Mickelson, R. H. Busch, R. Dill-Macky, C. K. Evans, W. G. Thompson, J. V. Wiersma, W. Xie, Y. Dong, and J. A. Anderson*

Table 7. Predicted least significant differences [LSD ($P = 0.05$)]† for Fusarium head blight disease index (DIS) among 14 wheat cultivars under differing levels of subsampling plot^{-1} (spike number), plot replication within environments, and environments.

	Replications with 10 spikes plot^{-1}					Replications with 20 spikes plot^{-1}					Replications with 30 spikes plot^{-1}				
No. of env.	2	3	4	6	8	2	3	4	6	8	2	3	4	6	8
1	1.58	1.45	1.38	1.31	1.27	1.52	1.41	1.35	1.29	1.25	1.50	1.39	1.34	1.28	1.25
2	1.12	1.03	0.98	0.93	0.90	1.08	1.00	0.95	0.91	0.89	1.06	0.99	0.95	0.90	0.88
3	0.87	0.80	0.76	0.72	0.70	0.84	0.77	0.74	0.71	0.69	0.82	0.77	0.74	0.70	0.69
4	0.74	0.68	0.65	0.61	0.60	0.71	[illegible]	0.63	0.60	0.59	0.70	0.65	0.63	0.60	0.58
6	0.60	0.55	0.52	0.49	0.48	0.57	0.53	0.51	0.49	0.47	0.57	0.53	0.50	0.48	0.47
8	0.51	0.47	0.45	0.43	0.41	0.49	[illegible]	0.44	0.42	0.41	0.49	0.45	0.43	0.42	0.41
10	0.46	0.42	0.40	0.38	0.37	0.44	0.41	0.39	0.37	0.36	0.43	0.40	0.39	0.37	0.36

† LSD $= t_{(0.05,\,df)} \times [2 \times (s^2_{\varepsilon} + r s^2_{CE})/re]^{1/2}$, where df = degrees of freedom for pooled error, r = number of replications, e = number of environments; s^2_{ε} (plot error variance) $= s^2_w/n + s^2_b$, where s^2_w is the within-plot variance with n spikes plot^{-1} evaluated, s^2_b is between plot variance, and s^2_{CE} is the estimated cultivar × environment variance. Estimated variances are as follows: $s^2_w = 0.7927$; $s^2_b = 0.1713$; $s^2_{CE} = 0.1424$.

Fuentes et al. 2005 Crop Science 45:1965-1972

University of Minnesota Wheat Breeding Timeline

Year	Generation	No. (Loc.)	Lr, Sr	FHB	Markers
1	Crossing/F_1	300			☑
	F_2 (300 x 1000)	300,000	☑		
2	F_3 Winter Nursery	30,000			
	F_4 Headrows	24,000 (2)	☑		
3	F_5 Scab	2,400 (2)	☑	☑	
4	Winter Nursery	1,000			☑
	Prelim. yield trial	550 (2-3)	☑	☑	
5-6	Adv. yield trial	170 (8-10)	☑	☑	
7-9	MN Variety trial	10 (12)	☑	☑	

Use of Markers

1. Parental Characterization
2. Enrichment of BC_1F_1's and 3-way crosses

3. Screen all F_6's (~1,000 lines) with 8 markers

Crossing Parent Marker Database

Name	Pedigree		Fhb1	Ax2*	Ax1	Dx5	Lr34	tan spot 5B	FHB 5A	Lr21
01S0263-28			1	1	0	1	1	1	0	0
03S0253-7	00S0323-7/99S0051-3-1		0	1	0	1	1	0	0	0
09FSP3	Albany sib 1		1	1	0	1	1	0	1	0
MN02072-7	MN97695/MN97518		1	1	0	1	1	1	0	0
MN03196	Alsen-1//Parshall/MN97665		1	1	0	1	1	0	0	0
MN05214-3	MN95229-40//RL4970-4/MN95229-40		1	1	0	1	1	1	0	0
MN06028	MN97695-4/MN95229-40		0	1	1	1	1	1	0	0
MN06075-4	MN99017-6/MN97695-LrW		0	1	0	1	0	0	0	0
MN07098-6	SD3696/MN97803-3BS		0	1	0	1	1	0	0	0
MN07185-1	MN02022-1/MN97695-LrW		0	1	0	1	0	0	0	0
MN07191-5	MN02207-1/MN97695-LrW		0	1	0	1	0	0	0	0
MN07199-6	MN97803-3BS/MN01333-A-1		0	1	0	1	0	1	0	0
MN08013-2	MN02149/MN02252-1		0	1	0	1	0	0	0	0
MN08032-8	ND 801/MN99436-6		0	1	0	1	0	0	0	1
MN08045-6	MN02207-1/MN97695-LrW//MN97803-Lr47		0	0	1	1	0	0	0	0
MN08046-1	MN02207-1/MN97695-LrW//MN97803-Lr47		0	0	1	1	0	0	0	0
MN08105-7	ORL-94346-1/MN97803-3BS//MN99436-6		0	1	0	1	0	0	0	1
MN08106-6	ORL-94346-1/MN97803-3BS//MN99436-6		0	1	0	1	0	0	0	1
MN08227-3	Knudson/MN95002-6B		0	1	0	1	1	0	0	0
ND808			1	1	0	1	0	1	1	1
RB07			0	1	0	1	0	0	0	1
Sabin			1	1	0	1	1	0	0	0

Fall 2011 BC1 Marker Screen

Cross	Pedigree	Markers	No. Seed	no genes	No. datapoints
11X120	Rollag*2/SD 1691	Fhb1	26	1	26
11X121	MN06018/MN05141-2//Prosper	Fhb1, fhb 5AS	16	2	32
11X122	MN06018/MN08301-6//MN07098-6	Fhb1, lr34, fhb 5AS	3	3	9
11X123	MN06018/03S0253-7//MN07098-6	Fhb1, fhb 5AS	4	2	8
11X125	MN06028/MN07199-6//09FSP3	ax1, lr34	22	2	44
11X126	MN06028/MN07338-6//Prosper	ax1, lr34	12	2	24
11X127	MN06028/MN08165-8//Prosper	ax1, lr34	10	2	20
11X128	MN06028/03S0253-7//MN03196-Sr22	ax1	7	1	7
11X131	MN06075-4/MN08046-1//09FSP3	ax2, ax1	24	2	48
11X136	Prosper/2*MN07199-6	Fhb1, fhb 5AS	16	2	32
11X137	Prosper/MN08032-8//MN07199-6	Fhb1, fhb 5AS	17	2	34
11X138	Prosper/MN08046-1//Sabin-Sr35	Fhb1, ax2, ax1, fhb 5AS	18	4	72
11X139	Prosper/MN08165-8//MN07098-6	Fhb1, fhb 5AS	15	2	30
11X140	Prosper/MN08301-6//MN03196	Fhb1, fhb 5AS	6	2	12
11X141	RB07/MN06028//Prosper	ax1, lr34	8	2	16
11X145	RB07/MN08046-1//MN07199-6	ax2, ax1	17	2	34
11X148	RB07/03S0253-7//MN02072-7	lr34	13	1	13
11X149	Gabo 56/2*MN02072-7	Fhb1	11	1	11
11X150	MN03196/Gabo 56//MN03196-Sr26	Fhb1	10	1	10
11X151	MN03196/MN07338-6//MN06075-4	Fhb1, lr34	12	2	24
11X152	MN03196/MN08165-8//MN07098-6	Fhb1, lr34	11	2	22
11X153	MN03196/03S0253-7//MN07098-6	Fhb1	19	1	19
11X155	MN08013-2/MN06018//Prosper	Fhb1, lr34, fhb 5AS	11	3	33
11X156	MN08046-1/MN06018//Prosper	Fhb1, ax2, ax1, lr34, fhb 5AS	18	5	90
11X157	MN08106-6/MN06018//MN07199-6	Fhb1, lr34, fhb 5AS	9	3	27
11X158	MN08106-6/MN06028//Prosper	ax1, lr34	19	2	38
11X159	MN08165-8/MN06018//MN08106-6	Fhb1, lr34, fhb 5AS	10	3	30
11X160	MN08165-8/MN07098-6//Prosper	lr34	16	1	16
11X163	09FSP3/MN06075-4//MN07098-6	Fhb1, lr34, fhb 5AS	21	3	63
11X164	09FSP3/MN03196//MN02072-7	fhb 5AS	4	1	4
11X165	09FSP3/2*MN07098-6	Fhb1, fhb 5AS	19	2	38
11X166	09FSP3//MN07199-6/MN07098-6	lr34	12	1	12
11X168	09FSP3//MN08032-8/MN07098-6	lr34	2	1	2
11X169	MN03196-Sr22//MN06028/MN07199-6	ax1, lr34	2	2	4
11X171	Rollag//Prosper/MN08013-2	Fhb1, fhb 5AS	5	2	10
11X172	Rollag*2/Gabo 56	Fhb1	28	1	28
			473		942

2010 F5 Selections (2011 PY Candidates)

Cross	Pedigree	StP Scab	VSK	Ax2*	Dx5	FHB 5AS	Fhb1	Lr21	Lr34
07X001	00H04*J3/MN03130-1-62	3	1	359	278	190	268	286	156
07X001	00H04*J3/MN03130-1-62	3	2	341	278	190	273	304	156
07X003	00H04*J3/MN05233	3	2	359	278	190	273	286	156
07X003	00H04*J3/MN05233	2	2	359	278	194	268	304	156
07X003	00H04*J3/MN05233	2	2	359	278	194	268	304	156
07X012	Tc*2/Am 44d Line 42A//MN99436-6	2	3	341	278	194	273	196	237
07X034	Glenn/MN03148	1	2	341	295	190	273	196	237
07X034	Glenn/MN03148	1	2	341	295	190	273	196	156
07X034	Glenn/MN03148	1	2	341	295	190	273	196	156
07X036	Howard/MN03118-2	2	2	341	295	203	268	196	237
07X036	Howard/MN03118-2	2	2	341	295	203	268	196	237

and about 1,000 more...

Funding

U.S. Wheat & Barley Scab Initiative

MN Small Grains Initiative (Scab, Leaf rust)

MN Wheat Res. & Prom. Council

Wheat Breeding Research Team

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