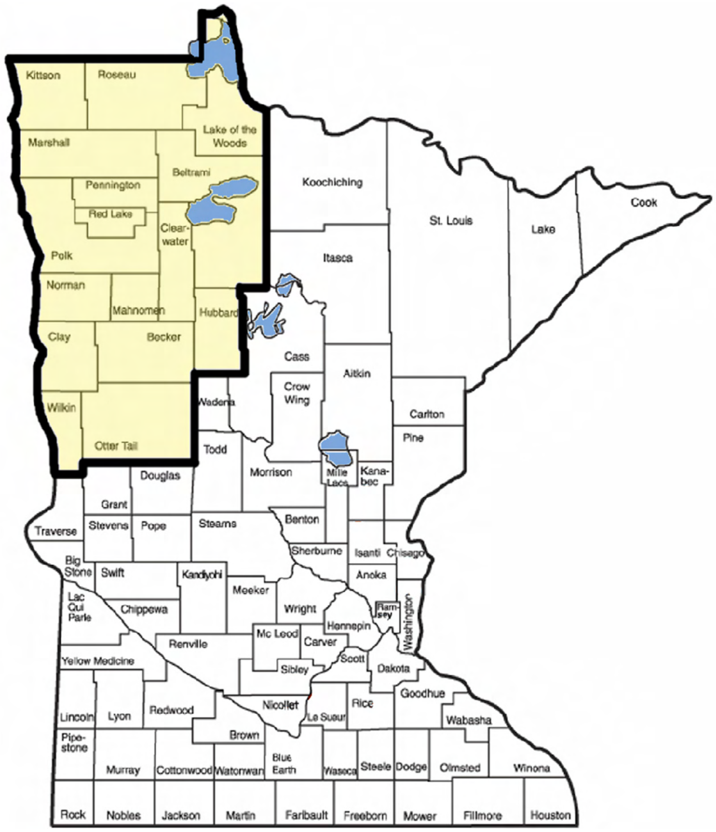


On-Farm Cropping Trials Northwest and West Central Minnesota

2008 Wheat Research Review

A report of research projects advised by the Small Grains Research & Communications Committee funded in part by the Minnesota Wheat Checkoff and administered by the Minnesota Wheat Research & Promotion Council and the University of Minnesota.

On-Farm Cropping Trials

The mission of the NWROC is to contribute, within the framework of the Minnesota Agricultural Experiment Station (MAES) and the College of Food, Agricultural, and Natural Resource Sciences to the acquisition, interpretation and dissemination of research results to the people of Minnesota, with application to the knowledge base of the United States and World. Within this framework, major emphasis is placed on research and education that is relevant to the needs of northwest Minnesota, and which includes projects initiated by Center scientists, other MAES scientists and state or federal agencies.

Contributors to the On-Farm Trials include Russ Severson, Extension Educator, Extension Regional Office, U of M Crookston; Doug Holen, Extension Educator, Extension Regional Office, Fergus Falls; Phillip Glogoza, Extension Educator, Extension Regional Office, Moorhead; Ray Bisek, Extension Educator, Mahnomen & Norman County, Mahnomen; Derek Crompton, Local Extension Educator, Roseau; Charla Hollingsworth, Extension Plant Pathologist, NW Research/Outreach Center, Crookston; Jochum Wiersma, Small Grain Specialist, Crookston; Paul Porter, Agronomy/Plant Genetics, Roseville; Bobby Holder, Soil Scientist, Crookston; Ian MacRae, Extension Entomologist, Crookston; Carlyle Holen, IPM Specialist, Crookston; Howard Person, Extension Educator, Pennington & Marshall County, Thief River Falls; Jim Orf, Dept Agronomy & Plant Genetics, St. Paul; Vince Crary, Extension Educator, Otter Tail County, New York Mills; Paul R. Peterson, Extension Agronomist – Forages, St. Paul; Albert Sims, Soil Scientist, Crookston.

This project was made possible thanks to the hard work of many people. This includes farmers, County and Regional Extension Educators, and specialists who conducted these trials, and their names are listed. Previous On-Farm Cropping Trials booklets can be found at
http://www.nwroc.umn.edu/Cropping_issues/NW_Crop_trials/On_Farm_Trials.htm.

2008 Wheat Research Review

Researchers submit progress reports on projects funded partially or in full by the committee's recommendation. Research progress is communicated to the public. Crop scientists participate in a research reporting session held each year that is open to the public. The Council feels this committee has been an efficient vehicle for not only prioritizing wheat checkoff funds, but also in improving the dissemination of results.Better practices to plant better wheat is our goal. To that end, we encourage your input on this committee, and your feedback on the wheat research projects that are funded by the Minnesota Wheat Checkoff.

Members of the 2008 Small Grains Research & Communications Committee include: Kenneth Asp, Minnesota Wheat Council; David Boehm, Northern Plains Regional Mgr.; Mike Bruer, Minnesota Wheat Council; David Garrett, AgriMaxLLC; Doug Holen, U of M Regional Extension Service; Peter Hvidsten; Carol Ishimaru, U of M Dept of Plant Pathology; Brian Jensen, Minnesota Wheat Council; Mark Jossund, Minnesota Wheat Council; Lacey, Brian Lacey, MN Barley; Rhonda K. Larson, Minnesota Wheat Council; Scott Lee; Dean Maruska, Bayer CropScience; Larry J. Smith, University of Minnesota; Brian Sorenson, Northern Crops Institute; David Torgerson, Minnesota Wheat; Kyle Vig; Jochum Wiersma, U of M Small Grains Specialist; Neil Wiese; Dave Willis, Agassiz Crop Management; Marv Zutz, Minnesota Barley.

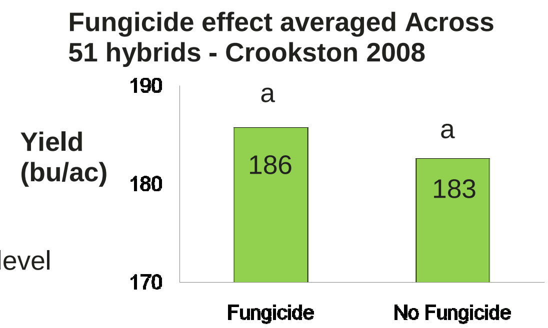
Information about the committee and previously funded research can be found online at www.smallgrains.org. Click on the Research tab.

Table of Contents - On-Farm Cropping Trials For NW & WC Minnesota

Table of Contents - Research Reporting Report

2008 Polk County Corn Hybrid Trial

Graph 1.



10% Probability level

Purpose of Study:
To evaluate corn hybrids in northwestern Minnesota in the 80 to 88 relative maturity range and to evaluate the effect of Headline fungicide on corn yield.

Company	Hybrid	RM	Trait	GDU BL	No Headline bu/ac	Headline bu/ac
Pioneer	39N99	89	HX1LLRR2	2020	***206.3***	**202.2**
NK	N15A	80	GTCBLL	2040	***203.6***	**194.5**
Dyna-Gro	52V01	87	RRVT3	2175	***203.4***	**193.6**
Hyland	HLB24R	81	YGCBRR	early	***200.0***	**201.8**
Proseed	787VT3	87	VT3	2030	***199.0***	**190.6**
Dyna-Gro	51V89	84	RRVT3	2100	***198.6***	**182.6**
Peterson	PFS56J86	86	VT3	2125	***197.1***	**196.5**
Pioneer	39B23	88	HX1LLRR3	2090	***195.4***	**193.3**
NK	N16MGTCBLL	82	GTCBLL	2110	***193.8***	**195.0**
REA Hybrids	2N396	83	RRYGCB	2100	***193.6***	**180.2**
Gold Country	85-04R	85	RR2	2250	***192.1***	**191.8**
Wensman	6087	87	RR2	2070	***191.3***	**188.9**
Proseed	884VT3	84	RRBT	2000	***190.8***	**206.4**
Hyland	HLR230	86	RR	early	***190.0***	**193.8**
Seeds 2000	8801VT3	88	VT3RW		***190.0***	**196.2**
Peterson	PFS37L84	84	RRYGCB	2035	***189.4***	**178.2**
Gold Country	8403CBR	84	RR2YGCB	2150	***188.6***	**196.5**
Garst	89Z07GT/CB/LL	88	GTCBLL	2180	***188.0***	**180.0**
Mycogen	2T220		YGRR		***187.7***	**176.5**
Garst	89527GTCBLL	80	GTCBLL	1990	***187.6***	**183.1**
NuTech	3A-484	84	RR	2160	***186.4***	**177.6**
Legend	LR9780RB	80	RRBT	1910	***184.9***	**181.7**
Mycogen	2K154	83	HerculexLLRR		**182.8**	**203.4**
DeKalb	DKC33-54	83	RR2		**182.7**	**201.2**
Legend	LR9783VT3	83	RRBTRW	1980	**182.3**	**187.6**
NuTech	3P-484	84	YGPLRR	2170	**182.2**	**184.7**
Seeds 2000	2822RRBT	82	YGCB		**181.4**	**185.7**

Partnership/Funding: Elliot & Eric Solheim Farm, Croplan Genetics & U of M NW Research and Outreach Center

For additional information:
Russ Severson

2008 Polk County Corn Hybrid Trial *(continued)*

Company	Hybrid	RM	Trait	GDU BL	No Headline bu/ac	Headline bu/ac
REA Hybrids	1787RR2	79	RR		**181.2**	**181.0**
REA Hybrids	1823YGCBRR2	85	RRYGCB	2200	**180.5**	**165.5**
Mycogen	2P174	85	YGRR		**179.2**	**194.4**
Proseed	781RR/BT	81	RRBT	1900	**179.0**	**203.4**
Hyland	HLR228	85	RR	early	**178.3**	**177.0**
Integra	9361RBC	86	RRCBRW	2185	**176.2**	**187.7**
Integra	65D85RB	84	RRCB	2050	**174.2**	**197.9**
Wensman	7083	80	YGVT3	2040	**174.2**	**176.4**
Croplan	2340RH	83	RR2HX1LL	2150	**173.7**	**171.3**
NK	N22-C2	87	GTCBLL	2260	**173.2**	**182.2**
Croplan	229RR2/BT	80	RR BT	2020	**173.0**	**173.3**
Croplan	238RR/BT	85	RR BT	2180	**172.9**	**172.6**
Legend	LR9584VT3	84	RRBTRW	1995	**172.6**	**179.0**
Dyna-Gro	51P15	85	RRYGCB	2125	**172.3**	**194.2**
Integra	9311RBC	81	RRCB	1950	**170.2**	**171.3**
NuTech	3C-383+	83	YGCBRR	2090	**169.6**	**170.4**
Gold Country	84-02CBR	84	RR2YGCB	2270	**168.8**	**186.7**
Seeds 2000	8201VT3	82	VT3		**168.2**	**164.0**
DeKalb	DKC35-19	85	RR2 YGCB	2260	**164.0**	**175.7**
Peterson	PFS54M83	83	VT3	2030	**163.4**	**175.8**
Pioneer	39V08	80	HX1LLRR4	1910	**163.1**	**188.6**
Wensman	7085	84	YGVT3	2000	**162.8**	**192.7**
DeKalb	DKC33-11	83	RR2/YGCB	2150	**159.4**	**168.4**
Garst	89N10GT	77	GTCBLL	1839	**152.9**	**168.6**
				Trial mean bu/ac =	**183**	**186**
				LSD .05% bu/ac =	**22.0**	**20.3**

Results:

With the cool 2008 growing season it was questionable whether the corn would reach black-layer prior to a killing frost but did make it being we did not have a killing frost until late October. Harvesting conditions were far from ideal with high corn ear moisture content and extremely wet soil conditions. We were able to harvest the hybrid trials on November 20 due to frozen ground to carry the plot combine. Special thanks goes out to Croplan Genetics and Guy Martin for the assistance with planting and harvesting these plots with their plot equipment. These plots were planted on May 5 and harvested November 20, 2008. Statistically there was no yield difference with or without Headline fungicide at the 0.10 level as is shown in graph 1.

The above table gives the hybrid characteristics and the yields we measured corrected to 15.5% moisture content for the 51 hybrids with and without Headline fungicide applied. As can be seen with the LSD at the .05% level at the bottom of the table hybrids not treated with Headline fungicide that differed by more than 22.0 bu/ac were significantly different from each other therefore the yields in blue or the top 22 hybrids are not statistically different from each other (Pioneer 39N99 through Legend LR9780RB). The same 51 hybrids treated with Headline fungicide, hybrids differing by less than 20.3 bu/ac are not statistically different from each other again being 22 hybrids with a high of 206.4 bu/ac (Proseed 884VT3) not different from 186.7 bu/ac. (Gold Country Seed 84-02CBR).

A special thanks goes out to Elliot and Eric Solheim for providing the space on their farm to conduct these trials and for obtaining the hybrids from the various companies.

Partnership/Funding: Elliot & Eric Solheim Farm, Croplan Genetics & U of M NW Research and Outreach Center

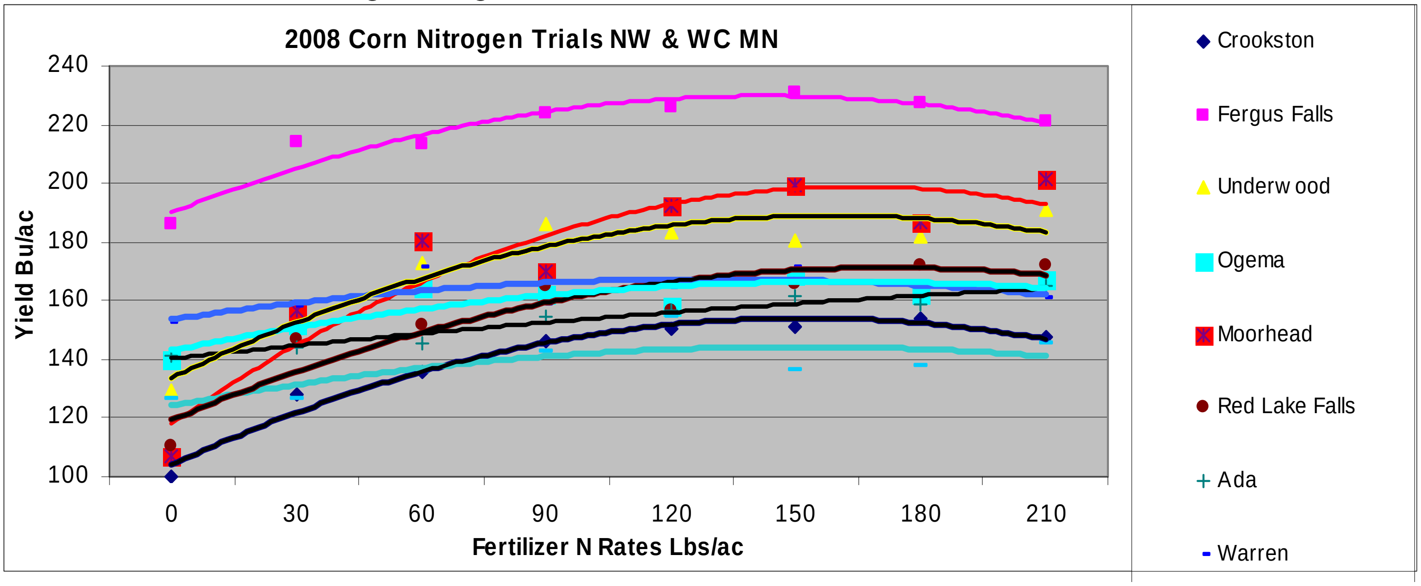
For additional information:
Russ Severson

Source: 2008 On-Farm Cropping Trials Northwest and West Central Minnesota
U of MN Extension Service, published January 2009

Corn Nitrogen Rate Fertility Trials in NW & WC MN

Project Leaders: Russ Severson & John Lamb
Cooperators: U of M NW Research & Outreach Center, U of M Soil Water & Climate Dept., Regional Extension Educators, Local Extension Educators and Farmer Cooperators
Experimental Design: RCB with four replications

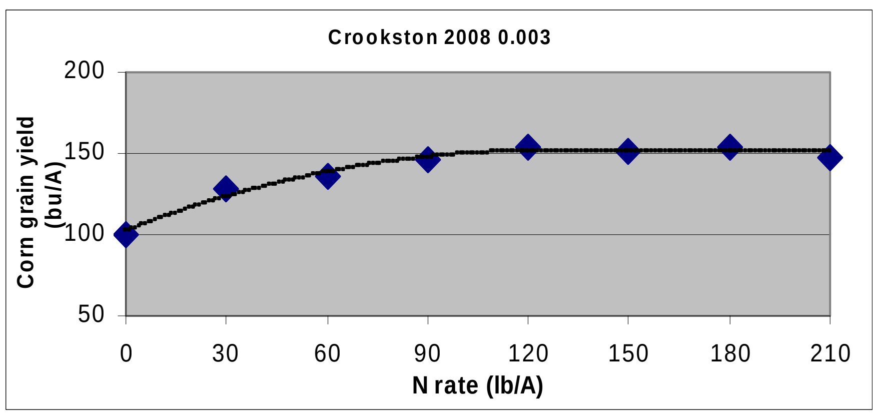
2008 Corn Grain Yields at Eight nitrogen Rates and Nine Locations in NW MN.

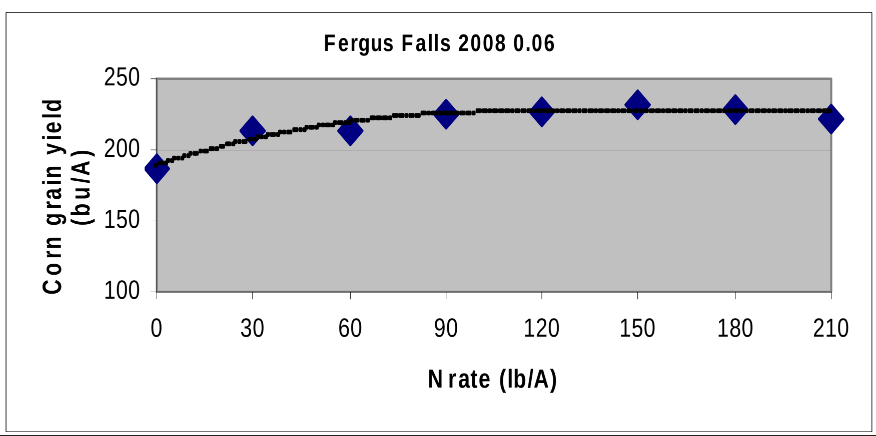


Purpose of Study:

In 2008 Extension Educators in NW Minnesota received funding to conduct Nitrogen Rate Fertility Trials at nine locations north of Interstate 94 to increase the data base for the new U of M nitrogen guidelines and validate the applicability of the N guidelines to this region of the state. The sites were established at Fergus Falls, Underwood, Ogema, Ada, Fosston, Red Lake Falls, Crookston, Warren and Moorhead.

The nitrogen rate trials were established in corn growers' production fields with fertilizer nitrogen rates of 0, 30, 60, 90, 120, 150, 180 and 210 pounds of nitrogen per acre with the treatments replicated four times. P, K & Zn were added to each site at sufficient rates.



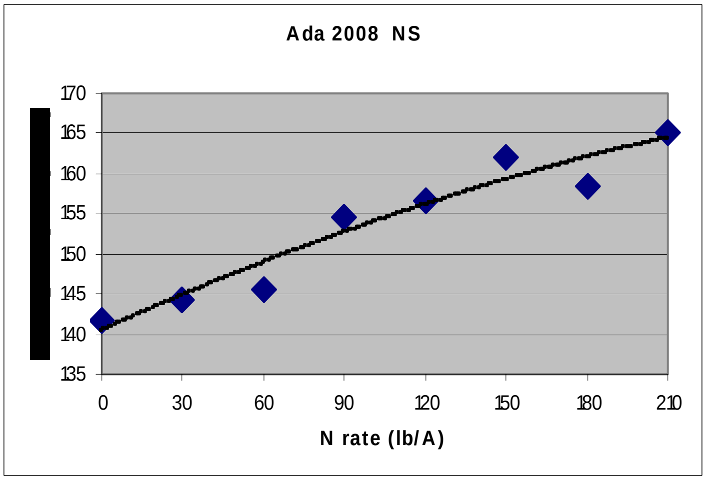


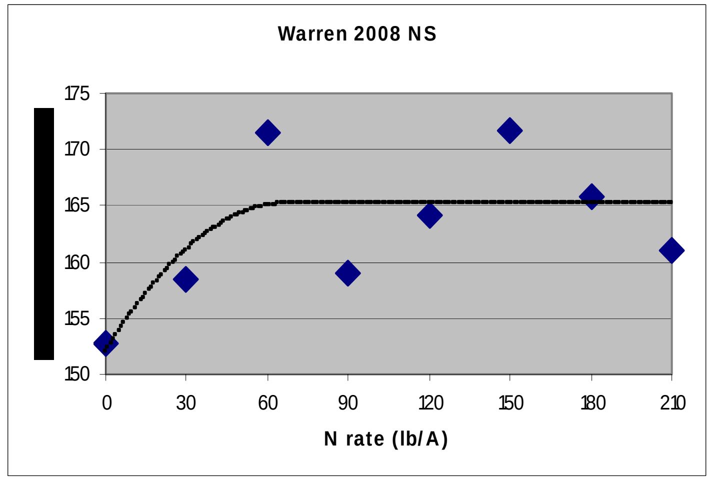
Partnership/Funding: Minnesota Corn Research and Promotion Council
NW Research and Outreach Center

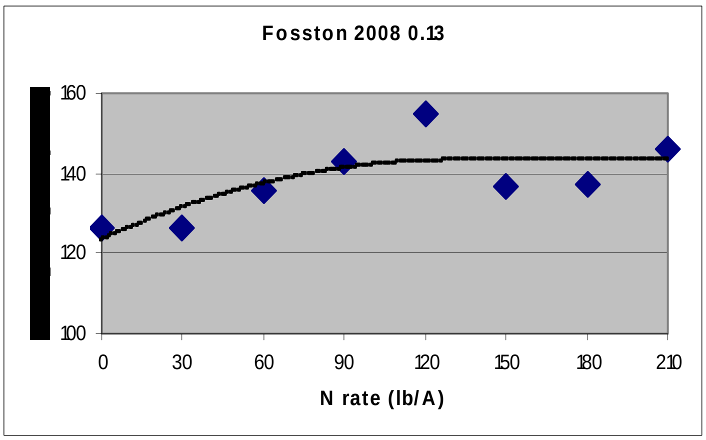
For additional information:
Russ Severson

Source: 2008 On-Farm Cropping Trials Northwest and West Central Minnesota
U of MN Extension Service, published January 2009

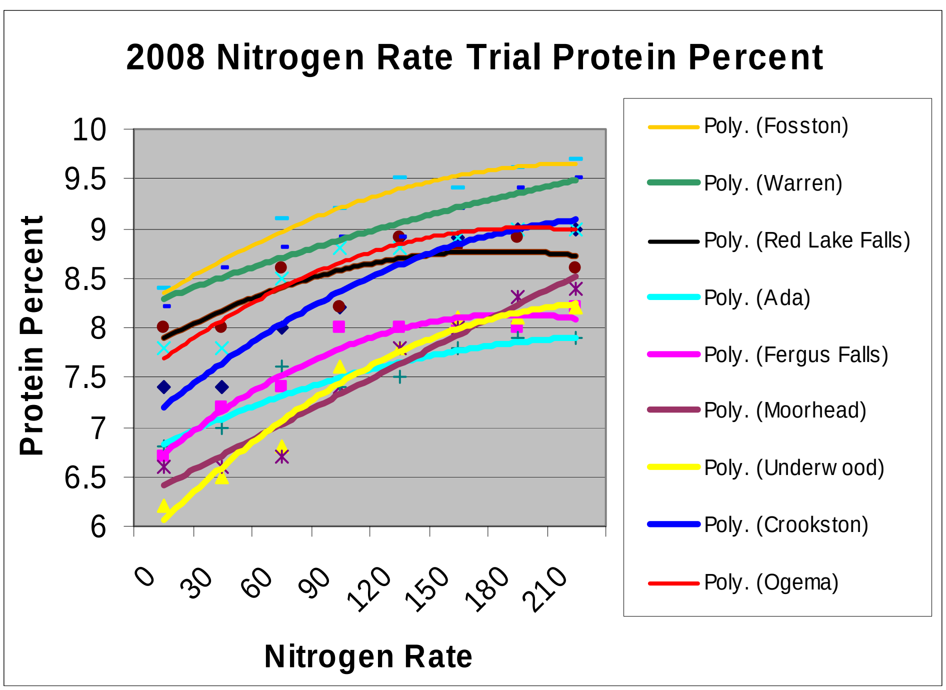
Corn Nitrogen Rate Fertility Trials in NW & WC MN *(continued)*







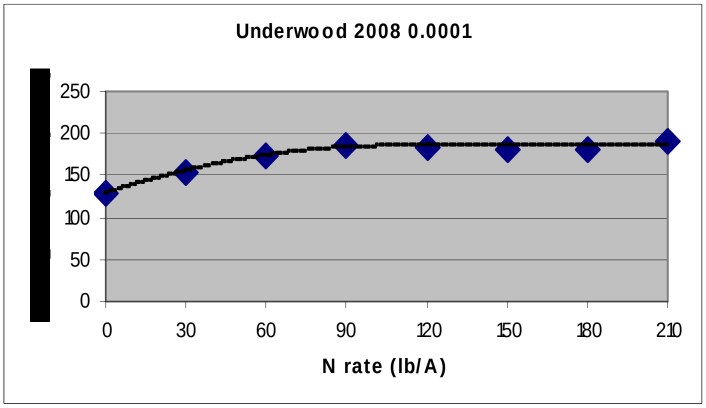
Results:
The nine locations were harvested on October 27—November 3 with 15 linear feet of each of the two center rows hand harvested, dried and shelled using a stationary corn-sheller. Variables grain yield, protein%, oil% Starch% and moisture% were measured using a NIR analyzer at the NW Research & Outreach Center. Significant nitrogen responses were measured at seven of the nine locations in 2008 as can be seen in the location yield graphs. Protein% was also significantly impacted by nitrogen fertility rate. Other variables have no yet been analyzed at this point.

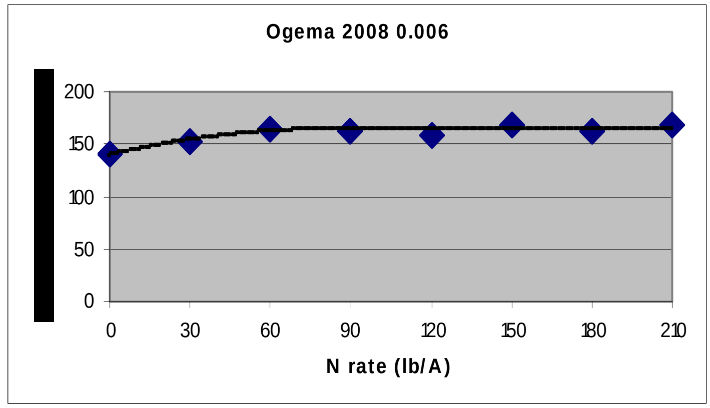


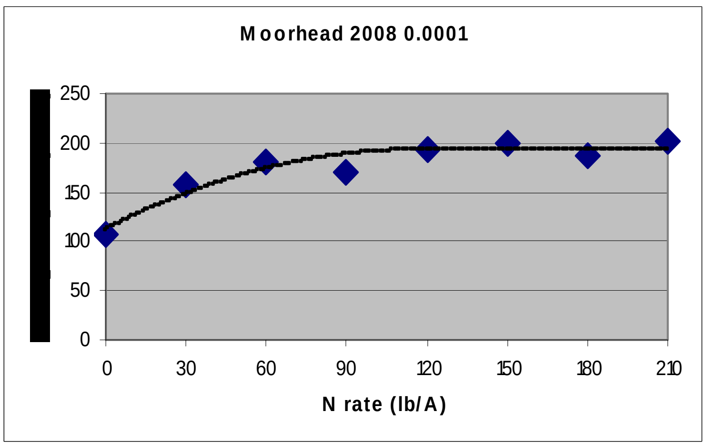
Basal stalk nitrate samples were harvested from each plot at each location for later analysis of the residual nitrated nitrogen remaining following the growing season. These results will be available later on.

The Economic optimum nitrogen rate analysis, statistical significance, previous crop and soil test values are listed in table 1.

Corn Nitrogen Rate Fertility Trials in NW & WC MN *(continued)*







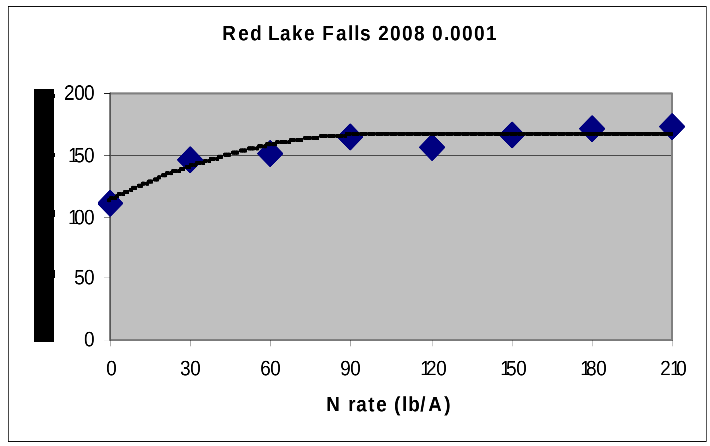


Table 1. Statistical significance , Economic Optimum Nitrogen Rate and Soil Test Value at each location.

Location	Warren	Crookston	Ogema	Underwood	Red Lake Falls	Fergus Falls	Moorhead	Ada	Fosston
Significance	N.S.	0.0026	0.006	0.0001	0.0001	0.0576	0.0001	N.S.	0.1303
EONR*	50.6	108.5	69.3	98.2	90.6	90.3	108.7	145.6	87.8
Soil Test N Lb/A 0-24"	79	47	43	22	40	15	42	84	38
Previous Crop	Wheat	Wheat	Sugarbeet	Soybean	Soybean	Soybean	Soybean	Corn	Soybean

** Economic optimum nitrogen rate at a 0.1 ratio of nitrogen price /corn price*

Research Cooperators: Russ Severson, John Lamb, Vince Crary, Doug Holen, Will Yliniemi, Jim Stordahl , Howard Person, Derek Crompton, Phil Glogoza, Randy Nelson and Ray Bisek

Farmer Cooperators: Bill, Eric & Nick Zurn, Gary Purath, Scott Balstad, Elliot & Eric Solheim, Wayne & Jay Leaderbrand, Phil & Dan Jennnen, Don & Mark Yutrzenka, Tim Thompson, and Dan & Glen Brandt.

Irrigated Corn Silage Hybrid Performance Evaluation - Otter Tail

Purpose of study:

Evaluate silage yield and quality performance of commercial corn hybrids in WC MN under irrigation.

Cooperator: Dan Dreyer
Nearest Town: Ottertail City
Soil Type: Sandy Loam
Tillage: Fall Chisel and Spring Disk
Previous Crop: Corn for Grain
Hybrid: Various (16)
Planting Date: May 8, 2008 (good soil H20)
Planting Rate: 35,700
Row Width: 30 inches
Fertilizer: Fall applied liquid manure 8000 gallons/A (264#N, 80#P, 176#K)
7-17-08 12.5 gallons/A 28%
7-22-08 12.5 gallons/A 28%
Herbicide: 5-21-08 Harness pre-emergence
6-27-08 Status 3 oz,
7-8-08 Status 3 oz
Harvest Date: 9-24-08; circular harvest pattern using 3-row pull-behind chopper into dump box and transported with 2 grain trucks. Weights obtained on-farm with pad scale. Chopper has kernel processor. Cutting height was 14inches.
Experimental Design: Randomized complete block (3 replications)

Table 1. Whole-plant moisture (Moist), dry matter (DM) and silage yields, and quality traits for corn hybrids planted at Ottertail, MN (Otter Tail County) in 2008.

Company/ Hybrid	Traits[1]	RM	Moisture	Yield [2] DM	Yield [2] Silage	Quality (concentration) [3] CP	NDF	IVD	NDFD	Starch	Milk Yield [4] /Ton	Milk Yield [4] /Acre
			(%)	(t/ac)	(t/ac)	(%)	(%)	(%)	(%)	(%)	(lb/ton)	(lb/ac)
DeKalb DKC 50-42	Bt, CRW, GLY	100	69.0	7.7	25.0	9.2	42	79	51	31	3,310	25,700
Pioneer 38P43	Bt,CRW,GLY,LL	94	66.1	7.8	23.0	8.5	43	77	47	31	3,180	24,700
Pioneer 37N16	Bt,CRW,GLY,LL	99	69.2	7.6	24.6	8.7	45	76	46	30	3,070	23,300
Elite Matrix		92	71.0	7.7	26.4	8.1	44	76	46	26	2,990	23,000
Hyland Seeds HL SR35	GLY,Lf	89	68.1	7.0	22.1	9.2	45	76	47	32	3,110	21,900
CPS* V3640		94	66.7	7.4	22.2	8.2	46	74	44	28	2,960	21,900
DeKalb DKC 45-79	Bt,CRW,GLY	95	68.9	7.9	25.3	8.6	51	72	45	25	2,760	21,700
Pioneer 35F37	GLY	105	64.4	7.0	19.7	8.8	46	76	47	32	3,060	21,500
DeKalb DKC 42-91	Bt, CRW,GLY	92	68.5	7.0	22.1	8.6	45	76	47	29	3,070	21,400
NuTech Seed 3U-997	CRW,GLY,Lf	97	66.9	7.0	21.1	9.4	48	75	48	28	3,000	21,000
Hyland Seeds HL S038	Bt,GLY	89	69.8	6.7	22.0	9.4	45	76	48	29	3,080	20,500
Dairyland 3094-6	GLY,HiDF	94	71.3	7.5	26.2	8.1	48	72	42	22	2,690	20,200
NuTech Seed 3A-306	GLY, Lf	106	65.9	6.8	20.0	8.8	47	74	44	28	2,930	20,000
Dairyland 3098	HiDF	98	68.2	6.7	21.1	8.7	46	75	45	26	2,970	19,900
Hyland Seeds HL SR42	GLY,Lf	95	67.9	6.9	21.6	8.8	50	71	43	25	2,730	18,900
NuTech Seed 5H-298	Bt,CRW,GLY	96	69.3	6.5	21.2	8.9	49	74	46	26	2,920	18,900
Mean			**68.2**	**7.2**	**22.7**	**8.8**	**46**	**75**	**46**	**28**	**2,990**	**21,500**
LSD (0.10)			**1.4**	**0.5**	**1.5**	**0.6**	**2**	**2**	**2**	**3**	**180**	**2,100**
CV			**1.5**	**5.2**	**4.8**	**5.1**	**4.5**	**1.9**	**3.9**	**8.0**	**4.3**	**6.9**

1 Bt, CRW, GLY, LL, Lf traits correspond to European corn borer tolerance, corn rootworm tolerance, glyphosate resistance, Liberty Link ® (glufosinate-ammonium) resistance, and leafy genetics, respectively.
2 **DM** yield is whole-plant corn yield at 100% dry matter; **Silage** yield is whole-plant corn yield at harvest moisture.
3 Quality concentration expressed as a % of DM, except NDFD (48-hr) which is expressed as a % of NDF.
4 Milk production potential calculated using MILK2006 (University of Wisconsin)
* Crop Production Service

Partnership: U of MN Forage Program
Funding: Private Seed Companies

For additional information:
D. Holen V. Crary P. Peterson
C. Sheaffer D. Swanson J. Larson

Source: 2008 On-Farm Cropping Trials Northwest and West Central Minnesota
U of MN Extension Service, published January 2009

Soybean Relative Maturity and Planting Date Influence on Optimal Yield

Cooperator: NW Research & Outreach Center
Nearest Town: Crookston
Soil Type: Bearden silty clay loam
Harvest Populations: 140,000
Harvest Date: 9-24-08 & 10/9/08
Experimental Design: Split plot with varieties as main plot and planting date as subplot

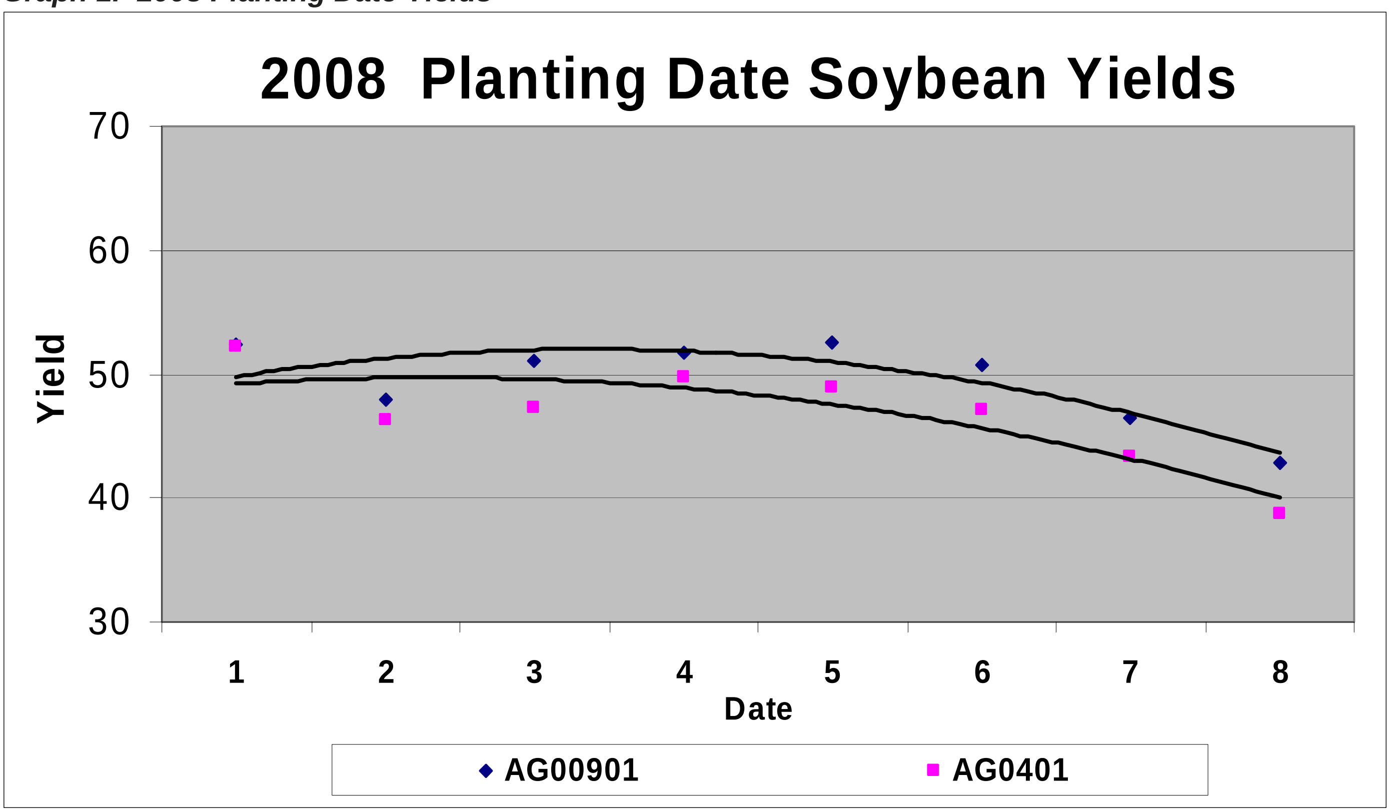
Purpose of Study:

To evaluate soybean relative maturity and planting date influence on optimal yield and soybean quality in northwestern Minnesota.

Results:

The plots were established utilizing two Asgrow cultivars with 00.9, and 0.4 relative maturities planted at eight different dates commencing April 18 and concluding on June 2. Due to cool soil temperatures, it took 38 days for the first planting date to emerge and the first 4 planting dates all emerged on May 26 & 27. Optimum yield was achieved with the first four planting dates due to the lateness of emergence as is noted in Graph 1. Average soil temperatures at the 2'' depth reached 55 degrees May 25.

Graph 1. 2008 Planting Date Yields



Partnership/Funding: Minnesota Soybean Research and Promotion Council NW Research and Outreach Center

For additional information:
Russ Severson

Soybean Relative Maturity and Planting Date Influence on Optimal Yield *(continued)*

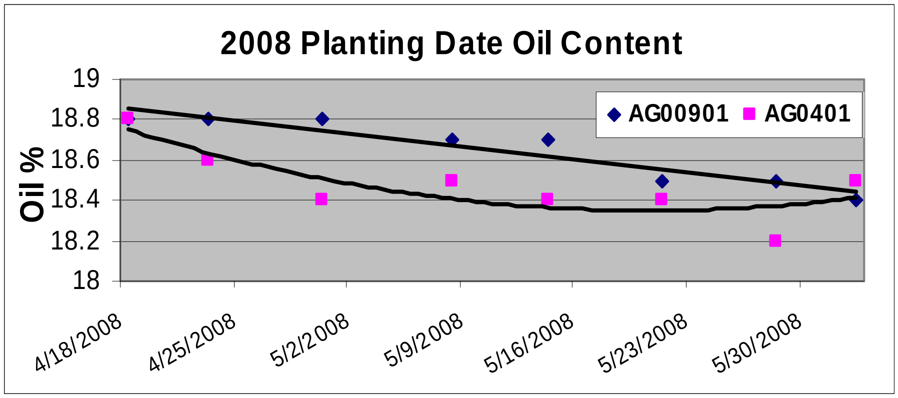
***Results** continued . . .*
Protein percentage was not affected by planting date and oil percent significantly decreased with delayed planting as is noted in Graph 2. These are identical results to the 2006 &2007 Planting Date Trials.

Soil temperature had a large effect on days from planting to emergence as can be seen in Graph 3, ranging from 14 days to 7 days from planting to emergence in 2007 to 38 days to 14 days in 2008.

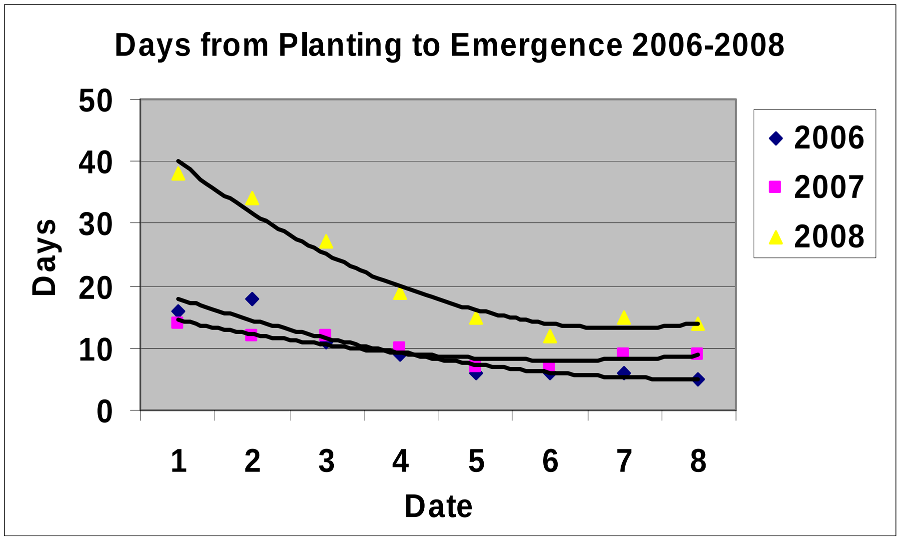
Graph 4 gives the average daily 2 inch soil temperatures for 2006 - 2008 trials. Mean soil temperatures at the 2 depths had achieved 55 degrees as early as April 25 in 2007. This was well above normal. It was May 1 of 2006 before soil temperatures exceeded 55 degrees. In 2008 it was May 25 before the average 2 inch soil temperature exceeded 55 degrees.

The growing conditions during 2008 were rather harsh for soybean production in the Red River Valley starting with a cool dry spring approaching borderline drought conditions by mid-July and extending into the first part of August. To utilize this information to make planting date decisions, several years of different environments need to be considered to determine a risk assessment of early planting of soybean.

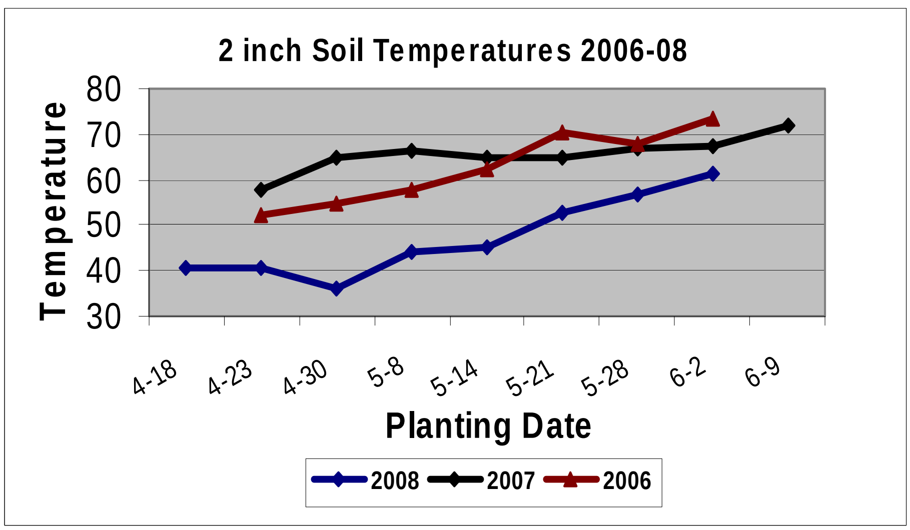
Graph 2. Percent oil by soybean variety and planting date. 2008.



Graph 3. Days from planting to emergence by planting date. 2006-08



Graph 4. 2" soil temperatures 2006—2008.



Source: 2008 On-Farm Cropping Trials Northwest and West Central Minnesota
U of MN Extension Service, published January 2009

2008 Polk County Soybean Variety Trials

Location: Fosston
Cooperator: Rick Roed
Planting Date: May 15, 2008
Soil test:
- N = 41 lb/ac 0-24”
- P = 20 ppm
- K = 183 ppm
- O.M. = 2.6%
- Carb. = 0.2%
- Salts = .20 mmho
- pH = 6.6

Herbicides
- PPI = Prowl

Roundup Varieties - June 30 and July 21
- 1 qt. Roundup PowerMax
- 1 qt Ammonium sulfate (39%)

Harvest Date: Early—Sept. 25, 2008
Late —Oct. 9, 2008

Location: Crookston
Cooperator: Elliot Solheim
Planting Date: May 14, 2008
Soil test:
- N = 53 lb/ac 0-24”
- P = 13 ppm
- K = 207 ppm
- O.M. = 3.1%
- Carb. = 7.3%
- Salts = .39 mmho
- pH = 8.3

Herbicides

Conventional Varieties – June 19
- Raptor 2 oz./ac + Rezult 1.6pt + 1.6pt./ac
- Crop Oil 1.5pt./ac

Roundup Varieties – June 23& July 17
- 1 qt.Roundup PowerMax + 1 qt. Am sulfate (39%)

All Varieties—July 17 - Lorsban 1 pt.
Harvest Date: Early—Sept. 24, 2008
Late —Oct. 9, 2008

Crookston/Fosston Roundup Ready Early Relative Maturity Soybeans 2008

			CROOKSTON			FOSSTON		
		Maturity	Percent of Mean			Percent of Mean		
Company	Variety	Rating	Protein	Oil	Yield*	Protein	Oil	Yield*
Asgrow	AG00901	00.9	96.9	104.5	111.0	100.9	97.9	92.4
Asgrow	AG0103	0.1	101.7	98.3	86.9	99.7	102.6	94.9
Croplan Genetics	RT0268	0.2	98.3	104.0	105.6	102.4	100.0	103.6
Dairyland Seed	DSR-0101/RR	0.1	98.6	100.0	93.7	97.6	102.1	102.0
Dairyland Seed	DSR-C750/RR	00.7	97.2	103.4	96.3	100.0	99.5	101.1
Dyna-Gro	32J01	0.1	100.8	94.4	101.2	98.8	100.5	89.5
Gold Country Seed	GCS0901RR	0.1	97.2	105.6	107.0	97.9	101.0	104.9
Hyland Seeds	HS 02R28	0.2	98.9	94.4	98.6	99.7	93.2	109.2
Hyland Seeds	RR Ridgeway	0.2	94.4	105.1	102.3	96.4	98.4	99.1
Integra Seed	79020R	0.2	101.1	93.2	115.4	104.5	88.0	114.8
Integra Seed	97014R	0.0	102.3	101.1	101.6	103.3	100.5	88.8
Legend Seed	0057RR	00.5	102.0	100.0	93.9	-	-	-
Legend Seed	0087RR	00.8	100.0	100.6	103.7	98.8	102.6	96.6
Legend Seed	0098RR	0.1	-	-	-	97.3	101.6	102.2
NK Brand	SO1-C9	0.1	100.6	102.8	93.7	103.6	99.5	96.7
NK Brand	SO2-M9	0.2	102.0	104.5	108.4	102.1	102.1	106.5
North Star Genetics, Ltd	NS 0021RR	00.9	100.0	100.0	99.5	98.2	102.1	96.9
NuTech Seed	6022	0.2	-	-	-	99.4	101.6	107.2
Peterson Farm Seeds	PFS07008RR	00.8	99.4	99.4	99.8	98.2	102.1	100.5
Peterson Farm Seeds	PFS0901RR	0.1	102.3	95.5	95.1	97.9	101.6	103.1
Peterson Farm Seeds	PFS1001RR	0.1	100.0	98.9	93.7	101.2	98.4	91.1
Pioneer Hi-Bred Int'l	90M02	0.0	102.5	98.3	97.4	103.3	98.4	87.7
Pioneer Hi-Bred Int'l	90Y20	0.2	100.6	100.0	108.4	102.7	99.0	109.4
Proseed, Inc	80-20	0.2	97.5	107.3	109.3	-	-	-
Seeds 2000	0081RR	00.8	100.3	97.7	95.1	98.2	102.1	102.2
Stine Seed Co.	0098-84	0.0	103.7	92.1	82.5	97.6	101.6	95.7
Stine Seed Co.	0283-4	0.2	98.3	105.1	106.1	103.3	99.0	103.6
Thunder Seeds, Inc.	29009RR	00.9	105.9	89.8	82.5	-	-	-
Thunder Seeds, Inc.	2901RR	0.1	96.3	106.2	115.9	97.3	101.0	102.2
Wensman	W20074RR	00.7	96.6	104.0	106.1	98.2	102.1	104.0
Wensman	W20096RR	00.9	101.4	97.2	87.6	102.1	98.4	92.8
Mean =			35.5%	17.7%	42.9bu/a	33.2%	19.2%	55.3bu/a
LSD .05 =			3.1%	4.5%	12.1%	2.4%	2.0%	13.0%

Yields that differ by less than 12.1% (Crookston), 13.0% (Fosston), are not statistically different from each other.

2008 Polk County Soybean Variety Trials *(continued)*

Crookston/Fosston Roundup Ready Late Relative Maturity Soybeans 2008

			CROOKSTON			FOSSTON		
		Maturity	Percentage of Mean			Percentage of Mean		
Company	Variety	Rating	Protein	Oil	Yield*	Protein	Oil	Yield*
Asgrow	AG0401	0.4	102.3	98.9	90.2	101.5	98.4	98.3
Croplan Genetics	RT0406	0.4	101.4	100.6	96.7	100.9	98.4	103.7
Dairyland Seed	DSR-0401/RR	0.4	99.7	100.0	104.6	101.2	100.0	101.5
Dyna-Gro	32T03	0.3	101.4	100.6	96.5	101.5	99.5	98.1
Dyna-Gro	34C06	0.6	96.3	100.6	116.6	95.8	98.4	111.5
Gold Country Seed	GCS2703RR	0.3	100.9	100.6	96.9	102.1	99.5	100.7
Gold Country Seed	GCS2806RR	0.6	97.1	100.0	124.2	96.1	99.5	113.0
Hyland Seeds	RR Rugged	0.3	94.3	108.4	74.1	95.8	105.9	76.0
Integra Seed	79031R	0.4	99.4	102.8	96.3	99.7	101.1	100.2
Legend Seed	0539RR	0.5	-	-	-	99.4	101.1	106.4
Legend Seed	0624RR	0.5	100.6	100.6	95.0	-	-	-
North Star Genetics, Ltd	NS 0413RR	0.4	98.6	103.4	98.5	100.3	100.0	95.6
North Star Genetics, Ltd	NS 0514RR	0.5	99.1	101.1	105.7	99.1	100.5	100.7
NuTech Seed	6042	0.4	-	-	-	101.8	94.7	95.9
NuTech Seed	NT-0330	0.3	101.4	100.6	95.0	100.6	99.5	101.5
NuTech Seed	NT-0525	0.5	105.5	95.5	95.9	-	-	-
NuTech Seed	NT-0636	0.6	96.6	99.4	121.4	-	-	-
Pioneer Hi-Bred Int'l	90Y41	0.4	-	-	-	95.2	109.6	93.1
Pioneer Hi-Bred Int'l	90M60	0.6	100.9	96.1	91.5	-	-	-
Proseed, Inc	60-40	0.4	100.6	101.1	99.6	101.5	98.4	108.1
Proseed, Inc	70-30	0.3	101.4	96.1	101.7	101.5	96.3	92.4
Stine Seed Co.	0306-4	0.4	102.0	98.9	91.1	101.5	99.5	101.2
Thunder Seeds, Inc.	2703RR	0.3	101.7	97.8	108.9	100.3	98.4	98.8
		0.3	-	-	-	100.3	100.0	104.9
Wensman	W2030RR	0.3	101.4	100.0	101.1	102.4	98.4	99.0
Mean =			34.8%	17.8%	45.9bu/a	33.3%	18.7%	59.2bu/a
LSD .05 =			4.0%	4.5%	17.0%	2.1%	1.6%	7.1%

Yields that differ by less than 17.0% (Crookston), 7.1% (Fosston), are not statistically different from each other.

Crookston Food Grade Soybean

Cooperator: Elliot Solheim

			Percent of Mean		
Company	Variety	RM	Protein	Oil	Yield*
Legend	0090	00.9	94.5	103.4	116.0
NDSU	Sheyenne	0.9	96.7	102.3	116.3
NDSU	Traill	0.0	101.1	100.0	109.8
SunOpta	Bravado	0.2	93.9	104.0	105.8
SunOpta	Imagine	0.4	101.4	91.4	87.7
SunOpta	Panther	0.7	101.4	102.9	88.9
SunOpta	SO-0070	0.5	104.2	94.9	102.2
SunOpta	Toki	0.6	106.4	92.6	86.8
SunOpta	Valor	0.2	101.9	96.6	118.8
Thunder	07005	00.5	98.3	102.9	120.3
UofM	MN0094SP	00.9	98.1	102.9	85.8
UofM	MN0095	00.9	93.1	108.6	125.2
UofM	MN0096SP	00.9	110.8	90.9	78.2
UofM	MN0101	0.1	96.7	104.0	119.1
UofM	MN0104SP	0.1	98.3	105.7	52.6
UofM	MN0105	0.1	101.7	97.7	86.2
Mean =			36.1%	17.5%	32.5 bu/a
LSD .05 =			4.2%	5.1%	24.9%

** Yields that differ by less than 24.9% are not statistically different from each other*

Funding: Polk County Soybean Growers Association

For additional information:
Russ Severson

2008 Red River Valley On-Farm Yield Trials - Spring Barley

Following are the results of the 2008 Red River Valley On-Farm Yield Trials. These regional trials were located throughout northwestern Minnesota

About the Trials:

The 2008 Red River Valley On-Farm Yield Trials were grown in 5 locations throughout the region. The locations, cooperators, and planting dates are summarized in Table 1. Conditions were cool and dry for most of the season. Only Perley suffered from excess precipitation early in the season. As a result the data collected in Perley was not included in the data analysis because extreme variability. Very little, if any, lodging was observed the past two summers as evidenced by the lodging scores in Table 3.

About the Entries:

The entries of the 2008 Red River On-Farm Yield Trials, including the breeder and the year of release, are listed in Table 2.

Table 1. Locations of the 2008 Red River Valley On-Farm Yield Trials.

Location	Cooperator	Planting Date	Harvest Date
Fergus Falls	John Walkup	4-23-08	8-5-08
Perley	Brian Hest	5-8-08	Not Harvested
Oklee	Ray Swenson	5-7-08	8-19-08
Strathcona	Jim Kukowski	5-7-08	8-19-08
Humboldt	Gerald Olsonawski	5-1-08	8-19-08

Interpretation of the Data:

This year one-year, two and three-year averages are reported. Within the table, the varieties are listed alphabetically. No single location data is presented to avoid misinterpretation of data. Single environment data has to be interpreted with caution. Performance data across multiple environments; single location/multiple years, or multiple locations/single year, and/or a combination of years and locations is more reliable. Performance data of individual locations is only available upon request. No data may be reproduced without written consent of the author.

In each table, the highest performer for each trait is printed in bold. The grain yield in each table is expressed as a percentage of the trial mean with the overall mean in bu/acre listed below. Presenting the data this way allows for better comparisons over years. Secondly, variety selection is based on the relative ranking of the cultivars, rather than the absolute yield. Comparisons between varieties should only be made within each column and not between columns or between tables. In addition to the overall mean for the trial, the Least Significant Difference is printed at the bottom of each column. The LSD is calculated using an alpha level of 5%. This indicates, if and when the observed difference between two varieties is larger than LSD unit that with 95% confidence the observed difference is a real difference rather than experimental error.

For additional information:
Jochum Wiersma

Red River Valley On-Farm Yield Trials - Spring Barley *(continued)*

Table 2. Spring barley entries on the Red River Valley On-Farm Yield Trials (2006-2008).

Breeder	Cultivar	Type	Year Released	2006	2007	2008
Anheuser Busch	Legacy*	6-row	2000	x	x	x
	Tradition*	6-row	2004	x	x	x
NDSU	Drummond*	6-row	2000	x	x	x
	Stellar ND*	6-row	2005	x	x	x
	Pinnacle	2-row	2008			x
U of MN	Robust*	6-row	1983	x	x	x
	Lacey*	6-row	2000	x	x	x
	Rasmusson	6-row	2008	x	x	x

* AMBA approved malting barley cultivars.

Table 3. Grain yield expressed as a percentage of the trial mean across locations for single year (2008) and multi-year (2006-2008) comparisons and agronomic characteristics of cultivars entered in the Red River Valley On-Farm Yield Trials.

Cultivar	Across All Locations							
	Grain Yield			3-Year Data				
	1 year	2 year	3 year	Plant Height	Lodging	Plump	Test Weight	Protein
	------ (% of mean) -----			(inches)	(1-9)*	(%)	(lb/bu)	(%)
Lacey	99.6	102.2	101.6	32.3	1.8	79.8	46.0	13.1
Legacy	98.5	100.6	96.9	32.6	2.0	71.3	42.8	12.6
Pinnacle**	**110.6**	-	-	**35.9****	2.1**	**94.5****	**46.6****	**10.6****
Rasmusson	103.3	**106.1**	**105.9**	31.3	1.9	73.9	44.7	12.6
Robust	94.6	96.3	95.8	34.0	2.1	76.8	45.2	13.3
Stellar	99.8	100.7	102.2	33.2	1.7	83.5	44.7	12.4
Tradition	94.6	93.9	96.5	32.5	**1.6**	81.5	45.2	12.8
CV	8.7	8.5	9.6	6.4		11.7	4.1	5.6
LSD (5%)	9.1	6.1	5.5	1.4		5.2	1.0	0.4
Mean	150.8	122.6	117.5	32.7		77.5	44.6	12.8

* 1=erect and 9=flat
** 1 year of data

2008 Red River Valley On-Farm Yield Trials—Spring Wheat

Following are the results of the 2008 Red River Valley On-Farm Yield Trials. These regional trials were located throughout northwestern Minnesota.

About the Trials:
The 2008 Red River Valley On-Farm Yield Trials were grown in 5 locations throughout the region. The locations, cooperators, and planting dates are summarized in Table 1. All trials were harvested and included in data analysis. Growing conditions were in general very favorable for small grains. Consequently yields were very high, with Fergus Falls and Oklee averaging over 99 and 103 bu/A across entries respectively.

Table 1. Location of the 2008 Red River Valley On-Farm Yield Trials.

Location	Cooperator	Planting Date	Harvest Date
Fergus Falls	John Walkup	4-23-08	8-13-08
Perley	Brian Hest	5-8-08	8-28-08
Oklee	Ray Swenson	5-7-08	8-25-08
Strathcona	Jim Kukowski	5-7-08	8-20-08
Humboldt	Gerald Olsonawski	5-1-08	8-20-08

About the Entries:
The entries of the 2008 Red River On-Farm Yield Trials, including the breeder and the year of release, are listed in Table 2. WestBred's Breaker was the only new entry in the trials. Some common entries, including Oxen, Granite, Ulen, and Trooper, were no longer tested.

Table 2. Hard Red Spring Wheat entries in the Red River On-Farm Yield Trials (2006-2008).

Breeder	Cultivar	Year Released	2006	2007	2008
AgriPro Wheat	Knudson	2001	x	x	x
	Freyr	2005	x	x	x
	Kelby	2006	x	x	x
	Kuntz	2007		x	x
NDSU	Alsen	2000	x	x	x
	Steele-ND	2004	x	x	x
	Glenn	2005	x	x	x
	Howard	2006	x		x
	Faller	2007		x	x
SDSU	Briggs	2002	x	x	x
	Granger	2004	x	x	x
	Traverse	2006	x	x	x
Thunderbird Seeds	Cromwell	2007		x	x
Trigen Seed Services	Hat Trick	2007	x	x	x
Univ. of Minnesota	Oklee	2003	x	x	x
	Ada	2006	x	x	x
	RB07	2007	x	x	x
	Tom	2008	x	x	x
WestBred	Bigg Red	2004	x	x	x
	Rush	2006	x	x	x
	Blade	2007		x	x
	Samson	2007		x	x
	Vantage	2007		x	x
	Breaker	2008			x

Interpretation of the Data:
One-, two-, and three-year averages for grain yield are reported. Within the table, the varieties are listed alphabetically. No single location data is presented to avoid misinterpretation of data. Single environment data has to be interpreted with caution. Performance data across multiple environments, either single location/ multiple year, or multiple location/ single year, and/or a combination of years and locations is more reliable. Performance data of individual locations is only available upon request. No data may be reproduced without written consent of the author.

In each table, the highest performer for each trait is printed in bold. The grain yield in each table is expressed as a percentage of the trial mean with the overall mean in bu/A listed below. Presenting the data this way allows for better comparisons over years. Secondly, variety selection is based on the relative ranking of the cultivars, rather than the absolute yield. Comparisons between varieties should only be made within each column and not between columns or between tables. In addition to the overall mean for the trial, the Tukey's Least Significant Difference (LSD) is printed at the bottom of each column. The LSD is calculated using an alpha level of 10%. This indicates that, if and when the observed difference between two varieties is larger than the LSD unit, with 90% confidence the observed difference is a real difference rather than experimental error.

For additional information: Jochum Wiersma

Red River Valley On-Farm Yield Trials—Spring Wheat *(continued)*

Table 3. Grain yield expressed as a percentage of the trial mean across all locations in single year (2008) and multi-year (2006-2008) comparisons and agronomic characteristics of cultivars entered in the Red River Valley On-Farm Yield Trials.

Cultivar	Across All Locations						
	Grain Yield			3-Year data			
	1 year	2 year	3 year	Plant Height	Lodging[1]	Test Weight	Protein
	----------- (% of mean)----------			(inches)	(1-9)	(lb/bu)	(%)
Ada	99.1	99.4	99.8	30.1	2.9	61.7	14.0
Alsen	96.2	94.5	95.3	30.3	1.9	60.6	14.4
Bigg Red	96.2	91.3	95.1	33.3	3	61.8	13.4
Blade[2]	98.6	102.0	-	31.9	-	**62.9**	13.7
Breaker[3]	100.6	-	-	32.3	1.5	62.2	13.7
Briggs	98.1	100.3	104.4	32.0	3.4	61.1	14.1
Cromwell[2]	98.5	101.8	-	32.1	2.1	61.8	13.9
Faller[2]	**106.3**	**111.5**	-	32.7	2.8	60.2	13.6
Freyr	98.7	102.2	101.1	32.8	2.3	59.9	13.9
Glenn	94.8	97.4	98.8	33.2	2	61.8	14.7
Granger	102.8	101.7	105.3	**33.6**	2.7	60.9	14.0
Hat Trick	99.9	102.2	101.3	32.0	2	61.1	14.2
Howard	98.2	97.1	99.7	31.1	2.8	61.4	14.4
Kelby	95.7	94.4	96.8	27.9	1.8	61.1	14.5
Knudson	104.3	107.8	106.8	30.4	2.4	61.2	13.7
Kuntz[2]	101.8	106.0	-	30.0	1.9	61.1	13.4
Marshall	81.6	72.5	76.1	28.5	2.6	57.1	13.7
Oklee	100.1	99.2	100.1	31.5	2.6	61.7	14.4
RB07	102.2	104.0	105.4	30.6	2.5	61.0	14.2
Rush	93.0	93.9	92.8	30.4	1.5	62.2	14.8
Samson[2]	104.1	107.8	-	29.7	2.7	60.4	13.6
Steele-ND	98.9	103.6	103.8	32.3	2.5	60.5	14.5
Tom	103.9	101.7	101.8	31.2	2.5	60.9	14.2
Traverse	104.1	110.2	**112.3**	33.0	2.4	59.2	13.3
Vantage[2]	91.2	91.9	-	31.2	1.5	62.2	**14.9**
LSD (10%)	17.1	13.6	11.7	1.6	0.8	1.5	0.6
Mean (bu/A)	90.8	80.6	74.7	32.0	2.4	61.4	13.9

[1] 1=erect and 9=flat
[2] 2-year data
[3] 1-year data

2008 Spring Wheat Variety Blend Study - Otter Tail County

Cooperator: John Walkup
Nearest Town: Fergus Falls
Soil Type: Clay Loam
Tillage: Fall—Disk, Spring—Digger and Field Cultivator
Previous Crop: Soybeans 2007 and Corn 2006
Planting Date: 4-23-08
Planting Rate: 1.4 million seeds/A
Row Width: 6 inches
Fertilizer: Fall Broadcast—90#N, 65#P, and 20#K (actual)
Varieties: Glenn, Faller, Rush, Granger, RB07, and Bigg Red
Blend 1 = Glenn and Faller (yield and quality)
Blend 2 = RB07 and Bigg Red (disease)
Blend 3 = Rush and Granger (lodging)
***blends were done at 67/33, 50/50, and 33/67% ratios
Herbicide: 6-10-08 Bronate Advanced + Arial XL
Harvest Date: 8-14-08
Experimental Design: Randomized Complete Block (3 reps)
Plot Size: 6.5 ft wide X 20 ft long

Purpose of Study:

Evaluate the performance of spring wheat varieties alone and in mixtures with foliar diseases, lodging, quality, and yield

Results:

In blend 1 (Table 1. Glenn/Faller), we saw no detectable differences with lodging, leaf diseases, test weight, and protein. There were however differences documented with moisture (11.4 to 12.9%) and yield (89.5 to 110.2 Bu/A). In the case of yield, there was an increase in bushels with the increase of Faller.

In blend 2 (Table 2. RB07/Bigg Red), kernel moisture and test weight were not significantly different amongst the treatments. Lodging, leaf diseases, protein, and yield were found to be statistically different. The varieties blended are known to be very different in leaf disease susceptibility and documented in this project (RB07 2.7% - Bigg Red 28.3% infection). This research illustrated the slowing of leaf disease spread with the increase of RB07 into the blended plots.

Blend 3 (table 3.) was made with Rush and Granger to examine the effects of variety blending on lodging. While small, differences were significant ranging from 1.7 to 3.0. Differences were also documented leaf disease and yield. Kernel moisture, test weight, and protein were not found to be different with treatment effects.

Partnership: NWROC

For additional information:
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218-998-5787
D. Holen J. Wiersma

2008 Spring Wheat Variety Blend Study — Ottertail County *(continued)*

Table 1. Blend 1 Treatments	Lodging at Harvest 1-9 scale (1 flat)	Disease Flag Leaf % 0-100	Moisture Percent	Test Wt Lbs/Bu	Protein Percent	Yield Bu/A
Glenn	2.7	3.7	**11.7**	62.7	14.6	**89.5**
Glenn 67%/Faller 33%	3.0	6.0	**11.4**	60.8	14.6	**92.3**
Glenn 50%/Faller 50%	2.7	3.0	**11.9**	62.0	14.2	**101.4**
Glenn 33%/Faller 67%	2.3	3.7	**12.9**	59.4	14.3	**99.7**
Faller	2.7	2.0	**11.9**	60.6	13.9	**110.2**
Mean	2.7	3.7	**12.0**	61.1	14.3	**98.6**
CV	29.5	49.9	**4.4**	2.3	3.4	**4.6**
LSD (P=.10)			**0.8**			**6.9**
Treatment Prob (F)	NS	NS	**0.0646**	NS	NS	**0.0037**

Table 2. Blend 2 Treatments	Lodging at Harvest 1-9 scale (1 flat)	Disease Flag Leaf % 0-100	Moisture Percent	Test Wt Lbs/Bu	Protein Percent	Yield Bu/A
RB07	**2.3**	**2.7**	11.4	60.4	**14.3**	**100.5**
RB07 67%/Bigg Red 33%	**4.0**	**11.7**	11.5	60.2	**13.7**	**98.5**
RB07 50%/Bigg Red 50%	**4.0**	**20.3**	11.6	61.1	**13.3**	**95.1**
RB07 33%/Bigg Red 67%	**3.7**	**28.3**	10.9	62.1	**13.7**	**91.1**
Bigg Red	**3.3**	**28.3**	12.0	60.8	**13.4**	**86.9**
Mean	**3.5**	**18.3**	11.5	60.9	**13.7**	**94.4**
CV	**20.1**	**34.3**	6.7	1.8	**2.8**	**5.9**
LSD (P=.10)	**1.1**	**9.5**			**0.6**	**8.4**
Treatment Prob (F)	**0.0892**	**0.0040**	NS	NS	**0.0750**	**0.0885**

Table 3. Blend 3 Treatments	Lodging at Harvest 1-9 scale (9 flat)	Disease Flag Leaf % 0-100	Moisture Percent	Test Wt Lbs/Bu	Protein Percent	Yield Bu/A
Rush	**1.7**	**28.0**	10.9	61.1	14.5	**97.7**
Rush 67%/Granger 33%	**2.0**	**8.7**	10.6	62.6	14.3	**91.6**
Rush 50%/Granger 50%	**2.0**	**8.7**	10.8	61.4	14.5	**98.6**
Rush 33%/Granger 67%	**2.7**	**8.0**	11.5	60.9	14.5	**92.9**
Granger	**3.0**	**7.7**	11.3	60.7	13.9	**87.7**
Mean	**2.3**	**12.1**	11.0	61.3	14.3	**93.7**
CV	**17.1**	**38.8**	8.0	1.6	2.1	**3.3**
LSD (P=.10)	**0.6**	**7.2**				**4.8**
Treatment Prob (F)	**0.0156**	**0.0029**	NS	NS	NS	**0.0181**

Source: 2008 On-Farm Cropping Trials Northwest and West Central Minnesota
U of MN Extension Service, published January 2009

2006-2008 Alfalfa Variety Evaluation Trial—Otter Tail County

Cooperator: Paul Beckman
Nearest Town: Underwood
Previous Crop: Wheat
Soil Type: Silty Loam
Tillage: Chisel Plow and Field Cultivator
Hybrid: Various (15 entries)
Planting Date: 5-17-06
Emergence Date: 5-27-06
Planting Rate: 16 lbs PLS/A
Row Width: 6 inches
Fertilizer: Spring 2006 applied Dairy Manure
9-12-07: 160 units K (0-0-60)
10-8-08: 130 units K (0-0-60)
Herbicide: 6-7-06 Raptor @ .031 lb + COC @ 1 Qt+ 28% @ 2 Qt
Insecticide: 6-30-08 Warrior @ 2.6 oz/A for Alfalfa Weevil
Harvest Dates: 2006: 7-28 and 10-6, 2007: 6-1, 7-6, and 9-12
2008: 6-10, 7-8, 8-13, and 10-8
Experimental Design: Randomized Complete Block (4 reps)
Plot Size: 3 feet by 20 feet

Purpose of study:
Evaluate yield potential of commercial and experimental alfalfa varieties in WC MN.

Entry (by total yield)		% Stand 5-10-08	2008 Harvest 6-10	7-8	8-13	10-8	2008 Total	2007 Total	2-yr Total	Relative 2-Yr Yield as % of Checks
Released Varieties	**Company**		*ton DM/acres*							
AMERISTAND 407TQ	America's Alfalfa	85	1.96	1.49	0.96	0.88	5.28	5.71	10.99	112
MAGNUM VI	Dairyland	78	1.80	1.34	0.96	0.92	5.02	5.62	10.64	109
PERFORM	Doebler's	88	1.78	1.38	0.96	0.98	5.10	5.50	10.60	108
54V46	Pioneer	89	1.91	1.33	0.89	0.87	4.99	5.44	10.43	107
GENOA	NK Brand	81	1.82	1.34	0.80	0.77	4.73	5.47	10.20	104
WL 343 HQ	W-L	90	1.82	1.37	0.84	0.73	4.75	5.22	9.97	102
6400 HT	Garst	81	1.77	1.22	0.76	0.76	4.51	5.32	9.83	100
6415	Garst	86	1.72	1.29	0.85	0.82	4.67	5.15	9.82	100
6443 RR	Garst	81	1.73	1.31	0.85	0.73	4.61	5.13	9.74	100
6200 HT	Garst	79	1.59	1.14	0.79	0.80	4.32	5.20	9.52	97
PHABULOUS III	Trelay	90	1.67	1.27	0.80	0.77	4.50	5.01	9.51	97
53Q30	Pioneer	75	1.55	1.05	0.75	0.72	4.07	4.95	9.02	92
Checks										
5312		88	1.77	1.23	0.88	0.85	4.73	5.53	10.25	105
ONEIDA VR		83	1.62	1.10	0.79	0.91	4.42	5.03	9.44	96
VERNAL		76	1.71	1.15	0.82	0.84	4.51	5.16	9.67	99
Mean...3 Checks		82	1.70	1.16	0.83	0.87	4.55	5.24	9.79	100
Mean Total		**83**	**1.76**	**1.27**	**0.85**	**0.85**	**4.72**	**5.34**	**10.06**	**103**
Range		19	0.41	0.43	0.21	0.27	1.21	0.76	1.97	20
LSD 5%		12	0.22	0.18	0.18	0.17	0.64	0.55	1.11	11
CV		9.9	9.0	10.0	15.0	14.3	9.7	7.3	7.8	7.8

Partnership: U of MN Forage Program
Funding: Private Seed Companies

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Source: 2008 On-Farm Cropping Trials Northwest and West Central Minnesota
U of MN Extension Service, published January 2009

Evaluation of Sunflower Germplasm for Resistance to Sclerotinia Head Rot

Nearest Town: Crookston
Planting Date: May 22, 2007
Row Spacing: 36 inch
Row Length: 20 feet
Plants Thinned: Approximately 1 plant/10 inches
Experimental Design: Randomized complete block with four replications
***S. sclerotiurum* Inoculation Dates**: August 5, 6, 7, 8, 9, 12, 13, 14, 18,
Misting Application Began: August 5
Misting Regime: 2 minutes misted, 13 minutes not misted 24 hrs/day
Disease Rating Scale: 0 to 5 where 0= no symptoms, 5 = head rotted

Results:
Damaging levels of Sclerotinia head rot developed uniformly across the experiment on many hybrids. Proseed 7052 had the lowest disease mean, but the hybrid wasn't significantly different from PANNAR PEX 3426, Seeds2000 X4994, ProSeed 6007, and ProSeed 7016. Six entries showed 100% rotted heads (susceptible check, CHS 08 EX1, CHS 08-EX5, CHS 08-EX6, Mycogen 8N358c1, Red River Commodities 2215), while the group wasn't significantly more diseased than 34 other hybrids.

Hybrid resistance is increasing over the years. Several hybrids are now more resistant than the resistant check entry used. As a general rule of thumb, confection-type hybrids continue to express more susceptibility to Sclerotinia head rot than non-confection types.

Germplasm entries submitted by industry are showing some tolerance to Sclerotinia head rot injury even under severe disease pressure. This indicates that advances are being made toward breeding for resistance to the disease.

Funding: National Sclerotinia Initiative
Collaborators: USDA Sunflower Unit, Fargo; NDSU Carrington and Langdon Research Extension Centers; Agriculture and Agri-Food Canada, Morden Research Station, Manitoba, Canada.

For additional information:
Charla Hollingsworth
Chris Motteberg

Evaluation of Sunflower Germplasm for Resistance to Sclerotinia Head Rot *(continued)*

Table 1. Sclerotinia head rot ratings taken on 8 October, 2008 from the sunflower disease nursery in Crookston.

No.	Company & Hybrid	*Rating
1	Proseed 7052	1.0
2	Pannar PEX 3426	1.3
3	Seeds 2000 X4994	1.5
4	Proseed 6007	1.6
5	Proseed 7016	1.8
6	CHS CHS08-EX3^	2.0
7	Seeds 2000 X9466	2.3
8	Proseed 7069	2.4
9	Tom Heaton 6N43	2.4
10	Interstate DKL39-80CL	2.6
11	Proseed 7207	2.7
12	Triumph TRX8445	2.7
13	Interstate MH7633	2.9
14	Seeds 2000 X9478	2.9
15	Seeds 2000 X9744	2.9
16	Pioneer 63N82	3.0
17	RESISTANT CHECK 3	3.1
18	Seeds 2000 X9766	3.1
19	Dyna-Gro 94C38	3.2
20	Seeds 2000 X9767	3.2
21	Proseed 6008	3.3
22	Tom Heaton 8TH525	3.3
23	RESISTANT CHECK 2	3.4
24	Tom Heaton 8TH603	3.4
25	Tom Heaton TH7025	3.4
26	Advanta Pacific F41269NS	3.5
27	Mycogen E88427	3.5
28	Pannar PEX 8579	3.5
29	Proseed 7025	3.5
30	Triumph TRX8344	3.6
31	Pannar PAN 7294	3.7
32	Pannar PEX 3296	3.7
33	Tom Heaton 8TH606	3.7
34	Advanta Pacific F30294NSRust	3.8
35	Mycogen E87425	3.8
36	Seeds 2000 X9714	3.8
37	Triumph R664	3.8
38	RESISTANT CHECK 1	3.9
39	Tom Heaton 8TH604	3.9
40	Triumph TRX8345	3.9
41	Advan Pac F51139NS,DM,IMI	4.0

No.	Company and Hybrid	*Rating
42	Interstate MH6643	4.0
43	Interstate MH7362	4.0
44	Dyna-Gro 94N82	4.1
45	Pannar PAN 7813^	4.1
46	Pannar PAN 7986	4.1
47	Tom Heaton 6N14	4.1
48	Dahlgren 9583 CL^	4.2
49	Mycogen E87323^	4.2
50	Tom Heaton 8TH605	4.2
51	Triumph TRX7322	4.2
52	Mycogen E87421	4.3
53	Seeds 2000 X3381^	4.3
54	Advanta Pacific F51179NS,DM	4.4
55	Advanta Pacific F69028^	4.4
56	RESISTANT CHECK 4	4.4
57	Advanta Pacific F10046HO	4.5
58	SUSCEPTIBLE CHECK 4	4.5
59	Tom Heaton TH8510	4.5
60	Triumph TRX7435HO	4.5
61	CHS CHS08-EX2^	4.6
62	CHS CHS08-EX-7^	4.6
63	Dyna-Gro 92N53	4.6
64	Triumph TRX8359C^	4.6
65	Mycogen E87355	4.7
66	Seeds 2000 X4367^	4.7
67	SUSCEPTIBLE CHECK 3	4.7
68	Tom Heaton 8TH607	4.7
69	Dahlgren 95EXP CL^	4.8
70	Interstate MH6640	4.8
71	Mycogen E86351	4.8
72	Pannar PEX 3295	4.8
73	Red River 2216^	4.8
74	Seeds 2000 X5412^	4.8
75	SUSCEPTIBLE CHECK 2	4.8
76	CHS CHS08-EX4^	4.9
77	CHS CHS08-EX1^	5.0
78	CHS CHS08-EX5^	5.0
79	CHS CHS08-EX-6^	5.0
80	Mycogen 8N358cl	5.0
81	Red River 2215^	5.0
82	SUSCEPTIBLE CHECK 1	5.0

*LSD(0.05) = 0.97
**Most hybrids were non-confection. Those with (^) are designated as confection.

2008 Red River Valley On-Farm Disease Management Trials

Test Specifics

		Dates		
Nearest Town	**Cooperators**	*Planted*	*Harvest*	***Previous Crop***
Fisher	Steve Ross of Ross Seed Co	1 May	19 Aug	soybean
St. Hilaire	Steve Ross of Ross Seed Co	5 May	20 Aug	soybean

Purpose of Study:
1. **Determine yield & quality responses of hard red spring wheat varieties when exposed to different environments using common disease management strategies. (Table 1).**
2. **Estimate net returns from each variety and disease management treatment.**

Tillage: Each spring wheat field was tilled and fertilized according to the best management production practices of the farm.

Varieties & Experimental germplasm lines: Ada, Alsen, Bigg Red, Breaker, Briggs, Faller, Freyr, Glenn, Hat Trick, Howard, Kelby, Knudson, Kuntz, RB 07, Samson, Steele-ND, Tom, Trooper, Vantage, Jenna, Brennan, WestBred BZ 903-504, WestBred CA 905-780, WestBred CA 905-781, WestBred CA 907-833, WestBred CA 907-836, WestBred CA 907-837, WestBred CA 907-838, WestBred CA 907-839, and Trigen 06MSP18

Experimental Design: Small plots arranged in a split plot statistical design with location as whole plots, variety as subplots and fungicide treatment as the sub-subplots.

Results:

Tan spot was not a production issue this year, and leaf rust established later than normal, causing little if any trouble. However, epidemics of bacterial stripe and black chaff were observed across the Valley. These bacterial diseases were associated with substantial crop losses in wheat. This comes only three years since our last bacterial stripe epidemic during 2005. Plants showing symptoms of wheat streak mosaic virus, a mite vectored disease, were widespread across the Valley, but incidence was low. Overall prevalence of Fusarium head blight was low, but several localized epidemics were reported from the north and central areas of the Valley.

Weather conditions were variable across locations. Scattered thundershowers, rather than large weather systems, provided local in-season precipitation as well as severe wind or tornadoes. The Fisher test site had too little precipitation, but plants managed to produce excellent yields in spite of this challenge. The St. Hilaire site had timely and sufficient rains which produced thick, lush plant canopies and incredible yields. This environment promoted powdery mildew development which was moderately severe on Hat Trick, a susceptible variety.

When averaged over both locations yield responses ranged from Glenn (78.1 bu/A) to Faller (107.8 bu/A), while test weights ranged from 62.7 lb/bu (Samson) to 65.9 lb/bu (Glenn) (Table 2A). The lowest protein content was detected from Kuntz (12.7%) while Glenn (14.9%) had the highest. After grain samples were graded, premiums and discounts were calculated. This showed Kuntz with the highest discount of the commercially-available varieties tested ($0.56/bu). Low quality contributed to substantial discounts in several of the experimental germplasm entries tested (Table 2B). Variety and disease management strategy data were analyzed from the 2007 and 2008 On-farm Disease Management Trials to increase statistical power. No significant effects were detected from any measurement collected ($P<0.05$) pertaining to variety or disease management strategy.

Summary:

Varieties responded well to this year's growing environment, producing excellent yields of high quality grain. An analysis of data from the last two years indicates that prophylactic applications of one or more fungicides did not significantly increase yield, quality, or net return in environments with low disease pressure.

Disclaimer:

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2008 Red River Valley On-Farm Disease Management Trials *(continued)*

Table 1. Disease management strategies tested during 2008 at two test locations in the Red River Valley.

			Application	
	Product	Active ingredient	Rate*	Timing
1	Nontreated control..	--	--	--
2	Dividend Extreme..	difenoconazole and mefenoxam	3 fl. oz./100 lbs.	seed applied
3	Headline................ Folicur/Proline.......	pyraclostrobin tebuconazole & prothioconazole	3 fl. oz./a 3 + 3 fl. oz./a	4-5 leaf early flower
4	Dividend Extreme.. Headline................ Folicur/Proline.......	difenoconazole & mefenoxam pyraclostrobin tebuconazole/prothioconazole	3 fl. oz./100 lbs. 3 fl. oz./a 3 + 3 fl. oz./a	seed applied 4-5 leaf early flower
5	Dividend Extreme.. Folicur/Proline.......	difenoconazole & mefenoxam tebuconazole & prothioconazole	3 fl. oz./100 lbs. 3 + 3 fl. oz./a	seed applied early flower
6	Folicur/Proline.......	tebuconazole & prothioconazole	3 + 3 fl. oz./a	early flower

*Treatments 3 through 6 included 0.125% Induce, a nonionic surfactant.

Table 2A. Varietal responses to disease management strategies at Fisher and St. Hilaire, MN.

Variety	Trtmt timing[1]	Yield (bu/A)	Test Wt. (lb/bu)	Protein (%)	Premium/ Discount[2] (bu)	Cash price ($/bu)	Fungicide + appl. cost[3] $/A	Estimated Return ($/a)
Ada	F	98.6	65.6	13.9	$-0.08	$6.58	$17.23	$631.56
U of M	L, F	99.8	64.5	13.7	$-0.16	$6.50	$23.55	$625.15
	None	93.2	65.1	13.7	$-0.16	$6.50	0.00	$605.80
	S, L, F	94.4	64.4	13.8	$-0.08	$6.58	$26.98	$594.17
	S	90.3	64.1	13.9	$-0.08	$6.58	$3.43	$590.74
	S, F	91.8	65.2	14.0	$-0.00	$6.66	$20.66	$590.73
	Mean	*94.7*	*64.8*	*13.8*	*$-0.09*	*$6.57*	*$15.31*	$606.36
Alsen	None	89.2	64.6	14.8	$0.00	$6.66	0.00	$594.07
NDSU	S, L, F	90.7	64.3	14.4	$0.00	$6.66	$26.98	$577.08
	F	88.8	63.8	14.4	$0.00	$6.66	$17.23	$574.18
	S, F	88.4	64.1	14.4	$0.00	$6.66	$20.66	$568.08
	L, F	87.8	64.4	14.2	$0.00	$6.66	$23.55	$561.20
	S	84.4	64.4	14.6	$0.00	$6.66	$3.43	$558.67
	Mean	*88.2*	*64.3*	*14.5*	*$0.00*	*$6.66*	*$15.31*	*$572.21*
Bigg Red	None	93.8	65.8	14.0	$0.00	$6.66	0.00	$624.71
WestBred	S	93.9	64.9	13.9	$-0.08	$6.58	$3.43	$614.43
	S, F	96.5	65.6	13.7	$-0.16	$6.50	$20.66	$606.59
	S, L, F	96.2	65.1	13.9	$-0.08	$6.58	$26.98	$606.02
	L, F	93.1	64.6	13.8	$-0.08	$6.58	$23.55	$589.05
	F	92.1	65.3	13.9	$-0.08	$6.58	$17.23	$588.79
	Mean	*94.3*	*65.2*	*13.9*	*$-0.08*	*$6.58*	*$15.31*	*$604.93*
Breaker	S, F	94.5	64.5	14.1	$0.00	$6.66	$20.66	$608.71
WestBred	F	93.6	64.8	13.8	$-0.08	$6.58	$17.23	$598.66
	S	90.6	64.5	13.9	$-0.00	$6.58	$3.43	$592.72
	None	88.4	65.3	14.0	$0.00	$6.66	0.00	$588.74
	S, L, F	90.2	64.8	13.9	$-0.08	$6.58	$26.98	$566.54
	L. F	86.9	63.6	13.8	$-0.08	$6.58	$23.55	$548.25
	Mean	*90.7*	*64.6*	*13.9*	*$-0.05*	*$6.61*	*$15.31*	*$583.94*

2008 Red River Valley On-Farm Disease Management Trials *(continued)*

Table 2A. Continued

Variety	Trtmt timing[1]	Yield (bu/ A)	Test Wt. (lb/bu)	Protein (%)	Premium/ Discount[2] (bu)	Cash price ($/bu)	Fungicide + appl. cost[3] $/A	Estimated Return ($/A)
Briggs	S, L, F	97.2	63.9	14.4	$0.00	$6.66	$26.98	$620.37
SDSU	F	92.3	64.0	14.6	$0.00	$6.66	$17.23	$597.49
	S, F	92.8	64.0	14.4	$0.00	$6.66	$20.66	$597.39
	None	87.9	64.3	14.4	$0.00	$6.66	0.00	$585.41
	S	88.0	64.0	14.6	$0.00	$6.66	$3.43	$582.65
	L, F	90.5	63.8	14.4	$0.00	$6.66	$23.55	$579.18
	Mean	*91.5*	*64.0*	*14.5*	*$0.00*	*$6.66*	*$15.31*	*$593.75*
Faller	F	107.8	64.5	13.1	$-0.40	$6.26	$17.23	$657.60
NDSU	None	99.9	64.2	13.2	$-0.32	$6.34	0.00	$633.37
	S	101.6	63.7	13.1	$-0.40	$6.26	$3.43	$632.59
	S, F	102.5	64.0	13.1	$-0.40	$6.26	$20.66	$620.99
	L, F	101.3	63.7	13.0	$-0.40	$6.26	$23.55	$610.59
	S, L, F	101.4	63.9	12.8	$-0.48	$6.18	$26.98	$599.67
	Mean	*102.4*	*64.0*	*13.1*	*$-0.40*	*$6.26*	*$15.31*	*$625.80*
Freyr	S, L, F	101.3	63.1	13.5	$-0.24	$6.42	$26.98	$623.37
AgriPro	S	92.9	63.7	13.9	$-0.08	$6.58	$3.43	$607.85
	None	91.8	63.7	13.9	$-0.08	$6.58	0.00	$604.04
	S, F	92.4	63.6	14.1	$0.00	$6.66	$20.66	$594.72
	L, F	94.5	62.8	13.7	$-0.16	$6.50	$23.55	$590.70
	F	88.9	63.4	14.0	$0.00	$6.66	$17.23	$574.84
	Mean	*93.6*	*63.4*	*13.9*	*$-0.09*	*$6.57*	*$15.31*	*$599.26*
Glenn	None	80.4	65.8	14.8	$0.00	$6.66	0.00	$535.46
NDSU	S, F	81.7	65.8	14.9	$0.00	$6.66	$20.66	$523.46
	F	81.0	65.9	14.8	$0.00	$6.66	$17.23	$522.23
	S, L, F	82.3	65.5	14.4	$0.00	$6.66	$26.98	$521.14
	S	78.1	65.8	14.9	$0.00	$6.66	$3.43	$516.72
	L, F	80.7	65.7	14.6	$0.00	$6.66	$23.55	$513.91
	Mean	*80.7*	*65.8*	*14.7*	*$0.00*	*$6.66*	*$15.31*	*$522.15*
Hat Trick	L, F	96.9	64.7	13.5	$-0.24	$6.42	$23.55	$598.55
Trigen	S, L, F	96.4	64.2	13.4	$-0.24	$6.42	$26.98	$591.91
	S	90.7	64.4	13.7	$-0.16	$6.50	$3.43	$586.12
	None	89.6	64.3	13.7	$-0.16	$6.50	0.00	$582.40
	F	90.3	64.9	13.8	$-0.08	$6.58	$17.23	$576.94
	S, F	91.1	64.9	13.8	$-0.08	$6.58	$20.66	$571.49
	Mean	*92.5*	*64.6*	*13.6*	*$-0.17*	*$6.49*	*$15.31*	*$584.57*

2008 Red River Valley On-Farm Disease Management Trials *(continued)*

Table 2A. Continued

Variety	Trtmt timing[1]	Yield (bu/A)	Test Wt. (lb/bu)	Pro-tein (%)	Premium/ Discount[2] (bu)	Cash price ($/bu	Fungicide + appl. cost[3] $/A	Estimated Return ($/a)
Knudson	S, L, F	98.7	63.9	13.4	$-0.24	$6.42	$26.98	$606.67
AgriPro	S	93.0	63.2	13.4	$-0.24	$6.42	$3.43	$593.63
	None	90.7	63.8	13.6	$-0.16	$6.50	0.00	$589.55
	L, F	95.1	63.1	13.4	$-0.24	$6.42	$23.55	$586.99
	S, F	94.6	64.0	13.4	$-0.24	$6.42	$20.66	$586.67
	F	89.5	63.7	13.5	$-0.24	$6.42	$17.23	$557.36
	Mean	*93.6*	*63.6*	*13.5*	*$-0.23*	*$6.43*	*$15.31*	*$586.81*
Kuntz	None	96.6	63.8	13.1	$-0.40	$6.26	0.00	$604.72
AgriPro	L, F	97.8	63.7	12.8	$-0.48	$6.18	$23.55	$580.85
	S, F	94.1	64.1	13.1	$-0.40	$6.26	$20.66	$568.41
	S, L, F	97.1	63.9	12.7	$-0.56	$6.10	$26.98	$565.33
	S	90.3	63.8	13.0	$-0.40	$6.26	$3.43	$561.85
	F	91.1	64.2	12.9	$-0.48	$6.18	$17.23	$545.77
	Mean	*94.5*	*63.9*	*12.9*	*$-0.45*	*$6.21*	*$15.31*	*$571.15*
RB 07	S, L, F	101.1	64.1	13.9	$-0.08	$6.58	$26.98	$638.26
U of MN	None	91.0	64.2	14.3	$0.00	$6.66	0.00	$606.06
	F	92.7	64.4	14.2	$0.00	$6.66	$17.23	$600.15
	L, F	93.0	64.2	14.0	$0.00	$6.66	$23.55	$595.83
	S, F	91.1	64.1	14.5	$0.00	$6.66	$20.66	$586.07
	S	86.1	64.0	14.3	$0.00	$6.66	$3.43	$570.00
	Mean	*92.5*	*64.2*	*14.2*	*$-0.01*	*$6.65*	*$15.31*	*$599.39*
Samson	S, F	97.9	63.3	13.4	$-0.24	$6.42	$20.66	$607.86
WestBred	F	96.5	63.3	13.4	$-0.24	$6.42	$17.23	$602.30
	None	91.6	62.9	13.6	$-0.16	$6.50	0.00	$595.40
	S, L, F	97.6	62.8	13.2	$-0.32	$6.34	$26.98	$591.80
	L, F	96.0	62.7	13.2	$-0.32	$6.34	$23.55	$585.09
	S	92.0	62.7	13.3	$-0.32	$6.34	$3.43	$579.85
	Mean	95.3	*63.0*	*13.4*	*$-0.27*	*$6.39*	*$15.31*	*$593.72*
Steele ND	F	96.0	64.4	14.3	$0.00	$6.66	$17.23	$622.13
NDSU	S, F	93.7	64.9	14.3	$0.00	$6.66	$20.66	$603.38
	S, L, F	94.0	64.8	14.0	$0.00	$6.66	$26.98	$599.06
	None	89.9	64.5	14.4	$0.00	$6.66	0.00	$598.73
	S	89.9	64.6	14.3	$0.00	$6.66	$3.43	$595.30
	L, F	91.2	64.4	14.2	$0.00	$6.66	$23.55	$583.84
	Mean	*92.5*	*64.6*	*14.3*	*$0.00*	*$6.66*	*$15.31*	*$600.41*

2008 Red River Valley On-Farm Disease Management Trials *(continued)*

Table 2A. Continued

Variety	Trtmt timing[1]	Yield (bu/A)	Test Wt. (lb/bu)	Pro-tein (%)	Premium/ Discount[2] (bu)	Cash price ($/bu	Fungicide + appl. cost[3] $/A	Estimated Return ($/a)
Tom	None	97.4	64.5	14.3	$0.00	$6.66	0.00	$648.68
U of M	F	96.4	64.5	14.2	$0.00	$6.66	$17.23	$624.79
	S, L, F	98.3	64.0	13.9	$-0.08	$6.58	$26.98	$619.83
	L, F	92.9	63.8	14.0	$0.00	$6.66	$23.55	$595.16
	S	88.2	64.5	14.1	$0.00	$6.66	$3.43	$583.98
	S, F	90.6	64.1	14.1	$0.00	$6.66	$20.66	$582.74
	Mean	*94.0*	*64.2*	*14.1*	*$-0.01*	*$6.65*	*$15.31*	*$609.20*
GRAND MEAN		92.7	*64.3*	*13.9*	*$-0.12*	*$6.54*	*$15.31*	*$590.24*

Footnotes from Table 2B apply to Table 2A.

Table 2B. Varietal and experimental germplasm entry responses to two disease management strategies at Fisher and St. Hilaire, MN.

Variety	Trtmt timing[1]	Yield (bu/A)	Test Wt. (lb/bu)	Protein (%)	Premium/ Discount[2] (bu)	Cash price ($/bu	Fungicide + appl. cost[3] $/A	Estimated Return ($/a)
Howard	None	93.8	64.6	14.2	$0.00	$6.66	0.00	$624.71
NDSU	L, F	97.0	63.8	13.8	$-0.08	$6.58	$23.55	$614.71
	Mean	*95.4*	*64.2*	*14.0*	*$-0.04*	*$6.62*	*$11.78*	*$619.71*
Kelby	None	87.9	64.2	14.8	$0.00	$6.66	0.00	$585.41
AgriPro	L, F	88.7	64.0	14.5	$0.00	$6.66	$23.55	$567.19
	Mean	*88.3*	*64.1*	*14.7*	*$0.00*	*$6.66*	*$11.78*	*$576.30*
Trooper	None	78.9	64.9	13.3	$-0.32	$6.34	0.00	$500.23
WestBred	L, F	79.5	64.5	13.3	$-0.32	$6.34	$23.55	$480.48
	Mean	*79.2*	*64.7*	*13.3*	*$-0.32*	*$6.32*	*$11.78*	*$490.35*
Vantage	None	78.9	64.3	14.8	$0.00	$6.66	0.00	$525.47
WestBred	L, F	82.4	63.5	14.4	$0.00	$6.66	$23.55	$525.23
	Mean	*80.7*	*63.9*	*14.6*	*$0.00*	*$6.66*	*$11.78*	*$525.35*
Jenna	None	97.9	63.5	13.6	$-0.16	$6.50	0.00	$636.35
AgriPro	L. F	101.0	63.4	13.4	$-0.24	$6.42	$23.55	$624.87
	Mean	*99.5*	*63.5*	*13.5*	*$-0.20*	*$6.46*	*$11.78*	*$630.61*
Brennen	L, F	92.5	64.2	14.5	$0.00	$6.66	$23.55	$592.50
AgriPro	None	88.9	64.5	14.7	$0.00	$6.66	0.00	$592.07
	Mean	*90.7*	*64.4*	*14.6*	*$0.00*	*$6.66*	*$11.78*	*$592.29*
BZ 903-504	L, F	101.5	62.2	13.3	$-0.32	$6.32	$23.55	$619.96
WestBred	None	96.1	63.4	13.4	$-0.24	$6.42	0.00	$616.96
	Mean	*98.8*	*62.8*	*13.4*	*$-0.28*	*$6.38*	*$11.78*	*$618.46*
CA 905-780	L, F	90.9	63.2	13.6	$-0.16	$6.50	$23.55	$567.30
WestBred	None	80.1	64.1	13.8	$-0.08	$6.58	0.00	$527.06
	Mean	*85.5*	*63.7*	*13.7*	*$-0.12*	*$6.54*	*$11.78*	*$547.18*

2008 Red River Valley On-Farm Disease Management Trials *(continued)*

Table 2B. Continued

Variety	Trtmt timing[1]	Yield (bu/A)	Test Wt. (lb/bu)	Protein (%)	Premium/ Discount[2] (bu)	Cash price ($/bu	Fungicide + appl. cost[3] $/A	Estimated Return ($/a)
CA 905-781	L, F	93.3	62.3	14.1	$0.00	$6.66	$23.55	$597.83
WestBred	None	90.3	63.0	13.9	$-0.08	$6.58	0.00	$594.17
	Mean	*91.8*	*62.7*	*14.0*	*$-0.04*	*$6.62*	*$11.78*	*$596.00*
CA 907-833	L, F	90.8	63.1	12.6	$-0.56	$6.10	$23.55	$530.33
WestBred	None	83.4	63.5	12.8	$-0.48	$6.18	0.00	$515.41
	Mean	*87.1*	*63.3*	*12.7*	*$-0.52*	*$6.14*	*$11.78*	*$522.87*
CA 907-836	L, F	94.2	62.1	12.6	$-0.56	$6.10	$23.55	$551.07
WestBred	None	86.7	61.5	12.6	$-0.56	$6.10	0.00	$528.87
	Mean	*90.5*	*61.8*	*12.6*	*$-0.56*	*$6.10*	*$11.78*	*$539.97*
CA 907-837	L, F	85.3	61.4	11.8	$-0.88	$5.78	$23.55	$469.48
WestBred	None	81.0	60.8	11.7	$-0.96	$5.70	0.00	$461.70
	Mean	*83.2*	*61.1*	*11.8*	*$-0.92*	*$5.74*	*$11.78*	*$465.59*
CA 907-838	L, F	88.3	63.5	14.7	$0.00	$6.66	$23.55	$564.53
WestBred	None	76.0	63.2	14.5	$0.00	$6.66	0.00	$506.16
	Mean	*82.2*	*63.4*	*14.6*	*$0.00*	*$6.66*	*$11.78*	*$535.34*
CA 907-839	L, F	94.4	64.4	12.1	$-0.80	$5.86	$23.55	$529.63
WestBred	None	87.6	64.5	12.1	$-0.80	$5.86	0.00	$513.34
	Mean	*91.0*	*64.5*	*12.1*	*$-0.80*	*$5.86*	*$11.78*	*$521.49*
06MSP18	None	104.9	63.5	12.3	$-0.72	$5.94	0.00	$623.11
Trigen	L, F	106.0	64.0	12.6	$-0.56	$6.10	$23.55	$623.05
	Mean	*105.5*	*63.8*	*12.5*	*$-0.30*	*$6.02*	*$11.78*	*$623.08*
GRAND MEAN		89.9	*63.4*	*13.5*	*$-0.30*	*$6.36*	*$11.78*	*$560.31*

[1]Fungicide treatment product, rate and timing: None= No fungicide treatment; S= Dividend Extreme, 3 oz/100 lbs as a seed treatment; F= Folicur and Proline 3 fl oz each/A at early flower; L, F= Headline, 3 fl oz/A at the 4-5 leaf stage and tank mix of Folicur and Proline 3 fl oz each/A at early flower; S, F= Dividend Extreme, 3 oz/100 lbs as a seed treatment and tank mix of Folicur and Proline 3 fl oz each/A at early flower; S, L, F= Dividend Extreme, 3 oz/100 lbs as a seed treatment followed by Headline, 3 fl oz/A at the 4-5 leaf stage and tank mix of Folicur and Proline 3 fl oz each/A at early flower. NOTE: Both the Headline treatment and Folicur + Proline (tank-mixed) treatment included 0.125% Induce, a nonionic surfactant.

[2]On 2 Oct. 2008, analysis started with a cash price of $6.66/bu. Protein premiums based up 0 per 1/5. Protein discounts based down 8 per 1/5. Protein adjustments were averaged across two experiment locations each having four replications.

[3]Fungicide costs based on Dividend Extreme at $133/gal, Headline at $270/gal, Folicur at $53/gal after rebate, Proline at $468/gal and early flower application cost of $5/A. Fungicide costs translate to Dividend Extreme $3.43/A; Headline $6.32/A; Folicur + Proline $12.23/A. No additional cost for application was added for seed treatment as it was treated at time of drill filling and the 4-5 leaf application would be made in combination with herbicide application.

Source: 2008 On-Farm Cropping Trials Northwest and West Central Minnesota
U of MN Extension Service, published January 2009

Prophylactic Application of Fungicide on Soybean for Increased Plant Health

Planted: 180,000 live seed/A on 15 May 08 into wheat residue
Herbicide: June 23, 1 qt. Roundup PowerMax + 1 qt. ammonium sulfate (39%)
July 17, same as above
Insecticide: July 17, 1 pt. Lorsban
Variety: Gold Country Seed 2703 RR
Experimental Design: Small plots arranged in a randomized complete block design with 4 reps.

Purpose of Study:
Determine seed yield and quality responses from soybean after an application of fungicide seed treatment and one or more applications of foliar-applied fungicide.

Fungicide treatments:

Trt	Product	Application Rate	Application Timing*
1	Nontreated control	--	--
2	Acronis + Acquire………	1.5 + 1.5 fl oz/cwt	seed applied
3	Acronis + Acquire……… Headline........................	1.5 + 1.5 fl oz/cwt 3 fl oz/A	seed applied 2-3 trifoliate
4	Acronis + Acquire……… Headline........................	1.5 + 1.5 fl oz/cwt 6 fl oz/A	seed applied R2-R3
5	Acronis + Acquire……… Headline........................ Headline........................	1.5 + 1.5 fl oz/cwt 3 fl oz/A 6 fl oz/A	seed applied 2-3 trifoliate R2-R3
6	Headline........................	3 fl oz/A	2-3 trifoliate
7	Headline........................	6 fl oz/A	R2-R3
8	Headline........................ Headline........................	3 fl oz/A 6 fl oz/A	2-3 trifoliate R2-R3
9	Headline........................ Headline........................	3 fl oz/A 6 fl oz/A	5-6 trifoliate R2-R3

**R2-R3 growth stage is full flower to beginning podding.*

Summary:
Soybeans responded well to this year's growing environment, producing excellent yields in small plots. Seed yield and quality responses from fungicide application did not occur during 2008. Using a fungicide seed treatment with prophylactic applications of foliar-applied Headline did not result in a significant increase in yield or seed quality.

Table 1. Soybean yield and quality responses to fungicide treatments at a site near Crookston during 2008.

Treatment	Stand height (cm)	Stand count (2 m row)	Protein (%)	Test weight (lb/bu)	Yield (bu/A)	1000 Seed wt. (g)	Oil (%)
1	80.5	17.3	34.8	60.81	55.7	129.23	17.4
2	82.8	19.0	35.9	60.89	50.6	123.52	16.7
3	82.3	18.3	36.0	61.13	49.6	122.67	16.8
4	81.8	18.8	35.0	60.62	54.9	128.13	17.2
5	82.5	16.5	35.0	61.04	54.0	126.04	17.3
6	82.8	20.3	35.0	60.72	53.1	129.59	17.3
7	79.5	17.5	34.5	60.57	58.9	133.09	17.6
8	80.5	18.5	34.7	60.49	56.6	132.78	17.4
9	83.8	18.5	35.2	60.82	54.9	129.67	17.2
Mean	81.9	18.3	35.1	60.79	54.3	128.30	17.2
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS

Partnership or funding information:
This project was funded by BASF and was conducted on the Elliott Solheim farm east of Crookston in cooperation with Russ Severson, Extension Educator.

For additional information:
Charla Hollingsworth
Chris Motteberg

2008 On-Farm Sulfur Fertility Study - Corn

Cooperator: Bill, Eric, Nick Zurn
Nearest Town: Section 27, Spring Creek Township, Becker Co. MN
Soil Type: Hamerly/Winger Complex.
Soil Test: pH-7.8, N-43 lbs, P-6ppm, S-14lbs (0-6)+48(6-24), O.M. 5.2%, salts mmho 0.48 + 0.33
Tillage: Fall-Chisel plow and Spring—field cultivated
Previous Crop: Sugar Beets
Planting Date: May 13, 2008
Variety: Pioneer 39D80 (85day) at 30,000
Row Width: 22”
Fertilizer: Applied and cultivated in before planting
Weed Management: Roundup
Harvest Date: Oct. 28 (hand)
Experimental Design: Small Plot(15’ x 30’) randomized (4 reps) dry granular, broadcast, and incorporated.

Purpose of Study:
to evaluate sulfur fertilizer products on corn yield. Questions have been raised if sulfur fertility is the yield limiting factor for heavy fine textured soils with a medium organic matter in NW Minnesota. U of MN soil fertility guidelines usually recommend a sulfur application on low O.M sandy soils or for certain specialty crops. Plot was placed in the cooperators’ field, that did not have a history of manure. Management was provided by the cooperators.

Results:
The results of this 2nd year study indicates that there is no agronomic advantage to yield for the 2 sulfur fertilizer products tested at either the 12.5 lb, or 25 lb., or the 50 lb rate for that class of soil in NW Minnesota. A similar study in 2005-2007, on similar type soils in Mahnomen and Norman County, evaluating sulfur fertilizer products on soybean yield, oil % and protein, yielded similar results of no added agronomic benefit to production.

MES-15: Fertilzer Applied:120-60-60 plus (1) control- 0lbs S, (2) 12.5lbsS, (3) 25lbsS, (4) 50lbsS; 15'x30' plots

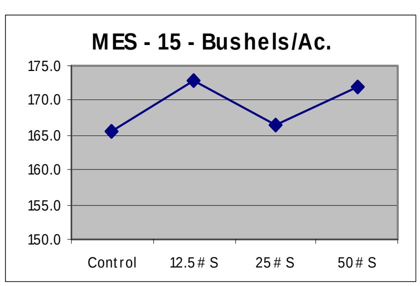
	Bushels	Test Wt.	Protein %	Starch %	Oil %
Control	165.4	53.38	8.68 a	72.68	2.44 a
12.5 # S	172.9	53.18	8.43 b	73.45	2.03 ab
25 # S	166.6	53.05	8.50 ab	73.23	2.10 ab
50 # S	172.1	53.38	8.40 b	73.38	2.01 b
LSD: 5%	**11.47**	**0.95**	**0.23**	**0.86**	**0.42**

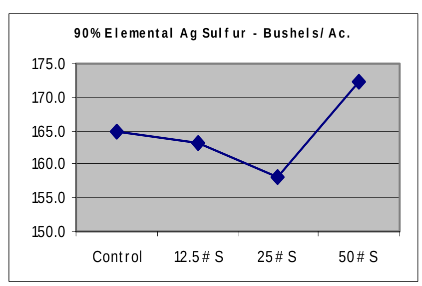
No significant differences measured in Yield, Test Wt., and % starch between treatments.

90% Elemental Ag.Sulfur: Fertilzer Applied:120-60-60 plus (1) control- 0lbs S, (2) 12.5lbsS, (3) 25lbsS, (4) 50lbsS; 15'x30' plots

	Bushels	Test Wt.	Protein %	Starch %	Oil %
Control	164.9	53.53	8.60	73.30	2.36
12.5 # S	163.3	54.00	8.65	72.95	2.44
25 # S	158.1	53.88	8.65	73.38	2.16
50 # S	172.1	53.78	8.45	73.53	2.15
LSD 5%	**15.91**	**1.07**	**0.31**	**0.68**	**0.41**

No significant differences measured in any of the variables at all treatment levels





For Additional Information:
Ray Bisek, Mahomen/Norman/Polk County Extension

Statistical Analysis using ANOVA: provided by Carlyle Holen, U of MN Extension. Yield Adjusted to 15.5 % moisture

Source: 2008 On-Farm Cropping Trials Northwest and West Central Minnesota
U of MN Extension Service, published January 2009

Canola Cultivar Evaluation—Roseau County

Cooperator: Kraig Lee
Nearest Town: Wannaska
Soil Type: Silty Loam
Tillage: Field Cultivator
Previous Crop: Wheat
Planting Date: May 12, 2008
Planting Rate: 5 Lbs/Acre
Row Width: 6 inches
Fertilizer: 90 Lbs/Nitrogen
Swathing Date: August 28, 2008
Harvest Date: September 17, 2008
Experimental Design: Randomized Complete Block (4 reps)
Plot Size: 25 feet by 6 feet

Purpose of Study:
Evaluate the performance of commercial canola varieties in Minnesota.

Results: A fairly late and wet spring provided less than ideal conditions for planting canola in 2008. However, a cool summer with adequate moisture provided canola in Minnesota to yield quite well in most areas. Average yields in Minnesota were over 300 lbs/acre higher than in 2007.

Table 1: Seed yield, growth characteristics and oil content of Non Roundup-Ready canola (Brassica napus) varieties (lb/acre at 8% moisture) at Wannaska in 2008.

Brand	Cultivar	Blackleg Resistance*	Days to Flower	Plant Lodging**	Plant Height cm	Days to Maturity	Seedling vigor score***	Yield lb/ac
Bayer	5440	R	50	1	45	95	2	3101.8
Bayer	5550	R	45	2	38	94	1	2964.4
Bayer	8440	R	46	0	30	91	1	2935.7
Bayer	953	N/A	43	2	35	89	1	2734.4
Bayer	5630	R	52	3	38	93	1	2707.3
Mycogen	DN051874	R	49	3	34	95	1	2576.2
Mycogen	845CL	MR	49	0	30	94	1	2411.8
Mycogen	DN051692	R	48	1	33	91	1	2339.9
Mycogen	DN051535	R	45	6	41	94	1	2336.7
Mycogen	DN051607	R	50	3	36	93	1	2255.2
Mycogen	830CL	R	49	5	43	95	1	2245.7
Mycogen	DN051493	R	47	6	43	95	1	2191.4
Mycogen	DN051505	R	50	7	39	93	1	2065.2
Mean								2528.1
LSD 0.05	<.0001							307.75
CV (%)								8.49

* Blackleg resistance rating provided by seed companies: R = Resistant, MR = Moderately Resistant, MS = Moderately Susceptible.
**Plant lodging score: 0 = no lodging, 9 = plants lying flat.
***Seedling vigor score: 1 = virogous, 9 = no vigor.

Funding: Private Seed Companies
Partnership: Minnesota Canola Council

For additional information:
P.M. Porter or D.S. Crompton

Canola Cultivar Evaluation—Roseau County *(continued)*

Table 2: Seed yield, growth characteristics and oil content of Roundup Ready canola (Brassica napus) varieties (lb/acre at 8% moisture) at Roseau in 2007.

Brand	Cultivar	Blackleg Resistance*	Days to Flower	Plant Lodging **	Plant Height cm	Days to Maturity	Seedling vigor score***	Yield lb/ac
Cargill	V1035	R	45	3	36	92	2	2841.4
Mycogen	G2X0039	R	47	6	47	95	2	2804.7
Croplan	Hyclass 924	R	43	2	39	91	1	2726.4
Brett Young	6051	MR	44	3	46	94	1	2686.5
Integra	IX087121	R	43	4	37	91	1	2672.1
Brett Young	6235	MR	47	1	46	95	1	2616.2
Mycogen	G2X0042	R	47	6	41	94	2	2605
Croplan	940	R	45	2	38	91	2	2573.1
Pioneer	45H28	R	46	3	42	95	2	2563.5
Mycogen	G2X0023	R	46	2	38	95	1	2545.9
Cargill	V2018	MR	48	3	40	91	1	2542.7
Mycogen	G2X0054	R	47	2	40	93	2	2514
Mycogen	G2X0024	R	49	4	38	93	1	2509.2
Cargill	V1037	R	46	3	44	93	1	2477.3
Cargill	04H272	MR	48	4	43	93	2	2464.5
Mycogen	G2X0044	R	46	2	38	95	2	2464.5
Proseed	30 Caliber	R	49	3	38	100	2	2459.7
Proseed	50 Caliber	R	45	3	40	94	2	2454.9
Cargill	V2010	MR	48	3	42	93	2	2432.5
Mycogen	G2X0022	R	51	2	47	95	2	2272.8
Proseed	2030	R	44	3	41	94	2	2208.9
Proseed	2066	MR	49	3	39	93	2	2146.6
Dekalb	DKL30-42	R	47	1	32	91	1	2862.2
Dekalb	IS3057	R	44	3	36	91	1	2827
Monsanto	G72021	R	44	1	28	88	1	2798.3
Dekalb	DKL72-55	MR	47	2	37	94	1	2783.9
NoBrand	WE0801	R	46	3	33	92	1	2739.2
Dekalb	DKL52-41	R	47	3	35	94	2	2697.7
Dekalb	DKL52-41Plus	R	46	1	29	91	1	2688.1
Monsanto	G75011	R	44	1	43	95	1	2645
Dekalb	IS7145	MR	46	5	42	90	1	2645
Monsanto	G72003	R	46	1	34	93	1	2630.6
Monsanto	G75449	R	44	1	38	92	1	2627.4
Monsanto	G64034	R	44	1	33	92	1	2593.9
Monsanto	Z4409	R	44	2	34	94	2	2514
Monsanto	G72061	R	45	1	39	94	1	2432.5
Monsanto	G67012	R	46	2	32	93	1	2127.5
Mean								2572.8
LSD 0.05	<.1395							447
CV (%)								12

* Blackleg resistance rating provided by seed companies: R = Resistant, MR = Moderately Resistant, MS = Moderately Susceptible.

**Plant lodging score: 0 = no lodging, 9 = plants lying flat.
***Seedling vigor score: 1 = virogous, 9 = no vigor.

Canada Thistle Control with Milestone at Seven Application Dates

Purpose of Study:
Canada thistle may be the most invasive introduced plant species in Minnesota. It is present in nearly every mile of roadside, in every non-cropland area, and has been the most prevalent noxious weed in Conservation Reserve Program (CRP) land. This plant is notoriously difficult to control in non-cropland areas and single applications of herbicides usually offer only temporary suppression. Suggestions for the best application timing varies with each herbicide label and there are suggestions for treatment at the rosette stage, or at the rosette to bud stage, or some labels offer no suggestions for application timing related to Canada thistle control. Two recently labeled herbicides for non-cropland sites provide real promise for making significant progress in managing this plant. Milestone® and ForeFront® R&P (Dow AgroSciences) both contain the active ingredient aminopyralid which provides longer term control of Canada thistle than any of the other products currently labeled for use. The question addressed by this research is: What is the optimum application timing for Canada thistle control with Milestone?

Procedures:
This research was conducted in 2007-2008 on the Don Andersen farm near Ada, MN on CRP land with a very heavy stand of Canada thistle (approximately 6.5 stems/sq yd). Herbicide applications were made every two weeks from June 1 to August 20 with Milestone applied at 5 and 7 oz/product per acre with NIS applied at 0.25% v/v. The herbicide treatments were applied in a randomized complete block design with four replications. Plots were 30 x 30 ft with a 3 ft alley between plots and a 15 ft alley between replicates that were mowed and sprayed with Milestone at 7 oz/A to minimize thistle movement into treatment areas. Herbicides were applied with a tractor mounted CO2 sprayer delivering 10 gpa at 35 psi and equipped with XR8001 flat fan nozzles. The established cover included a wide variety of grasses and forbs including smooth brome, big bluestem, Indiangrass, goldenrod spp., perennial sowthistle, and alfalfa.

Table 1. Canada thistle stage and environmental conditions at each application timing.

Date	Canada thistle stage	Temp °F	Wind - mph	RH%	Soil moisture
6/01/07	Rosette - emergence to 1 ft tall	70	3-7 E	67	moist
6/15/07	4-20 inches tall - flower buds on 30% of stems	70	3-8 SW	78	wet
6/28/07	4-24 inches tall - less than 1% of stems in flower	72	2-4 W	59	moist
7/12/07	12-30 inches tall – 75% of stems with flowers	60	1-3 S	77	moist
7/23/07	6-30 inches tall – 70% dispersing seed	100	calm	-	dry
8/09/07	4-30 inches tall – seed dispersed some plants dying	77	1-4 SW	-	dry
8/23/07	4-30 inches tall – mature plants dying	52	calm	85	dry

Results and Discussion:
Canada thistle produces new shoots during the growing season on a nearly continuous basis with a larger 'flush' of rosettes in the spring and fall. In the spring, the emergence of new Canada thistle rosettes is regulated by temperature[1], day length, and other factors such as mowing. In NW Minnesota, Canada thistle emergence typically begins in early May and new rosettes will emerge from along the large horizontal root system for the entire growing season. This results in Canada thistle plants (patches) with numerous interconnected stems (or clones) at several different stages of growth at the same time, as we observed on 6/28/07 (Table 1) with stems ranging in height from 4 to 24 inches tall and rosette and flowering stage plants adjacent to one another. Figure 1 shows the increase in Canada thistle stem number, from June 1 to July 13 from untreated plots. In the two week period from June 1 to June 15 there was a 44% increase in rosette number, and from June 15 to June 29 the increase was 18%. Thereafter, the number of new rosettes initiated slows but does not stop during this time.

Milestone® provided excellent control at the 5 and 7 oz/A rates on all but two of the application dates. On June 1, Milestone® applied at 5 oz/A resulted in significantly lower control compared to the other application dates at the same application rate. We think that incomplete emergence of rosettes resulted in less total uptake of herbicide by the interconnected plant. Uptake of Milestone® by Canada thistle is believed to be less efficient through the soil when plants are emerging, compared to leaf tissue. Though not statistically significant, the June 1 application timing at 7 oz/a rate was the least effective timing at this herbicide rate. We are not certain if the lower control on the July 23 at 5 oz/A, was related to less translocation of herbicide to the root system during seed shed as mature plants were declining. We believe it is more likely this reduced control was related to very stressful conditions (100 °F) at application.

Canada Thistle Control with Milestone at Seven Application Dates *(continued)*

Based on this one research location and one set of environmental conditions, the window for optimum application for Milestone appears to be quite long.

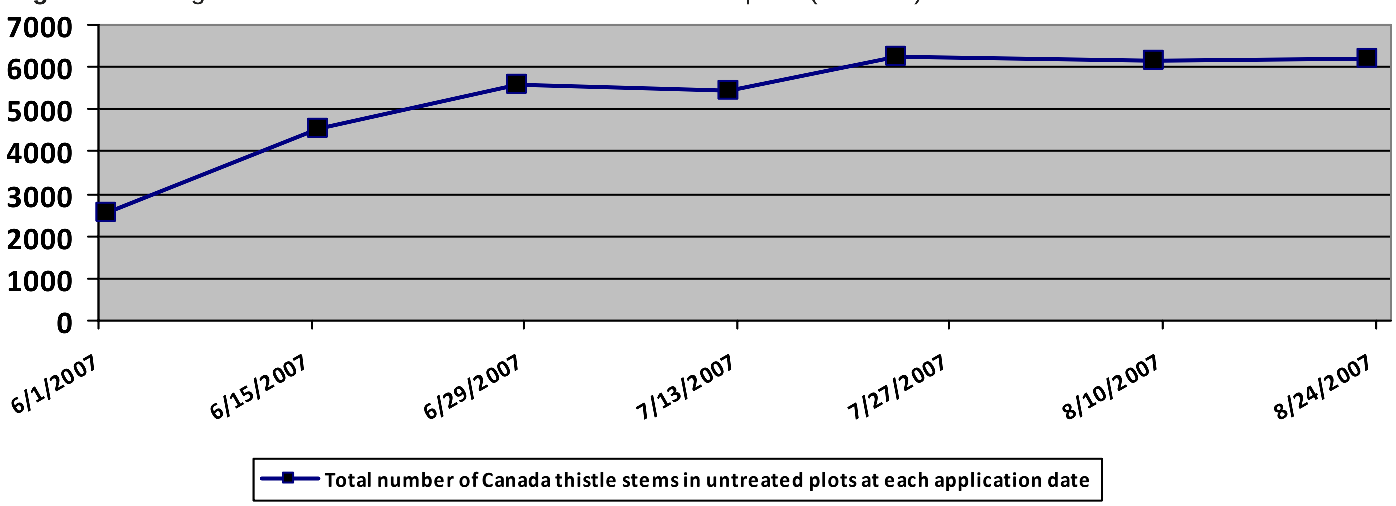
1. Applications made when the most advanced plants at the site are in the bud stage of development through the month of August appear equally effective. However, it may be adviseable to avoid applications when there is strong environmental stress such as drought and high temperatures.
2. Milestone applied at the 7 oz/A rate compared to the 5 oz/A rate appears to provide more consistent control across all application dates (not statistically significant) and is especially evident during timings when plant stage or environmental stress is less than optimum.

[1]*Forcella, F., Archer, D.W., Spokas, K.A. 2007. Canada Thistle Phenology: Emergence, Growth, Anthesis, and Death of Shoots [Abstract]. Weed Science Society of America.*

Table 2. Canada thistle control at seven application timings.

Treatment	Rate (oz/a)	Application Date	7/24/08 % Control[1]
Milestone +NIS	5	June 1	70
Milestone +NIS	7	June 1	87
Milestone +NIS	5	June 15	91
Milestone +NIS	7	June 15	94
Milestone +NIS	5	June 28	93
Milestone +NIS	7	June 28	95
Milestone +NIS	5	July 12	90
Milestone +NIS	7	July 12	92
Milestone +NIS	5	July 23	82
Milestone +NIS	7	July 23	90
Milestone +NIS	5	August 9	92
Milestone +NIS	7	August 9	92
Milestone +NIS	5	August 23	92
Milestone +NIS	7	August 23	97
LSD (0.05)			12

Figure 1. Change in Canada thistle stem number in untreated plots (7200 ft2) over time.



Acknowledgements: The authors wish to thank the NWROC for their generous assistance with equipment and labor. We also thank Lynn Haake with the NWROC for technical assistance. We appreciate the support provided by Dow AgroSciences.

For additional information:
Carlyle Holen
Bobby Holder and Mary Halstvedt

Source: 2008 On-Farm Cropping Trials Northwest and West Central Minnesota
U of MN Extension Service, published January 2009

Soybean Variety Trial - Norman County 2008

Cooperators:	Bryan Hest, Perley, MN, Pazdernik Agronomy Ser., MN Ext. Ser. & Soybean Companies
Plots:	Replicated 2 times, 12-22" rows at approx 700 feet long
Planting Date:	May 21, 2008
Harvest Date:	Dec. 5, 2008
Seed Treatment:	0=None, 1.=Cruiser, 2.=Maxmim XL, 3.=Apron XL
Tillage:	Fall Chisel, Spring Field Cultivate
Chemicals:	Roundup Orig. Max. at 26oz./A + 2 oz. of Select Max on July 12, 2nd App. Roundup Orig. Max on Aug. 8. with 1/2 pt./A Lorsban
Statistical analysis:	Moisture, Oil%, Protein % run at NWROC ANOVA run by Carlyle Holen, MES-NWROC, Crookston, MN Mahnomen Co. Ext: 218-935-2226 or Norman Co. Ext. 218-784-5550, Email: Bisek001@umn.edu Pazdernik Agronomy Services, email: pazdernik@loretel.net or phone:218-206-4499

Soybean Plot Norman County 2008

Company	Variety	Maturity	Seed Count/#	Seed Treat.	% Moist.	% Oil	% Protein	Adj. Yield 13.0% M
Integra	78070R	0.7	3200	2	16.1	18.6	33.2	44.8
Stine	0634-4	0.6	3040	0	16.2	17.9	34.5	43.9
Dairyland Seeds	0602	0.6	3300	0	16.4	18.9	32.8	41.4
Asgrow Seeds	AG0604	0.6	3410	0	16.8	19.1	32.9	38.9
Peterson Seeds	0707RR	0.7	none	0	16.4	19.3	31.5	38.7
Nutech Seeds	NT0651	0.6	none	0	16.4	17.0	35.6	38.6
Nutech Seeds	NT-0706	0.7	3400	0	16.8	18.5	33.0	38.6
Mustang Seeds	M-066RR	0.6	none	0	16.3	19.2	32.5	38.4
Pioneer Hi-Bred	90M80	0.8	3350	0	16.4	19.3	32.1	37.3
Pioneer Hi-Bred	90M60	0.6	2900	0	16.2	18.1	34.1	36.6
Hyland Seeds	Rockport	0.6	2700	0	16.3	19.4	33.0	35.7
Croplan	0669	0.6	none	0	16.6	17.6	35.7	35.3
Thunder Seeds	706RR	0.6	none	0	16.1	19.5	32.3	33.4
Dyna-Gro UAP	34C06	0.6	3600	3	16.7	18.6	32.4	30.8
NK Brand	0K9	0.2	none	0	16.6	18.3	35.8	28.8
Legend Seeds	0624RR	0.6	3600	0	16.8	17.9	35.1	27.9
		Plot Averages =			16.47	18.3	33.55	36.29
		LSD 0.05% =			0.36	0.79	1.68	5.23

For additional information:
Ray Bisek

Source: 2008 On-Farm Cropping Trials Northwest and West Central Minnesota
U of MN Extension Service, published January 2009

Corn Hybrid Variety Trial - Mahnomen County 2008

Cooperators: Bryan Klabunde, Waubun, MN, Pazdernik Agro Ser., Mahnomen Ext. Ser. & Corn Companies
Previous Crop: Soybeans
Planting date: May 6, 2008
Fertilizer: 381 #/A =N100,P33,K55,S15; Liq 7-17-3 at 2.5 gal./A with Riser with planter
Planter: John Deere Maximerge
Chemicals: Roundup Ready in July , Headline in August
Statistical analysis: ANOVA Procedure run by Carlyle Holen, MES-NWROC, Crookston, MN

Company	Variety	mat.	GMO Type	* Seed Treat.	**Stand Ct. 1/1000 A	Broken Stalks	% Moist.	Test Weight	***Adjusted 15.5%M Yld
Mustang Seeds	2307 VT3	86	RRVT3	3	30	0	25.6	50	**169.2**
Hyland Seeds	HL R230	86	RR	3	27	2	24.1	47.3	**168.1**
Proseed	0787	87	VT3	0	29.5	0	23.9	49.7	**167.2**
Dekalb Seeds	DKC36-37	86	RR2	3	28	0	23.0	51.7	**166.5**
Wensman	W6087	86	RR	3	26	1	24.1	51.0	**166.2**
Dyna-Gro UAP	52V01	87	VT3	4	26	0	24.1	50.0	**166.2**
Peterson Seeds	56J86	86	VT3	3	30.5	0	24.5	50.1	**165.9**
Pannar Seeds	3B220	86	RR/CRW	2	28.5	0	23.7	51.4	**165.8**
Integra	9361VT3	86	VT3	3	26	0	24.2	50.6	**165.7**
Legend Seeds	9887	87	RR/YG	3	29	0	22.9	52.0	**165.7**
Proseed	0884	84	VT3	0	27.5	0	22.2	51.5	**163.5**
Gold Co. Seed	83-02 R	83	RR	0	22	0	27.0	48.7	**163.4**
Dyna-Gro UAP	51P15	85	RR/YGCB	4	31	1	22.2	51.7	**162.2**
Wensman	W7083	80	VT3	3	28	0	22.0	52.1	**162.1**
Gold Co.Seed	92-03 VT3	92	RR/BT/CBW	0	31.5	1	23.6	50.5	**161.1**
Pannar Seeds	3C870	87	Gt/CB	2	27	0	23.4	49.4	**161.1**
Seeds 2000	8201VT3	82	VT3	3	33	0	22.3	51.1	**160.9**
Legend Seeds	9385	85	RB	3	29.5	0	22.0	51.7	**160.7**
Nutech Seeds	3C-389	89	RR/YGCB	2	27	0	26.8	47.7	**160.4**
Nutech Seeds	3P-484	84	RR/YGPL	2	25.5	0	22.6	51.5	**160.3**
Pioneer Hi-Bred	39B23	86	RR/HX1/LL	2	32.5	0	25.0	50.9	**160.0**
Wensman	W7087	85	VT3	0	31	0	23.3	51.7	**159.8**
Legend Seeds	9783	83	RB	1	27.5	0	22.5	51.0	**158.9**
Stine	9204	93	VT3	4	27.5	0	25.6	48.7	**158.2**
Pannar Seeds	3A135	85	VT3	0	33.5	0	23.3	51.2	**158.1**
Dekalb Seeds	DKC33-54	83	RR2	3	30.5	0	21.6	52.4	**157.9**
Hyland Seeds	HL CVR44	88	RR/Bt/CRW	3	32	0	21.5	52.8	**157.6**
Nutech Seeds	3C-292+	92	RR/YGCB	2	32.5	0	26.3	49.0	**156.5**
Dekalb Seeds	DKC38-89	89	VT3	3	31.5	0	27.7	48.3	**156.2**
Peterson Seeds	54M83	83	VT3	3	29	0	22.1	52.8	**155.8**
Gold Co. Seed	84-02CBR	84	RR/Bt	0	31	1	22.5	52.4	**154.8**
Hyland Seeds	HL R228	85	RR/Bt	3	27	0	23.1	49.8	**154.0**
Terning Seeds	TS8000	83	RR2	3	27	1.5	25.8	47.9	**153.4**
Pioneer Hi-Bred	39N99	88	RR/HX1/LL	2	29	0	26.3	50.4	**153.3**
Peterson Seeds	27L84	84	RR2	3	32.5	0	24.7	48.7	**153.1**
Mustang Seeds	2304 VT3	84	RRVT3	3	28	0	23.7	49.4	**152.9**
Dyna-Gro UAP	51V89	84	VT3	4	29.5	0	22.1	50.9	**151.6**
Integra	65D85RB	84	RB	3	30	1	22.1	51.0	**149.8**
Pioneer Hi-Bred	39V08	80	RR/HX1/LL	3	27.5	0	20.6	52.5	**148.7**
Integra	9311RBC	81	RR/YG/R	3	23	0	21.7	52.4	**147.0**
					Plot Average =		23.64	50.60	**159.50**
					***LSD 0.05* =**		1.77	1.95	**12.06**

* Seed Treatment: 0=Unknown, 1.=Trilex, 2=Cruiser, 3=Poncho 250, 4.=MaximXL+Poncho 250
** Stand Counts: two rows counted at 1/1000 /acre, reported the average
*** Adjusted Yield: Wet Combine weights were 0.0628 lower than elevator scale weights, yields adjusted up to elevator scale weights and adjusted to 15.5% Moisture

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Identifying New Sources of Resistance to Major Leaf Spot Pathogens in Hard Red Spring Wheat

Tika Adhikari , NDSU, Fargo, ND

Executive Summary

Tan spot, caused by *Pyrenophora tritici-repentis* [(Died.) Drechs.] is a devastating disease in wheat worldwide. Eight pathogenic races of *P. tritici-repentis* have been identified based on reactions on a set of standard wheat cultivars. Another leaf spot disease, Stagonospora nodorum blotch (SNB), is caused by *Phaeosphaeria nodorum,* reduces both grain yield and quality. These fungi produce host selective toxins in sensitive wheat cultivars and can cause up to 50% yield losses. Planting resistant cultivars is the best approach for managing these diseases in wheat. Therefore, newly identified sources for resistance to these diseases can be useful in wheat breeding programs.

Research Objectives

(i) To identify accessions of common wheat from the core subset with resistance to both tan spot and SNB,

(ii) To identify wheat accessions which might have resistance to additional fungal leaf diseases,

(iii) To confirm and validate the newly identified resistance genes effective against leaf spot pathogens, and

(iv) To provide wheat breeders the new sources of resistance to multiple leaf spot pathogens and utilize them in wheat breeding programs

Materials and Methods

A set of 825 accessions from the Germplasm Resources Information Network (NSGC) core subset was selected to represent diverse habit (517 spring, 308 winter), and country of origin (89 countries from six continents) (Table 1).

Identifying sources of resistance to Tan spot.

P. tritici-repentis race 1 is the most widely distributed in North America. Therefore, isolate Pti2 representing race 1, was used in this study. Two-week-old seedlings were spray-inoculated (3 X 10^3 conidia mL^{-1}) until run-off. Disease was scored 8 d after inoculation using a 1 to 5 scale (Lamari and Bernier, 1989), where 0-2 was considered resistant and 2.1-5 susceptible.

Identifying sources of resistance to Stagonospora nodorum blotch (SNB)

An aggressive isolate Sn2000 of *P. nodorum* collected from North Dakota was used in this study. This isolate has been used previously for varietal screening. Seedlings were spray-inoculated (1 X 10^6 spores mL^{-1}) at two leaf stage with a hand and rated for disease reaction 8 d after inoculation using a 0 to 5 scale (Liu et al., 2004) where 0-2 was considered resistant and 2.1-5 susceptible.

For both diseases, experiments were conducted in the greenhouse at North Dakota State University, Fargo, ND. Experiments were laid out in a randomized complete block design with three replications and repeated twice. Three plants planted in each cone were considered as an experimental unit. Nine leaves (total 18 leaves) per replication were rated for each disease.

Results

Analysis of variance of disease data for tan spot and SNB confirmed that no significant (P < 0.05) genotype X experiment interaction. Thus, the results of the two experiments were combined and mean disease score of each accession calculated. Of 517 spring wheat accessions tested, 100 (19.3%) were resistant to tan spot and 96 (18.5%) were resistant to SNB (Table 1). Of the 308 winter accessions tested, 116 (37.6 %) were resistant to tan spot and 122 (39.6%) were resistant to SNB (Table 1). In all, 88 accessions were found resistant to both diseases. Not only were fewer spring accessions resistant, but the proportion of highly susceptible accessions with scores >4 were much higher among spring accessions (59.1% for SNB, 59.5% for tan spot) compared to winter accessions (20.7 % for SNB, 17.5% for tan spot) (Fig. 1A and 1B). Two spring wheat accessions from Canada and six wheat accessions from Mexico were resistant to tan spot. Four winter wheat accessions (CItr 11849, CItr 17529, CItr 17421 and CItr 13701) from the United States were resistant to tan spot. Similarly, two spring wheat accessions CItr 12782, and CItr 13457 from the United States, one spring wheat accession CItr 14261 from Canada, and two spring wheat accessions CItr 8429 and CItr

14313 from Mexico were resistant to SNB. Eleven winter wheat accessions from the United States were resistant to SNB.

Of the 111 spring wheat accessions from Africa, South Africa had maximum with four spring wheat accessions resistant to tan spot, and Sudan had with four spring wheat accessions resistant to SNB. Of the 126 spring wheat accessions from Asia, China had maximum number of six and four spring wheat accessions resistant to tan spot and SNB, respectively. Similarly, of the 87 winter wheat accessions, China also had maximum eight and seven accessions resistant to tan spot and SNB, respectively. Of the 158 spring wheat accessions evaluated from Europe, Russia had maximum with eight spring wheat accessions and Portugal had maximum with eight spring wheat accessions resistant to tan spot and SNB. Similarly of the 155 winter wheat accessions from Europe, both Belgium and Bosnia Herzegovina each had seven accessions resistant to tan spot. Belgium also had eight winter wheat accessions resistant to SNB. Of the 80 spring wheat accessions assessed from South America, Uruguay and Brazil had maximum with seven and six accessions resistant to both tan spot and SNB. Similarly, of the 34 winter wheat accessions from South America, Chile had maximum with 18 and 11 accessions resistant to tan spot and SNB, respectively.

Application /Use:

Wheat cultivars with high levels of resistance are often the best management strategy to avoid losses from plant diseases. The most successful cultivars will have resistance to all major diseases within the target production area. In this study, we identified 88 accessions from the NSGC core subset that are resistant to both tan spot and SNB based on our experimental results. These resistant accessions need to be evaluated to other foliar diseases of wheat. Previous studies identified sources of resistance to tan spot and SNB in durum, wild and synthetic lines. Since the accessions we evaluated are commercially cultivated wheat varieties, breeding lines, or landraces, and have diverse geographic origins, they are likely to have diverse resistance gene constitutions, and can be used directly in wheat breeding.

Economic Benefit to a Typical 500 Acre Wheat Enterprise

Sources of resistance to multiple diseases will be utilized in wheat breeding programs in collaboration NDSU and UM wheat breeders. Developing high yielding and disease resistant varieties will have significant benefit to wheat growers in MN and ND.

Related Research

Evaluating these resistant cultivars to other leaf diseases and identifying molecular markers are in progress.

Recommended Future Research

Developing mapping crosses, analyzing their genetic of resistance and mapping populations with molecular markers are potential areas for future research.

Publications

Manuscript in preparation

Appendix

Table 1. Numbers of spring wheat and winter wheat accessions tested showing resistant§ and susceptible¶ reactions against tan spot and Stagonospora nodorum blotch (SNB) from six continents§.

	Spring						Winter					
	Tan spot			SNB			Tan spot			SNB		
Continent	**Resis-tant (n)**	**Total (n)**	**Resis-tant (%)**	**Resis-tant (n)**	**Total (n)**	**Resis-tant (%)**	**Resis-tant (n)**	**Total (n)**	**Resis-tant (%)**	**Resis-tant (n)**	**Total (n)**	**Resis-tant (%)**
Africa	12	111	10.8	15	111	13.5	0	3	0.0	0	3	0.0
Asia	22	126	17.5	15	126	11.9	23	87	26.4	24	87	27.6
Australia	0	9	0.0	0	9	0.0	1	3	33.3	2	3	66.7
Europe	33	158	20.9	36	158	22.8	68	154	44.15	69	154	44.80
North America	8	31	25.8	5	31	16.1	4	25	16.0	11	25	44.0
South America	24	80	30.0	24	80	30.0	20	35	57.14	16	35	45.71
Unknown	1	2		1	2			1		0	1	
Total	**100**	**517**	**19.3**	**96**	**517**	**18.5**	**116**	**308**	**37.6**	**122**	**308**	**39.6**

§ Wheat accessions were classified as resistant (R) if the average disease mean score <2 in the greenhouse, North Dakota State University, Fargo, ND.
¶ Wheat accessions classified as susceptible (S) if the average disease mean score >2 in the greenhouse, North Dakota State University, Fargo, ND.

Fig 1A

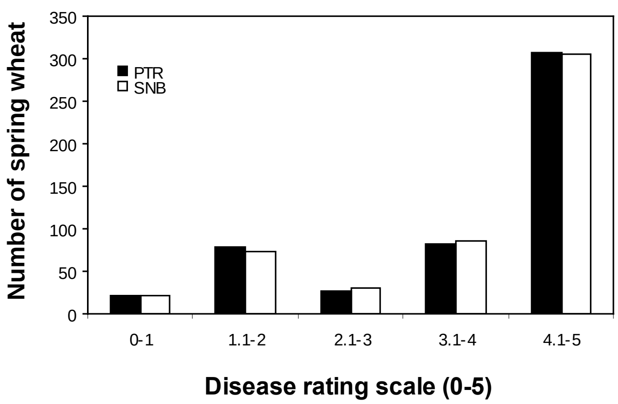
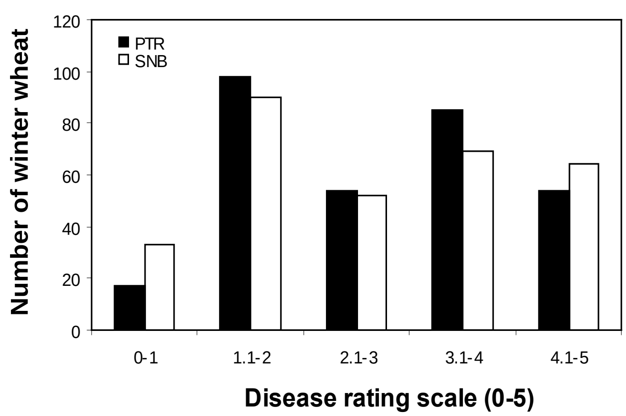


Fig 1B



Wheat Breeding and Genetics

James A. Anderson, Dept. of Agronomy and Plant Genetics, U of M

Research Question

The objectives of this proposal are to i) develop improved varieties and germplasm combining high grain yield, disease resistance, and end-use quality; and ii) provide performance data on wheat varieties adapted to the state of Minnesota.

Results

'Tom' (MN01311-A-1) was released in 2008. Tom (97T-1003/Verde) has medium maturity, height, and straw strength. Tom has shown consistently high grain yields, especially in northern locations, moderate leaf rust resistance, and Fusarium head blight resistance comparable to Alsen. Tom has above average test weight and grain protein. Tom has moderate resistance to stem rust race Ug99 that is currently damaging wheat crops in Africa. Tom is comparable to the AgriPro variety Freyr in terms of its performance and attributes.

The variety was named in memory of Tom Anderson, of Barnesville, MN who passed away in 2007. Tom, a proud member of the Minnesota Wheat Growers Association was a leader in obtaining state and federal funding for Fusarium Head Blight (scab) research. Tom served a number of other organizations and was recognized numerous times for his contributions and commitment to agriculture.

During the 2007/2008 crossing cycle, 323 crosses were made. The Variety Trial, which contained 26 released varieties, 11 University of Minnesota experimental lines, and 6 experimental lines from other programs and was grown at Crookston, Lamberton, Morris, Roseau, St. Paul, Stephen, Waseca, and 5 on-farm locations in the Red River Valley. During the 2008 growing season, 120 advanced experimental lines were evaluated in replicated advanced yield trials at Crookston, Morris, and St. Paul. A total of 370 preliminary yield trial lines were tested in unreplicated plots at Crookston, Morris, and St. Paul. Fusarium-inoculated, misted, replicated nurseries were established at Crookston, Morris, and St. Paul. The disease nurseries involve collaboration with agronomists and pathologists at Crookston and Morris and with personnel from the Plant Pathology Department and the USDA-ARS. Data from the yield and scab nurseries are summarized and published in Prairie Grains and the U of M Extension Service's Minnesota Varietal Trials Results.

One advanced experimental line, MN03358-4, underwent seed increase during 2008 and is a candidate for release in 2009. MN03358-4 is a mid-maturity hard red spring wheat with high grain yields and good scab resistance. The pedigree of MN03358-4 is MN98389/MN97518. MN03358-4 has been a consistently high yielder in Minnesota and the hard red spring wheat region, performing well in the 2006 and 2007 regional performance nurseries. Grain protein and test weight are average compared to other cultivars. MN03358-4 is moderately resistant to preharvest sprouting with good falling numbers. Straw strength is below average. MN03358-4 is resistant to stem rust and moderately resistant to prevalent races of leaf rust and other leaf diseases. MN03358-4 has moderate resistance to Fusarium head blight (scab), comparable to Tom and better than RB07.

Application/Use

Experimental lines that show improvement over currently available varieties are recommended for release. Improved germplasm is shared with other breeding programs in the region. Scientific information related to efficiency of breeding for particular criteria is presented at local, regional, national, and international meetings and published.

Materials and Methods

All yield nurseries are grown in small, replicated plots (typically 40-50 sq. ft. harvested area per plot). Fusarium-inoculated nurseries at Crookston, Morris, and St. Paul consist of single 4 to 6 ft. rows, with 1 to 3 replications. Fusarium-infected corn seed or spray-applied macroconidia are used as inoculum. The plot areas are misted periodically to maintain a high humidity environment for at least three weeks after anthesis.

Related Research

These funds provide general support for our breeding/genetics program. Additional monetary support for breeding-related research comes from the Minnesota Agricultural Experiment Station and the U.S. Wheat and Barley Scab Initiative via USDA-ARS.

Our breeding project is a participant in a new USDA-CSREES project whose objectives are to discover DNA markers linked to pre-harvest sprouting resistance and use DNA markers associated with other key genes to increase the efficiency of the breeding project.

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Accelerated Breeding for Resistance to Fusarium Head Blight

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Research Question

Complete resistance to Fusarium Head Blight (FHB) is unknown, yet genetic variability for resistance is well documented. Steady progress toward increasing resistance levels has been demonstrated by breeding programs through the implementation of repeatable screening procedures. Breeding programs must sustain efforts to simultaneously select resistant materials with desirable agronomic characteristics. The objective of this program is to use traditional plant breeding and selection techniques to develop hard spring wheat varieties that possess agronomic characteristics worthy of release in addition to acceptable levels of FHB resistance.

Results

We have progressed to the point where most entries retained in our advanced yield trial (AYT) are thought to be at least moderately resistant to FHB. Entries that do not perform adequately are generally discarded after the first year of AYT observation. Our 2008 AYT results are presented in the appendix. During the 2008 growing season, 42 entries were tested within the AYT. Seventeen unreleased experimental breeding entries had FHB disease index values that were less than the test average. Among the unreleased entries, sixteen were found to have tombstone ratings that were less than average. Of the seventeen entries with below average disease index values, thirteen also had less than average tombstone ratings. Eight of these thirteen entries also produced more grain than average and six had test weights that were heavier than average. Among the final group of six most desirable entries, two were SD3851 and SD3948. Each of these entries have undergone various procedures involved with seed increase for eventual release. Of most immediate interest, however, is SD3851. Over the past several testing years, SD3851 has become known as an entry with very heavy test weight, good yield potential, early heading date, and perhaps the highest level of FHB resistance that we have identified (Tables 1 and 2). We are prepared to release SD3851 to growers in 2009 and it is anticipated that SD3948 will be released in 2010.

Application/Use

With the progression of time, increases in FHB resistance levels should help to prevent devastating loses to growers caused by severe FHB outbreaks.

Materials and Methods

Breeding efforts to increase resistance began within this program after the 1993 FHB epidemic in the spring wheat production region. Both mist-irrigated greenhouse and field screening nurseries were established and disease evaluation methods were developed. Breeding materials are evaluated for FHB resistance using three generations per year: two in the greenhouse and one in the field. We have the capacity to screen 4000 individual hills in each greenhouse season. We also have 4 acres in the field under mist-irrigation. Both the field and greenhouse nurseries are inoculated with grain spawn (corn and wheat that is infested with the causal fungus) and spore suspensions. Mist-irrigation is used to provide a favorable environment for infection. Approximately 25 percent of the experimental populations possess Fhb1 as a source of resistance. Most of what remains are crosses with various “field resistant” advanced breeding lines. Experimental materials are advanced through the program in the following fashion;

Year 1	Field	Space planted F_2 populations
Year 1	Fall greenhouse	$F_{2:3}$ hills
Year 1	Spring greenhouse	$F_{3:4}$ hills
Year 2	Field	$F_{4:5}$ progeny rows
Year 2	Off-season Nursery	$F_{5:6}$ progeny rows
Year 3	Field	$F_{5:7}$ Yield Trials (1 replication, 2 locations)
Year 4	Field	$F_{5:8}$ Yield Trials (2 replications, 5 locations)
Year 5	Field	Advanced Yield Trials (3 reps, 9 locations)

F_2 populations are planted in the field and individual plants are selected. These are advanced to the fall screening greenhouse where seed from each plant is sown as individual $F_{2:3}$ hills and evaluated for FHB resistance. Four plants from each of the top 25% of the hills are advanced to the spring greenhouse. They are sown as individual $F_{3:4}$ hills and evaluated for FHB resistance. Those with FHB resistance nearly equal to or better than ND2710 are advanced to the mist-irrigated field nursery as $F_{4:5}$ progeny rows. They are evaluated again for resistance and general agronomic performance. Plants are selected within the superior progeny rows and sent to New Zealand as $F_{5:6}$ progeny rows for seed increase. A portion of seed from each selected plant is also grown in the fall greenhouse to confirm that the resistance is stable. If the FHB resistance of an $F_{5:6}$ line is confirmed, then the respective progeny row is harvested in New Zealand. In the following South Dakota field season, the selected lines are tested in a two replication, multi-location yield trial. Those that have agronomic performance and yield similar to current varieties are included in more advanced multi-location, replicated yield trials the following year. In year 5, the lines advanced through this program are included in our AYT along with entries from the traditional breeding program. Agronomic and FHB data collected from the 2008 AYT are presented in the appendix along with 2007 – 2008 averages of AYT entries which were common over the two years.

Economic Benefit to a Typical

500 Acre Wheat Enterprise

The presence of FHB inoculum within fields and favorable weather conditions are just two factors that heavily influence whether this disease will become problematic. Immediate economic benefits are therefore difficult to assess. When conditions become favorable for disease presence, however, varieties with elevated FHB resistance levels can help to reduce potentially serious losses for growers.

Appendix

Table 2. South Dakota State University advanced yield trial spring wheat entries ranked according to FHB disease index values (lowest to highest – collected at Brookings) presented along with agronomic data obtained from three replication tests conducted at eight test environments in both 2007 and 2008.

ENTRY	FHB DIS INDEX	TOMBSTONE (%)	GRAIN YIELD (BU/AC)	TEST WEIGHT (LB/BU)	GRAIN PROTEIN (%)	HEAD DATE (D > 6/1)	PLANT HEIGHT (INCHES
SD3851	11.07	2.67	48.98	59.23	13.81	19.83	33.40
SD4027	12.76	7.50	52.70	58.81	14.15	19.33	33.20
SD3976	22.81	2.83	50.10	59.89	14.92	21.00	33.15
SD3948	28.69	5.00	52.89	58.73	13.95	20.56	33.26
SD4011	29.67	5.33	51.18	56.87	14.88	21.78	31.13
BRIGGS	31.23	2.50	52.06	57.88	14.58	21.28	32.83
ALSEN	31.90	5.50	45.08	57.43	15.03	23.67	31.69
SD4023	32.23	4.67	51.63	58.30	13.56	24.06	30.72
TRAVERSE	32.33	17.83	53.90	55.50	13.47	21.86	34.68
SD4033	32.75	10.17	51.65	58.87	13.73	22.72	30.86
SD4073	33.14	24.67	55.06	55.61	14.05	23.81	32.93
SD4018	34.07	11.00	53.38	56.95	14.37	21.92	31.53
SD3997	35.33	5.17	51.72	58.82	14.62	21.81	35.87
SD4029	36.25	31.33	50.90	54.85	13.68	22.50	31.40
SD4046	36.45	10.33	48.71	58.06	13.61	22.44	34.72
SD3983	36.96	4.17	51.58	58.07	13.46	22.11	33.52
GRANGER	37.53	7.50	51.53	58.34	14.09	22.75	35.80
KNUDSON	37.76	4.00	50.22	57.64	14.72	21.75	32.53
SD4059	38.25	15.67	49.66	57.16	14.15	23.03	32.78
SD4072	38.40	9.17	53.94	57.08	14.26	23.25	32.81
RUSS	40.01	4.17	46.93	55.63	14.05	23.03	34.49
SD4036	40.57	20.50	50.60	56.42	13.61	21.22	27.96
REEDER	40.84	6.67	38.57	54.79	14.05	24.17	31.87
SD4024	41.49	10.00	53.14	58.32	13.90	24.56	29.58
KELBY	42.20	5.33	45.81	57.69	15.10	21.94	27.63
STEELE-ND	42.23	8.50	54.28	58.49	14.82	23.08	33.64
SD4035	43.08	10.50	52.03	56.72	13.81	21.75	30.59
OXEN	43.81	22.00	43.16	54.57	14.01	22.22	31.02
MEAN	38.70	12.24	49.23	58.18	14.15	22.73	32.58
LSD (0.05)	10.55	12.64	2.21	0.57	0.39	1.83	0.25
CV %	29.86	107.36	8.30	2.12	7.42	5.69	3.71

Table 1. South Dakota State University advanced yield trial spring wheat entries ranked according to FHB disease index values (lowest to highest – collected at Brookings) presented along with agronomic data obtained from three replication tests conducted at seven test environments in 2008.

ENTRY	FHB DIS INDEX	TOMB-STONE (%)	GRAIN YIELD (BU/AC)	TEST WEIGHT (LB/BU)	GRAIN PROTEIN (%)	HEAD DATE (D > 6/1)	PLANT HEIGHT (INCHES)
SD3943-21	19.89	1.33	59.58	58.25	13.61	24.44	34.33
SD3948	20.42	3.67	56.38	58.98	13.69	24.00	34.72
SD3976	20.61	4.00	55.76	60.09	14.58	24.00	34.96
TRAVERSE	20.82	5.67	60.36	56.00	13.45	25.22	36.25
SD3851	21.72	3.67	57.12	59.26	13.59	23.22	35.67
BRIGGS	23.66	2.67	55.56	58.15	14.34	24.67	34.41
SD4141	23.90	4.33	49.01	57.36	14.09	23.00	33.94
SD4018	23.98	3.67	59.13	57.35	14.27	25.17	33.54
SD4033	24.17	3.67	56.98	59.25	13.63	25.89	32.34
ALSEN	24.30	2.67	54.82	58.38	14.92	26.56	33.60
SD4027	25.09	2.33	54.86	59.00	14.09	23.00	35.07
SD3997	25.17	6.67	58.58	58.89	14.43	25.11	37.22
SD3983	26.59	5.33	57.24	58.46	13.26	25.67	35.41
SD4100	26.63	8.67	59.40	58.07	14.14	26.50	37.19
KELBY	27.57	3.33	51.71	57.62	14.89	24.61	29.79
FALLER	27.59	5.00	61.66	58.24	14.27	28.72	34.70
SD4112	27.82	5.00	58.54	58.13	13.96	24.22	34.20
SD4105	27.98	5.33	54.43	59.26	13.53	24.61	34.30
SD4046	28.06	10.67	52.84	58.56	13.53	25.33	36.40
SD4029	28.17	4.33	57.57	55.31	13.68	25.39	33.54
SD4073	28.45	7.67	63.73	56.27	14.03	27.28	35.01
SD4091	28.60	5.33	51.85	57.41	14.60	25.78	35.51
SD4136	29.05	10.00	55.67	56.63	13.58	20.44	33.73
SD4023	29.12	3.67	57.18	58.90	13.28	28.00	32.68
SD4119	30.00	3.33	54.50	59.34	13.91	27.11	35.20
SD4011	30.33	6.33	56.13	57.27	14.52	25.22	32.55
OXEN	30.45	5.67	48.11	54.02	14.02	25.78	33.02
SD4089	31.06	10.00	51.46	55.28	13.22	25.22	31.60
SD4078	31.39	8.00	63.39	56.89	13.08	24.28	32.02
SD4072	31.46	8.33	60.80	58.17	14.55	27.22	35.12
GRANGER	31.88	5.67	55.77	58.54	13.92	26.28	37.22
SD4076	32.32	6.00	60.22	59.48	14.01	23.72	33.18
SD4059	33.33	5.67	53.77	56.72	14.12	26.78	33.18
SD4024	33.82	10.00	58.64	58.74	13.81	27.94	30.79
KNUDSON	33.85	5.67	57.21	58.26	14.73	25.22	34.07
SD4036	34.13	5.00	52.76	56.27	13.52	24.61	30.05
SD4109	34.33	6.67	57.95	57.32	13.73	25.89	33.83
SD4133	35.33	8.00	53.02	56.78	13.88	26.83	37.69
SD4035	35.50	5.67	55.93	56.38	13.74	25.17	32.41
RUSS	35.84	2.67	54.07	55.94	14.24	26.78	36.51
STEELE-ND	36.80	8.67	61.55	58.89	14.91	26.50	35.07
REEDER	39.68	4.00	46.44	55.36	13.99	27.56	33.18
MEAN	28.83	5.57	56.23	57.70	13.99	25.45	34.17
LSD (0.05)	11.08	7.21	3.56	0.50	0.30	2.52	2.48
CV %	17.00	41.77	6.84	2.40	3.42	6.25	5.44

Examining Sulfur Rates for Wheat & Split Application versus a Single Split Broadcast

Daniel Kaiser, Department of Soil, Water and Climate, U of M

Research Question

Decreased additions of sulfur to the atmosphere through low sulfur diesel fuel and reductions in industrial emissions have lead to a decrease in incidental deposition of sulfur for crops. This has left some to question if sulfur needs to be supplied to most crops as fertilizer. Current recommendations for sulfur fertilizer applications in Minnesota are limited to sandy soils with low organic matter contents. A single broadcast application of 25 lbs of sulfur or 10 to 15 lbs applied with the drill is typically sufficient in sandy soils. However, responses to sulfur in corn grown on fine textured soils have lead to questions about other crops. In fine textured soils the organic matter generally will mineralize around 4 pounds of sulfur per percent organic matter based on previous work in Minnesota. These rates are generally enough to maximize yields for most crops. Sulfur is essential in plant and grain protein which can be important in crops such as wheat that are sold based on their quality. Therefore, it is important to study sulfur response in light of the current situation to make sure not only yields, but also grain quality is being maximized, and whether the current recommendations are relevant for the current environmental conditions around the state.

Sulfur is taken up into plants in the sulfate form, which in the soil, is susceptible to leaching losses. Soil organic matter contains a large storehouse of sulfur for plants, but must be mineralized before plants can utilize it. In cool wet springs or in soils with low organic matter levels, plant available sulfur may remain low and additional fertilizer may be required. If a highly soluble source of sulfur fertilizer is applied to soils with a high leaching potential sulfur may move out of the root zone before it is needed. Nitrate nitrogen is also in a form that is highly susceptible for leaching losses. Split applications of nitrogen are recommended on sandy soils to limit the potential for loss. Would spring wheat benefit from a split application of sulfur relative to the pre-plant application, and if a deficiency is seen will an in-season application of sulfur be sufficient to correct a deficiency? Slow release forms of nitrogen are being marketed as an alternative that limits N losses by protecting the nitrogen from losses by either creating a barrier that prevents N loss or keeping it in a form that is less susceptible for losses early in the season. Slow release sulfur fertilizers are rare although elemental sulfur can easily be found and is in a form that will slowly become available as it is mineralized throughout the growing season, but may not be available early in the season when uptake of many nutrient including sulfur can be rapid. Would a balance of highly- and slowly soluble fertilizer sources act like a slow release fertilizer source and keep more sulfur available throughout the season, and would this be beneficial in terms of yield and protein content in wheat?

The focus of this study is to compare how wheat growth, yield, and grain quality are affected by sulfur fertilization. Specific objectives of this study are to; 1) study the impacts of sulfur fertilization rates on wheat growth, sulfur uptake, yield, and grain protein content; 2) determine if a slow-release fertilizer source is more efficient at supplying sulfur to wheat throughout the growing season as compared to a highly soluble form (ammonium sulfate); and 3) compare wheat response to applying sulfur according to current recommendation as a single pre-plant broadcast application versus a split application of half the recommended rate broadcast pre-plant and half applied in-season.

Methods

Three trials were established in 2008, two on coarse textured soils (Oklee and Strathcona) and one on a fine textured soil (Perley) (Table 1). Initial soil samples were collected from each replication prior to treatment application from the 0 to 6, 6 to 12, and 12 to 24 inch depth increments except for the Strathcona location where only 0 to 6 inch sample was taken due to stones in the profile at 8 inches below the soil surface. At all locations a single spring wheat variety, Glenn, was seeded in row spaced 6 inches apart at a rate to establish a final stand of 32 plants per square foot. Additional pest control was completed according to recommended practices for the region.

Two fertilizer sources, ammonium sulfate (AMS)

(21-0-024) and micro-essentials S-15™ (Mosaic) (MES-15) (13-33-0-15), were applied before seeding at rates of 0, 12.5, 25, and 37.5 lbs of S per acre. Micro-essential S-15 consists of a mixture of mono-ammonium phosphate, ammonium sulfate, and elemental sulfur. The relative proportion of sulfur supplied by MES-15 is approximately 50% from ammonium sulfate and 50% from elemental sulfur. The product MES-15 is not currently being marketed as a slow-release fertilizer source, but the elemental sulfur contained in the product provides a source of sulfur that will be available over the growing season while the ammonium sulfate will be available right away to insure a constant supply of sulfur throughout the season. At tillering each pre-seeding fertilizer plot was split into thirds and no-, 12.5, and 25 lbs of additional sulfur was applied as a top dress application of ammonium sulfate. To balance out nitrogen and phosphorus applied by treatments, ammonium nitrate (34-0-0) and triple-superphosphate (0-46-0) was applied so that all treatments received identical rates according to the highest rates applied. Additional K (0-0-60) was applied across all plots to limit response. All treatment combinations were replicated four times at each location.

Plant samples were taken around the tillering and soft dough growth stage dried, weighed, and analyzed for total sulfur concentration and uptake. At tillering the above ground portion of plants were sampled from 3 feet of linear row in each main plot (32 samples). At soft dough the above ground portion of 3 liner feet of row were taken from each pre-plant and tillering fertilizer combination (96 samples). A 5 by 20 foot plot area was harvested for yield (adjusted to 13.5% moisture) and a subsample of grain was saved and analyzed for protein content and test weight. Statistical analysis was conducted using analysis of variance procedure assuming fixed main treatment effects (fertilizer source, spring application rate, and tillering application rate) and random block effects.

Results and Discussion

Plant Response

Analysis of early plant response data shows that plant growth (Table 2), sulfur concentration (Table 3), and sulfur uptake (Table 4) were not affected by sulfur source or application rate at any location. Average plant growth differed between sites, which is reasonable based on planting dates and differences in rainfall between sites. Also, trials at Oklee and Strathcona were slightly past tillering when sampled, while plants were at tillering at Perley. Average sulfur concentration in plants differed between sites even though the same variety was used at all location. Differences could not clearly be attributed to soil test levels or early season growth, but could be consistent with the growth stage when the plants were sampled. Early plant sulfur uptake was not affected at any site which is not surprising based on effects on early plant weight and sulfur uptake.

Plant weight at soft dough was significantly influenced by one or more treatment effects at all locations (Table 5). Analysis within sites determined that there was no significant increase or decrease in plant weight from sulfur source, pre-seeding application rate, or application rate at tillering when averaged across the other affects at the Perley and Strathcona locations. At Oklee the in-season application rates increased plant weight slightly by 2 and 6% for the 12.5 and 25 lb rates, respectively, when averaged across source and pre-seeding application rate. At Strathcona analysis of data shows a slight decrease in plant weight as sulfur application rate increased from the application of MES-15. Decreasing plant weights were also observed at Oklee and Stratchona with increasing S rates from AMS when no additional sulfur was applied at tillering, although these results failed to reach any statistical difference at the accepted level. Reasons for decreased growth are not clear; however, they did not have any subsequent influence on grain yield or protein content.

Yield, Grain Protein, and Test Weight

Spring wheat yields were seldom affected by sulfur application at the sites studied (Table 6). Analysis of the data showed slightly higher yields (2 bu/ac) with an in-season application of sulfur following application of MES-15 in the spring across rates at Oklee. According to the spring soil test data there would be a slight chance of response at this location. In sandy soils a sulfur test value between 7 and 12 would indicate that responses to sulfur are possible. Soil tests below 7 indicate a likely response while above 12 would indicate a very small probability that sulfur fertilizer will increase yields. Differences between fertilizer sources would not necessarily be unexpected since MES-15 contains some elemental sulfur which may or may not totally become available depending on soil and weather conditions. The cool weather that persisted for long periods this spring may have caused limited sulfur mineralization in the soil. However, differences between yields and responses for plots receiving AMS and MES-15 where no fertilizer was applied are unclear and may indicate that responses are due to large variations in soil test values within this location. Soil test results were similar in the top six inches at Perley even though yield responses were not seen at this location. However, sulfur content below six inches was nearly double at this location and it is likely that enough sulfur was available in these depths to satisfy crop needs. Overall, site average yields were highest at Oklee at 95.5 bu/ac followed by Strathcona (89.7 bu/ac), and Perley (75.0 bu/ac).

Grain protein levels averaged 15.1, 15.0, and 15.7% at Oklee, Perley, and Strathcona, respectively (Table 7). Application of 25 lbs at tillering did slightly increase grain protein at Perley. This increase only accounted for 0.1% when averaged across products and application rates. At all other locations there was no evidence that broadcast sulfur applied before seeding helped increase grain protein and that an in-season application of sulfur would increase protein further that the broadcast application before seeding alone or the two applied in combination. The lack of significance between products indicates that for this variety the addition of elemental sulfur did not increase grain protein. In contrast, grain test weight was significantly affected by one or more treatments at Oklee and Strathcona (Table 8). Differences between AMS and MES-15 were small but significant at Strathcona with an average difference of 0.5 lbs/bu. At Oklee, test weight was increased by 1.6 lbs per bushel when no- versus 25 lbs of S was applied as MES-15 in the spring. No clear relationship could be found between grain yield, protein, and test weight.

First Year Summary

Over the sites studied there was no clear evidence that spring wheat yields or grain protein concentration was increased by pre-seeding, in-season, or split application of sulfur. These sites were selected to represent two traditional and one non-traditional location thought to respond to sulfur. It is likely that soil organic matter contents at these sites were high enough to supply all the sulfur needs of crops even though two locations were considered to be coarse textured soils. An additional year of data would be beneficial to determine how this year's climate may have affected results. Further analysis of plant sulfur concentration at soft dough and grain sulfur content is currently being conducted and results will be available at a later time.

Related Research

This project is one of five projects currently being conducted by researchers at the University of Minnesota related to sulfur management. Three projects relate to sulfur management in corn production in Minnesota and include sulfur rate studies for corn in Northwest Minnesota, sulfur management in corn grown in reduced tillage systems, and zinc and sulfur management in corn in southern Minnesota. Another trial is currently underway looking at management of sulfur through starter fertilizers applied in corn and soybeans, and field scale management and variation to sulfur fertilizer. Past projects looking at rates and sulfur fertilizers applied to spring wheat, but did not integrate all of the components of the current study. The long-term goal of this work is to take the current studies and combine them with past research to update some of our current extension publications to provide producers with the most current and up-to-date information to make the best management decisions for their operations.

Recommended Future Research

The outlook for future research on sulfur is not clear based on the results found in this and other studies. Application to coarse textured soils still clearly shows the greatest probability of response to sulfur fertilization. Based on visual deficiencies this season a location in southern Minnesota will be targeted on a field on an eroded side hill with low organic matter. These fields have been increasingly reported to be deficient in sulfur and some generalizations from other research projects this year have hinted to the possibility of sulfur being deficient in these locations.

Appendix

Table 1. Initial Soil Series Information								
	0-6" Soil Test Data +				Extractable Sulfur ++			
Location	P	K	pH	OM	0-6"	6-12"	12-24"	ave
	----ppm----			-----%----	------------------*ppm*--------------------------			
Oklee	10	124	8.1	4.0	8	8	12	10
Perley	12	332	7.3	6.7	8	17	19	16
Strathcona	18	140	8.0	3.6	17	na	na	na

+ P. Olsen phosphorus; K, ammonium acetate potassium; pH, soil pH; OM, Organic matter.
++ Extractable sulfur from selected depth increments and " average (avg.)

Table 2. Treatment effects on above ground plant dry biomass at tillering						
		Application Rate				
						Overall
Location	**Product**	**0**	**12.5**	**25**	**37.5**	**avg.**
		--tons ac^{-1}--				
Oklee	AMS	1.14	1.10	1.02	1.20	1.12
	MES15	1.31	1.14	1.19	1.09	1.18
	avg	1.23	1.12	1.11	1.15	1.15
	--	--	--	--	--	--
Perley	AMS	0.45	0.40	0.46	0.41	0.43
	MES15	0.47	0.43	0.44	0.45	0.45
	avg.	0.46	0.41	0.45	0.43	0.44
	--	--	--	--	--	--
Strathcona	AMS	0.96	0.98	0.90	0.86	0.92
	MES15	0.84	0.84	0.95	0.94	0.89
	avg.	0.90	0.91	0.93	0.90	0.91

Table 3. Treatment effects on plant sulfur concentration at tillering						
		Application Rate				
						Overall
Location	**Product**	**0**	**12.5**	**25**	**37.5**	**avg.**
		----------------------------%--------------------------------				
Oklee	AMS	0.37	0.34	0.34	0.32	0.34
	MES15	0.33	0.31	0.33	0.29	0.32
	avg.	0.35	0.32	0.33	0.31	0.33
	--	--	--	--	--	--
Perley	AMS	0.37	0.38	0.34	0.38	0.37
	MES15	0.36	0.38	0.37	0.36	0.37
	avg.	0.37	0.38	0.36	0.37	0.37
	--	--	--	--	--	--
Strathcona	AMS	0.40	0.39	0.37	0.40	0.39
	MES15	0.40	0.38	0.39	0.39	0.39
	avg.	0.40	0.38	0.38	0.40	0.39

Table 4. Treatment effects on sulfur uptake at tillering						
		Application Rate				
						Overall
Location	**Product**	**0**	**12.5**	**25**	**37.5**	**avg.**
		----------------------------pounds ac^{-1}--------------------------------				
Oklee	AMS	8.4	7.4	6.8	7.8	7.6
	MES15	8.7	7.1	7.8	7.7	7.8
	avg.	8.6	7.3	7.3	7.8	7.7
	--	--	--	--	--	--
Perley	AMS	3.3	3.0	3.2	3.1	3.2
	MES15	3.3	3.3	3.3	3.2	3.2
	avg.	3.3	3.1	3.2	3.1	3.2
	--	--	--	--	--	--
Strathcona	AMS	7.3	7.5	6.5	6.9	7.1
	MES15	6.8	6.3	7.3	7.4	6.9
	avg.	7.2	6.9	6.9	7.1	7.0

Table 5. Treatment effects on above ground plant dry biomass at soft dough										
		Fertilizer Source and Tillering Sulfur Application Rate								
		AMS				MES15				
Location	Spring S Rate	0	12.5	25	avg.	0	12.5	25	avg	Overall avg
	-lbs ac^{-1}-	--tons ac^{-1}----------------------------------								
Oklee	0	5.22	5.10	4.50	4.94	4.88	4.90	4.80	4.86	4.90
	12.5	4.77	4.89	5.42	5.03	4.67	5.17	5.42	5.09	5.06
	25	4.48	5.14	4.96	4.86	4.56	4.36	5.30	4.74	4.80
	37.5	4.45	5.19	5.88	5.17	5.55	4.70	4.71	4.99	5.08
	avg.	4.73	5.08	5.19	5.00	4.92	4.78	5.06	4.92	4.96
		--	--	--	--	--	--	--	--	--
Perley	0	5.80	5.31	5.07	5.39	4.43	5.02	4.96	4.80	5.10
	12.5	5.02	5.25	5.64	5.30	5.90	5.01	4.97	5.29	5.30
	25	5.48	5.75	5.22	5.48	5.50	4.47	4.87	4.95	5.21
	37.5	4.65	5.56	4.57	4.93	4.52	3.64	6.02	4.73	4.83
	avg.	5.24	5.47	5.12	5.28	5.09	4.53	5.20	4.94	5.11
		--	--	--	--	--	--	--	--	--
Strathcona	0	3.99	3.86	3.43	3.76	4.01	4.33	4.90	4.41	4.08
	12.5	4.06	3.83	3.79	3.89	4.27	3.63	3.79	3.90	3.89
	25	4.65	3.55	4.04	4.08	4.12	4.30	4.01	4.14	4.11
	37.5	4.01	4.84	4.27	4.37	3.81	3.72	4.25	3.93	4.15
	avg.	4.18	4.02	3.88	4.03	4.05	3.99	4.24	4.09	4.06

Table 6. Treatment effects on wheat yield

		Fertilizer Source and Tillering Sulfur Application Rate								
		AMS				MES15				
Location	Spring S Rate	0	12.5	25	avg.	0	12.5	25	avg	Overall avg
	-lbs ac^{-1}-	bushels ac^{-1}								
Oklee	0	96.4	95.8	95.6	95.9	94.3	95.4	96.4	95.4	95.6
	12.5	97.2	96.3	92.3	95.3	93.7	93.7	96.9	94.8	95.0
	25	97.8	97.8	95.1	96.9	94.6	96.4	93.2	94.7	95.8
	37.5	94.9	95.3	95.9	95.4	93.7	97.2	96.8	95.9	95.6
	avg.	96.6	96.3	94.7	95.9	94.1	95.7	95.8	95.2	95.5
Perley	0	76.0	77.0	75.3	76.2	74.6	76.7	76.4	75.9	76.0
	12.5	73.5	71.0	75.4	73.5	72.5	74.0	76.7	74.4	74.0
	25	77.7	73.9	77.3	76.4	76.0	74.3	76.0	75.4	75.9
	37.5	72.8	72.8	74.3	73.2	70.3	76.9	76.0	74.8	74.0
	avg.	74.9	73.9	75.7	74.8	73.5	75.5	76.3	75.1	75.0
Strathcona	0	89.9	86.5	88.2	88.2	88.5	91.1	93.0	90.9	89.5
	12.5	86.4	89.6	83.5	86.5	90.1	89.4	87.0	88.8	87.7
	25	90.2	87.3	93.2	90.2	87.9	91.4	88.6	89.3	89.8
	37.5	90.2	90.5	88.4	89.7	95.6	98.4	87.3	93.8	91.7
	avg.	89.2	88.5	88.3	88.7	90.5	92.6	89.0	90.7	89.7

Table 7. Treatment effects on grain protein content

		Fertilizer Source and Tillering Sulfur Application Rate								
		AMS				MES15				
Location	Spring S Rate	0	12.5	25	avg.	0	12.5	25	avg	Overall avg
	-lbs ac^{-1}-	%								
Oklee	0	15.1	15.0	15.3	15.1	15.2	15.1	15.2	15.2	15.1
	12.5	15.2	15.0	15.1	15.1	15.3	15.1	15.1	15.2	15.1
	25	15.4	15.3	15.2	15.3	15.2	15.1	15.1	15.1	15.2
	37.5	15.0	15.2	15.2	15.1	15.1	15.1	14.9	15.0	15.1
	avg.	15.2	15.1	15.2	15.2	15.2	15.1	15.0	15.1	15.1
Perley	0	14.9	15.1	15.2	15.0	15.0	14.9	15.2	15.0	15.0
	12.5	15.1	15.0	15.1	15.1	14.8	15.0	15.2	15.0	15.0
	25	15.2	14.9	15.1	15.1	14.9	14.9	15.0	15.0	15.0
	37.5	15.0	15.0	15.2	15.1	14.8	14.9	14.9	14.9	15.0
	avg.	15.0	15.0	15.1	15.1	14.9	14.9	15.1	15.0	15.0
Strathcona	0	15.8	15.9	15.7	15.8	15.8	15.7	15.7	15.7	15.8
	12.5	15.7	15.6	15.8	15.7	15.7	15.8	15.7	15.7	15.7
	25	15.8	15.7	15.7	15.7	15.7	15.8	15.8	15.7	15.7
	37.5	15.7	15.8	15.5	15.6	15.4	15.4	15.5	15.4	15.5
	avg.	15.7	15.7	15.6	15.7	15.6	15.7	15.7	15.7	15.7

Table 8. Treatment effects on grain test weight									
		Fertilizer Source and Tillering Sulfur Application Rate							
		AMS				**MES15**			
Location	Spring S Rate	0	12.5	25	avg.	0	12.5	25	avg	Overall avg
	-lbs ac^{-1}-	--pounds bu -1------------------------------------								
Oklee	0	61.7	61.4	61.7	61.6	60.1	60.1	60.1	60.1	60.8
	12.5	60.8	61.1	61.5	61.1	61.3	60.4	60.4	60.7	60.9
	25	60.6	61.1	61.9	61.2	61.1	61.0	60.2	60.7	61.0
	37.5	60.4	61.1	60.7	60.8	61.9	61.2	62.0	61.7	61.2
	avg.	60.9	61.2	61.5	61.2	61.1	60.7	60.7	60.8	61.0
		--	--	--	--	--	--	--	--	--
Perley	0	59.4	59.6	59.8	59.6	59.5	60.4	59.7	59.9	59.7
	12.5	60.9	59.4	59.9	60.1	60.8	60.2	59.5	60.1	60.1
	25	60.4	61.1	60.5	60.7	60.1	60.4	59.8	60.1	60.4
	37.5	59.6	60.4	60.0	60.0	60.0	58.7	59.6	59.4	59.7
	avg.	60.0	60.1	60.1	60.0	60.1	59.9	59.7	59.9	60.0
		--	--	--	--	--	--	--	--	--
Strathcona	0	60.6	61.1	60.7	60.8	60.6	60.0	59.6	60.1	60.4
	12.5	61.2	61.3	61.1	61.2	60.6	59.6	60.2	60.1	60.7
	25	60.4	60.6	60.4	60.5	61.8	60.5	61.2	61.2	60.8
	37.5	60.8	60.3	60.0	60.4	60.1	59.5	59.6	59.7	60.0
	avg.	60.7	60.8	60.6	60.7	60.8	59.9	60.2	60.3	60.5

Determining Wheat Response to Tile Drainage in the Red River Valley

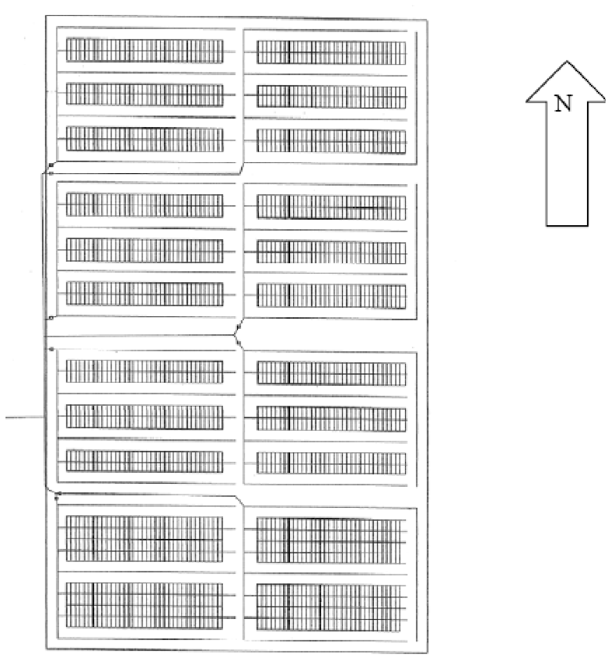
Hans Kandel, Department of Plant Sciences, NDSU

Research Question

The research will investigate the yield response of winter wheat and spring wheat grown under tiled and non-tiled conditions. In addition to measuring yield, crop plants will be evaluated for disease and other growth characteristics. Soil scientist will monitor water table, soil properties, and temperature between tiled and non-tiled experimental units.

Results

In the spring of 2008 permits where obtained to implement the tile drainage research. In July 2008 Tile was installed by Field Drainage, Inc. according to the plan.



Eight experimental units were created, each with a control structure. Tile lines are 25 feet apart and drain to a main ditch to the west. Winter Wheat was seeded in north south direction with a small plot planter. Plot size is 5 feet x 18 feet with 7 inch row spacing.

Table 1. Winter Wheat at NW 22, 2008

	Initial
	plant
Variety	stand
	(plt /a)
Jerry	985,733
Lyman	1,040,000
Hawken	1,080,000
Accipiter	938,793
LSD 0.05	106,340
Non drained	1,020,000
Drained	999,815
	NS

Application/Use

The research has just stared and yield observations will take place in 2009.

Econimic Benefit to a Typical 500 Acre Wheat Enterprise

Financial calculations will be made after research data is collected in 2009, 2010, and 2011.

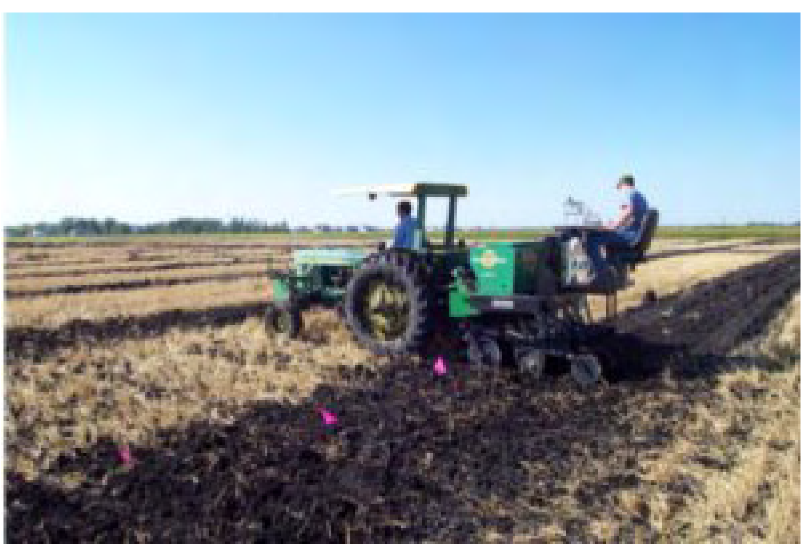
Publications

‘NDSU Starts Tile Drainage Research Project’ - http://www.ag.ndsu.edu/news/newsreleases/2008/aug-21-2008/ndsu-starts-tile-drainage-research-project and http://www.agnewsonline.com/TileDrainage.pdf

‘Searching for a middle ground’ - Drought in the west, excessive moisture in the east ... many farmers looking for relief, Whitney Pandil-Eaton.Staff Writer Minot Daily News. 10/26/2008. http://www.minotdailynews.com/page/content.detail/id/520398.html

Installing the main tile at the research site.

Control structure at research site



Seeding winter wheat fall 2008

Developing Leaf Spot Resistant HRSW Cultivars Adapted for W. Minnesota and E. North Dakota

Mohamed Mergoum, Department of Plant Sciences, NDSU

Research Question

(1) To transfer newly identified resistance to leaf spots including tan spot, Stagonospora nodorum blotch, and Septoria tritici blotch into hard red spring wheat germplasm.

(2) To develop cultivars with durable and multiple leaf spot resistance genes those are adapted to Western Minnesota and Eastern North Dakota.

Results

Previously, the Minnesota Wheat Research and Promotion Council funded a project entitled “Screening for Leaf Spots Resistance in Hard Red Spring Wheat” wherein elite lines were identified to be resistant to the leaf spotting disease complex comprising of tan spot (TS), Stagonospora nodorum blotch (SNB) and Septoria tritici blotch (STB). In the present project entitled “Developing leaf spot resistant hard red spring wheat cultivars adapted for western Minnesota and eastern North Dakota”. The novelty of the resistance genes present in these resistant sources was determined in the first studies through genetic and molecular studies. Subsequently efforts are being made to transfer the leaf spotting resistance into genetic material adapted to the western Minnesota and eastern North Dakota wheat growing regions.

The results from our previous studies revealed that ND 735 (Mergoum et al. 2006) possesses major genes for resistance to multiple races of Pyrenophora tritici-repentis (TS) and Phaeosphaeria nodorum (SNB) (Singh et al. unpublished). Genetic and mapping results confirm that culture filtrate can be used a surrogate to spore inoculation to races/pathogens tested and identification of user friendly markers closely linked to the resistance genes further enhances the potential of marker assisted selection for leaf spot resistance breeding. Presently, a M.S. student is dissecting the genetics of resistance to STB in the population Steele-ND/ND735 and promising results are expected.

The resistant cultivar Oklee and breeding lines MN03291 and ND 735 are adapted to the Northern Great Plains of North America and are resistant to TS, SNB, and STB (Mergoum et al. 2007; Mergoum et al. 2006). Additionally, genotypes 92MREHTR28B, CIMMYT L no. 18, Intros no. 7, Salamouni, and 2000 Spelt no. 20 were found to be resistant to the three leaf spot diseases tested. These resistant sources also come from a diverse genetic background and potentially possess different genes for resistance to leaf spotting diseases. Unfortunately, these sources are not well adapted to the Northern Plains region where spring wheat is grown. Although, the incorporation of resistance from these sources will require several breeding cycles, the use of these sources will result in cultivars with broad, effective, and durable resistance to leaf spot diseases.

Since 2007, the adapted resistant sources (Oklee, MN03291, and ND735) have been hybridized with other adapted wheat cultivars in order to develop breeding populations. The F1 and F2 generations and advance population of these crosses are being developed and evaluated for agronomic and disease resistance in the wheat breeding programs at NDSU, Fargo in order to develop tan spot resistant cultivars. Additionally, to broaden the genetic base of resistance to tan spot, the resistance from ‘un-adapted’ lines; Intros # 7, 2000 Spelt # 20, 92

MREHTR28B, and CIMMYT L # 18, is also being introgressed into the locally adapted germplasm. These un-adapted resistant sources were crossed with locally adapted high yielding germplasm and backcross population of these crosses are being developed, and will be advanced and evaluated for agronomic traits and leaf disease resistances in the wheat breeding programs at NDSU, Fargo in order to develop tan spot resistant cultivars.

Application/Use

The information on the genetics of resistance for leaf spots in spring wheat and the resistant germplasm developed is providing vital information/resources to breeders in developing resistant varieties. The identification of resistant lines/genotypes possessing novel resistance genes and its use in development of broad genetic base resistant wheat cultivars with high quality and agronomic characteristics is necessary to efficiently and economically manage leaf spots diseases, thus minimizing losses in grain yield and quality which will improve the economic return of wheat producers in the spring wheat region in general, and in MN and ND, in particular. These superior cultivars, in conjunction with crop rotation, will provide an effective and environmentally safe means of controlling leaf spotting diseases. With durable and broad base resistant varieties the use of fungicides, a practice not often environmentally safe and cost effective, would not be necessary. Improved control of leaf spots with resistant varieties should minimize losses in grains yield and quality thereby increasing opportunities for local value-added processing.

Materials and Methods

To transfer the leaf spotting resistances into germplasms adapted to the Western Minnesota and Eastern North Dakota, the resistant genotypes were selected based on the reaction of genotypes to different races/pathogens of leaf spotting diseases tested under greenhouse condition (Singh et al. 2006; Mergoum et al. 2006, 2007). Hybridization and development of breeding population is being carried in greenhouse/field since 2007. Backcross populations are developed to introgress resistance from the 'unadapted resistant sources'. A pedigree and backcross selection methods are being used in greenhouse and field to develop germplasm which may lead ultimately to cultivars resistant to tan spot. The adapted resistant sources which include Oklee, MN03291, and ND735, have been hybridized heavily with other adapted wheat cultivars in order to develop breeding populations. Presently, advance populations of these crosses are being evaluated for agronomic and disease resistance in the wheat breeding programs at NDSU, Fargo in order to develop tan spot resistant cultivars. Additionally, to incorporate novel resistance to leaf spotting diseases the resistance from lines; Intros # 7, 2000 Spelt # 20, 92 MREHTR28B, and CIMMYT L # 18, is also being introgressed into the locally adapted germplasm. These un-adapted resistant sources were crossed with locally adapted high yielding germplasm and backcross population of these crosses are being developed, advanced, and evaluated for agronomic and disease resistance in the wheat breeding programs at NDSU, Fargo in order to develop tan spot resistant cultivars.

Eronomic Benefit to a Typical 500 Acre Wheat Enterprise

Leaf spots on average cause yield losses from 10-15% and cause loss in grain quality by grain shriveling, dark smudge, and black point. Previous genetic studies indicate a narrow genetic base of resistance to tan spot (Anderson et al., 1999; Singh and Hughes, 2005). Development of new resistant common wheat varieties, in conjunction with crop rotation, will provide an effective and environmentally safe means of controlling leaf spots. Information and the germplasm developed from this study is used by the plant breeders in development of durable resistant varieties. This will minimize the losses due to leaf spot and improve the economic efficiency of wheat production. The genetic studies identified novel genes for resistance that are being utilized in broadening the genetic base of resistance in commercial varieties and thus reduce the possibility of existing resistance genes breaking down. Improved control of leaf spot with resistant varieties should minimize losses in grains yield and quality thereby increasing opportunities for local value-added processing.

Related Research

Previous studies have involved screening for new sources of resistance to tan spot of wheat in greenhouse or field evaluations (Mergoum et al. 2007, Singh et al. 2006, Riede et al., 1996), inheritance of resistance (Anderson et al., 1999, Gamba and Lamari, 1998; Gamba et al., 1998, Singh and Hughes 2005) and race structure of the pathogens (Ali and Francl, 2003; Singh et al. 2007). Significant efforts have been made in identifying molecular markers for the resistance genes (Faris et al., 1997; Friesen and Faris, 2004, Singh et al. 2006) and in molecular biology of host-pathogen interaction (Ciuffetti and Tuori, 1999; Strelkov and Lamari, 2003).

Recent studies conducted by our research group have identified resistant sources to leaf spotting disease after evaluating 126 advanced breeding lines developed for the northern Great Plains of USA (Mergoum et al. 2007; Singh et al. 2006). The resistance of these adapted sources will be transferred to other cultivars in order to develop superior varieties.

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Recommended Future Research

1) Dissecting the genetics of resistance to STB in the population Steele-ND/ND735
2) Additional molecular work is required to identify flanking molecular markers closely linked to the resistance genes identified for leaf spotting disease in population Steele-ND/ND735.
3) Development of additional crosses and backcrosses with the an objective of developing adapted cultivars for Western MN and Eastern ND.
4) Development and evaluation of advanced resistant material for agronomic and quality traits as a part of varietal development program.

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Identifying High HRSW Cultivars with High Yield Potential to Meet Special End-uses

Mohamed Mergoum, Department of Plant Sciences, NDSU

Research Objectives

1) To evaluate and identify elite HRSW lines with high yield potential
2) To initiate breeding efforts to select high yielding cultivars by screening HRSW germplasm based on yield potential at early breeding stages.

Introduction

There has been no specific research to look at the longer term advancement yield potential in the HRSW breeding program. The yield data currently available reflects the overall performance of these cultivars, including the quality and environmental effects. Elsewhere, yield potential research on varieties developed in Mexico for an irrigated environment found that breeders had achieved gains in yield potential of about 1.1% per year during the period 1950 to 1982 with little evidence that yield potential had reached a plateau (Waddington et al., 1986). Improvements in grain yield were associated with increases in grain number per unit area and grains per spike, but not in kernel weight. Biomass increases and greater grain survival were the main factors contributing to increased yield in the most recently released cultivars of those evaluated in this study.

Periodic evaluation of genetic improvement in hard red spring wheat is essential for understanding yield-limiting factors for major economic traits, illustrating the importance of plant breeding to stakeholders and the public, and identifying traits or target environments that might require additional research (Cox et al., 1988). Evaluation of wheat germplasm for a given traits such as yield potential is necessary to allow us to detect genetic variation in traits associated with advances in crop productivity. Determining where genetic gain has been made or lacking in the past can lead researchers to new strategies for future improvements in crop productivity (Donmez et al., 2001). In 2006, an initiative was launched by the HRSW wheat breeding programs in the spring wheat area (MN, SD, and ND) with the support of the Minnesota Wheat Research and Promotion Council to identify high yielding HRSW elite lines among existing wheat germplasm. The results from 2007 and preliminary data from 2008 trials are promising. Many wheat lines which yielded significantly higher than commonly grown cultivars could be identified among the NDSU, SDSU, and the U of MN wheat germplasm.

Results

Part 1: Field evaluation and identification of elite HRSW lines with high yield potential: 2007 and 2008

The 2008 data are still being collected and analyzed. So far, agronomic data from two locations, Prosper and Grand Forks only, have been analyzed and are reported in this report in Tables 1 and 2 (Appendix). We will still have to do quality analysis on these samples from the two locations.

In 2008, the climatic conditions were erratic across ND. While dry conditions prevailed in the Western parts of ND, leading to one of the worst harvest in small grains crops; the high rainfall in the Eastern parts have resulted in general, in record yields. Excess of rain in some parts of the Eastern parts has also caused many problems such as difficulties to access the fields and harvest wheat on time. This was the case of our trial at Grand Forks location. The preliminary data shows that grain yield potentials were in general high, particularly at Prosper (Table 1) and Carrington (data not reported) given the relatively good conditions that prevailed in The Eastern parts of ND and in Western MN. However, the yield at Grand Forks (Table 2) were relatively, low since harvest was done very late (due to wet conditions) causing yield losses due to many factors including lodging, shattering,…etc.

At Prosper, the yields in general were relatively, average compared to the yield obtained by the growers in the region and given the good conditions that prevailed in these parts of the Sate. However, compared to 2007, the 2008 yields were high. The average yield score varied between a high of 83.1 bu/ac registered by the SDSU line SD3623 and a low of 26.7 bu/ac scored by MN03075, a line from the U of MN program. The average yield trial was 61.5 bu/ac compared to 43.2 bu/ac of 2007. Many lines showed high yields levels and did not differ significantly from SD3623. Among these lines, we can emphasize particularly, SD4059 (82.4 bu/ac) from the SDSU breeding program, ND05-14-323(75.7 bu/ac) and ND05-13-64 (74.2 bu/ac) lines from NDSU HRSW breeding program. The ND 805 NDSU HRSW line released as Faller was also among the high yielding genotypes with 70.8 bu/ac. Faller is becoming a very popular wheat cultivar in the the Eastern ND and Western MN region. The performance of Faller in 2008 has confirmed its high yield obtained in 2007 50.8 bu/ac) compared to the highest yielding cultivar Knudson (54.4 bu/ac).

At the Grand Forks trial, the growing conditions were excellent in general. However, excess rains at maturity and harvest time have delayed harvest causing severe damage to the crop and yield were relatively low. They ranged from 59.2 to 39.2 bu/ac scored on the NDSU durum cultivar Grenora and the Trigen line 05MSP6, respectively. The highest yielding spring wheat cultivar was ND 805 (Faller) from NDSU with 57.7 bu/ac. In 2007, Grenora yield (54.5 bu/ac) was relatively similar to 2008, except that it was the lowest cultivar in the trial. This shows the high yielding HRSW cultivars suffered severe yield losses (caused by lodging and shattering) while Grenora did not. Other genotypes that showed high yielding performance included Trical 118 (53.9 bu/ac), a triticale line from Great Lakes followed by Hyland cultivar Hoffman with similar yield and the MN line MN03148-3 (53.0 bu/ac).

The data from Carrington, where irrigation was available to supplement the normal rainfall, are not reported in this report since they were not available when this report was elaborated.

Test weights were very variable as in the case of yield. While test weights registered at Prosper were in the normal range with an average of 59.5 lb/bu, at Grand Forks, they were relatively low, in general, with an average of 58 lb/bu. At both locations, as excepted Glenn registered the highest test weight with 61.6 and 63.6 lb/bu at Grand Forks and Prosper, respectively. At Grand Forks, test weight of all genotypes - except Glenn, ND05-13-64 and Trooper (60.4 lb/bu)- were lower than 60lb/bu.

Part 2. Breeding high yielding spring wheat cultivars

The long term objective of our breeding program supported by this project is to develop high yielding cultivars. This can achieved by emphasizing crosses involving high yielding genotypes in order to incorporate or pyramid genes for high yield. Grain yield is one of the –if not the – most genetically complex traits that breeders have to face. In addition to its genetic complexity, it is very much influenced by other genetic traits such as biotic and abiotic stresses, environmental factors including the climatic conditions, soil type, and most importantly, the interactions between grain yield and these factors.

Starting in spring 2007 and continuing in 2008, many crosses involving the highest yielding cultivars such as Faller, Knudson, Traverse and many of our NDSU elite lines and lines from SDSU and MN have been accomplished. The F1 generation of these crosses are usually, grown in the greenhouse in the Fall or Spring. The following segregating generations (F2 populations, F3, F4, F5,… families) will be grown in the in the field here in ND in summer, or advanced in winter nurseries conducted at Arizona or New Zealand.. Selection in the segregation generations will be based on the phenotypic appearances of the plant such as vigor, height, lodging, and diseases reactions. By using winter nurseries, we hope to start doing early generation testing for yield in the summer of 2010.

Application/Use

Our success as breeding programs rely on the information on the performances of the elite wheat and cultivars and germplasm in our region. Future gains in genetic is crucial for the future breeding activities on grain yield. The genetic variability for grain yield in our elite adapted wheat germplasm will provide vital information/resources to the breeders in the spring wheat region to develop high yielding wheat cultivars adapted to ND and MN, in particular. This ongoing project will determine the potential wheat cultivars possessing high yields or potential adapted parent that will be used in the development of high yielding spring wheat varieties. Consequently, this will provide improvements in the economy of the wheat growers and industry.

Materials and Methods

The experiments were conducted in 2007 and 2008 at the Carrington Research Center where irrigation is available; and Prosper and Grand Forks, two ND eastern locations where high rainfall usually prevails. Approximately 40 genotypes developed by the NDSU, SDSU, the U of MN, and other breeding programs in the region were evaluated. The experiment was laid out in a randomized complete bloc design (RCBD) with four replicates. The plots size was 6 rows 30 cm apart and 5 m long, similar to our elite and advanced yield trials. In order to allow these genotypes to express their yield potential, prior to seeding, fertilizer were applied. An additional amount of N will be applied during tillering based on crop requirements to achieve maximum yields. At Carrington, the experiment was irrigated when there is 30% depletion of the available moisture from the top 60 cm of the soil. A full weed and some disease and insect control program was employed so that no known manageable factor will constrain yield. Yield, yield components, and other agronomic and quality traits were measured.

Economic Benefit to a Typical 500 Acre Wheat Enterprise

Highly productive cultivars with resistance to the main pests in the region, in conjunction with adequate fertilization and crop rotation, will provide an effective and environmentally sound way to increase the farmers' income in MN and ND and will also benefit the wheat industry and end-users in general. With recent favorable prices for wheat worldwide, if maintained, the grain yield will certainly become the driving force in the breeding programs. We have seen in2008 crop season, that high yielding wheat cultivars such as Faller is well accepted by growers. Demand for Faller seed is growing substantially. By focusing on grain yield, the MNRPC has shown that its vision to the future of wheat industry was on the right path as the competition for the grain product between the traditional end-users and the 'new' end users such as 'Bio-fuel' sector is just in the beginning. Therefore, developing high yielding cultivars in wheat will be paramount for our spring wheat growers.

Related Research

The yield data currently available reflects the overall performance of these cultivars, including the quality and environmental effects. In our recent studies in ND, data shows, that genetic progress has been made in many agronomic traits, including grain yield in NDSU HRSW germplasm since 1986 (Underdahl et al., 2007). Most importantly, the progress in grain yield was made while maintaining high quality standards and increasing resistance into newly released NDSU HRSW cultivars. Elsewhere, yield potential research on varieties developed in Mexico for an irrigated environment found that breeders had achieved gains in yield potential of about 1.1% per year during the period 1950 to 1982 with little evidence that yield potential had reached a plateau (Waddington et al., 1986). Improvements in grain yield were associated with increases in grain number per unit area and grains per spike, but not in kernel weight. Biomass increases and greater grain survival were the main factors contributing to increased yield in the most recently released cultivars of those evaluated in this study. Periodic evaluation of genetic improvement in hard red spring wheat is essential for understanding yield-limiting factors for major economic traits, illustrating the importance of plant breeding to stakeholders and the public, and identifying traits or target environments that might require additional research (Cox et al., 1988). Evaluation of wheat germplasm for given traits, such as yield potential, is necessary to allow us to detect genetic variation in traits associated with advances in crop productivity. Determining where genetic gain has been made or lacking in the past can lead researchers to new strategies for future improvements in crop productivity (Donmez et al., 2001). Since 2006, the initiative launched by the HRSW wheat breeding programs in the spring wheat area (MN, SD, and ND) with the support of the MN Wheat Research and Promotion Council to identify high yielding HRSW elite lines among existing wheat germplasm is bearing fruits. Results from 2007 and 2008 trials are promising. Wheat lines which yielded significantly higher than commonly grown cultivars could be identified among the NDSU, SDSU, and the MN wheat germplasm.

Recommended Future Research

1. Development of additional genetic population and advance of the existing population.
2. Screening of the segregating population in order to determine the genetics progress in grain yield
3. Evaluation of advanced material as a part of varietal development program.

Regional Linkages to Other Research Activities: This is rather a regional research activity that may lead to further collaboration and strengthen the strong ties between the breeding programs in the region. This research initiative is credited to the Minnesota Wheat Research and Promotion Council (MNWRPC) group who launched this effort in 2006. The venture included the states of MN, SD, and ND HRSW, and other major breeding programs in the region. This initiative has allowed our breeding programs to emphasize yield as the main driving force to release cultivars.

Additional Sources of Funding: Obviously, this is a relatively long term goal and will require constant funding. This project is just a small component of the Spring Wheat Breeding Program, Dep. of Plant Sciences, NDSU, Fargo. It is well understood that developing cultivars is a long term objective and requires substantial infrastructure, financial, and human resources. These assets are available and are being provided by the HRSW breeding program with the objective to develop high yielding wheat cultivars that meet ND and MN wheat growers. Continuous funds from all the parties concerned such as the MNRPC will be needed and requested in the future.

Appendix

Table 1. Means of yield and agronomic traits of wheat and triticale entries included in 2007 yield potential grown in Grand Forks, ND in 2008.

Entry	Name	Institution	DH	Height	TW	Yield
1	Glenn*	NDSU	56.0	30.7	61.6	46.0
2	ND 803	NDSU	56.0	31.7	59.1	50.2
3	ND 805	NDSU	57.0	28.7	59.2	57.7
4	ND05-13-119	NDSU	57.0	29.3	59.1	52.8
5	ND05-13-129	NDSU	56.0	30.0	59.1	48.6
6	ND05-13-145	NDSU	59.0	31.3	59.5	51.2
7	ND05-13-28	NDSU	57.3	31.0	59.0	44.9
8	ND05-13-64	NDSU	56.0	30.3	60.4	45.9
9	ND05-14-323	NDSU	57.3	29.7	59.1	51.6
10	ND06-13-46	NDSU	61.3	31.7	58.0	50.5
11	ND06-14-205	NDSU	56.0	30.7	58.2	44.7
12	ND06-14-243	NDSU	59.7	33.0	58.1	46.5
13	ND06-14-279	NDSU	56.0	29.7	59.8	51.8
14	SD3623	SDSU	56.0	32.7	58.2	49.9
15	SD3868	SDSU	56.0	32.7	54.3	49.3
16	SD3870	SDSU	56.0	31.0	54.1	51.7
17	SD4023	SDSU	58.7	27.7	59.2	51.1
18	SD4029	SDSU	56.0	29.3	57.7	48.7
19	SD4037	SDSU	58.7	25.3	57.3	46.7
20	SD4059	SDSU	56.0	28.3	56.9	40.6
21	SD4073	SDSU	58.0	30.7	57.6	51.3
22	MN03075	UMN	57.3	26.3	56.8	51.6
23	MN03098	UMN	58.0	29.0	59.3	49.6
24	MN03018	UMN	59.0	28.0	57.0	51.2
25	MN03244	UMN	56.0	30.0	58.1	45.3
26	MN03148-3	UMN	57.0	30.3	59.1	53.0
27	MN05084	UMN	56.3	28.3	56.4	48.0
28	MN05209	UMN	56.7	28.7	57.8	49.9
29	MN06113	UMN	57.3	25.3	58.3	50.7
30	HY 977-B	AGRIPRO	58.3	28.0	54.3	46.3
31	01S0202-2S	AGRIPRO	57.3	24.3	56.2	49.9
32	Knudson*	AGRIPRO	56.0	27.0	57.7	49.1
33	Trooper*	WESTBRED	63.0	26.0	60.4	46.5
34	Granite*	WESTBRED	56.0	25.3	59.9	50.7
35	Banton*	TRIGEN	56.0	27.7	59.8	48.4
36	05MSP6	TRIGEN	56.0	25.0	57.7	39.2
37	Trical 118	GREAT LAKES	57.0	26.0	51.5	55.9
38	Hoffman	HYLAND	62.3	33.7	58.4	53.9
39	Mountrail	NDSU	63.7	28.3	56.8	50.4
40	Grenora	NDSU	63.3	28.7	56.9	59.2
Maximum			63.7	33.7	61.6	59.2
Minimum			56	24.3	51.5	39.2
Mean			57.7	29	58	49.5
CV			2.5	4.78	1.21	12.84
LSD			2.35	2.26	1.14	10.33

Table 2. Means of yield and agronomic traits of wheat and triticale entries included in 2007 yield potential grown in Prosper, ND in 2008.

Entry	Name	Institution	DH	Height	TW	Yield
1	Glenn*	NDSU	57.0	36.0	63.6	53.9
2	ND 803	NDSU	57.0	34.3	59.7	54.0
3	ND 805	NDSU	59.7	35.0	61.0	70.8
4	ND05-13-119	NDSU	59.7	34.7	60.2	71.0
5	ND05-13-129	NDSU	57.7	36.0	61.3	55.4
6	ND05-13-145	NDSU	59.0	35.3	61.2	59.5
7	ND05-13-28	NDSU	59.0	38.0	59.9	56.3
8	ND05-13-64	NDSU	57.0	37.0	62.6	74.2
9	ND05-14-323	NDSU	59.3	34.3	62.3	75.7
10	ND06-13-46	NDSU	61.0	38.3	58.4	50.3
11	ND06-14-205	NDSU	57.3	36.7	61.3	55.0
12	ND06-14-243	NDSU	60.0	36.7	58.9	60.0
13	ND06-14-279	NDSU	57.3	37.0	63.6	68.2
14	SD3623	SDSU	56.3	40.3	61.6	83.1
15	SD3868	SDSU	57.3	39.3	59.6	65.6
16	SD3870	SDSU	57.7	39.0	59.7	72.3
17	SD4023	SDSU	59.3	32.7	61.3	52.7
18	SD4029	SDSU	57.7	35.3	56.3	69.1
19	SD4037	SDSU	56.3	29.3	56.3	63.8
20	SD4059	SDSU	57.0	37.0	61.8	82.4
21	SD4073	SDSU	58.7	36.7	57.7	60.6
22	MN03075	UMN	59.7	34.3	55.9	36.7
23	MN03098	UMN	57.7	33.3	60.3	69.3
24	MN03018	UMN	60.3	34.7	57.9	64.2
25	MN03244	UMN	57.3	34.3	61.4	70.7
26	MN03148-3	UMN	58.0	35.0	60.2	64.6
27	MN05084	UMN	59.3	35.3	59.3	66.4
28	MN05209	UMN	59.0	34.0	60.3	57.9
29	MN06113	UMN	57.3	31.7	59.5	67.6
30	HY 977-B	AGRIPRO	59.3	36.0	54.0	50.1
31	01S0202-2S	AGRIPRO	57.0	29.0	59.0	68.9
32	Knudson*	AGRIPRO	59.7	32.7	59.7	52.4
33	Trooper*	WESTBRED	61.0	32.7	61.4	63.7
34	Granite*	WESTBRED	57.7	29.7	57.5	39.8
35	Banton*	TRIGEN	58.0	34.7	61.5	64.4
36	05MSP6	TRIGEN	57.0	31.0	58.1	54.4
37	Trical 118	GREAT LAKES	57.0	29.0	51.6	40.9
38	Hoffman	HYLAND	64.0	44.3	57.4	60.3
39	Mountrail	NDSU	62.0	37.7	58.2	55.4
40	Grenora	NDSU	61.3	34.7	59.0	57.1
	Maximum		64	44.3	63.6	83.1
	Minimum		56.3	29	51.6	36.7
	Mean		58.6	35.1	59.5	61.5
	CV		1.19	3.67	2.14	14.7
	LSD		1.13	2.09	2.07	14.69

Isolating a Fusarium Head Blight Resistance Gene

Gary J. Muehlbauer, Department of Agronomy and Plant Genetics, U of M

Research Question

Fusarium head blight (FHB) is a major disease problem for Minnesota wheat growers. There are few genes that exhibit resistance to FHB. One major gene (Fhb1), located on chromosome 3BS, exhibits partial resistance to FHB. Fhb1 has been incorporated into breeding programs and resulted in new varieties with improved resistance. However, the new varieties are still susceptible during a severe FHB epidemic. Unfortunately, the Fhb1 gene that underlies resistance has not been isolated. The objective of this proposal is to identify candidate genes for Fhb1. We will use high-throughput sequencing technologies coupled with specialized genetic stocks to identify candidate genes for Fhb1.

Results

We have conducted sequencing of genetic stocks carrying either the resistance allele or susceptible allele at the Fhb1 locus. We have obtained approximately 140,000 sequences from each genotype. Currently, we are analyzing these sequences. In addition, we are working toward obtaining 300,000 sequences from each genotype.

Application/Use

(Our goal is to identify candidate genes for Fhb1. Identifying the gene will provide the perfect marker for breeding FHB resistance genotypes, and the ideal candidate for developing transgenic plants carrying FHB resistance.

Materials and Methods

We used specialized wheat genetic stocks developed in Jim Anderson's lab. These stocks carry either the resistance of suceptible allele at the Fhb1 locus. We inoculated spikes of both genotypes with Fusarium graminearum, isolated RNA and prepared a library for each genotype of the expressed genes for both genotypes. We used next generation sequencing technologies and sequenced approximately 140,000 genes from both genotypes. Currently, we are using bioinformatics approaches to identify potential candidates for the Fhb1 gene.

Econimic Benefit to a Typical 500 Acre Wheat Enterprise

Fusarium head blight is a major disease problem in the wheat growing regions of Minnesota. Yield and quality losses due to this disease can be devastating. Prophylactic fungicide treatments can cost $15/acre. In addition, in severe FHB disease years the crop is not worth harvesting. Therefore, the economic benefits to this research are large.

Related Research

We are using genomics to identify genes and mechanisms involved in FHB resistance. We are using Affymetrix GeneChips for barley, wheat and Fusarium graminearum. These GeneChips provide the opportunity to examine the expression of thousands of genes in a single experiment. We have identified wheat, barley and F. graminearum genes that are expressed during the wheat-F. graminearum (Jia et al., submitted manuscript) and barley-F. graminearum interactions (Boddu et al., 2006; 2007; Guldener et al., 2006). We have developed models for the interaction between wheat/barley and F. graminearum. Recently, we have identified genes that have the potential to provide resistance in transgenic plants.

We have developed transgenic wheat carrying a variety of antifungal protein genes. These plants exhibit a reduction in FHB severity in the greenhouse and field (Mackintosh et al., 2007; Shin et al., 2008). In addition, we have begun to develop transgenic plants carrying genes that have been identified in the genomics studies described above.

Recommended Future Research

We will continue to develop and test transgenic wheat carrying an array of genes with the potential to enhance resistance to FHB. We have an active gene discovery program with the goal of identifying novel genes that have the potential to provide resistance to FHB. The sequencing effort associated with this funding is one of our gene discovery efforts. As these genes are identified, we will incorporate them into our wheat transformation program and test the effects of these genes in transgenic plants.

Appendix

Recent publications related to project:

Boddu, J., S. Cho, W.M. Kruger and G.J. Muehlbauer. 2006. Transcriptome analysis of the barley-Fusarium graminearum interaction. Mol. Plant-Microbe Interact. 19:407-417.

Güldener, U., K. Seong, J. Boddu, S. Cho, F. Trail, J-R. Xu, G. Adam, H-W. Mewes, G.J. Muehlbauer and H.C. Kistler. 2006. Development of a Fusarium graminearum Affymetrix GeneChip for profiling fungal gene expression in vitro and in planta. Fungal Genet. Biol. 43:316-325.

Cuomo, C.A., et al., 2007. The Fusarium graminearum genome reveals a link between localized polymorphism and pathogen specialization. Science 317:1400-1402.

Chang, Y-L., S. Cho, H.C. Kistler, H-C. Sheng and G.J. Muehlbauer. 2007. Bacterial artificial chromosome-based physical map of Gibberella zeae (Fusarium graminearum). Genome 50:954-962.

Boddu, J., S. Cho and G.J. Muehlbauer. 2007. Transcriptome analysis of trichothecene- induced gene expression in barley. Mol. Plant-Microbe Interact. 20:1364-1375.

Mackintosh, C.A., J. Lewis, L.E. Radmer, S. Shin, S.J. Heinen, L.A. Smith, M.N. Wyckoff, R. Dill-Macky, C.K. Evans, S. Kravchenko, G.D. Baldridge, R.J. Zeyen and G.J. Muehlbauer. 2007. Overexpression of defense response genes enhances the resistance of wheat to Fusarium Head Blight. Plant Cell Rep. 26:479-488.

Shin, S., C.A. Mackintosh, J. Lewis, S.J. Heinen, L. Radmer, R. Dill-Macky, G.D. Baldridge, R.J. Zeyen and G.J. Muehlbauer. 2008. Transgenic wheat expressing a barley class II chitinase gene has enhanced resistance to Fusarium Head Blight. J. Exp. Bot. 59:2371-2378.

Jia, H., S. Cho and G.J. Muehlbauer. Transcriptome analysis of a wheat near-isogenic line pair carrying Fusarium head blight resistant and susceptible alleles. Submitted to Molecular Plant-Microbe Interactions.

Gardiner, S., J. Boddu, G. Adam, F. Berthiller and G.J. Muehlbauer. Deoxynivalenol-induced gene expression in barley. In preparation for submission to Molecular Plant Pathology.

Recent abstracts related to project:

Gardiner, S.A., H. Jia, J. Boddu and G. J. Muehlbauer. 2008. Microarray analysis of deoxynivalenol-induced gene expression in susceptible (cv. Morex) barley. American Phytopathological Society Meeting Abstracts.

Jia, H., S. Cho and G.J. Muehlbauer. 2008. Transcriptome analysis of a wheat near-isogenic line pair carrying fusarium head blight resistant and susceptible alleles. Plant and Animal Genome Meeting Abstracts.

Shin, S.H., J.M. Lewis, C.A. Mackintosh, A. Elakkad, K. Wennberg, S.J. Heinen, R. Dill-Macky, G. J. Muehlbauer. 2007. Transgenic wheat with enhanced resistance to Fusarium Head Blight. National Scab Forum Abstracts.

Boddu, J., H.C. Kistler and G.J. Muehlbauer. 2007. Role of trichothecenes in the barley-Fusarium graminearum interaction. National Scab Forum Abstracts.

Recent talks presented related to project:

“Exploiting genomics for understanding the Triticeae-Fusarium graminearum interaction” at the University of Nebraska, Lincoln, NE

Genomics of the Triticeae-Fusarium graminearum interaction” at the Danforth Center, St. Louis, MO

Polycoated Urea to Enhance Fertilizer N Utilization Efficiency

Albert L. Sims, University of Minnesota, NWROC

Research Question

1) Evaluate, compare, and contrast the fertilizer N utilization of polycoated urea and straight urea by hard red spring wheat.
2) Determine if hard red spring wheat varieties that vary in their grain yield and protein potential respond differently to the two sources of N.

Results

At the soft dough growth stage there was no differential effects of spring wheat variety or N source on total biomass and N accumulation at either experimental site (Table 1). Total biomass accumulation had a curvilinear response to increasing N rates (Figure 1). Maximum biomass accumulation occurred with 60 to 90 lbs N/A at both sites. There tended to be slightly greater biomass at Site C than Site R, which was probably due to the nearly 2 weeks earlier planting at Site C. Total N accumulation increased throughout the range of increasing N rates with no difference between sites (Figure 2). Though the plant continued to accumulate N as N application increased, the biomass potential was apparently limited by something other than N.

Grain yield and protein followed expected patterns with respect to differences between the two spring wheat varieties. Knudson had greater grain yield and lower grain protein than Alsen. The interaction between varieties and N rates was not significant at either site (Table 1). Thus the grain yield and protein response to N rates was similar for the two varieties. At both sites, maximum grain yield occurred between 90 to 120 lbs applied N/A (Figure 3). However, grain protein increased throughout the range of applied N rates (Figure 4).

Interactions between N rates and N sources were not significant for grain yield at either site or grain protein at site R (Table 1). At site C, there was a significant interaction between these factors for grain protein. Nevertheless, visual evaluation of grain yield (Figure 5) and protein (Figure 6) response to N rates of both N sources were similar at both experimental sites. Urea produced greater grain yields than ESN regardless of N rate (Figure 5). However, ESN produced greater grain protein concentration than urea regardless of N rates (Figure 6). Interestingly, protein differences between the two N sources increased as N rate increased, this interaction was significant only at Site C, while a the same time grain yield differences tended to decline at higher N rates.

Materials and Methods

Two field experiments were established near the University of Minnesota's Northwest Research and Outreach Center (NWROC) near Crookston, Minnesota; one 5 miles west of NWROC (Site R) and the other 7 miles south of NWROC (Site C). Soils at Site C and Site R were a Bearden silty clay loam and Bearden-Colvin Complex, respectively. Official taxonomy of Beardon soil is fine-silty, mixed, superactive, Frigid Aeric Calciaquoll and of Colvin soil is fine-silty, mixed, superactive, Frigid Typic Calciaquoll. Treatment and experimental designs at both locations were a 2 (N sources) by 2 (wheat varieties) by 6 (N rates) factorial in a randomized complete block design.

Two N sources, urea and Environmentally Safe Nitrogen (ESN™), were broadcast over assigned plots in the spring of 2008. After tillage with a field cultivator to incorporate fertilizer and prepare a seed bed, two hard red spring wheat varieties, Alsen and Knudson, were planted. Nitrogen fertilizer was applied at six N rates equivalent to 0, 30, 60, 90, 120, and 150 lbs. N/A. Fertilizer was applied just previous to wheat planting on April 9 at Site C and April 17 at Site R. Both sites had adequate soil test P levels so no P fertilizer was applied.

Individual plot sizes were five feet wide, 10 seed rows separated by six inches, and either 22 feet long (Site C) or 25 ft long (Site R). A bare gap of about one foot existed between each plot. Replications or blocks were separated by ten feet alleys to accommodate herbicide and fungicide applications and plant sampling. Herbicides and fungicides were applied as need and recommended. At the soft dough growth stage, whole plants were sampled from three feet of the fourth seed row by clipping at the soil surface, drying, and processing to determine total biomass and total N accumulation. At grain maturity, the entire plot was harvested with a small plot grain combine. Grain was initially dried then weighed for yield and a subsample was used to determine test weight and grain protein using NIR technology.

Statistical analysis was done using SAS 9.1 and the Proc Mixed procedure with slice analysis and targeted single degree contrasts where appropriate. Regression used in each figure was determined from the contrast analysis.

Related Research

Many attempts have been made, or are currently being made, to improve fertilizer N utilization efficiency in wheat production. Raun et al. (2001) has shown that winter wheat canopy light reflectance in the spring after dormancy is broken can be used to predict the yield potential. Fertilizer N is then applied in the spring to meet that yield potential. The yield potential is based on the growth of the winter wheat crop the previous fall and after growth resumes in the spring. In northwest Minnesota, Sims (2007) attempted to correlate spring wheat yield and protein with canopy light reflectance readings throughout the growing season. He found the canopy light reflectance relationship to yield and protein were different between two spring wheat varieties and that it was not able to distinguish treatments that differed by 7 to 10 bushel A-1. One reason for the difference in results between the two research projects might the actually growing season of the two crops. Spring wheat production in northwest Minnesota is approximately a 90-day growing season, planting to harvest, compared to 90+ days from dormancy to harvest in winter wheat production.

Other research has attempted to use split applications of fertilizer N to increase utilization efficiency. This management strategy applied some fertilizer N, if necessary, as preplant then applied the additional fertilizer N at or soon after tillering.

Theoretically, this would reduce potential N losses in the soil environment during the time when the wheat crop was establishing itself and would apply the necessary fertilizer N at a time when rapid growth and high N demand were just starting. Two issues have been raised with this strategy. One, is a second trip through the field is necessary to apply the in-season fertilizer N and two, soil moisture conditions must be adequate to activate and carry the fertilizer N into the crop root zone before potential volatilization losses occur. Timing of applying the fertilizer N and getting it into position of availability for the growing spring wheat crop is critical. Twenty-one site years of spring wheat research from northwest Minnesota in the 1990s clearly showed that most effective fertilizer N strategy was to preplant apply sufficient fertilizer N (J.A. Lamb and G.W. Rehm, personal communications). In these trials, spring wheat grain yield and protein with split fertilizer N applications did not exceed those achieved with adequate preplant fertilizer N applications.

Fertilizer N use research often finds 50 to 60% of the fertilizer N applied is harvested in the crop it is applied to (Hauck, 1985). It is also not unusual for total N budgets to not be able to account for 20 to 30 % of the fertilizer N applied. It is assumed that this unaccounted for N is lost from the system via ammonia volatilization, nitrate leaching below the root and sampling zone, and/or nitrous oxide loss from nitrate denitrification. Nitrogen accounted for, but not harvested in the crop, may be found as residual inorganic N or as organic N. In the latter case, subsequent crops will harvest some of this fertilizer N. The longer the fertilizer N is exposed to the soil environment the greater the chances that it will be diverted from crop utilization. World wide, fertilizer N utilization in wheat is about 30% (Raun et al. 2001). Theoretically, the closer the fertilizer N availability is timed with the crop requirements, the higher the likelihood to increase the fertilizer N utilization efficiency.

Tisdale et al., (1993) wrote that the ideal fertilizer N source would be capable of releasing N over an extended period of time and in accordance with crop needs. Technology exists to delay or slow the release of available N by developing N products with low water solubility, modifying water soluble N sources to delay the release of N, and chemicals to control the hydrolysis of urea and conversion of ammonium to nitrate (Hauck, 1985). In recent decades coated urea N sources have been developed to slow the release, availability, and potential losses of N. Sulfur coated urea (SCU) is probably the most well known and has been available for sometime. In this case, imperfections in the sulfur coating allow water to migrate through the coating, dissolve the urea granule, and the liquid N to migrate to the soil environment (Hauck, 1985).

Allen (1984) reported that increasing temperature also increased the release of N from SCU suggesting some biodegradation of the sulfur coating enhancing the N release. There is also a tendency for the sulfur coating to rupture under dry conditions, thus exposing the urea-N to the soil environment under less than ideal conditions. Sometimes a sealant is applied the SCU (Sartain, 2007). Microbial decomposition of the sealant will expose the sulfur coating imperfections and allow water migration. Since microbial activity and decomposition is temperature related, the release of coated N will correspond to warmer temperatures when crop growth is being stimulated. Other coated urea sources may use different coatings, but the temperature related microbial decomposition process is similar. Once the coating is decomposed, the urea granule is exposed to the soil environment like straight urea. The slow release component is based on differences in decomposition among the various coated granules applied. These N sources tend to be very expensive and have been primarily used in high value or ornamental crops. More recent technology applies a poly material as a coating to the urea granule. The polycoating does not require microbial decomposition, but uses osmosis and diffusion to release the N. Water is drawn to and diffuses through the polycoating, dissolves the urea granule, and the liquid N diffuses back through the coating into the soil environment. The slow release is based on the diffusion process which is affected by several factors, but perhaps the most important is temperature. As temperature increases, diffusion increases.

The release of the polycoated N will be based the rate of diffusion and the ability to draw water into and through the coating. The cost of these polycoated urea N sources seems to add about $0.10 per pound of N applied. At today's high N prices this proportional cost is less than it would have been 5 years ago and places this material in a price range more amenable for spring wheat production.

Research has clearly shown that applying sufficient fertilizer N prior to planting spring wheat in northwest Minnesota is the most effective overall management practice. Yet, the desire to improve fertilizer N utilization is more important at today's high fertilizer N prices. Can best fertilizer N management practices and the potential benefits of polycoated urea improve fertilizer N utilization be combined? The polycoated urea would be more expensive than straight urea, but a single preplant application of fertilizer would eliminate the need and risks associated with in-season split applications.

Preliminary data suggests that under adequate growing conditions, it may not only be possible, but the improved utilization more than paid for the extra cost of the polycoated urea.

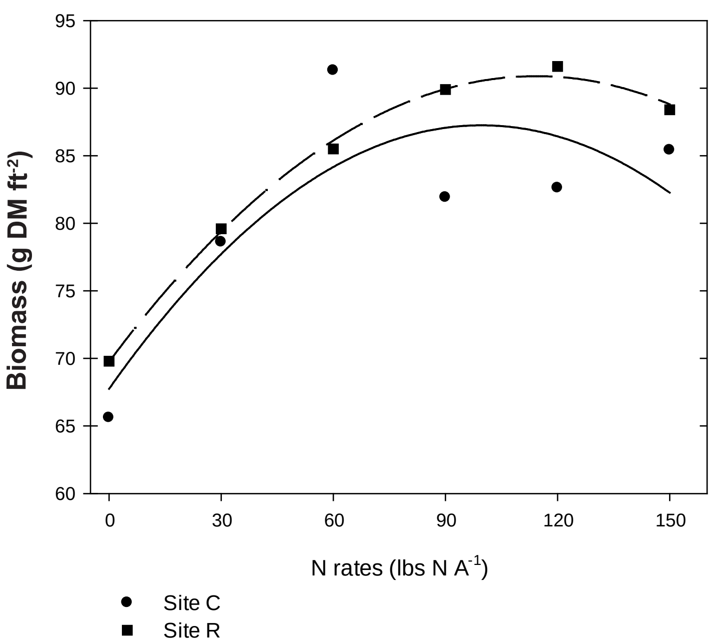


Figure 1. Total biomass accumulation, averaged over spring wheat variety and N sources, response to applied N rates at two experimental sites.

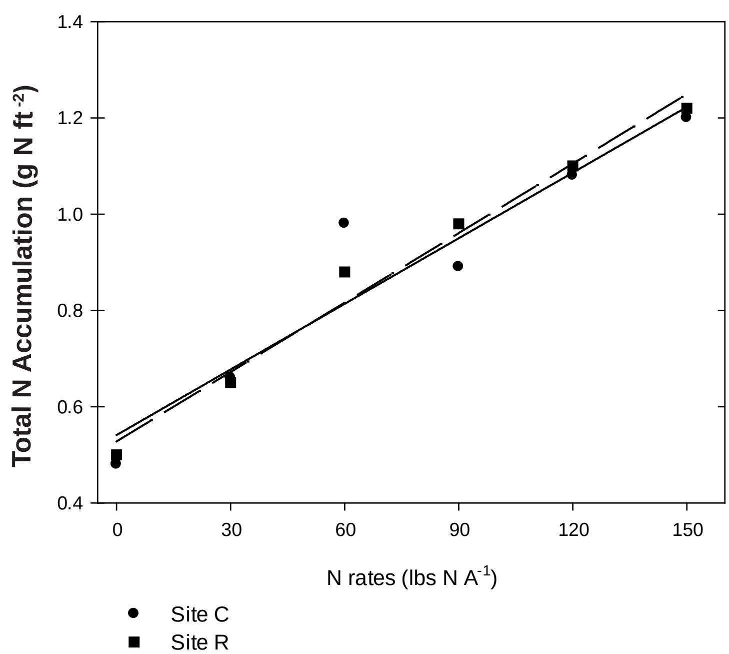


Figure 2. Total N accumulation, averaged over spring wheat variety and N sources, response to applied N rates at two experimental sites.

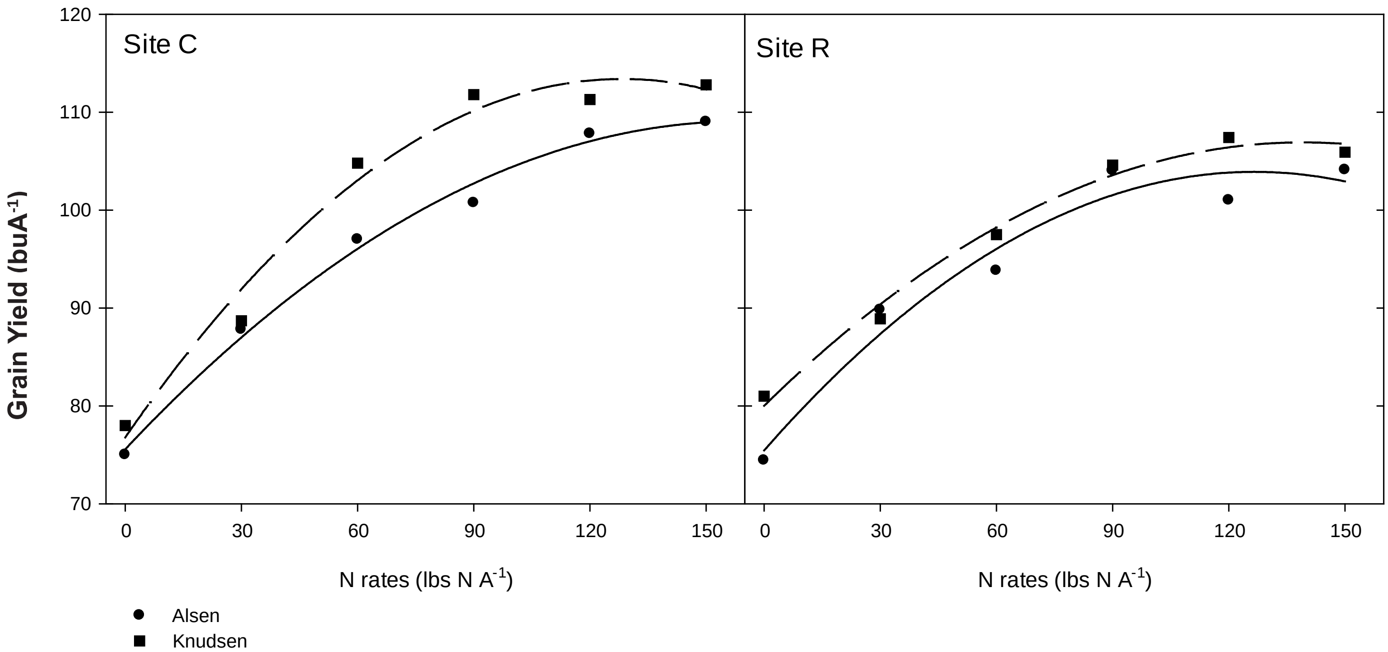


Figure 3. Grain yield response, averaged over N sources, of two spring wheat varieties to applied N rates at two experimental sites.

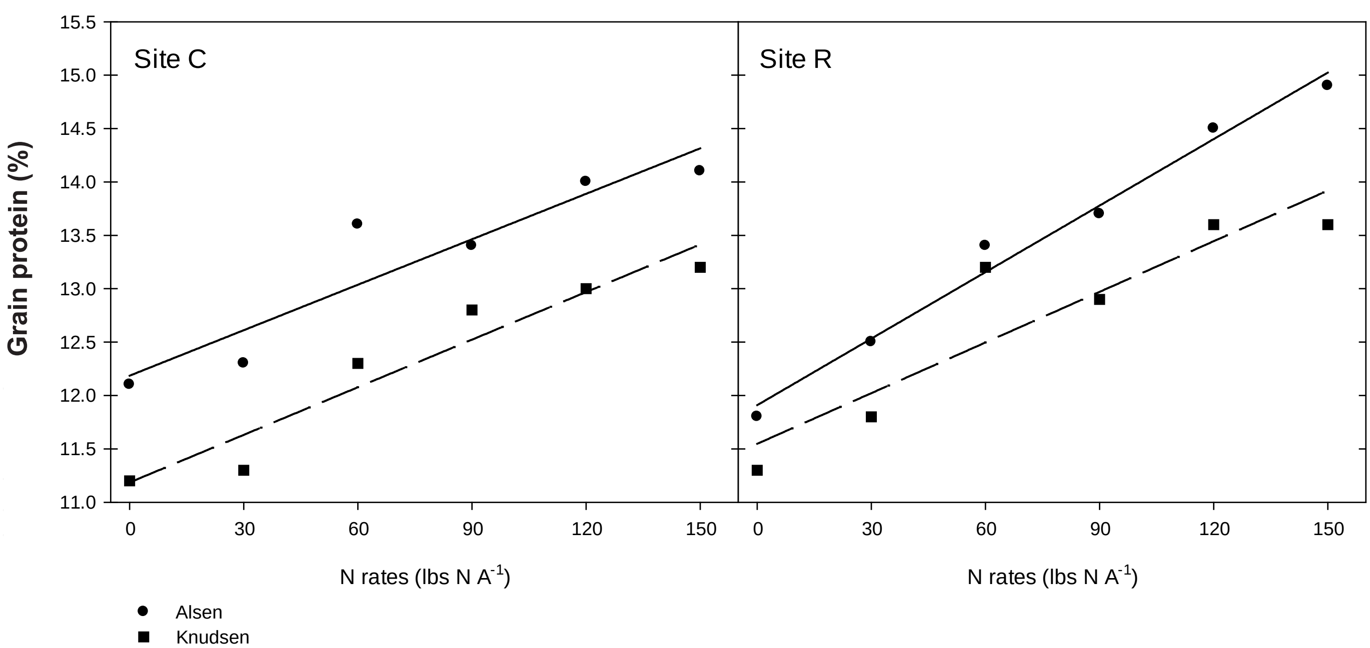


Figure 4. Grain protein response, averaged over N sources, of two spring wheat varieties to applied N rates at two experimental sites.

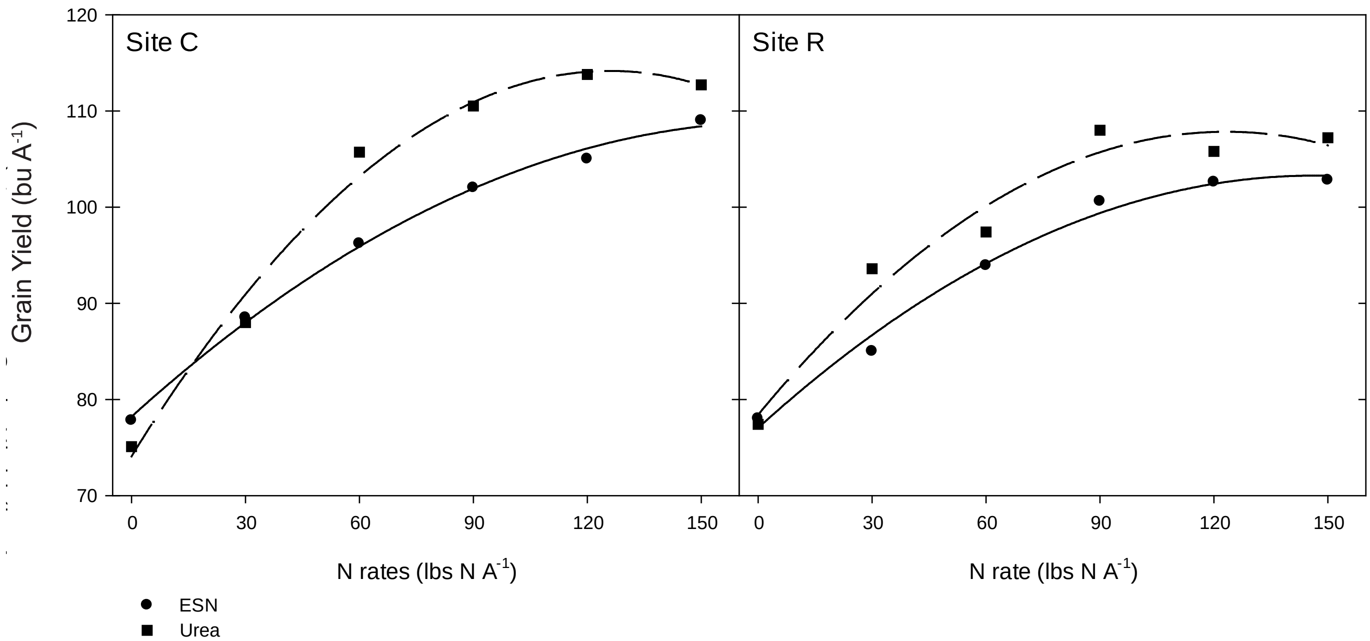


Figure 5. Grain yield response, averaged over spring wheat varieties, to applied N rates of two N sources at two experimental sites.

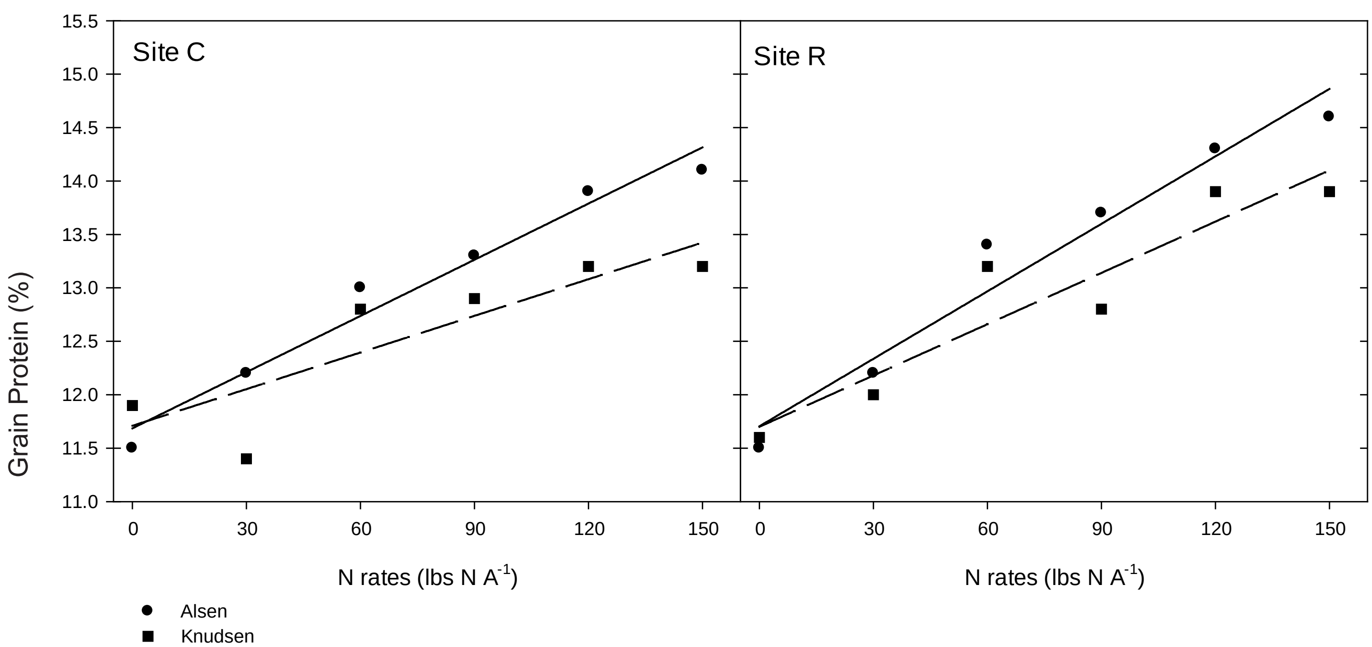


Figure 6. Grain yield response, averaged over spring wheat varieties, to applied N rates of two N sources at two experimental sites.

Evaluation of HRS Wheat Grown in MN for Refrigerated Dough Production

Senay Simsek, Department of Plant Sciences, NDSU

Research Question

i) What are the best cultivars to produce refrigerated dough with minimum quality concerns?
ii) Which locations from MN are the best to provide Hard Red Spring (HRS) wheat that could be used for refrigerated dough production?

Results

Table 1 shows the results of the proximate analysis, arabinoxylan structure and xylanase activity over the three locations for six HRS wheat varieties.

Table 1. Proximate analysis, arabinoxylan structure and xylanase activity of Hard Red Spring (HRS) Wheat varieties grown in MN.

		Proximate Analysis		Arabinoxylan						Xylanase Activity	
		Total Starch	Protein	Flour			Whole Wheat			Whole Wheat	Flour
Location	Variety	DWB	DWB	A/X	% Total		A/X	% Total		mU/g	mU/g
Crookston	Faller	76.81	15.14	0.70	1.11		0.76	2.82		2.75	0.51
	Glenn	73.00	17.12	0.79	0.97		0.71	3.77		2.73	0.58
	Knudson	76.99	14.90	0.71	1.19		0.83	3.14		2.47	0.49
	Oklee	57.38	16.66	0.82	1.31		0.81	3.44		1.52	0.84
	RB07	58.15	15.86	0.78	1.46		0.81	3.60		1.38	0.54
	Traverse	63.59	14.92	0.74	1.14		0.85	3.11		3.76	0.36
Lamberton	Faller	62.32	14.93	0.70	1.30		0.80	3.82		1.36	0.33
	Glenn	61.14	16.57	0.75	1.28		0.75	3.23		2.14	0.29
	Knudson	66.78	14.19	0.80	1.26		0.84	3.35		1.57	0.49
	Oklee	59.38	15.29	0.71	1.42		0.72	3.76		1.25	0.53
	RB07	64.72	15.95	0.80	1.14		0.81	3.75		1.30	0.20
	Traverse	56.24	13.19	0.75	1.50		0.83	3.94		1.98	0.22
Morris	Faller	74.71	13.40	0.67	1.46		0.76	3.44		2.43	0.44
	Glenn	60.78	14.71	0.82	1.13		0.74	2.96		3.01	0.45
	Knudson	65.57	13.34	0.70	1.14		0.77	3.61		2.30	0.61
	Oklee	62.94	14.65	0.78	1.03		0.72	3.50		2.01	0.43
	RB07	74.01	14.74	0.72	1.23		0.76	3.46		1.35	0.34
	Traverse	74.46	13.00	0.77	1.54		0.77	3.57		2.57	0.21
	LSD	**2.22**	**0.57**	**0.14**	**0.38**		**0.07**	**0.50**		**0.49**	**0.09**

A=Arabinose, X=Xylose, DWB

Dough syruping % values according to storage day were shown for each variety across growing locations in Table 2. The increase of dough syruping during storage was also shown as difference between dough syruping % at day 10 and day 0. Data in Table 2 indicated that variety and dough storage days had strong cross over interactions. For example, variety Faller showed lower dough syruping than RB07 at day 0 among Crookston samples but it showed much higher dough syruping than RB07 at day 10 (Table 2). While Traverse grown at Lamberton showed lower dough syruping % values at day 0, 3, and 7 than other varieties except for Oklee it showed higher dough syruping values than other varieties at day 10. Variety and locations also showed severe cross over interactions for all dough syruping % values. For example, Traverse showed the lowest dough syruping % values at day 0 among flours produced in Lambert but it showed the highest values among varieties grown at Crookston (Table 2). Analysis of variance also indicated very significant (P<0.001) interaction of variety and growing location (Table 3). These cross over interactions are not desirable for the selection of varieties since breeders need to test varieties grown across many locations.

Mean values of varieties over storage days were shown in Fig. 1 for three growing locations. As indicated in the figure, growing locations affected significantly variations in dough syruping. **Wheat flours produced at Lamberton showed significantly lower dough syruping than flours produced at Crookston and Morris while flours from Morris showed higher dough syruping % values than**

other locations except for Faller. Analysis of variance also indicated that the effect of location had significant (P<0.001) effect on dough syruping despite the severe cross over interaction effects (Table 3). These results confirmed that growing environments significantly affected variation of dough syruping %. Specifically, the bars shown in Fig. 1 represent standard error values calculated from dough syruping % values of storage days. Thus, the standard error values represent stability of dough syruping during dough refrigeration storage and the higher standard error indicates the lower stability of variety over storage. Oklee and Glenn showed lower standard error values than other varieties grown at Crookston and Lamberton. RB07 showed lower standard error values than other varieties at Crookston but higher standard error values at Lamberton than other varieties. Varieties from Morris did not show large difference of standard error values as observed for other locations.

These results also suggested that dough syruping was significantly affected by three way interaction effect of storage day, location, and variety as shown by analysis of variance (Table 3). Despite those interactions, Oklee and Glenn generally showed consistently low mean dough syruping % and standard error values than other varieties. **This result indicated that Oklee and Glenn had greater stability over refrigeration storage regardless of growing locations.**

Table 2. Dough Syruping % according to storage days.

		Day 0	Day 3	Day 7	Day 10	Day10-Day 0
Location	Variety	% DS	% DS	% DS	% DS	% DS
Crookston	Faller	1.84	2.59	3.16	10.32	8.49
	Glenn	1.21	1.45	2.39	3.05	1.84
	Knudson	2.72	2.80	3.32	6.58	3.86
	Oklee	1.07	1.49	1.57	3.46	2.39
	RB07	3.05	3.98	3.79	4.40	1.35
	Traverse	6.35	7.83	8.05	14.83	8.48
Lamberton	Faller	2.90	3.16	5.53	6.73	3.83
	Glenn	1.04	1.56	2.33	3.15	2.11
	Knudson	1.77	2.73	4.18	5.50	3.74
	Oklee	0.55	0.67	0.50	2.05	1.50
	RB07	2.40	2.43	7.33	8.23	5.83
	Traverse	0.82	1.01	1.53	6.67	5.85
Morris	Faller	1.33	1.88	2.74	2.80	1.47
	Glenn	2.09	3.42	4.69	4.66	2.57
	Knudson	7.21	6.71	7.38	6.76	-0.45
	Oklee	1.18	1.95	2.62	3.31	2.13
	RB07	10.31	10.21	11.85	13.50	3.19
	Traverse	9.82	10.79	11.04	11.79	1.98
LSD		0.76	0.55	0.62	1.99	2.39
LSD: least significant difference at P<0.05.						

Table 3. Analysis of variance for dough syruping % values.

Source	DF	Mean Square	F Value
Day	3	78.2	252.7
Location	2	121.4	612.4
Day*Location	6	6.5	32.8
Variety	5	127.9	408.8
Day*Variety	15	3.3	10.5
Location*Variety	10	45.2	144.4
Day*Location	6	6.5	20.8
Day*Variety	15	3.3	10.5
Day*Location*Variety	30	2.5	8.1
F values were signicant at P<0.001.			

The stability of Oklee and Glenn was also exhibited in Fig. 2. Fig. 2 shows mean % and standard error values of dough syruping of variety that were calculated using means of variety in a location for each storage day. Oklee and Glenn showed lower mean and standard error values across all the storage days, indicating they had greater stability across growing locations as well as refrigeration storage. On the other hand, RB07 and Traverse showed higher mean dough syruping % and standard error values than other varieties across all the locations. Fig. 3 shows mean and standard error values of degree of dough syruping (DDS). DDS indicated increase of dough syruping during refrigeration storage. Oklee and Glenn also showed lower mean and standard error values than other varieties, indicating that they showed smaller increase of dough syruping regardless of growing locations.

The greater stability of Oklee and Glenn over other varieties was also indicated by stability statistic estimates including ecovalence (Wricke 1962) and stability variance (Shukla 1972) (Table 4). The lower values of those stability estimates indicate the greater stability of a variety over growing locations. Oklee and Glenn consistently showed lower estimates than other varieties across all storage days, indicating that they had greater stability over growing locations than Faller, RB07, and Traverse. Although Knudson showed higher standard error values (Fig. 2) than Oklee and Glenn, ecovalence and stability variance values indicated that it also had a greater stability than Faller, RB07, and Traverse. Mean centered values in a location were used for the calculation of the ecovalence and stability variance values, which measure deviation of response of a variety to environments from the mean response of total varieties (Kang 2003). Knudson showed lower ecovalence and stability variance values since its response to growing locations were more parallel to mean response of all the varieties than other varieties in this experiment.

Table 4. Stability Statistic Values of Wheat Varieties for Dough Syruping (%) over Growing Locations

	Day 0		Day 3		Day 7		Day 10		Day 10 - Day 0	
Varieties	W_i	σ_i^2	W_i	σ_i^2	W_i	σ_i^2	W_i	σ_i^2	W_i	σ_i^2
Faller	14.3	9.3	13.6	8.9	17.8	11.8	49.1	33.9	12.1	7.9
Glenn	3.7	1.4	2.3	0.4	0.4	-1.3	0.3	-2.7	5.9	3.2
Knudson	2.1	0.2	1.3	-0.3	0.7	-1.0	2.6	-0.9	2.7	0.8
Oklee	5.4	2.7	3.8	1.5	1.9	-0.1	3.5	-0.2	4.1	1.9
RB07	13.0	8.4	9.7	6.0	13.7	8.7	22.8	14.2	15.2	10.2
Traverse	15.9	10.6	21.3	14.7	27.0	18.7	37.0	24.9	7.7	4.6

W_i ecovalence σ_i^2 stability variance

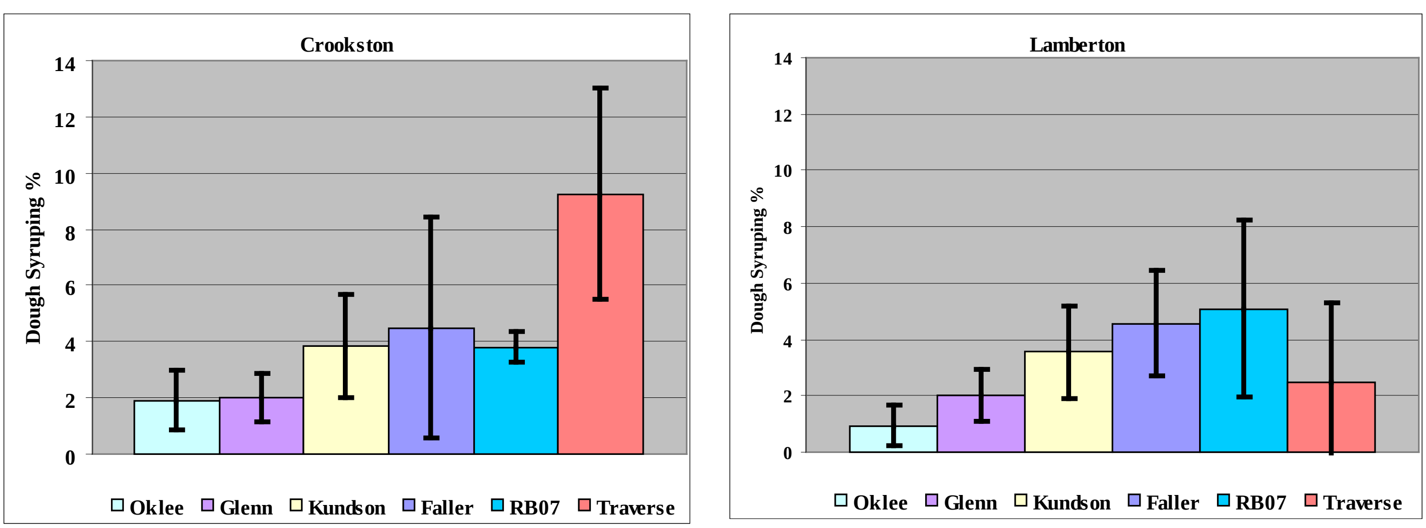
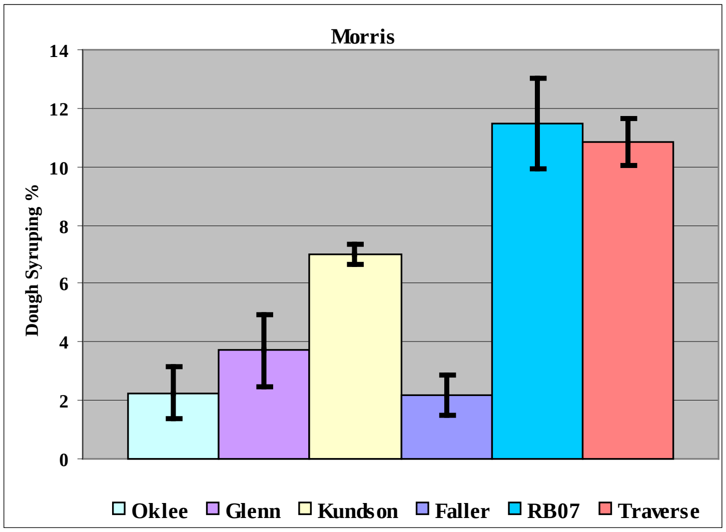
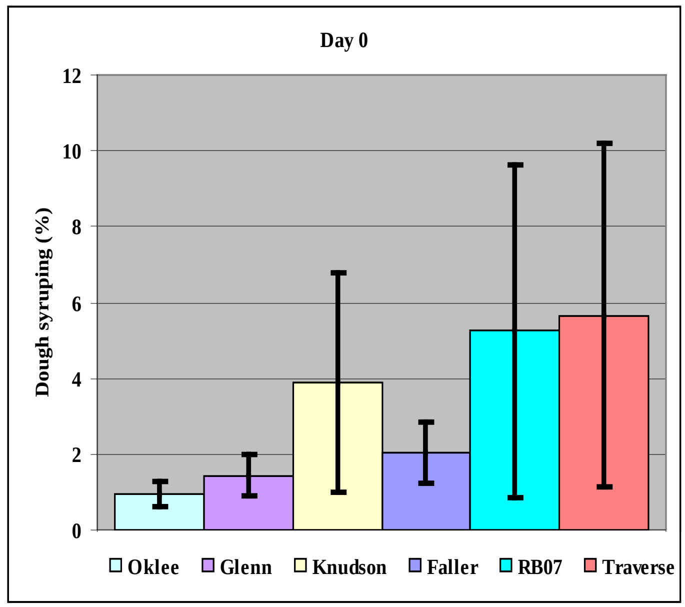


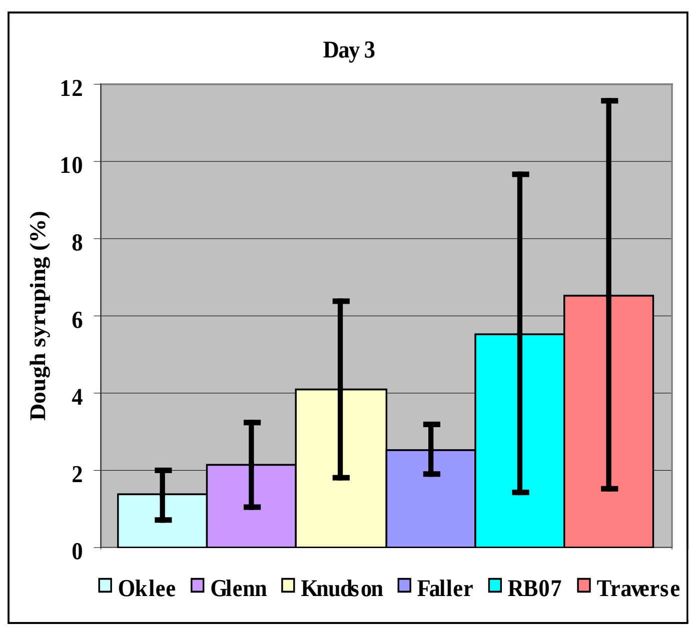
Fig 1. Mean values of varieties over storage days for three growing locations. Error bars represent standard error values calculated from dough syruping % values of storage days.



Although Knudson showed high stability across growing environments, GGE biplot also indicated that it had higher mean dough syruping across growing environments. A GGE biplot was also drawn for DDS (Fig. 5). The plot also indicated that Oklee and Glenn had lower mean DDS values with greater stability across growing locations.



The mean performance and stability of varieties for dough syruping was further analyzed by GGE biplot analysis. GGE biplot analysis has an advantage that genotype main effect and genotype and environment interaction effect for a target trait can be simultaneously evaluated by a plot (Yan and Tinker 2005). GGE biplots were constructed using standardized values of two way data of 6 varieties by 3 locations for all storage days under assumption that every environment is equally important in this experiment (Yan and Tinker 2005) (Fig. 4). The first and second PCs explained more than 90 % of total variations for all storage days in this experiment (Fig. 4). This result indicated that GGE biplots represented well the standardized values of dough syruping data for all storage days. Average environment axis (AEA) is the line that passes through the biplot origin and mean values of PC scores of growing location as shown Fig. 4. The corresponding point of a variety on AEA indicates mean performance of the variety for dough syruping. For example, line A, the single arrowed line in Fig. 4 for day 0, points lower mean dough syruping across growing locations (Yan and Tinker 2006). Fig. 4 clearly indicates that Oklee and Glenn had lower mean dough syruping across growing locations for all storage days. Contrastingly, Traverse and RB07 showed consistently higher mean dough syruping across locations for all the storage days. The length of a line from AEA to point of a variety indicates variability of a variety among growing locations (Yan and Tinker 2006). For example length of one arrowed line B in Fig 4 for day 0 indicated variability of variety Faller across growing locations. The longer length of the line means the poorer stability for a variety. As already shown by ecovalence and stability variance values, GGE biplots indicated that Oklee, Glenn, and Knudson had greater stability than other varieties for all storage days.



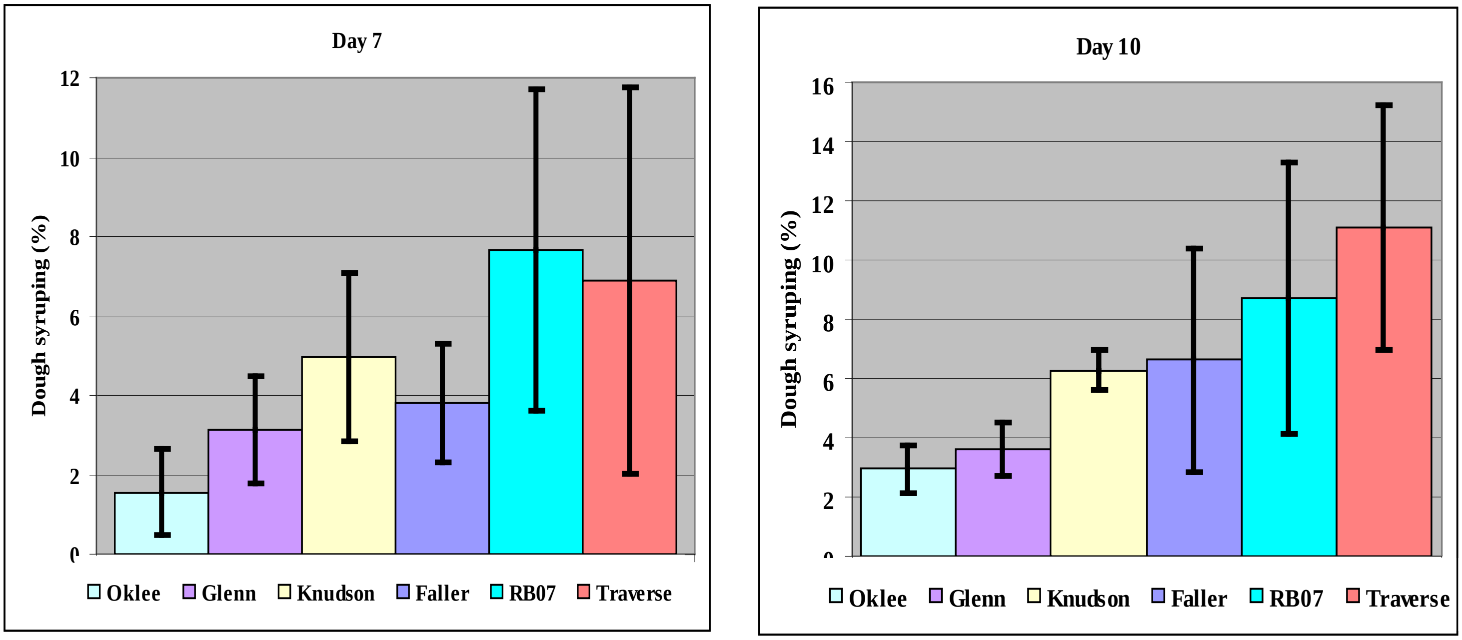


Fig 2. Mean values of varieties over three growing locations for dough syruping %. Error bars represent standard error values calculated from mean dough syruping % values of varieties in a location.

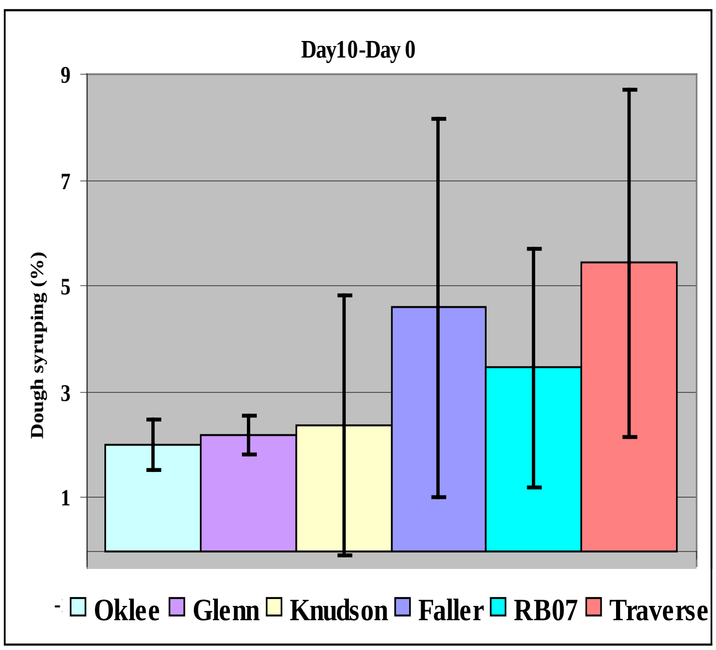


Fig 3. Mean values of varieties over three growing locations for difference of dough syruping between day 10 and day 0. Error bars represent standard error values calculated from mean difference values of varieties in a location.

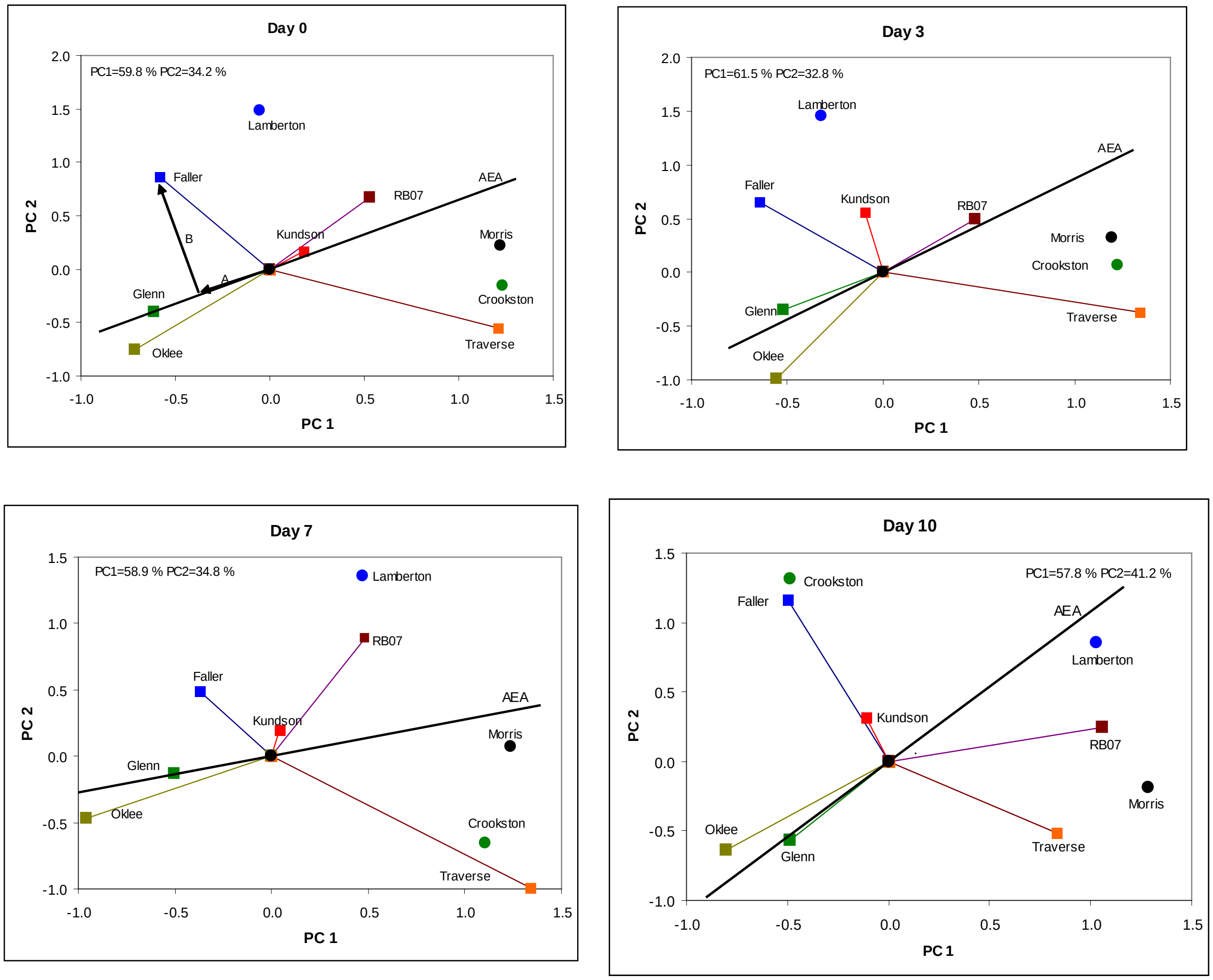


Fig. 4. The genotype-by-genotype-by-environment (GGE) bi-plot for dough syruping of refrigeration days. AEA=average environment axis

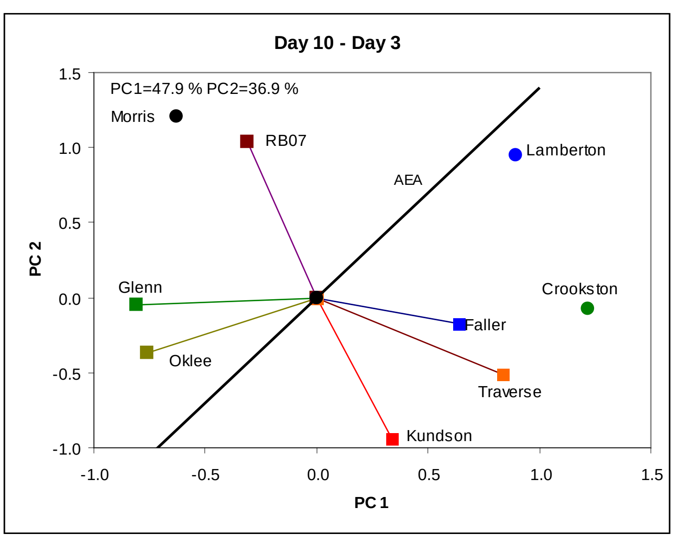


Fig. 5. The genotype-by-genotype-by-environment (GGE) bi-plot for dough syruping difference between day 10 and day 0. AEA=average environment axis.

Conclusion

This research was performed to evaluate dough syruping during refrigeration storage for hard spring wheat flours produced in three locations in Minnesota. Dough syruping showed significant cross over interactions between variety, location, and refrigeration day. Despite the significant interactions, Glenn and Oklee showed higher stability across growing locations and storage days. Stability estimates such as ecovalence and stability variance values support our conclusion. Specifically, GGE biplot analysis indicated that Oklee and Glenn had lower dough syruping with higher stability across growing locations compare to other varieties. GGE biplot indicated that Knudson also showed stable performance across locations, but it showed greater mean dough syruping than Oklee and Glenn across locations. GGE biplots also indicated that RB07 and Traverse had higher dough syruping and variability across locations than other varieties. These results suggest that i)HRS wheat varieties, which have great stability over growing locations and refrigeration could be developed despite the significant genotype and environment interaction effect; 2) Glenn and Oklee are the two best varieties for refrigerated dough production; iii) Lamberton is the best location to produce HRS wheat for production of refrigerated dough.

Application and Use

Refrigerated dough is more than a $1.6 billion industry in the USA. It is one of the fastest growing segments of the grain-based industry, both domestically and internationally, due to its ease of use and capacity to keep freshness during extended periods of refrigerated storage. Currently, HRS wheat is NOT used for the production of refrigerated dough in the food industry because of “dough syruping problem” during storage (personal communications, Dave Katzke, General Mills). Dough syruping problem has been linked to xylanase activity and arabinoxylan chemistry in wheat. Therefore, results of this study are going to be very useful for end-users to buy wheat from certain locations or even particular variety to produce refrigerated dough with superior quality.

Materials and Methods

Materials: Flours and whole ground wheat was obtained from USDA-ARS HRS and Durum Wheat Quality Laboratory at NDSU, Fargo, ND. Megazyme kits for total starch and Xylanase activity analysis were obtained from Megazyme International Ireland Ltd., Wicklow, Ireland.

Proximate analysis: The flours were analyzed for moisture and protein according to Approved Methods 44-15A and 46-30 (AACC 2000). Total starch analysis was completed using the Megazyme total starch kit (Megazyme International Ireland Ltd., Wicklow, Ireland) according to Approved Method 76-13 (AACC 2000).

Total arabinoxylan and arabinose to xylose ratio: Arabinose and xylose content of the flour and whole wheat was determined by preparation of alditol acetates then analysis by GC on a HP5890 Series II with FID detector. A supelco SP™-2380 column (Supelco Bellefonte, PA) was used. The alditol acetates were prepared by the method of Blakeney et al. with some modifications. Sugars were hydrolyzed from the flour with 2M TFA while being heated at 121°C for 1 hr., and myo-Inositol was added as an internal standard. This was evaporated under nitrogen followed by the addition of Ammonium hydroxide and Sodium borohydride in DMSO. The reduced monosaccharides were acetylated by the addition of 1-methylamizizol and Acetic anhydride. The acetates were extracted with dichloromethane which was removed and evaporated. The acetylated sugars were then dissolved in 1ml of acetone and analyzed with the GC. Total arabinoxylan was calculated by addition of the total arabinose and xylose determined by GC analysis. The arabinose to xylose ratio was calculated by dividing the total arabinose by total xylose as determined by GC analysis.

Xylanase activity: The Xylanase activity of the flour and whole wheat was determined using the Megazyme Xylanase assay kit ((Megazyme International Ireland Ltd., Wicklow, Ireland). A liquid extract was obtained from the flour and whole wheat by shaking with sodium acetate buffer for one hour. The extract was added to four test tubes to which the assay tablets were added and incubated overnight as to the Megazyme procedure. The extract was read against a blank at the absorbance of 630nm on a Multiscan Ascent microplate reader (Thermo Electron Co., Vantaa, Finland). The percent Xylanase activity was determined by calculating the absorbance against a standard curve.

Dough syruping: The percent of syrup formation was calculated by measuring the amount of liquid exuded from the dough after centrifugation and dividing it by the total dough weight. Samples of the dough (4g) were stored in centrifuge tubes for ten days and centrifuged on day 0, 3, 7, and 10. The sample was weighed and the liquid was removed with a pipette and the tube was gently dried with a tissue.

The tubes were re-weighed and the difference was calculated to be the amount of syruping liquid (Gys et al 2003).

Statistical analysis: Statistical analyses were performed using SAS System for Windows (V. 9.1, SAS Institute, Cary, NC). Analysis of variance was performed using GLM procedure. Dough syruping data was analyzed by split-split-plot-design considering storage day as a main plot factor, growing location as a subplot factor and variety as a sub-sub plot factor. All factors were considered as fixed in analysis of variance. Stability of wheat variety across growing locations was estimated by calculating ecovalence (Wi) (Wricke 1962) and stability variance (Shukla 1972) values using a SAS program coded by Kang (2003). The genotype-by-genotype-by-environment (GGE) bi-plot analysis was performed as described by Yan and Tinker (2005, 2006). The variety x location two way data of dough syruping was standardized and was decomposed into principal components (PC), using singular value decomposition and the biplot was drawn using the first two PCs. Singular value decomposition and calculation of PC scores of variety and location were performed using SAS (Version 9.1, SAS Institute Inc., Cary, NC).

Economic Benefit to a Typical 500 Acre Wheat Enterprise

Nationally and internationally, hard red spring wheat has a reputation for being one of the premium quality wheat classes, often fetching a higher value for the producers. It is because of its ability to be used as a blending or "improver" wheat for other types of wheat, and for the production of specialty wheat products like multi-grain breads, bagels, pizza crusts, frozen dough, etc. that customers are willing to pay a premium in the market.

As competition increases, MN wheat needs to continually find ways to maintain and improve its share in the market. One area that appears to have potential for significant growth in the near future, both in the U.S. and internationally is use in refrigerated dough. The reasons why hard red spring wheat is not widely used in this particular wheat product application currently, and why there is a need to conduct research to hopefully isolate varieties or locations that have minimal to zero problems with syrupy dough were explained above. The research may also prove useful in helping customers overcome this limitation with the current hard red spring wheat crop. There are many other benefits customers could derive from hard red spring wheat in refrigerated dough products, but at the present time, the adverse risk from dough syruping problems on product quality is too great.

Additionally, results will help the UMN wheat breeding program, consequently for the Minnesota wheat producers, to develop wheat varieties that have target pentosan content and xylanase activity. Since the water-soluble pentosan fraction is under genetic control, the potential exists for new varieties with targeted water-soluble pentosans that have better end-use functionality.

As a summary, this data will help to expand the market for HRS wheat grown in MN.

Related Research

What is dough syruping?

Refrigerated dough quality during storage is very critical. Under some conditions, liquid can separate from the dough and form syrup that can leak out of the package (see picture left). This phenomenon is called "dough syruping" and is unacceptable for the consumers (Courtin et al., 2006). Studies have shown that this problem is linked to the pentosan (arabinoxylans) population of the flour (Gys et al., 2003). To prevent dough syruping, the food industry is very careful about what kind of flour is used. HRS wheat flour is not used for refrigerated dough production, and currently industry is using other classes of flours. However, there is a demand to investigate the performance of HRS wheat flour for production of refrigerated dough since it has superior flour quality and baking characteristics.

How pentosans related to refrigerated dough quality?

Pentosans have high water holding capacity, which can impact the end-use quality of food products produced with wheat through modification of water relations. Pentosans are functionally divided into the classes of water-soluble and insoluble. Insoluble pentosans are associated with cell wall structure, while soluble pentosans have been shown to affect flour end-use quality. Wheat and rye pentosans are important functional ingredients in baked products affecting water binding, rheology and starch retrogradation. They also protect the gas retention in dough due to the viscous influence on gluten-starch films. Water holding capacity of pentosans was shown by many researchers with different methods. One of the major studies was done at NDSU, in which researches tried to determine the water holding capacity by measuring changes in the farinograph dough consistency after addition of water extractable or water unextractable pentosans to flour. When pentosans are added to the dough, part of the water associates with pentosans, which results in a higher consistency of the dough. Based on this method, researchers determined that pentosans can hold water up to 9 times of their weight in water (Kim et., 1977).

What effects the pentosan production in wheat?

Previous studies with soft wheat showed that the concentration of water-soluble class of pentosans in wheat is mainly determined genetically, while the growing environment had a relatively minor influence. It was further demonstrated that the water-insoluble pentosan fraction is more influenced by the growing environment (Finnie et al., 2006).

One of the objectives of the proposed research is to delineate the influence of HRS wheat variety and growing environment on variation in water-soluble, water-insoluble and total pentosan contents of flour, which has significant effect on flour quality in relation to refrigerated dough production.

What happens during refrigeration storage?

Xylanases (enzymes), naturally present in the wheat, break down the pentosans. Then, water holding capacity of dough decreases and dark syrup forms. Additional to pentosan population, the nature and activity of the enzyme in the flour is very critical to prevent dough syruping. The enzyme activity in the flour might be genetically controlled or environment-dependent for HRS wheat since previous studies showed location dependent enzyme activity changes (Rodrigez-Kabana et al., 1982, preliminary studies of Dr. Simsek). For that reason, determination of xylanase activity along with pentosan population studies will be performed.

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Recommended Future Research

Current data represents the results from 1 year trial. It would be very useful if the research can be replicated 1 or 2 more year using the same locations and varieties.Even though current publish data suggests that dough syruping and refrigerated dough quality is linked to arabinoxylans and xylanase activity, further research is still needed to investigate the changes in protein composition in refrigerated dough during storage.

Publications

We plan to submit the results of the research as an abstract; Senay Simsek, Jim Anderson, Jae-Bom Ohm, Mohamed Mergoum. "Evaluation of Hard Red Spring Wheat Grown in MN for Refrigerated Dough Production". American Association Cereal Chemists-International, Annual Meeting, September 13-16, 2009, Baltimore, Maryland, USA.

We also plan to submit the results as a manuscript to "Journal of Food Science".

Soft Red Winter Wheat Germplasm Evaluation

Jochum Wiersma, Northwest Research & Outreach Center, U of M

Research Question

The Minnesota Wheat Research & Promotion Council identified the need to develop high yielding winter wheat varieties as a research priority during their Wheat Summit in the spring of 2006. The underlying reason for this need is the potential to use (winter) wheat as source of starch for ethanol production rather than corn. The current bio-fuel boom is almost exclusively corn ethanol based. Although improvements in corn genetics have allowed corn to expand further north, northwest Minnesota is still on the periphery of the Corn Belt.

To allow Northwest Minnesota to take advantage of the bio-fuel boom requires a different raw commodity than corn. Winter wheat and other winter cereals, like winter barley and triticale, may be this alternative. Establishing a (new) winter wheat breeding program to breed high yielding winter wheat suitable for ethanol production is both a costly and long-term commitment. Variety development in winter wheat will take a minimum of 8 to 10 years from the initial crosses until a variety's introduction into the market. A more prudent and effective way to address the short and intermediate goals to develop wheat as a source for ethanol production is to evaluate the agronomic performance of existing cultivars from other parts of the world. European winter wheat cultivars are often selected for just grain yield, indiscriminate of the protein content and quality, as much of the winter wheat is used for feed rather than food. Likewise, soft red winter wheat varieties are selected for lower protein content compared to the hard red winter wheat cultivars. The objective of this research is to evaluate the agronomic performance of a limited number of winter wheat varieties from the eastern USA, Canada, and Europe.

Results

All but the hard red winter wheat entries Roughrider and Jerry, included as checks, suffered 80 to 100% winterkill in 2007 and no yield data was collected in 2007. In 2008, the trials in Lamberton and Crookston suffered less winter kill compared to 2007 (Table 1). The trial in Roseau had no significant winter kill, yielding an excellent trial for measuring the yield potential and other agronomic characteristics under Minnesota growing conditions (Table 2). The two soft red winter wheat varieties from Pioneer HiBred program were the highest yielding entries in the trials with 155 and 156 bu/A, respectively. This is 36 bu/A or 30% higher than the highest yielding hard red winter wheat in the trial and illustrates the yield potential of other classes of wheat in relation to hard red spring and winter wheat varieties.

The yield potential of Pioneer accessions is combined with acceptable agronomic characteristics, including straw strength, disease resistances, and maturity. The winter hardiness of the Pioneer germplasm as well as the other eastern US varieties (Kaskaskia, GLCG7552) tended to be less than the checks Jerry and Roughrider. The European accessions (Ellvis, Kosack, Leiffer, Lucius, Moscow 39, Mulan, and Olivin) tended to be very short and very late maturing and very susceptible to both stem and leaf rust, making their adaptation to Minnesota questionable. The Canadian accessions (the numbered lines and CDC Ptarmigan) from Dr. Brian Fowlers' program appear to be well adapted to Minnesota with excellent winter hardiness, acceptable straw strength and maturity, and a high grain yield potential.

Application and Use

A number of the tested lines and cultivars, especially the soft red winter wheat and Canadian winter wheat accessions, appear to have potential in Minnesota. Winter kill remains the first limiting factor for successful production and continued testing and adoption of no-till practices in our variety testing procedures will be key to determine the large scale, commercial viability of these accessions across the state.

Materials and Methods

A total of 19 entries from the US, Canadian and European breeding programs were collected and entered in the trials in 2007 and 2008. In 2007, the nurseries were planted in Lamberton, St. Paul, and Crookston. In 2008, the nurseries were planted in Lamberton, Crookston, and Roseau using a randomized complete block design with 3 replicates. Nurseries were planted near the optimum seeding date for winter wheat in each location and year. Nurseries were established using standard plot equipment without any standing stubble. Fall establishment, winter kill, spring vigor as well as disease and agronomic performance data were collected in 2007 and 2008.

Economic Benefit to a Typical
500 Acre Wheat Enterprise

It is difficult to estimate what the economic benefit is to a 500 acre wheat enterprise as no price information is available for soft red winter wheat in Minnesota. Using hard red winter wheat as guide, the 30% yield advantage of the top yielding varieties would equate to an additional $99,000 in gross farm receipts when we assume a cash bid of $5.50/bu.

Table 1. Percent winterkill of 21 winter wheat and winter triticale accessions tested in Crookston and Lamberton in 2008.

Variety	Crookston (%)	Lamberton (%)
CDC Ptarmigan	64	12
DH00-18-196	0	0
DH00-18-69*R	42	0
DH01-25-5-5*R	71	12
DH02-15-95	50	7
DH99-37-100	26	2
Ellvis	83	85
GLCG75	88	22
Jerry[1]	40	0
Kaskaskia	94	5
Kosack	85	58
Leiffer	98	85
Lucius	100	38
Moscow 39	43	7
Mulan	99	100
Olivin	93	55
Pioneer 25R23	90	38
Pioneer 25R47	80	5
Roughrider[1]	11	2
S00-159-8	65	13
S01-285-7*R	34	2
Trical815[2]	94	10
Mean	65.0	25.3
CV	33.3	72.0

[1] Hard red winter wheat checks
[2] Winter triticale

Table 2
Grain yield, test weight, grain protein and disease severity of 21 winter wheat and winter triticale accessions tested in Roseau in 2008.

Variety	Yield (bu/A)	Test Weight (lbs/bu)	Grain Protein [1] (%)	Leaf Spotting Disease (%)	Leaf Rust (%)
Pioneer 25R47	155.6	55.0	9.7	5	2
Pioneer 25R23	155.2	57.8	10.1	1	4
DH01-25-5-5*R	148.2	54.5	9.8	3	7
Kaskaskia	141.5	58.3	9.8	7	4
GLCG75	135.4	57.4	10.8	8	9
DH00-18-69*R	135.3	59.0	9.9	3	12
S01-285-7*R	131.6	59.3	11.1	5	5
Leiffer	130.5	54.5	10.8	0	4
DH00-18-196	129.0	58.3	10.7	11	23
DH02-15-95	127.3	55.1	10.1	4	9
DH99-37-100	126.4	59.8	9.9	4	3
Lucius	125.2	55.8	11.2	3	3
Mulan	123.7	53.8	11.5	3	10
CDC Ptarmigan	123.6	54.7	9.2	0	15
Moscow 39	120.7	59.2	11.9	4	3
Kosack	119.4	57.2	10.6	12	8
Jerry[2]	119.1	58.5	11.6	12	10
S00-159-8	117.1	57.2	9.7	6	6
Olivin	116.5	54.7	11.8	2	4
Trical815[3]	109.5	46.8	10.7	3	5
Ellvis	106.8	49.9	11.0	4	4
Roughrider[2]	93.0	59.7	11.3	4	6
Mean	126.9	56.2	10.6		
LSD	15.9	1.4	1.0		
CV	7.6	1.5	5.8		

[1] Corrected to 12.5% moisture
[2] Hard red winter wheat checks
[3] Winter triticale

Liquid vs Dry Phosphorus Fertilizer Formulations with Air Seeders

Jochum Wiersma, Northwest Research & Outreach Center, U of M

Research Question

The objective of this research is to compare HRSW biomass, P accumulation, and grain yield response to various rates of pre-plant broadcast and starter (banded with the seed) applications of liquid (10-34-0) and dry (11-52-0) P fertilizer sources when the seed is planted in a 4 inch wide bands with an airseeder.

Results

Neither total biomass nor total P accumulation were significantly affected by the experimental factors used in this trial (Table 1). One exception was a significant application method by P source interaction for biomass accumulation at Site S. This exception was caused by a 12% increase in biomass accumulation with starter application of dry P fertilizer compared to the broadcast application, but there was no application method difference with the liquid P fertilizer. The lack of any significant effect at NWROC was surprising because visually we could detect P rate differences early in the growing season. Apparently, by the soft dough stage these differences had been minimized. Averaged across all experimental factors, total biomass was 127 and 140 g DM ft^{-2} at NWROC and Site S, respectively. At the same respective sites, total P accumulation was 0.144 and 0.194 g P ft^{-2}. Clearly, Site S had greater biomass production, and thus greater P accumulation than NWROC.

Experimental treatment factors primarily affected grain yield and, to a less extent, grain protein (Table 1). At both experimental sites, P fertilizer application method significantly affected grain yield. Starter P increased grain yields compared to pre-plant broadcast applications (Fig 1a and 2a). However, only at NWROC did applied P rates affect grain yield. A significant interaction between P application method and P rate for grain yield at NWROC (Table 1) was primarily caused by the greater yield response to starter P rates compared to broadcast P rates (Fig 1a). Grain protein was reduced with starter applications at NWROC (Table 1 and Fig 3a), which we think was probably due to the strong relative grain yield response to starter applications. Phosphorus source significantly affected grain yield and protein only at Site S (Table 1). Grain yield was 2 to 5 bu A^{-1} greater with the liquid P source than the dry P source (Fig 2b). At the same time grain protein was reduced 0.1 to 0.2% with the liquid P source (Fig 4b). Though P source was not significant at NWROC, the dry P source tended to produce slightly greater grain yields than the liquid source at lower P rates (Fig 1b), which was the opposite observed at Site S.

Application and Use

Predicting the P fertilizer need for spring wheat production has been difficult and frustrating for many researchers over the last several decades. When a response does occur, it is sufficient to justify the application of P fertilizer and would be costly to the growers had they not applied P fertilizer. But, in most instances, the response to applied P has been minimal at best. The trial discussed here has been no exception. We deliberately searched and found experimental sites with low STP levels to provide the greatest probability of observing a response to P fertilizer. A relatively strong yield response to fertilizer P application occurred in one of the three site years (two each of 2007 and 2008 growing seasons.

In this trial, we used an airseeder with a seed distribution pattern about 4 inches wide. While this may change the dynamics of the proportion of the seed bed planted compared to the normal disk opener grain drill, it appears not to have changed the general effects of P fertilizer management. When a response occurred, there was a strong tendency for a more favorably grain yield response with starter applications compared to a pre-plant broadcast application.

Whether that P should be liquid or dry is not clear from this trial. Results from Site S suggest a liquid source may be more effective, but this is was one of four site years on a mostly non-responsive site. The NWROC site was responsive to P fertilizer application, but source made no significant difference.

Our data would suggest that growers should shop for the cheapest source of P fertilizer for their spring wheat production systems. But, once the decision on the source is made starter applications of that fertilizer should be strongly considered.

Material and Methods

Two field experiments were established in the 2008 growing season. One on the University of Minnesota's Northwest Research and Outreach Center (NWROC) and another site about 8 miles east by southeast of NWROC (Site S). Soils at both locations have been classified as Wheatville silt loam (coarse-silty over clayey, mixed over smectitic, superactive, Frigid Aeric Calciaquoll). Soil test P levels was 2 ppm at both locations suggesting a high likelihood of a response to the application of P fertilizer at both experimental sites.

A 2 X 2 X 5 factorial treatment design was used with two P sources (liquid 10-34-0 and dry 11-52-0), two application methods (broadcast prior to planting and starter applied with the seed at planting) and five P rates (0, 20, 40, 60, and 80 lbs P2O5 A-1 equivalent). The experimental design was a randomized complete block with four replications. Initial plots were 10 ft wide and 50 ft long, but were later cut back to 30 ft long from the center of each initial 50 ft plot. Broadcast fertilizer was applied just prior to planting by either hand spreading (dry) or using a sprayer mounted on an all terrain vehicle (liquid). Starter fertilizer was applied with a modified airseeder that applied seed and fertilizer in rows 4 inches wide and spaced 10 inches apart.

Hard red spring wheat (Knudson) was planted on April 17 at NWROC and May 5 at Site S. At the soft dough stage, whole plants from one row three feet long was clipped at ground level, dried and processed to determine total biomass and total P accumulation. At physiological maturity, five feet from the center of each plot was harvested with a plot combine. The grain was dried then weighed to determine yield and a sub-sample was used to determine test weight and grain protein via NIR.

Statistical analysis was done using Proc Mixed procedures in SAS 9.1. Differences among the various factors were characterized with slice analysis and targeted single degree of freedom contrasts. Regression lines in the figures included in this report are based on the results of those contrasts.

Economic Benefit to a Typical
500 Acre Wheat Enterprise

Currently university P fertilizer management guidelines indicate P rates can be reduced 35 to 50 % when banded or applied as a starter at planting compared to pre-plant broadcast rates. If 60 lbs P_2O_5 A^{-1} is recommended as broadcast, similar production levels can more than likely be achieved by using 30 to 40 lbs P_2O_5 A^{-1} as a starter at planting. Assuming $1 per lbs of P2O5 this is a savings of $20 to $30 per acre. On a 500 acre wheat enterprise, this is a savings of $10,000 to $15,000.

Related Research

Calcium carbonates, common in most soils of northwest Minnesota, tend to tie up phosphorus (P) making it relatively less available for crop production. Many growers maintain soil test P (STP) levels in the medium to high levels, or attempt to do so, by applying relatively large amounts of P fertilizer to ensure against a potential P deficiency in the crop. Currently, this practices is not considered best P management practice by the University of Minnesota because of low economic returns for the amount of P fertilizer applied when STP levels are high, potential environmental consequences of over application of P, and because some soils strongly tie up P and STP hardly change or are difficult to maintain. In recent years, exceptionally high fertilizer costs are forcing growers to reevaluate their P management strategies in order to maintain positive profit margins. In HRSW production, P fertilizer can be either applied broadcast prior to planting or banded with the seed at planting. Banding P fertilizer in HRSW production is frequently recommended because banding reduces the fertilizer-soil contact thus reducing potential for chemical tie up of the P, but also because banding places the fertilizer in a concentrated zone near the plant roots. Banding P fertilizer generally requires less P fertilizer than broadcast applications to obtain similar yields. Peterson et al., (1981) reported that the effectiveness of banded P relative to broadcast P will increase as STP levels decrease. That is, at very low STP broadcast applications require nearly three times the amount of P as banding to obtain the same yield. At low to medium STP levels, broadcast applications require nearly twice as much P as banding. At higher STP levels, there is little difference between application methods, but very little P is generally required at all.

Earlier research in northwest Minnesota has not shown consistent responses to P fertilizer in HRSW production, especially when STP levels are 4 ppm (low category) or higher. This result has occurred regardless of P fertilizer application method of generally dry P fertilizers. Recent research in Australia found that liquid P fertilizer sources may be more beneficial for wheat production than dry P fertilizer sources on highly calcareous soils (Lombi et al, 2004). The research suggests that dry fertilizer granules draw water from the surrounding soil that brings with it soluble calcium that will tie up the P as the granule dissolves. This appears not to be as large a concern for liquid P fertilizer sources because it is already dissolved. Though soils in northwest Minnesota do not contain nearly the amount of calcium carbonate as those in Australia where this trial was conducted, it did stimulate the question of whether we do not often see a HRSW response to P because we generally use dry P fertilizer.

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Peterson, G. A., D. H. Sander, P. H. Grabouski, and M. L. Hooker. 1981. A new look at row and broadcast phosphate recommendations for winter wheat. Agron. J. 73:13-17.

Recommended Future Research

Future research needs to examine the use, interpretation, and management of soil test P levels for wheat production. Many growers strive to build and maintain the STP levels in the medium to high levels. This suggests that lower STP levels indicate insufficient levels of P for wheat production. If STP levels do reveal soils with insufficient levels of P, then wheat should respond to the application of P fertilizer. Many research projects conducted over several decades by different researchers have observed very few incidents where spring wheat responds to P fertilizer application when the starting STP levels were in the low category. Currently, a strategy is being developed by nutrient management specialists in the University of Minnesota system to reevaluate current P fertilizer management recommendations and how STP should be used in those recommendations. As that strategy is being developed, I would encourage the Minnesota Wheat Growers to consider participating in this work.

Appendix

Table 1. Statistical analysis for the P rate by P source by P application method trial at two experimental sites.

	NWROC					Site S			
	Grain	Grain	Total	Total		Grain	Grain	Total	Total
Source§§	Yield	Protein	Biomass	P		Yield	Protein	Bio-mass	P
	---------- PR > F ---------								
App	***	**	ns	ns		***	ns	ns	ns
P Source	ns	ns	ns	ns		*	**	ns	ns
P rate	***	***	ns	ns		ns	ns	ns	ns
App by P Source	ns	ns	ns	ns		ns	ns	*	ns
App by P rate	*	**	ns	ns		ns	ns	ns	ns
P Source by P rate	ns	ns	ns	ns		ns	ns	ns	ns
3-way	ns	ns	ns	ns		ns	ns	ns	ns

§ ***, **, *, and ns represent significance at 0.001, 0.01, 0.05, and not significant, respectively.
§§ App represents broadcast and starter P fertilizer applications, Source represent liquid and dry P fertilizer sources, and P rate represent 5 applied P rates of 0 – 80 lbs P_2O_5 A^{-1} equivalent.

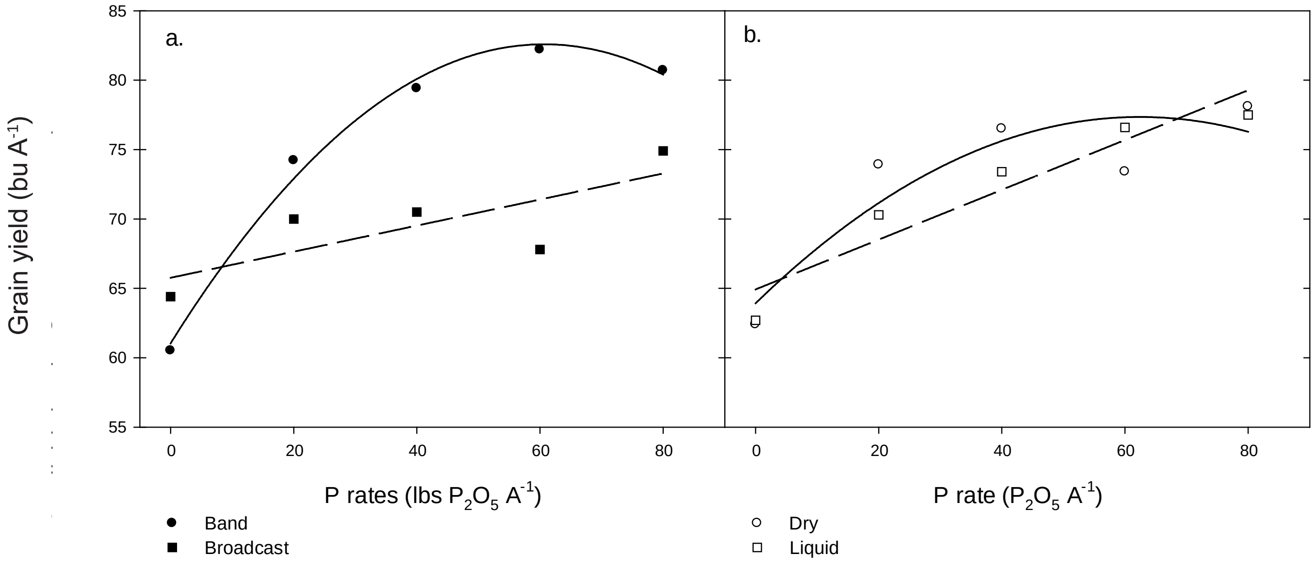

Figure 1. Grain yield response to applied P rates at NWROC experimental site when applied as either a starter at planting or pre-plant broadcast (a) or using a dry or liquid P fertilizer source (b).

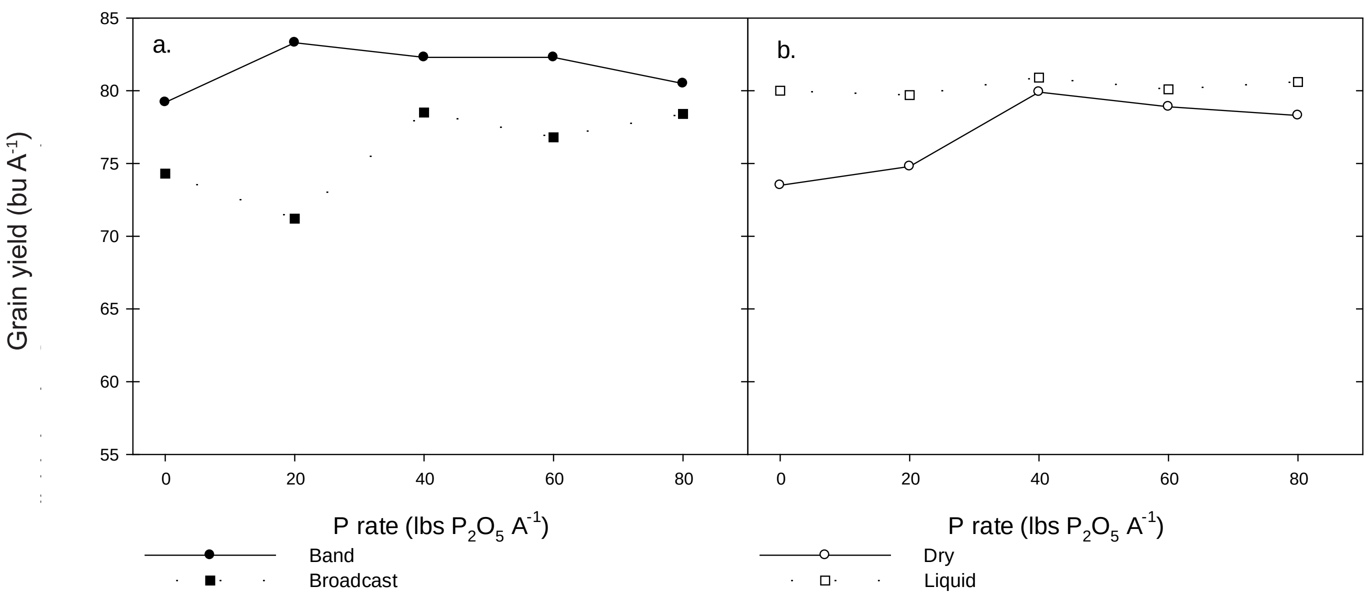

Figure 2. Grain yield response to applied P rates at Site S experimental site when applied as either a starter at planting or pre-plant broadcast (a) or using a dry or liquid P fertilizer source (b).

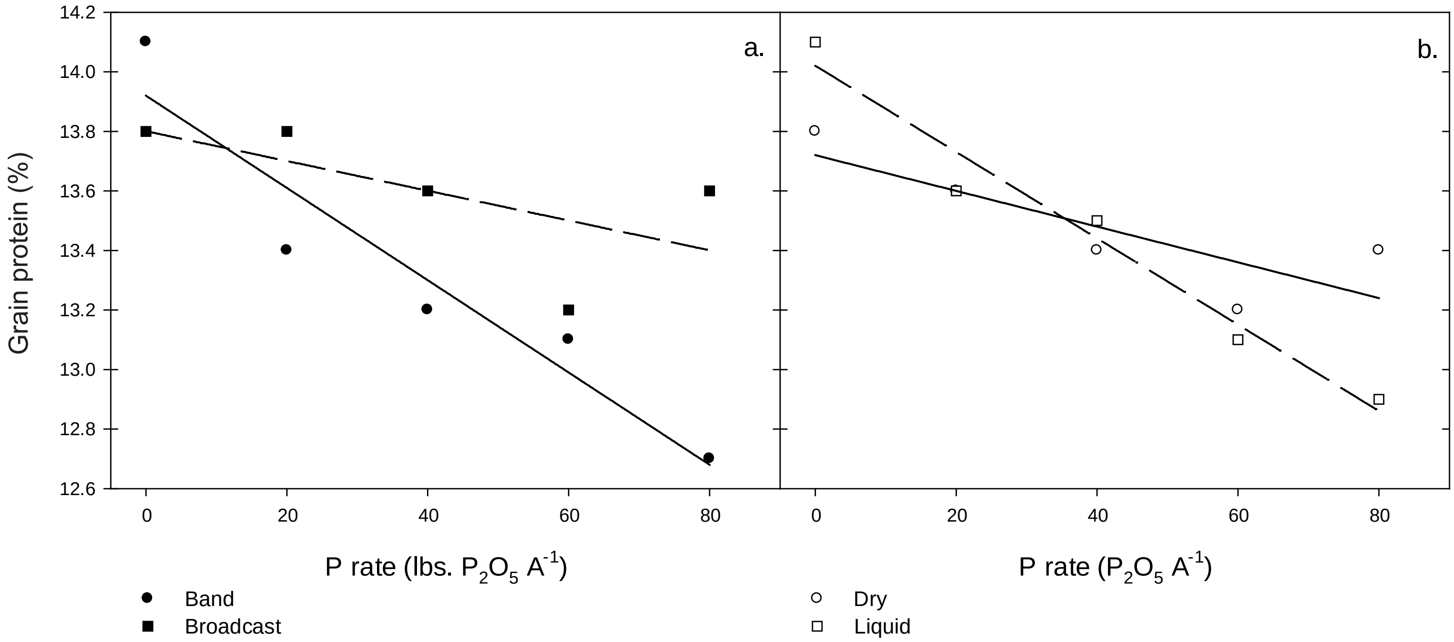

Figure 3. Grain protein response to applied P rates at NWROC experimental site when applied as either a starter at planting or pre-plant broadcast (a) or using a dry or liquid P fertilizer source (b).

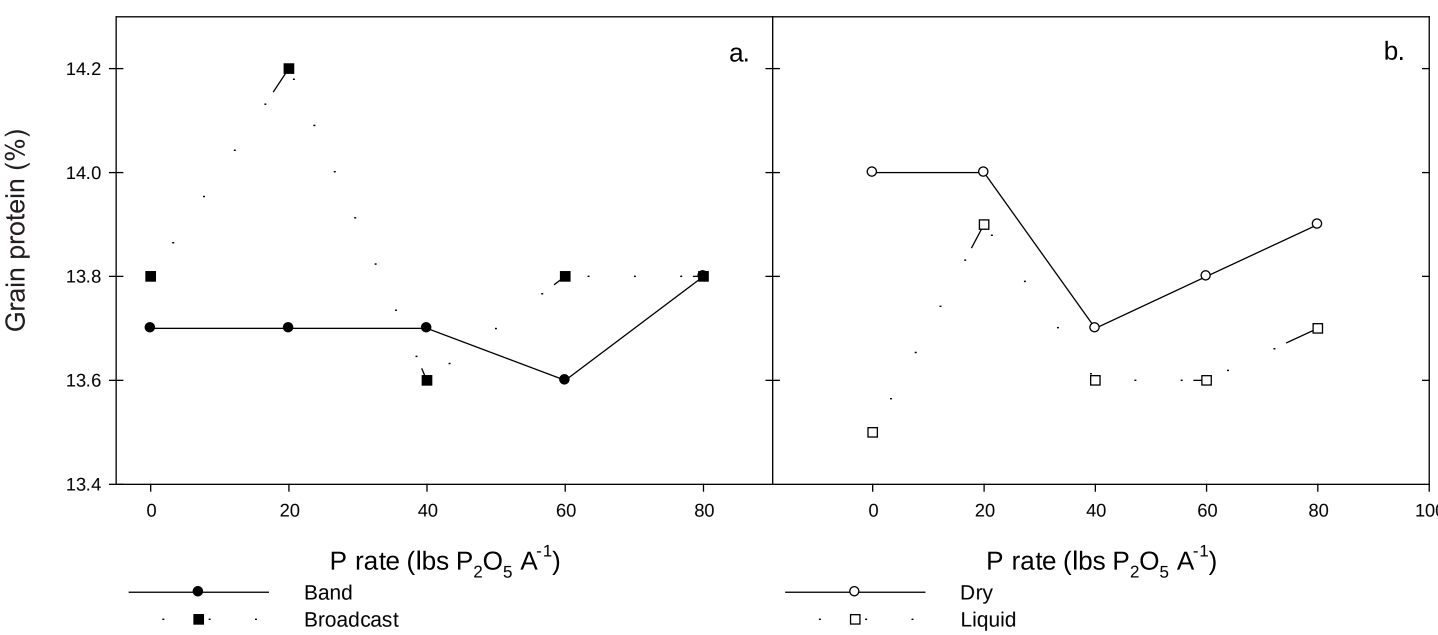

Figure 4. Grain protein response to applied P rates at Site S experimental site when applied as either a starter at planting or pre-plant broadcast (a) or using a dry or liquid P fertilizer source (b).

Continuation of the Intensive Management of the State Variety Trials for Hard Red Spring Wheat

Jochum Wiersma, Northwest Research & Outreach Center, U of M

Related Research

Due to the increased use of fungicides on wheat in Minnesota, we have implemented an additional variety trial in which fungicides are applied at the time of herbicide application (Feekes 5), flag leaf emergence (Feekes 9), and at the onset of flowering (Feekes 10.51). The objective of the research is to test varieties under both the conventional and intensive management approach, to measure varietal performance when fungal diseases are controlled to the maximum extent possible, and to report both sets of yield data. The practice of three fungicide applications during the growing season is not recommended. Grower's decisions regarding fungicide applications should be based on the available decision support systems, and only if and when disease levels are forecasted to reach economic damaging levels.

Results

The additional performance evaluations were carried out adjacent to the conventional (no fungicides applied) trials. The trials were conducted in Lamberton, Morris, Crookston, and Roseau. The trial in Morris was lost due to herbicide drift. Yield data of both the conventional and intensive management trials are summarized in Table 1. In 2008, the fungicide regime as applied in these trials increased grain yield across varieties 2.8 to 7.1 bu/A. The 2 and 3 year comparisons showed around a 5 bu/A yield increase across varieties and locations. Rather than the average increases in grain yield, the response of individual varieties provide the most useful information; varieties like Samson, Ada, Hat Trick, or Marshall that are rated susceptible to leaf rust, and/or powdery mildew benefited most from fungicide applications.

Application and Use

The last 5 years have clearly shown that significant rank changes occur for grain yield when the yield trials are treated with fungicides to prevent fungal pathogens affecting grain yield. These results are in line with the previously reported results in the literature (Guy et al. 1989; Jorgenson et al. 1994; Puppala et al. 1998, Wiersma and Motteberg 2005). This simple approach to test varieties under both the conventional and intensive management approach and to report both sets of yield data has been well received by growers. It is now an integral part of the State Variety Trials for Hard Red Spring Wheat.

Materials and Methods

The HRSW yield trials at the Research and Outreach Centers in Lamberton, Morris, Crookston, and the Magnusson Research Farm in Roseau Roseau have been expanded to include two identical, adjacent trials that differ in their pest management regime. The two management approaches are the standard system of conducting yield trials in which insects and fungal pathogens are not controlled and a second management approach that included the use of a fungicide at Feekes 5 in combination with fungicide treatments at Feekes 9 and 10.51 as well as the use of an insecticide to control any insect pests. The two management approaches are labeled 'intensive' and 'conventional'.

For the application at Feekes 5, Stratego (Bayer CropScience, Alexander Drive, Research Triangle Park, NC 27709, USA) - a mixture of 11.4% trifloxystrobin and 11.4% propiconazole - is used. Based on the recommendations for early season fungicide applications in the UK, one half of the labeled rate or 366 ml/ha of Stratego is applied (Home Grown Cereal Authority, 2000). For the application at Feekes 9, the labeled rate of 292 ml/ha of Tilt (propiconazole) (Syngenta Crop Protection, Inc., P.O. Box 18300, Greensboro, NC 27419) is used. For the fungicide application at Feekes 10.51, the labeled rate of 440 ml/ha of Prosaro (12.8% prothioconazole + 12.8% tebuconazole) (Bayer CropScience, Alexander Drive, Research Triangle Park, NC 27709, USA) is used. Fungicide applications are made using a tractor mounted sprayer that is equipped with 8002 Twin-Jet nozzles (Spraying Systems Co., North Avenue, Wheaton, IL 60188, USA) delivering 150 L/ha at 275 kPA. Fungicides are applied either in the morning or early evening to reduce drift. The timing of each application was based on the growth stage of the individual plots. Aphids are controlled based on the University of Minnesota threshold with a labeled insecticide.

Plots are harvested with a small plot combine. Harvested grain is dried and cleaned with a Clipper office tester and cleaner (Seedburo Equipment Co., Chicago, IL 60607, USA). Grain yield and test weight are expressed as bu/A and lbs/bu, respectively. Grain protein content is determined on a 0.5 kg sub-sample by near infrared transmission using a Tecator Infratec 1229 Grain Analyzer (Foss North America, Inc., Eden Prairie, MN 55344, USA) following AACC method 39-10 (American Association of Cereal Chemists 1995).

Economic Benefit to a Typical 500 Acre Wheat Enterprise

The economic benefit to a typical 500 acre wheat enterprise will vary greatly depending on the season's growing conditions and the disease reaction of individual varieties. While the Lamberton location showed significant leaf rust pressure, the locations in Crookston and Roseau showed very little disease overall. Consequently the yield differences were a lot smaller in the northern location as compared to Lamberton in 2008. The economic benefit to typical 500 acre wheat enterprise is a function of the variety considered. In 2008, varieties like Faller and Knudson showed little to no yield differences between the two sets of trials and thus one or more fungicide treatments were unwarranted. This could have resulted in a minimum cost savings of $3000.-, while controlling disease problems in Samson or Marshall in Lamberton could have yielded an additional $50,000 plus in gross farm receipts if we assume a cash bid of $6.50/bu.

Appendix

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Publications

Minnesota Varietal Trials Results, January 2007
Minnesota Varietal Trials Results, January 2008
Minnesota Varietal Trials Results, January 2009

Appendix (Continued): Table 1 - Grain yield (bushels per acre) of hard red spring wheat varieties grown under conventional and intensive management.

	North							*South*							*State*					
	2008		*2-year*		*3-year*			*2008*		*2-year*		*3-year*			*2008*		*2-year*		*3-year*	
Variety	*Conv*	*Int*	*Conv*	*Int*	*Conv*	*Int*		*Conv*	*Int*	*Conv*	*Int*	*Conv*	*Int*		*Conv*	*Int*	*Conv*	*Int*	*Conv*	*Int*
Ada	79.4	82.9	70.4	79.7	70.9	81.8		34.0	46.2	51.8	57.0	53.9	59.1		64.3	70.6	62.4	69.9	63.2	71.5
Albany	85.0	89.4	–	–	–	–		33.4	48.6	–	–	–	–		67.8	75.8	–	–	–	–
Alsen	76.8	75.3	65.2	69.1	69.3	72.3		41.4	47.0	48.7	56.3	49.8	55.9		65.0	65.8	58.1	63.6	60.5	64.9
Bigg Red	81.2	80.7	67.2	74.7	–	–		44.5	50.8	51.8	63.4	–	–		69.0	70.8	60.6	69.8	–	–
Blade	83.4	83.8	74.1	74.8	–	–		42.8	43.3	54.5	58.5	–	–		69.9	70.3	65.7	67.8	–	–
Breaker	84.8	86.3	–	–	–	–		40.3	45.2	–	–	–	–		70.0	72.6	–	–	–	–
Briggs	79.7	83.0	74.9	80.0	78.1	83.2		40.1	45.3	56.8	59.2	58.3	60.1		66.5	70.4	67.1	71.1	69.1	72.7
Cromwell	84.6	88.9	76.0	81.0	–	–		35.2	39.8	47.4	51.1	–	–		68.1	72.5	63.7	68.2	–	–
Faller	98.0	100.1	89.5	91.7	–	–		41.9	46.6	62.0	64.6	–	–		79.3	82.2	77.7	80.1	–	–
Freyr	82.8	87.3	74.7	82.0	75.2	82.7		39.8	46.5	52.5	59.5	55.9	61.6		68.5	73.7	65.2	72.3	66.4	73.1
Glenn	81.3	85.4	71.7	76.5	74.2	75.5		36.9	39.7	47.8	52.3	47.6	51.3		66.5	70.1	61.5	66.1	62.1	64.5
Granger	77.5	81.6	69.7	74.5	72.2	76.1		51.8	52.9	61.4	64.9	60.8	65.5		68.9	72.0	66.1	70.4	67.0	71.3
Hat Trick	84.3	87.1	70.8	77.2	–	–		38.6	39.3	53.3	57.1	–	–		69.1	71.1	63.3	68.6	–	–
Howard	83.0	85.7	73.6	80.0	77.7	80.5		46.9	51.6	55.0	62.4	57.9	63.7		71.0	74.3	65.6	72.4	68.7	72.9
Kelby	84.7	82.0	76.4	78.0	75.1	77.4		39.8	54.1	50.5	57.5	48.6	55.9		69.7	72.7	65.3	69.2	63.0	67.6
Knudson	81.8	81.2	74.9	78.1	77.3	81.0		49.4	53.4	61.5	66.8	61.1	64.4		71.0	71.9	69.2	73.2	69.9	73.5
Kuntz	87.1	87.5	76.6	82.0	–	–		34.4	44.9	51.9	55.3	–	–		69.5	74.0	66.0	70.5	–	–
Marshall	76.6	83.0	60.8	80.4	65.3	82.0		23.8	41.8	33.7	54.7	39.4	56.8		59.0	69.3	49.2	69.3	53.5	70.5
Oklee	82.0	84.8	71.9	78.6	71.9	76.7		35.7	45.1	47.1	56.2	49.5	56.9		66.6	71.6	61.3	69.0	61.7	67.7
RB07	82.5	87.6	72.7	76.6	–	–		39.9	48.1	49.8	56.1	–	–		68.3	74.4	62.9	67.8	–	–
Rush	77.1	72.7	69.0	70.4	67.6	70.9		37.0	43.0	47.9	50.5	48.0	49.3		63.8	62.8	59.9	61.9	58.7	61.1
Samson	91.4	98.3	80.8	89.6	–	–		38.6	54.0	53.7	64.4	–	–		73.8	83.5	69.2	78.8	–	–
Steele-ND	77.7	83.6	71.2	77.2	75.6	80.6		40.3	45.6	55.2	57.2	57.8	57.5		65.2	70.9	64.4	68.6	67.5	70.1
Tom	82.3	87.1	–	–	–	–		40.6	43.8	–	–	–	–		68.4	72.6	–	–	–	–
Traverse	88.1	82.9	79.9	79.8	82.3	81.4		52.0	58.6	61.4	71.7	64.1	70.5		76.1	74.8	71.9	76.3	74.0	76.4
Vantage	85.1	89.3	73.2	78.9	–	–		37.5	49.6	49.9	61.3	–	–		69.2	76.1	63.2	71.4	–	–
Mean (bu/A)	82.6	85.4	73.3	78.7	73.8	78.7		40.3	47.4	52.4	59.0	53.8	59.2		68.5	72.8	64.3	70.3	64.7	69.8
LSD (0.05)	10.5	9.2	7.5	7.7	6.2	6.3		9.6	7.0	6.8	8.2	5.5	5.9		8.6	7.2	5.4	6.1	4.3	4.5
No. Environ-ments	2	4	6		1	3	5		3	7	11									

Red River Valley Winter Wheat Production and the Responses of Management Inputs on Yield, Quality, and Economics

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Research Question

Winter wheat is established in the fall, permitting vegetative growth and early reproductive development during the cool temperatures of fall and early spring. Crop growth under these environmental conditions favors the development of more uniformly productive tillers and spikes than in spring planted cereals. However, proper management is needed in order to realize this higher yield potential in a consistent and profitable manner. The objective of this research is to determine which inputs commonly used in spring wheat are applicable in winter wheat and how these inputs interact with different winter wheat cultivars.

Results

No-till planting occurred on September 1, 14, and 28 in Fergus Falls, Casselton, and Crookston. The trial in Lamberton was planted on September 6, 21, and October 11. Nitrogen was top-dressed to treatments 1 and 4 after each planting date. Rain followed each planting date and mild temperatures resulted in rapid emergence and excellent initial stands. Plant population differences were detectable and were captured with stand counts. The mild temperatures in September extended through much of October. Growth and development of three planting dates were well ahead of the long-term average as a lack of cold temperatures through much of October didn't force dormancy until well into the month of November. Tan spot was prevalent across the sites and visually worst in the earliest planting date. Fergus Falls suffered severe drought stress and is not included in this initial analysis.

The delay in planting did not result in an increase in winterkill or delay off maturity for either cultivar in Crookston (Table 2). This indicates that the very mild 2007 fall in Crookston allowed enough growth that not only all planting dates hardened off sufficiently but also that all vernalization requirements were met across planting dates. In contrast, a delay in heading date was observed in both Lamberton and Prosper as planting was delayed (Table 2). This delay in maturity as planting is delayed has previously been reported by Fowler (1992) and signals that the vernalization and/or the winter hardiness were adversely impacted by the delay in planting. Jagalene headed approximately 4 days earlier across treatments compared the Jerry at both Prosper and Lamberton, while other input combinations did not affect heading date for either cultivar (data not shown).

Like heading date, plant height was not affected by either planting date or the other input combinations for either cultivar in Crookston (Table 2). In contrast, plant height decreased as planting was delayed in Prosper and Lamberton (Table 2). The reduction in plant height it likely a result of reduced spring vigor of the later seeding dates that slow development in early spring. Consequently more of the development of the winter wheat occurs later in the spring when temperatures have increased and growing degree days accumulate faster resulting in a shorter crop.

The lack of disease pressure in combination with the lack of response to the delay in planting date ultimately resulted that no differences were detected in grain yield, test weight, or grain protein in Crookston (Table 3). Jagalene yielded more than Jerry, but no differences were detected between input combinations within either cultivar. The differences in growth and development that were observed in Prosper did not affect grain yield, test weight, or grain protein as planting was delayed (Table 3). Jerry yielded more than Jerry, but no statistically significant differences were found between the different input combinations within or across planting dates for each variety individually (Table 3). This is unexpected as differences were found for the level of leaf rust and/or leaf diseases between treatments (data not shown) and points to a possible lack of precision resulting in a large experimental error. A possible solution is to increase the number of replication in the future years. A significant input combination x planting date interaction was found in Lamberton (data not shown). However, initial interpretation of the data does not answer which input was most influential. Similar to Prosper, Jerry yielded more than Jagalene when averaged across input combination.

Table 2 – Heading date and plant height of cv Jagalene and Jerry as affected by planting date in Lamberton, Prosper, and Crookston in 2008.

Planting Date	Heading Date			Plant Height		
	Crookston	Prosper	Lamberton	Crookston	Prosper	Lamberton
	----------- (June) ---------------------			---------------- (cm) -------------------		
Early	22	15	6	100	94	61
Optimum	22	17	7	96	92	70
Late	23	20	11	97	88	58
LSD(0.05)	ns	1	1	ns	3	8

Table 3 – Grain yield of cv Jagalane and Jerry across planting dates in Lamberton, Prosper, and Crookston in 2008

Treatment	Lamberton		Prosper		Crookston	
	Jagalene	Jerry	Jagalene	Jerry	Jagalene	Jerry
	-- bu/A --					
1 (Check)	49	63	79	79	127	107
2	62	61	94	106	133	116
3	62	60	99	110	139	117
4	59	68	91	99	140	114
5	55	64	95	97	137	106
6	56	71	91	111	139	128
7	56	60	92	100	132	110
8	61	62	99	113	143	119
LSD(0.05)	ns	ns	ns	ns	ns	ns

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Application and Use

Winter wheat can be an important component of the cropping systems in Minnesota and North Dakota. The primary constraint to winter wheat production in both states has been stand loss and winter injury. Newer varieties and production practices have reduced this risk, making winter wheat a more viable option. Winter wheat is very well suited for no-till cropping systems in which standing residue traps snow and reduces winter kill by insulating the crop from lethal temperatures.

Winter wheat can spread out the demands of labor and equipment on the farm as it is planted and harvested when there are few management activities occurring in other crops. As a component of the cropping system, winter wheat can reduce soil losses from wind during the winter months and runoff in the spring. Furthermore, winter wheat can be highly productive and profitable as it has higher yield potential than spring wheat. The evaluation of crop inputs commonly used in spring wheat in winter wheat will help ensure that the full yield potential and profitability of winter wheat can be realized.

Materials and Methods

The trial was established in the fall of 2007 in Crookston, Prosper, Fergus Falls, and Lamberton.

Experimental treatments were organized in a split-plot arrangement with 3 replicates. Planting dates was used as the whole plot treatments to facilitate the seeding of the individual plot with a tractor mounted plot drill. The planting dates were approximately two weeks apart with the first planting date being two weeks prior to the optimum planting date and the third seeding date being two weeks past the optimum planting date at each of the four locations.

The HRWW cultivars 'Jagalene' and 'Jerry' in combination with the eight different combinations of inputs were considered the split plot treatments. The HRWW cultivars Jerry and Jagalene were chosen because of their difference in winter hardiness, leaf rust resistance and plant height. The combinations of other inputs that were included in this trials were a standard versus (23 plants/ft2) an increased seeding rate (28 plants/ft2), the use of a seed treatment (Dividend Extra), application of all N requirements pre-plant versus a split application of N in the fall and following pring, and the use of fungicides at the 4-5 leaf stage, flag leaf emergence, and to suppress FHB at flowering.

For the application at Feekes 5, Stratego (Bayer CropScience, Alexander Drive, Research Triangle Park, NC 27709, USA) - a mixture of 11.4% trifloxystrobin and 11.4% propiconazole - was used. Based on the recommendations for early season fungicide applications in the UK, one half of the labeled rate or 366 ml/ha of Stratego was applied (Home Grown Cereal Authority, 2000). For the application at Feekes

Table 1. Overview of the different input combinations applied to cv 'Jerry' and 'Jagalene' planted at three different planting dates in Crookston, Fergus Falls, Lamberton, MN and Prosper, ND.

Treatment	Seeding Date	Seeding Rate	Seed Treatment	N Split Application	Fungicides Early	Flag Leaf	Flowering
1	(early)	-	-	-	-	-	-
2		-	+	+	+	+	+
3		+	-	+	+	+	+
4		+	+	-	+	+	+
5		+	+	+	-	+	+
6		+	+	+	+	-	+
7		+	+	+	+	+	-
8		+	+	+	+	+	+
9	(optimum)	-	-	-	-	-	-
10		-	+	+	+	+	+
11		+	-	+	+	+	+
12		+	+	-	+	+	+
13		+	+	+	-	+	+
14		+	+	+	+	-	+
15		+	+	+	+	+	-
16		+	+	+	+	+	+
17	(late)	-	-	-	-	-	-
18		-	+	+	+	+	+
19		+	-	+	+	+	+
20		+	+	-	+	+	+
21		+	+	+	-	+	+
22		+	+	+	+	-	+
23		+	+	+	+	+	-
24		+	+	+	+	+	+

9, the labeled rate of 292 ml/ha of Tilt (propiconazole) (Syngenta Crop Protection, Inc., P.O. Box 18300, Greensboro, NC 27419) was used. For the fungicide application at Feekes 10.51, the labeled rate of 440 ml/ha of Prosaro (12.8% prothioconazole + 12.8% tebuconazole) (Bayer CropScience, Alexander Drive, Research Triangle Park, NC 27709, USA) was used. Fungicide applications were made using a tractor mounted sprayer that is equipped with 8002 Twin-Jet nozzles (Spraying Systems Co., North Avenue, Wheaton, IL 60188, USA) delivering 150 L/ha at 275 kPA or with a backpack sprayer delivering an equivalent spray volume and pressure. Fungicides were applied either in the morning or early evening to reduce drift. The timing of each application was based on the growth stage of the individual plots.

The proposed crop input combinations are summarized in Table 1. The 'drop-out' treatment design allowed evaluation of the efficacy of individual crop input decisions in a much more efficient manner compared to a full or fractional factorial design. An underlying assumption, however, is that all crop inputs considered are additive in nature.

Harvested grain was dried and cleaned. Grain yield and test weight were adjusted to 13.5% moisture and expressed as bu/A and lbs/bu, respectively. Grain protein content was determined on a 0.5 kg subsample by near infrared transmission using a Tecator Infratec 1229 Grain Analyzer (Foss North America, Inc., Eden Prairie, MN 55344, USA) following AACC method 39-10 (American Association of Cereal Chemists 1995).

Photo 1. Stand of winter wheat no-till planted September 14, 2007, in standing spring wheat stubble near Crookston on October 26, 2007.

Photo 2. Stand of winter wheat no-till planted September 28, 2007, in standing spring wheat stubble near Crookston on October 26, 2007.

UNIVERSITY OF MINNESOTA EXTENSION SERVICE
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2008 Wheat, Barley and Oat Variety Performance in Minnesota
Preliminary Report

Preface
Jochum Wiersma

Record high prices for old and new crop wheat in March made many almost giddy about wheat; it is not often that a virtually guaranteed profit can be locked in prior to planting despite rapidly escalating input costs. The record prices for the three major commodities resulted in competition for acreage and consequently higher contract prices for many of the smaller commodities and specialty crops, including barley. The malt and brewing industry also signaled a willingness to work with the region's producers to maintain and even expand barley acreage and ensure a domestic supply of malt barley that is both secure and reliable.

Temperatures in the first half of April were unseasonably cool and late April rains and snow slowed spring field-work further. By the third week of April, topsoil moisture was rated adequate for most of Minnesota; likewise, sub-soil moisture was rated adequate for all but the northeastern third of the state. By the end of April land preparation and planting for all crops were about two weeks behind the 5-year average. By April 27th, only 6% of spring wheat was planted compared to 15% in 2007 and 33% average on that date.

Field work did not start in earnest until the end of first week of May. By May 4th, spring wheat was 19% planted compared to 61% last year and 64% for the 5-year average. Just short of half the acreage was planted between May 4th and May 11th. Planting neared completion by May 18th as 91% of spring wheat was planted. All small grains were planted by the fourth week of May. As average temperatures continued to be unseasonable cool, emergence and initial development of the small grains was slow. Only 39% of spring wheat emerged by May 18th, compared to 74% emerged in 2007. By the end of May, emergence remained behind at 71%, trailing by 22% compared to last year.

Lack of precipitation started to impact topsoil moisture in the heart of the Red River Valley, but heavy precipitation across the state in the first week of June alleviated any drought concerns. As average temperatures remained below average, crop development continued to be further delayed and was well behind not only last year, but the 5-year average. The wet weather continued through the middle of the month causing drown outs and flooding all along the South Dakota border and well into the southern and central portions of the Red River Valley. The cool temperatures resulted in very lush wheat and barley crop with a tremendous yield potential as both tiller and head initiation occurred during very cool, favorable growing conditions. Fortunately, lodging problems were generally limited to the areas that endured severe thunderstorms in late July.

The trend of slightly cooler to normal growing conditions continued and heading was on average two weeks later than last year. Likewise harvest was several weeks later, with growers in the most northern counties - like Roseau and Lake of the Woods - not being able to harvest until well into the month of September.

The USDA forecasted Minnesota's spring wheat yield to average 50 bushels per acre on July 1. In the September Small Grain Summary, Minnesota's spring wheat yield was adjusted up to 56 bushels per acre, the second highest average yield ever recorded. Individual reports of grain yield exceeding 90 bushels per acre were not uncommon.

The overall quality of the crop was excellent with little to no concerns about contamination with DON, the mycotoxin associated with Fusarium head blight. Test weight was generally excellent while grain protein varied greatly with many producers reporting lower than expected/desired grain protein contents and, consequently, sizeable discounts at harvest.

Disease problems, in general, were low with tan spot being the most prevalent. Leaf rust caused only significant losses when left untreated in late planted spring wheat. Some late planted spring wheat in Roseau and Lake of Woods had significant damage due to FHB. Disheartening and sobering is the fact that the weather-based risk models appeared to under predict the risk of economic losses due to FHB in these instances. This should remind all that vigilance against this disease remains paramount. An integrated approach of not only fungicides but also crop rotation and variety selection are crucial to limit economic losses to this disease.

Spring wheat acreage increased 6% to 1.85 million acres planted and 1.80 million acres harvested. Winter wheat acreage jumped another 15% to 75,000 acres statewide in 2008. The average winter wheat yield improved 4 bushels to 52 bushels per acre this year. Barley acreage remained stable at 110,000 acres while oat acreage declined slightly to 175,000 acres. The increase in acreage and the near record production meant that Minnesota spring wheat production was up 30 percent from 2007, breaking 100 million bushels for the first time since 2003.

Introduction

Successful small grain production begins with selection of the best varieties for a particular farm or field. For that reason, varieties are compared in trial plots on the Minnesota Agricultural Experiment Station (MAES) sites at St. Paul, Rosemount, Waseca, Lamberton, Morris, and Crookston. In addition to the six MAES locations, trials are also planted with a number of farmer cooperators. These plots are handled such that the factors affecting yield and performance are as close to uniform for all entries at each location as possible.

The MAES 2008 Wheat, Barley and Oat Variety Performance in Minnesota Preliminary Report is presented under authority granted by the Hatch Act of 1887 to the Minnesota Agricultural Experiment Station to conduct performance trials on farm crops and interpret data to the public.

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Variety Classifications

Varieties are listed in the tables alphabetically. No other distinction or classification is used to group varieties. Seed of tested varieties can be eligible for certification, and use of certified seed is encouraged. However, certification does not imply a recommendation. Registered and certified seed is available from seed dealers or from growers listed in the 'Minnesota Crop Improvement Association 2009 Directory', available through the Minnesota Crop Improvement Association office in St. Paul or online at http://www.mncia.org/publications.html.

Interpretation of the Data

The presented data are the preliminary variety trial information for single (2008) and multiple year (2006-2008) comparisons in Minnesota. The yields are reported as a percentage of the location mean, with overall mean (bu/A) listed below. Two-year and especially one-year data are less reliable and should be interpreted with caution. Similarly, averages across multiple environments, whether they are different years and/or locations, provide a more reliable estimate of mean performance. The least significant difference or LSD is a statistical method to determine whether the observed yield difference between any two varieties is due to true, genetic differences between the varieties or to interactions with other variables such as a difference in soil fertility or experimental error. If the difference in yield between two varieties equals or exceeds the LSD value, the higher yielding one was indeed superior in yield. If the difference is less, the yield difference may have been due to chance rather than genetic differences, and we are unable to distinguish between the two varieties. The 5% unit indicates that with 95% confidence, the observed difference is indeed a true difference in performance. Lowering this confidence level will allow more varieties to appear different from each other, but also increases the chances that false conclusions are drawn.

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SPRING WHEAT

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The results of the state yield trials are summarized in Tables 1 through 6. The average yield across the southern testing locations (St. Paul, Waseca, Lamberton and Morris) was 56 bu/A in 2008. This compares to an average of 58 bu/A in 2007 and a three-year average of 66 bu/A. The northern locations (Crookston, Stephen and Roseau) averaged 82 bu/A in 2008 compared to 74 bu/A last year and the three-year average.

Tables 2, 3, and 4 present the relative grain yield of tested varieties in 1, 2, and 3-year comparisons. ‘Traverse’, the 2006 release from SDSU, was the top yielding cultivar in both the northern and southern testing locations in 2008. ‘Faller’ continued to impress in the northern locations but did not do as well in the southern locations in 2008, largely due to below par results in St. Paul and Waseca. In the 2-year comparisons Traverse and Faller share the high mark for grain yield. Based on three years of trial comparisons, ‘Briggs’, ‘Faller’, ‘Howard’, ‘Knudson’, ‘RB07’, and ‘Steele-ND’ continue to do well across the state.

The varietal characteristics are presented in Tables 1, 5, and 6. Losses and damages due to Fusarium head blight (FHB) were minimal in 2008. Vigilance toward FHB remains paramount while close attention should be given to the leaf rust resistance ratings. Varieties that are rated 4 or better are considered the best hedge against the diseases. Varieties that are rated 7 or higher are likely to suffer significant economic losses under even moderate disease pressure. Briggs, Glenn, Steele-ND, Howard, Faller, and RB07 maintained a 1 rating for leaf rust. Carefully consider a variety’s rating to leaf and stripe rust, and plan to use a fungicide if a variety is rated 5 or higher to either leaf rust or stripe rust and disease levels warrant treatment. The foliar disease rating represents the total complex of leaf diseases other than the rusts, and includes the Septoria complex and tan spot. Although varieties may differ for their response to each of those diseases, the rating does not differentiate among them. Exceptions are ‘Ada’ and ‘Hat Trick’ which are rated susceptible to powdery mildew. Therefore, the rating should be used as a general indication and only for varietal selection in areas where these diseases historically have been a problem or if the previous crop is wheat or barley. Control of leaf diseases with fungicides may be warranted, even for those varieties with an above average rating.

Leading varieties in Minnesota, based on acres planted in 2007, include Knudson, 'Freyr', Glenn, Oklee and Briggs with approx. 12%, 11%, 10%, 9%, and 8% respectively. 'Breaker' was the only new entry in the trials, while testing of some well-known varieties including 'Oxen', 'Granite', 'Ulen' and 'Polaris' was discontinued.

Variety selection for 2009 continues to be a balance between yield potential, disease responses, and grain quality. Faller and Glenn are proven varieties that provide the best available genetic resistance to FHB and should be considered as hedges against this disease. Other varieties with a 4 or better scab rating and above-average yield include Blade, Cromwell, Freyr, Hat Trick, and Tom. Faller, Briggs, Knudson, Traverse, and RB07 continue to impress as high yielding varieties across the state. Traverse's poor agronomic characteristics and grain protein content, however are a major drawback for this variety. Varieties with above-average yield in on-farm testing and protein include Blade, Briggs, Cromwell, Granger, Howard, RB07 and Steele-ND.

BARLEY

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Yield averages for barley in Minnesota were 65 Bu/A compared to 56 Bu/A last year resulting in production of about 7.2 million bushels. Growing conditions were generally good across the five test locations for barley variety trials in Minnesota. The highest yields were in Roseau and the lowest in St. Paul (Table 7). Fusarium head blight (FHB) was essentially absent presumably due to unfavorable conditions for disease development.

The yield data in Table 7 were collected from advanced yield trials that contain the important varieties for the region planted in five locations in the state. Yield data is presented as percent of the mean of the varieties listed in the table. The mean of the varieties is presented in bu/A. Rasmusson, Legacy, Tradition, and Lacey were the highest yielding varieties based on three year state averages (Table 7). Drummond is the most lodging resistant of the group (Table 8). The two-rowed variety Conlon had the plumpest grain while Legacy was a little thinner than the other varieties.

Table 9 describes the reaction of the currently grown varieties to the five major diseases in the region. Disease reaction is based on at least three years of data and scored from 1 – 9 where 1 is most resistant and 9 is most susceptible. While there are some small differences among the varieties for resistance to some of these diseases, these differences are small and should not be the primary basis for selection among the different varieties.

OATS

Deon Stuthman, Roger Caspers, Ruth Dill-Macky,
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Oat acreage declined 3% to 175.000 acres across the state. The state average yield improved with 8 bu/A to 68 bu/A. The cooler growing conditions favored not only crop development yield potential but also crown rust development. By early June buckthorn bushes in most parts of the state were heavily infected, providing a majority of the local inoculum. The level of crown rust infection in the oat crop, however, was les than expected in most areas due to drier, unfavorable conditions as the progressed. The average yield across the five primary test sites was 107 bu/A, 3 bushels less than last year's 110 bu/A average.

Stallion (SD) and Excel (Purdue) continue to be top ranking oat varieties for grain yield across the state in both single year and multiple year comparisons. Esker (WI) is a close third.

Table 1. Origin and agronomic characteristics of Hard Red Spring Wheat varieties in Minnesota in single year (2008) and multiple year comparisons (2006-2008).

Variety	Agent/Origin[1]	Year of Release	Days to Heading[2] - days -	Plant Height[2] - inches -	Straw Strength[3]
Ada	MN	2006	62.3	31.1	4
Alsen	NDSU	2000	61.7	32.9	4
Bigg Red	WestBred	2004	62.6	35.1	6
Blade	WestBred	2007	63.0	32.7	4
Breaker	WestBred	2008	62.6	32.5	3
Briggs	SDSU	2002	60.3	32.5	7
Cromwell	Thunder Seed	2007	63.6	32.3	5
Faller	NDSU	2007	63.4	31.9	5
Freyr	AgriPro	2004	63.0	32.9	6
Glenn	NDSU	2005	60.6	34.2	4
Granger	SDSU	2004	61.8	35.4	7
Hat Trick	Trigen	2006	62.7	31.3	5
Howard	NDSU	2006	61.9	34.2	7
Kelby	AgriPro	2006	60.1	29.0	4
Knudson	AgriPro	2001	62.7	31.1	5
Kuntz	AgriPro	2007	63.0	30.1	4
Marshall	MN	1982	64.8	30.1	4
Oklee	MN	2003	60.3	31.7	6
RB07	MN	2007	60.5	31.6	5
Rush	WestBred	2006	60.8	31.7	2
Samson	WestBred	2007	62.8	29.6	2
Steele-ND	NDSU	2004	62.0	34.1	7
Tom	MN	2008	61.9	32.9	7
Traverse	SDSU	2006	60.3	34.6	6
Vantage	WestBred	2007	66.3	32.1	2
Mean			62.2	28.9	

[1] Abbreviations: MN = Minnesota Agricultural Expt. Station; NDSU = North Dakota State University Research foundation; SDSU = South Dakota Agricultural Expt. Station.; Trigen = Trigen Seed Services LLC.
[2] 2008 data.
[3] 1-9 scale in which 1 is the strongest straw and 9 is the weakest. Based on 2004-2008 data. The rating of newer entries may change by as much as one rating point as more data is collected.

Table 2. Relative grain yield of Hard Red Spring Wheat varieties in southern locations in Minnesota in single year (2008) and multiple year comparisons (2006-2008).

	Lamberton			Morris [1]			St. Paul			Waseca		
Variety	1 yr.	2 yr.	3 yr.	1 yr.	2 yr.	3 yr.	1 yr.	2 yr.	3 yr.	1 yr.	2 yr.	3 yr.
	----- % of mean -----											
Ada	85	95	100		99		74	77	86	104	82	87
Alsen	103	97	96		89		103	98	96	90	92	96
Bigg Red	111	102	101		99		99	100	98	92	99	98
Blade	106	108	–		-		101	103	–	96	100	–
Breaker	100	–	–		-		103	–	–	105	–	–
Briggs	100	111	110		108		110	110	107	83	92	95
Cromwell	88	87	–		-		99	99	–	90	90	–
Faller	104	119	117		115		87	97	102	93	106	105
Freyr	99	100	101		109		104	108	105	95	95	97
Glenn	92	98	95		82		100	101	95	88	95	92
Granger	129	124	120		105		99	99	98	76	100	102
Hat Trick	96	104	100		105		76	78	83	94	105	103
Howard	117	114	112		107		112	114	110	115	118	111
Kelby	99	100	96		84		121	127	119	97	106	103
Knudson	123	124	119		109		91	89	93	109	104	103
Kuntz	86	94	–		-		105	103	–	94	96	–
Marshall	59	61	67		83		74	73	82	65	56	69
Oklee	89	89	90		95		111	112	106	98	108	105
RB07	99	103	105		100		109	110	107	111	105	102
Rush	92	92	91		88		112	104	99	95	95	91
Samson	96	102	–		-		108	105	–	110	109	–
Steele-ND	100	107	106		111		104	109	105	118	119	111
Tom	101	98	95		91		105	107	106	86	90	91
Traverse	129	123	124		115		98	99	103	117	119	117
Vantage	93	96	–		-		100	90	–	100	95	–
Mean (bu/A)	40	44	46		69		70	65	74	59	56	60
LSD (0.05)	23.8	22.3	14.2		17.1		9.6	12.4	13.8	23.3	21.6	17.0

[1] The Morris 2008 trial was abandoned due to herbicide drift damage. The 2-year data is from 2006-2007.

Table 3. Relative grain yield of Hard Red Spring Wheat varieties in northern locations in Minnesota in single year (2008) and multiple year comparisons (2006-2008).

	Crookston			Roseau			Stephen			On-Farm		
Variety	1 yr.	2 yr.	3 yr.	1 yr.	2 yr.	3 yr.	1 yr.	2 yr.	3 yr.	1 yr.	2 yr.	3 yr.
	-- % of mean--											
Ada	99	97	97	93	98	98	99	98	94	99	100	99
Alsen	95	92	93	91	85	92	87	88	91	96	94	95
Bigg Red	92	92	93	105	89	94	88	90	91	96	91	93
Blade	101	101	–	101	104	–	93	100	–	99	103	–
Breaker	102	–	–	104	–	–	106	–	–	101	–	–
Briggs	96	100	105	97	112	108	87	94	98	98	101	104
Cromwell	102	101	–	103	110	–	95	97	–	99	103	–
Faller	114	123	117	123	125	121	103	115	110	106	112	–
Freyr	105	107	104	95	99	99	95	98	98	99	103	101
Glenn	94	97	95	103	100	104	105	98	98	95	99	100
Granger	95	95	95	93	99	101	85	88	93	103	101	104
Hat Trick	100	97	92	104	96	94	100	108	98	100	103	100
Howard	98	99	103	103	105	107	95	102	103	98	–	–
Kelby	101	101	102	104	112	103	108	103	98	96	95	97
Knudson	100	104	106	98	103	104	100	106	106	104	108	108
Kuntz	106	109	–	105	100	–	107	103	–	102	107	–
Marshall	96	84	89	89	81	85	86	84	83	82	72	76
Oklee	94	95	95	105	104	99	103	99	97	100	99	101
RB07	106	108	108	94	90	91	112	109	112	102	105	105
Rush	88	89	88	99	103	96	103	98	99	93	95	94
Samson	110	112	–	112	111	–	108	112	–	104	108	–
Steele-ND	96	99	101	93	99	104	96	96	100	99	105	106
Tom	99	101	103	100	105	105	118	107	110	104	101	102
Traverse	103	107	108	110	115	115	118	115	116	104	111	111
Vantage	89	96	–	117	104	–	91	98	–	91	93	–
Ada	99	97	97	93	98	98	99	98	94	99	100	99
Mean (bu/A	98	88	84	68	59	66	79	74	73	91	81	75
LSD (0.05)	5.7	10.4	11.5	11.9	17.9	14.8	17.3	17.2	12.6	17.1	13.6	10.4

Table 4. Relative grain yield of Hard Red Spring Wheat varieties in Minnesota in single year (2008) and multiple year comparisons (2006-2008).

	State			North			South		
Variety	1 yr.	2 yr.	3 yr.	1 yr.	2 yr.	3 yr.	1 yr.	2 yr.	3 yr.
	---------------------------------- % of mean --------------------------------------								
No. Environments	6	13	20	3	6	9	3	7	11
Ada	93	93	94	97	98	96	84	86	91
Alsen	94	92	93	91	89	92	98	95	95
Bigg Red	96	95	96	94	90	92	99	99	99
Blade	99	102	–	98	102	–	100	103	–
Breaker	103	–	–	104	–	–	103	–	–
Briggs	95	103	104	93	102	104	98	104	104
Cromwell	97	98	–	100	103	–	93	93	–
Faller	105	114	112	113	121	116	93	106	107
Freyr	99	101	102	99	102	100	99	101	102
Glenn	98	97	95	100	98	99	94	96	92
Granger	95	101	101	91	94	96	100	107	106
Hat Trick	95	98	96	101	100	95	87	95	96
Howard	103	106	106	96	101	103	114	113	110
Kelby	105	107	102	104	105	101	107	109	103
Knudson	102	105	105	99	105	105	105	105	105
Kuntz	102	102	–	106	104	–	96	99	–
Marshall	81	75	81	91	83	86	67	65	74
Oklee	100	101	99	100	99	97	101	102	100
RB07	106	104	104	108	104	105	107	104	104
Rush	98	97	94	98	97	95	101	98	94
Samson	108	109	–	109	111	–	106	106	–
Steele-ND	100	104	105	95	98	101	108	110	108
Tom	102	102	101	106	105	106	97	98	96
Traverse	111	112	113	110	112	113	112	112	114
Vantage	98	96	–	97	98	–	98	95	–
Mean (bu/A)	69	65	67	82	74	74	56	58	61
LSD (0.05)	9.1	6.9	5.3	10.1	8.1	6.7	15.6	11.3	8.0

Table 5. Grain quality characteristics of Hard Red Spring Wheat varieties in Minnesota in single year (2008) and multiple year comparisons (2006-2008).

Variety	Test Weight 1 yr.	Test Weight 2 yr.		Protein[1] 1 yr.	Protein[1] 2 yr.		Baking Quality[2]	Pre-Harvest Sprouting[3]
	---- lbs/bu ----			---- % ----				
Ada	61.9	61.7		14.1	14.2		med.-high	2
Alsen	61.5	61.1		14.7	15.0		high	2
Bigg Red	63.2	62.5		14.0	13.7		med.-low	4
Blade	62.5	62.6		14.5	14.7		–	5
Breaker	62.7	–		14.3	–		–	–
Briggs	61.2	61.3		14.4	14.7		med.	2
Cromwell	61.9	61.8		14.6	14.7		–	3
Faller	60.8	60.9		14.3	14.3		med.	2
Freyr	60.0	60.0		14.2	14.3		med.	2
Glenn	63.5	63.4		15.3	15.5		high	1
Granger	60.9	60.8		14.9	14.7		med.	4
Hat Trick	62.0	61.6		14.0	14.0		med.-low	4
Howard	60.8	61.2		14.7	14.9		med.-high	1
Kelby	61.4	61.2		14.6	14.7		med.	1
Knudson	61.1	61.0		13.6	13.8		med.-high	3
Kuntz	60.4	60.3		13.9	13.9		–	2
Marshall	58.4	57.8		13.6	13.5		low	2
Oklee	62.0	61.4		15.0	14.9		low-med.	3
RB07	60.8	60.6		14.4	14.8		med.-high	2
Rush	62.5	62.0		14.7	14.7		med.-high	2
Samson	60.2	59.9		13.9	13.9		–	4
Steele-ND	61.5	61.5		14.8	15.0		high	2
Tom	61.2	61.0		14.2	14.3		med.	1
Traverse	58.9	58.5		13.9	13.8		low	4
Vantage	62.6	62.2		15.4	15.3		–	2
Mean	61.4	61.1		14.4	14.5			

[1] 12% moisture basis.
[2] 2003-2007 crop years.
[3] 1-9 scale in which 1 is best and 9 is worst. Values of 1-3 should be considered as resistant.

Table 6. Disease reactions[1] of Hard Red Spring Wheat varieties in Minnesota in multiple year comparisons (2005-2007).

Variety	Leaf Rust	Stripe Rust	Stem Rust[2]	Other Leaf Diseases[3]	Scab
Ada	5	1	2	5[4]	6
Alsen	5	1	1	6	4
Bigg Red	8	–	2	7	3
Blade	2	–	2	3	4
Breaker	2	–	2	3	–
Briggs	1	1	2	5	5
Cromwell	4	–	1	4	4
Faller	1	–	1	3	4
Freyr	4	1	4	4	4
Glenn	1	1	1	4	3
Granger	3	1	1	4	5
Hat Trick	5	–	4	5[4]	4
Howard	1	–	1	4	6
Kelby	3	–	1	4	5
Knudson	2	3	3	3	6
Kuntz	3	–	1	4	6
Marshall	8	1	1	7	7
Oklee	4	1	1	5	5
RB07	1	1	1	5	5
Rush	5	–	4	5	5
Samson	5	–	1	6	7
Steele-ND	1	1	1	4	6
Tom	4	–	1	5	4
Traverse	5	–	2	5	5
Vantage	5	–	3	6	5

[1] 1-9 scale where 1=most resistant, 9=most susceptible.
[2] Stem rust levels have been very low in production fields in recent years, even on susceptible varieties.
[3] Includes tan spot, septoria, bacterial leaf blight, and powdery mildew.
[4] These varieties are more susceptible to powdery mildew.

Table 7. Relative grain yield of barley varieties at several locations in Minnesota in single year (2008) and multiple year comparisons (2006-2008).

	Crookston		Morris		Stephen		St. Paul		Roseau		State	
Variety	1 yr.	3 yr.	1 yr.	2 yr.[1]	1 yr.	3 yr.	1 yr.	3 yr.	1 yr.	3 yr.	1 yr.	3 yr.
	% of mean											
Conlon	86	91	-	90	67	88	71	79	101	94	81	88
Drummond	100	100	-	95	102	99	103	107	88	96	98	100
Lacey	109	103	-	104	114	109	115	104	108	99	112	103
Legacy	104	101	-	108	109	109	99	105	95	99	102	104
Rasmusson[2]	103	105	-	110	108	104	111	110	115	--	109	107
Robust	96	97	-	93	94	91	90	98	92	99	93	96
Stander	95	100	-	99	100	94	99	100	97	105	98	100
Stellar-ND	100	101	-	97	107	102	95	93	98	100	100	99
Tradition	107	100	-	104	99	104	116	104	107	107	107	103
Mean (bu/A)	123	110	-	81	118	102	109	101	135	100	121	101
LSD (0.05)	18.4	8.1	-	11.2	9.9	8.9	19.2	8.6	14.8	8.5	7.9	4.0

[1] Only two years of data, 2006 and 2007. [2] Only 1 year of Roseau data available.

Table 8. Agronomic characteristics of barley varieties in Minnesota in multiple year comparisons (2004-2008).

Variety	Type	Use	Days to Heading	Plant Height	Lodging	Plump	Protein
			-- days --	- inches -		--- % ---	--- % ---
No. Environments			15	14	15	12	12
Conlon	2-row	Malt	57	31.7	med.	93	13.5
Drummond	6-row	Malt	58	32.3	v. strong	83	13.7
Lacey	6-row	Malt	59	32.4	strong	87	14.1
Legacy	6-row	Malt	59	33.5	med.	82	13.4
Rasmusson[2]	6-row	Malt	58	30.9	strong	84	13.2
Robust	6-row	Malt	58	34.5	med.	86	13.9
Stander	6-row	Feed	59	31.7	strong	85	13.5
Stellar-ND[1]	6-row	Malt	58	32.4	strong	86	13.1
Tradition	6-row	Malt	59	33.0	med.	86	13.3

[1] Only three years of plump and protein data, 2005-2007.
[2] Only three years of plump and protein data, 2004-2006.

Table 9. Disease reaction[1] of barley varieties in Minnesota in multiple year comparisons.

Variety	Fusarium Head Blight	Net Blotch	Septoria Speckled Leaf Blotch	Spot Blotch	Stem Rust[2]
Conlon	7	5	9	3	1
Drummond	8	7	9	2	1
Lacey	8	8	9	2	1
Legacy	7	5	9	2	1
Rasmusson	8	9	9	2	1
Robust	8	8	9	2	1
Stander	9	8	9	2	1
Stellar-ND	8	7	9	2	1
Tradition	8	7	9	2	1

[1] 1-9 scale where 1=most resistant, 9=most susceptible.
[2] Reaction to the dominant strain of the stem rust pathogen.

Table 10. Relative grain yield of oat varieties in Minnesota in multiple year comparisons (2006-2008).

	Rose-mount		Waseca		Lamberton		Morris		Crookston		State	
Variety	1 yr.	3 yr.	1 yr.	3 yr.	1 yr.	3 yr.	1 yr.	2 yr[1].	1 yr.	3 yr.	1 yr.	3 yr.
	--- % of mean ---											
Baker	108	105	102	99	100	98	-	92	90	99	99	99
Beach	90	95	92	102	107	102	-	108	101	105	99	102
Buckskin	88	95	68	101	102	102	-	113	106	113	94	105
Esker	106	106	109	101	104	101	-	95	93	104	102	102
Excel[2]	105	106	102	108	107	109	-	111	102	103	104	107
Kame	80	94	88	96	107	101	-	92	73	93	87	95
Morton	71	88	96	104	93	96	-	90	100	98	92	95
Souris[2]	104	105	108	105	93	95	-	96	99	105	100	101
Stallion	112	108	92	106	110	109	-	111	91	98	101	106
Winona	91	98	75	79	102	88	-	91	72	82	85	87
Mean (bu/A)	76	93	70	90	115	108	-	127	126	123	97	107
LSD (0.05)	17.6	7.1	14.8	8.9	14.5	8.3	-	9.1	9.9	6.2	6.9	3.5

[1] The Morris 2008 trial was abandoned due to herbicide drift. The 2-year data are from 2006-2007.
[2] Two year data, 2007 and 2008.

Table 11. Relative grain yield of oat varieties in Minnesota in a single year (2008) comparison at off-station locations

Variety	Stephen
	--- % mean ---
Baker	108
Beach	100
Buckskin	95
Esker	105
Excel	103
Kame	76
Morton	103
Souris	110
Stallion	103
Winona	97
Mean (bu/A)	148
LSD (0.05)	5.4

Table 12. Agronomic characteristics of oat varieties in Minnesota in multiple year comparisons (2006-2008).

Variety	Days to Heading --- days ---	Plant Height - inches -	Lodging[1]	Test Weight - lb/bu -	Groat[2] -- % --
Baker	61	32	2.0	41.3	69.3
Beach	64	36	1.8	42.9	71.4
Buckskin	61	32	1.9	42.6	70.1
Esker	59	32	2.1	40.5	71.7
Excel[2]	59	31	2.0	40.0	67.8
Kame	58	30	1.9	38.8	70.7
Morton	64	36	2.0	40.6	69.4
Souris[2]	63	31	1.7	42.1	72.7
Stallion	63	36	2.4	41.9	70.5
Winona	57	31	1.9	41.0	71.6
Mean	61	33	2.0	41.2	70.5

[1] 1=Erect, 5=Flat.
[2] 2007-08 data, adjusted for 3 years.

Table 13. Disease reactions of oat varieties in Minnesota in single year (2008) comparisons.

Variety	Crown Rust[1]	Smut[2]	BYDV[3]
Baker	S	R	3.5
Beach	MS	MR	7.0
Buckskin	S	S	3.5
Esker	MS	R	4.5
Excel	MS	S	1.5
Kame	MS	MR	7.0
Morton	S	R	6.0
Souris	MR	R	5.0
Stallion	MS	S	6.5
Winona	S	MR	4.0

[1] R=resistant, MR=moderately resistant, MS=moderately susceptible and S=susceptible.
[2] Artificially inoculated nursery; R=resistant, MR=moderately resistant, MS=moderately susceptible and S=susceptible.
[3] Barley Yellow Dwarf Virus score from Univ. of Illinois with 1=no symptoms, 9=dead.

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