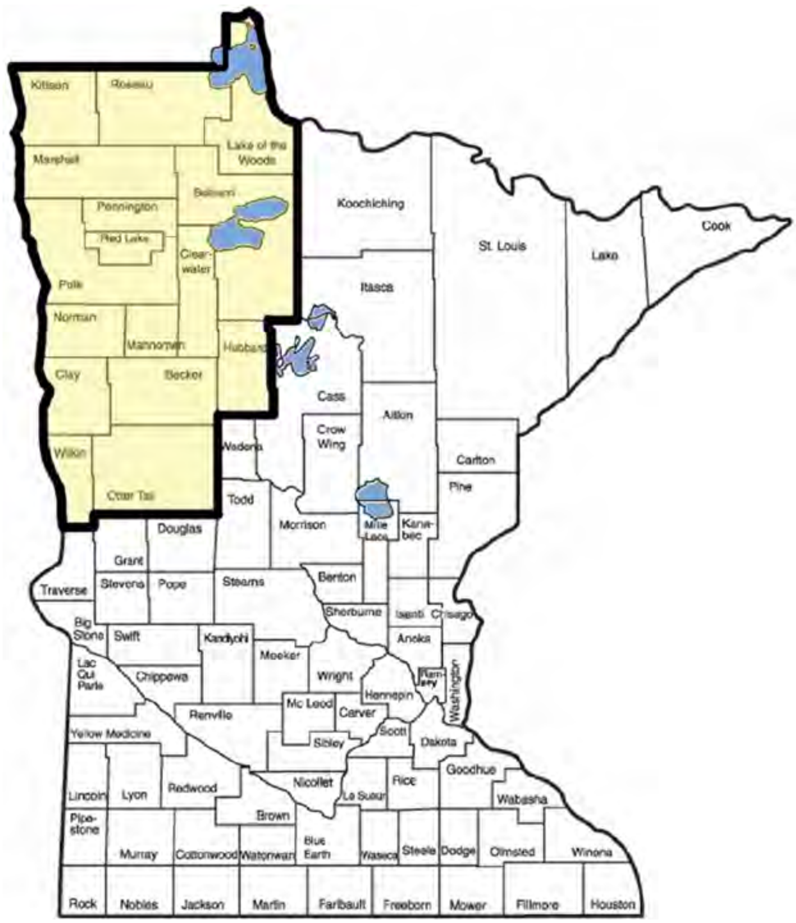
On-Farm Cropping Trials Northwest & West Central Minnesota and 2014 Minnesota Wheat Research Review



Minnesota Soybean Research & Promotion Council

Minnesota Wheat Research & Promotion Council

University of Minnesota Extension
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This is the seventh year the Research Review and On-Farm Cropping Trials have been combined into one booklet. Up until then, these reports have been published separately.

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, rseverso@umn.edu; Doug Holen, Extension Educator, Extension Regional Office, Fergus Falls, holen009@umn.edu; Phillip Glogoza, Extension Educator, Extension Regional Office, Moorhead, glogo001@umn.edu; Jochum Wiersma, Small Grain Specialist, Crookston, wiers002@umn.edu; Howard Person, Extension Educator, Pennington and Marshall Counties, Thief River Falls, perso005@umn.edu; Jim Orf, Dept Agronomy & Plant Genetics, St. Paul, orfxx001@umn.edu; Jeff Coulter, Extension Agronomist, Dept of Agronomy, St. Paul, coult077@umn.edu; Albert Sims, Soil Scientist, Crookston, simsx008@umn.edu; J Dan Kaiser, Extension Soil Scientist, St. Paul, dekaiser@umn.edu; Randy Nelson, Extension Educator, Clay County, MN, nels1657@umn.edu;

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://smallgrains.org/wheat-research-reports/

2014 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 2014 - 2015 Small Grains Research & Communications Committee include Brian Borge; Tony Brateng, Ryan Casavan, Wensman Seed; Mark Fillbrandt, Bigg Dogg Agg; David Garrett; Doug Holen, U of M Extension Service; Carter Hontvet; Peter Hvidsten; Scott Lee; Kevin Leiser; Richard Magnusson; Dave Willis, Agaassiz Crop Management; Greg LeBlanc, MN Wheat Council, David Torgerson, MN Wheat; Jochum Wiersma, U of M Small Grains Specialist; Marv Zutz, MN Barley.

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

Table of Contents:

On-Farm Cropping Trials For NW & WC MN

Wheat Research Reports - Funded in part by the Minnesota Wheat check-off

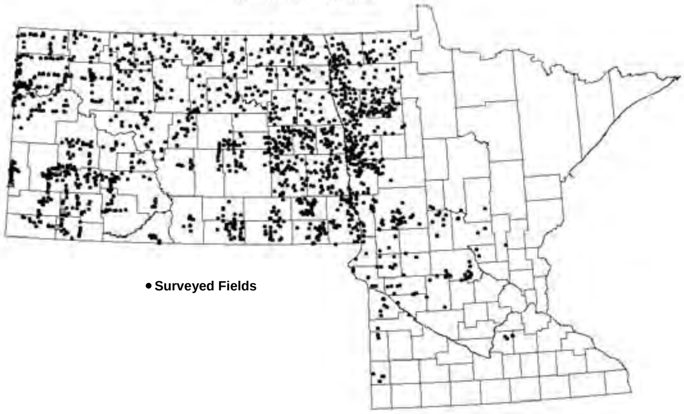
2014 Statewide Small Grains Pest Survey

Cooperator: Minnesota Association of Wheat Growers, NDSU IPM Survey

Purpose of Study:
The objective of this project was to allow for timely small grain crop staging and pest identification across the state of MN in order to inform producers of current crop conditions and potential threats. Information was released through media (e.g., radio, internet-based news releases, archived web pages, consultant conversations and e-mail. The survey was conducted in coordination with the established NDSU IPM Survey, providing extensive, continuous coverage of small grains across MN and ND.

Small Grain Field Locations Visited for Survey

Season Final, 2014



Results:
Field surveys were initiated the last week of May. Delayed planting conditions resulted in most of the crop being in the initial leaf to tillering stages, however there was earlier planting of a portion of the crop and reflected in some locations in the jointing stage *(see map for Growth Stages - June 9 to 20)*.

The most important insect related production issues were the appearance of cereal aphids which reached threshold levels in some regions of both states.

Small grain diseases by prevalence were Tan Spot, occurring throughout the region; Bacterial Leaf Streak in SW and WC MN; *Septoria* occurring with high incidences in NW MN; Barley Yellow Dwarf incidence was found where aphids established in WC MN; and, Head blight (scab) in SW and WC MN where wet conditions during heading contributed to higher than forecasted infections.

When reviewing the maps. ***Incidence*** is defined as "the percent of sampled plants with the disease." ***Severity*** is defined as "the percent of plant tissue that is diseased on affected plants." Therefore, maps that report incidence are reporting percent plants affected. Severity tells us how bad infections were.

To receive notification of the survey, subscribe to the Northwest Cropping Issues Newsletter at:

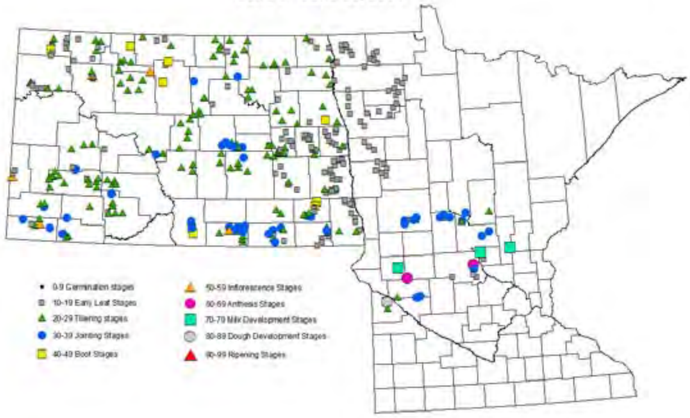
http://nwroc.umn.edu/Cropping_Issues/index.htm

Archived maps are maintained by NDSU and can be found at:

http://nwroc.umn.edu/Cropping_Issues/index.htm

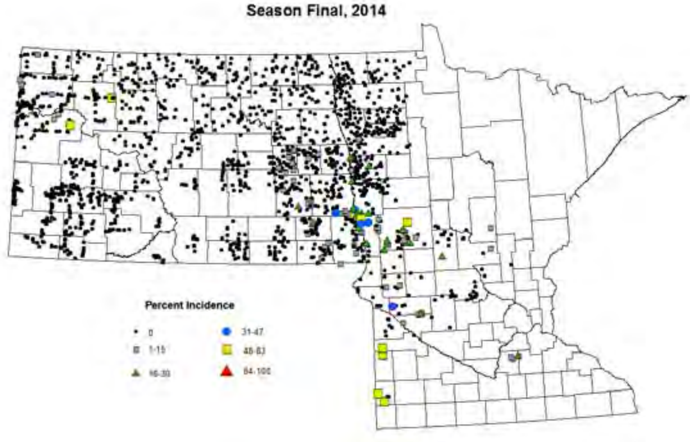
Wheat Growth Stages

June 9 - June 20, 2014



Wheat BYDV

Season Final, 2014

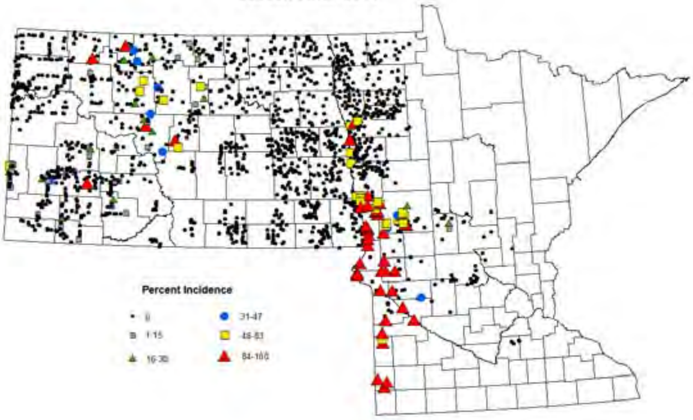


For Additional Information:
Phil Glogoza, Doug Holen, Jochum Wiersma, and Madeleine Smith

Project Funding Provided by:
Minnesota Association of Wheat Growers

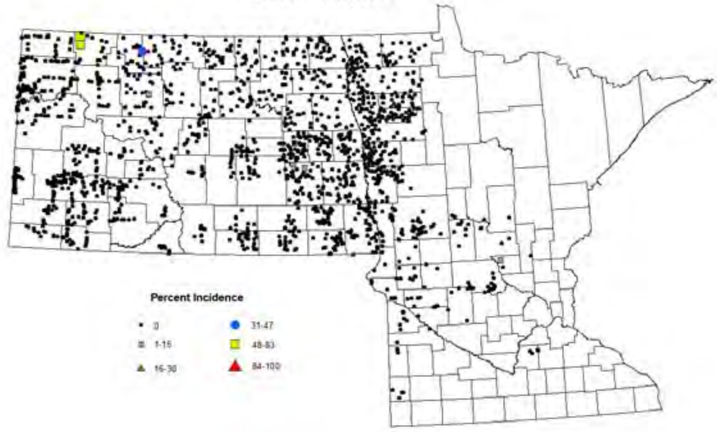
Wheat Bacterial Leaf Blight Incidence

Season Final, 2014



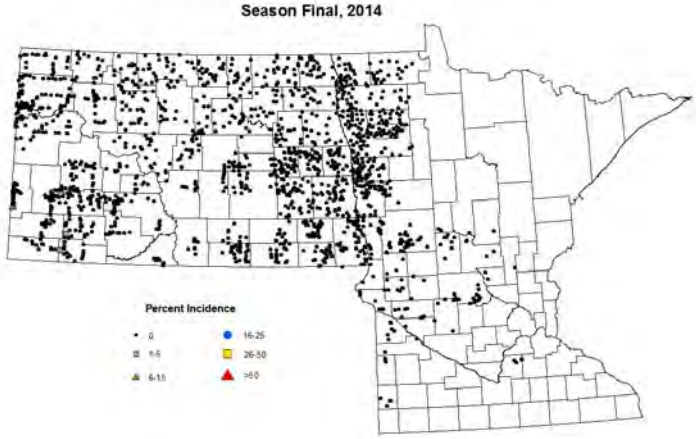
Wheat Streak Mosaic Virus

Season Final, 2014



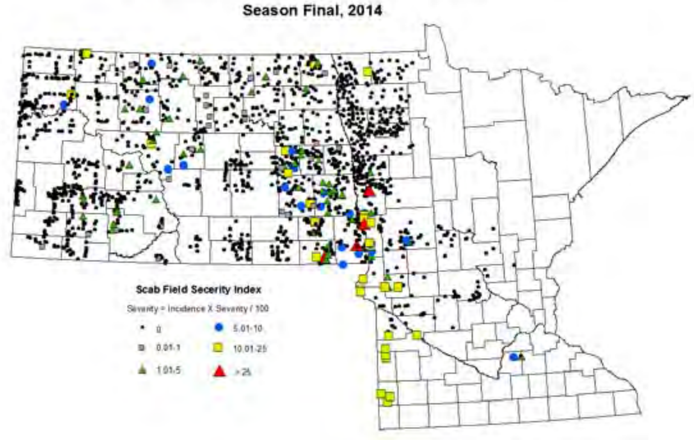
Wheat Stripe Rust Incidence

Season Final, 2014



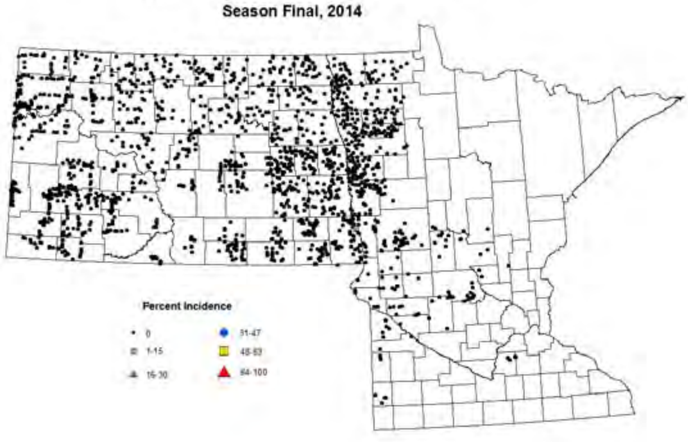
Wheat Scab Field Severity Index

Season Final, 2014



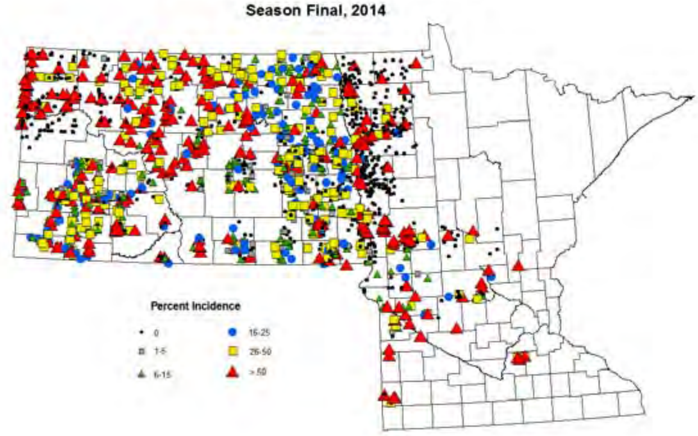
Wheat Stem Rust Incidence

Season Final, 2014



Tan Spot Percent Incidence

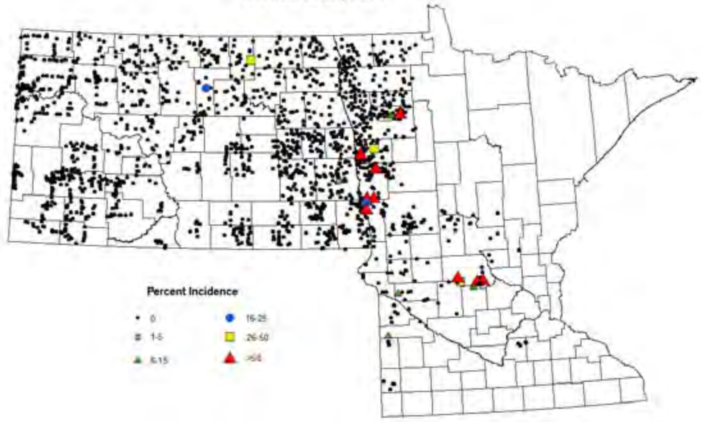
Season Final, 2014



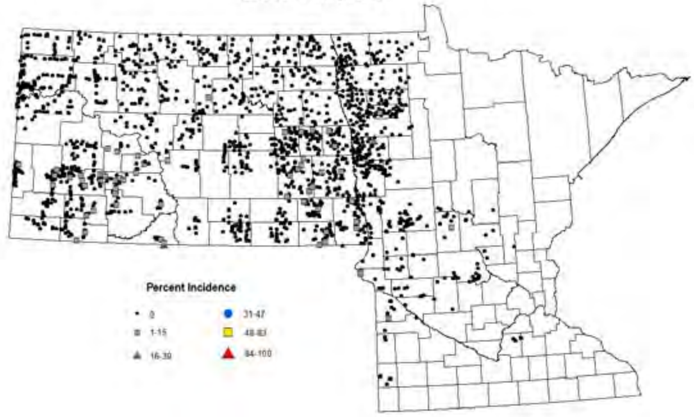
For Additional Information:

Phillip Glogoza, Doug Holen, Jochum Wiersma and Madeleine Smith

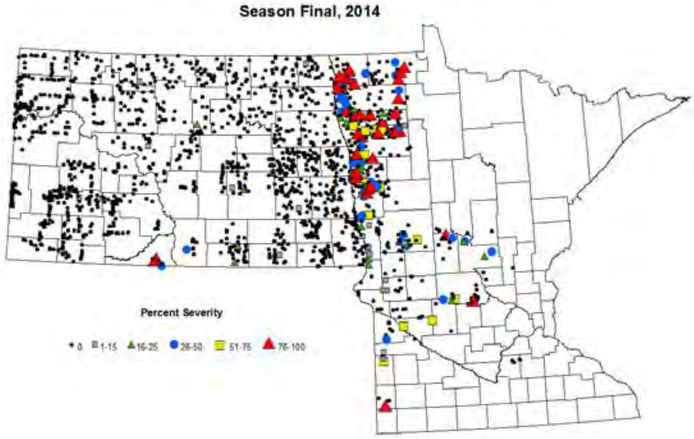
Wheat Leaf Rust Percent Incidence
Season Final, 2014



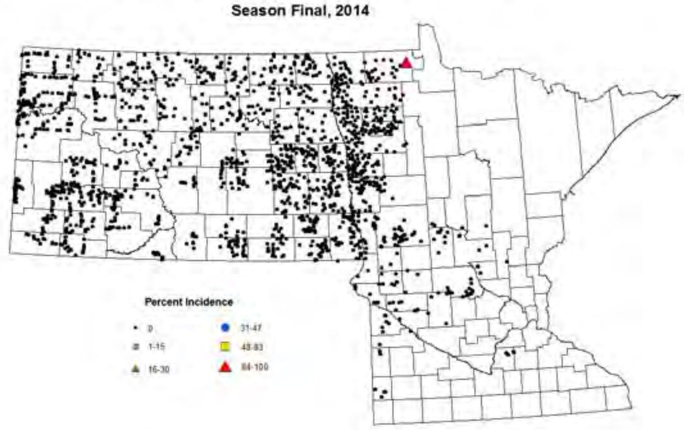
Wheat Ergot Percent Incidence
Season Final, 2014



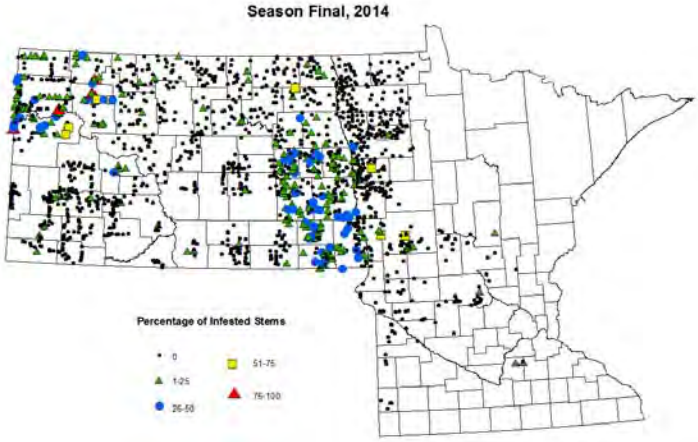
Wheat Septoria SSP Incidence
Season Final, 2014



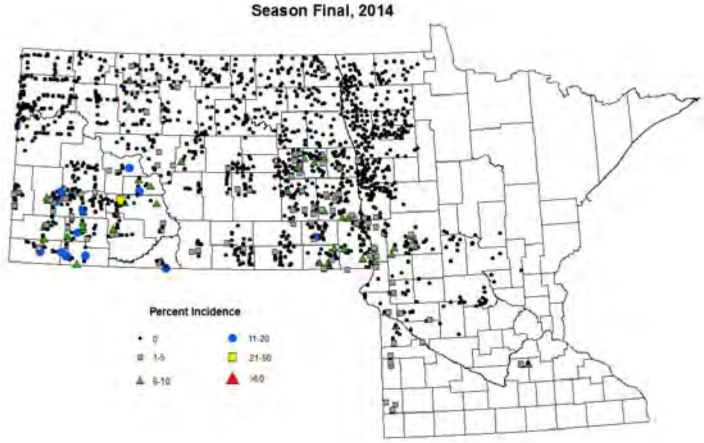
Wheat Powdery Mildew Incidence
Season Final, 2014



Aphids in Wheat
Season Final, 2014



Wheat Stem Maggot
Season Final, 2014



For Additional Information:

Phillip Glogoza, Doug Holen, Jochum Wiersma and Madeleine Smith

Foliar Fertilizer Application for Hard Red Spring Wheat

Nearest Town:	Fergus Falls—Otter Tail County
Soil Type:	Formdale - Buse Complex
Experimental Design:	Factorial design within a randomized complete block design with 4 replications Factor 1: Wheat Variety (Faller, Glenn, Mayville, RB07, Select, and Vantage) Factor 2: Foliar fertilizer source 1) No foliar fertilizer 2) 28% Urea ammonium nitrate solution (28-0-0) 3) Copper-field™ (21-0-0-0.3 Cu-0.15 Fe) Foliar rates applied a total of 15 lbs of N per acre 5 GPA 28%; 7.5 GPA Copper-field N-tense™ and Trophy Gold™ were added each at a rate of 0.25% v/v All treatments applied with water at a total spray volume of 12 GPA
Soil Test Data:	Bray P1-P: 16 ppm Ammonium acetate K: 204 ppm pH: 6.7 Soil organic matter: 5.0% DTPA: Cu 1.9 ppm Fe 38.8 ppm

Purpose of Study: To compare sources of nitrogen for post-anthesis application to wheat for increasing protein concentration among six hard red spring wheat varieties.

Results:

Treatments compared two sources of foliar nitrogen. The 28% UAN treatment contained roughly 1/2 of the total nitrogen in the urea for. The copper-field treatment contained a higher percentage, 3/4, of the total nitrogen in the urea form. The copper-field also contained iron and copper in the chelated for.

Treatment main effects are summarized in Table 1. Yield varied among varieties with Faller producing the greatest grain yield and Glenn the least. Grain protein concentration response was the inverse of grain yield as expected.

Foliar application of the two fertilizer sources affected grain yield and grain protein concentration. Grain yield did not differ between the 28% and the non-fertilizer control. The copper-field treatment generally reduced yield. Grain protein concentration was increased by 0.2 -0.3% on average for both foliar treatments. Increased protein concentration for the copper-field treatment may have been due to decreased grain yield.

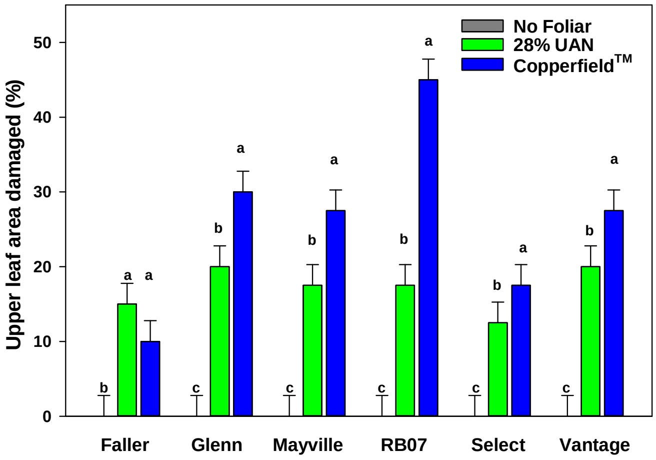
Table 1. Summary of main treatment effects for hard red spring wheat grain yield and protein concentration and protein yield.

	Grain		Protein
Main Effect	Yield	Protein	Yield
Variety	-bu/acre-	---%---	--lb/acre--
Faller	89a	12.1f	638ab
Glenn	59d	14.2c	506d
Mayville	61d	14.9a	548c
RB07	72b	14.0d	607b
Select	65c	13.4e	524cd
Vantage	75b	14.7b	664a
Foliar			
None	72a	13.7b	591a
28%	73a	14.0a	612a
Copper-field	65b	13.9a	540b
	Statistics (*P>F*)		
Variety	<0.001	<0.001	<0.001
Foliar	<0.001	<0.01	<0.001
Var. x Foliar	0.03	0.01	0.02

For Additional Information:
Contact Daniel Kaiser (dekaiser@umn.edu)

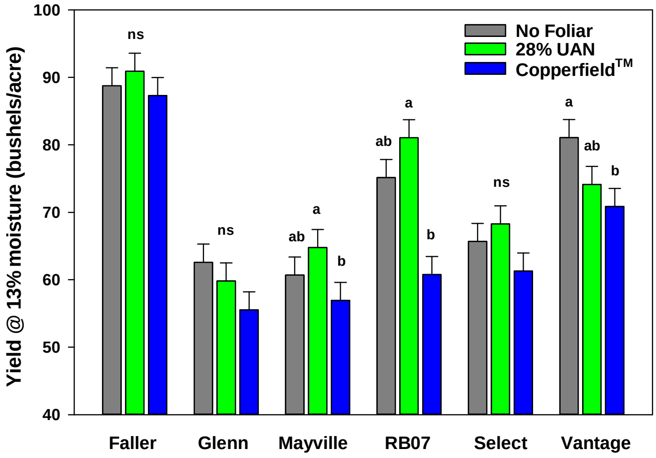
Project Funding Provided by:
West-Central Inc.

Fergus Falls, 2014 HRSW Foliar Damage



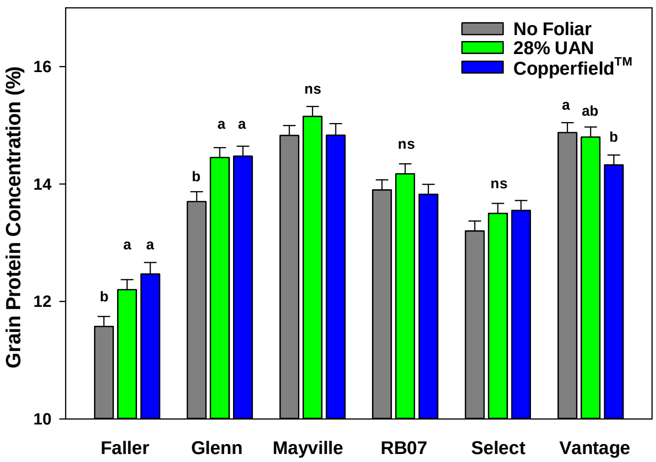
Foliar damage varied by foliar fertilizer source and by variety. Foliar damage was generally greater for plots treated with Copper-field. The only variety that did not exhibit greater damage with Copper-field was Faller while RB07 exhibited the greatest total damage. Increased damage was likely due to the higher percentage of total N as urea in Copper-field. Lower rates of this produce are typically suggested. In this study we wanted to compare equal amounts of total applied N. The amount of N applied post-anthesis, 15 lbs, it typically suggested for increasing protein concentration. Damage potential of the fertilizer source should be a major consideration when choosing a product to apply

Fergus Falls, 2014 HRSW Grain Yield Data



Grain yield was not increased or decreased similarly across all varieties. Although a lowering trend in grain yield existed, statistically the yield of Faller, Glenn, and Select did not differ among treatment. No treatment differed relative the control for Mayville. Vantage and RB07 both had lower yield for the Copper-field treatment. The large yield reduction for RB07 was consistent with the greater leaf damage from the foliar application. A lower application rate may have resulted in less damage and a smaller or no reduction in grain yield.

Fergus Falls, 2014 HRSW Grain Protein Data



Grain protein concentration was increased by foliar fertilizer but only for the varieties Faller and Glenn. Grain protein concentration was slightly decreased by foliar fertilizer use for the variety Vantage. There was no effect on grain protein concentration for the varieties Mayville, RB07, and Select. There was no indication why specific varieties responded for both grain yield and grain protein concentration.

For Additional Information:
Contact Daniel Kaiser (dekaiser@umn.edu)

Nitrogen Rate on Irrigated Hard Red Spring Wheat

Nearest Town:	Staples, MN (Wadena Co.)
Soil Type:	Verndale loamy sand
Previous Crop:	Edible bean
Experimental Design:	Factorial within a randomized complete block design with 4 replications
	Factor 1: wheat variety (Faller, Mayville, and RB07)
	Factor 2: nitrogen rate (0, 60, 120, 180, 240, and 300 lbs N per acre)
	Nitrogen was split applied with 50% applied at emergence and 50% at the boot stage
Preliminary Soil Test:	16 lb N per acre at 2' depth
	Bray P1-P: 43 ppm
	Ammonium acetate K: 88 ppm
	1.6% Soil organic matter
	pH: 7.3

Purpose of Study: The purpose of this study was to determine optimum nitrogen rates for hard red spring wheat grown on an irrigated sandy soil. We also wanted to determine if varieties varied in their potential response to S.

Results:

The varieties were selected based on tissue analysis for a survey of HRSW varieties utilizing the variety trials. Flag leaf nitrogen concentration was surveyed. The varieties selected exhibited differences in their response to nitrogen in environments that vary in nitrogen availability. One variety was selected that responded less in a high N environment (Faller), one was deemed as average (Mayville), and one as above average (RB07).

There was no difference in the response to nitrogen among the three varieties studied. Faller did result in a greater yield per acre than Mayville or RB07 but the amount of N required to maximize yield was similar. Total protein produced per acre (protein yield) also differed for variety and nitrogen rates. Since protein yield was highly dependent on yield there was a similar lack of interaction between variety and nitrogen rate on protein yield.

Grain protein concentration was the only measured variation that exhibited an interaction between variety and nitrogen rate.

HRSW Grain Yield Data: Staples 2014

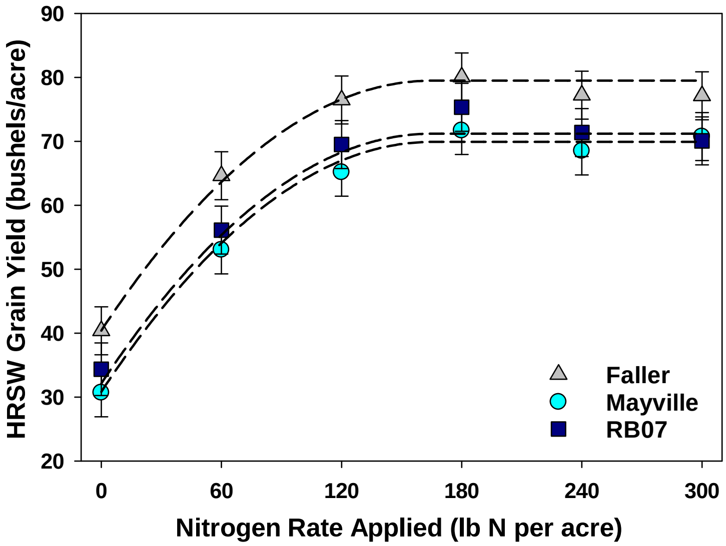


Table 1. Summary of statistical significance for grain yield and protein concentration data and protein yield per acre.

	Grain		Protein
	Yield	Protein	Yield
	-----------------P>F-----------------		
Variety	<0.001	<0.001	<0.01
Nrate	<0.001	<0.001	<0.001
Variety x N rate	0.99	0.04	0.95

For Additional Information:
Contact Daniel Kaiser (dekaiser@umn.edu)

Project Funding Provided by:
Minnesota Wheat Research and Communication Council

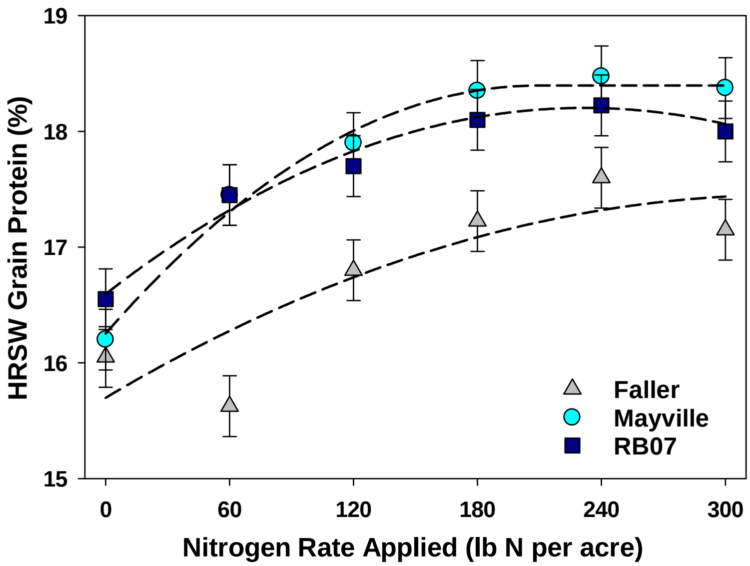
The interaction between variety and nitrogen rate that occurred for grain protein concentration could not be easily explained and was likely due to differences in the effect of variety for various nitrogen rates.

Grain protein concentration was generally maximized by around 240 lbs of applied nitrogen for all varieties. Grain protein concentration did appear to plateau around the highest nitrogen rates applied.

Grain yield was maximized by 164 lbs of applied N. Grain protein yield per acre was maximized by an additional 20-30 lbs of N which was nearly half what is usually required for field in Northwest Minnesota. Residual N was low (near 15 lbs) and likely did not contribute to the yield response. The amount of N needed to maximize yield only is comparable to the amount required for non-irrigated soil in northwest Minnesota. The major difference in nitrogen management is that split application of N should be favored for coarse textured irrigated soils to ensure adequate N is available.

Maximum return to nitrogen rates are summarized in Table 2 for various price rations. Since grain protein concentration were relatively high in this study (greater than 14%) for all varieties discounts could not be incorporated into the economic analysis. The amount of N applied in irrigation water also should be considered. Water from the irrigation well at Staples was sampled but the data are not currently available. Nitrate applied towards the middle to end of he growing season could have resulted in the high grain protein concentration.

HRSW Grain Protein Data: Staples 2014



HRSW Grain ProteinYield Data: Staples 2014

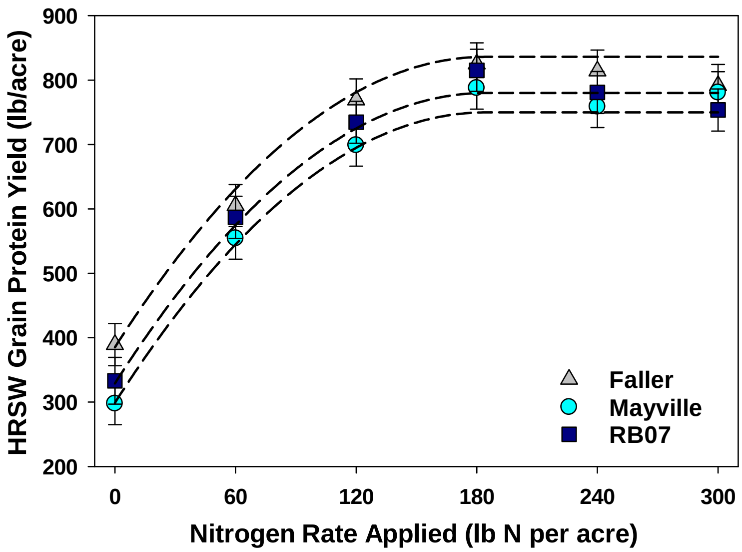


Table 2. Maximum return to nitrogen data for irrigated wheat summarized for various price ratios (price of N: value per bushel HRSW) based on data collected in 2014 at Staples, MN.

Price Ratio	-$1	MRTN	+$1
	----------	lb N/ac	----------
0.00	153	164	na
0.05	136	148	160
0.10	118	130	142
0.15	101	113	125
0.20	83	95	107

For Additional Information:
Contact Daniel Kaiser (dekaiser@umn.edu)

Corn Hybrid Response to Seeding Rate in Northwestern MN

Locations: Crookston, MN (Polk Co.), East Grand Forks, MN (Polk Co.), Hendrum, MN (Norman Co.), Mahnomen, MN (Mahnomen Co.), and Newfolden, MN (Marshall Co.)

Plot Layout: Hybrid and seeding rate combinations replicated 4 times at each location

Objectives:

Evaluate corn response to seeding rate for three hybrids of differing comparative relative maturity (CRM).

Results:

Average corn grain yield ranged from 134 to 181 bu/acre among locations. Corn grain yield was affected by seeding rate at all locations. Seeding rates of 34,700 or higher produced the greatest yield at all locations.

Yield differed among hybrids at Crookston, East Grand Forks, and Mahnomen, MN. At each of these three locations, yield was greatest with the 86 CRM hybrid, intermediate with the 80 CRM hybrid, and least with the 74 CRM hybrid. Yield did not differ among hybrids at the two lowest yielding locations (Hendrum and Newfolden, MN).

Seeding rate	Crookston	East Grand Forks	Hendrum	Mahnomen	Newfolden
seeds/A	------------ Yield (bu/A)† ------------				
23,100	163 c‡	173 b	142 b	143 b	124 c
28,900	174 b	176 b	140 b	158 a	130 bc
34,700	178 ab	185 a	163 a	158 a	135 ab
40,500	182 a	185 a	157 a	161 a	143 a
46,300	175 ab	185 a	151 ab	151 a	136 ab

† Data averaged across three hybrids. At Crookston, data also are averaged across three planting dates.

‡ Within a given location, yield values followed by the same letter do not differ at the 10% probability level.

As expected, grain moisture at harvest was greatest with the 86 CRM hybrid and least with the 74 CRM hybrid at each location. Grain moisture did not differ between the 74 and 80 CRM hybrids at Hendrum, MN.

Hybrid	Comparative relative maturity	Crookston	East Grand Forks	Hendrum	Mahnomen	Newfolden
		------------ Yield (bu/A)† ------------				
P7443R	74	159 c‡	167 c	155 a	138 c	134 a
39V07	80	174 b	180 b	145 a	150 b	136 a
P8640AM	86	191 a	196 a	152 a	174 a	131 a
		-- Grain moisture at harvest (%)† --				
P7443R	74	20.8 c‡	14.0 c	18.4 b	16.3 c	21.9 c
39V07	80	24.9 b	16.8 b	19.3 b	17.3 b	25.0 b
P8640AM	86	31.1 a	19.6 a	24.7 a	22.4 a	32.3 a

† Data averaged across five seeding rates. At Crookston, data also are averaged across three planting dates.

‡ Within a given location, yield or grain moisture values followed by the same letter do not differ at the 10% probability level.

For Additional Information:
Jeff Coulter, Jerry Buckley, Howard Person, and Nathan Jonhnson, Univ. of MN Extension

Funding provided by the MN Corn Growers Association and DuPont Pioneer. Thanks to NDSU for planting the East Grand Forks, Hendrum, Mahnomen, and Newfolden locations. Thanks to the Northwest Research and Outreach Center for help with the research at Crookston.

Pre-plant versus side-dress Nitrogen for corn in NW Minnesota

Nearest Town: Waubun (Mahnomen Co.) & Hendrum (Norman Co.)

Soil Type: Mahnomen County: Sverdrup sandy loam
Norman County: Fargo silty clay

Row Width: 30"

Experimental Design: Split plot within a randomized complete block design
Main plot pre-plant nitrogen rates: 0, 40, 80, 120, 160, and 200 lbs N per acre
Split plot side-dress N (pre-plant N + side-dress N): 0 + 120, 40 + 80, 80 + 40, 120 + 40, 160 + 40, and 200 + 40 lbs N/acre
Nitrogen source: urea (46-0-0)
Side-dress urea treated with Agrotain and applied between V4-V6
4 replications

Previous Crop: Mahnomen County: previous crop soybean
Norman County: previous crop spring wheat

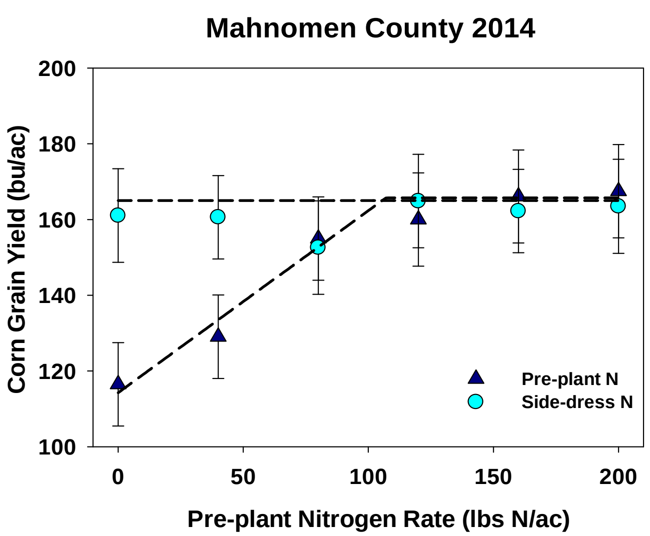
Purpose of Study:
To determine if split application of nitrogen would result in greater corn yield in Northwest Minnesota

Results:
Corn grain yield was increased by pre-plant nitrogen at both locations. Economic optimum nitrogen rates (EONR) for both locations were near 100 lbs of N per acre.

Side-dress application of nitrogen increased corn grain yield for the lowest two pre-plant application rates, 0 and 40 lbs of N per acre. There was no yield advantage of split application of nitrogen for pre-plant nitrogen rates 80 lbs of N or greater.

Side-dress application of nitrogen did not increase yield for applied N rates higher than the EONR. Application of 120 lbs of N resulted in similar yield when applied all as a pre-plant or a side-dress application.

The data provides evidence that a single pre-plant application of nitrogen alone may be enough to result in maximum corn grain yield even if early season rainfall may favor leaching losses



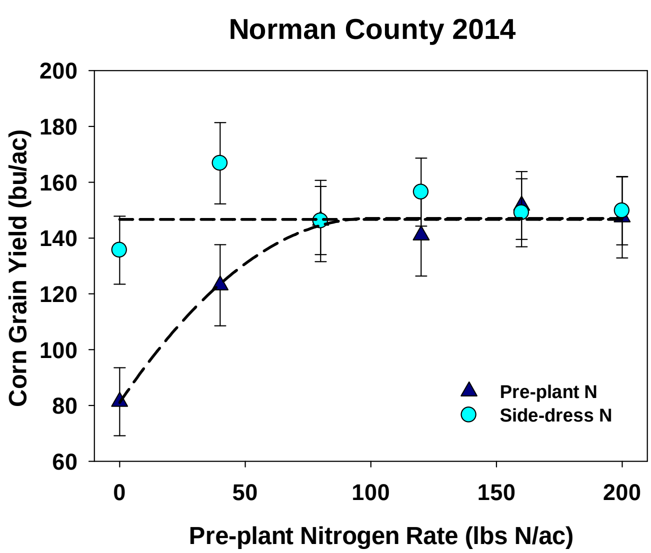


Table 1. Summary of economic optimum nitrogen rates using the maximum return to N model for two locations in Northwest Minnesota during 2014.

	Ratio of Price N:Price per bushel of corn					
Location	0.00	0.05	0.10	0.15	0.20	0.25
	-------------------lb N/acre-----------------					
Mahnomen	107	107	107	107	107	107
Norman	99	93	88	82	77	71

For Additional Information:
Contact Daniel Kaiser (dekaiser@umn.edu)

Project Funding Provided by:
Minnesota Corn Research and Promotion Council

Corn Response to Sulfur Fertilizer—Mahnomen/Marshall Co.

Nearest Town: Waubun (Mahnomen Co.) & New Folden (Marshall Co.)
Soil Type: Mahnomen County: Fargo silty clay
Marshall County: Grimstad fine sandy loam
Row Width: 30”
Experimental Design: Randomized complete block design
Four sulfur rates: 0, 10, 20, and 30 lbs S per acre
Sulfur source: ammonium sulfate (21-0-0-24)
Sulfur applied at or prior to planting
4 replications

Purpose of Study:
To determine if sulfur can increase corn yield on high organic matter soils in Northwest Minnesota.

Results:

Yield potential was generally affected by wet then dry weather conditions at each location.

Yield data exhibited large variability especially at the Norman location. Some plot data was discarded that was abnormally low yielding.

Corn grain yield was not increased at either location nor did the two site average differ indicating no benefit from sulfur fertilizer application at either site.

There was no statistical difference in grain moisture taken at harvest. The Norman site did exhibit a slight increasing trend in grain moisture with increasing sulfur rate. Typically sulfur has been shown decrease moisture of the harvested grain. The corn exhibited greater moisture stress at the Norman site. The increase in grain moisture may have been a result of sulfur and an positive benefit for corn grown under nitrogen or moisture stress.

This data supports previous research in a lack of response to sulfur on soils with high organic matter concentration.

Table 1. Summary of corn grain yield (adjusted to 15.5% moisture) response to sulfur rate at locations in NW Minnesota.

Sulfur Rate	Marshall	Norman	Average
- lb S/ac -	----------Bushels/acre----------		
0	153	132	144
10	155	127	143
20	152	128	143
30	156	133	146
	Statistical Significance		
P>F	ns	ns	ns

Table 2. Summary of corn grain moisture response to sulfur rate at locations in NW Minnesota.

Sulfur Rate	Marshall	Norman	Average
-lb S/ac-	----------------%----------------		
0	20.5	16.7	18.6
10	20.1	16.7	18.4
20	22.1	18.5	20.3
30	20.1	18.0	19.0
	Statistical Significance		
P>F	ns	ns	ns

For Additional Information:
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Project Funding Provided by:
Minnesota Corn Research and Promotion Council

On-Farm Evaluation of Cover Crops following Corn Silage - Stearns Co.

Cooperator:	Dan Ley
Nearest Town:	Roscoe
Soil Type:	Sandy Loam
Tillage:	No till
Previous Crop:	Corn Silage
Planting Date:	May 16, 2014
Row Width:	30”
Fertilizer:	Within UMN rec’s
Planting Population:	29,000
Harvest Date:	October 20, 2014
Experimental Design:	Replicated, randomized complete block
Partners:	Stearns Co SWCD and NRCS

Purpose of Study:

Row crop systems using conventional tillage allow the soil to be idle from October/November through April/May. This often leaves the soil vulnerable to wind and water erosion, and nutrient loss due to leaching and runoff.

Cover crops are one tool that growers can utilize to protect and enhance their most valuable resource: productive soil. Lack of knowledge about this practice creates a barrier to adoption. While time is limited to establish cover crops after corn for grain or soybeans are harvested, there is a small window to seed cover crops after corn is harvested for silage.

Objectives:

Evaluate cereal rye cover crop establishment using three different seeding methods: no-till drill (Photo 1), broadcast and incorporate, slurry seeding and no cover crop to determine differences in the subsequent corn yield.

Results:

Cover crops were planted 9/11/13 right at silage harvest. The field received 1.5” of rain 2-3 days later. This greatly improved the chance of successful establishment. Rye growth was about 6-8” before cold temps ended the season. The spring was very wet and terminating the rye was not completed until the rye was 10-14” tall.

Where the rye was very thick and tall (no-till drill and broadcast-incorporate), had a negative effect on emergence and corn growth (Table 1, Photo 2). The slurry seed rye did not have the full emergence and therefore had similar corn emergence and growth as using no cover crops (Table 1). Plant growth factors affected crop yield, with more rye biomass negatively effecting yield (Table 1).

Conclusion: While cover crops offer soil protection and other benefits, a spring cover crop must be treated as a weed and terminated at 2-4 inches or it could negatively effect the primary crop yield.

Photo 1. No-till drill planting fall cereal rye.

Photo 2. Corn planted into fall broadcast cereal rye.

Table 1. Fall cover crop seeding methods and corn growth and yield response.

TRT	June 8 Stand (plants/a)	June 8 Height (inches)	Corn Yield (bu/a)
Slurry Seeded	26,917 a	19.4 b	148 a
No-till Drill	23,667 b	16.2 c	117 b
Bdcst Incorp	18,917 c	15.2 c	94 c
No Cover Crop	27,750 a	20.5 a	154 a

Means followed by different letters are significantly different at the 95% confidence level.

For Additional Information:
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Project Funding Provided by:
MN Corn Growers and MN SARE

2014 Corn Hybrid Trials— Marshall/Polk/Mahnomen Counties

Cooperator:	Duane Pazdernik (Mahnomen), Matthew Kruger (Polk), Rodney Liedberg (Marshall)
Nearest Town:	Mahnomen, East Grand Forks, Newfolden
Previous Crop:	Soybean (Mahnomen), Soybean (Polk), Wheat (Marshall)
Planting Date:	Mahnomen and East Grand Forks sites planted 5/23 and Newfolden site 5/27
Row Width:	30" rows
Harvest Date:	Mahnomen 10/23, Sherack 10/24, Newfolden10/31
Experimental Design	Alpha Lattice Design with 4 replications

Purpose of Study: Evaluate the performance of commercially available corn hybrids in Northwestern MN.

Results: Yield and moisture data from 4 replications is summarized in the tables below. Yields are adjusted to 15.5% moisture.There were significant differences in moisture and yield between corn hybrids at all locations.

Preliminary

North zone, early maturing (<81) corn hybrid trial results for a single location, Marshall Co., MN, 2014.

Brand	Variety	RM	Moisture	Yield
			(%)	(bu/a)
NuTech/G2 Genetics	5H-7802	78	25.2	135.5
NuTech/G2 Genetics	3F-775™	75	21.6	134.2
Peterson Farms Seed	71N78	78	20.7	132.0
Mustang	1278VT2P	78	21.2	130.9
Wensman Seed	W 8076VT2RIB	79	22.5	128.8
NuTech/G2 Genetics	5Z-379™	79	25.1	124.9
Thunder	4578 RR	78	21.6	121.7
Legacy Seeds	L-1814 VT2PRO	79	24.3	119.5
Mustang	1279VT2P	79	23.3	118.7
Dahlman	R39-11	78	27.5	118.7
NK	N07H-3110	77	19.0	118.6
Peterson Farms Seed	71C80	80	22.8	117.3
Legend Seeds	LS 9279 VT2PRIB	79	23.9	116.6
REA Hybrids	1B102	76	25.4	116.4
Proseed	1377	77	23.0	116.2
Proseed	1280	80	23.9	113.7
NorthStar Genetics - Viking	VS 80-580	80	24.8	112.3
Nuseed	2771 GT	77	27.4	111.5
Thunder	4377 RR	77	28.8	109.8
Mycogen	2D095	80	29.2	109.0
Wensman Seed	W 80809VT2PRO	80	24.5	108.8
Thunder	6180 VT2P RIB	80	25.3	107.2
Nuseed	8001 VT2P	80	25.7	107.0
REA Hybrids	1B801	80	22.9	106.6
REA Hybrids	1B790	79	24.5	106.5
Partners Brand	PB 5030GT	80	31.1	99.8
NK	N09V-3110	79	25.3	99.7
Partners Brand	PB 4833RR	78	30.2	92.8
Mean			24.7	115.5
CV (%)			4.7	6.9
LSD (0.1)			2.4	13.9

Preliminary

North zone, late maturing (>81) corn hybrid trial results for a single location, Marshall Co., MN, 2014.

Brand	Variety	RM	Moisture	Yield
			(%)	(bu/a)
Legacy Seeds	L-2314 VT2PRO	83	26.3	141.5
REA Hybrids	2V550	85	27.0	131.7
Legacy Seeds	L-2213 VT2PRO	82	23.2	128.4
REA Hybrids	2B850	85	28.4	126.3
Producers Hybrids	4363 VT2RIB	83	24.0	125.0
Thunder	4585 RR	85	27.0	124.9
Dahlman	R41-28VT2PRIB	81	23.8	124.0
Hyland Seeds	3175	84	32.4	123.6
Thunder	5181 RR	81	22.7	122.7
Wensman Seed	W 80841VT2RIB	84	25.6	121.1
Nuseed	8504 VT2P	85	27.4	120.1
Partners Brand Check	PB 5203		29.4	119.0
Peterson Farms Seed	71D83	83	24.8	118.2
Thunder	6385 VT2P RIB	85	25.1	118.1
Thunder	4383 VT2P RIB	83	24.3	116.7
Proseed	1185	85	31.2	116.6
NorthStar Genetics - Viking	VS 85-572	85	25.5	116.4
Hyland Seeds	8166RA	83	29.3	115.8
NorthStar Genetics - Viking	VS 81-481	81	27.1	115.1
Peterson Farms Seed	98E84	84	37.0	114.5
Proseed	1283	83	25.8	114.1
Hyland Seeds	4164	83	28.4	113.6
Hyland Seeds Check	8180		32.4	113.1
REA Hybrids	1B820	82	25.2	112.9
NuTech/G2 Genetics	3F-781™	81	23.9	112.3
Legacy Seeds	L-1943 VT2PRO	81	23.0	112.2
Partners Brand	PB 5203GT	82	31.1	111.4
Legend Seeds	LS 9482 VT2PRIB	82	27.0	111.2
Thunder	6382 VT2P RIB	82	28.9	110.4
Hyland Seeds	8180RA	84	31.9	110.0
NuTech	5N-183	83	28.5	107.8
Mycogen	2Y189	85	33.1	104.1
Mycogen	2R158	83	30.7	103.8
Nuseed	8202 VP3220	82	31.0	102.6
Proseed	1382	82	28.3	100.9
Partners Brand Check	PB 4833RR		28.3	99.7
Hyland Seeds	8201RA	84	36.6	92.2
Hyland Seeds Check	8201RA		37.8	90.2
Mean			28.2	114.8
CV (%)			4.7	6.9
LSD (0.1)			2.4	13.9

Preliminary

North zone, early maturing (<81) corn hybrid trial results for a single location, Polk County, MN, 2014.

Brand	Variety	RM	Moisture	Yield
			(%)	(bu/a)
NuTech/G2 Genetics	5H-7802	78	19.4	192.4
NuTech/G2 Genetics	3F-775™	75	18.0	186.2
Partners Brand	PB 5030GT	80	18.0	183.8
Mycogen	2D095	80	19.8	183.6
Legend Seeds	LS 9279 VT2PRIB	79	19.1	181.0
Peterson Farms Seed	71N78	78	18.3	179.7
NK	N07H-3110	77	16.7	178.6
REA Hybrids	1B102	76	20.0	177.8
Proseed	1280	80	18.1	176.6
NuTech/G2 Genetics	5Z-379™	79	20.2	176.1
NorthStar Genetics - Viking	VS 80-580	80	19.1	175.7
Thunder	6180 VT2P RIB	80	20.0	175.6
Thunder	4377 RR	77	22.0	175.5
REA Hybrids	1B801	80	18.6	175.4
NK	N09V-3110	79	18.6	175.4
Nuseed	2771 GT	77	20.5	175.2
REA Hybrids	1B790	79	19.1	173.7
Mustang	1278VT2P	78	18.6	173.0
Legacy Seeds	L-1814 VT2PRO	79	17.3	171.1
Proseed	1377	77	16.9	169.2
Thunder	4578 RR	78	17.5	169.1
Peterson Farms Seed	71C80	80	18.2	167.7
Nuseed	8001 VT2P	80	19.0	167.6
Dahlman	R39-11	78	18.5	165.2
Mustang	1279VT2P	79	18.0	160.3
Wensman Seed	W 8076VT2RIB	79	17.9	160.1
Partners Brand	PB 4833RR	78	19.8	158.7
Wensman Seed	W 80809VT2PRO	80	19.1	156.0
Mean			18.8	173.6
CV (%)			5.7	5.9
LSD (0.1)			2.3	20.2

Preliminary

North zone, late maturing (>81) corn hybrid trial results for a single location, Polk County, MN, 2014.

Brand	Variety	RM	Moisture	Yield
			(%)	(bu/a)
Nuseed	8504 VT2P	85	19.9	206.0
Proseed	1185	85	20.9	201.6
Hyland Seeds	8166RA	83	20.1	197.3
Hyland Seeds Check	8201RA		18.8	195.7
Partners Brand Check	PB 5203		18.3	194.4
Mycogen	2Y189	85	21.1	193.4
NuTech	5N-183	83	19.8	193.2
Hyland Seeds Check	8180		20.8	192.7
NorthStar Genetics - Viking	VS 85-572	85	19.7	191.2
REA Hybrids	2B850	85	17.7	191.1
REA Hybrids	2V550	85	19.0	190.6
Hyland Seeds	4164	83	18.1	189.3
NorthStar Genetics - Viking	VS 81-481	81	17.4	188.7
Thunder	4585 RR	85	19.6	187.5
Partners Brand	PB 5203GT	82	19.9	186.5
Nuseed	8202 VP3220	82	19.5	186.2
NuTech/G2 Genetics	3F-781™	81	19.1	185.9
Proseed	1382	82	19.3	185.1
Proseed	1283	83	19.5	185.0
Legend Seeds	LS 9482 VT2PRIB	82	19.1	184.2
Hyland Seeds	3175	84	21.4	182.8
Hyland Seeds	8180RA	84	20.5	182.8
Hyland Seeds	8201RA	84	21.3	182.5
Thunder	6382 VT2P RIB	82	22.1	180.8
Legacy Seeds	L-2213 VT2PRO	82	17.7	180.6
Producers Hybrids	4363 VT2RIB	83	18.4	180.0
Peterson Farms Seed	98E84	84	19.3	178.4
Legacy Seeds	L-1943 VT2PRO	81	18.0	176.5
Mycogen	2R158	83	18.3	176.2
Thunder	6385 VT2P RIB	85	17.2	174.7
Peterson Farms Seed	71D83	83	18.2	173.4
Partners Brand Check	PB 4833RR		19.5	173.3
Legacy Seeds	L-2314 VT2PRO	83	20.5	172.9
Wensman Seed	W 80841VT2RIB	84	19.4	172.2
Thunder	4383 VT2P RIB	83	19.2	169.2
Thunder	5181 RR	81	18.5	166.0
Dahlman	R41-28VT2PRIB	81	19.6	166.0
REA Hybrids	1B820	82	18.4	160.5
Mean			19.4	183.5
CV (%)			5.7	5.9
LSD (0.1)			2.3	20.2

Preliminary

North zone combined (Ramsey, Grand Forks, Marshall and Polk Cos.) early maturing (<81) corn hybrid trial results, 2014.

Brand	Variety	RM	Moisture	Yield
			(%)	(bu/a)
NuTech/G2 Genetics	5H-7802	78	19.1	161.3
Mustang	1278VT2P	78	18.8	151.8
Peterson Farms Seed	71N78	78	18.4	151.2
NuTech/G2 Genetics	3F-775™	75	18.1	150.3
Legend Seeds	LS 9279 VT2PRIB	79	19.4	147.1
NK	N07H-3110	77	16.4	146.5
Legacy Seeds	L-1814 VT2PRO	79	19.0	145.8
Mycogen	2D095	80	21.6	144.7
Wensman Seed	W 8076VT2RIB	79	18.1	144.7
Partners Brand	PB 5030GT	80	19.9	144.6
NuTech/G2 Genetics	5Z-379™	79	19.5	144.3
NK	N09V-3110	79	19.8	143.9
Thunder	4578 RR	78	18.0	143.8
Proseed	1280	80	18.9	143.0
Nuseed	2771 GT	77	20.0	142.9
Proseed	1377	77	18.4	142.9
REA Hybrids	1B102	76	19.1	142.7
Peterson Farms Seed	71C80	80	19.0	142.0
NorthStar Genetics - Viking	VS 80-580	80	19.5	141.3
Thunder	6180 VT2P RIB	80	19.8	141.1
REA Hybrids	1B801	80	18.3	140.7
Thunder	4377 RR	77	21.4	140.0
REA Hybrids	1B790	79	19.0	139.5
Mustang	1279VT2P	79	18.7	136.9
Wensman Seed	W 80809VT2PRO	80	19.3	136.7
Nuseed	8001 VT2P	80	19.7	135.7
Dahlman	R39-11	78	19.9	133.9
Partners Brand	PB 4833RR	78	21.2	126.4
Mean			19.2	143.1
CV (%)			12.2	10.1
LSD (0.1)			2.2	11.5

Preliminary

North zone combined (Ramsey, Grand Forks, Marshall and Polk Cos.) late maturing (>81) corn hybrid trial results, 2014.

Brand	Variety	RM	Moisture	Yield
			(%)	(bu/a)
REA Hybrids	2V550	85	19.8	165.6
Thunder	4585 RR	85	20.5	160.3
Legacy Seeds	L-2314 VT2PRO	83	20.8	160.1
Nuseed	8504 VT2P	85	20.5	158.4
Proseed	1185	85	22.0	157.7
REA Hybrids	2B850	85	20.2	156.1
Mycogen	2Y189	85	22.9	154.6
Hyland Seeds	8166RA	83	21.6	153.9
Legacy Seeds	L-2213 VT2PRO	82	18.7	153.7
NorthStar Genetics - Viking	VS 85-572	85	20.2	153.5
Partners Brand	PB 5203GT	82	21.5	152.9
NuTech/G2 Genetics	3F-781™	81	19.7	152.0
Hyland Seeds	4164	83	20.6	151.7
Thunder	4383 VT2P RIB	83	19.0	149.7
Proseed	1382	82	20.8	148.8
Thunder	6382 VT2P RIB	82	21.6	148.3
Legend Seeds	LS 9482 VT2PRIB	82	20.2	148.1
Thunder	6385 VT2P RIB	85	19.3	148.0
NuTech	5N-183	83	20.4	147.8
Hyland Seeds	3175	84	22.8	147.5
Peterson Farms Seed	71D83	83	18.9	147.1
Proseed	1283	83	19.6	145.8
Hyland Seeds	8180RA	84	22.1	145.8
Producers Hybrids	4363 VT2RIB	83	19.3	145.5
Nuseed	8202 VP3220	82	21.4	145.2
Peterson Farms Seed	98E84	84	22.8	145.0
NorthStar Genetics - Viking	VS 81-481	81	20.0	144.9
Dahlman	R41-28VT2PRIB	81	19.5	144.2
Wensman Seed	W 80841VT2RIB	84	20.3	144.1
Mycogen	2R158	83	21.2	142.4
Hyland Seeds	8201RA	84	24.3	141.3
Thunder	5181 RR	81	18.8	140.9
Legacy Seeds	L-1943 VT2PRO	81	18.7	139.9
REA Hybrids	1B820	82	19.4	139.9
Mean			20.6	149.4
CV (%)			12.2	10.1
LSD (0.1)			2.2	11.5

Preliminary

Central zone, early maturing (<86) corn hybrid trial results for a single location, Mahnomen Co., MN, 2014.

Brand	Variety	RM	Moisture	Yield
			(%)	(bu/a)
Thunder	4585 RR	85	20.6	199.1
Proseed	1385	85	19.1	194.3
Dahlman	R43-23VT2PRIB	85	20.5	194.0
REA Hybrids	1B820	82	17.7	188.9
Dahlman	R42-21VT2PRIB	84	19.8	188.6
Peterson Farms Seed	75K85	85	20.7	187.1
REA Hybrids	2V550	85	18.4	185.8
Nuseed	2852 GTCBLL	85	21.4	185.7
Channel	182-62VT2PRIB	82	18.7	184.1
NorthStar Genetics - Viking	VS 85-572	85	19.5	181.7
Integra	3537	85	20.9	181.0
Partners Brand	PB 5203GT	82	19.0	180.9
NuTech	5N-183	83	17.3	178.6
Producers Hybrids	4593 VT2RIB	85	19.3	178.6
Mustang	2235VT2P	85	21.0	177.8
REA Hybrids	2B850	85	18.3	176.1
Proseed	1185	85	20.8	175.1
Proseed	1384	84	19.4	174.3
NuTech/G2 Genetics	5Z-379™	79	18.0	173.7
Thunder	4383 VT2P RIB	83	17.6	173.4
Thunder	6385 VT2P RIB	85	19.3	173.1
NK	N20Y-3220	85	18.9	173.0
NK	N19L-3110A	85	18.7	172.7
Mycogen	2G164	85	18.6	171.6
Nuseed	8504 VT2P	85	18.6	170.9
Channel	183-23VT2PRIB	83	18.5	170.5
Proseed (Check)	1185	85	20.9	170.3
Dairyland	DS-7085	85	18.9	169.4
Mycogen	2Y189	85	20.6	169.1
Channel	181-92VT2PRIB	81	17.9	167.0
Nuseed	8202 VP3220	82	18.4	166.7
Thunder	5181 RR	81	18.5	165.7
Thunder	6382 VT2P RIB	82	19.9	165.3
Partners Brand (Check)	PB 5630GT	82	18.7	165.2
Peterson Farms Seed	98E84	84	18.0	161.0
Dairyland	DS-6284	84	22.0	157.6
Peterson Farms Seed	71D83	83	19.1	156.7
Mean			19.3	175.8
CV (%)			3.5	4.5
LSD (0.1)			1.8	17.2

Preliminary

Central zone, late maturing (>86) corn hybrid trial results for a single location, Mahnomen Co., MN, 2014.

Brand	Variety	RM	Moisture	Yield
			(%)	(bu/a)
NorthStar Genetics - Viking	VS 88-116	88	20.8	202.4
NorthStar Genetics - Viking	VS 91-591	91	21.4	200.4
Mustang	2287VT2P	87	19.9	199.7
Dahlman	R44-26VT2PRIB	89	20.8	194.4
Thunder	4990 RR	90	21.9	193.7
REA Hybrids	2B870	87	18.7	193.3
Nuseed	8701 VT2P RIB	87	21.0	192.3
Peterson Farms Seed	74K89	89	21.6	192.3
Thunder	7188 VT2P RIB	88	21.7	192.2
Legacy Seeds	L-2643 VT2PRO	86	20.5	191.6
Thunder	7993 VT2P	93	25.9	191.5
Thunder	6987 VT2P RIB	87	19.7	191.0
Peterson Farms Seed	73D91	91	22.2	190.5
Dairyland	DS-9487RA	87	20.5	190.2
Legacy Seeds	L-2813 VT2PRO	87	20.0	190.1
NuTech/G2 Genetics	5F-091™	91	24.2	188.1
Wensman Seed	W 8097VT2RIB	88	21.6	187.9
Dahlman	R45-22VT2PRIB	90	21.9	187.8
Wensman Seed	W 80866VT2RIB	86	18.4	186.6
Mustang	2686VT3P	86	20.6	185.8
Proseed	1288	88	25.2	185.3
Hyland Seeds	8295RA	88	21.6	185.2
Thunder	4391 VT2P RIB	91	22.0	185.1
Mycogen	2J238	88	21.8	184.9
NorthStar Genetics - Viking	VS 92-110	92	27.3	184.0
Legend Seeds	LS 9487 VT2PRIB	87	21.5	183.9
Legacy Seeds	L-2910 VT3PRO	88	20.5	182.7
Producers Hybrids	4933 VT2RIB	89	21.6	182.5
Hyland Seeds	8202RA	89	21.7	182.4
Peterson Farms Seed	77H87	87	20.3	182.2
Stine	R9201VT3Pro	86	20.5	181.7
Wensman Seed	W 80903VT2RIB	90	22.5	181.5
Mycogen	2T277	87	22.3	181.5
Nuseed	9001 VP3220	90	23.2	180.8
Proseed	990	90	23.3	180.6
Stine	R9209VT2Pro	91	26.9	179.4
Legacy Seeds	L-2914 VT2PRO	88	22.5	179.1
Proseed	1286	86	21.1	178.7
Legend Seeds	LS 9386 VT3PRIB	86	20.3	178.2
Legacy Seeds	L-3011 VT3PRO	90	20.8	177.4
Partners Brand	PB 5630GT	86	17.7	176.7
Legend Seeds (Check)	LS 9487 VT2PRIB	87	22.3	176.2
Dairyland	DS-9791RA	91	26.1	175.5
Integra	9361	86	19.2	172.2
NuTech	5B-290	90	22.3	171.0
NK	N23M-3011A	88	19.8	170.5
Integra	3912	89	23.5	170.4
NuTech (Check)	5N-186	86	19.9	169.6
Stine	R9206RR	89	21.0	168.6
NuTech	5N-186	86	19.6	159.4
Mean			21.6	183.4
CV (%)			3.5	4.5
LSD (0.1)			1.8	17.2

Preliminary

Central zone combined (Cass, Steele, Griggs and Mahnomen Cos.) early maturing (<86) corn hybrid trial results, 2014.

Brand	Variety	RM	Moisture	Yield
			(%)	(bu/a)
Thunder	4585 RR	85	20.5	198.4
Nuseed	2852 GTCBLL	85	20.7	193.4
REA Hybrids	2V550	85	19.0	191.6
Dahlman	R43-23VT2PRIB	85	20.5	191.6
Dahlman	R42-21VT2PRIB	84	19.9	191.5
Proseed	1385	85	19.5	191.2
REA Hybrids	1B820	82	17.5	189.9
Peterson Farms Seed	75K85	85	20.2	189.8
Thunder	4383 VT2P RIB	83	17.5	189.6
Partners Brand	PB 5203GT	82	19.6	187.9
Proseed	1185	85	19.8	187.7
Mycogen	2G164	85	18.3	186.6
NuTech/G2 Genetics	5Z-379™	79	17.3	184.8
Producers Hybrids	4593 VT2RIB	85	17.3	184.7
NorthStar Genetics - Viking	VS 85-572	85	19.6	182.4
Mustang	2235VT2P	85	20.7	181.9
Channel	183-23VT2PRIB	83	18.7	181.8
Dairyland	DS-7085	85	18.4	181.3
Integra	3537	85	20.5	181.3
Mycogen	2Y189	85	19.6	180.3
Channel	182-62VT2PRIB	82	18.1	180.1
Thunder	6385 VT2P RIB	85	19.4	180.0
NK	N19L-3110A	85	18.3	179.8
Proseed	1384	84	19.3	179.4
NuTech	5N-183	83	17.6	179.0
Peterson Farms Seed	71D83	83	18.3	178.0
Channel	181-92VT2PRIB	81	17.0	177.9
NK	N20Y-3220	85	20.2	177.5
Nuseed	8504 VT2P	85	17.1	177.3
Thunder	5181 RR	81	17.8	176.8
Nuseed	8202 VP3220	82	20.3	175.1
Peterson Farms Seed	98E84	84	17.4	175.1
Dairyland	DS-6284	84	21.5	173.8
Thunder	6382 VT2P RIB	82	19.8	172.8
REA Hybrids	2B850	85	17.7	171.1
Mean			19.0	182.9
CV (%)			5.9	4.4
LSD (0.1)			1.3	10.1

Preliminary

Central zone combined (Cass, Steele, Griggs and Mahnomen Cos.) late maturing (>86) corn hybrid trial results, 2014.

Brand	Variety	RM	Moisture	Yield
			(%)	(bu/a)
Thunder	4990 RR	90	21.0	208.5
NorthStar Genetics - Viking	VS 88-116	88	21.4	204.3
Wensman Seed	W 8097VT2RIB	88	21.4	202.6
Thunder	7993 VT2P	93	25.4	200.7
Dahlman	R44-26VT2PRIB	89	21.5	199.6
NorthStar Genetics - Viking	VS 91-591	91	21.4	198.4
Peterson Farms Seed	73D91	91	22.4	197.8
NuTech/G2 Genetics	5F-091™	91	22.2	197.6
NuTech	5B-290	90	22.1	197.6
Peterson Farms Seed	74K89	89	21.8	196.4
Dahlman	R45-22VT2PRIB	90	21.5	196.4
Mustang	2287VT2P	87	19.5	196.3
Thunder	7188 VT2P RIB	88	22.0	195.7
Proseed	990	90	22.6	195.3
NorthStar Genetics - Viking	VS 92-110	92	26.5	195.2
Hyland Seeds	8295RA	88	21.5	194.8
REA Hybrids	2B870	87	19.9	194.8
Proseed	1286	86	19.8	194.7
Legacy Seeds	L-2813 VT2PRO	87	19.8	194.4
Nuseed	9001 VP3220	90	21.9	193.0
Legacy Seeds	L-3011 VT3PRO	90	20.8	192.4
Wensman Seed	W 80866VT2RIB	86	18.8	192.3
Thunder	6987 VT2P RIB	87	19.2	191.8
Peterson Farms Seed	77H87	87	19.8	191.7
Legacy Seeds	L-2643 VT2PRO	86	20.8	191.5
Dairyland	DS-9487RA	87	21.2	190.4
Wensman Seed	W 80903VT2RIB	90	22.4	190.3
Producers Hybrids	4933 VT2RIB	89	22.1	189.5
Nuseed	8701 VT2P RIB	87	20.2	189.4
Hyland Seeds	8202RA	89	21.4	188.7
Proseed	1288	88	23.5	188.1
Legend Seeds	LS 9487 VT2PRIB	87	21.0	188.1
Mycogen	2J238	88	21.1	188.0
Legacy Seeds	L-2910 VT3PRO	88	19.9	187.1
Stine	R9209VT2Pro	91	26.3	186.7
Thunder	4391 VT2P RIB	91	22.2	185.7
Legend Seeds	LS 9386 VT3PRIB	86	20.1	184.6
Stine	R9201VT3Pro	86	19.8	184.5
Integra	3912	89	23.4	184.5
Legacy Seeds	L-2914 VT2PRO	88	21.8	183.5
Mycogen	2T277	87	20.8	183.2
Mustang	2686VT3P	86	19.8	182.7
Stine	R9206RR	89	19.8	181.8
Dairyland	DS-9791RA	91	26.6	179.8
NuTech	5N-186	86	18.5	179.5
Partners Brand	PB 5630GT	86	19.4	179.1
NK	N23M-3011A	88	20.0	176.8
Integra	9361	86	19.1	174.0
Mean			21.4	190.8
CV (%)			5.9	4.4
LSD (0.1)			1.3	10.1

Preliminary

Southern zone combined (Ransom, Richland and Sargent Counties) early maturing (<94) corn hybrid trial results, 2014.

Brand	Variety	RM	Moisture	Yield
			(%)	(bu/a)
Legacy Seeds	L-3022 GENSS	92	21.3	227.2
Nuseed	9304 VT2P	93	22.4	226.7
Thunder	4990 RR	90	20.4	226.3
Dahlman	R46-27VT2PRIB	92	22.4	225.9
Legend Seeds	LS 9492 VT2PRIB	92	22.6	224.8
Peterson Farms Seed	76S92	92	22.3	224.6
Mustang	3291VT2P	91	20.5	221.5
NuTech	5B-290	90	20.3	221.1
Mustang	3292VT2P	92	22.6	220.7
Peterson Farms Seed	73D91	91	21.1	220.6
Integra	9412	91	21.5	219.1
Legacy Seeds	L-3043 VT2PRO	93	23.2	216.9
Dairyland	DS-9791RA	91	22.8	216.8
Legacy Seeds	L-3011 VT3PRO	90	20.2	216.3
REA Hybrids	4B285 RIB	93	21.2	216.3
Hyland Seeds	8315RA	92	23.0	216.1
Mustang	3893GENSS	93	21.3	215.8
Mycogen	2V357	93	23.2	214.6
Nuseed	9001 VP3220	90	20.0	214.0
Proseed	1392	92	22.8	213.9
Proseed	1191	91	21.1	213.2
Thunder	7993 VT2P	93	21.8	212.8
Integra	3912	89	20.9	211.6
Dairyland	DS-9487RA	87	20.7	211.0
Hyland Seeds	8305RA	90	21.1	209.7
NK	N31H-3000GT	93	20.2	207.2
Peterson Farms Seed	74K89	89	20.1	207.1
Thunder	7188 VT2P RIB	88	20.0	205.3
Proseed	990	90	19.8	205.1
Thunder	4391 VT2P RIB	91	21.3	204.0
Partners Brand	PB 6255VT2-RIB	92	22.7	203.6
Dairyland	DS-9093	93	25.2	200.6
Wensman Seed	W 90910STXRIB	91	22.8	199.8
Thunder	6987 VT2P RIB	87	18.4	195.1
NuTech	5N-186	86	18.0	195.1
NK	N23M-3011A	88	19.8	191.4
Proseed	1393	93	21.2	188.5
Mean			21.3	210.7
CV (%)			1.8	3.3
LSD (0.1)			0.9	10.8

Preliminary

Southern zone combined (Ransom, Richland and Sargent counties) late maturing (>94) corn hybrid trial results, 2014.

Brand	Variety	RM	Moisture	Yield
			(%)	(bu/a)
REA Hybrids	4B953 RIB	95	21.7	236.5
Dahlman	R47-35VT3PRIB	94	22.9	228.3
Integra	9455	95	19.9	227.1
Peterson Farms Seed	81W95	95	23.1	226.4
REA Hybrids	4B941 RIB	97	22.6	225.6
Wensman Seed	W 90941STX	94	21.4	223.9
Thunder	9595 VT3P RIB	95	23.1	223.8
Nuseed	9505 VT2P RIB	95	23.1	223.8
NorthStar Genetics - Viking	VS 94-571	94	21.6	222.6
NuTech/G2 Genetics	5F-399™	99	24.6	222.5
NuTech/G2 Genetics	5F-295™	95	21.9	222.5
Stine	R9422VT3Pro	96	22.5	222.4
Proseed	1396	96	22.1	221.9
NuTech/G2 Genetics	5F-198™	98	22.3	220.7
Wensman Seed	W 90967STXRIB	96	23.8	220.3
Thunder	7396 VT2P RIB	96	21.8	220.2
Legacy Seeds	L-3844 GENSS	98	22.0	219.6
Legacy Seeds	L-3712 VT3PRO	96	23.0	219.4
Thunder	101-97 SS RIB	97	22.1	219.0
Peterson Farms Seed	82H99	99	23.5	216.7
Legacy Seeds	L-3423 GENSS	94	23.5	216.3
Nuseed	9504 VT3P RIB	95	22.7	216.0
Legacy Seeds	L-3612 VT3PRO	95	22.0	216.0
Peterson Farms Seed	55S96	96	23.4	215.6
Peterson Farms Seed	88A97	97	23.5	215.2
NuTech	5V-195	95	22.2	212.4
Thunder	101-95 SS RIB	95	23.5	212.1
Stine	R9311VT3Pro	94	21.7	211.7
Legend Seeds	LS 9495 VT3PRIB	95	23.5	211.4
NuTech/G2 Genetics	5X-894™	94	20.4	210.5
NuTech/G2 Genetics	5X-698™	98	22.4	208.4
NuTech/G2 Genetics	5Y-196™	96	20.6	206.7
NK	N41Y-3111	98	25.3	205.2
Proseed	1295	95	23.8	198.4
Mean			22.6	218.2
CV (%)			1.8	3.3
LSD (0.1)			0.9	10.8

Soybean Response to Micronutrients in NW Minnesota

Location: Ada and Gully, MN

Fertilizer: Treatments

1) 10 lbs Zinc (Zn) per acre
2) 10 lbs Manganese (Mn) per acre
3) 2 lbs Boron (B) per acre
4) 20 lbs Chloride (Cl) per acre

Treatments were compared to a control (no fertilizer) and consisted of all possible combinations of the four micronutrients studied. Phosphorus and Potassium kept at non-limiting levels. Fertilizer was broadcast and incorporated before planting

Weed Management: Glyphosate

Experimental Design: Randomized complete block design with 4 replications. Yields are reported at 13% grain moisture.

Objective:

The purpose of this study was to determine if there is a potential yield response in soybean to selected micro-nutrients applied broadcast before planting.

Experimental Methods:

The studies at Ada was laid out using a factorial design. There were sixteen total treatments consisting of one, two, three, or four of the micronutrients applied together. All treatments were hand applied prior to planting and incorporated prior to planting. Trials were established at twelve field locations across Minnesota with six established in 2013 and six in 2014.

Initial soil test results are given in Table 1. Soil phosphorus levels were High to Very High at all sites . Soil potassium ranged from Medium to Very High, and zinc (Zn) ranged from low to high using current interpretations for corn. Soil tests were also run for manganese (Mn), boron (B), and chloride (Cl). There currently are no critical levels for these elements for soybean in Minnesota. Soybeans are responsive to Mn, however, yield responses are typically seen in areas of the country with soils that have been historically deficient in Mn.

Research in Michigan has shown soybean yield increases due to Mn and recommendations exist in that state when soil test levels are less than 24 ppm. Sandy soils with high soil pH have been traditionally responsive to manganese in Michigan. Three locations tested lower than this level. Since there is no clear evidence of past yield responses to Mn in Minnesota, we cannot say that Mn was low. However, the high soil pH and relatively low Mn concentration may

Table 1. Initial soil test data for 0-6" samples collected before treatment application for 2013-2014 soybean micronutrient studies.

			Soil Test							
Year	Location	County	P	K	Zn	Mn	B	Cl	OM	pH
			ppm						--%--	
2013	Ada	Norman	14*	177	0.4	11.0	0.57	10.7	3.7	8.1
	Lamberton	Redwood	13	150	0.9	47.2	0.65	6.3	4.5	5.8
	Rochester	Olmsted	47	143	2.1	34.8	0.27	6.3	2.1	5.8
	St. Charles	Winona	14	105	0.8	48.8	0.27	6.8	3.0	6.7
	Stewart 1	McLeod	13*	173	1.5	26.5	0.79	6.0	7.3	7.4
	Stewart 2	McLeod	26	134	1.6	46.6	0.80	6.0	5.2	6.8
2014	Ada	Norman	17	368	1.5	7.3	0.99	14.4	6.1	7.4
	Lamberton	Redwood	34	145	1.9	57.0	0.88	3.4	4.4	5.4
	Rochester 1	Olmsted	25	256	2.8	28.7	0.80	124.5	4.6	6.5
	Rochester 2	Olmsted	17	161	2.5	33.2	0.43	13.2	2.2	5.9
	Stewart 1	McLeod	25	179	1.5	14.1	1.09	3.2	6.5	7.7
	Stewart 2	McLeod	37	172	1.9	31.5	0.91	4.1	4.8	7.0

P, Bray-P1 phosphorus; K, ammonium acetate potassium; Zn, DTPA zinc; Mn, DTPA manganese; B, hot water extracted boron; Mg, amonium acetate extractable magnesium; OM, organic matter loss on ignition; pH, 1:1 soil:water ;na, data not available. not available.

*Olsen-P test was used instead of the Bray-P1

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Project Funding Provided by:
Minnesota Soybean Research and Promotion Council

Table 2 summarizes yield data collected from the factorial study. There was no clear evidence of a response to micronutrients at any location. In general, the trend was for slightly lower yields with Zn, B, and Cl at Ada 2013 and most other locations that year.

The only location were there was a significant difference in grain yield was at the site near Rochester in 2013 and Stewart in 2014 where the yield with B was around 2 bu/ac less with the 2 lb application rate compared to the control. The Rochester location was on a sandy soil which likely magnified negative impacts of B application. Stewart was a clay loam soil. Boron toxicity symptoms were noted within the same field for a 5 lb/ac B rate in 2011. It appears that the 2 lb rate may still be too much even in a year where soils were cool and excessively wet early in the growing season.

Soil test values were examined but were not helpful in determining where responses would occur. In-fact, the large variation in soil test values and no evidence of a yield response calls into question the value of micronutrient soil tests for use in soybean.

Tissue analysis was also conducted but the data has not yet been returned from the lab for 2014. Plant tissue data from 2013 is not shown but application of boron, zinc, and chloride increase concentration of the respective elements in both trifoliate leaf tissue collected at R2 and in grain nutrient concentration. Tissue nutrient concentration indicates that the micros are being taken up by soybean but are not needed for increasing soybean grain yield.

2-Year Summary

- There was no yield advantage for applying Zn, Mn, B, or Cl to soybean.
- The lack of response was consistent among locations and for the yield average across locations and years.
- The potential effect of the climatic conditions at individual locations may have limited potential for determining treatment differences.
- Soil tests did not aid in the determination of where micronutrient deficiencies may occur.

Table 2. Soybean Gain yield Summary of a micronutrient study conducted near Ada, MN and the average yield across twelve locations studied across MN from 2013-2014.

	Zn Rate (lbs/ac)		Mn Rate (lbs/ac)		B Rate (lbs/ac)		Cl Rate (lbs/ac)	
	0	10	0	10	0	2	0	20
	------bu/ac------							
Ada 2013	25.1a	24.4a	26.8a	26.8a	27.1a	26.5a	28.1a	25.4a
Ada 2014	37.5a	38.7a	37.1a	39.0a	37.5a	38.7a	38.1a	38.1a
Twelve Site Average	42.9a	42.7a	42.8a	42.8a	42.9a	42.8a	43.0a	42.7a

*numbers followed by the same letter are not significantly different at $P \leq 0.10$

Yield and Quality of Organically Grown Soybean Treated With a Plant Stimulant— Clay County

Cooperator: Lynn Brakke Organic Farms
Nearest Town: Comstock, MN
Soil Type: Fargo Silty Clay
Spring Tillage: One pass with a field cultivator
Previous Crop: Corn
Planting Date: 5/29/2014
Variety: Sheyenne
Row Width: 22 inches
Planting Population: 200,000
Harvest Date: 10/1/14
Experimental Design: Randomized Complete block with four replicates

Purpose of Study:

Evaluate Dakota REV™ CPF 6000 on soybean yield and quality in an organic production system.

Materials and Methods:

Dakota REV™ CPF 6000 was applied in-furrow to soybean using a John Deere 7300 Vacuum Planter. All plots except untreated check received product at one or two quarts per acre. Field plots were 18 rows wide and 30 feet long. Stand counts were taken on middle two rows (rows 9 and 10) on 11 June and 1 October. Five plants per plot were harvested on 1 October, from row 8 or 11, to determine pod count and 100 seed weight. At harvest, ten feet of row was collected from the middle two rows of each plot and used to determine yield and quality. Soybean yield was adjusted to 13% moisture.

Results:

There was no significant difference between treatments for stand counts taken on 11 June and 1 October (data not shown). There was no significant difference between treatments for yield, protein, oil, pod count, or hundred seed weight (table 1).

Table 1. Yield, quality, pod count, and seed weight from organically grown soybean treated with Dakota REV™ CPF 6000. Comstock, MN, 2014.

Treatment	Yield (*bu/ac*)	Protein (%)	Oil (%)	Pod count (number/plant)	100 seed weight (g)
Untreated check	31.7	33.4	18.2	27.0	13.0
Dakota REV™ CPF 6000 1 qt/a	32.9	33.2	18.2	22.9	13.4
Dakota REV™ CPF 6000 2 qt/a	33.7	33.3	18.2	22.9	12.7
$LSD_{0.05}$ =	*NS*	*NS*	*NS*	*NS*	*NS*

For Additional Information:
Randy Nelson

Project Funding Provided by:
Thanks to Jim Cameron, Northwest Research and Outreach Center, Crookson, MN, for assistance with threshing and quality analysis.

Soybean Variety Evaluations by UMN Soybean Breeding Project—NW MN

Purpose of Study:

Each year Minnesota Agricultural Experiment Station scientists conduct performance tests of appropriately adapted public and private soybean entries. Companies are charged a fee for each entry they enter to partially cover the costs of conducting these tests. A stipulation of the testing program is that the company is marketing or intends to begin marketing the entry in the next growing season. This information is also available electronically at the websites:

http://www.maes.umn.edu/Research/Crop_Variety_Trials/Soybean/index.htm

www.mnsoybean.org

Presented in this brief report are the results from northwest Minnesota and do not reflect the entire results of the statewide varietal trials. The results provided are from the locations of Roseau, Crookston, Thief River Falls, Shelly, and Moorhead for standard evaluation. There are results for Soybean cyst nematode varietal evaluations from Gary and Mahnomen. A third site was lost due to herbicide spray drift prematurely terminating the growing plants.

There will be additional information included in the final and full report published by the Minnesota Agricultural Experiment Station which can be accessed at the link provided above.

Soybean test locations and maturity zones.

Results:

Yield

Because maturity is a very important attribute, entries are arranged in the tables in order of their actual or estimated 2014 calendar date of maturity and not yield performance. Later-maturing entries usually can be expected to have higher yields than earlier maturing types. If you wish to correctly compare yields, do so only between entries with similar calendar dates of maturity, usually within 3 to 5 days. More reliable comparisons can be made using yields from several consecutive years. All yield determinations were made from replicated tests harvested with a plot combine.

The yield information is presented as a percent of the mean of the test. The actual mean value is given at the bottom of each table. Values over 100 indicate the entry had a yield greater than the mean while those less than 100 have a yield less than the mean. LSD values associated with data in these tables are measures of variability within the trials. The LSD numbers beneath the yield columns indicate whether the difference between yields is due to genetics or other factors, such as variations in the environment. If yield differences between two entries equals or exceeds the LSD value, the higher yielding entry probably was superior in yield. A difference less than the LSD value is probably due to environmental factors. The LSD values are given on the percent of mean data, not the actual yields. A 20% level of significance is used in all these tables. This means that yield differences exceeding the stated LSD value are real 80% of the time.

For Additional Information:
Dr. Jim Orf, Art Killam, and Phillip Glogoza

Project Funding Provided by:
MN Soybean Research and Promotion Council

Table 1. Performance and characteristics of conventional, special purpose and transgenic soybean varieties, far northern zone; Crookston, Roseau and Thief River Falls, 2012-2014.

		Mat.	Yield, % of Mean			% of Mean		Mat.	Phyto.	Chlorosis	Seed	Trans
Entry	Originator	Date	2012-2014	2013-2014	2014	Protein	Oil	Rating	Gene	Score	Treat	Trait
0074 RR2YN	Nuseed	9-19	-	-	95	96	96	00.7	Rps1c	1.0	-	R2
PB-00766R2	Prairie Brand Seeds	9-20	-	-	108	102	102	00.7	S	1.4	-	R2
5B005R2	Mycogen Seeds	9-20	105	112	104	101	106	00.5	Rps1c	1.0	CCMVA	R2
Integra 20076N	Wilbur-Ellis Co	9-20	-	-	97	100	98	00.7	Rps1c	1.3	-	R2
MN0071	Minnesota AES	9-20	-	-	77	103	107	00.7	Rps1a	1.9	-	CV
35007 R2YN	Thunder Seed	9-21	-	-	107	99	101	00.7	S	1.8	CMP	R2
LS00734N	Legacy Seeds	9-21	-	-	105	99	106	00.7	Rps1c	1.5	MPP	R2
H007R4	Hefty Seed Co	9-21	-	-	94	99	102	00.7	Rps1c	1.3	IS	R2
DSR-C905/R2Y	Dairyland Seed Co	9-22	-	110	113	98	101	00.9	Rps1c	1.8	CMO	R2
HS 006RYS24	Hyland Seeds	9-22	-	102	106	100	97	00.6	Rps1k	1.5	CMV	R2
6007	NuTech - G2	9-22	-	-	104	101	103	00.7	Rps1k	1.8	SCE	RR
MN0095	Minnesota AES	9-22	-	100	104	103	100	00.9	Rps1k	1.8	-	CV
X54G007R2	Mycogen Seeds	9-22	-	-	103	99	103	00.7	Rps1c	1.8	CCMVA	R2
Cavalier	N. Dakota AES	9-22	-	-	83	70	70	00.7	Rps6	1.9	-	CV
H008R3	Hefty Seed Co	9-23	-	-	102	98	101	00.8	Rps1c	1.3	IS	R2
32005 R2Y	Thunder Seed	9-23	92	89	99	100	102	00.5	Rps1c	1.3	CMP	R2
HS 007RY32	Hyland Seeds	9-23	-	-	99	100	102	00.7	Rps1c,k	1.3	CMV	R2
Integra 20031	Wilbur-Ellis Co	9-24	-	-	114	98	99	00.7	Rps1c	1.8	-	R2
PB-00844R2	Prairie Brand Research	9-24	105	104	109	100	103	00.8	S	1.5	-	R2
33009 R2YN	Thunder Seed	9-24	104	104	107	99	102	00.9	Rps3a	1.8	CMP	R2
MN0107	Minnesota AES	9-24	91	84	102	105	97	0.1	Rps1k	1.8	-	CV
PB-00950R2	Prairie Brand Seeds	9-24	99	114	99	102	102	00.9	S	1.5	-	R2
5G009R2	Mycogen Seeds	9-24	98	104	96	99	99	00.9	Rps1c	1.5	CCMVA	R2
Integra 20215	Wilbur-Ellis Co	9-25	-	-	106	100	98	0.0	Rps1c	2.0	-	R2
P01T23R	Dupont Pioneer	9-25	-	99	100	99	103	0.1	Rps1c	1.5	IMMP	R1
DSR-C918/R2Y	Dairyland Seed Co	9-26	-	-	104	103	101	0.1	Rps1k	1.3	CMO	R2
Astro	Thunder Seed	9-26	-	-	102	98	102	00.5	S	1.3	CMP	R2
6000	NuTech - G2	9-26	-	-	101	98	102	0.0	Rps1k	1.8	SCE	RR
P01T06R	Dupont Pioneer	9-26	-	-	99	99	105	0.1	Rps1c,6	1.5	IMMP	R1
HS 01RY02	Hyland Seeds	9-26	-	-	99	100	101	0.1	Rps1k	1.3	CMV	R2
MN0208CN	Minnesota AES	9-26	-	-	95	105	95	0.2	Rps1a	1.2	-	CV
MN0404CN	Minnesota AES	9-26	-	-	91	102	103	0.4	Rps1k	2.0	-	CV
H009R3	Hefty Seed Co	9-27	-	-	105	100	97	00.9	Rps3a	1.5	IS	R2
5B012R2	Mycogen Seeds	9-27	-	-	103	102	105	0.1	S	1.5	CCMVA	R2
MN0302	Minnesota AES	9-28	-	-	92	102	102	0.3	Rps1k	2.1	-	CV
PB-0131R2	Prairie Brand Seeds	9-29	-	-	108	106	99	0.2	S	2.3	-	R2
H01R4	Hefty Seed Co	9-29	-	-	93	102	102	0.1	Rps1c+3a	1.5	IS	R2
PB-0291R2	Prairie Brand Research	9-30	-	108	105	101	97	0.2	S	2.0	-	R2
LS 00833N	Legacy Seeds	9-37	-	-	113	100	101	0.8	Rps1c	1.5	MPP	R2
Mean		9-24	37.6 bu/a	38.7 bu/a	37.4 bu/a	32.7%	16%					
LSD 20%			3%	3%	2%							

[1] Greenhouse test results do not agree with originator's designation.

* Designates Special Purpose Variety

LSD numbers beneath yield columns indicate whether the difference between yields is due to genetics or other factors, such as variations in environment.
If yield difference between two entries equals or exceeds the LSD value the higher-yielding entry probably was superior in yield.
A difference less than the LSD value probably is due to environmental factors.

Table 2. Performance and characteristics of conventional, special purpose and transgenic soybean varieties, northern zone;
Crookston, Moorhead and Shelly, 2012-2014.

Entry	*Originator*	*Mat. Date*	*Yield, % of Mean* 2012-2014	2013-2014	2014	*% of Mean* Protein	Oil	*Mat. Rating*	*Phyto. Gene*	*Chlorosis Score*	*Seed Treat*	*Trans Trait*
H008L3	Hefty Seed Co	9-23	-	-	82	99	101	00.8	Rps1k	3.0	Ino Sys	LL
MN0095	Minnesota AES	9-23	98	92	78	100	105	00.9	Rps1a	2.4	-	CV
MN0208CN	Minnesota AES	9-25	-		101	106	102	0.3	Rps1a	2.5	-	CV
PO3T68R2	Dupont Pioneer	9-26	-	-	95	99	98	0.3	Rps1c	2.0	IMMP	R2
HS 01RY02	Hyland Seeds	9-26	-	-	93	96	101	0.1	Rps1k	2.0	CMV	R2
Integra 20126	Wilbur-Ellis Co	9-26	-	-	90	98	101	0.1	Rps3a	1.8	-	R2
MN0404CN	Minnesota AES	9-26	-		90	100	105	0.4	Rps1k	3.1	-	CV
H0212L	Hefty Seed Co	9-26	-	-	89	99	103	0.2	Rps1k	3.3	Ino Sys	LL
LS 0214	Legacy Seeds	9-26	-	-	87	98	103	0.2	Rps3a	2.8	MPP	R2
MK0249*	Richland IFC Inc	9-26	-	60	75	95	101	0.2	Rps1	3.5	-	CV
DST02-001/R2Y	Dairyland Seed	9-27	-	-	105	101	100	0.2	Rps1k	3.0	CMO	R2
02RE03	Stine Seed	9-27	-	-	102	100	99	0.2	S	2.0	-	R2
2034 RR2YN	Nuseed	9-27	-	-	100	102	101	0.3	Rps1c	1.5	-	R2
5401 LL	Thunder Seed	9-27	-	-	88	101	102	0.1	Rps1k	3.3	CMP	LL
MK0205*	Richland IFC Inc	9-27	76	60	70	104	99	0.2	Rps1	3.0	-	CV
DST-0305/R2Y	Dairyland Seed	9-28	-	107	118	96	101	0.3	Rps1k	2.5	CMO	R2
5B033R2	Mycogen Seeds	9-28	-	-	108	99	105	0.3	Rps1k	2.0	CPNCMVA	R2
HX 01RY41	Hyland Seeds	9-28	-	-	107	100	97	0.1	Rpa1k1[1]	2.8	CMV	R2
3503 R2Y	Thunder Seed	9-28	-	-	104	104	96	0.3	S	2.3	CMP	R2
7063	NuTech - G2	9-28	-	98	101	97	108	0.6	Rps1c	1.8	SCE	R1
5303 LLN	Thunder Seed	9-28	-	92	99	102	101	0.3	Rps1k	3.3	CMP	LL
6021	NuTech - G2	9-28	-	105	89	101	102	0.2	S	1.8	SCE	R1
DSR-0514/R2Y	Dairyland Seed	9-29	-	-	109	100	101	0.5	Rps3a,1c[1]	2.5	CMO	R2
PB-0131R2	Prairie Brand Seeds	9-29	-	-	108	100	97	0.2	S	3.3	-	R2
P05T24R	Dupont Pioneer	9-29	-	114	107	100	98	0.5	Rps1k	2.5	IMMP	R1
H02R3	Hefty Seed Co	9-29	-	-	100	99	98	0.2	Rps3a	2.3	Ino Sys	R2
LS 0334	Legacy Seeds	9-29	-	-	98	101	100	0.3	Rps1k	2.3	MPP	R2
6036	NuTech - G2	9-29	-	-	91	101	104	0.3	Rps1k	2.0	SCE	R1
5205 LLN	Thunder Seed	9-29	-	104	85	102	99	0.5	Rps1k	3.5	CMP	LL
MK0508*	Richland IFC Inc	9-29	92	94	73	99	98	0.8	Rps1	3.3	-	CV
DSR-0404/R2Y	Dairyland Seed	9-30	117	116	118	99	99	0.4	Rps3a	2.5	CMO	R2
HS 05RYS25	Hyland Seeds	9-30	-	112	116	98	94	0.5	S	3.0	CMV	R2
PB-0441R2	Prairie Brand Seeds	9-30	109	101	113	98	95	0.4	S	2.5	-	R2
15R05N	Peterson Farm Seed	9-30	-	-	110	101	100	0.5	S	2.5	-	R2
X54050NR2	Mycogen Seeds	9-30	-	-	109	101	100	0.5	Rps3a	2.3	CPNCMVA	R2
15R04	Peterson Farm Seed	9-30	-	-	109	98	98	0.4	S	2.8	-	R2
PB-0524R2	Prairie Brand Research	9-30	-	-	106	101	98	0.5	S	2.8	-	R2
Integra 20456	Wilbur-Ellis Co	9-30	-	-	106	101	99	0.4	Rps3a	3.3	-	R2
2051 RR2Y	Nuseed	9-30	-	-	105	99	99	0.5	S	1.8	-	R2
5B040R2	Mycogen Seeds	9-30	-	114	104	101	99	0.4	Rps3a	2.0	CPNCMVA	R2
Integra 20109	Wilbur-Ellis Co	9-30	-	-	104	100	98	0.2	Rps3a	2.5	-	R2
P06T28R	Dupont Pioneer	9-30	-	-	100	100	99	0.6	Rps1k	2.0	IMMP	R1
3205 R2Y	Thunder Seed	10-1	-	110	105	101	98	0.5	S	2.8	CMP	R2
5B066R2	Mycogen Seeds	10-1	-	114	102	99	98	0.6	S	3.0	CPNCMVA	R2
HS 06RY26	Hyland Seeds	10-1	-	-	102	99	99	0.6	S	2.8	CMV	R2
H06Y12	Hefty Seed Co	10-1	-	-	100	97	99	0.6	S	1.8	Ino Sys	R2
14R06N	Peterson Farm Seed	10-2	-	-	99	104	96	0.6	S	2.8	-	R2
3406R2YN	Thunder Seed	10-3	-	-	105	101	95	0.6	S	2.0	-	R2
3506 R2YN	Thunder Seed	10-3	-	-	103	103	100	0.6	S	2.3	CMP	R2
PB-0609R2	Prairie Brand Seeds	10-4	-	116	117	98	99	0.6	S	2.3	-	R2
07RF33	Stine Seed	10-4	-	-	103	98	99	0.7	Rps3a	2.3	-	R2
X14061R2	Prairie Brand Research	10-4	-	-	102	100	95	0.6	S	2.3	-	R2
15R07N	Peterson Farm Seed	10-5	-	-	115	99	103	0.6	S	1.8	-	R2
PB-0777R2	Prairie Brand Research	10-5	-	-	103	98	102	0.7	S	3.8	-	R2
Mean		9-29	41.8 bu/a	44.5 bu/a	44.1 bu/a	33.6%	16.9%					
LSD 20%			3%	3%	5%							

[1] Greenhouse test results do not agree with originator's designation.

* Designates Special Purpose Variety

LSD numbers beneath yield columns indicate whether the difference between yields is due to genetics or other factors, such as variations in environment.
If yield difference between two entries equals or exceeds the LSD value the higher-yielding entry probably was superior in yield.
A difference less than the LSD value probably is due to environmental factors.

Table 5. Characteristics of special-use soybean varieties, northern zone;
Crookston and Moorhead, 2014.

Entry	Originator	Mat. Rating	Special Characteristics	Hilum Color	Phyto. Gene	Chlorosis Score	Seeds/Lb.	Trans Trait
MN0071 (00)	Harmony x OT92-8	9-20	EARLY	Brown	Rps1a	2.8	3,220	CV
MN0083	M97-121138 x MN0091	9-21	SSR	Yellow	Rps6	3.0	3,691	CV
MN0095	M92-270029 x M93-313185	9-22	EARLY	Imperfect Black	Rps1a	2.0	4,127	CV
Traill	M82-996 X KG20	9-22	EARLY	Yellow	Rps1a	1.8	3,027	CV
M06-320039	MN0201 X MN1105SP	9-23	PROTEIN	Yellow	Rps1a	2.8	3,290	CV
MN0107	MN0302 X Daksoy	9-23	EARLY	Yellow	Rps1k	2.8	2,987	CV
M07-257111	MN1701CN X M99-326040	9-25	SMALL SCN	Yellow	Rps1a	3.5	4,018	CV
MN0208CN	MN0902CN X MN0201	9-25	SCN	Yellow	Rps1a	2.0	3,466	CV
M07-292111	M01-315029 x MN1106CN	9-26	SCN	Yellow	S	1.8	3,466	CV
M08-450148	UM3 X PI200508	9-26	SMALL	Yellow	Rps1a	2.3	4,540	CV
MN0082SP	MN0202SP X UM3	9-26	SMALL	Yellow	Rps1a	2.8	7,094	CV
MN0091	Glacier X S19-90	9-26	SSR	Yellow	Rps1c	3.5	3,047	CV
MN0302	M84-93 X Archer	9-26	EARLY	Buff	Rps1k+6	3.0	3,439	CV
MN0404CN	MN0902CN X MN0304	9-26	EARLY	Brown	Rps1k+6	2.8	3,632	CV
MK0205*	Richland IFC Inc	9-26	SMALL	Yellow	Rps1	3.5	6,053	CV
M07-236092	Lambert X M99-326040	9-27	SMALL	Buff	S	2.0	3,815	CV
M07-278126	M00-110002 x Sheyenne	9-27	YIELD	Yellow	Rps1a	2.0	3,197	CV
MN0304	Archer X Glacier	9-27	EARLY	Imperfect Black	Rpsq	2.5	3,338	CV
MK0249*	Richland IFC Inc	9-27	SMALL	Yellow	Rps1	3.0	4,680	CV
M06-289001	M00-351195 X M00-365181	9-28	SCN	Yellow	S	2.3	4,054	CV
M07-306034	SDX98-7452 X M98-283046	9-28	PROTEIN	Yellow	S	3.3	2,948	CV
MK0508*	Richland IFC Inc	9-29	SMALL	Yellow	Rps1	3.3	5,974	CV
M07-303013	MN1806SP X M99-340047	9-30	PROTEIN	Yellow	Rps1a	2.5	2,467	CV
M03-238028	UM3 X MN0201	10-1	SMALL	Yellow	Rps1a	2.5	4,495	CV
M07-306032	SDX98-7452 X M98-283046	10-1	PROTEIN	Yellow	S	2.8	2,929	CV
M04-178018	UM3 X Black Kato	10-3	SMALL BLACK	Black	Rps1a	3.0	4,054	CV

* Special Purpose Lines from Table 2.

Table 6. Performance of special-use soybean varieties, northern zone;
Crookston and Moorhead, 2012-2014.

		Maturity	% of Mean	% of Mean	
Entry	Originator	Date	2014	Protein	Oil
MN0071 (00)	Harmony x OT92-8	9-20	90	95	103
MN0083	M97-121138 x MN0091	9-21	112	98	99
MN0095	M92-270029 x M93-313185	9-22	98	98	104
Traill	M82-996 X KG20	9-22	118	99	96
M06-320039	MN0201 X MN1105SP	9-23	86	112	84
MN0107	MN0302 X Daksoy	9-23	110	101	98
M07-257111	MN1701CN X M99-326040	9-25	100	98	97
MN0208CN	MN0902CN X MN0201	9-25	113	101	96
M07-292111	M01-315029 x MN1106CN	9-26	124	96	102
M08-450148	UM3 X PI200508	9-26	98	95	99
MN0082SP	MN0202SP X UM3	9-26	79	98	95
MN0091	Glacier X S19-90	9-26	51	97	95
MN0302	M84-93 X Archer	9-26	117	98	97
MN0404CN	MN0902CN X MN0304	9-26	122	97	103
MK0249*	Richland IFC Inc	9-26	79	95	101
M07-236092	Lambert X M99-326040	9-27	79	99	97
M07-278126	M00-110002 x Sheyenne	9-27	106	91	99
MN0304	Archer X Glacier	9-27	116	100	99
MK0205*	Richland IFC Inc	9-27	79	104	99
M06-289001	M00-351195 X M00-365181	9-28	114	101	93
M07-306034	SDX98-7452 X M98-283046	9-28	96	108	92
MK0508*	Richland IFC Inc	9-29	79	99	98
M07-303013	MN1806SP X M99-340047	9-30	106	107	88
M03-238028	UM3 X MN0201	10-1	94	101	93
M07-306032	SDX98-7452 X M98-283046	10-1	93	104	96
M04-178018	UM3 X Black Kato	10-3	104	101	97
Mean		9-26	38.9 bu/a	34.9%	17.2%
LSD 20%			2%		

LSD numbers beneath yield columns indicate whether the difference between yields is due to genetics or other factors, such as variations in environment. If yield difference between two entries equals or exceeds the LSD value the higher-yielding entry probably was superior in yield. A difference less than the LSD value probably is due to environmental factors.
* Special Purpose Lines from Table 2.

Table12. Performance and characteristics of soybean varieties,norhern zone at soybean cyst nematode infested sites; Gary and Mahnomen, 2014.

		Mat.	Yield, % of Mean			% of Mean		Mat.	Phyto.	Chlorosis	SCN	Seed	Trans
Entry	Originator	Date	2012-14	2013-14	2014	Protein	Oil	Rating	Gene	Score	Rating	Treat	Trait
PB-00766R2	Prairie Brand	9-18	-	-	96	100	99	00.7	S	1.5	MR	-	R2
MN0071	Minnesota AES	9-18	-	-	93	101	103	00.7	Rps1a	1.7	S	-	CV
33009 R2YN	Thunder Seed	9-18	92	81	83	97	104	00.9	Rps3a	1.5	S	CMP	R2
MN0095	Minnesota AES	9-18	-	92	68	101	99	00.9	Rps1a	1.9	S	-	CV
35007 R2YN	Thunder Seed	9-19	-	-	108	99	103	00.7	S	1.8	MR	CMP	R2
MN0107	Minnesota AES	9-19	-	-	84	105	94	0.1	Rps1k	2.8	S	-	CV
MN0208CN	Minnesota AES	9-22	-	101	109	103	104	0.2	Rps1a	2.2	R	-	CV
MN0404CN	Minnesota AES	9-23	-	-	91	98	103	0.4	Rps1k	1.9	R	-	CV
MN0302	Minnesota AES	9-24	-	-	98	101	108	0.3	Rps1k	2.3	S	-	CV
7063	NuTech - G2	9-25	-	92	115	95	104	0.6	Rps1c	1.5	S	SCE	R1
PB-0524R2	Prairie Brand	9-28	-	-	109	101	96	0.5	S	1.5	MR	-	R2
AG0835	Monsanto - Asgrow	9-31	-	-	124	98	100	0.8	S	1.5	MR	-	R2
3408 R2YN	Thunder Seed	9-31	-	-	109	99	100	0.8	Rps1c	2.0	MR	CMP	R2
3506 R2YN	Thunder Seed	9-31	-	-	108	102	94	0.6	S	2.5	MR	CMP	R2
PB-0777R2	Prairie Brand	9-31	-	112	104	97	93	0.7	S	1.5	MR	-	R2
Mean		9-24	28.1 bu/a	31.3 bu/a	25.7 bu/a	34.8%	16%						
LSD 20%			5%	7%	2%								

[1] Greenhouse test results do not agree with originator's designation.

LSD numbers beneath yield columns indicate whether the difference between yields is due to genetics or other factors, such as variations in environment.
If yield difference between two entries equals or exceeds the LSD value the higher-yielding entry probably was superior in yield.
A difference less than the LSD value probably is due to environmental factors.

Table 15. Greenhouse bioassay and field plot tests of soybean varieties in northern zone for resistance to soybean cyst nematode; Gary and Mahnomen 2014.

				Greenhouse Test		Field Egg Index		Field Reproductive Index	
			SCN	HG Type 0		GARY	MAHNOMEN	GARY	MAHNOMEN
		Mat.	Resist.	(race 3)					
Entry	Originator	Rating	Source‡	FI	Res.§	Ei	Ei	Pf/Pi	Pf/Pi
AG0835	Monsanto - Asgrow	0.8	S	28.2	MR	29.8	6.8	3.8	1.4
3506 R2YN	Thunder Seed	0.6	PI88788	22.3	MR	12.9	14.8	1.9	1.3
3408 R2YN	Thunder Seed	0.8	PI88788	23.5	MR	25.7	1.3	2.8	1.3
PB-0524R2	Prairie Brand	0.5	PI88788	19.8	MR	5.7	48.5	1.0	1.4
7063	NuTech - G2	0.6	PI88788	80.2	S	395.4	31.3	39.0	2.1
35007 R2YN	Thunder Seed	0.07	PI88788	28.3	MR	17.0	56.3	6.8	1.3
33009 R2YN	Thunder Seed	0.09	PI88788	102.8	S	80.2	58.5	21.5	3.5
PB-0777R2	Prairie Brand	0.7	PI88788	20.7	MR	39.1	8.8	4.7	1.5
PB-00766R2	Prairie Brand	00.7	PI88788	17.2	MR	9.5	5.8	2.3	1.2
MN0095	Minnesota AES	00.9	S	90.6	S	54.0	93.0	34.6	2.0
MN0107	Minnesota AES	0.1	S	87.0	S	33.4	107.0	35.2	8.3
MN0302	Minnesota AES	0.3	S	68.2	S	75.1	21.0	16.9	4.1
MN0208CN	Minnesota AES	0.2	PI88788	9.9	R	6.7	0.8	1.8	0.8
MN0404CN	Minnesota AES	0.4	PI88788	7.1	R	13.4	0.8	1.2	0.8
MN0071	Minnesota AES	00.7	S	78.9	S	106.9	13.3	14.0	4.3

‡ Resistance source provided by originator: S = susceptible.
§ SCN resistance rating: R = resistant at FI 10% or less; MR = moderately resistant at FI 11-30%;
LR = low resistant at FI 31-60%; S = susceptible at FI >60%.

LR = low resistant at FI 31-60%; S = susceptible at FI >60%.

Soybean Seeding Rate x Planting Date x Seed Treat

Locations: East Grand Forks, MN (Polk Co.), Hendrum, MN (Norman Co.), Barnesville, MN (Clay Co.) and Newfolden, MN (Marshall Co.)

Plot Layout: Soybeans were planted at 2 different planting dates using a split plot design

Objectives:

Evaluate soybean response to different populations at different planting dates with and without a seed treatment. Seeding rates were between 75000 and 200000 Live Seeds Per Acre at intervals of 25000. All populations were planted with and without a seed treat. Planting dates for the "Early" Planting Date were between May 21 and May 28. The planting Date for the "Late" Treatment was June 25.

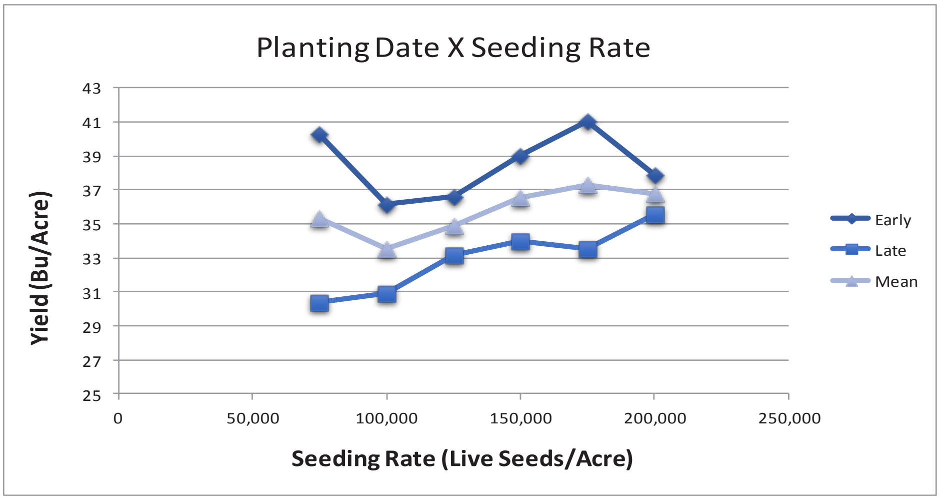
Results:

Planting date had a significant affect on yield.

Seeding Rate had a significant effect on yield

There was also a significant interaction between planting date and population.

Seed Treatment produced no significant effect on yield at any location or across 4 locations.



Seeding Rate x Planting Date

Seeding Rate	Early	Late
75,000	40.294	30.3947
100,000	36.1565	30.9491
125,000	36.6074	33.1783
150,000	39.0544	33.9605
175,000	41.0598	33.518
200,000	37.9133	35.5689

Mean 35.72124167
CV 5.321763498
LSD 4.304307

Seeding Rate Across Planting Dates

Seeding Rate	Yield (Bu/Acre)
75000	35.3443
100000	33.5528
125000	34.8929
150000	36.5074
175000	37.2889
200000	36.7411

Mean 35.79662
CV 3.786670362
LSD 2.2495375

For Additional Information:
Jerry Buckley, Howard Person, and Nathan Jonhnson, Univ. of MN Extension

Funding provided by Minnesota Soybean Growers Association. Seed was provided by Asgrow-Dekalb. Thanks to Grant Mehring at NDSU for assistance with Statistical analysis.

Coordinated County Variety and Research Trials — NW Region

Purpose of Study:

The data presented here is part of a coordinated effort by MN County Soybean Grower to evaluate regional varieties in multiple locations by maturity group.

Associations, ND County Crop Improvement Associations, U of MN Extension and NDSU and to expand the amount of research information that soybean growers have access to in NW Minnesota and SE North Dakota. These trials are funded by Minnesota & North Dakota Soybean Check-off and entry fees are paid by seed companies.

There were a total of 12 locations across MN and ND that participated in this coordinated effort: Nine were MN soybean county associations and three were ND county crop improvement associations. In Minnesota, each trial location had additional research trials on either plant populations and micro nutrients or fungicides.

About This Variety Plot Trial:

The County Soybean Variety Plots are randomized small plot trials. They utilized three replicated blocks in each location. The soybean plots were planted with a Haldrup small plot cone planter and harvested with a small plot Zurn combine. For weed control, the plots were sprayed with glyphosate by the farmer-cooperator using commercial size equipment, utilizing driving lanes through the plots.

Data Interpretation:

Statistics are a mathematical tool used to summarize and interpret groups of numbers. In these tables we used a LSD (least significant difference) test to determine if differences in yield are due to genetic differences between varieties or due to other causes such as variability in soil type or fertility, or other environmental factors.

If the difference between two varieties exceeds the LSD value, it means that with 80 percent probability, the higher yielding variety is significantly different in yield. If the difference between two varieties is less than the LSD value, then the variety yields are considered the same. The LSD number is also a measure of variability within a trial and a large number indicates there is more variability in a location compared to a location with a small LSD number.

Coefficient of Variation (CV) is an indicator of how much variability there was within the soybean trial location (uneven seeding rate, emergence, insect damage, disease, soil type etc.) that was not due to any effect of the varieties. A CV of less than 15 indicates a very uniform trial site. Therefore, differences in soybean yields are the result of varieties rather than other external factors.

County Collaborators:

Howard Person, U of MN Extension Educator, Marshall & Pennington Counties; Jerry Buckley, U of MN Extension Educator, Norman & Mahnomen Counties; Brian Zimprich, NDSU Extension Agent, Ransom County; NDSU Extension Agent, Steele County and Alicia Harstad, NDSU Extension Agent, Steele County.

(In this publication, all yields are adjusted to 13% moisture.)

For Additional Information:
Howard Person and Jerry Buckley, UMN Extension
Brian Zimprich and Alicia Harstad, NDSU Extension Service

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Minnesota Soybean Research and Promotion Council
North Dakota Soybean Council

Coordinated NW MN County Soybean Board of Directors, ND Crop Improvement Officers/Directors & Plot Information

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Planting Date: May 23, 2014 Harvest Date: October 7, 2014

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Planting Date: May 24, 2014 Harvest Date: October 9, 2014

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Planting Date: May 29, 2014 Harvest Date: October 8, 2014

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Planting Date: May 27, 2014 Harvest Date: October 11, 2014

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Planting Date: May 25, 2014 Harvest Date: October 15, 2014

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Cooperator/Location: Mike Flint, Elbow Lake, MN
Planting Date: May 24, 2014 Harvest Date: October 9, 2014

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Cooperator/Location: Kyle Mehrkens, Thief River Falls, MN
Planting Date: May 28, 2014 Harvest Date: October 11, 2014

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Cooperator/Location: Matthew Krueger, East Grand Forks, MN
Planting Date: May 23, 2014 Harvest Date: October 2, 2014

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Jim Kukowski, Vice President/MSGA State Delegate, Strathcona, MN kukowskiseed@wiktel.com
Cooperator/Location: Bill Bendickson, Warroad, MN
Planting Date: May 28, 2014 Harvest Date: October 10, 2014

North Dakota

Steele County
Steele County Crop and Livestock Improvement Association
Alicia Harstad, Steele County Extension
Cooperator/Location: Brandon Roller, Hope, ND
Planting Date: May 22, 2014 Harvest Date: October 9, 2014

Ransom County
Ransom County Crop Improvement and Livestock Association
Brian Zimprich, Ransom County Extension
Cooperator/Location: Tim Huether, Lisbon, ND
Planting Date: May 22, 2014 Harvest Date: October 10, 2014

Cass County
Cooperator/Location: NDSU Prosper Research Farm, Prosper, ND
Planting Date: May 29, 2014 Harvest Date: October 8, 2014

Tractor provided by Valley Plains Equipment.
We thank you!

Valley Plains Equipment

Characteristics of Soybean Varieties and Variety Placement Across Zones

PHYTOPHTHORA ROOT ROT is a destructive soil borne disease that can cause soybean stand loss and reduced plant productivity. The primary means of managing this disease is to plant varieties that are resistant to the pathogen. This is a bit of a 'cat and mouse' game since there are over 55 races of this disease and approximately eight single resistance genes, designated as *Rps* genes that are used in soybean that offer different spectrums of control. Each *Rps* gene offers control of several races of phytophthora but no gene offers control of all races. The key to managing this disease is to know which *Rps* gene is used in each soybean field you plant and make an annual evaluation of how well it is performing. For example, if the soybean variety you have chosen has a Rps 1k gene and you plant it in two fields and you notice phytophthora is very low in field A but is pretty noticeable in spots in field B, you want to make field notes to avoid using the Rps 1K gene in field B in future soybean variety selections.

SOYBEAN CYST NEMATODE (SCN) is a highly damaging pest of soybean. Surveys indicate this pest is expanding its range in NW Minnesota and you should be testing your soil to determine if it is present. Crop rotation and planting SCN resistant varieties are the primary means for managing this microscopic roundworm.

SEED TREATMENTS: 1-16: Fungicides / 17-19: Insecticides / 20: Inoculants / 21: Other

Ref #:	Treatment	Ref #:	Treatment	Ref #:	Treatment
1	Azoxystrobin	8	Mefenoxam	15	Trichoderma harzianum Rifai
2	Bacillus pumilus	9	Metalaxyl	16	Trifloxystrobin
3	Bacillus subtilis	10	Pyraclostrobin	17	Clothianidin
4	Captan	11	Streptomyces griseoviridis	18	Imidacloprid
5	Fludioxonil	12	Streptomyces lydicus	19	Thiamethoxan
6	Ipconazole	13	Thiabendazole	20	Bradyrhizobium japonicum
7	Mancozeb	14	Thiram	21	Other

In the Seed Treatment column on the form: List each of the seed treatments present on the variety. (I.e. If the variety is treated with CruiserMaxx Plus (mefenoxam, fludioxonil, thiamethoxam) you would put 8,5,19 in the box. If the seed treatment list does not include one of the compounds use the number 21.)

Phytophthora	
Ref #:	Gene:
1	Rps 1a
2	Rps 1b
3	Rps 1c
4	Rps 1k
5	Rps 3
6	Rps 4
7	Rps 6

SCN Trait:	
Ref #:	Trait
1	PI88788
2	Peking
3	Other

Company	Variety	Relative Maturity	Phytophthora Gene	Seed Treatment *(see chart above for reference)*	SCN Trait	ZONE 1	ZONE 2	ZONE 3	ZONE 4
						Hallock Newfolden Warroad	East Grand Forks Thief River Falls Hope	Waubun Ada Prosper	Elbow Lake Barnesville Lisbon
Channel	0507R2	0.5	3	9, 10, 21	1		X		
Channel	0508R2	0.5	4	9, 10, 21			X		
Channel	0707R2	0.7	4	9, 10, 21	1			X	
Channel	0807R2	0.8	3	9, 10, 21	1			X	X
Channel	0205R2	0.2	3	9, 10, 21		X			
Dahlman Seed	Dahlman 52009RR2Y	00.9	3				X		
Dahlman Seed	Dahlman 5203RR2Y	0.3	5				X	X	
Dahlman Seed	Dahlman 5309NRR2Y	0.9	3		1				X
Dahlman Seed	Dahlman 5405NRR2Y	0.5	5		1			X	X
Dairyland Seed	DSR-0514/R2Y	0.5	4	5, 8, 19	1		X	X	
Dairyland Seed	DSR-0711/R2Y	0.7	4	5, 8, 19	1		X	X	X
Dairyland Seed	DSR-1340/R2Y	1.3	3	5, 8, 19					X
Dairyland Seed	DSR-C198/R2Y	00.9	4	5, 8, 19		X			
Dairyland Seed	DST02-001/R2Y	0.2	4	5, 8, 19		X			
Dyna-Gro Seed	S04RY55	0.4	3	5, 8, 19, 21			X		
Dyna-Gro Seed	S06RY24	0.6	4	5, 8, 19, 21			X	X	
Dyna-Gro Seed	S07RY45	0.7	3	5, 8, 19, 21			X	X	
Dyna-Gro Seed	S08RY23	0.8	5	5, 8, 19, 21				X	
Dyna-Gro Seed	S09RY64	0.9		5, 8, 19, 21				X	
Dyna-Gro Seed	34RY03	0.3	3	5, 8, 19, 21		X	X		
Dyna-Gro Seed	S006RY75	00.6				X			
Dyna-Gro Seed	S007RY44	00.7	3	5, 8, 19, 21		X			
Dyna-Gro Seed	S008RY43	00.8	3	5, 8, 19, 21		X			
Hefty Seed Co	H 06Y12	0.6		6, 9, 17				X	
Hefty Seed Co	H 007R4	00.7	3	6, 9, 17	3, 3	X	X		
Hefty Seed Co	H 008R3	0.8	3	6, 9, 17	3, 3	X	X		
Hefty Seed Co	H 01R4	0.1	3, 5	6, 9, 17		X	X		
Hefty Seed Co	H 02R3	0.2	5	6, 9, 17		X	X	X	
Hyland Seeds	HS 01RY02	0.1	4	8, 5, 19		X	X		
Hyland Seeds	05RYS25	0.5		8, 5, 19	1	X	X		

Company	Variety	Relative Maturity	Phytophthora Gene	Seed Treatment *(see chart for reference)*	SCN Trait	ZONE 1 Hallock Newfolden Warroad	ZONE 2 East Grand Forks Thief River Falls Hope	ZONE 3 Waubun Ada Prosper	ZONE 4 Elbow Lake Barnesville Lisbon
Hyland Seeds	HS 06RY26	0.6		5, 8, 19			X	X	X
Hyland Seeds	HS 09RYS12	0.9	3, 4	5, 8, 19	1			X	X
Hyland Seeds	HS 11RY07	1.4	3	5, 8, 19					X
Hyland Seeds	HS 15RYS45	1.5	5	5, 8, 19					X
Hyland Seeds	HS 006RYS24	00.6	4	5, 8, 19	1	X	X		
Hyland Seeds	HS 007RY32	00.7	3, 4	5, 8, 19		X			
Integra	Integra 20815N	0.8	3		1,3				X
Integra	Integra 20915N	0.9			1, 3				X
Integra	Integra 21115N	1.1	4		1,3				X
Legacy Seeds, Inc.	LS 0634 RR2	0.6	4	20, 21	1		X	X	X
Legacy Seeds, Inc.	LS 0833 NRR2	0.8	3	20, 21	1			X	X
Legacy Seeds, Inc.	LS 1134 NRR2	1.1	3	20, 21	1				X
Legacy Seeds, Inc.	LS 1314 NRR2	1.3	4	20, 21	1				X
Legacy Seeds, Inc.	LS 00834 RR2	00.8	3	20, 21		X			
Legacy Seeds, Inc.	LS 0134 RR2	0.1	5	20, 21		X	X		
Legacy Seeds, Inc.	LS 0214 RR2	0.2	5	20, 21		X	X	X	
Legacy Seeds, Inc.	LS 0334 RR2	0.3	4	20, 21		X	X	X	
Legend Seeds	LS 03R22	0.3	5				X	X	
Legend Seeds	LS 06R24N	0.6	4		3		X	X	
Legend Seeds	LS 10R551N	1	3		3				X
Legend Seeds	LS 12R24N	1.2	4		3				X
Legend Seeds	02R21	0.2	3			X			
Legend Seeds	LS 003R21	0.03	3			X			
Mycogen	5B033R2	0.3	4	5, 8, 19, 21			X		
Mycogen	5B040R2	0.4	5	5, 8, 19, 21			X		
Mycogen	5B066R2	0.6		5, 8, 19, 21				X	
Mycogen	5B081R2	0.8	4	5, 8, 19, 21				X	
Mycogen	5N091R2	0.9	5	5, 8, 19, 21	1			X	X
Mycogen	5N122R2	1.2	4	5, 8, 19, 21	1				X
Mycogen	X54070NR2	0.7					X		
Mycogen	5B012R2	0.1		5, 8, 19, 21		X			
Mycogen	5G009R2	00.9	3	5, 8, 19, 21		X			
Mycogen	X54J009R2	00.9	4	5, 8, 19, 21		X			
NorthStar Genetics	NS 0096R2	00.9	3				X		
NorthStar Genetics	NS 0318R2	0.3	5	5, 8, 19			X	X	
NorthStar Genetics	NS 0480NR2	0.2	5	5, 8, 19	1		X	X	
NorthStar Genetics	NS 0537NR2	0.5		5, 8, 19				X	
NorthStar Genetics	NS 0839NR2	0.8	3	5, 8, 19	1			X	X
NorthStar Genetics	NS 1040NR2	1.0	3	5, 8, 19	1				X
NorthStar Genetics	NS 629NR2	0.6	4	5, 8, 19	1				X
NorthStar Genetics	NS 949R2	0.9	5	5, 8, 19					X
NorthStar Genetics	NS 0060NR2	00.6	3	5, 8, 19	1	X			
NorthStar Genetics	NS 0080R2	00.6	3	5, 8, 19		X	X		
NorthStar Genetics	NS 0088R2	00.8	3	5, 8, 19	1	X			
NorthStar Genetics	NS 0200NR2	0.2	3	5, 8, 19	1	X			
NuTech	G2 6036	0.3	4	20, 21			X		
NuTech	G2 6083	0.8		20, 21				X	

Company	Variety	Relative Maturity	Phytophthora Gene	Seed Treatment *(see chart for reference)*	SCN Trait	ZONE 1 Hallock Newfolden Warroad	ZONE 2 East Grand Forks Thief River Falls Hope	ZONE 3 Waubun Ada Prosper	ZONE 4 Elbow Lake Barnesville Lisbon
NuTech	G2 6084 R2	0.8	4	20, 21				X	X
NuTech	G2 6093	0.9	4	20, 21				X	X
NuTech	G2 6134	1.4	3	20, 21					X
NuTech	G2 7063	0.6	4	20, 21	2		X	X	
NuTech	G2 7104 R2	1.0	4, 7	20, 21	1				X
NuTech	G2 6000	0.0	4	20, 21		X	X		
NuTech	G2 6007	00.7	4			X			
NuTech	G2 6021	0.2		20, 21		X	X		
Partners Brand Seed Co.	PB0351R2	0.3	3	5, 8, 19	1		X		
Partners Brand Seed Co.	PB00651R2	0.6	3	5, 8, 19	1	X			
Partners Brand Seed Co.	PB00741R2	0.7	3	5, 8, 19	1	X			
Partners Brand Seed Co.	PB00941R2	0.9	3	5, 8, 19	1	X	X		
Partners Brand Seed Co.	PB0251R2	0.2	5	5, 8, 19		X	X		
Peterson Farms Seed	14R06N	0.6	4	9, 10, 21	1		X	X	
Peterson Farms Seed	14R09N	0.9		9, 10, 21	1			X	X
Peterson Farms Seed	14R11N	1.1	4	9, 10, 21	1				X
Peterson Farms Seed	14R13	1.3	5	9, 10, 21					X
Peterson Farms Seed	15R04	0.4	5	9, 10, 21			X		
Peterson Farms Seed	15R05N	0.5	5	9, 10, 21	1		X	X	
Peterson Farms Seed	15R07N	0.7	3	9, 10, 21	1		X		
Peterson Farms Seed	15R14N	1.4	3	9, 10, 21	1				X
Peterson Farms Seed	13R03	0.3	5	9, 10, 21		X		X	
Peterson Farms Seed	14R008	00.8	3	9, 10, 21		X			
Peterson Farms Seed	14R02	0.2	3, 5	9, 10, 21		X			
Peterson Farms Seed	15R006N	0.7	3	9, 10, 21	1	X			
Prairie Brand Seeds	PB0240R2	0.2	3	5, 8, 19, 21			X		
Prairie Brand Seeds	PB-0291R2	0.2	5	5, 8, 19, 21			X		
Prairie Brand Seeds	PB-0441R2	0.4	5	5, 8, 19, 21			X		
Prairie Brand Seeds	PB-0598R2	0.5	5	5, 8, 19, 21	1		X		
Prairie Brand Seeds	PB-00760R2	00.7				X			
Prairie Brand Seeds	PB-00844R2	00.8	3	5, 8, 19, 21	1	X			
Prairie Brand Seeds	PB-00950R2	00.9	3	5, 8, 19, 21		X			
Prairie Brand Seeds	PB-0131R2	0.2	3	5, 8, 19, 21		X			
Producers Hybrids	0301R2	0.3	5	5, 8, 19	1		X	X	
Producers Hybrids	0602NR2	0.6	4	5, 8, 19	1		X	X	
Proseed	30-60	0.6	3				X		
Proseed	30-80	0.8	3					X	
Proseed	P2 20-30	0.3	5				X		
Proseed	P2 20-70	0.7	4				X		
Proseed	P2 20-90	0.9	5					X	
Proseed	30-20	0.2	5			X			
Proseed	30-70	00.7	3			X			
Proseed	30-90	00.9	5			X			
Proseed	P2 20-80	00.8	3			X			
REA Hybrids	64G94	0.4		9, 10, 18	1		X	X	
REA Hybrids	65G22	0.5		9, 10, 18			X		
REA Hybrids	66G14	0.6	4	9, 10, 18	1			X	

Company	Variety	Relative Maturity	Phytophthora Gene	Seed Treatment *(see chart for reference)*	SCN Trait	ZONE 1 Hallock Newfolden Warroad	ZONE 2 East Grand Forks Thief River Falls Hope	ZONE 3 Waubun Ada Prosper	ZONE 4 Elbow Lake Barnesville Lisbon
REA Hybrids	69G13	0.9	5	9, 10, 18					X
REA Hybrids	69G14	0.9	3	9, 10, 18	1			X	X
REA Hybrids	R0815	0.8	3	9, 10, 18	1			X	X
REA Hybrids	R1215	1.2		9, 10, 18	1				X
REA Hybrids	55G14	00.5		9, 10, 18	1	X			
REA Hybrids	58G82	00.8	4	9, 10, 18		X	X		
REA Hybrids	62G22	0.2	3	9, 10, 18		X	X		
Renk Seeds	RS084NR2	0.8	3	5, 8, 19				X	
Renk Seeds	RS033R2	0.3	5	5, 8, 18			X		
Nuseed	2051 RR2Y	0.5		5, 8, 19			X	X	X
Nuseed	2074 RR2YN	0.7	4	5, 8, 19	1			X	X
Nuseed	2093 RR2YN	0.9	3	5, 8, 19	1				X
Nuseed	2122 RR2YN	1.2	4	5, 8, 19	1				X
Nuseed	0074 RR2YN	00.7	3	5, 8, 19	1	X	X		
Nuseed	2034 RR2YN	0.3	3	5, 8, 19	1	X	X	X	
Stine Seed	03RD66	0.3	3				X		
Stine Seed	04RF36	0.4					X		
Stine Seed	06RE02	0.6	4				X		X
Stine Seed	Stine 11RD00	1.1	5						X
Syngenta	NK S007-Y4	00.7	3	5, 8, 19, 21			X		
Syngenta	NK S009-J1	00.9	5	5, 8, 19, 21			X		
Syngenta	NK S07-B6	0.7	4	5, 8, 19, 21				X	
Syngenta	NK S09-K4	0.9		5, 8, 19, 21	1			X	
Thunder Seed, Inc	3114 R2Y	1.4	3	5, 8, 19					X
Thunder Seed, Inc	3205 R2Y	0.5		5, 8, 19				X	X
Thunder Seed, Inc	33009 R2YN	00.9	5	5, 8, 19	3			X	
Thunder Seed, Inc	3408 R2YN	0.8	3	5, 8, 19	3			X	X
Thunder Seed, Inc	3503 R2Y	0.3		5, 8, 19			X	X	
Thunder Seed, Inc	3511 R2YN	1.1		5, 8, 19					X
Thunder Seed, Inc	32005 R2Y	00.5	3	5, 8, 19		X			
Thunder Seed, Inc	34006 R2Y	00.6		5, 8, 19		X	X		
Thunder Seed, Inc	35007 R2YN	00.7		5, 8, 19		X	X		
Thunder Seed, Inc	Astro R2Y	00.8		5, 8, 19		X	X		
Wensman Seed	W 3024R2	0.2	3	9, 10, 17, 18, 21			X		
Wensman Seed	W 3030R2	0.2	3	9, 10, 17, 18, 21			X		
Wensman Seed	W 3032R2	0.4	5	9, 10, 17, 18, 21				X	
Wensman Seed	W 3062NR2	0.6	4	9, 10, 17, 18, 21	1			X	
Wensman Seed	W 3080NR2	0.8	3	9, 10, 17, 18, 21	1			X	X
Wensman Seed	W 3090NR2	0.8	5	9, 10, 17, 18, 21	1				X
Wensman Seed	W 3102NR2	1.0		9, 10, 17, 18, 21	1				X
Wensman Seed	W 30061NR2	00.6	3	9, 10, 17, 18, 21	1	X			
Wensman Seed	W 30084R2	00.8	3	9, 10, 17, 18, 21		X			
Wensman Seed	W 30099R2	00.9	4	9, 10, 17, 18, 21		X	X		

Zone 1 - Hallock, Newfolden, Warroad - EARLY Maturity

Company	Variety	Relative Maturity	Hallock Yield (bu/A)	Newfolden Yield (bu/A)	Warroad Yield (bu/A)	Average Across Locations (bu/A)
Legend Seeds, Inc	LS 003R21	00.3	58.2	43.6	22.7	40.9
Legend Seeds, Inc	LS 003R24N	00.3	52.6	44.1	35.5	44.1
Legend Seeds, Inc	LS 005R24	00.5	57.6	45.1	40.7	47.7
REA Hybrids	53G32	00.3	48.1	44.0	32.0	41.4
REA Hybrids	55G14	00.5	56.9	45.8	35.5	46.1
Thunder Seed, Inc	32005 R2Y	00.5	47.9	43.9	22.3	38.0
		Mean	53.6	44.4	31.5	43.0
		CV	3.1	4.7	12.5	15.7
		LSD 0.2	2.9	4.0 (NS)	7.6	5.0
		Top 1/3	58.2 - 54.8	45.8 - 45.1	40.7 - 34.6	47.7 - 44.5
		Mid 1/3	54.7 - 51.4	45.0 - 44.4	34.5 - 28.5	44.4 - 41.3
		Bottom 1/3	51.3 - 47.9	44.3 - 43.6	28.4 - 22.3	41.2 - 38.0

Top 1/3 of Yield Range by location
Mid 1/3 of Yield Range by location
Bottom 1/3 of Yield Range by location

Zone 1 - Hallock, Newfolden, Warroad - LATE Maturity

Company	Variety	Relative Maturity	Hallock Yield (bu/A)	Newfolden Yield (bu/A)	Warroad Yield (bu/A)	Average Across Locations (bu/A)
Channel	0205R2	0.2	55.8	47.4	33.7	45.6
Dairyland Seed	DSR-C918/R2Y	00.9	57.8	34.2	39.7	43.9
Dairyland Seed	DST02-001/R2Y	0.2	54.6	33.6	36.7	41.5
Dyna-Gro Seed	34RY03	0.3	59.4	52.4	46.3	52.7
Hefty Seed Co	H 01R4	0.1	60.0	43.3	36.6	46.6
Hefty Seed Co	H 02R3	0.2	57.4	33.0	40.0	43.2
Legacy Seeds, Inc.	LS 0134 RR2	0.1	59.3	40.3	40.8	46.8
Legacy Seeds, Inc.	LS 0214 RR2	0.2	62.1	41.4	38.0	47.2
Legacy Seeds, Inc.	LS 0334 RR2	0.3	59.3	39.6	40.0	46.2
Legend Seeds, Inc	LS 02R21	0.2	57.6	47.7	40.5	48.6
Mycogen	5B012R2	0.1	53.1	42.2	41.3	45.5
Mycogen	5G009R2	00.9	56.7	48.8	39.6	48.4
Mycogen	X54J009R2	00.9	57.4	40.4	37.1	45.0
Northstar Genetics	NS 0200NR2	0.2	52.4	40.3	34.3	42.3
Nuseed	2034 RR2YN	0.3	59.1	47.3	35.1	47.2
NuTech	G2 6000	0.0	49.8	36.2	30.9	38.9
NuTech	G2 6021	0.2	55.4	37.0	35.6	42.6
Partners Brand Seed Co	PB00941R2	00.9	52.0	37.5	34.0	41.2
Partners Brand Seed Co	PB0251R2	0.2	58.0	42.9	45.5	48.8
Peterson Farms Seed	13R03	0.3	58.0	43.9	44.5	48.8
Peterson Farms Seed	14R02	0.2	55.7	41.0	38.6	45.1
Prairie Brand Seeds	PB-00950R2	00.9	55.7	39.1	44.5	46.4
Prairie Brand Seeds	PB0240R2	0.2	58.0	46.0	37.6	47.2
Wensman Seed	W 30099R2	00.9	57.2	46.1	41.6	48.3
		Mean	56.7	41.7	38.9	45.8
		CV	4.0	8.7	9.0	12.8
		LSD 0.2	3.1	4.4	5.4	3.6
		Top 1/3	62.1 - 58.0	52.4 - 45.9	46.3 - 42.1	52.7 - 48.1
		Mid 1/3	57.9 - 53.9	45.8 - 39.4	42.0 - 37.9	48.0 - 43.5
		Bottom 1/3	53.8 - 49.8	39.3 - 33.0	37.8 - 33.7	43.4 - 38.9

Top 1/3 of Yield Range by location
Mid 1/3 of Yield Range by location
Bottom 1/3 of Yield Range by location

Zone 1 - Hallock, Newfolden, Warroad - MID Maturity

Company	Variety	Relative Maturity	Hallock Yield (bu/A)	Newfolden Yield (bu/A)	Warroad Yield (bu/A)	Average Across Locations (bu/A)
Dyna-Gro Seed	S006RY75	00.6	55.1	47.0	34.8	45.7
Dyna-Gro Seed	S007RY44	00.7	53.7	50.1	38.5	47.5
Dyna-Gro Seed	S008RY43	00.8	55.8	47.7	43.1	48.9
Hefty Seed Co	H 007R4	00.7	53.9	44.4	33.7	44.0
Hefty Seed Co	H 008R3	00.8	59.0	45.7	31.5	45.4
Hyland Seeds	HS 006RYS24	00.6	52.1	51.3	32.8	45.4
Hyland Seeds	HS 007RY32	00.7	52.2	48.5	31.5	44.1
Integra	20031	00.7	59.9	44.7	39.3	48.0
Integra	20076N	00.7	54.0	45.3	33.8	44.4
Legacy Seeds, Inc.	LS 00834 RR2	00.8	52.3	43.8	33.7	43.3
Northstar Genetics	NS 0060NR2	00.6	52.3	43.0	36.9	44.1
Northstar Genetics	NS 0080R2	00.6	57.7	44.7	34.6	45.7
Northstar Genetics	NS 0088R2	00.8	56.1	44.0	33.0	44.4
Nuseed	0074 RR2YN	00.7	48.5	41.2	36.3	42.0
NuTech	G2 6007	00.7	54.7	50.8	35.0	46.8
Partners Brand Seed Co.	PB00651R2	00.6	49.8	48.3	39.7	45.9
Partners Brand Seed Co.	PB00741R2	00.7	56.2	43.9	31.7	43.9
Peterson Farms Seed	14R008	00.8	51.1	50.4	38.4	46.6
Peterson Farms Seed	15R006N	00.7	49.6	40.1	32.9	40.9
Prairie Brand Seeds	PB-00766R2	00.7	48.3	41.2	42.6	44.1
Prairie Brand Seeds	PB-00844R2	00.8	58.9	55.5	35.4	50.0
Proseed	30-07	00.7	57.0	41.2	26.4	41.5
Proseed	P2 10-08	00.8	61.9	45.6	39.2	48.9
Proseed	P2 11-07	00.7	59.7	47.6	37.7	48.3
Proseed	P2 20-08	00.8	58.5	51.9	38.9	49.7
REA Hybrids	58G82	00.8	53.9	47.9	36.8	46.2
Thunder Seed, Inc	34006 R2Y	00.6	56.3	45.5	37.8	46.5
Thunder Seed, Inc	35007 R2YN	00.7	50.9	41.6	34.7	42.4
Thunder Seed, Inc	Astro R2Y	00.8	62.1	56.3	43.2	53.9
Wensman Seed	W 30061NR2	00.6	54.1	48.9	34.7	45.9
Wensman Seed	W 30084R2	00.8	51.7	55.8	42.3	49.9
		Mean	54.8	46.9	36.2	45.9
		CV	4.4	7.5	8.0	12.5
		LSD 0.2	4.0	5.0	4.9	3.6
		Top 1/3	62.1 - 57.5	56.3 - 50.9	43.2 - 37.4	53.9 - 49.6
		Mid 1/3	57.4 - 52.9	50.8 - 45.5	37.3 - 31.8	49.5 - 45.3
		Bottom 1/3	52.8 - 48.3	45.4 - 40.1	31.7 - 26.4	45.2 - 40.9

Top 1/3 of Yield Range by location
Mid 1/3 of Yield Range by location
Bottom 1/3 of Yield Range by location

Project Funding provided in part by:

Minnesota Soybean Research & Promotion Council

North Dakota Soybean Council

University of Minnesota Extension

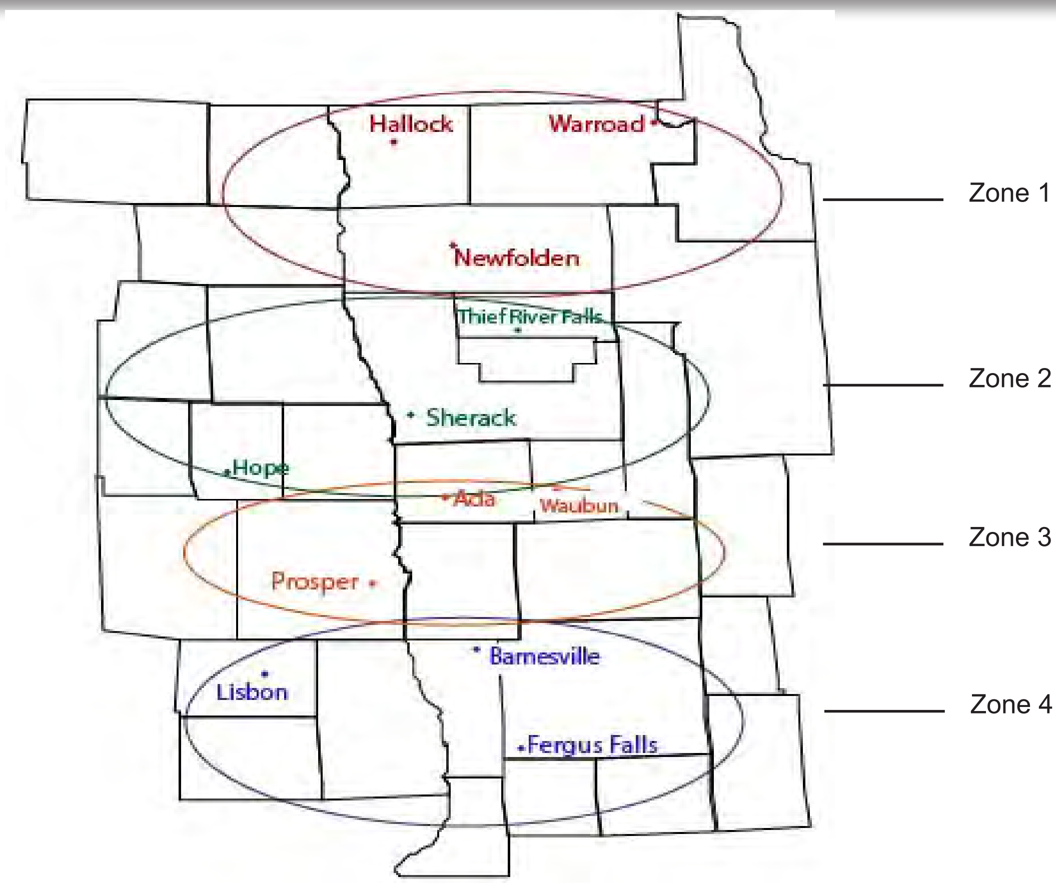
NDSU Extension Service North Dakota State University

Zone 2 - Thief River Falls, East Grand Forks, Hope - EARLY Maturity

Company	Variety	Relative Maturity	East Grand Forks Yield (bu/A)	Thief River Yield (bu/A)	Hope Yield (bu/A)	Average Across Locations (bu/A)
Hefty Seed Co	H 007R4	00.7	52.9	44.1	28.3	41.8
Hefty Seed Co	H 008R3	00.8	49.8	45.0	30.0	41.6
Hyland Seeds	HS 006RYS24	00.6	44.8	46.6	31.3	40.9
Northstar Genetics	NS 0080R2	00.6	49.6	44.2	31.0	41.6
Nuseed	0074 RR2YN	00.7	47.0	42.0	27.2	38.0
Proseed	30-07	00.7	49.9	47.4	26.0	39.7
REA Hybrids	58G82	00.8	57.5	40.2	26.8	43.6
Syngenta	NK S007-Y4	00.7	43.1	39.8	30.0	37.6
Thunder Seed, Inc	34006 R2Y	00.6	52.3	42.4	29.5	41.4
Thunder Seed, Inc	35007 R2YN	00.7	46.8	47.3	27.4	40.5
Thunder Seed, Inc	Astro R2Y	00.8	53.4	53.9	37.4	48.3
		Mean	49.7	44.8	29.5	41.4
		CV	5.4	9.3	10.8	15.3
		LSD 0.2	5.0	6.7 (NS)	6.0 (NS)	3.5
		Top 1/3	57.5 - 52.7	53.9 - 49.2	37.4 - 33.6	48.3 - 44.7
		Mid 1/3	52.6 - 47.9	49.1 - 44.5	33.5 - 29.8	44.6 - 41.1
		Bottom 1/3	47.8 - 43.1	44.4 - 39.8	29.7 - 26.0	41.0 - 37.6

Top 1/3 of Yield Range by location
Mid 1/3 of Yield Range by location
Bottom 1/3 of Yield Range by location

County Soybean Variety Trial Locations



Zone 2 - Thief River Falls, East Grand Forks, Hope - LATE Maturity

Company	Variety	Relative Maturity	East Grand Forks Yield (bu/A)	Thief River Yield (bu/A)	Hope Yield (bu/A)	Average Across Locations (bu/A)
Channel	0507R2	0.5	39.4	58.0	36.6	44.6
Channel	0508R2	0.5	47.3	51.7	37.0	45.3
Dairyland Seed	DSR-0514/R2Y	0.5	63.1	52.3	36.1	50.5
Dairlyland Seed	DSR-0711/R2Y	0.7	51.6	56.7	39.5	49.3
Dyna-Gro Seed	S04RY55	0.4	47.7	60.8	39.9	49.5
Dyna-Gro Seed	S06RY24	0.6	57.3	54.4	40.4	50.7
Dyna-Gro Seed	S07RY45	0.7	62.3	55.3	41.9	53.2
Hyland Seeds	HS 05RYS25	0.5	54.1	59.5	39.1	50.9
Hyland Seeds	HS 06RY26	0.6	57.4	49.4	46.6	51.1
Integra	20456	0.4	53.6	52.8	38.1	48.2
Legacy Seeds, Inc.	LS 0634 NRR2	0.6	55.1	49.7	41.0	48.6
Mycogen	5B040R2	0.4	58.8	52.1	44.7	51.9
Mycogen	X54070NR2	0.7	54.5	60.8	43.1	52.8
Nuseed	2051 RR2Y	0.5	57.0	54.5	47.5	53.3
NuTech	G2 7063	0.6	55.8	50.1	31.9	45.9
Peterson Farms Seed	14R06N	0.6	53.9	52.5	40.5	49.0
Peterson Farms Seed	15R04	0.4	53.9	49.6	36.7	46.7
Peterson Farms Seed	15R05N	0.5	51.5	48.2	33.5	44.4
Peterson Farms Seed	15R07N	0.7	36.1	56.3	41.1	44.5
Prairie Brand Seeds	PB-0291R2	0.4	48.2	57.8	36.5	47.5
Prairie Brand Seeds	PB-0441R2	0.5	55.2	47.7	42.6	48.5
Prairie Brand Seeds	PB-0598R2	0.5	55.8	48.1	42.5	48.8
Producers Hybrids	0602NR2	0.6	54.5	59.3	38.3	50.7
Proseed	P2 11-50	0.5	61.1	52.2	46.8	53.4
REA Hybrids	64G94	0.4	50.4	58.1	46.6	51.7
REA Hybrids	65G22	0.5	51.1	54.1	39.3	48.4
Stine Seed	04RF36	0.4	46.9	51.3	38.5	45.5
Stine Seed	06RE02	0.6	50.8	52.0	33.7	45.5
		Mean	53.0	53.8	40.0	48.9
		CV	11.6	5.3	8	10.7
		LSD 0.2	10.2	5.2	5.8	NS
		Top 1/3	63.1 - 54.1	60.8 - 56.4	47.5 - 42.3	53.4 - 50.4
		Mid 1/3	54.0 - 45.1	56.3 - 52.0	42.2 - 37.1	50.3 - 47.4
		Bottom 1/3	45.0 - 36.1	51.9 - 47.7	37.0 - 31.9	47.3 - 44.4

Top 1/3 of Yield Range by location
Mid 1/3 of Yield Range by location
Bottom 1/3 of Yield Range by location

Project Funding provided in part by:

North Dakota Soybean Council
Our World is Growing

Minnesota Soybean Research & Promotion Council

Zone 2 - Thief River Falls, East Grand Forks, Hope - MID Maturity

Company	Variety	Relative Maturity	East Grand Forks Yield (bu/A)	Thief River Yield (bu/A)	Hope Yield (bu/A)	Average Across Locations (bu/A)
Dahlman Seed	Dahlman 52009RR2Y	00.9	46.7	30.1	30.5	35.8
Dahlman Seed	Dahlman 5203RR2Y	0.3	59.8	46.2	35.0	47.0
Dyna-Gro Seed	34RY03	0.3	48.9	51.0	37.9	46.0
Hefty Seed Co	H 01R4	0.1	51.3	47.4	32.5	43.7
Hefty Seed Co	H 02R3	0.2	61.0	49.2	36.3	48.8
Hyland Seeds	HS 01RY02	0.1	57.9	43.9	31.7	44.5
Integra	20126	0.1	56.9	40.9	30.9	42.9
Integra	20215	0.2	56.8	46.4	29.9	44.3
Legacy Seeds, Inc.	LS 0134 RR2	0.1	57.3	50.9	40.4	49.5
Legacy Seeds, Inc.	LS 0214 RR2	0.2	54.6	48.0	36.1	46.2
Legacy Seeds, Inc.	LS 0334 RR2	0.3	66.3	51.9	44.9	54.4
Mycogen	5B033R2	0.3	55.0	51.9	35.1	47.3
Northstar Genetics	NS 0096R2	00.9	50.4	41.9	33.3	41.8
Northstar Genetics	NS 0318R2	0.3	58.6	41.1	35.1	44.9
Northstar Genetics	NS 0480NR2	0.2	57.2	51.7	37.9	48.9
Nuseed	2034 RR2YN	0.3	56.9	45.8	38.4	47.0
NuTech	G2 6000	0.0	54.4	46.2	33.6	44.7
NuTech	G2 6021	0.2	53.8	49.5	33.0	45.4
NuTech	G2 6036	0.3	58.2	46.3	33.9	46.3
Partners Brand Seed Co	PB00941R2	00.9	52.6	40.8	27.4	40.3
Partners Brand Seed Co	PB0251R2	0.2	58.9	49.1	32.7	46.9
Partners Brand Seed Co	PB0351R2	0.3	63.6	43.6	33.1	46.8
Prairie Brand Seeds	PB-0131R2	0.2	60.0	52.7	31.0	47.9
Producers Hybrids	0301R2	0.3	58.5	50.6	42.9	50.4
Proseed	30-20	0.2	57.1	48.8	36.3	47.4
Proseed	P2 20-30	0.3	62.4	50.3	36.2	49.6
Renk Seeds	RS033R2	0.3	59.5	48.7	36.2	48.1
Stine Seed	03RD66	0.3	59.6	42.1	36.6	46.1
Syngenta	NK S009-J1	00.9	51.2	50.3	36.0	45.8
Thunder Seed, Inc	3503 R2Y	0.3	61.0	57.5	37.8	52.1
Wensman Seed	W 30099R2	00.9	58.7	44.0	34.6	45.8
Wensman Seed	W 3024R2	0.2	58.1	49.4	31.6	46.4
Wensman Seed	W 3030R2	0.2	48.9	38.4	33.6	40.3
		Mean	56.7	46.9	34.9	46.2
		CV	4.7	4.9	8.7	14.3
		LSD 0.2	4.6	3.7	4.6	3.5
		Top 1/3	66.3 - 59.8	57.5 - 48.4	44.9 - 39.1	54.4 - 48.2
		Mid 1/3	59.7 - 53.3	48.3 - 39.3	39.0 - 33.3	48.1 - 42.0
		Bottom 1/3	53.2 - 46.7	39.2 - 30.1	33.2 - 27.4	41.9 - 35.8

Top 1/3 of Yield Range by location
Mid 1/3 of Yield Range by location
Bottom 1/3 of Yield Range by location

Project Funding provided in part by:

University of Minnesota Extension — Driven to Discover℠

NDSU Extension Service — North Dakota State University

Zone 3 - Waubun, Ada, Prosper - EARLY Maturity

Company	Variety	Relative Maturity	Waubun Yield (bu/A)	Ada Yield (bu/A)	Prosper Yield (bu/A)	Average Across Locations (bu/A)
Dahlman Seed	5203RR2Y	0.3	55.1	50.8	57.4	54.5
Hefty Seed Co	02R3	0.2	49.8	49.6	60.6	53.3
Hyland Seeds	HS 01RY02	0.1	40.5	41.4	59.4	46.9
Integra	20300	0.3	29.5	48.1	62.6	46.7
Legacy Seeds, Inc.	0214 RR2	0.2	26.7	45.9	66.0	46.2
Legacy Seeds, Inc.	0334 RR2	0.3	50.1	54.6	65.0	56.7
Northstar Genetics	0318R2	0.3	36.3	51.2	56.2	48.1
Northstar Genetics	0480NR2	0.2	39.3	54.2	63.0	52.0
Nuseed	2034 RR2YN	0.3	43.1	49.3	58.3	50.5
Peterson Farms Seed	13R03	0.3	45.4	55.9	55.7	50.1
Producers Hybrids	0301R2	0.3	40.4	50.2	61.1	51.6
Thunder Seed, Inc	33009 R2YN	00.9	25.3	34.3	53.9	38.1
Thunder Seed, Inc	3503 R2Y	0.3	37.6	52.8	58.7	49.7
		Mean	39.9	49.1	59.8	49.6
		CV	17.1	8.0	5.1	9.7
		LSD 0.2	12.4	5.8	5.5	6.2
		Top 1/3	55.1 - 45.2	55.9 - 48.7	66.0 - 62.0	56.7 - 50.5
		Mid 1/3	45.1 - 35.3	48.6 - 41.5	61.9 - 58.0	50.4 - 44.3
		Bottom 1/3	35.2 - 25.3	41.4 - 34.3	57.9 - 53.9	44.3 - 38.1

Top 1/3 of Yield Range by location
Mid 1/3 of Yield Range by location
Bottom 1/3 of Yield Range by location

Zone 3 - Waubun, Ada, Prosper - LATE Maturity

Company	Variety	Relative Maturity	Waubun Yield (bu/A)	Ada Yield (bu/A)	Prosper Yield (bu/A)	Average Across Locations (bu/A)
Channel	0807R2	0.8	34.2	51.4	62.0	49.2
Dyna-Gro Seed	S08RY23	0.8	47.8	51.3	58.4	52.5
Dyna-Gro Seed	S09RY64	0.9	49.3	56.4	65.9	57.2
Hyland Seeds	HS 09RYS12	0.9	47.7	49.1	64.4	53.7
Legacy Seeds, Inc.	LS 0833 NRR2	0.8	45.1	50.2	60.6	52.0
Legend Seeds, Inc	LS 09R23N	0.9	40.7	50.4	62.7	51.3
Legend Seeds, Inc	LS 10R551N	1.0	41.8	55.3	61.6	52.9
Mycogen	5B081R2	0.8	49.1	47.8	50.0	49.0
Mycogen	5N091R2	0.9	50.7	53.2	56.7	53.6
Northstar Genetics	NS 0839NR2	0.8	41.3	40.9	56.3	46.2
NuTech	G2 6083	0.8	45.6	46.8	56.9	49.8
NuTech	G2 6084 R2	0.8	36.2	47.4	51.0	44.8
NuTech	G2 6093	0.9	45.1	48.9	51.1	48.3
Peterson Farms Seed	14R09N	0.9	53.8	52.3	60.2	55.4
Prairie Brand Seeds	PB-0863R2	0.8	45.1	52.5	56.6	51.4
Proseed	30-80	0.8	45.1	52.5	70.8	56.1
REA Hybrids	69G14	0.9	43.8	54.4	56.2	51.1
REA Hybrids	R0815	0.8	51.6	54.9	55.0	53.8
Renk Seeds	RS084R2	0.8	38.8	52.6	58.5	50.0
Syngenta	NK S09-K4	0.9	46.2	45.4	54.9	48.8
Thunder Seed, Inc	3408 R2YN	0.8	48.6	52.2	63.5	54.8
Wensman Seed	W 3080NR2	0.8	40.8	53.1	58.6	50.8
		Mean	44.9	50.9	58.7	51.5
		CV	7.4	5.3	6.7	9.0
		LSD 0.2	6.1	4.5	6.7	4.4
		Top 1/3	53.8 - 47.3	56.4 - 51.2	70.8 - 64.2	57.2 - 53.1
		Mid 1/3	47.2 - 40.8	51.1 - 46.0	64.1 - 57.6	53.0 - 49.0
		Bottom 1/3	40.7 - 34.2	45.9 - 40.9	57.5 - 51.0	48.9 - 44.8

Top 1/3 of Yield Range by location
Mid 1/3 of Yield Range by location
Bottom 1/3 of Yield Range by location

Zone 3 - Waubun, Ada, Prosper - MID Maturity

Company	Variety	Relative Maturity	Waubun Yield (bu/A)	Ada Yield (bu/A)	Prosper Yield (bu/A)	Average Across Locations (bu/A)
Channel	0707R2	0.7	38.9	49.2	54.3	47.5
Dahlman Seed	Dahlman 5405NRR2Y	0.5	47.5	48.5	50.4	48.8
Dairyland Seed	DSR-0514/R2Y	0.5	37.4	48.3	56.9	47.5
Dairyland Seed	DSR-0711/R2Y	0.7	44.4	52.4	63.4	53.4
Dyna-Gro Seed	S06RY24	0.6	52.7	51.7	63.6	56.0
Dyna-Gro Seed	S07RY45	0.7	45.5	52.0	59.3	52.3
Hefty Seed Co	H 06Y12	0.6	42.0	52.9	58.4	51.1
Hyland Seeds	HS 05RYS25	0.5	51.9	50.3	58.2	53.5
Hyland Seeds	HS 06RY26	0.6	52.6	53.9	54.5	53.6
Integra	20600	0.6	49.1	50.2	61.2	53.5
Legacy Seeds, Inc.	LS 0634 NRR2	0.6	37.0	49.1	57.4	47.8
Mycogen	5B066R2	0.6	41.7	51.7	58.4	50.6
Northstar Genetics	NS 0537NR2	0.5	42.3	48.9	66.4	52.5
Nuseed	2051 RR2Y	0.5	45.2	54.3	61.2	53.6
Nuseed	2074 RR2YN	0.7	44.1	58.8	52.3	48.4
NuTech	G2 7063	0.6	52.8	58.7	49.0	50.2
Peterson Farms Seed	14R06N	0.6	45.0	48.6	60.6	51.4
Peterson Farms Seed	15R05N	0.5	43.1	52.0	51.4	48.8
Prairie Brand Seeds	PB-0777R2	0.7	42.8	47.6	61.7	50.7
Producers Hybrids	0602NR2	0.6	44.1	53.1	52.4	49.4
Proseed	30-60	0.6	38.8	49.8	64.6	51.1
REA Hybrids	64G94	0.4	48.1	50.5	49.2	49.3
REA Hybrids	66G14	0.6	40.5	46.6	46.0	44.4
Syngenta	NK S07-B6	0.7	43.5	51.6	59.0	51.4
Thunder Seed, Inc	3205 R2Y	0.5	46.4	53.9	57.0	52.4
Wensman Seed	W 3032R2	0.4	50.2	51.1	58.1	53.2
Wensman Seed	W 3062NR2	0.6	46.9	54.3	57.2	52.8
		Mean	45.0	50.7	57.1	50.9
		CV	10.3	3.9	6.9	8.2
		LSD 0.2	8.5 (NS)	3.1	7.3	NS
		Top 1/3	52.8 - 47.6	58.7 - 54.7	66.4 - 59.6	56.0 - 52.1
		Mid 1/3	47.5 - 42.5	54.6 - 50.7	59.5 - 52.8	52.0 - 48.2
		Bottom 1/3	42.4 - 37.0	50.6 - 46.6	52.7 - 46.0	48.1 - 44.4

Top 1/3 of Yield Range by location
Mid 1/3 of Yield Range by location
Bottom 1/3 of Yield Range by location

Zone 4 - Elbow Lake, Barnesville, Lisbon - MID Maturity

Company	Variety	Relative Maturity	Elbow Lake Yield (bu/A)	Barnesville Yield (bu/A)	Lisbon Yield (bu/A)	Average Across Locations (bu/A)
Channel	0807R2	0.8	55.7	64.1	58.2	59.0
Dahlman Seed	5309NRR2Y	0.9	56.7	50.9	57.7	55.6
Hefty Seed Co	09R4	0.9	59.3	44.3	55.5	53.9
Hefty Seed Co	10R4	1.0	59.3	53.5	56.1	56.7
Hyland Seeds	HS 09RYS12	0.9	57.4	56.1	54.3	56.0
Integra	20815N	0.8	60.5	44.7	56.8	54.9
Integra	20915N	0.9	61.7	63.7	61.7	62.3
Legacy Seeds, Inc.	0833 NRR2	0.8	57.3	57.7	58.3	57.8
Legend Seeds, Inc	10R551N	1.0	59.1	58.4	57.9	58.6
Mycogen	5N091R2	0.9	56.1	46.5	59.3	54.8
Northstar Genetics	0839NR2	0.8	64.8	49.6	57.9	58.2
Northstar Genetics	0949R2	0.9	54.9	59.7	66.2	60.4
Northstar Genetics	1040NR2	1.0	62.7	59.3	55.7	59.3
Nuseed	2093 RR2YN	0.9	61.4	35.4	56.0	52.4
NuTech	G2 6084 R2	0.8	53.9	57.5	49.6	53.4
NuTech	G2 6093	0.9	41.1	52.6	52.6	48.5
NuTech	G2 7104 R2	1.0	58.2	37.5	59.1	52.9
Peterson Farms Seed	14R09N	0.9	57.2	41.8	59.5	53.9
Proseed	30-80	0.8	54.5	53.4	55.9	54.8
REA Hybrids	R0815	0.8	62.3	51.1	59.3	58.3
REA Hybrids	69G13	0.9	62.7	58.8	62.0	61.5
REA Hybrids	69G14	0.9	68.6	59.7	57.8	62.3
Thunder Seed, Inc	3408 R2YN	0.8	56.7	64.3	58.0	59.4
Wensman Seed	3080NR2	0.8	58.6	59.2	58.0	58.7
Wensman Seed	3090NR2	0.8	68.3	54.9	59.8	61.7
Wensman Seed	3102NR2	1.0	64.7	61.6	61.2	62.7
		Mean	*59.0*	*53.7*	*57.9*	*57.2*
		CV	*8.1*	*16.9*	*3*	*5.8*
		LSD 0.2	*7.4*	*NS*	*2.8*	*5.5*
		Top 1/3	*68.6 - 59.4*	*64.3 - 54.7*	*66.2 - 60.7*	*62.7 - 58.0*
		Mid 1/3	*59.3 - 50.2*	*54.6 - 45.1*	*60.6 - 55.2*	*57.9 - 53.3*
		Bottom 1/3	*50.1 - 41.1*	*45.0 - 35.4*	*55.1 - 49.6*	*53.2 - 48.5*

Top 1/3 of Yield Range by location
Mid 1/3 of Yield Range by location
Bottom 1/3 of Yield Range by location

Zone 4 - Elbow Lake, Barnesville, Lisbon - EARLY Maturity

Company	Variety	Relative Maturity	Elbow Lake Yield (bu/A)	Barnesville Yield (bu/A)	Lisbon Yield (bu/A)	Average Across Locations (bu/A)
Dahlman Seed	5405 NRR2Y	0.5	68.9	49.7	52.8	57.9
Dairyland Seed	0711/R2Y	0.7	67.2	59.8	54.9	60.6
Hyland Seeds	HS 06RY26	0.6	68.8	61.9	59.4	63.4
Legacy Seeds, Inc.	0634 NRR2	0.6	63.3	55.0	53.8	57.4
Northstar Genetics	629NR2	0.6	63.6	55.3	54.4	58.1
Nuseed	2051 RR2Y	0.5	68.1	62.9	61.6	64.2
Nuseed	2074 RR2YN	0.7	66.9	57.2	55.4	59.8
Stine Seed	06RE02	0.6	59.4	58.2	48.9	55.5
Thunder Seed, Inc	3205 R2Y	0.5	68.0	60.5	60.8	63.1
		Mean	66.0	57.8	55.8	60.0
		CV	*6.2*	*7*	*3.8*	*5.9*
		LSD 0.2	*7.1*	*6*	*4.1*	*3.4*
		Top 1/3	*68.9 - 65.7*	*62.9 - 58.5*	*61.6 - 57.4*	*64.2 - 61.3*
		Mid 1/3	*65.6 - 62.5*	*58.4 - 54.1*	*57.3 - 53.2*	*61.2 - 58.4*
		Bottom 1/3	*62.4 - 59.4*	*54.0 - 49.7*	*53.1 - 48.9*	*58.3 - 55.5*

Top 1/3 of Yield Range by location
Mid 1/3 of Yield Range by location
Bottom 1/3 of Yield Range by location

Zone 4 - Elbow Lake, Barnesville, Lisbon - LATE Maturity

Company	Variety	Relative Maturity	Elbow Lake Yield (bu/A)	Barnesville Yield (bu/A)	Lisbon Yield (bu/A)	Average Across Locations (bu/A)
Dairyland Seed	1340/R2Y	1.3	50.9	41.9	61.8	52.4
Hefty Seed Co	14R3	1.4	57.1	42.8	65.1	57.3
Hyland Seeds	HS 11RY07	1.4	50.4	41.9	63.2	53.4
Hyland Seeds	HS 15RYS45	1.5	51.5	45.4	63.5	54.2
Integra	21115N	1.1	62.4	45.6	62.1	56.0
Legacy Seeds, Inc.	1134 NRR2	1.1	57.0	32.6	60.7	52.1
Legacy Seeds, Inc.	1314 NRR2	1.3	53.6	39.7	61.0	52.1
Legend Seeds, Inc	12R24N	1.2	57.9	47.1	61.2	58.5
Legend Seeds, Inc	13R556N	1.3	56.2	52.4	62.0	57.9
Mycogen	5N122R2	1.2	52.6	34.2	54.2	48.4
Nuseed	2122 RR2YN	1.2	54.9	43.5	58.3	54.7
NuTech	G2 6143	1.4	50.9	39.1	54.5	50.0
Peterson Farms Seed	14R11N	1.1	55.5	49.6	63.2	58.2
Peterson Farms Seed	14R13	1.3	52.4	41.0	64.0	53.4
Peterson Farms Seed	15R14N	1.4	50.2	47.1	64.4	55.2
Proseed	P2 30-12	1.2	49.7	46.7	61.8	55.4
REA Hybrids	R1215	1.2	63.9	45.0	62.5	58.8
Stine Seed	11RD00	1.1	53.7	39.8	56.3	51.2
Thunder Seed, Inc	3511 R2YN	1.1	58.8	36.7	58.8	53.0
Thunder Seed, Inc	3114 R2Y	1.4	55.2	49.3	60.6	57.6
		Mean	*54.7*	*43.1*	*61.0*	*54.5*
		CV	*8.1*	*16.4*	*2.8*	*8.5*
		LSD 0.2	*5.8*	*NS*	*3.1*	*5.2*
		Top 1/3	*63.9 - 59.2*	*52.4 - 45.8*	*65.1 - 61.5*	*58.8 - 55.3*
		Mid 1/3	*59.1 - 54.5*	*45.7 - 39.2*	*61.4 - 57.9*	*55.2 - 51.8*
		Bottom 1/3	*54.4 - 49.7*	*39.1 - 32.6*	*57.8 - 54.2*	*51.7 - 48.4*

Top 1/3 of Yield Range by location
Mid 1/3 of Yield Range by location
Bottom 1/3 of Yield Range by location

Sorted by 7 Location Average - Combined Zones 1-2-3

Below is a list of varieties that were planted in 7 locations within Zones 1, 2 & 3

The colors represent the ranking of each variety based on how it yielded in its maturity group at each location.

			Zone 1			Zone 2		Zone 3		
Company	Variety	Relative Maturity	Hallock Yield (bu/A)	Newfolden Yield (bu/A)	Warroad Yield (bu/A)	East Grand Forks Yield (bu/A)	Thief River Falls Yield (bu/A)	Waubun Yield (bu/A)	Ada Yield (bu/A)	7 location average (bu/A)
Legacy Seeds, Inc.	LS 0334 RR2	0.3	59.3	39.6	40.0	66.3	51.9	50.1	54.6	51.7
Nuseed	2034 RR2YN	0.3	59.1	47.3	30.9	56.9	46.2	43.1	49.3	47.5
Legacy Seeds, Inc.	LS 0214 RR2	0.2	62.1	41.4	38.0	54.6	48.0	26.7	45.9	45.3
Average Across Locations (bu/a) EARLY			**53.6**	**44.4**	**31.5**	**49.7**	**44.8**	**39.9**	**49.1**	
Average Across Locations (bu/a) MID			**54.8**	**46.9**	**36.2**	**56.7**	**46.9**	**45.0**	**50.7**	
Average Across Locations (bu/a) LATE			**56.7**	**41.7**	**38.9**	**53.0**	**53.8**	**44.9**	**50.9**	

Top 1/3 of Yield Range by location
Mid 1/3 of Yield Range by location
Bottom 1/3 of Yield Range by location

(Yield Range = highest yield - lowest yield)

Sorted by 5 Location Average - Combined Zones 1-2

Below is a list of varieties that were planted in 4 of the 5 locations within Zoned 1 & 2.

The colors represent the ranking of each variety based on how it yielded in its maturity group at each location.

			Zone 1			Zone 2		
Company	Variety	Relative Maturity	Hallock Yield (bu/A)	Newfolden Yield (bu/A)	Warroad Yield (bu/A)	East Grand Forks Yield (bu/A)	Thief River Falls Yield (bu/A)	5 location average (bu/A)
Thunder Seed, Inc.	Astro R2Y	0.8	62.1	56.3	43.2	53.4	53.9	53.7
Legacy Seeds, Inc.	LS 0334 RR2	0.3	59.3	39.6	40.0	66.3	51.9	51.3
Partners Brand Seed Co.	PB0251R2	0.2	58.0	42.9	44.5	58.9	43.6	51.1
Wensman Seed	W 30099R2	0.9	57.2	46.1	41.6	58.7	44.0	50.9
Legacy Seeds, Inc.	LS 0134 RR2	0.1	59.3	40.3	40.8	57.3	50.9	49.4
Legacy Seeds, Inc.	LS 0214 RR2	0.2	62.1	41.4	38.0	54.6	48.0	49.0
Nuseed	2034 RR2YN	0.3	59.1	47.3	30.9	56.9	46.2	48.5
Thunder Seed, Inc.	34006 R2Y	0.6	56.3	45.5	37.8	52.3	42.4	48.0
Partners Brand Seed Co.	PB00941R2	0.9	52.0	37.5	45.5	52.6	49.1	46.9
Hyland Seeds	HS 006RYS24	0.6	52.1	51.3	32.8	44.8	46.6	45.3
NuTech Seed	G2 6021	0.2	55.4	37.0	34.0	53.8	46.6	45.0
NuTech Seed	G2 6000	0	49.8	36.2	35.6	54.4	49.5	44.0
Thunder Seed, Inc.	35007 R2YN	0.7	50.9	41.6	34.7	46.8	47.3	43.5
Nuseed	0074 RR2YN	0.7	48.5	41.2	35.0	47.0	42.0	42.9
Average Across Locations (bu/a) EARLY			**52.7**	**44.4**	**31.5**	**49.7**	**44.8**	
Average Across Locations (bu/a) MID			**54.8**	**46.9**	**36.2**	**56.7**	**46.9**	
Average Across Locations (bu/a) LATE			**56.7**	**41.7**	**38.9**	**53.0**	**53.8**	

Top 1/3 of Yield Range by location
Mid 1/3 of Yield Range by location
Bottom 1/3 of Yield Range by locaiton

(Yield Range = highest yield - lowest yield)

Project funded in part by:

Minnesota Soybean Research & Promotion Council

North Dakota Soybean Council

University of Minnesota Extension — Driven to Discover

NDSU Extension Service — North Dakota State University

Sorted by 4 Location Average - Combined Zones 2-3

Below is a list of varieties that were planted in 4 of the 5 locations within Zones 2 & 3.

The colors represent the ranking of each variety based on how it yielded in its maturity group at each location.

			Zone 2		Zone 3		
Company	Variety	Relative Maturity	East Grand Forks Yield (bu/A)	Thief River Falls Yield (bu/A)	Waubun Yield (bu/A)	Ada Yield (bu/A)	4 location average (bu/A)
Legacy Seeds, Inc.	LS 0334 RR2	0.3	66.3	51.9	50.1	54.6	55.7
Thunder Seed, Inc	3503 R2Y	0.3	61.0	57.5	46.4	53.9	54.7
Dyna-Gro Seed	S06RY24	0.6	57.3	54.4	52.7	51.7	54.0
Dyna-Gro Seed	S07RY45	0.7	62.3	55.3	45.5	52.0	53.8
Hyland Seeds	HS 06RY26	0.6	57.4	49.4	52.6	53.9	53.3
Dahlman Seed	Dahlman 5203RR2Y	0.3	59.8	46.2	55.1	50.8	53.0
Dairyland Seed	DSR-0711/R2Y	0.7	51.6	56.7	44.4	52.4	51.3
Producers Hybrids	0602NR2	0.6	54.5	52.2	43.1	53.1	50.7
Northstar Genetics	NS 0480NR2	0.2	57.2	51.7	39.3	54.2	50.6
Producers Hybrids	0301R2	0.3	58.5	48.8	44.1	50.5	50.4
Dairyland Seed	DSR-0514/R2Y	0.5	63.1	52.3	37.4	48.3	50.3
Peterson Farms Seed	15R05N	0.5	51.5	56.3	45.0	47.6	50.1
Nuseed	2051 RR2Y	0.5	57.0	50.1	43.1	49.3	49.9
Nuseed	2034 RR2YN	0.3	56.9	46.2	45.2	48.6	49.2
Peterson Farms Seed	14R06N	0.6	53.9	49.6	40.4	50.2	48.5
Legacy Seeds, Inc.	LS 0634 NRR2	0.6	55.1	49.7	37.0	49.1	47.7
Northstar Genetics	NS 0318R2	0.3	58.6	41.1	36.3	51.2	46.8
Legacy Seeds, Inc.	LS 0214 RR2	0.2	54.6	48.0	26.7	45.9	43.8
		Average Across Locations (bu/a) EARLY	**49.7**	**44.8**	**39.9**	**49.1**	
		Average Across Locations (bu/a) MID	**56.7**	**46.9**	**45.0**	**50.7**	
		Average Across Locations (bu/a) LATE	**53.0**	**53.8**	**44.9**	**50.9**	

Top 1/3 of Yield Range by location
Mid 1/3 of Yield Range by location
Bottom 1/3 of Yield Range by location

(Yield Range = highest yield - lowest yield)

Sorted by 5 Location Average - Combined Zones 3-4 Data (from harvest results)

Below is a list of varieties that were planted 5 locations within Zoned 3 & 4.

The colors represent the ranking of each variety based on how it yielded in its maturity group at each location.

			Zone 3		Zone 4			
Company	Variety	Relative Maturity	Waubun Yield (bu/A)	Ada Yield (bu/A)	Barnesville Yield (bu/A)	Fergus Falls Yield (bu/A)	Lisbon Yield (bu/A)	5 location average (bu/A)
Hyland Seeds	HS 06RY26	0.6	52.6	53.9	68.8	61.9	60.8	59.6
Dairyland Seed	DSR-0711/R2Y	0.7	44.4	52.4	67.2	59.8	61.6	57.1
Thunder Seed, Inc	3205 R2Y	0.5	46.4	53.9	68.0	60.5	55.4	56.9
Nuseed	2051 RR2Y	0.5	45.2	48.6	68.1	62.9	55.4	56.0
Thunder Seed, Inc	3408 R2YN	0.8	48.6	52.2	56.7	64.3	55.7	55.5
Wensman Seed	W 3080NR2	0.8	40.8	53.1	58.6	59.2	59.1	54.2
Nuseed	2074 RR2YN	0.7	44.1	52.0	66.9	57.2	48.9	53.8
Legacy Seeds, Inc.	LS 0833 NRR2	0.8	45.1	50.2	57.3	57.7	58.0	53.6
Dahlman Seed	Dahlman 5405NRR2Y	0.5	47.5	48.5	68.9	49.7	52.8	53.5
Mycogen	5N091R2	0.9	50.7	53.2	56.1	46.5	59.8	53.3
Channel	0807R2	0.8	34.2	51.4	55.7	64.1	58.2	52.7
Peterson Farms Seed	14R09N	0.9	53.8	52.3	57.2	41.8	57.8	52.6
Hyland Seeds	HS 09RYS12	0.9	47.7	49.1	56.1	46.5	59.8	51.9
Legacy Seeds, Inc.	LS 0634 NRR2	0.6	37.0	49.1	57.3	57.7	58.0	51.8
Northstar Genetics	NS 0839NR2	0.8	41.3	40.9	64.8	49.6	57.7	50.9
		Average Across Locations (bu/a) EARLY	**39.9**	**49.1**	**49.1**	**66.0**	**55.9**	
		Average Across Locations (bu/a) MID	**45.0**	**50.7**	**50.7**	**59.0**	**57.9**	
		Average Across Locations (bu/a) LATE	**44.9**	**50.9**	**50.9**	**54.7**	**61.0**	

Top 1/3 of Yield Range by location
Mid 1/3 of Yield Range by location
Bottom 1/3 of Yield Range by location

(Yield Range = highest yield - lowest yield)

Thank you to the following seed companies for participating in the 2014 Soybean Variety Trials:

Channel - www.channel.com
Dahlman Seed Company - www.dahlmanseed.com
Dairyland Seed Company - www.dairylandseed.com
Dyna-Gro Seed - www.dynagroseed.com
Hefty Seed Company - www.heftyseed.com
Hyland Seeds - www.hylandseeds.com
Integra Seed - www.integraseed.com
Legacy Seeds - www.legacyseeds.com
Legend Seeds - www.legendseeds.net
Mycogen Seeds - www.mycogen.com
NorthStar Genetics - www.northstargenetics.com
Nuseed/Seeds 2000 - www.seeds2000.net
NuTech Seed - www.nutechseed.com
Partners Brand Seed - www.partnersbrandseed.com
Peterson Farms Seed - www.petersonfarmsseed.com
Prairie Brand - www.prairiebrand.com
Producers Hybrids - www.producershybrids.com
Proseed Inc. - www.proseed.net
REA Hybrids - www.rea-hybrids.com
Renk Seeds - www.renkseed.com
Stine Seeds - www.stineseed.com
Syngenta - www.syngenta.com
Thunder Seed Inc. - www.thunderseeds.com
Wensman Seed Company - www.wensmanseed.com

County Variety Plot Trial Participants includes:

Becker/Mahnomen County Soybean-Corn Growers Association
Clay/Wilkin County Soybean-Corn Growers Association
Steele County Crop and Livestock Improvement Association
Kittson County Soybean Growers Association
Marshall County Soybean Growers Association
Norman County Soybean-Corn Growers Association
Otter Tail/Grant County Soybean-Corn Growers Association
Pennington/Red Lake County Soybean-Corn Growers Association
Polk County Soybean-Corn Growers Association
Ransom County Crop and Livestock Improvement Association
Roseau/Lake of the Woods County Soybean Growers Association

Wheat Yield and Protein as Influenced by In-Furrow (down the tube) Phosphorus, Potassium and Coated Urea (ESN)

Nancy Jo Ehlke, Dept. of Agronomy and Plant Genetics, St. Paul

Research Questions

The soils of northern Minnesota are variable, in large part due to the activity of glaciers during the last ice age. These soils, which were influenced by the activity of glacial Lake Agassiz, have pH levels that range from 7.8 to 8.4. As soil pH levels increase from 7 to the mid-8's, the availability of certain essential elements necessary for plant growth and development is restricted and nutrient uptake by plant roots is hindered. As an example, research trials with phosphorus suggests plant roots have a limited time, in the cold soils of early spring, to utilize applied phosphorus as these soil factors reduce phosphorus availability for uptake by plant roots in high pH soils.

Recent research at the U of MN Magnusson Research Farm has suggested an improvement in wheat development, growth, and yield from phosphorus applied a 2X rate compared to the standard rate of phosphorus applied in-furrow. It is also theorized that broadcast applications of additional phosphorus on these high ph soils may have added benefit to not only the present wheat crop but the subsequent crop of soybeans. An increase in uptake of early season phosphate by wheat roots is theorized to improve plant growth and development which may lead to increased wheat yields, improved quality, and ultimately profitability.

A new formulation of nitrogen called ESN (environmentally sensitive nitrogen) is a time released coated urea product with improved seed safety compared to other forms nitrogen. This coated urea can be applied in-furrow at nitrogen rates up to three times the current safe rate of urea. The polymer coated, time released formulation supplies nitrogen to the crop throughout the entire growing season and reduces nitrogen loss through volatilization, denitrification, and leaching.

Phosphorus and ESN applied in-furrow at planting time have the potential to increase wheat growth, development and yields. Small plot and large on-farm research trials will be designed to provide scientific data to provide answers to these research questions in the spring wheat production systems in northern Minnesota's environmental conditions.

Results

See tables on page 60 and 61

Application/Use

The rationale for this research is to compare the standard phosphate starter with and without ESN and a 2X rate of phosphorus fertilizer starter program in spring wheat. The elevated phosphorus levels may improve early season wheat growth and development in the high pH soils of northern MN. A coated urea product may offer the potential to improve wheat yield and quality (protein), especially if the product is not released into the soil solution until later in the plant developmental stages of the spring wheat.

Material and Methods

Treatment applications, data collection, data analysis and summaries will be conducted by the University of Minnesota to insure unbiased, scientifically valid research results. This fertility research integrates small plot replicated trials with large, replicated on-farm trials. The Magnusson Research Farm (located 6 miles northwest of Roseau, MN) will be the site for the small plot replicated research trials. The Magnusson Research Farm is a 40 acre site that was gifted to the University of Minnesota to conduct agricultural research that will have a positive impact on crops produced in the area. The Farm is the northern most research site in Minnesota with unique environmental conditions that make this an attractive location for crop research. Results of this field research will be summarized for potential publication in regional publications (e.g. Prairie Grains Magazine) and scientific journals. Research findings from the large on-farm trials and the small plot trials will be presented at regional and local wheat growers meetings.

The experimental design for the small plot research was a randomized complete block with 4 replications. Spring wheat was seeded with and without a starter fertilizer. The starter fertilizer was applied down the tube with the seed. These small plots were managed similar to area wheat production fields. Flag leaves were collected for tissue analysis. Plots were harvested for yield with a small plot combine with sub-samples from each plot for wheat seed quality assessments.

The small plot fertility trial had 13 fertility treatments plus a control (no starter fertilizer) treatment for a total of 14 treatments replicated four times for a total of 56 individual plots. Total nitrogen application equaled 140# nitrogen for all plots.

Treatment list:	
No added P or K	MES 10 + K (9-30-30-7) - In-furrow
Standard P & K (9-30-30) - Broadcast	MES 10 (2x) + K (18-60-30-14) - In-furrow
Standard P & K (9-30-30) - In-furrow	Standard P & K + AMS (9-30-30-7) - In-furrow
Elevated P & K (18-60-60 - Broadcast	MES 10 + K + ESN (39-30-30-7) - In-furrow
Elevated P & K (18-60-60) - In-furrow	Standard P & K + ESN (39-30-30) - In-furrow
Elevated P normal K (18-60-30) - In-furrow	Standard P & K + ESN (69-30-30) - In-furrow
Elevated P normal K (13-45-30) - In-furrow	Elevated P normal K + ESN (39-60-30) - In-furrow

Data collected: Background soil fertility, plant vigor ratings, crop color rating, chlorophyll meter ratings (taken at jointing and flag leaf stages of wheat development), flag leaf tissue test, crop yield, and crop quality parameters (test weight, protein).

The on-farm trials were conducted at 2 Roseau area locations . Location 1 is located northwest of Roseau on Rice Farms. Location 2 is located west of Roseau on Magnusson Farms. Field trial design will be a randomized complete block design with three replications at each site. The on-farm cooperators selected to participate in this research utilize new technologies and advanced management practices to maximize wheat yields such as seed treatments, aggressive fertility rates, and fungicide treatments. Each site will have two treatments replicated three times (six strips). Each site had a standard in-furrow application of 6-30-30. An added treatment of 12-60-0 was applied by University of Minnesota personel prior to final seedbed preparation

Total applied nitrogen will be the same for each treatment based on the producer's specific yield goal for wheat. Plot size will be one pass of the air seeder feet wide by 500 feet long to accommodate the production practices and the farmer cooperators equipment.

Economic Benefit to a Typical 500 Acre Wheat Enterprise

At location 2 where P_2O_5 levels were low, a significant wheat yield advantage was realized. A significantly higher soil P_2O_5 level was measured in soil post-harvest indicating an accumulation of phosphorous in the soil is possible for future crop use.

Related Research

Minnesota Turf Seed Council has on-going fertility research program in perennial ryegrass. Minnesota Agricultural Fertilizer Research and Education Council funded fertility research in wheat in 2012. Minnesota Soybean Research and Promotion Council funded fertility research in soybean in 2014.

Recommended Future Research

Research should be repeated during the second year of the grant to validate first year results

2014 Phosphorous Application to Spring Wheat Location 1=Rice Farm-3 mi. North and 5 mi. west of Roseau Variety - Linkert							
					Test wt.		
	Yield-Bu./acre *		% Protein		#/bushel		
Treatment	Loc.1	Loc.2	Loc.1	Loc.2	Loc.1	Loc.2	
Standard In Furrow (7-30-30)	66.7	74.1	13.8	14.7	62	63.5	
Standard In Furrow (7-30-30)+13-60-0	66.7	82.5	14.1	14.5	62	63.5	
broadcast prior to spring tillage							
LSD @5% level	NS	4.6	NS	NS	NS	1	
CV	4	5	3	4	32	31	

Experimental Design: RCB w/3reps Plots size=70' x 600' Broadcast application of MAP(7-30-0) prior to
*Assume 63#/bu @12.5% moisture **Objectives:** Wheat yields in 2014 and soybean in 2015
phosphorus is feasible in high PH soils

2014 Wheat Fertility Trial Magnusson Research Farm--Samson Wheat Broadcast urea added to all treatment										
			Yield **	Yield		RCI [3]		Vigor [4]		
TRT#	Trts	App*	Bu./acre	% of mean	% Protein	3-Jul	8-Jul	3-Jul	8-Jul	
1	0-0-0	NONE	96	86	14.1	256	336	7	6	
2	9-30-30	B	111	101	13.3	374	451	8	7.8	
3	9-30-30	I	108	97	13	370	456	8.3	8.3	
4	18-60-60	B	109	98	12.9	404	448	8.3	8.3	
5	18-60-60	I	115	104	12.9	375	473	8.5	9	
6	18-60-30	B	112	101	12.9	390	454	8.8	8.3	
7	18-60-30	I	112	101	12.8	385	456	8.3	9	
8	13-45-30	I	108	97	13.1	389	461	8.3	8.5	
9	9-30-30-7s	B	104	94	12.6	387	466	8.5	8.3	
10	18-60-30-14s	I	120	108	12.8	427	488	8.5	9	
11	9-30-30-7s	I	113	102	13	412	472	8	8.5	
12	39-30-301	I	108	98	13.8	341	401	7.5	7.5	
13	69-30-302	I	115	103	14.4	369	426	8	7.8	
14	39-60-301	I	119	107	13.4	422	467	8.8	8.8	
LSD @5% level			9	7	0.8	61	44	1	1	
CV			6	6	4	11	7	9	8	

App*= Application method: I - In furrow and B - broadcast. Yield**-corrected to 12% moisture.
number -more chlorophyll. [4] Vigor=9-best plant vigor Test wts./Bushel =62.5#(all treatments within .3#/bu.)
Soil test results- Post harvest-2014 P_2O_5= treatments 1 & 3= 6ppm; treatment 5= 6.5ppm

Location 2=Magnusson Farms-1mi.west and 1 mile north of Roseau Variety-Samson									
Soil test ppm - P_2O_5						Tissue tests at anthesis			
Spring		post harvest		RCI		phosphorus		potassium	
Loc.1	Loc.2	loc.1	loc.2	Loc.1	Loc.2	Loc.1	Loc.2	loc.1	loc.2
9.5	4	7	2.7	306	791	0.27	0.27	2.2	1.6
9.5	4	9.7	4	319	801	0.28	0.28	2.5	1.5
NS	NS	NS	NS	NS	NS				
2	1	10	1	9	1				

final seed bed tillage to both locations with 12' Gandy drop spreader.
Compare 2015 soybean yield where additional fertilizer was applied to determine if 'stockpiling ' of

application to equal 140#/ac. total added nitrogen										
Heading	Tissue sampling data - 7/22 (anthesis)									
Date	B	Ca	Fe	Mg	Mn	N	P	K	S	Zn
21	3.8	0.6	83	0.32	25	4.1	0.29	1.68	0.38	17
21	4	0.7	99	0.42	28	4.1	0.29	1.83	0.35	16
21	4.5	0.6	90	0.34	28	3.9	0.3	1.73	0.33	15
21	4	0.6	102	0.34	29	3.9	0.3	1.73	0.33	15
22	4.3	0.6	99	0.37	34	4	0.3	1.91	0.3	15
21	3.5	0.7	97	0.34	29	4	0.3	1.8	0.33	16
22	3.8	0.7	106	0.4	39	4	0.3	1.72	0.34	15
21	4.3	0.6	95	0.38	34	4	0.3	1.74	0.33	15
21	4	0.6	97	0.36	29	4	0.29	1.76	0.31	15
23	4.8	0.8	116	0.46	41	4.1	0.32	2.1	0.35	16
22	3.8	0.6	101	0.34	32	3.9	0.3	1.9	0.31	15
21	4	0.7	95	0.34	28	4	0.31	1.72	0.35	16
21	4.5	0.7	100	0.37	32	4.1	0.31	1.71	0.36	16
21	4.5	0.7	100	0.43	38	4.1	0.32	1.89	0.31	16
1	1	0.1	15	0.07	8	0.2	0.02	0.35	0.05	1.7
2	17	10	11	13	18	4	6	14	11	8

[1] ESN applied in furrow 30#N/acre [2] ESN applied in furrow 60#N/acre [3] RCI=Relative chlorophyll index- higher
Mean Yields = 111 Bu./acre planted 6/4/2014 Soil test results- Spring 2014 P_2O_5= 4ppm SO_4=5ppm NO_3=34#/acre

Use of Recurrent Mass Selection to Pre-breed Hard Red Winter Wheat for Resistance to Major Biotrophic and Nectrotrophic Diseases

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Research Questions

A recurrent mass selection pre-breeding program that is based on the dominant male-sterility gene, *Ms2*, is being implemented to facilitate the continuous development of improved hard red winter wheat breeding parents with high levels of winter-hardiness coupled with effective resistance against major diseases such as Fusarium head blight (FHB), leaf and stem rust, tan spot, bacterial leaf streak (BLS) and Stagonospora nodorum blotch (SNB). This long term pre-breeding program will operate in parallel with the conventional winter wheat breeding program and will serve to systematically assemble (pyramid) new useful genes in adapted genotypes that can be used more effectively in crosses with the elite germplasm.

In the first three years (this funding application), selection will focus on:

a. Increasing the level of cold-hardiness in the population.
b. Raising the frequency of genes for insensitivity to SNB and tan spot.
c. Establishing the durable rust resistance genes, *Lr34/Yr18, Sr2* as well as the FHB resistance genes, *Fhb1* and *Fhb5A*.
d. Introducing additional major and minor gene resistance to the cereal rusts.
e. Introducing BLS resistance.
f. establishing a regular recurrent mass selection program with inbreeding and field testing of the male parents

Materials and Methods

Recurrent selection is based on consecutive cycles of intense selection followed by random intercrossing of the selected plants. The hybrid progeny from each cross cycle then constitutes the next population with which the procedure will be repeated. Successful application of this selection strategy requires an ability to readily and randomly intercross large numbers of plants. This can be done in wheat by employing a dominant gene for male sterility such as *Ms2.*

A diverse base population for recurrent mass selection is being developed. The *Ms2* gene has been incorporated within the hybrid population such that the F_1 always segregates 1:1 for male sterility: male fertility. The base population will be systematically improved through selection. Both male and female plants will be selected, however, only male plants will be evaluated in the field. Female plants will be derived from the F_1 produced in each season whereas the male plants used in a particular season will be selected among advanced generation segregates derived from crosses made in preceding years. Following their use in a crossing block, the male parents will also be evaluated for possible commercial use.

All plants will be grown in containers. In each season the spikes of selected, male-sterile females will be cut open to facilitate pollination. During pollination, selected female plants will be positioned lower and surrounded by selected male plants. Mild wind agitation (fan) will be used to enhance cross-pollination. The containers will be arranged in a manner that will promote randomness of pollination.

Characterization and selection of parent plants will be based on markers (where available), seedling screening (rust, tan spot and SNB resistance) and field screening (winter survival, disease resistance, yield and quality).

At the onset of selection (first three years), field tested male parents will not yet be available. While field testing and inbreeding of the male component is being implemented, interim male parents will be derived from backcross breeding attempts and a routine pedigree breeding program.

Results

In total three cycles of crosses will be made during the project funding period. The first cross was completed in February/March, 2013.

<u>The second cross:</u> A second crossing cycle was completed in February/March, 2014, when the following was done: (a) The *Ms2* male sterility gene was found to give more complete and regular penetrance of male sterility than *Ms3* and therefore introduced. In coming cycles it will completely replace *Ms3*. (b) Additional disease resistance genes that have been backcrossed into winter-hardy HRWW backgrounds (2011-2013) were introduced through new male parents. These included: *Lr34, Lr53* and *Lr62* (leaf rust); *Sr22, Sr26, Sr39* and *Sr50* (stem rust); and *Fhb1* (FHB). (c) A facility to do marker-assisted screening was developed and used to select for the stem rust resistance genes. In the third cross cycle (January/February, 2015) the number of markers and numbers of plants screened with markers will be increased further.

<u>Development of Norstar near-isogenic parents with pyramided resistance:</u> Since Norstar is believed to be the most winter-hardy genotype available, backcrosses aimed at pyramiding combinations of resistance genes in its

genetic background were initiated in 2013. The purpose is to include the pyramided genotypes among the male parents in future recurrent selection crossing blocks. Five B_3F_2 populations, each segregating for *Fhb1* and *RhtB1b* (semi-dwarfing gene) plus *Sr39 & Lr34; Lr53; Sr2; Sr26,* and *Sr50*, were obtained and are currently being screened for the selection of homozygotes to be used as parents.

Selection of future male parents with resistance/insensitivity to tan spot and SNB: In 2014, inbreeding coupled with seedling selection was initiated with random male-fertile F_2 plants from an earlier RMS base population that involved 110 winter and spring habit varieties and lines. The F_2 generation was screened for tan spot resistance using inoculum from a mix of races. Plants were inoculated at the two-to-three leaf stage, approximately seven days after their 56 day vernalization period and later moved to a growth chamber. Evaluations were done seven days after inoculation, where only the resistant and intermediate individuals were selected, and the 803 selected F_3 subsequently advanced through unselected single seed descent (SSD). In parallel, seeds of each lineage were planted in a greenhouse without vernalization so as to be able to identify and remove those families that had the spring growth habit. In the next phase approximately 600 F_4 will be divided into two equal populations that will be screened respectively for SNB (one isolate) and tan spot (mixed inoculum of five races). The most resistant/insensitive plants will be kept and allowed to self in order to obtain $F_{4:5}$ inbred lines. Selected $F_{4:5}$ lines from the two disease groups plus controls will be evaluated as a single group (replicated trial) with individual isolates/races and toxins to identify the best lines which will then be used as parents. The same material will also be field planted and evaluated for winter-survival.

Attempt to identify additional, potentially diverse and useful variation for resistance/susceptibility to tan spot and SNB that can be utilized for parent selection and pre-breeding: A collection of 50 genotypes are being evaluated as additional sources of resistance to tan spot and SNB. Lines developed from these will be used as male parents in future crossing blocks. The 50 lines include the following: Twenty three lines that are either $F_{4:6}$ SSD derived inbred lines or DH lines that derive from two crosses, i.e. cross 11M225 = RWG10/Jerry (21 lines) and cross 11M237 = RWG28/Norstar. Lines RWG10 and RWG28 are spring wheats with pyramided resistance to FHB, tan spot and SNB developed by Dr. Steven Xu (USDA–ARS, Northern Crop Science Laboratory, Fargo). The genes present in RWG10 (pedigree = BG282/3*Alsen) include *tsn1, snn2, QTs.fcu-1BS*, and *Fhb1*. BG290 (pedigree = BG290/3*Alsen) has the same genes as RWG10, plus an additional tan spot insensitivity QTL, i.e. *QTs.fcu-3BL*. The selections showed good winter survival in 2014 and each has *Fhb1*, yet they were not tested for the presence of tan spot or SNB insensitivity. Another ten lines were obtained from Dr Art Klatt (Plant and Soil Sciences, *Oklahoma State University*). These are derivatives from crosses between hard red spring and synthetic wheat. The synthetics have an accession of *Aegilops tauschii* in their pedigrees and were selected based on their resistance to tan spot (field). Five winter wheat lines of international origin (Chile, France, Belgium, Sweden and Bosnia-Herzegovina) that were reported to be resistant to tan spot are also included. The remaining lines constitute selections from the NDSU HRWW breeding program that have good winter survival as well as FHB and BLS resistance.

Preparation for making the third cross (January/February, 2015): Male and female populations have been planted and vernalized since October 2014 in preparation for a third set of crosses. (a) The F_1 female component derive from the 2014 RMS crossing block and will be selected following seedling inoculation and marker screening for the presence of three leaf rust resistance genes, four stem rust resistance genes plus *Fhb1*. (b) The new male parents will include winter-hardy cross and backcross derivatives with the following genes: *Lr19, Lr34, Lr46, Lr50, Lr51, Lr53, Lr56, Lr62* and *Lr68* (leaf rust); *Sr2, Sr22, Sr26, Sr35, Sr39*, and *Sr50* (stem rust); *Fhb1, Fhb5A* (FHB); unknown, but strong resistance to BLS (field-selected, 2 sources); tan spot and SNB resistance/insensitivity (3 sources). Marker-aided screening of this material will begin in December 2014 and will be extended to also include additional leaf and stem rust resistance genes.

Application and Use

The (pre-breeding) population will be continuously enriched with respect to useful disease resistance and adaptation genes. Following each (annual) selection cycle the best male-fertile F_2 plants will be harvested separately and the F_3 field planted for continued inbreeding and selection. In this manner new and diverse segregating families will be established each year. Superior inbred lines selected in the F_5 to F_7 will be utilized in the crossing block of the main breeding program and will also be evaluated further for possible commercialization.

Economic Benefit to a Typical 500 Acre Wheat Enterprise:

The disease-causing pathogens targeted in the project annually cause significant wheat yield losses in the Northern Great Plains and even modest changes in the average level of resistance in new cultivars will be of considerable benefit to producers. The targeted diseases include some that are notoriously difficult to breed resistance for (for example tan spot, bacterial leaf streak, SNB and FHB) since resistance/insensitivity is based on numerous quantitative trait loci each making only a small contribution to the total resistance phenotype.

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The project aims to assemble a wide spectrum of useful known and new resistance and adaptation genes through pre-breeding in winter-hardy genetic backgrounds. The majority of the target genes are not currently available in the HRWW primary breeding pool. Pre-breeding through recurrent selection is being applied to gradually improve the general genetic background in which the newly introduced genes occur and to concentrate/assemble them into more complex combinations that will be more useful in pedigree breeding. This will make it possible to also develop new varieties with better resistance gene combinations and yield stability.

Related Research (effort)

A hard red winter wheat pedigree breeding program was initiated at NDSU during 2011. Annually, 500-700 new crosses are being made among winter wheat parents. A primary aim is to broaden the spectrum of disease resistance genes available for varietal development. Many of the known genes for resistance to the rusts, FHB, tan spot, SNB and BLS are not available in winter-hardy genetic backgrounds that are adapted to North Dakota. Furthermore the resistance genes often occur singly in very diverse and poorly adapted backgrounds making it even more difficult to combine multiple genes in a single line. This pre-breeding program is meant to supplement and facilitate the pedigree breeding effort.

Recommended Future Research:

a. Continue to enrich the population with new resistance genes and increase the frequencies of those genes through recurrent selection.
b. Develop and field test inbred lines derived from the male F_1 of each crossing cycle.
c. Evaluate the possibility to implement genomic selection for the numerous disease resistance genes, in particular, the many QTL associated with resistance to the necrotrophic pathogens.

Exploiting Genetic Variation for Wheat Improvement in the Northern Great Plains

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Research Questions

Crop improvement is predicated on exploiting genetic variation. Without this variation, breeders cannot advance germplasm for any of the important traits of interest to growers. This project seeks to answer the question: what degree can we enhance economically important traits in wheat using diverse germplasm from the USDA Spring Wheat Core Collection.

This germplasm enhancement project is based on nested association mapping (NAM) and was initiated in 2013. It is a long-term and broad-based program that will provide a rich source of genetic diversity for many traits that are or may become important to wheat growers in the region. This includes, but is not limited to: yield, protein content, milling and baking quality, root growth, stand establishment, nitrogen use efficiency, water use efficiency, and disease and insect resistance.

Results

Based on single nucleotide polymorphic (SNP) marker data provided by the Triticeae Coordinated Agricultural Project (TCAP), the Spring Wheat Core Collection held by the USDA-ARS National Small Grains Collection was grouped into four subpopulations based on their degree of relatedness. We then selected 409 accessions that represent the greatest genetic and geographic diversity in the Spring Wheat Core Collection. These 409 accessions were designated as the “Spring Wheat Diversity Collection” (SWDC) and evaluated in the field for various traits.

As expected, a wide range of phenotypic diversity was observed for many of the traits in the SWDC. UM wheat breeder Jim Anderson selected 16 accessions from the St. Paul nursery exhibiting superior phenotypes, i.e. normal heading date, short-stature, good straw strength, disease resistance, etc. Phenotype data collected on the SWDC from the field were collated and analyzed. Twelve of the 16 accessions selected by Jim Anderson, plus 18 additional ones selected based on a) genetic diversity as assayed by SNP markers, b) phenotype data collected from the field, and c) geographic origin comprised the final set of select germplasm for development of NAM populations. These 30 (12 + 18) Nested Association Mapping Parental Selects (NAMPS) were sown in the fall greenhouse for crossing with cultivar RB07, selected by Jim Anderson as the recurrent parent. In December 2013, the first crosses of the NAMPS were made with RB07 in the greenhouse. All but five of these crosses were successful; thus, we will be developing 25 NAM populations from the parents listed in Table 1. Many of these NAMPS are quite diverse in their morphology compared to RB07 (Figure 1). Crossed seed from these hybridizations were planted in the 2014 fall greenhouse for backcrossing to RB07. This was done to recover more of the superior genetic constitution of RB07 since some of the NAMPS are unadapted to the Midwest production region. About 100 BC1 crossed seed from each cross was planted in the 2014 fall greenhouse and will be harvested by the end of December. Then, one arbitrarily selected seed (single seed descent) from each about 2,500 BC_1F_1 plants will be grown in the 2014 spring greenhouse and harvested in April 2015.

Preliminary phenotyping data were collected on the NAMPS in the field in 2014 and compared to the recurrent parent RB07. We identified a number of NAMPS that exhibited superior disease resistance (to stem rust; Fusarium head blight, and leaf rust) and agronomic (plant height) phenotypes (Table 1). Parents that differ genetically from RB07 for a particular trait can be mapped in the derived NAM population.

Application/Use

The germplasm developed from this project will serve as superior, adapted parental material for regional breeding programs aiming to enhance wheat for many different traits, including but not limited to yield, protein content, milling and baking quality, root growth, stand establishment, nitrogen use efficiency, water use efficiency, and disease and insect resistance.

Material and Methods

To start the project, nearly 2,200 accessions of the Spring Wheat Core Collection were genotyped with 90,000 SNP markers by TCAP and analyzed for their genetic relatedness using Principal Coordinate Analysis (PCA). Then, 409 accessions were selected that represent the greatest genetic and geographic diversity in the Spring Wheat Core Collection. These 409 accessions, designated as the “Spring Wheat Diversity Collection” (SWDC), were evaluated for various traits (i.e. heading date, height, awn length and lodging as well as general disease reactions to stem rust, leaf rust, bacterial leaf streak, and Fusarium head blight) in the field at Crookston and St. Paul in 2013. Also included in the nursery as controls were the Minnesota wheat varieties of Linkert, Norden, Rollag, Sabin, and Marshall as well as the selected recurrent parent of

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RB07. In the end, 30 accessions were selected for NAM population development based on: a) genetic diversity as assayed by SNP markers, b) phenotype data collected from the field, and c) geographic origin. NAM population development was started with the first cross of these 30 select lines to the recurrent parent RB07. All but five of these crosses were successful. Thus, the final project will include 25 NAM populations. F_1's from the first crosses were backcrossed to RB07 to recover more of the superior genetic constitution of recurrent parent since some of the NAMPS are unadapted to the Midwest production region. About 100 BC1 crossed seeds from each cross were planted in the 2014 fall greenhouse and will be harvested by the end of December. We will continue to advance these populations over several additional generations to achieve greater homozygosity, which is required for future genotyping and phenotyping.

Economic Benefit to a Typical 500 Acre Wheat Enterprise

Cultivars bred with one or more of the enhanced traits derived from the NAM populations will increase profitability for wheat producers in the region. It is important to note that this pre-breeding project has a longer-term horizon for results. In this respect, it is similar to breeding programs since it will take several years before direct economic benefits will be realized by growers.

Related Research (effort)

As the NAM populations are developed, we will evaluate them for many different traits of importance to regional wheat producers, including agronomic traits (heading date, height, yield, lodging, etc.), milling and baking quality (flour yield, protein, absorption, mixing time, loaf volume, etc.), and disease resistance (rusts, root rots, bacterial leaf streak, etc.). Other colleagues in the region also have expressed a strong interest in evaluating the NAM populations for specific traits of importance to their programs. Additionally, to effectively map and transfer genes controlling traits in the NAM populations, genotyping must be done. Currently, genotyping by sequencing (GBS) is the best method for achieving a sufficiently large number of markers for a reasonable cost. I will be seeking other sources of funding to conduct GBS on the NAM populations.

Recommended Future Research

In order to fully realize the great potential of NAM populations for enhancing wheat germplasm in the northern Great Plains region, the full course of population development must be followed. The following scheme would be used to develop the NAM populations before advanced homozygous seed stocks are available for multiple trait evaluation.

Revised Timetable for Nested Association Mapping Population Development of Wheat

2013 Fall GH:

-- Plant accessions in August-September, make crosses to RB07 in November and harvest crossed (F_1) seed in December. *(Status: Completed)*

2014 Winter GH:

-- Plant crossed (F_1) seed in late December-early January, make backcrosses to RB07 in March, and harvest BC_1 crossed seed in April. *(Status: Completed)*

-- Establish a genetically pure seed increase of the original 25 NAM parents. *(Status: Completed)*

2014 Summer field:

-- Plant BC_1 crossed seed from each cross combination in the field at St. Paul in April *(Status: Postponed until fall greenhouse season to ensure no populations are lost due to weather-related calamities).*

-- Disease assessments of original 25 NAM parents. *(Status: Completed)*

2014 Fall GH:

-- Plant BC_1 crossed seed from each cross combination in the greenhouse and harvest in December. *(Status: In progress)*

-- Collate and analyze data taken from the field on the NAM parents. *(Status: Completed)*

2015 Winter GH:

-- Plant one arbitrarily selected single seed (for single seed descent) from each about 2,500 BC_1F_1 plants and harvest in April (represents 1st selfed generation).

-- Test NAM parents for stem rust reaction at the seedling stage.

-- Seed of NAM parents and RB07 will be distributed to cooperators around the region so they can test them for their traits of interest. Parents that differ from RB07 for a particular trait can be mapped in the derived NAM population.

2015 Summer field:

-- Plant BC_1F_2 seed in St. Paul in April, record agronomic trait notes from May to July, and harvest in August (2nd selfed generation).

-- Collate all data collected on the NAM parents and RB07 by our cooperators and by us.

2015 Fall GH:

-- Plant BC_1F_3 seed in greenhouse in August-September and harvest in December (3rd selfed generation).

-- Test parents for leaf rust reaction at the seedling stage.

2016 Winter GH:

-- Plant BC_1F_4 seed in greenhouse in January and harvest in March (4th selfed generation).

-- Distribute seed of populations of interest to cooperators for their field tests.

2016 Summer field:
-- Plant NAM populations (and parents) segregating for various traits and obtain year 1 phenotype data from the field.
-- Collate all data collected on the NAM populations and parents by our cooperators and by us.

2016 Fall GH:
-- Plant BC_1F_5 seed (5th selfed generation), extract DNA from seedlings, and perform genotype by sequencing (GBS) if funding can be procured.
-- Plant NAM populations (and parents) segregating for various traits and obtain first experiment phenotype data from the greenhouse.

2016 Winter GH:
-- Analyze GBS data for the NAM populations.
-- Plant NAM populations (and parents) segregating for various traits and obtain second experiment phenotype data from the greenhouse.

2017 Summer field:
-- Plant NAM populations (and parents) segregating for various traits and obtain year 2 phenotype data from the field.
-- Collate all data collected on the NAM populations (and parents) by our cooperators and by us.

2017 Fall:
-- Analyze data.
-- Identify and distribute advanced lines with enhanced traits to regional breeders for crossing in their programs.
-- Write up manuscripts for publication.
-- Continue evaluations of derived materials until variety candidates are identified.

Appendix

Figure 1. Diversity of spike types in wheat accessions PI 384403 (top left) and PI 189771 (top right) in comparison with Minnesota wheat cultivar RB07.

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Appendix (continued)

Table 1. Spring wheat core collection accessions selected as parents for development of nested association mapping populations and selected phenotypic data from 2014 at St. Paul and Crookston.

				STP SR*	STP SR	STP	FHB CRK,	STP
LID	**ID1**	**ID2**	**Origin**	**Race MCC**	**Race QCC**	**LR**	**Ave Disease**	**Plant Height**
003	CItr	14819	Eritrea	R	R	R	3.0	93
004	CItr	15006	Nepal	S	S	R	3.5	97
005	PI	62364	Venezuela	R	MR	R	3.5	91
006	PI	153785	Brazil	S	MS	S	3.0	107
008	PI	181458	Finland	S	MS	S	2.0	99
009	PI	189771	Tunisia	S	S	S	4.0	94
010	PI	193938	Brazil	R	R	S	2.5	119
011	PI	199806	Peru	S	S	R	5.0	80
012	PI	205714	Peru	R	R	S	1.0	112
013	PI	213602	Argentina	R	R	S	3.0	110
014	PI	220455	Egypt	R	R	S	2.5	104
015	PI	278392	Palestine	S	S	R	3.0	97
016	PI	282922	Argentina	MR	MR	R	1.5	109
017	PI	344018	Angola	R	R	R	3.0	88
018	PI	345693	Belarus	S	S	S	2.5	115
020	PI	374254	Mali	S	S	S	4.0	81
021	PI	384403	Nigeria	S	S	R	5.0	67
022	PI	430750	Yemen	MR	R	R	5.0	80
023	PI	449298	Spain	R	R	S	4.0	74
024	PI	519465	Zimbabwe	R	R	S	5.0	58
025	PI	519580	Chile	R	R	S	4.0	85
026	PI	520033	Kenya	R	R	R	3.5	91
027	PI	520371	Syria	R	MR	S	4.0	89
029	PI	565238	Bolivia	R	R	S	4.5	82
030	PI	623147	Iran	S	S	S	4.0	110
P1	RB07	RB07	USA	R	R	R	2.5	86

LID=Lab identification number; ID1-ID2=Cereal Investigation number for *Triticum* or Plant Introduction number; Origin=Country of origin; STP SR=Stem rust reaction at St. Paul to races MCCF or QCCJ; LR=Leaf rust reaction at St. Paul; FHB CRK=Fusarium head blight reaction at Crookston; Plant heights at St. Paul are in centimeters.

R=Resistant; MR=Moderately Resistant; MS=Moderately Susceptible and S=Susceptible

FHB rating scale is 1=most resistant and 5=most susceptible

Spring Wheat Responses to Starter Fertilizer, Micronutrient and Root Inoculant

Amitava Chatterjee, Dept. of Soil Science, NDSU

Research Questions

Can we increase spring wheat yield and protein content with additions of (1) starter fertilizer (11-52-0@40 lb/ac), (2) copper, (3) zinc, (4) sulfur, and (5) root inoculants and their combinations?

Results

Highest wheat grain yield of 51.3 Bu/ac was observed with starter fertilizer (11-52-0@40 lb/ac) in addition to recommended NPK fertilizers but statistically different from only check treatment (32.7 Bu/ac). Grain protein content (12.9%) was highest with copper (@ 5 lb/ac) and sulfur (@10lb/ac) with recommended NPK but treatments were statistically same.

Application/Use

We will examine whether we can increase the grain yield and protein content by advanced soil fertility management practices with mid-row bander and nutrients.

Material and Methods

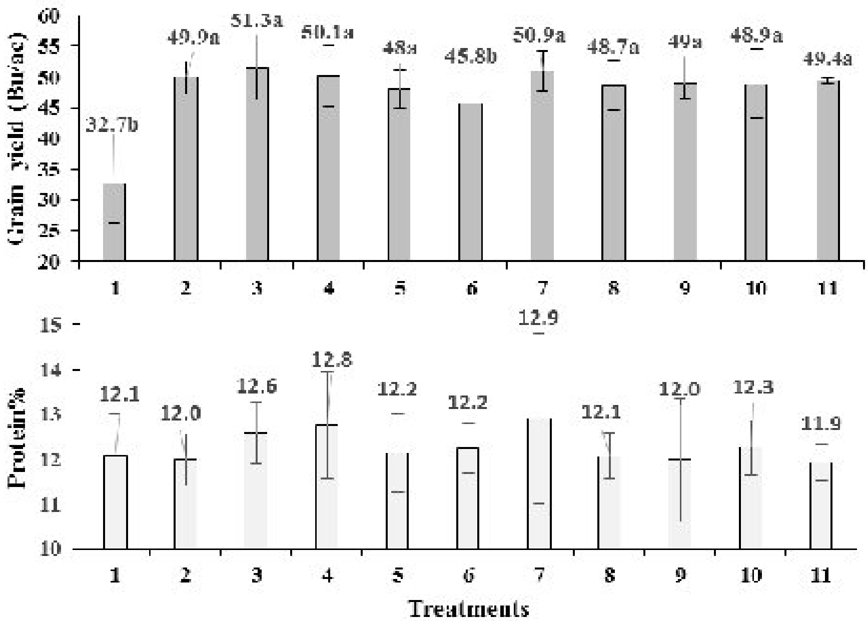
This is the first year of the three-year trial. Treatment combinations are (1)control (no fertilizer applied), 2. recommended N@ 130 lb N/ac, 3. starter fertilizer (11-52-0) @ 40 lb/ac, 4. sulfur @10 lb/ac (as ammonium sulfate), 5. copper @ 5 lb/ac, 6. zinc @ 3 lb/ac, 7. copper + sulfur (as $CuSO_4$ matching the amount of Cu and S with treatment 4 and 5) , 8. zinc + sulfur (as $ZnSO_4$ matching the amount of Zn and S with treatment 5 and 6), 9. copper + zinc + sulfur (as $CuSO_4$ and $ZnSO_4$ matching the amount of Cu, Zn and S with treatment 4, 5 and 6), 10. root inoculant (Trichoderma spp.) and 11. root inoculant+ (Trt. 9: copper + zinc+ sulfur). Trial was conducted at Glyndon, MN (Dave Watt farm). Plots are laid out in randomized block design with four replications. Plot size was 30 feet by 11 feet. Fertilizers were mid-row banded (Borgault) and planting was done at the end of May. Harvesting was done by a small-plot combine in August 2014. Initial values for soil nitrate nitrogen at 0-6 and 6-24 inch soil depth are 13 and 27 lb/ac, respectively.

Figure 1. Mid-row banding of fertilizer materials with the help of Borgault unit for spring wheat during 2014 growing season at Glyndon, MN.

Economic Benefit to a Typical 500 Acre Wheat Enterprise

Soil fertility management has potential to increase grain yield and protein content.

Figure 2. Spring wheat grain yield (Bu/ac) and protein content (%) in response to mid-row banding of nutrients during 2014 growing season at Glyndon, MN. Small letters indicate significance at 95% significance level and same letter indicate no significant difference between treatment.



Accelerated Breeding for Resistance to Fusarium Head Blight

Karl Glover, Plant Sciences, South Dakota State University

Research Questions

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 largely repeatable FHB 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 germplasm and cultivars that possess agronomic characteristics worthy of release in addition to acceptable levels of FHB resistance.

Results

Entries retained in the advanced yield trial (AYT) are thought to be at least moderately resistant to FHB. Those that do not perform adequately are generally discarded after the first year of AYT observation. 2014 AYT results are presented in the appendix. Thirty-six experimental breeding lines were tested along with twelve check cultivars during the 2014 growing season. Of the thirty-six experimental lines, seventeen had FHB disease index (DIS) values that were less than the test average. Ten of these seventeen entries also had Fusarium damaged kernel (FDK) values that were below average. Among these ten, seven produced more grain than average and the test weight of six was also heavier than average. One of these six (SD4362)) is presently under consideration for release as a new cultivar. Specifically, SD4362 will likely be released this fall and be made available to Certified seed producers in spring 2015.

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.

Material and Methods

Focused 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 4,500 individual hills in the greenhouse. We also have 4 acres in the field under mist-irrigation. Both the field and greenhouse nurseries are inoculated with grain spawn (corn 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, 8 locations)

F_2 populations are planted in the field and individual plants are selected. These are advanced to the fall 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 ‘Brick’ 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 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 its resistance. 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 cultivars are included in more advanced, multi-location, replicated yield trials the following year. In year 5, lines advanced through this portion of the program are included in the AYT along with entries from the traditional portion of the program. Performance data with respect to DIS and FDK, along with agronomic potential from the 2014 AYT are presented in Table 1 of the appendix.

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, cultivars with elevated FHB resistance levels can help to reduce potentially serious losses for growers.

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 eight test environments in 2014

ENTRY	FHB DIS INDEX	TOMB-STONE (%)	GRAIN YIELD (BU/AC)	TEST WEIGHT (LB/BU)	GRAIN PROTEIN (%)	HEAD DATE (D > 6/1)	PLANT HEIGHT (INCHES)
SD4511	15.56	23.67	55.54	61.38	14.90	30.17	46.83
SD4383	15.59	37.50	59.10	58.62	14.75	24.83	38.98
FOREFRONT	15.92	33.33	59.01	60.30	14.73	26.00	42.92
BRICK	16.36	28.00	56.84	60.85	14.90	23.06	40.26
SD4472	16.51	42.50	56.00	59.16	14.89	26.28	38.37
SD4362	17.99	28.33	58.13	60.64	14.87	23.33	42.18
SD4321	18.17	27.83	52.91	59.08	16.27	25.56	41.35
SD4393	18.61	37.50	57.84	59.65	15.00	27.22	37.69
SD4450	18.69	36.67	55.71	60.10	14.95	25.22	40.11
SD4330	18.70	35.33	55.24	60.98	15.30	27.00	42.69
SD4299	19.09	34.17	57.67	59.47	15.07	31.72	38.98
SD4501	19.09	40.83	50.96	59.90	16.04	26.61	40.14
SD4514	19.13	29.50	56.31	60.65	15.12	29.56	44.10
SD4471	19.50	34.50	57.70	59.23	14.42	26.22	39.94
SD4493	20.12	39.17	53.43	59.33	14.94	26.89	37.26
SD4451	20.25	50.00	56.69	59.94	15.05	25.89	39.43
PREVAIL	21.32	35.00	61.21	59.55	14.09	28.83	39.43
SD4416	21.65	30.83	54.84	59.87	15.09	28.00	39.51
SD4470	22.07	22.83	52.76	58.67	14.66	25.78	39.66
STEELE-ND	22.63	42.50	51.14	58.97	15.00	28.11	40.06
SD4517	22.67	40.83	50.50	57.82	15.23	27.06	38.65
SD4400	22.82	33.33	53.99	59.37	14.83	29.61	43.62
FALLER	22.92	36.17	60.30	59.91	13.90	30.39	40.11
SD4543	23.08	30.00	54.59	60.21	14.94	28.00	43.57
SD4496	23.11	27.00	54.96	59.51	15.24	25.72	42.56
SD4539	23.13	39.17	54.52	59.40	14.80	29.61	42.69
SD4506	23.91	40.83	51.84	60.02	15.18	28.33	43.90
SD4469	23.96	25.33	54.10	58.65	14.78	26.78	41.22
SD4492	24.05	37.00	53.68	60.19	14.70	24.44	41.02
SD4537	24.17	37.50	58.13	60.70	14.80	29.44	40.24
SD4403	24.23	28.33	55.45	59.95	15.14	29.72	40.52
ADVANCE	24.35	32.50	55.41	59.62	14.28	29.78	38.62
SD4520	24.35	30.33	50.80	59.98	14.77	31.44	43.70
SD4515	24.58	40.33	54.33	59.21	15.48	27.06	39.13
BRIGGS	24.65	44.17	51.13	58.28	15.10	26.56	40.14
SD4546	24.99	45.00	56.65	61.17	15.10	23.94	40.16
SD4477	25.02	37.50	57.59	59.32	15.08	28.50	37.29
SELECT	25.33	45.33	55.36	60.08	14.67	24.61	40.74
SD4532	25.53	49.17	53.26	60.10	14.55	27.44	41.98
SD4529	26.63	37.50	54.03	59.76	15.30	27.94	42.23
GRANGER	26.93	50.00	52.62	59.30	14.78	28.28	44.10
OXEN	27.30	51.67	51.72	56.54	14.78	27.44	36.98
TRAVERSE	27.31	47.50	57.99	56.71	14.43	26.89	41.78
SD4465	27.87	38.33	57.63	59.64	14.66	27.22	39.61
SD4548	28.00	44.17	46.62	60.66	16.10	29.22	40.42
SD4524	29.63	40.83	57.87	59.43	14.00	27.50	39.51
SD4518	30.45	51.67	48.18	59.40	15.13	29.00	41.10
KNUDSON	30.61	44.17	51.96	58.78	14.20	30.83	37.21
MEAN	22.68	37.41	54.88	59.58	14.92	27.48	40.68
lsd (0.05)	6.24	11.54	1.47	0.30	0.19	0.80	0.91
cv (%)	17.40	20.02	5.59	1.62	3.12	7.48	5.24

Strategies for Meeting N Requirements of Wheat with New Fertilizer and Fertilizer Additives

Joel Ransom, Dept. of Plant Sciences, NDSU

Research Questions

What is the value of nitrogen stabilizing technologies on nitrogen efficiency when applied in the fall?

What amount of ESN can safely be placed with spring wheat seed at the time of planting?

Results

Experiments were conducted in three locations. At the Prosper site, the fall application treatments were lost so we basically have two locations with the full set of treatments. The two locations in MN varied significantly in their overall yield and protein with Red Lake Falls averaging 54.8 bu/a and 13.9% protein and Argyle averaging 97.6 bu/a and 12.1% protein. Averaged over the two sites, when 100% fall applied ESN was compared to 100% fall applied urea, yields were only slightly greater but the protein content of the grain was a 1.5% higher. Of the treatments with 100% the N at Argyle (the highest yielding site), the highest yield was obtained with 100% ESN applied with the seed in the spring. Proteins with spring applied treatments were slightly higher than will fall applied treatments. Spring applied Instinct did not improved yield or protein compared to urea alone but with applications it appeared to improve protein. The data also suggests that it is relatively safe to place ESN with seed up to 90 lbs N. Urea can be damaging to plant stands at about 50 lbs N, though in some cases higher rates could be used safely. Additional research is needed to verify the potential value of these N stabilizers on spring wheat yield and protein.

Application/Use

These results are preliminary. Therefore, we are not comfortable in recommending any of the treatments including in the research. N extenders in the environments where this research was conducted probably did not improve yield and protein enough to cover their cost, at least not consistently. Therefore, additional focused research on key treatments in the future, should provide a way forward in developing an useful recommendation. Applying ESN in the fall looks promising and may be an option that would be attractive to growers. The research proposed for 2015 will focus on this and will broaden the soil types where the research is conducted. Perhaps one recommendation that could be made at this point is that if a grower wishes to apply some of his fertilizer with his seed at planting, using ESN would be a safe way to deliver this fertilizer.

Material and Methods

Experiments were established in three locations: Red Lake Falls, Argyle and Prosper. These experiments were replicated four times. The following treatments were included (90 lb was the 100% rate):

0-Check
50% Optimal N Rate-100% ESN
50% Optimal N Rate-75:25 ESN:urea
50% Optimal N Rate-50:50 ESN:urea
75% Optimal N Rate-100% ESN
75% Optimal N Rate-75:25 ESN:urea
75% Optimal N Rate-50:50 ESN:urea
100% Optimal N Rate-100% ESN
100% Optimal N Rate-75:25 ESN:urea
100% Optimal N Rate-50:50 ESN:urea
125% Optimal N Rate-100% ESN
125% Optimal N Rate-75:25 ESN:urea
125% Optimal N Rate-50:50 ESN:urea
FALL-100% Optimal N Rate Broadcast-100% ESN
FALL-100% Optimal N Rate Broadcast-100% Urea
SPRING- 50% ESN : 50% Urea Broadcast Late Pre or at seeding
SPRING-100% Optimal N Rate Broadcast-100% Urea
SPRING-50% Urea:50% UAN at 4 leaf stage
SPRING-100% Optimal N Rate Broadcast-100% Instinct
FALL-100% Optimal N Rate Broadcast-50:50 ESN:Urea
FALL-100% Optimal N Rate Broadcast-75:25 ESN:Urea
FALL-100% Optimal N Rate Broadcast-100% Instinct
FALL-50% Optimal N Rate Broadcast-100% ESN
FALL-50% Optimal N Rate Broadcast-100% Urea

Yield, test weight, and protein were measure at harvest.

Economic Benefit to a Typical 500 Acre Wheat Enterprise

Since these results are preliminary, we are not prepared to estimate an economic benefit.

Recommended Future Research

We propose to focus on fall applications of ESN in our future research. It would also be interesting to look at an increased rate of Instinct.

Optimum Use of Nitrogen Fertilizers to Maximize Spring Wheat Grain Yield and Protein Concentration

Albert Sims, NWROC, Crookston

Research Questions

The objective of this project was to identify optimum nitrogen (N) fertilizer management practices that can maximize hard red spring wheat (HRSW) grain yield and protein concentration; and subsequently net economical profits to producers.

Results

In this trial, we wanted to determine the effects of applying 30 lbs. N ac^{-1} as a foliar application at either the tiller or immediately after the anthesis growth stages. This N would be in addition to the pre-plant N applied. Optimum N was determined as 150 lbs. N ac^{-1} (soil residual nitrate-N plus 127 lbs. fertilizer N). To test whether any effect of the foliar N was due to its application time or the additional 30 lbs. N, an additional treatment was established that supplied optimal N plus 30 lbs. N ac^{-1} applied pre-plant with no additional foliar N. There was no difference in grain yield, grain protein, or test weight between the optimal pre-plant N and the optimal plus 30 lbs. N pre-plant N treatments. This confirmed our selection of the optimal N rate and allows us to focus our attention on the foliar application of N. Subsequent statistical analyses and discussion dropped the optimal plus 30 lbs. pre-plant N treatment.

Applying fertilizer N did increase grain yield and grain protein compared to the 0 N control (Table 1). However, there were no significant differences in these variables whether pre-plant fertilizer N was supplied as PCU or urea (Table 1). Grain yields were 44, 72, and 73 bu ac^{-1} in the control, PCU and urea treatments, respectively. Grain proteins were 12.2, 13.3 and 13.1% in the control, PCU, and urea treatments, respectively. Grain test weight was not affected by the source of fertilizer N, but the application of fertilizer N increased test weight relative to the 0 N control (Table 1).

As originally designed, this trial was to include a normal spring time applied pre-plant fertilizer N application with normal planting and a later planting. An additional set of treatments included late season fertilizer application and planting. This was to replicate the potential of weather conditions delaying planting after the fertilizer was applied or perhaps delaying both fertilization and planting. Unfortunately in 2014, everything was delayed due to weather so the normal planting in this trial was actually May 21, which would typically have been close to our late planting and fertilizing target. So, instead of waiting 4 weeks for the delayed, or late, planting and fertilizing, as originally specified, the late planting and fertilization happened on June 9.

Plant stand count was measured at the three leaf stage, but no significant differences were found among the treatments (Table 1). Whole plant tissue sampling was conducted at soft dough stage to determine if any of the treatments impacted the tissue biomass accumulation or tissue N concentration. Tissue biomass accumulation significantly deceased when planting was delayed whether fertilization was delayed or not compared to normal planting and N fertilization (Fig. 1A). However, we found normal planting and N fertilization had significantly lower tissue N concentration compared to late planting and fertilization treatments (Fig. 1B).

Delayed planting, with or without delayed N fertilization, significantly reduced grain yield and grain test weight, but resulted in significantly greater grain protein (Fig 1C, 1D and 1E). Most of the effects were caused by delayed planting, but delayed fertilization did have some affect (comparisons of treatment 1 and 2 in Fig 1). It suggest that differences found in tissue biomass accumulation and N accumulation at soft dough stage due to delayed planting and delayed N fertilization translated into differences in grain yield and grain protein concentration. Previous research found that cold, dry early season conditions resulted in lower grain yields and higher grain protein when PCU was used as the N source compared to urea (Farmaha and Sims, 2013a, 2013b). One of the questions from those previous trials was whether we would see a similar difference in N sources if the PCU was applied a few weeks prior to when the wheat was planted. In 2014, the wet early season conditions that delayed both fertilizer application and planting apparently neutralized any potential differences between these two N sources.

Thirty pounds of N were applied via foliar applications at tiller or immediately after anthesis. There were no interactions between foliar N or pre-plant N source (Table 1). There was no significant effect of foliar application on stand count and tissue biomass accumulation but it did increase tissue N concentration measured at soft dough stage (Table 1). Timing of foliar application did not make a difference in tissue N concentration (Fig. 2A). Previous research found that 30 lbs. N Ac^{-1} at tillering increased grain yield and at anthesis increased grain protein (Woolfolk et al., 2002; Bly and Woodard, 2003). In this study, grain

continued on page 74

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yield was not affected by an application of N at the tiller growth stage (Fig 2B). There was a slight, but significant decrease, in grain yield when N was applied at the anthesis growth stage (Fig 2B). It is suspected that part of this grain yield decline was caused by burning of the upper canopy leaves caused by the foliar N spray. Though the spray was applied during the cooler part of the day, those particular days were quite warm which can enhance leaf burning. Compared to only pre-plant N, foliar N applied at both tiller and anthesis increased grain protein, with the greatest increase occurring with the anthesis application (Fig 2C). Similar results with foliar application rate and timing on hard red spring wheat were observed in South Dakota by Bly and Woodard (2003). There was, however, a slight decline in grain test weight with foliar N application (Fig 2D).

Material and Methods

This experiment was conducted in 2014 at Northwest Research and Outreach Center (NWROC), Crookston, MN. Treatments included two N fertilizer sources- PCU (polymer coated urea) and urea; three pre-plant N application and planting combinations (normal fertilization and normal planting, normal fertilization and late planting, and late fertilization and late planting), and three foliar N applications (none, tillering, and anthesis). Pre-plant N was 127 lbs. N Ac^{-1} plus soil residual nitrate-N, which was considered an optimal N rate for this location. Foliar N treatments added an additional 30 lbs. N Ac^{-1} at either tillering or anthesis. Two additional treatments were added, a 0 N control and an optimal N plus 30 lbs. N Ac^{-1} applied pre-plant. In 2014, prolonged wet spring conditions delayed N fertilization and planting. Normal N fertilization and planting was done on 05/21/2014 and delayed N fertilization and planting was done on 06/09/2014. Albany, a high-yielding and low protein cultivar was seeded on 36 plots on 05/21/2014 and on 72 plots at 06/09/2014. Each plot contained 10 seeded rows spaced 6 inches apart and measured 5 ft. wide by 18 ft. in length. Fertilizers were hand broadcasted and incorporated in the soil to a 10 cm depth using a field cultivator. Whole plant samples were collected from each plot (four rows, 3ft. in length) at soft dough growth stage to measure dry biomass accumulation and N concentration. At physiological maturity, plots were harvested using a small plot combine to measure grain yield and protein concentration. Plots seeded earlier were harvested on 08/26/2014 and seeded later were harvested on 09/17/2014.

Economic Benefit to a Typical 500 Acre Wheat Enterprise

This study suggested no yield penalty was realized when PCU was used as the N source when the spring conditions were sufficiently moist that PCU-N was released to the soil. Of course, most growers would not use PCU as the sole source of N because of the risk in yield lag if soil conditions are drier and the extra expense of PCU-N. But, this study did confirm that foliar applications of N can be beneficial to increasing grain protein concentration. Whether it is economically beneficial will be determined by the potential low protein discounts and what the yield potential of the crop is. Wiersma and Sims (2014) have developed a decision making tool comparing N costs and protein discounts to help growers make that decision. Unfortunately there is yet a tool developed to diagnose the potential grain protein in time for a foliar N application to be beneficial.

Related Research

The current experiment addresses questions raised based on the findings from our previous experiments (Farmaha and Sims, 2012a and 2012b). We had two separate experiments in 2013 that showed that delayed planting due to the wet spring conditions can significantly reduce grain yield but the amount of loss depends upon how late the crop was planted. 2013 was an abnormal growing season so data from this year alone was not sufficient to comment whether the effect of treatments on grain yield and protein concentration was stand alone or was confounded with the environmental issues. Therefore, the current experiment was planned but with few modifications in the treatments.

Recommended Future Research

This experiment should be conducted for one more year and may be under different environments.

Table 1. Significance of *F*-values of fixed effects on stand count, whole plant tissue biomass accumulation, tissue N concentration, wheat grain yield, protein concentration, and grain test weight measured at physiological maturity (Zadok's scale 92).

Source of variation	Stand count	Tissue biomass accumulation*	Tissue N concentration	Grain yield	Protein concentration	Test weight
	––––––––––––––––––––––––––––––––*P* value ––––––––––––––––––––––––––––––					
Fert_Planting	0.5569	<0.0001†	<0.0001	<0.0001	<0.0001	<0.0001
NSource	0.3900	0.0982	0.1814	0.7262	0.4298	0.9888
Fert_Planting x NSource	0.1747	0.9685	0.5335	0.8261	0.2838	0.3794
Foliar	0.6742	0.2655	<0.0001	0.0353	<0.0001	0.0007
Fert_Planting x Foliar	0.1870	0.3354	0.0203	0.0939	0.3104	0.1603
NSource x Foliar	0.9954	0.7598	0.4027	0.5949	0.5081	0.5105
Fert_Planting x NSource x Foliar	0.5499	0.6649	0.8482	0.7382	0.6720	0.6236

* Samples to measure tissue biomass accumulation and nitrogen concentration were collected at soft dough stage.
† Value less than 0.05 indicates that effect is significant.

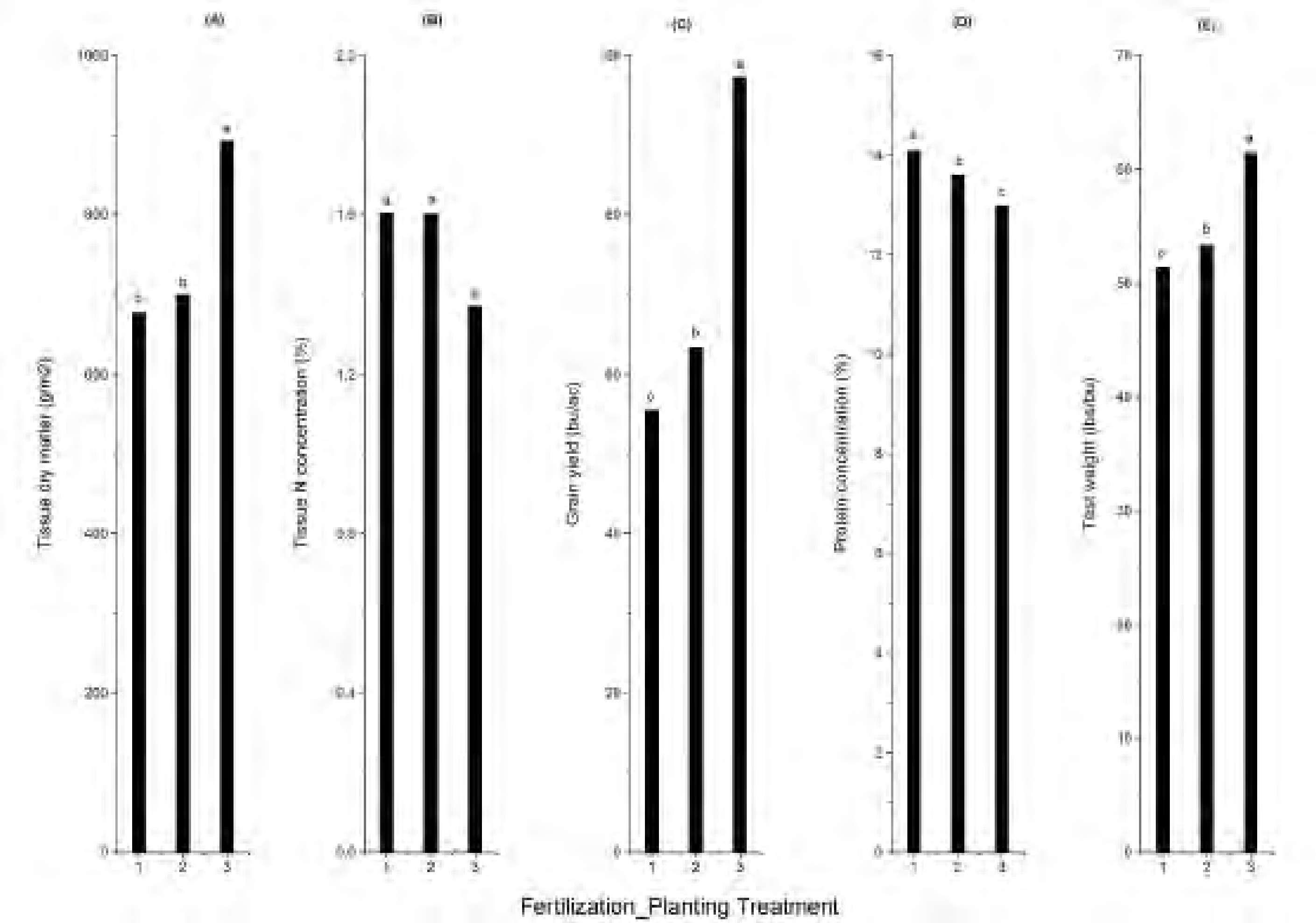

Fig. 1. Effect of N fertilizer application time and planting time on soft dough tissue dry matter accumulation (A) and tissue N concentration (B), grain yield (C), protein concentration (D), and grain test weight (E). Same lowercase letters indicate no significant difference fertilization_planting treatments for the given variable. Treatment 1: Late planting, Late fertilization; 2: Late planting, normal fertilization; 3: Normal planting, normal fertilization. Normal N fertilizer application and planting was done on 5/21/2014 and late N fertilizer application and planting was done on 6/09/2014.

Appendix (continued)

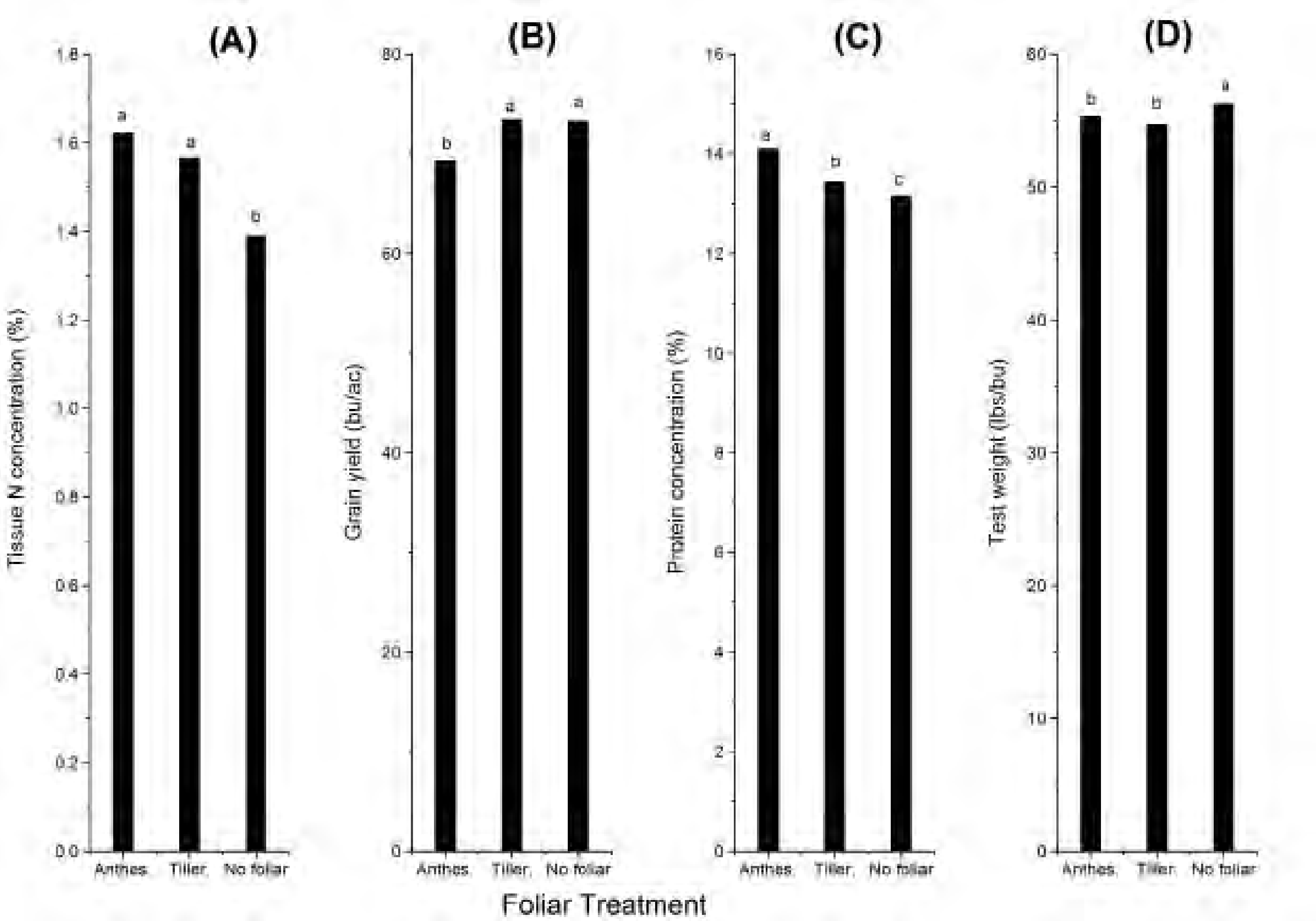

Fig. 2. Effect of nitrogen foliar application (30 lbs N/ac) on soft dough tissue N concentration (A), grain yield (B), protein concentration (C), and grain test weight (D). Same lowercase letters indicate no significant difference foliar treatments for the given variable. Anth., Till., and No fol. are foliar N application at the time of anthesis (Zadok's scale 60), foliar N application at the time of tillering (Zadok's scale 23), and no foliar application, respectively.

Publications

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Reduction in Colon Cancer Risk by Red Wheat Consumption

Daniel Gallaher, Dept. of Food Science & Nutrition, U of M

Research Questions

Colon cancer is the third most common cancer in both men and women. We have recently accumulated results from several animal studies demonstrating that red wheat has a significant ability to reduce colon cancer risk. White wheat, depending on the marker of colon cancer risk used, had either less ability than red wheat or no ability to reduce cancer risk.

The overall objective of this proposal will be to determine the effect of feeding red wheat and white wheat on risk of colon cancer risk in an animal model, the carcinogen-treated rat. The specific aims will be as follows:

1) To confirm that red wheat reduces the number of pre-cancerous lesions that develop in the colon of carcinogen-treated rats, particularly in relation to white wheat.
2) To determine whether red wheat reduces the development of cancer stem cells in the colon of carcinogen-treated rats.

Results

The graduate student conducting the study has now acquired the skills that will be used in measuring the pre-cancerous lesions and has begun learning the immunohistochemical techniques that will be used in determining the number of cancer stem cells that develop. The 10 week animal feeding trial is concluding now, and tissues are being processed and sent to the histology laboratory for preparation for immunohistochemistry. Counting of pre-cancerous lesions will begin in the next 1-2 weeks. Immunohistochemical detection of cancer stem cellswill begin in 4-6 weeks.

Application/Use

If our hypothesis is correct, that red wheat will reduce colonic pre-cancerous lesions and accumulation of cancer stem cells in the colon, this will provide much more convincing evidence that red wheat protects against colon cancer. This message can be used to promote red wheat consumption. Given that currently there is a growing movement promoting consumption of gluten-free (i.e. non-wheat containing) foods, this would provide a strong justification for including red wheat-containing products in the diet.

Material and Methods

We have administered a colon-specific carcinogen (dimethylhydrazine) to three groups of rats (12 per group) and then 4 days later begin feeding one of three diets, as follows: a wheat-free control diet, a diet containing 65% refined red wheat, and a diet containing 65% refined white wheat. After 10 weeks, the rat colons are removed and cleaned. One half the colon (split longitudinally) will be used for counting a common marker of early colon cancer risk, called aberrant crypt foci, under a light microscope by our usual procedure. The other half will be processed for detection of a stem cell marker. This will be done by immunohistochemistry. Briefly, the colon will be fixed in formalin, embedded in paraffin, and cut into very thin sections (4 µm) *en face*, which will be mounted on glass slides. The sections on the slide will then be covered with a solution containing an antibody specific for the stem cell marker (called Lgr5), followed by another solution which will cause a color to develop wherever there is antibody bound to Lgr5. The amount of color is then measured under a light microscope using image analysis software. If red wheat decreases the amount of color, this indicates that it decreased the number of cancer stem cells that developed in the crypts.

Economic Benefit to a Typical 500 Acre Wheat Enterprise:

If our findings show a reduction in colon cancer risk in our animal model, as hypothesized, this can be used to promote red wheat consumption, and to offer a counter message to those promoting gluten-free diets. This could increase demand for red wheat, and thus potentially increase the price of red wheat.

Related Research

We are currently conducting studies examining the effect of vegetables on reducing risk of colon cancer, using a food-borne carcinogen that develops in well-done meat and fish. This carcinogen belongs to a group of compounds referred to as heterocyclic aromatic amines (HAA). Since HAA are present in the diet, they represent a more realistic carcinogen than the carcinogen used in our present project – dimethylhydrazine – which is not found in the diet. If our studies with HAA indicate that it is an appropriate carcinogen for use in studies of diet and colon cancer, we would consider using HAA as the colon carcinogen in future studies of the reduction in colon cancer risk with red wheat, in order to provide greater relevance to the studies.

Recommended Future Research

Unfortunately, human studies of reduction in risk in colon cancer are extremely expensive and difficult, and can only be done using very indirect, and therefore uncertain, markers. Thus, animal studies will continue to be the type of studies that will need to be done. Although most studies of colon cancer in animal models use a chemical carcinogen, such as we are doing, there are genetic models of colon cancer. To further establish the cancer-protecting effect of red wheat, a study using one of these genetic models of colon cancer could be used. Establishing a protective effect of red wheat against colon cancer in both chemically-induced colon cancer and genetically-induced colon cancer would be extremely powerful evidence that red wheat protects against colon cancer.

Variation in Response to Sulfur Among Spring Wheat Genotypes

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

Research Questions

1) Does the application of sulfur (S) increase grain yield and grain protein concentration of hard red spring wheat, and if so, what is the optimal application rate for S?

2) Can plant tissue analysis be used to determine whether hard red spring wheat varieties differ in their potential response to S fertilizer?

3) Can S increase the baking quality of break made from hard red spring wheat and is there an impact of S nutrition on the potential production of acrylamide during baking?

Results

The field sites were selected to represent differing conditions that may affect response to S (Table 1). The site at Crookston included a soil with poor drainage and a relatively high concentration of soil organic matter at the soil surface. Past research funded from 2008 to 2009 by the Minnesota Wheat growers found no impact of S on a single variety, Glenn, grown, in Northwest Minnesota. Kimball represented a site with a medium surface soil texture over gravelly subsoil. This site, while higher in organic matter, should have a greater potential to leach sulfate. However, the total amount of sulfate-S in the top two feet was the greatest at Kimball (Table 2). Increased sulfate-s could be due to previous manure application at this site. Kimball was not irrigated thus there were not incidental application of sulfate-S through irrigation water. Staples was irrigated and had the lowest concentration of soil organic matter in the top six inches of soil. Past research with corn has shown that response to S can greatly be affected by the amount of sulfate-S applied with irrigation water. It was found that as much as 10-15 lbs of S, as sulfate, could be applied on an annual basis depending on the amount of irrigation water applied over the growing season. Increased rainfall in June (Table 1) decreased the need for irrigation until late in the growing season. This could potentially increase the response to fertilizer S at this location. Currently, S fertilizer is only recommended for sandy soils with low concentration of organic matter in the surface soils.

Statistical significance, by location, for spring wheat grain yield, grain protein concentration, and the total amount of protein produced per acre is summarized in Table 3. As expected, yield differed consistently among the varieties. Faller produced the greatest yield across sites followed by RBO7, Mayville, Glenn, Vantage, and lastly, Select. The only surprise out of the ranking was Glenn which was one of the top yielding varieties at two locations (Crookston and Staples). Grain protein concentration was greatest for Vantage and Glenn while Faller producing the least. Total protein produced per acre was greatest for the top yielding variety, Faller, and the varieties with the greatest protein (Glenn and Vantage). The only surprise in the site data was the high protein concentrations measured at Staples. We are in the process of analyzing the grain for total nitrogen to determine if the levels produced were as high as measured on the NIR. Higher levels might be expected if nitrate levels in the irrigation water were high enough to continually feed nitrate in the plant at or post anthesis.

The varieties were selected based on flag leaf tissue data collected from the variety trials at anthesis during 2011 and 2012. Selections were made based on varieties that tended to have increased concentration in S at sites were S availability appeared to be greater (RB07 and Mayville), varieties that appeared to respond no better or worse than others [average varieties (Select and Glenn)], and varieties that appeared to respond less to increased availability of S (Faller and Vantage). The sets were designed to compare varieties that were higher yield, low protein, and low yield high protein. We quested whether the flag leaf tissue concentration would indicate that a variety is more or less responsive to S.

There was no detectable increase in yield at the Crookston and Kimball locations. Yield data for these locations was analyzed together. Data from Staples were analyzed separately as S increased yield only at Staples. Figure 1 summarizes yield data from Crookston and Kimball while Staples is summarized in Figure 2. We were interested whether an interaction between S and variety would occur across sites to determine if varieties responded differently to fertilizer application. The interaction was highly insignificant for all of the locations which indicate that the varieties studied had a similar grain yield response to S at all of the locations. When averaged across varieties, grain yield was increased by 6 bushels per acre (Figure 3) by the lowest rate of S applied (7.5 lbs per acre) which is surprising as our current suggestions for similar soil types is nearly three times that rate. Grain yield was similar between the 7.5 and 15 lb S application rates. One piece of data that has not been considered is the amount of S applied in the irrigation water. A sample has been submitted for analysis but we have not received the data at this time. Once the data is available it may provide information on why a response only occurred to the lowest rate of S. Since irrigation did not begin until July, the amount of S needed to increase yield may have been small since the amount taken up is low early in the growing season.

Grain protein concentration was not affected at any location while the total amount of protein produced was increased by S applied at Staples due to the increase in grain yield (data are not shown). The fact that grain protein concentration was not affect is not surprising as it confirms previously collected data. The total concentration of protein is typically affected by nitrogen and not S. We have seen instances where the type of protein in the grain may change due to an application of S but the total concentration remains unchanged. For instance, S containing proteins such as cysteine and methionine can be increased when S is applied relative to other non-S containing proteins. While S can impact nitrogen utilization in plants the lack of nitrogen deficiency in this study (nitrogen was kept at non-limiting levels) resulted in a low chance for S to affect nitrogen nutrition in the plant. There is no evidence that farmers growing hard red spring wheat should be concerned that S may be limiting protein levels.

Baking quality, amino acid concentration in grain, and grain and flag leaf S concentration measurements were planned for this research. While the data have been collected we still are waiting on analysis to be conducted since most of this work will be funded by in-kind work. A supplemental report will be provided including this data once it is made available for analysis. We anticipated that only the yield and grain protein concentration would be available for the year-end report for the initial funding request.

Application/Use

The data from the first year of this project indicate that some changes may be required to the current fertilizer guidelines for wheat. Changes were made when the Fertilizer Guidelines for Wheat in Minnesota publication was updated in 2012. Some changes included a general framework of S guidelines for eroded low organic matter soils (less than2.0% organic matter in the top six inches). An addition year of data would be beneficial to compare the response that occurred at the Staples location to determine if our current suggestion of 25 lbs of S may be greater than what is required to grow wheat on irrigated sandy soils in Minnesota.

There may be some benefit in baking quality with S. However, until protein premium/discounts reflect quality over the quantity there may be a limited impact to the bottom line of a wheat grower. Since this work was being conducted in-kind at the USDA grain quality lab there was no cost for this work included in the budget of this grant. Previous research has demonstrated benefits of S on baking quality. This study provides a better comparison as it includes multiple varieties.

Our goal for comparing the varieties was to determine if tissue sampling could be used to determine responsiveness of varieties to S. Since there was no evidence that a variety by S interaction occurred, it is unlikely that the tissue data had much value in determining whether S would benefit one variety over another. One caution about this work is that since yield was only affected at one location it is hard to draw hard conclusions unless the effect can be replicated. More locations and one or two additional years of funding would greatly benefit this project to determine if similar effect can be replicated across sites and years. Overall, our data from this study and past research indicated that significant caution should be taken when using plant tissue samples for guiding fertilizer application.

Material and Methods

Small plot S fertilization studies will be established alongside selecting spring wheat variety trials. Three locations were studies. Sites at Crookston Kimball were non-irrigated and an irrigated site was established at Staples. Six wheat varieties will be selected using the stability analysis conducted for spring wheat flag leaf tissue among varieties in 2011 and 2012 at 17 locations. Two varieties will be selected that were considered in the high, average, and low response to S categories and that vary in protein and yield potential. The varieties preliminarily selected are Faller, Vantage, Select, Glenn, Mayville, and RB07. Sulfur rates used will be a non-fertilized control (0 lbs S per acre) and rates of 7.5 and 15 lbs of S per acre. Sulfur was applied to the soil surface at seeding. The source of S was granular ammonium sulfate (21-0-0-24). Nitrogen was applied to balance the rate of nitrogen applied with the high rate of ammonium sulfate. Nitrogen, phosphorus, and potassium were kept at non-limiting rates according to current recommendations. Blanket N was split applied at Staples with half of the N applied after seeding prior to emergence and the remaining applied near the boot stage. All S, P and K were applied as a single application prior to or at-seeding (S treatments).

Grain yield was measured for all plots and a sub-sample of grain was collected and will be analyzed for protein, nitrogen, and S concentration. Baking quality and amino acid concentration (asparagine) will be measured to determine potential for acrylamide formation. Acrylamide concentration will not be directly measured. Grain cysteine and methionine may also be measured to compare with total S uptake. Due to the difficulty of analysis, the amino acid concentration and baking quality data may not be available for the November 15 reporting. The data will be made available to the Minnesota Wheat Research and Communication Council as a supplementary report when fully analyzed.

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Economic Benefit to a Typical 500 Acre Wheat Enterprise

Assuming a wheat price of $6 per bushel, the response at Staples would result in an additional $36 per acre in added crop value across the varieties. If S cost was $0.50 per lb of S, the rate needed to increase yield (7.5 lb per acre) would cost a grower $3.75 per acre resulting in a net profit of $32.25 per acre and would total $16,125 for a 500 acre operation. The question remains whether the 7.5 lb rate is needed? Since we did not use a smaller rate it is unclear if application of 5 lb of S would result in the same yield. However, the low cost of the treatment relative to the added value of the crop can easily pay for the additional cost of the fertilizer. When S is deficient, application of S is highly profitable for hard red spring wheat.

Even with the low total cost associated with the rate of S needed to increase yield, if a site is not responsive a grower should highly consider using money intended for S for nitrogen especially in years where yield potential and protein discounts are greater. Since there has been no evidence for increased grain protein due to S application in several studies dating back to 2008 S should not play a role in making decisions on fertilizer application for increasing grain protein concentration.

Related Research

A S study was concluded in 2009 which was funded by the Minnesota Wheat Growers that studied the effect of S source, rate, and timing for wheat grown on soils with relatively high concentration of organic matter. This current study provided supporting data for the previous research but focuses on questions received following the previous study on whether we would expect response to S to be greater for varieties which are greater yielding than Glenn which was used in the previous research. We are also following up on information collected in a study funded in 2011 and 2012 that included a survey of flag leaf tissue nutrient concentration. The current research will determine if there is any value in tissue concentration data and whether tissue concentration can help predict a varieties responsiveness to a specific fertilizer.

Recommended Future Research

Since we have not been able to consistently detect significant yield response to S application in hard red spring wheat an additional year or two of follow up research would be beneficial to see if we can replicate responses that occurred at Staples in 2014. In addition, we would like to continue targeting field sites on lower organic matter, eroded, soils to see if we can replicate data collected in corn which suggests soils with less than 3.0% organic matter in the top six inches may be highly responsive to S. Additional years would provide a stronger set of guidelines for when and where to apply S in hard red spring wheat.

Our initial contacts with growers of irrigated wheat also indicate a need to study nitrogen guidelines for irrigated coarse textured soils. While there acreage may be low there is some wheat grown in rotation with other crops on irrigated soils. All of our current research has focused on the primary wheat growing regions in Minnesota which are non-irrigated. A nitrogen study was established at Staples along with the S study in 2014. Additional funding for S research would allow us to also conduct nitrogen studies under irrigation that would provide data for nitrogen guidelines for irrigated wheat.

Publications

Kaiser, D.E., J.J. Wiersma, and J.A. Anderson. 2014. Genotype and Environment Variation in Elemental Concentration of Spring Wheat Flag Leaves. Agron. J. 106:324-336.

**Paper was a summary of work funding by MN wheat for the 2011 and 2012 growing seasons

Appendix

Table 1. Trial location, planting information, and monthly total precipitation for spring wheat S rate studies.

					Monthly Total Precipitation		
Location	County	Soil Type	Soil Texture	Seeding Date	May	June	July
					-----inches-----		
Crookston	Polk	Wheatville	Sandy Loam	17-May	2.6	6.8	2.2
Kimball	Stearns	Fairhaven	Silt Loam	26-Apr	4.4	7.6	1.9
Staples	Wadena	Verndale	Sandy Loam	7-May	3.6	5.9	7.8

Table 2. Spring soil test averages across replications for Spring wheat S trials.

Location	Soil Test (0-6")† P	K	SOM	pH	Sulfate-S‡
	-------ppm-------		---%---		--lb/ac--
Crookston	8	128	4.0	8.0	48
Kimball	98	200	5.1	7.1	76
Staples	46	120	1.9	7.0	52

† P, Bray-P1 phosphorus; K, ammonium acetate potassium; SOM, soil organic matter; pH, soil pH.

‡ 0 to 2 foot soil sulfate-S

Table 3. Summary of statistical signficance of main effects of variety (V), sulfur rate (S), and their interaction (VxS) for spring wheat grain yield, protein concentration, and total protein produced per acre.

	Grain Yield†			Grain Protein†			Protein Yield†		
Location	V	S	VxS	V	S	VxS	V	S	VxS
	-----				$P>F$				-----
Crookston	<0.001	0.42	0.56	<0.001	0.81	0.82	<0.001	0.85	0.56
Kimball	<0.001	0.52	0.21	<0.001	0.87	0.44	<0.001	0.33	0.28
Staples	<0.001	<0.001	0.28	<0.001	0.34	0.12	0.03	<0.01	0.43

Table 4. Summary of hard red spring wheat grain yield, grain protein concentration, and protein production per acre for individual varieties at Crookston (CR), Kimball (KI), and Staples (ST) Minnesota during 2014. Average values were calculated for data across three sulfur rates and across locations (AVG).

	Grain Yield†				Grain Protein†				Protein Yield†			
	CR	KI	ST	AVG	CR	KI	ST	AVG	CR	KI	ST	AVG
	--------bushels/ac (@ 13%)--------				--------%(@ 12%)--------				--------pounds/ac (@ 13%)--------			
Faller	82a	83a	86a	84a	12.8d	14.4e	17.2d	14.8e	635b	733a	897a	755a
Glenn	84a	60d	79b	74c	14.6a	15.9b	18.8b	16.4b	734a	570c	889a	731ab
Mayville	68c	80a	76bc	75bc	14.4ab	15.3c	18.0c	15.9c	591c	732a	817bc	713b
RB07	75b	80a	79b	78b	13.5c	14.9d	17.8c	15.4d	607bc	709a	843abc	718b
Select	70c	68c	74bc	71d	14.2b	15.5bc	17.8c	15.8c	595c	625b	795c	672c
Vantage	68c	74b	73c	72cd	14.2b	17.1a	20.0a	17.1a	577c	750a	873ab	734ab

† within columns, numbers followed by the same letter are not statistically significant at $P \leq 0.05$ probability level.

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Figure 1. Summary of variety response to sulfur averaged together for the Crookston and Kimball locations studied in 2014.

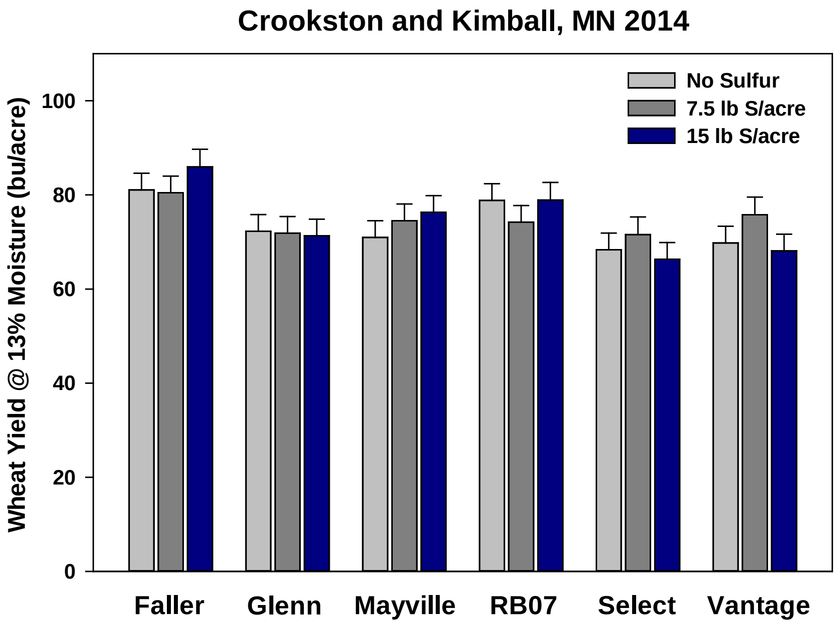
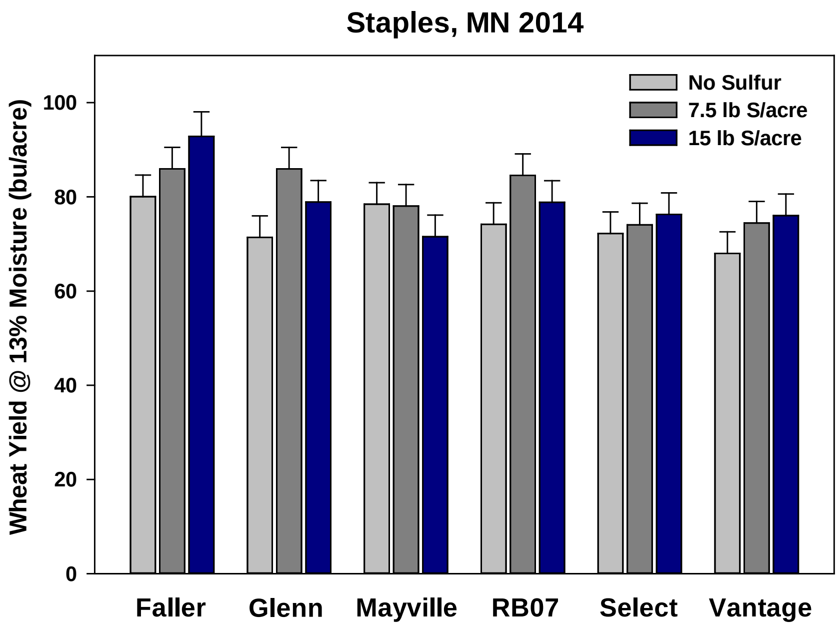
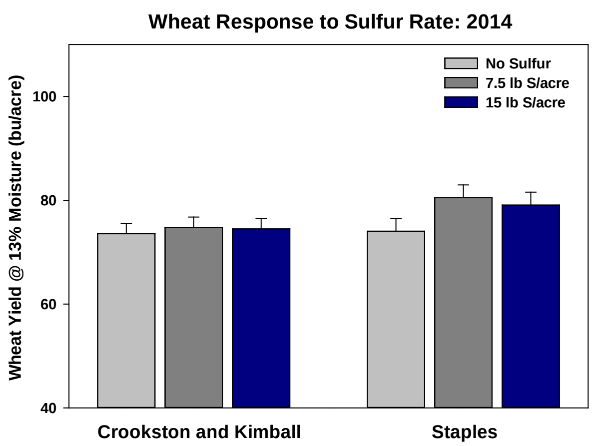


Figure 2. Summary of variety response to sulfur at the Staples, Mn locations studied in 2014.





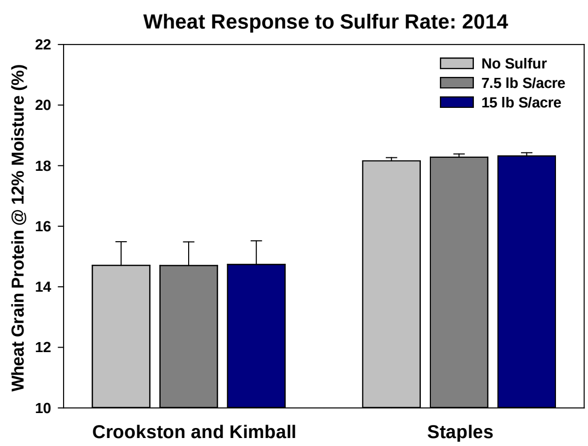


Figure 3. Impact of sulfur rate on hard red spring wheat grain yield and grain protein concentration for Crookston and Kimball (average across location) where sulfur did not increase yield and Staples were an application of 7.5 lbs of S per acre increased yield over the control (no sulfur).

University of Minnesota Wheat Breeding Program

James Anderson, Dept. of Agronomy & Plant Genetics, U of M, St. Paul

Research Questions

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

During the 2013/2014 crossing cycle, 278 crosses were made. The State Variety Trial, which contained 31 released varieties, 15 University of Minnesota experimental lines, and 5 experimental lines from other programs was grown at a total of 15 locations in 2014. During the 2014 growing season, another 228 advanced experimental lines were evaluated in advanced yield trials at 8-11 locations. An additional 668 lines were evaluated in preliminary yield trials at 1-2 locations. A total of 7,730 yield plots were harvested in 2014. Fusarium-inoculated, misted nurseries were established at Crookston and St. Paul. Inoculated leaf rust nurseries were conducted at Crookston and St. Paul and a stem rust nursery was also conducted at St. Paul. The disease nurseries involve collaboration with agronomists and pathologists at Crookston 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 MAES's 2014 Minnesota Field Crop Trials bulletin.

MN08165-8 (MN02268-1/MN01333-A-1) is a candidate for release and has higher protein and grain yield than Vantage (Table 1). Other advanced experimental lines that are candidates for release in the next 1-2 years are MN10261-1 and MN11325-7. Data of these two experimental lines, recent U of MN releases, and popular varieties are shown in Table 1.

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Table 1. Comparison of MN08165-8, MN10261-1, and MN11325-7 with other wheat varieties. Varieties are sorted from highest to lowest yielding based on 2 Yr. yield

	Year Release	MN Acreage 2014	Yield (bu/A)			Test Wt (Lb/Bu)	Protein (%)	Straw Strength	Leaf Rust	Bacterial Leaf Streak	Scab
Entry		**%**	**2014**	**2-Yr**	**3-Yr**	**2-Year**	**2-Year**	**1–9**	**1–9**	**1–9**	**1–9**
MN11325-7	–	–	84.3	88.5*	–	–	13.7*	4	4	4–5	4–5
LCS Albany	2008	6.2%	88.8	88.5	85.0	60.5	12.9	5	2	6	4
Prosper	2011	20.7%	87.8	87.2	81.0	60.3	13.5	6	5	4	5
Faller	2007		87.7	86.1	79.7	60.3	13.4	5	5	4	4
MN10261-1	–	–	83.5	82.0	–	61.5	14.4	4	1	3	3–4
Forefront	2012		82.7	80.7	77.1	60.9	14.5	5	2	3	3
MN08165-8	–	–	79.7	78.8	75.5	60.3	15.5	5	1	4	4-5
Samson	2007	3.6%	77.3	78.5	76.2	58.8	14.1	3	5	5	8
SY Soren	2011	8.3%	80.2	78.3	75.7	60.6	14.5	4	3	4	4
RB07	2007	1.9%	77.8	77.8	73.3	60.3	14.3	5	2	6	4
Norden	2012	2.3%	77.8	77.4	73.4	61.7	13.9	3	2	4	5
Vantage	2007	1.3%	75.9	76.3	71.5	61.7	15.1	2	6	7	5
WB-Mayville	2011	18.1%	75.3	75.3	73.2	59.4	14.7	3	3	6	7
Linkert	2013	3.9%	75.6	75.2	71.7	60.4	15.0	2	3	4	5
Rollag	2011	4.8%	76.7	75.0	71.4	61.1	14.9	3	4	4	3
No. Env.			15	28	41						
* Estimated based on performance in 10 AY2 trials in 2013 with Faller and LCS Albany as checks.											

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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.

Material and Methods

All yield nurseries are grown in small, replicated plots (typically 40-75 sq. ft. harvested area per plot). Fusarium-inoculated nurseries at Crookston 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. Leaf and stem rust nurseries are spray inoculated with spore suspensions and surrounded by a border seeded to mixture of susceptible varieties to further increase disease pressure.

Economic Benefit to a Typical 500 Acre Wheat Enterprise

Choice of variety is one of the most important decisions growers make each year. The development of high-yielding varieties that are resistant to the prevalent diseases and have good end-use quality are necessary to increase grower profit and protect against constantly changing pathogens and pests. As an example, a new variety that yields 4% higher will produce 3 extra bushels in a field that averages 75 bu/A.

Related Research

These funds provide general support for our breeding/genetics program. Additional monetary support for breeding-related research in 2014 came from the Minnesota Agricultural Experiment Station, the U.S. Wheat and Barley Scab Initiative via USDA-ARS, and National Research Initiative Competitive Grant no. 2011-68002-30029 (Triticeae-CAP) from the USDA National Institute of Food and Agriculture.

Recommended Future Research

We will continue to operate the breeding program using similar methodologies in the future, but are also exploring the integration of genomic selection with DNA markers to more efficiently select for important traits and speed our rate of genetic progress. If successful, I anticipate genomic selection being a routine feature of our breeding program, using even lower cost DNA marker systems in the future.

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Evaluating a New Rapid Technique to Assess Spring Wheat Flour Performance

Franciso Diez-Gonzalez, Dept. of Food and Nutrition, U of M, St. Paul

Research Questions

Variability in flour performance and consistency under manufacturing conditions remains an issue for processors. The reasons for variability are many, including genetics, environmental conditions, aging of wheat during the year, blending of wheats and the particular milling fractions that are blended to deliver flour of a certain specification. However, there is evidence that some wheat varieties maintain their quality despite variability in growing season. Wheat is transacted in the market based on protein content, but flour performance is based on protein quality – an attribute that remains difficult to measure or quantify. Recent research from our laboratory working with Eastern hard and soft wheats, demonstrated that a new technique – Glutopeak tester –can distinguish differences between flours with similar protein quantity. However, similar work has not been conducted with western wheat varieties. These observations led us to the next phase of research where we focus on individual wheat varieties. This project proposes to assess if this new technique has the potential predictive capabilities of assessing flour performance. The glutopeak tester is a high shear based technique that provides two attributes of gluten quality; torque that is an indication of strength of gluten and time to peak that is an indication of kinetics of gluten aggregation. The test is rapid (<5 min) and it requires only about 9 g of sample. If the technique has predictive capabilities, then it will be of great value to wheat breeders, elevators, millers and processors to asses wheat quality as opposed to merely protein quantity.

Results

We compared performance of flours from 32 spring wheat varieties grown in different environments during 2012 and 2013 using industry standard procedures to measure water absorption, mixing strength, loaf volume, etc. We subjected the same flours to the glutopeak test, a fast 5-10 min. test that could be used at grain elevators, to test its ability to predict mixing and baking properties. During the test, the sample is mixed with water (ratio of flour : water about 1:1) and subjected to intense mechanical action on the speed of the rotating element (from 1900 to 3000 rpm). These conditions - allowing for the formation of gluten - promote a strong increase in the consistency of the slurry up to a maximum peak. From that moment, the continuous mechanical stress causes the breakdown of the gluten network, a phenomenon recorded as a decrease in consistency (see Figure 1). Using this technique we were able to demonstrate that flours with similar protein content had different gluten aggregation kinetics and conversely wheat flours with different protein content had similar aggregation kinetics in terms of Peak Maximum Time and Peak Torque (Figure 1a). During gluten aggregation, some samples showed different peak torque and peak time but they exhibited the similar values for the area under the peak indicating that they required a similar energy for gluten aggregation and a similar volume of the corresponding bread (samples A and B in Figure 1b). Other samples were characterized by a different aggregation kinetics, but they were different in the energy necessary for gluten aggregation and therefore in loaf volume (samples C and D in Figure 1b). Further studies are underway to explain what is the driving force of these differences in gluten aggregation. Considering the data set analyzed (n=128), samples with high peak torque exhibited faster aggregation (low peak maximum time; $r=-0.62$; $p<0.01$; see Table 1) and they were able to keep high value of consistency even after prolonged mixing (2 min after the peak; $r = 0.90$; $p<0.01$; see Table 1).

The charts that report the min, max, average and median values of protein content, peak maximum time, peak torque, area under the curve of the flours of 128 spring wheat samples (see Figure 2) highlight that the set of samples is well distributed around the mean values (the mean and median values are very similar). Samples grown in Stephen, MN - characterized by relatively high protein content - show a faster aggregation (low peak maximum time) and strong gluten formation (high peak torque) on average. Considering the area under the curve - that takes into consideration both the peak torque and time for gluten aggregation - samples grown in Roseau, MN exhibited the lowest value, suggesting weaker gluten aggregation performances compared to the samples grown in Oklee and Stephen. As regard the effect of growing year, wheat grown in Stephen 2012 showed - on average - stronger protein network forming than samples grown in Stephen in 2013.

Taking into consideration all the samples (n=128), the peak maximum time from the Glutopeak test was correlated with the bake mixing time ($r=0.62$; $p<0.01$ see Table 2) and the farinographic stability ($r=0.48$; $p<0.01$ see Table 2). Interesting, samples that required higher energy for gluten aggregation exhibited higher mixograph pattern ($r=0.40$; $p<0.01$ see Table 2) and farinographic stability ($r=0.39$; $p<0.01$ see Table 2).

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Based on the results obtained using the GlutoPeak, 4 varieties (Knudson, Marshall, Prosper and Samson) were chosen for further investigation, because of their high variability (e.g. >20% for the area under the peak). Unlikely, the SDS-solubility data of the dough did not show any strong correlation with the indices from the GlutoPeak test. Samples with faster aggregation exhibited high solubility at the dough development time ($r=-0.48$; $p <0.1$). A larger set of samples should be investigated.

Interesting, a significant negative correlation between the maximum torque (that corresponds to the peak occurring as gluten aggregates) and the fluorescence intensity ($r=-0.71$; $p<0.01$) was observed, suggesting that flours with greater number of hydrophobic patches on the protein surface (great fluorescence intensity) create a weak gluten network during aggregation.

Application/Use

Results demonstrated that gluten aggregation kinetics of varieties grown in different locations and over different years were different. the new technique can be successfully used for characterizing spring wheat lines.

Material and Methods

Thirty-two varieties of spring wheat were grown in three locations (Roseau, Stephen and Oklee) in 2012-2013, for a total of 128 samples. On the basis of the results, 4 varieties (Knudson, Marshall, Prosper, Samson) were chosen for investigating the protein solubility and the hydrophobic interactions during dough-making.

The gluten aggregation properties of flours were measured using the GlutoPeak (Brabender GmbH and Co KG, Duisburg, Germany), according to (Kaur Chandi & Seetharaman, 2012). An aliquot of 8.5 g of flour was dispersed in 9.5 ml of 0.5M $CaCl_2$. Sample and solvent temperature was maintained at 34 °C by circulating water through the jacketed sample cup. The paddle was set to rotate at 1900 rpm and each test ran for 7 min. The following indices were determined: *i)* Maximum Torque expressed in Brabender Equivalents (BE) - corresponding to the peak occurring as gluten aggregates; *ii)* Peak Maximum Time expressed in minutes - corresponding to the time at peak torque; *iii)* Area under the peak expressed in arbitrary units (AU) - corresponding to the energy required for gluten aggregation; iv) loss of torque 2 minutes after the peak (%) related to the ability of strength of the gluten network during prolonged mixing.

A Farinograph-AT (C.W. Brabender Inc., South Hackensack, NJ, USA) equipped with a 10 g mixing bowl was used for preparing the dough (at 30°C and 63 rpm). All the dough samples were prepared at a constant water absorption level (60%). Samples were collected at the dough development time and at the end of the test (20 min mixing) and immediately transferred to liquid nitrogen followed by freeze-drying. The freeze-dried samples were ground using a pestle and mortar in order to have a powder sample with particle size less than 0.5 mm. Freeze-dried samples containing ~1 mg protein were suspended in 1 mL of a 0.05 M sodium phosphate buffer (pH 6.8) containing 2.0% sodium dodecyl sulfate (SDS) and transferred to a shaker for 60 min at room temperature. After centrifugation (10,000×g for 5 min), the amount of protein in the supernatant was determined colorimetrically using the RC-DC Protein Assay (Bio-Rad, Hercules, CA, USA) based on the Lowry assay (Lowry *et al*., 1951). Bovine serum albumin was used as a standard and results were expressed as mg soluble protein/g protein.

Rearrangement of hydrophobic patches on the protein surface of selected samples were measured by spectrofluorometric technique, monitoring the chemical environment of extrinsic flourophore1,8-anisolino naphthalene sulfonate (ANS), as described by Bonomi et al. (2004). A Farinograph-AT (C.W. Brabender Inc., South Hackensack, NJ, USA) equipped with a 10 g mixing bowl was used for preparing the dough (at 30°C and 63 rpm). All the dough samples were prepared at a constant water absorption level (60%). ANS (0.2 mM) was added to the water used for making the dough. Dough samples for analyses were collected at the dough development time, corresponding to the time from first addition of water to the point of maximum consistency range. Fresh samples were pulled from the farinograph with minimal additional physical manipulation, transferred to a fluorescence cell (quartz-windowed standard surface) and analyzed within 3 min. A fluorophotometer (LS 55, Perkin Elmer, Waltham, MA, USA) was used to measure emission spectra from 400-600 nm with excitation at 390 nm.

References

Kaur Chandi, G., Seetharaman, K. (2012) Optimization of gluten peak tester: a statistical approach. Journal of Food Quality 35, 69-75.

Lowry, O.H., Rosebrough, N., J., Farr, A., Randall, R.J. 1951. Protein measurement with the folin phenol reagent. Journal of Biological Chemistry, 193, 265-275.

Related Research

Using this technique, Dr. Seetharaman was able to demonstrate that flours with similar protein content had different gluten aggregation kinetics and conversely wheat flours with different protein content had similar aggregation kinetics. Given that commercial flours are a blend of different wheat varieties and/or types, he conducted a flour blending study to assess the impact on gluten aggregation kinetics. Results suggested that different proportions of wheat types in a given blend influence gluten aggregation kinetics. A further exploration to understand reasons for these observations was conducted by isolating gliadin and glutenin from different wheat types (eastern soft, eastern hard, and western hard). The results showed that gliadin and glutenin proteins in the different wheat types were inherently different and blending of gliadin and glutenin from different wheat types did not result in similar gluten aggregation kinetics.

The project is a collaboration with Dr. Jim Anderson, Wheat Breeder, University of Minnesota and used wheat varieties developed by other scientists in the region.

Recommended Future Research

- Relating gluten aggregation properties and hydrophobic interactions testing a larger number of varieties, years and locations
- Applying proteomics and thiolomics approach to understand variability in flour performance from wheats grown in different environmental conditions.

Appendix

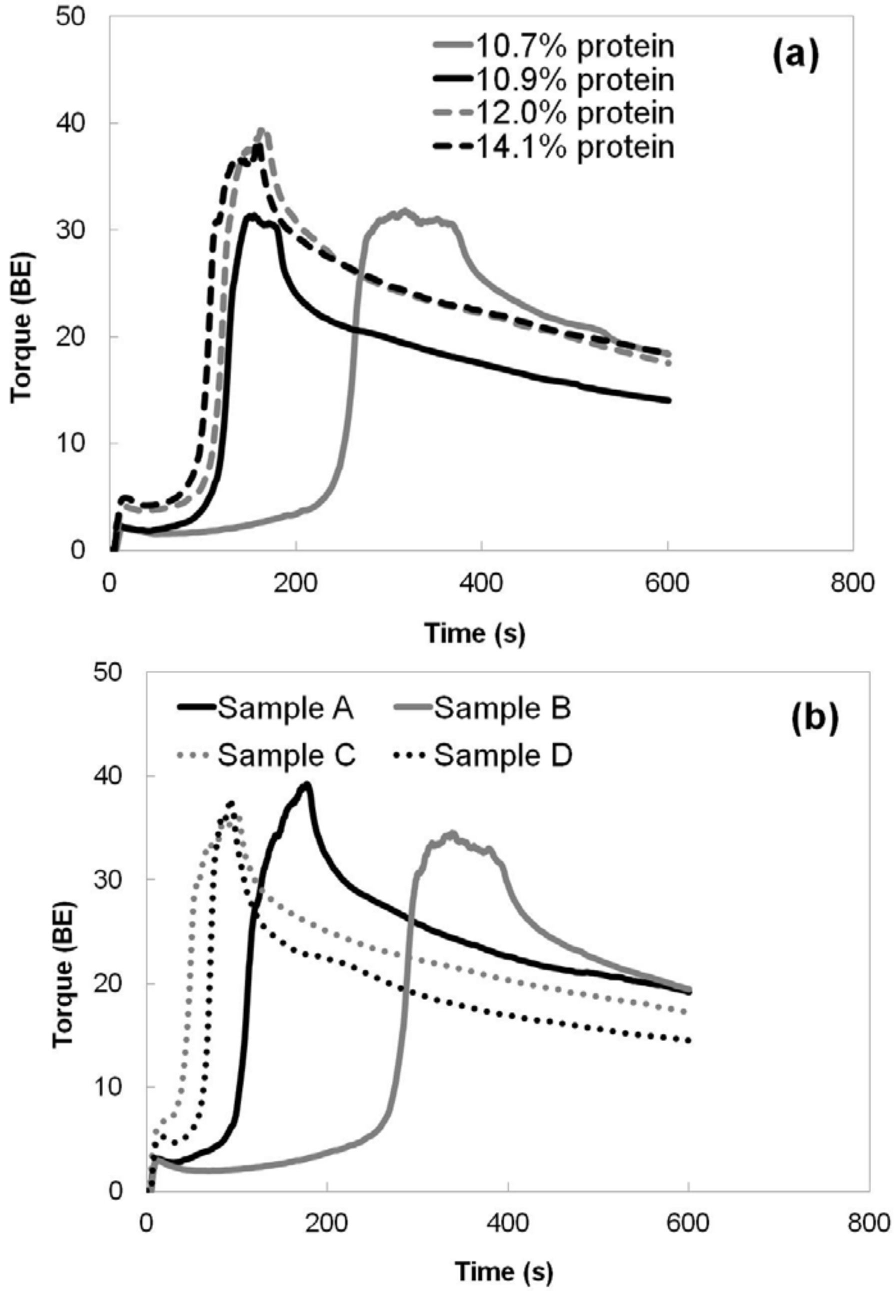

Figure 1. Examples of GlutoPeak curves

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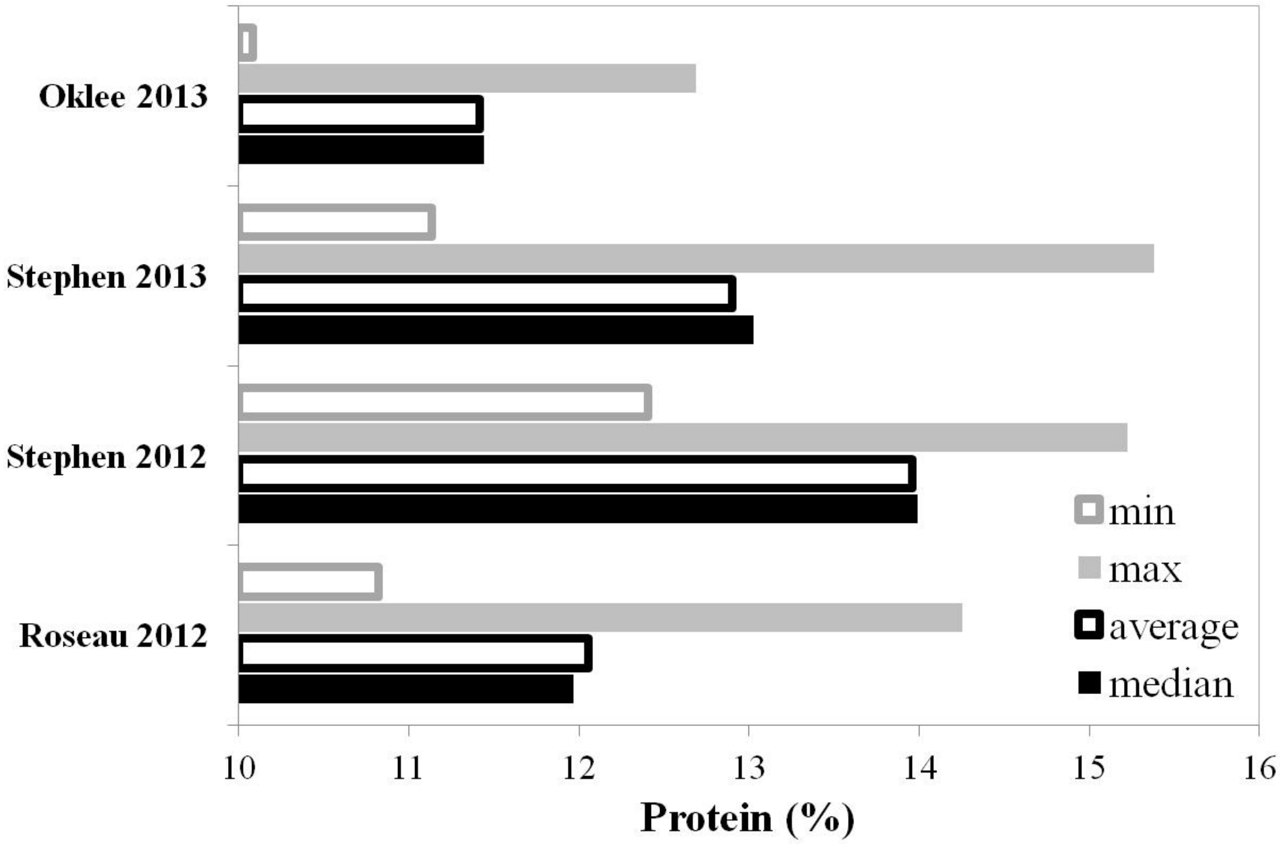

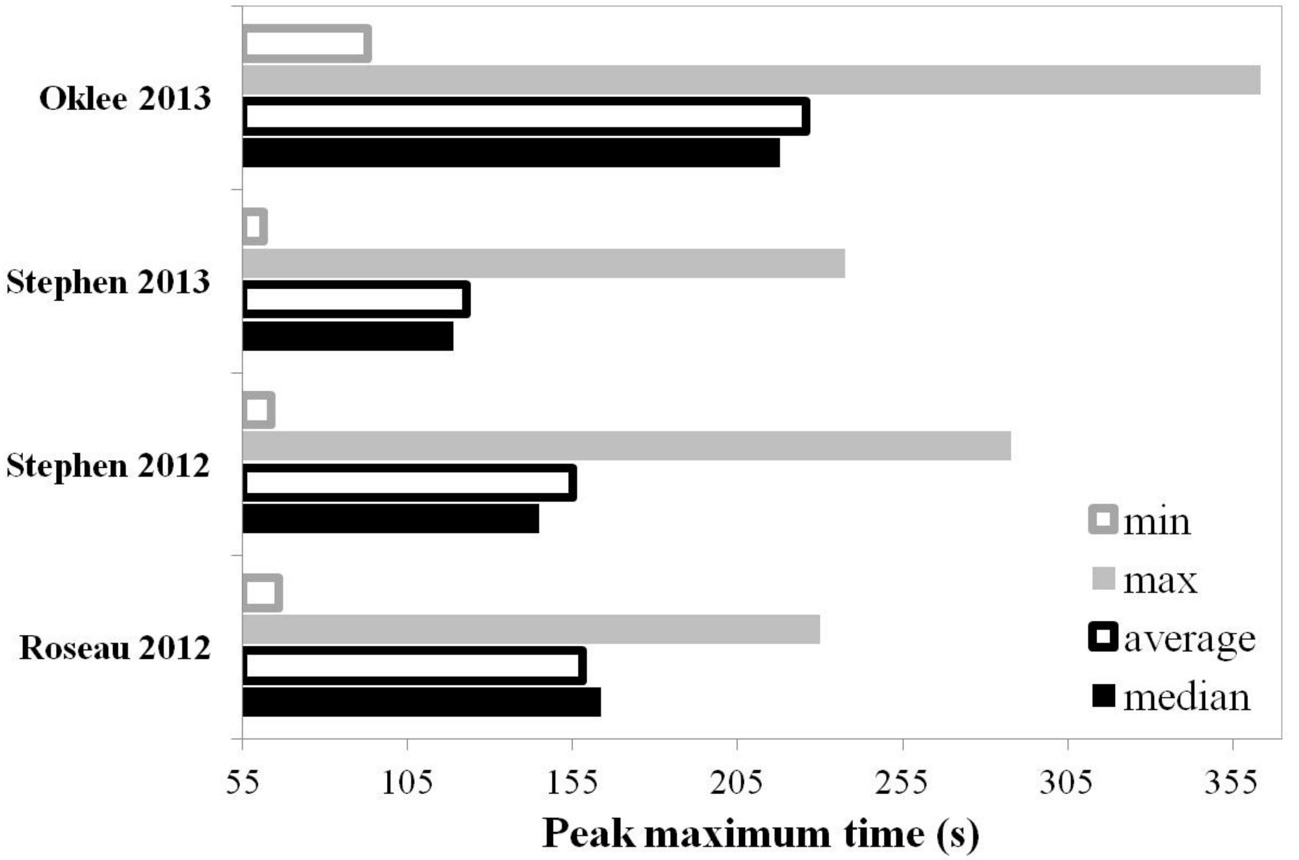

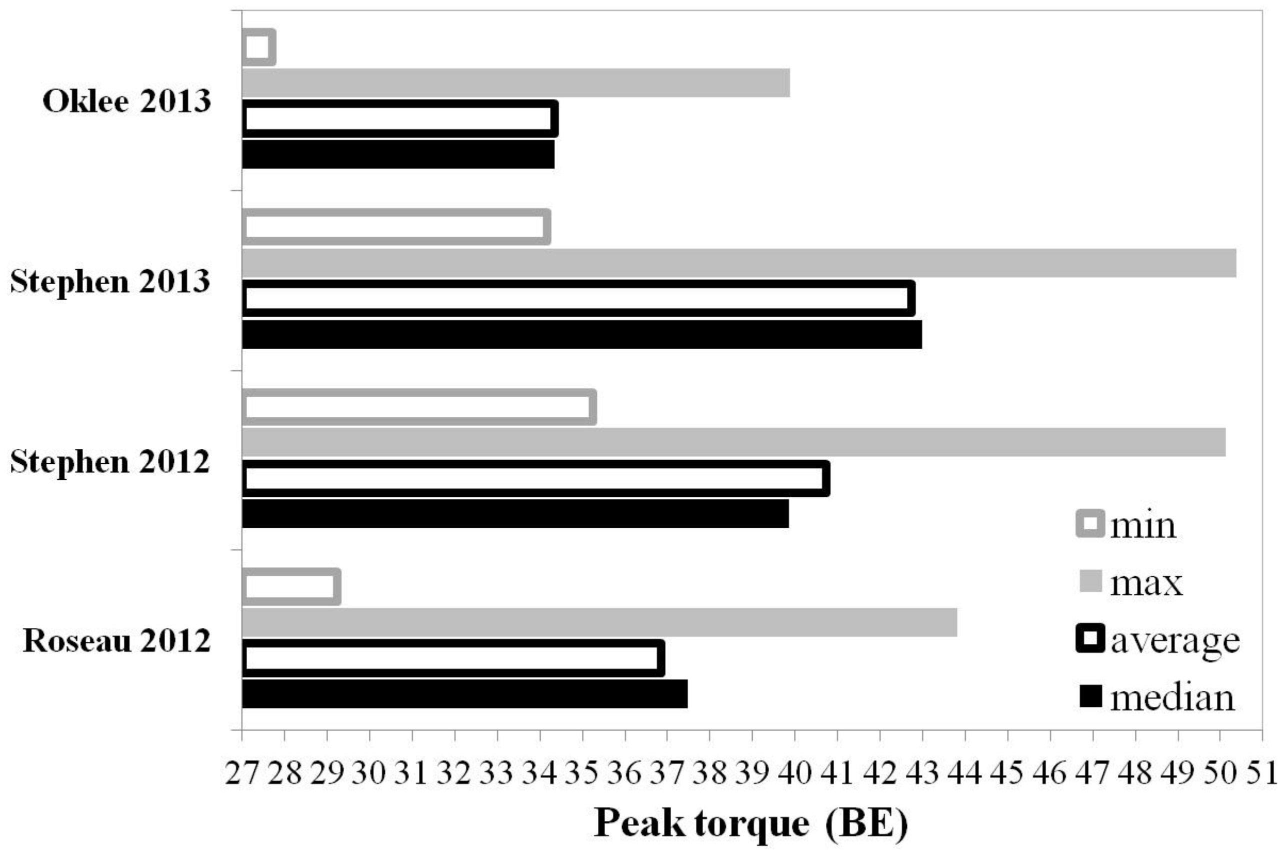

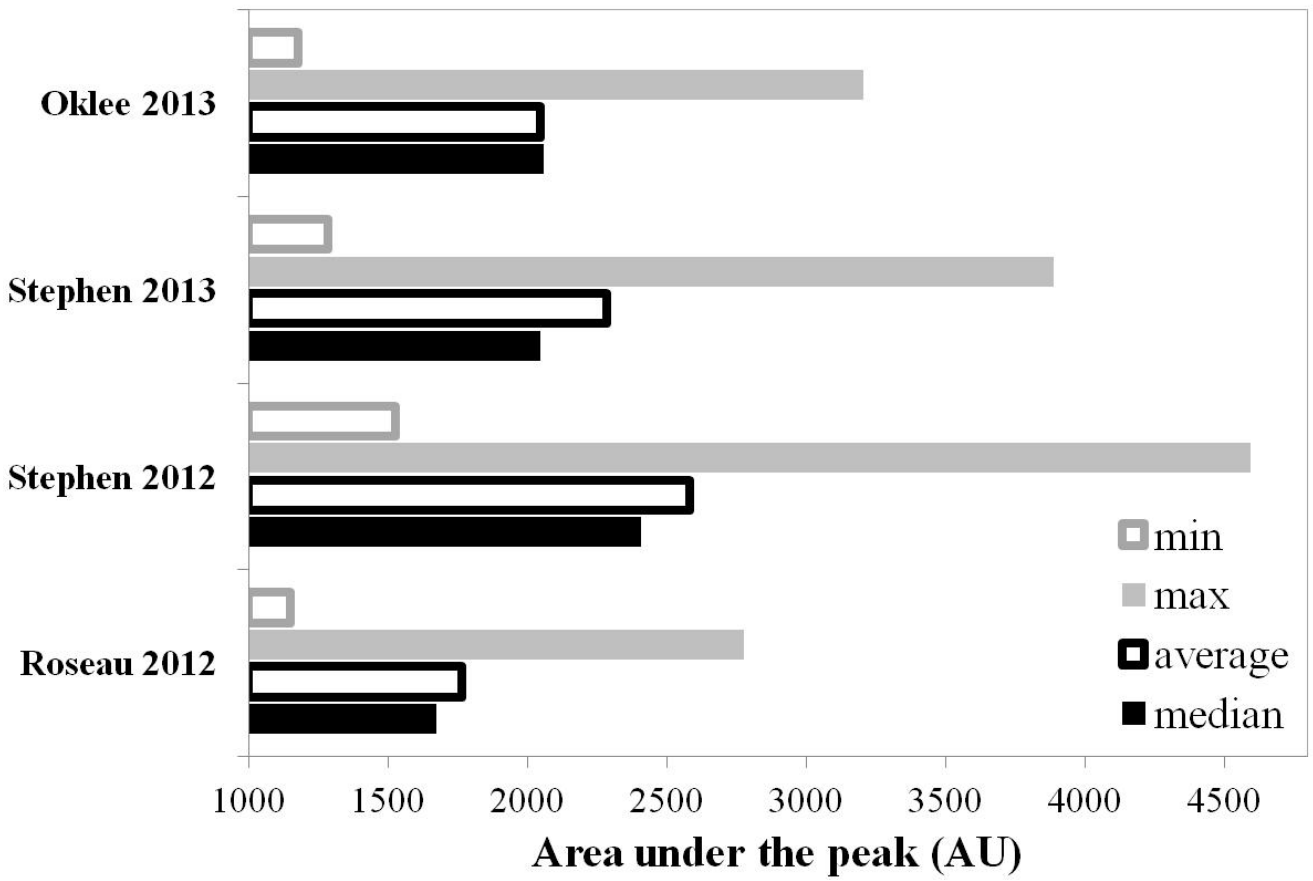

Figure 2. Min, max, average and median values for protein and GlutoPeak of 32 spring wheat varieties grown in different environments.

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Table 1. Glutopeak indices: Pearson coefficients

	Peak Maximum Time	*Peak Torque*	*Energy peak*	*Torque 2 min after peak*
Peak Maximum Time	1			
Peak Torque	-0.62	1		
Energy peak	0.28	0.37	1	
Torque 2 min after peak	-0.46	0.90	0.45	1
n.s. not significant				

Table 2. Mixing profile: Pearson coefficients

	Peak Maximum Time	*Peak Torque*	*Energy peak*	*Torque 2 min after peak*
Mixograph Pattern	0.28	n.s.	0.40	0.37
Bake mixing time	0.62	-0.34	n.s.	n.s.
Farinographic stability	0.48	n.s.	0.39	n.s.
n.s. not significant				

Evaluating Wheat Germplasm and Wheat Varieties for Waterlogging Tolerance

Xinhua Jin, Dept. of Agricultural and Biosystems Engineering, NDSU

Research Questions

Waterlogging (WL) stress affects wheat growth and wheat yield. Selecting wheat WL tolerance germplasm and breeding for wheat WL tolerance variety are the most effective and economic way to solve the problem. Using a constant water level control device and measureable parameters indicating wheat water and nutrient status, it is possible to speed up the screening process and rank the germplasm and variety that are more tolerant than others.

Results

Two seasons of experiments were conducted to pre-screen the WL tolerance of 40 wheat germplasms and varieties during the study period. In the first season with sufficient nitrogen fertilizer application, the results showed that all 40 wheat germplasms survived a prolonged 33 day WL conditions. The wheat with WL treatment showed a better growth. However, the root systems exhibited a significant difference between the WL and non-waterlogged (Non-WL) conditions (Figure 1). Comparing wheat growth in two totes, one with WL treatment and the other without, the fresh wheat biomass with WL was 68% higher than that with Non-WL, but the root length with WL was 67% shorter than that with Non-WL treatment, probably due to easy access of water in WL treatments. This also proved that with WL condition, sufficient nitrogen in the soil can reduce the damage caused by excess water, and application of nitrogen fertilizer to field after WL stress is an effective practice for recovery.

In the second season, nitrogen fertilizer was not applied, while the only nutrient for wheat growth came from the field soil used in the experiment. After wheat was germinated and in 3-4 leaves, WL treatments started. Stomatal conductance was measured with a SC-1 Leaf Porometer (Decagon Devices, Inc., Pullman, WA).Leaf chlorophyll content was measured with a SPAD-502DL Plus Chlorophyll Meter (Spectrum Technologies Inc., Aurora, IL) every 2-3 weeks. In general, crop growth and yield increased with stomatal conductance and chlorophyll content in linear or non-linear relationships. Table 1 shows the average stomatal conductance and leaf chlorophyll content for the 40 wheat germplasms and wheat varieties and their ranks according to an index value. The index value was estimated from the weighted average of 40, 30, and 30% from the 1st, 2nd, and 3rd measurement. The heavier weight was assigned to the first measurement on May 15 because young wheat was more vulnerable to WL stress than those more matured. Stomatal conductance represents crop in response to excess water, while chlorophyll content indicates the crop growth in response to excess water induced lack of nutrient supply. Therefore, combining the two measureable parameters and ranking them together, the top 10 ranked germplasms and varieties to WL stress are XWC12-2, XWC12-4, Faller, XWC13-109, Glenn, XC04A-1030, XWC11-65, Prosper, XWC12-6, and XWC12-1.

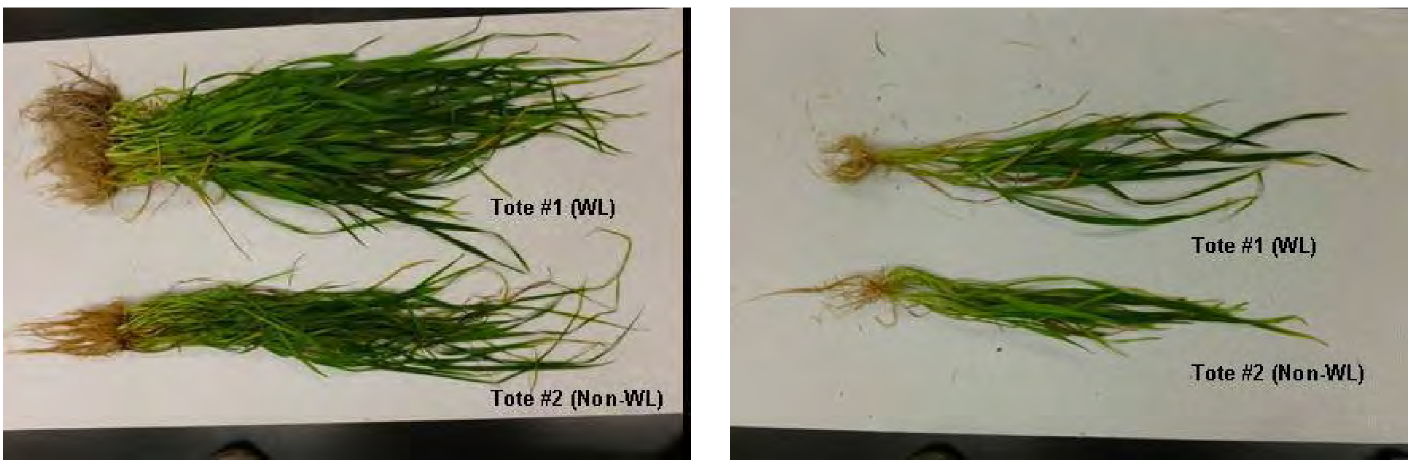

Figure 1. Comparison of wheat growth difference between waterlogged (WL) and non-waterlogged (Non-WL) plants with sufficient nitrogen fertilizer application.

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Table 1. Comparison and rank of wheat germplasm and variety based on stomatal conductance and leaf chlorophyll.

Entry	Stomatal Conductance (mmol/m²/s)					Entry	Chlorophyll (SPAD unit)				
	5/15	6/5	6/23	Index	Rank		5/15	6/5	6/23	Index	Rank
XWC12-4	410	326	371	373	1	XWC12-2	36	42	22	34	1
XWC12-2	206	672	132	324	2	XWC13-109	44	26	22	32	2
Faller	381	495	49	316	3	XWC12-4	46	25	17	31	3
Alsen	610	120	45	293	4	XWC12-8	35	28	24	30	4
XWC12-6	315	245	306	291	5	XWC11-003	30	26	29	29	5
XWC11-65	480	125	166	279	6	Faller	35	27	21	28	6
Prosper	371	248	166	273	7	Glenn	30	23	24	26	7
XC04A-1030	266	242	261	257	8	Barlow	35	23	14	25	8
Glenn	333	98	247	237	9	XC04A-1030	32	20	21	25	9
XWC11-002	411	127	106	234	10	XWC11-69	36	16	19	25	10
XWC11-63	80	187	470	229	11	XWC12-1	37	27	6	25	11
XWC13-109	243	236	183	223	12	XWC11-65	32	13	25	24	12
XC02B-121	209	121	335	220	13	XC02B-130	35	21	12	24	13
XWC11-67	326	173	116	217	14	Prosper	26	30	16	24	14
XWC12-1	276	235	79	205	15	XC02B-121	35	11	20	23	15
XWC11-68	372	91	83	201	16	XWC11-008	37	5	19	22	16
XC02B-130	265	97	206	197	17	XC02B-120	26	18	20	22	17
XWC11-005	295	115	148	197	18	XWC12-6	31	13	19	22	18
XWC11-007	278	202	56	189	19	XWC11-68	36	11	14	22	19
XWC11-004	285	72	176	188	20	XWC11-72	29	12	21	22	20
XC02B-116	237	219	90	188	21	XWC12-9	26	13	22	21	21
XWC12-8	186	228	137	184	22	CS	29	17	15	21	22
XWC11-59	271	133	104	180	23	XWC12-7	30	11	19	21	23
XWC12-5	286	168	41	177	24	XWC12-3	32	14	12	21	24
Barlow	207	133	168	173	25	XWC11-002	30	14	14	20	25
XWC11-72	246	102	138	170	26	XWC11-63	26	14	19	20	26
XWC12-7	208	102	173	166	27	XWC11-75	28	16	14	20	27
XWC12-3	187	200	93	163	28	XC02B-116	29	13	15	20	28
XC02B-126	213	170	67	156	29	XWC11-59	31	13	11	20	29
XC02B-120	138	230	100	154	30	XWC11-61	27	11	18	19	30
XWC11-75	176	123	151	153	31	XWC11-006	30	14	9	19	31
XWC11-69	165	85	162	140	32	XWC12-5	28	14	12	19	32
XWC11-62	126	185	109	139	33	XC02B-115	32	9	12	19	33
XWC11-008	95	32	295	136	34	XWC11-004	27	11	16	19	34
CS	81	209	120	131	35	XWC11-67	25	18	12	19	35
XWC11-61	139	97	140	127	36	XWC11-62	26	16	10	18	36
XC02B-115	161	92	93	120	37	Alsen	23	20	10	18	37
XWC12-9	146	80	108	115	38	XWC11-007	28	13	9	18	38
XWC11-006	143	78	67	101	39	XC02B-126	26	15	10	18	39
XWC11-003	104	50	33	66	40	XWC11-005	23	11	17	18	40

Application/Use

The primary drive force for this project is to help collaborator Cai's research group to speed up their germplasm selection process and improve wheat waterlogging tolerance by introducing genes from wild species into the wheat genome. The experimental results were applied by the group immediately in their follow-up research. The performance of five wheat varieties provided useful and immediate information to local production farmers when choosing appropriate varieties in their 2015 spring season. Instead of focusing on crop yield only, if the fall soil moisture is high, and field has poor drainage, three varieties, Faller, Glenn, and Prosper, showed better growth and higher tolerance to waterlogging conditions.

Material and Methods

The two experiments were conducted in two large growth chambers, located at the Plant Sciences Department, North Dakota State University with automatic light, temperature, and relative humidity control. In each chamber, three totes, each with 40 growth cones in two racks, were setup side by side, but each tote had its own individual water control device that was located near the edge of the chamber. A split random design experiment was performed in each tote, which resulted in two treatments (WL and Non-WL) and three replicates. A total of 240 growth cones, each planted with three wheat seeds, were used in each experiment. Water level was automatically controlled by a constant head device, and crop water consumption was measured by an automatic ET-gage. Pictures were taken 2-3 times per week to monitor wheat response to water. Stomatal conductance was measured by SC-1 Leaf Porometer and leaf chlorophyll content was measured by SPAD-502DL Plus Chlorophyll Meter three times in the season. Due to large number of plants and small space in the growth chamber, each measurement took 1-2 days for two persons to accomplish. All wheat germplasm materials were provided by Cai. Wheat varieties were supplied by the Plant Sciences Department. Lab experiments on seed survival rate under waterlogging conditions are current in progress.

Economic Benefit to a Typical
500 Acre Wheat Enterprise

Comparing spring wheat yield in 2011 and 2012, the yield difference was 10 bu/ac for the northwest region of Minnesota. The difference was probably mainly caused by excess moisture conditions in 2011. Using $7/bu current wheat price as a starting point, the economic benefit to a typical 500 acre wheat enterprise is $35, 000 when maintaining all other conditions the same.

Related Research

Cai's group is working on alien gene introgression for waterlogging tolerance from wild species into wheat. This research has provided significant information to develop an efficient screening procedure of waterlogging tolerance in the alien gene introgression project and wheat breeding programs. Jia also received funds from ND State Board of Agricultural Research & Education and Wheat Commission to assess ND wheat varieties and germplasm for waterlogging tolerance. In addition, Jia's major research is on impact of drainage water management on crop yield and soil/water quality that she often observed various crop responses to waterlogging conditions in field situations. The lab and field research project provided a full picture of waterlogging stress effect on farming.

Recommended Future Research

Trait evaluation is a critical procedure for wheat germplasm and variety development. Little research has been done in the assessment of wheat's response to waterlogging conditions. This initial study has generated important information for developing an efficient waterlogging screening procedure in wheat and identified wheat genotypes with different responses to waterlogging conditions. I would like to continue this research to develop an accurate selection criterion for wheat germplasm/variety development by evaluating the response of the adaptive physiological traits to different water stress and help wheat research programs screen germplasm and breeding materials for waterlogging tolerance. I will use measureable and visible physiological traits, such as stomatal conductance, chlorophyll content, tiller number, kernels, and grain yield, to assess wheat germplasm stress tolerance under different growing stages. In addition, I will extend the project to a complete full season in a greenhouse environment in order to measure tiller number, kernels, and grain yield. Along the road, field testing of wheat waterlogging tolerance can be conducted using lysimeters in fields with drainage control.

Minnesota Small Grain Pest Survey Scouting

Doug Holen, U of M Extension Regional Office, Morris

Research Questions

The objective of this project was to allow for timely small grain crop progress and pest identification across the state of Minnesota in order to inform producers of current crop conditions and potential threats. Information was released through media (e.g. weekly radio programs, internet-based news releases, archived web pages, and e-mail). The survey was conducted in coordination with the established NDSU IPM Survey, providing extensive, continuous coverage of small grain production spanning Minnesota and North Dakota.

Results

2012: Field surveys were initiated the last week of May. Most years that would have coincided with the beginning of agronomic management decisions. However, the warm early spring accelerated crop progress and grain crops as far north as southeast North Dakota had already reached anthesis (early flower), while most fields in northwest Minnesota were in the jointing stage (see map for growth stages May 28 to June 8).

Unfortunately, the early season also saw early and significant migrations of aster leafhopper and cereal aphids. These events were prior to the start of the surveying but their presence resulted in increased incidence of BYDV/ Aster Yellows which was found later. The two pathogens express similar symptoms in wheat and barley making it difficult to distinguish them from one another in the field.

2013: Field surveying was initiated in the latter half of May and in full progress with the first of June. A very slow and delayed planting due to an extended winter and cold/ wet spring had the small grains growth significantly behind traditional calendar landmarks. A total of 43 counties were at some time samples throughout the growing season across MN. The start of season was somewhat quite from a pest standpoint with tan spot, septoria, and some cereal aphids identified throughout the state but not in economic severities. The end of season saw a lot more documentation of pests such as armyworms, scab, barley yellow dwarf, bacterial leaf blight, and rusts. Aside from the armyworms, most of the pests were at post treatment plant stages however surveying identified that scab was a larger production component than originally calculated.

It is important to understand the distinction between incidence and severity for plant pathogens when reviewing the maps. Incidence is defined as the percent of sampled plants with the pest. Severity is defined as the percent of plant material that is damaged on affected plants. Therefore, maps that report incidence are reporting percent plants affected. Severity tells us how bad infections were when identified.

2014: Field surveys were initiated the last week of May. Delayed planting conditions again resulted in most of the crop being in the initial leaf to tillering stage, however there was earlier planting of a portion of the crop and reflected in locations at the jointing stage *(see map for Growth Stages - June 9 to 20).*

The most important insect related production issues were the appearance of cereal aphids which reached threshold levels in some regions of both states.

Small grain diseases by prevalence were Tan Spot, occurring throughout the region; Bacterial Leaf Streak in SW and WC MN; *Septoria* occurring with high incidences in NW MN; Barley Yellow Dwarf incidence was found where aphids established in WC MN; and, Head Blight (scab) in SW and WC MN where wet conditions during heading contributed to higher than forecasted infections.

When reviewing the maps. ***Incidence*** is defined as "the percent of sampled plants with the disease." ***Severity*** is defined as "the percent of plant tissue that is diseased on affected plants." Therefore, maps that report incidence are reporting percent plants affected while severity tells us how bad infections were.

Efforts this year contributed significantly to the identifying Bacterial Leaf Streak statewide severity and presence in addition to varietal responses to the pathogen. The collected data has also proved valuable in explaining final yield and quality reports across the state with a better understanding of contributing factors.

Application/Use

This pest survey was developed and implemented for the early and correct identification of small grain insect and pathology pests across the state of Minnesota and to combine and report those findings with the ongoing project at North Dakota State University (NDSU). The concept builds on the efforts of year one that created a regional approach to surveying and reporting pest data to producers, researcher, consultants, and agricultural industry. The outcomes included identification of growth stages, wheat / barley BYDV, Bacterial Leaf Blight, Wheat Streak Mosiac Virus, Stripe and Leaf Rust, Fusarium Blight, Tan Spot, Septoria, Powdery Mildew, Oat Crown Rust, Ergot Wheat Stem Maggot, Cereal Aphids, Aster Leafhoppers, Armyworms

The data collected was reported weekly in print with the NDSU Pest Survey Report and Northwest Cropping Issues but was also disseminated to other researchers. The findings were represented to consultants and seed industry personnel, as well as discussed at summer plot tours. Sites included LeCenter, Mora, Benson, DeGraff, Fergus Falls, Perley, Strathcona, Hallock and the Northwest Research and Outreach field day in Crookston.

This detection and reporting system notified producers of the presence or absence of pests and the incidence and severity of the problem. With that data, producers could make educated, timely, and effective decisions leading to an economically feasible integrated pest management approach. The data collected represented pests found, but equally important was the time they were identified, as well as those not found.

Material and Methods

2012: Two pest scouts were hired to collect the needed data. Scout 1 (Jason Rogers) worked under the supervision of Jochum Wiersma with a home base of Underwood, represented production areas of Northwestern Minnesota. Scout 2 (Derrick Nelson) worked under the supervision of Doug Holen out of Fergus Falls with geographic responsibilities of West Central, Central, and Southern Minnesota. This project had oversight from faculty of the University of Minnesota St. Paul campus as well as training for job responsibilities and data reporting with NDSU. Three travel courses were mapped from each home base and traveled weekly to assure maximum geographic representation. Random fields, along with predetermined sites were sampled with data collection taking place on site with the use of notebook computer systems. Samples were collected for verification if questions persisted with findings. All data components were downloaded and forwarded to Phil Glogoza who formatted the data set and then passed it through to NDSU for reporting in their system. Generated data sets were then also forwarded to supervisors. Supervisors were in constant communications with the scouts allowing for current knowledge on findings. About 35 fields per week were sampled between the two scouts. Some fields were revisits if a pest population warranted monitoring, otherwise new sites were sought.

2013: Two pest scouts were hired to collect the needed data. Scout 1 (Drew Underdahl) worked under the supervision of Jochum Wiersma and Madeleine Smith with a home base of Crookston, surveying the production areas of Northwestern Minnesota. Scout 2 (Aaron Bengston) worked under the supervision of Doug Holen out of Fergus Falls with geographic responsibilities of West Central, Central, and Southern Minnesota. Travel and sampling objectives were to represent small grain production areas with data gathered. Both scouts sampled weekly and rotated traveled routes in regions to allow for the largest possible geographic and data representation. While the scouts randomly selected fields for sampling, some fields were targeted as concerns were brought to our attention and occasional fields revisited to monitor pest progress. Goals were to have each scout sample 15 to 20 fields per week.

2014: Two pest scouts were hired to collect the needed data. Scout 1 (Olivia Fischer) worked under the supervision of Jochum Wiersma and Madeleine Smith with a home base of Crookston, surveying the production areas of Northwestern and to some extent Central Minnesota . Scout 2 (Aaron Bengston) worked under the supervision of Doug Holen out of Fergus Falls and Phil Glogoza in Moorhead with geographic responsibilities including West Central, Central, and Southern Minnesota. Travel and sampling objectives were to represent small grain production across Minnesota. Both scouts sampled weekly and rotated traveled routes in regions to allow for the largest possible geographic representation. While the scouts randomly selected fields for sampling, some fields were targeted as concerns were brought to our attention and occasional fields revisited to monitor pest progress. Goals were to have each scout get 15 to 20 fields per week. Scouts were identifiable as University of Minnesota employees with marked vehicles and shirts.

Economic Benefit to a Typical 500 Acre Wheat Enterprise

The economic benefit was the timing and correct identification of small grain pests. With that information, producers knew what pest was present, when it was detected, at what levels, and plant growth stage it was found. Decisions could then be made as to whether or not treatment was necessary, and which products and rates were needed if thresholds were found. Equally important were decisions that pesticide applications were not economically justified due to pest populations and/or plant growth stage. As history has shown, millions of dollars have been lost due to pests such as leaf rust and fusarium head blight, as well as millions spent on pesticides in hope of controlling these and many other small grain pests. An average producer will apply fungicide one to two times per season and insecticide if needed. These efforts allowed for the timely notification of pest populations and allowing for the proper expenditure of money for pest management when and where needed. Much more insecticide was applied to small grains this season as a result of the early detection and alarming populations of aster leafhoppers across two state areas.

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Related Research *(effort)*

At this time there is no related effort in Minnesota. The Minnesota Department of Agriculture had previously performed something similar across the state for all crops. That program no longer exists. The absence of an outstate plant pathologist within the University of Minnesota Extension system also highlighted the need for such a project in the beginning. For three seasons, the project supervisors have responded to statewide pathology questions and programming. This approach saved many faculty hours by reducing the need for travel to investigate client reports while establishing and process for timely collection and representation of area-wide survey data.

There are currently multi-state surveys in collecting specific information on Bacterial Leaf Streak disease and its prevalence and race typing.

NDSU has had the pest survey system in place for many years and our goal from the beginning planning stages was to incorporate our data into their program for a stronger and regionally larger report.

With the hiring of a small grains pathologist at NWROC in Crookston, our team added a strong contributor to collecting, reporting, and making recommendations.

Recommended Future Research

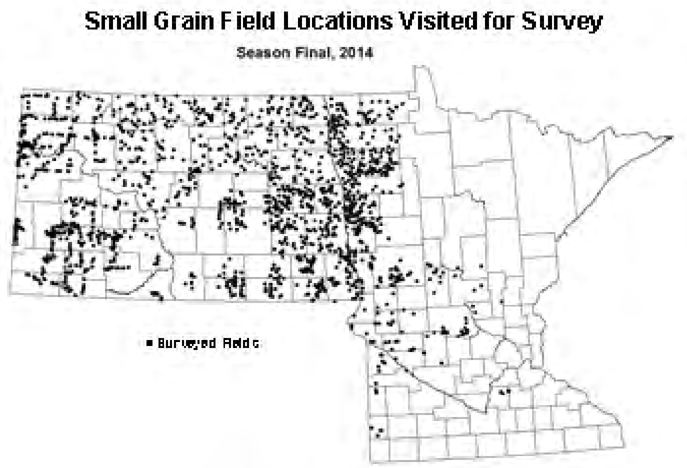
It is our belief that this surveying effort should continue and can be routinely improved upon with timely starts to the surveying season and quicker data turnaround time to the agricultural community. Discussions have taken place throughout the granting period of adding crops to the survey in tying crop production systems together over time with all pest components of rotations represented. Currently, conversations are occurring to have this effort serve as a template for expanded crop pest surveying.

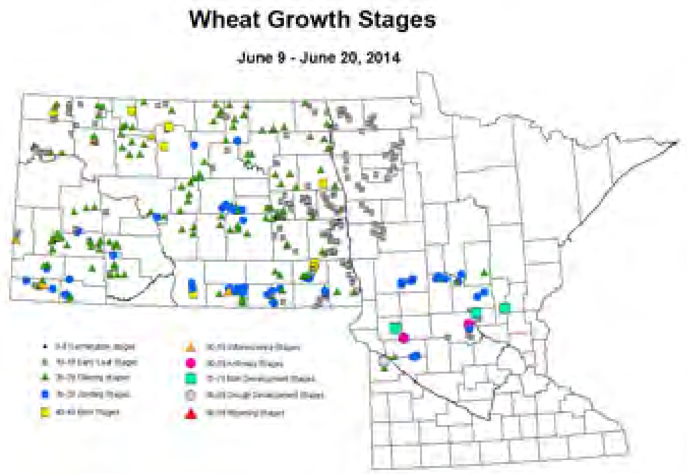
The benefits of this program include: identify the presence of regional pests in a timely fashion, save countless hours of small grain researchers time and resources in travel and communications, improve knowledge of localized pest conditions, increase visibility and perception of overall effort in small grains, establish a cooperative effort with NDSU, generate data for use by local coops, consultants, researchers, and producers.

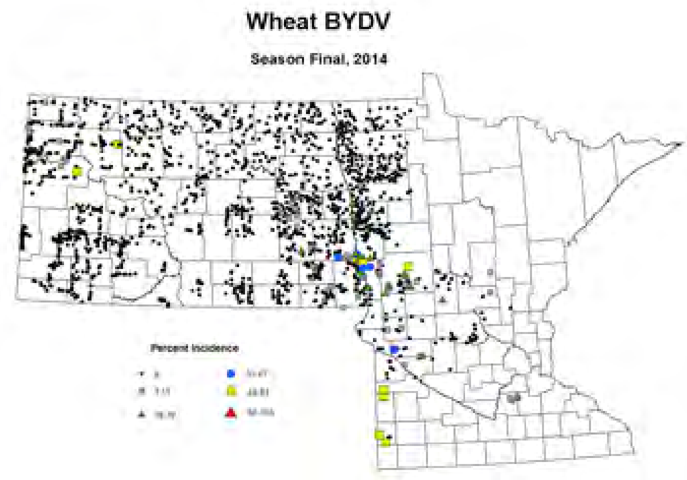
Suggestions to improve the surveying system: Daily log of data collected and dissemination; cooperate with NDSU for training and reporting; better equip the scouts to make the best use of their time; use rental vehicles; develop cards with information on where to access the data that the scouts can hand out to clientele when approached; and, better planning of travel paths for more direct routes to the most possible fields.

This effort has been successful in correctly identifying many production pests as well as areas in which pests were not present. This information was very useful in small grain field days, workshops, and producer conversations across the state.

Appendix

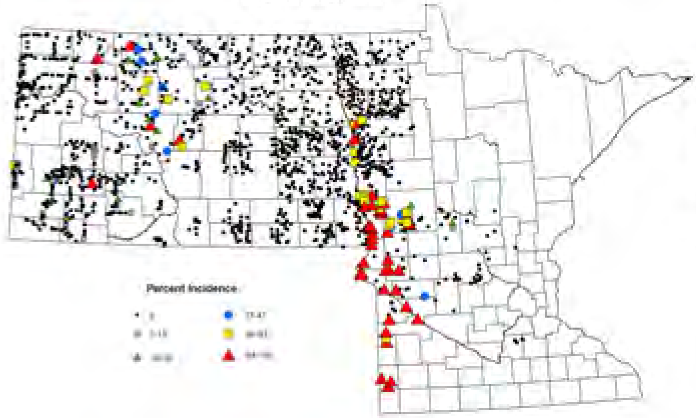






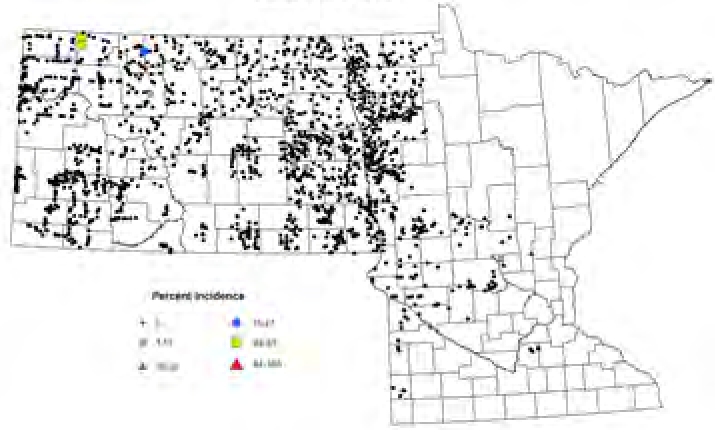
Wheat Bacterial Leaf Blight Incidence

Season Final, 2014



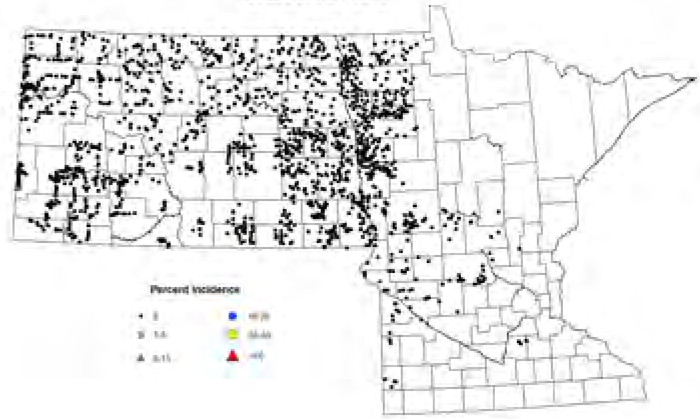
Wheat Streak Mosaic Virus

Season Final, 2014



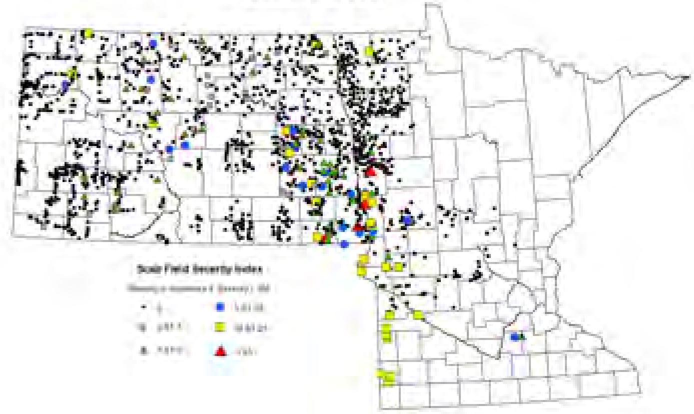
Wheat Stripe Rust Incidence

Season Final, 2014



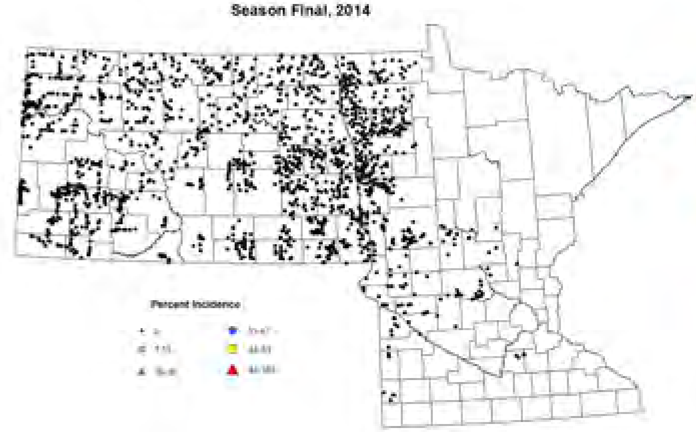
Wheat Scab Field Severity Index

Season Final, 2014



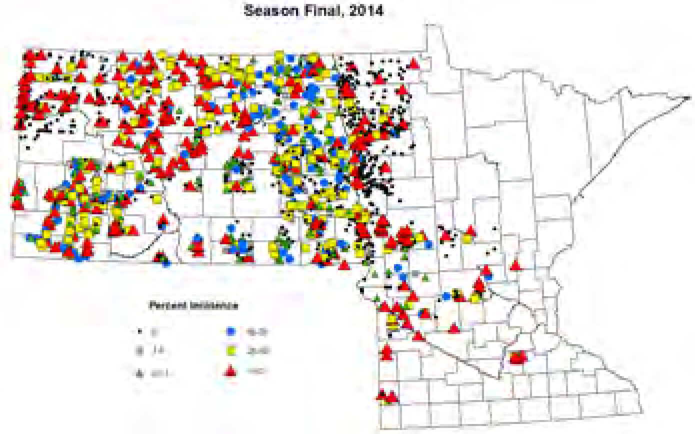
Wheat Stem Rust Incidence

Season Final, 2014



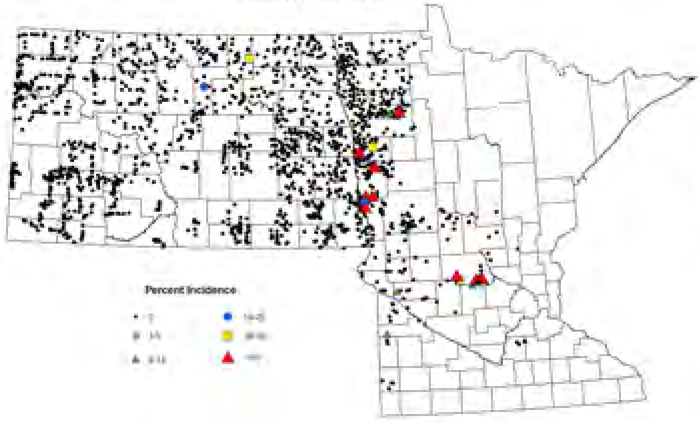
Tan Spot Percent Incidence

Season Final, 2014



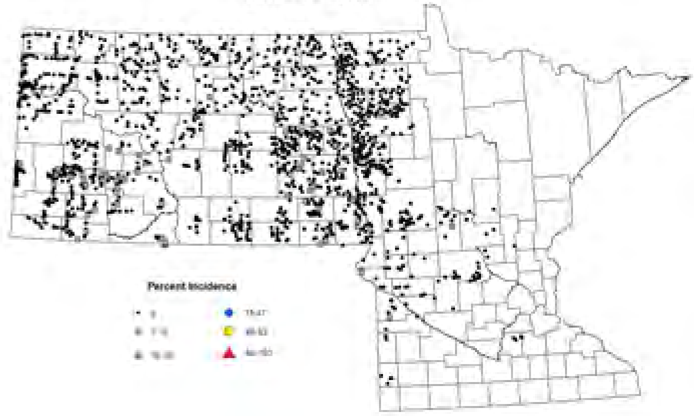
Wheat Leaf Rust Percent Incidence

Season Final, 2014



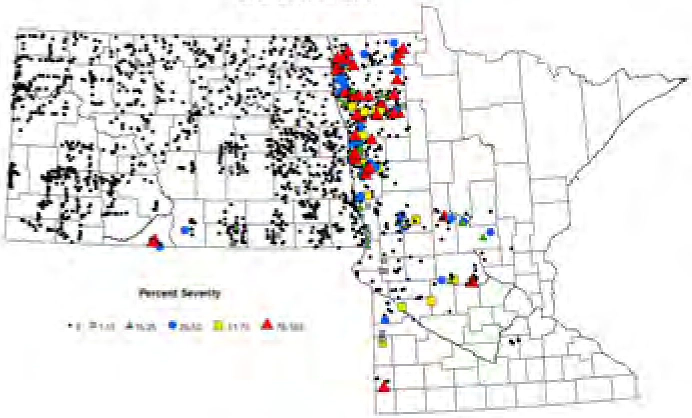
Wheat Ergot Percent Incidence

Season Final, 2014



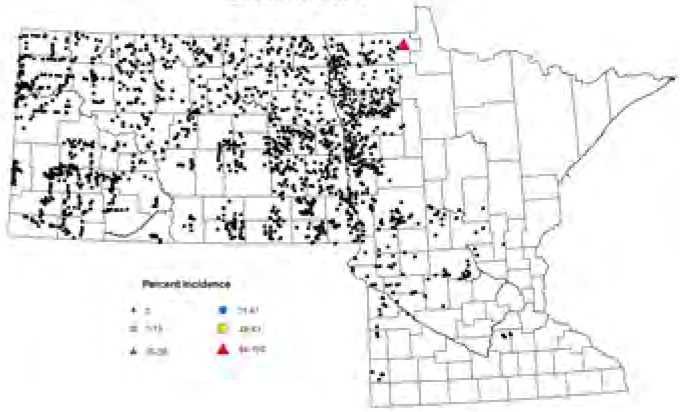
Wheat Septoria SSP Incidence

Season Final, 2014



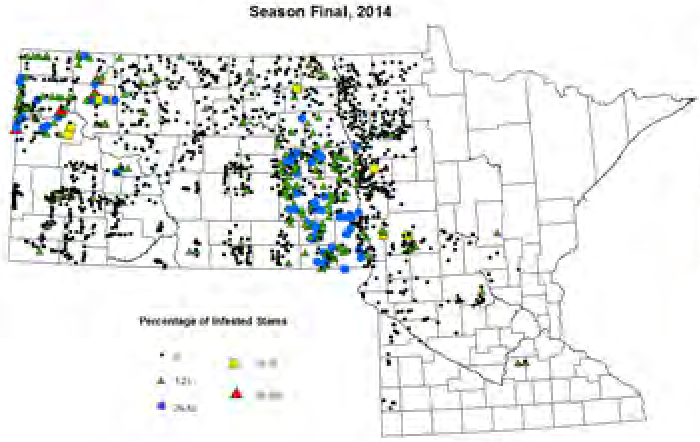
Wheat Powdery Mildew Incidence

Season Final, 2014



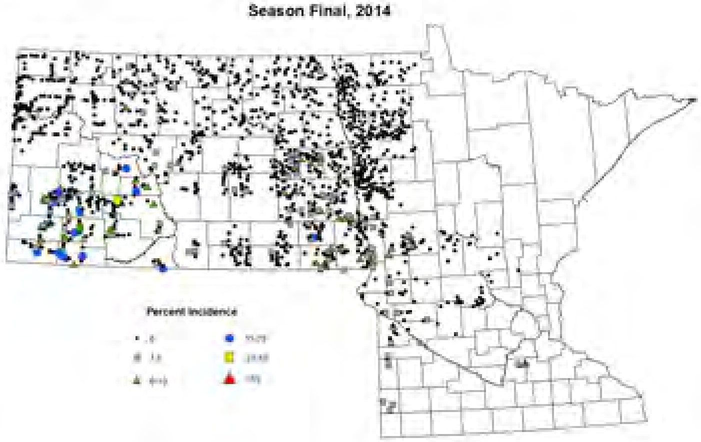
Aphids in Wheat

Season Final, 2014



Wheat Stem Maggot

Season Final, 2014



Assessing Gluten Quality - Acquisition of Front Face Fluorescence Spectrophotometer to Study Gluten Quality

Franciso Diez-Gonzalez, Dept. of Food and Nutrition, U of M, St. Paul

Research Questions

Predicting flour performance and consistency remains a challenge for processors, mainly due to the issue that the nature of interactions between the protein sub-units is different in different types of wheat. Wheat protein quality is being recognized as more important than protein quantity. In recent work in our laboratory, we showed that flour performance is in part related to the kinetics of gluten aggregation as measured by using a Glutopeak tester - a new high shear based procedure developed by Brabender. Furthermore, it has been shown that the nature of gluten aggregation is dependent on the type of protein-protein interaction – either hydrophobic interaction or disulphide interaction (Huschka et al., 2012). Front-face fluorescence is a well established technique to observe protein conformational changes in protein-based matrices during processing and to assess structural features of proteins in wheat flour dough. The acquisition of Front face fluorescence spectrophotometer is critical to analyzing the nature of interactions in wheat varieties grown in different years and locations.

Results

Fluorescence spectroscopy is a very powerful tool for studying protein structural changes in complex matrices, such as food products. The fluorescence spectrum is determined by the chemical environment of a fluorescent component (in proteins, it is usually the fluorescent amino acid tryptophan), and therefore, changes in the emission spectra of tryptophan often occur in response to conformational transitions, subunit association, substrate binding, or denaturation of the proteins present in the sample. There is a shift of the maximum of emission to higher wavelength when tryptophan moves from a hydrophobic surrounding to a hydrophilic one (e.g. from the protein interior to the aqueous media). Also fluorescence intensity can change: some molecules can work as quenchers and adsorb the emitted light (Bonomi et al., 2004).

Traditionally, fluorescence studies have been performed on clear solutions. Cereal matrices are characterized by a dominant presence of proteins - gliadins and glutelins - that cannot be brought into solution without significant alteration of their structural features. Solid-state Fluorescence (also known as front-face fluorescence) represents a useful tool for extending studies on reporter molecules to insoluble proteins in semisolid systems, such as those often found in foods.

Information about protein structural organization may be gathered also by using fluorescent dyes. One of the most popular probes is 1-anilinonaphthalene-8-sulfonate (ANS), that becomes fluorescent when interacting with a hydrophobic region, making it possible to study protein structural changes in complex systems after a specific treatment (Bonomi et al., 2004). Titration with ANS may provide information on both the number of surface hydrophobic sites and their average affinity towards the probe. Differences observed at high ANS concentration are more likely to result from changes in the number of probe binding sites, whereas changes observed at low concentrations of ANS would be an indication of changes in the affinity of hydrophobic moieties to the fluorescent probe (Bonomi et al., 2004). Previous studies demonstrated that probe concentrations around 0.2 mM at 40% moisture would be best suited for investigating the behaviour of wheat flours (Huschka et al., 2012). For this reason, in this study, a probe concentration of 0.2 mM was used.

The wavelength of maximum fluorescence emission provides information about the hydrophobic properties of the dough, as it relates to alterations in the chemical environment that surrounds hydrophobic “reporters” (amino acids residues such as tryptophan or non covalently bound probes, such as ANS in this study). In this study, the maximum intensity of ANS emission remained at 470 nm for all the samples, indicating a stable environment for the bound probe (see Figure 1).

Differences in intensity values among the samples suggest different exposure of hydrophobic sites on the protein surface (see Figure 2). In particular, low intensity suggests high hydrophobic interactions between proteins. In other words, hydrophobic regions involved in protein-protein interactions were no longer available for binding of the probe and therefore decreased fluorescence intensity was observed. The effect of the location on hydrophobic interactions in wheat doughs seems to be predominant to the effect of the year. Indeed, dough samples can be clearly distinguished into two groups: the varieties cultivated in Roseau and those cultivated in Oklee exhibited high intensity, while samples cultivated in Stephen in 2012 and 2013 were characterized by low maximum intensity values, indicating a more compact network structure as a result of either low exposure (intramolecular hydrophobic interactions) or increased intermolecular hydrophobic interactions.

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The emission fluorescence spectra in Figure 1 provide evidence for the appearance of a red-shifted shoulder in the emission fluorescence spectrum (especially for dough samples prepared from Knudson, Marshall, and Samson). Indeed, the extent of probe exposure may be inferred by the ratio of fluorescence intensity at emission wavelengths typical of each species (Caldinelli et al., 2004). The shift toward 505 nm with ANS represents a re-orientation of the probe in the hydrophobic patches of the protein from a mostly buried location to a partially exposed one, which leads to a red-shift in fluorescence. Figure 3 shows the ratio between ANS fluorescence intensities at 505 and 470 nm. This ratio provides an estimate of the "red shift" in the fluorescence emission of protein-bound ANS. In general, Knudson and Samson exhibited an important shift towards 505 nm of the fluorescence emission maximum compared to Marshall and Prosper. Depending on the variety, location and year increased or decreased the exposure of ANS but a clear trend was not observed (see Figure 3).

Finally, comparing the results obtained from ANS fluorescence and those from the Glutopeak test - a new high shear based test that measures the aggregation properties of gluten in wheat flour - a significant negative correlation between the maximum torque (that corresponds to the peak occurring as gluten aggregates) and the fluorescence intensity ($r=-0.71$; $p<0.01$) suggesting that flours with greater number of hydrophobic patches on the protein surface (great fluorescence intensity) create a weak gluten network during aggregation.

Application/Use

The approach here proposed is a rapid technique that requires small amount of sample (10 g for dough preparation; ~1g for analysis). For this reason, it can be used as a routine part of the research working with plant breeders to assess different wheat varieties. In addition, understanding the hydrophobic interactions in wheat dough complements the research capabilities and leverage synergies to both assess quality and understand the reasons for wheat variability. Moreover, the quantitation of protein hydrophobicity can be an essential step for prediction of protein functionality.

Material and Methods

Thirty-two varieties of spring wheat were grown in different locations (Roseau, Oklee, and Stephen) in 2012-2013, for a total of 128 samples were characterized using a new approach that measures the aggregation properties of wheat gluten. On the basis of the results, 4 varieties (Knudson, Marshall, Prosper, Samson) were chosen for investigating the hydrophobic interactions during dough-making.

Rearrangement of hydrophobic patches on the protein surface of selected samples were measured by spectrofluorometric technique, monitoring the chemical environment of extrinsic flourophore1,8-anisolino naphthalene sulfonate (ANS), as described by Bonomi et al. (2004). A Farinograph-AT (C.W. Brabender Inc., South Hackensack, NJ, USA) equipped with a 10 g mixing bowl was used for preparing the dough (at 30°C and 63 rpm). All the dough samples were prepared at a constant water absorption level (60%). ANS (0.2 mM) was added to the water used for making the dough. Dough samples for analyses were collected at the dough development time, corresponding to the time from first addition of water to the point of maximum consistency range. Fresh samples were pulled from the farinograph with minimal additional physical manipulation, transferred to a fluorescence cell (quartz-windowed standard surface) and analyzed within 3 min. A fluorophotometer (LS 55, Perkin Elmer, Waltham, MA, USA) was used to measure emission spectra from 400-600 nm with excitation at 390 nm.

References

Bonomi, F., Mora, G., Pagani, M. A., & Iametti, S. (2004). Probing structural features of water insoluble proteins by front-face fluorescence. Analytical Biochemistry, 329, 104–111

Caldinelli, L., Iametti, S., Barbiroli, A., Bonomi, F., Piubelli, L., Ferranti, P., et al. (2004). Unfolding intermediate in the peroxisomal flavoprotein D-amino acid oxidase. Journal of Biological Chemistry, 279, 28426–28434.

Huschka, B., Bonomi, F., Marengo, M., Miriani, M., Seetharaman, K. (2012). Comparison of lipid effects on structural features of hard and soft wheat flour proteins assessed by front-face fluorescence. Food Chemistry, 133, 1011-1016.

Related Research

Previously Dr. Seetharaman has published a study on the effect of differences in flour type relating to their protein quantity and quality on their tryptophan solvation behavior as well as their affinity for hydrophobic probes.The project is a collaboration with Dr. Jim Anderson, Wheat Breeder, University of Minnesota and used wheat varieties developed by other scientists in the region.

Recommended Future Research

- Relating gluten aggregation properties and hydrophobic interactions testing a larger number of varieties, years and locations
- Applying proteomics and thiolomics approach to understand variability in flour performance from wheats grown in different environmental conditions.

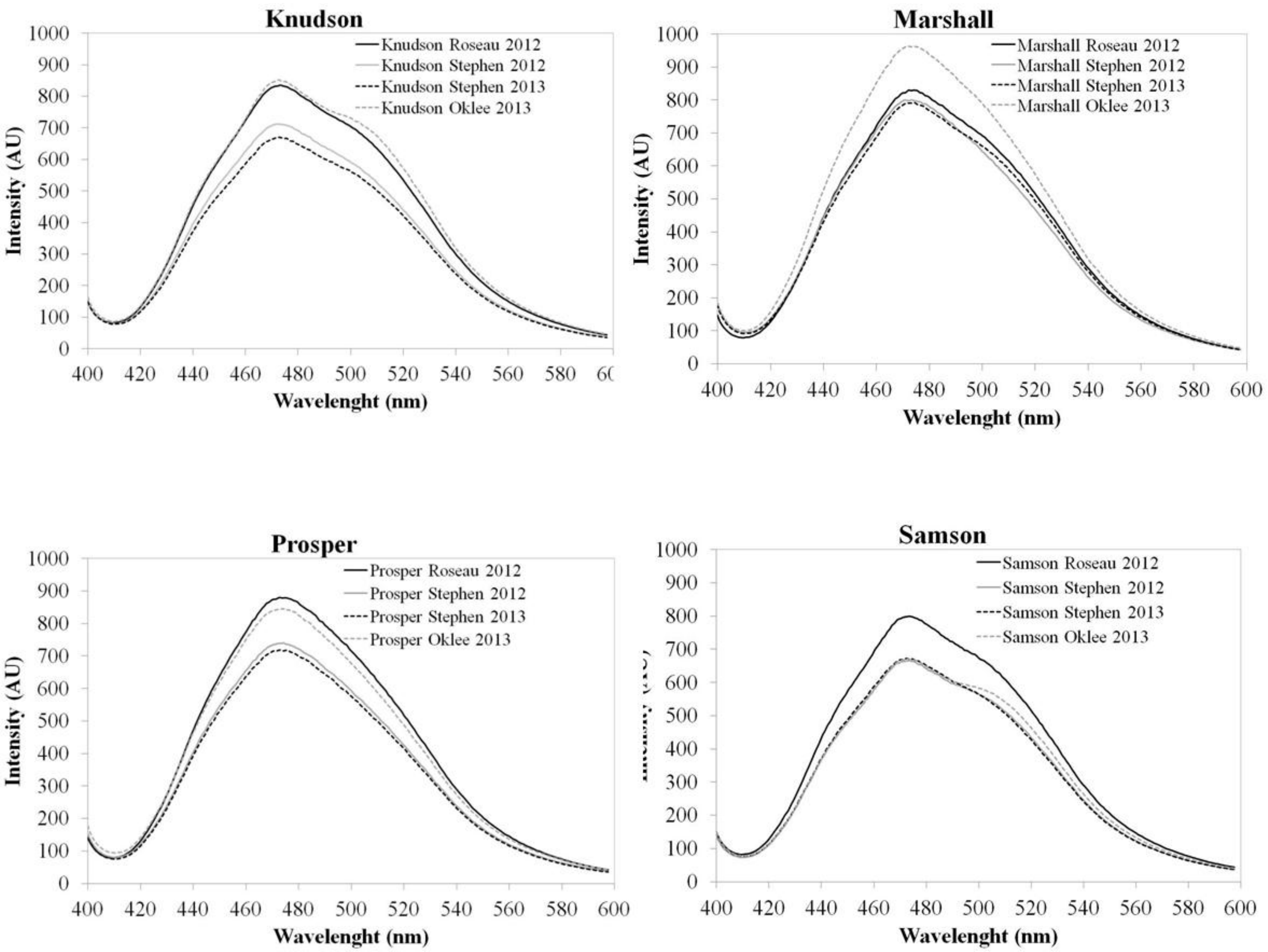

Figure 1. Fluorescence emission spectra of dough samples collected at the dough development time

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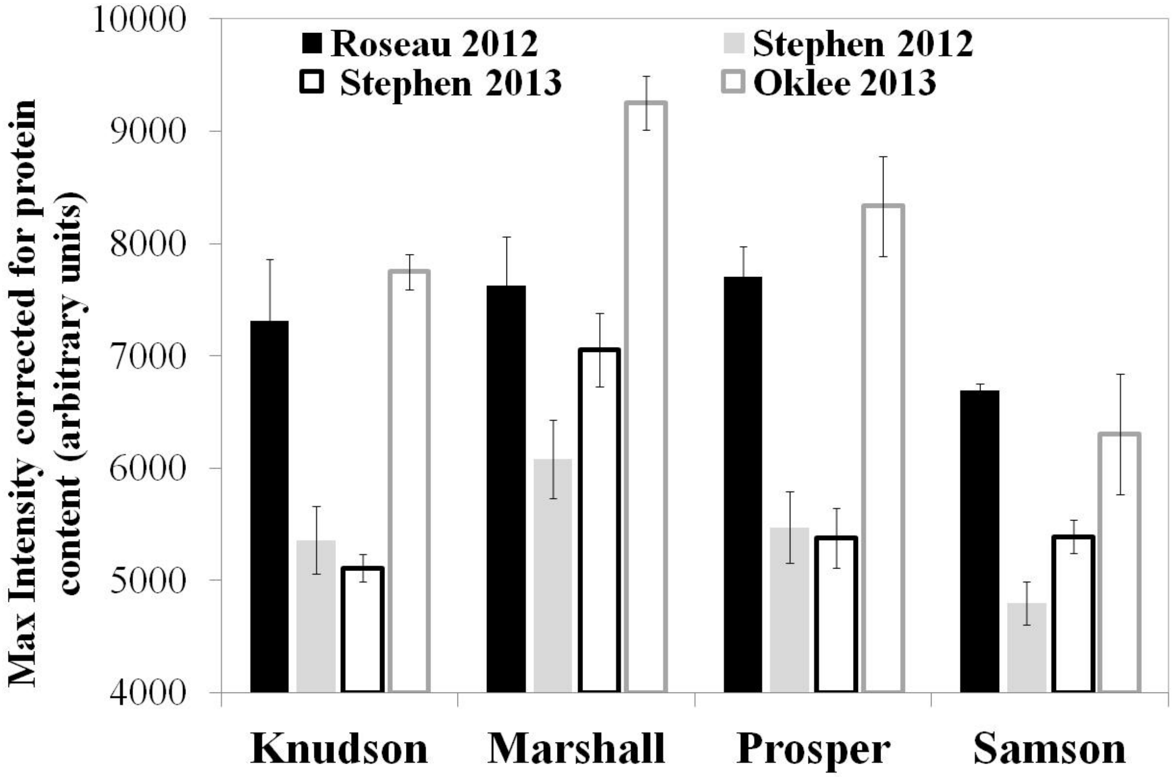

Figure 2. Fluorescence intensity of dough samples corrected for the protein content. Lower values indicate better quality.

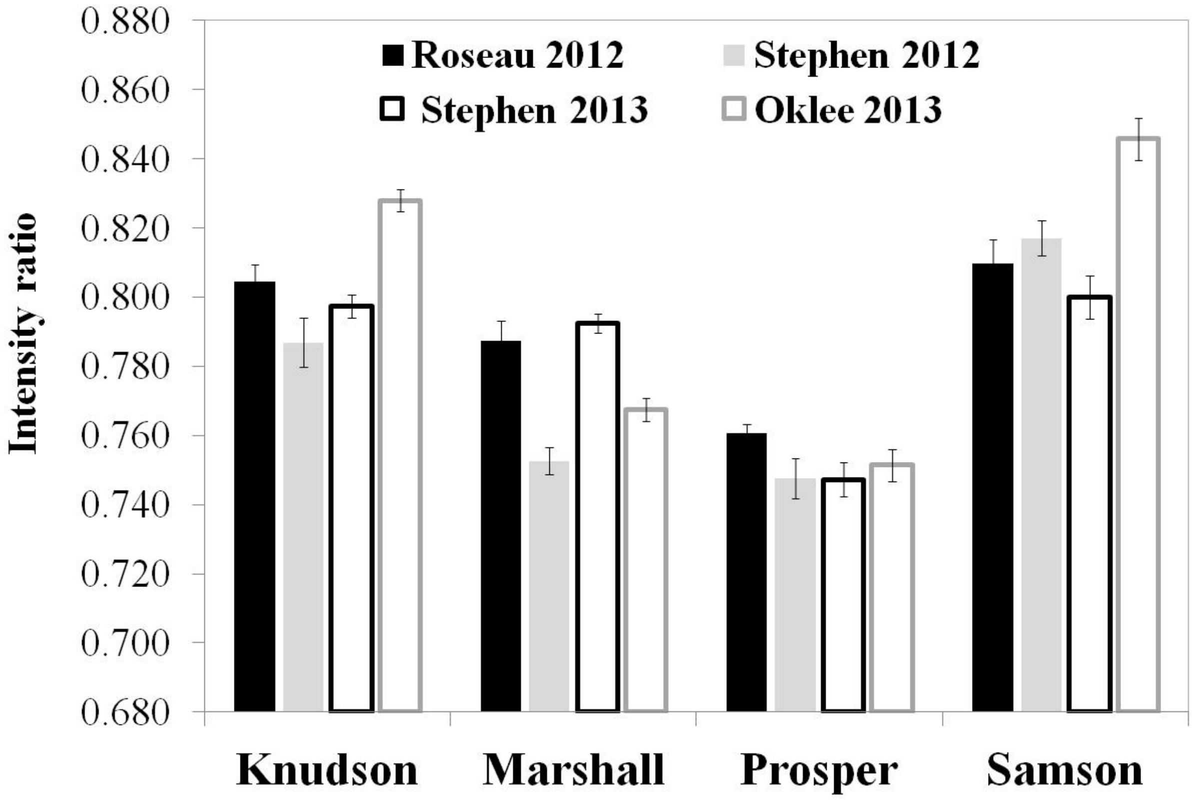

Figure 3. Ratio between ANS fluorescence emission intensities at 505 nm and 470 nm. Higher values indicate better quality.

Seed Treatment Trial Evaluating the Effectiveness of Different Active Ingredients Against Latent Root Rot and Crown Rots of Wheat

Madeleine Smith, Northwest Research and Outreach Center, Crookston

Research Questions

- To determine the relative efficacy of different active ingredients for control of root rot diseases

- To develop best management practices for the use of seed treatments for spring wheat production in Minnesota

Results

In 2013 across all locations, no significant differences were detected in stand counts, plant heights, biomass or grain yield either between treatments or compared to the untreated control. In 2014, again no differences were detected for grain yield either between treatments or compared to the untreated control, except in the trials near Fergus Falls and Benson. In the Fergus Falls trial tebuconazole reduced grain yield compared to the untreated control (p=0.005). In the trial near Benson Raxil MD increased yield compared to the untreated control (P=0.015). This increase in grain yield was likely the result of a higher initial stand observed with Raxil MD when compared to the control (P= 0.014).

No late season symptoms were observed in plots at any of the sites in 2013 or 2014. Preliminary data from the fungal isolations made on mature crowns and roots suggests however that several fungal species, including Fusarium spp. can readily be found. Fungal isolations will continue through the winter months and this data will be analyzed to see if there are any differences in the fungal populations evident between treatments.

The preliminary results from this study suggest that seed treatments will not be needed indiscriminately for the protection of initial stand. The decision to use a seed treatment therefore will continue to be a function of the condition of the seed lot and whether loose smut or other seed born disease require control and/or the field history. In only 1 out of 8 environments across the past two years did one of the seed treatments result in a better initial stand compared to the untreated control. In addition, the preliminary data from the fungal isolations clearly show that, whilst we might be able to protect the germinating seed and therefore the initial stand establishment, mature plants are still susceptible to late-season infections. These data suggest that seed treatments are not efficacious throughout the whole growing season. Being able to control and/or reduce infections past the window of efficacy of the seed treatments is an important factor in years when plants are at risk of drought stress. These infected root systems are compromised and are less efficient at taking up water and nutrients. Therefore, rather than relying on seed treatments, genetic resistance to crown and root rot may provide better all-round disease control with less economic risk compared to a seed treatment.

Application/Use

Several fungal species are known to attack wheat seedlings which can result in seedling blights causing poor initial stand establishment. These include fungi such as *Pythium* spp., *Fusarium* spp., *Rhizoctonia*, and *Bipolaris sorokiniana*. In order to combat this, many crop protection companies have developed seed treatments which aim to combat these diseases and improve seedling vigor. This has led to their wide adoption in wheat growing regions around the world. However, there is little evidence in the scientific literature to demonstrate the efficacy of seed treatments against different fungi and the cost benefit of using these treatments to the grower each year.

Trying to understand which fungicide treatments give the best control of root diseases and the environmental factors which put stand establishment at the most risk, allow growers to only pay for seed treatments when they are likely to provide a benefit to the crop

Material and Methods

In 2013 and 2014 trials were located at four on-farm locations around the state of Minnesota. In 2013 sites were located at Strathcona, Crookston, Fergus Falls and Kimball. In 2014 The same locations were used except that the southern location was moved from Kimball to Benson. A randomized complete block design with 5 replicates was set up at each location. Plots were 5ft x 15 ft.

The seed treatments (listed in table 1 in the appendix) were applied to seed using a Hegi small-batch seed treater to coat seed. The rate of the product applied was selected according to labelling regulations. Treatments were selected on the basis of utilizing a range of different fungicides with different modes of action, and selecting both products which combine different fungicides as well as having individual active ingredients represented.

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Stand counts were made at the 2 leaf stage by counting the number of plants in a one foot section of row three times at randomly located sections of each plot to obtain an average. Plant heights were measured from the base of the plant to the top of the highest leaf at physiological maturity from 6 plants each plot representative of the average height in the plot. Biomass was measured by collecting and weighing the aerial parts of plants removed from three one foot sections in each plot after drying in a drying oven to remove moisture.

Economic Benefit to a Typical 500 Acre Wheat Enterprise

Indiscriminate use of seed treatments provides no economic benefit to a wheat enterprise whilst it increases the cost of production by $4.- to $12.- per acre. The decision to use a seed treatment therefore will continue to be a function of the condition of the seed lot and whether loose smut or other seed-born disease requires control and/or the field history. In only 1 out of 8 environments across the past two years did one of the seed treatments result in a better initial stand compared to the untreated control.

Related Research

The seed treatment trials conducted in Minnesota these past two years were also carried out by Pravin Gautam at North Dakota State University this past season as part of the Upper Great Plains Wheat pathology collaboration (UGPWPC).

Recommended Future Research

It is imperative that we set up a disease nursery with high inoculum pressure to continue testing the efficacy of seed treatment but also to allow us to assess the level of resistance to these pathogens in released varieties and breeding lines. Initial steps are already underway at the Northwest Research and Outreach to develop field inoculation methods for root rot diseases. The results in 2014 suggest that producing good disease pressure for crown rot is possible in a field situation and this work will continue in 2015. In these disease nurseries we will carefully monitor soil temperatures and other environmental conditions to allow correlation with disease development.

Appendix

Table 1. Fungicidal Seed Treatments Used in Trials

Treatment	a.i	conc. (%)	amount (g a.i/lb)	a.i	conc. (%)	amount (g a.i/lb)	a.i	conc. (%)	amount (g a.i/lb)
Control									
Charter HL				triticonazole	50	0.023			
Stamina	pyrachlostrobin	18.4	0.022						
Stamina F3	pyrachlostrobin	1.59	0.022	triticonazole	1.59	0.022	metalaxyl	0.93	0.013
Dyna Shield							metalaxyl	28.35	0.063
Dyna Shield (reduced)							metalaxyl	28.35	0.010
Raxil MD				tebuconazole	0.48	0.007	metalaxyl	0.64	0.009
Raxil MD Extra	imazalil	1	0.015	tebuconazole	0.43	0.006	metalaxyl	0.58	0.009
Tebuconazole				tebuconazole	0.48	0.007			
Vibrance Extreme	sedaxane	1.22	0.010	difenoconazole	5.86	0.049	mefenoxam	1.46	0.012
Vibrance	sedaxane	45.45	0.011						
Systiva	fluxapyroxad	32	0.022						
Evergol Energy [1]	Prothioconazole	7.18	0.023	Penflufen	3.59	0.012	Metalaxyl	83.49	0.272

[1] Only used in the 2014 trials

Continuing Breeding Adapted Spring Wheat Cultivars to Better Serve Minnesota Wheat Growers

Mohamed Mergoum, Dept. of Plant Sciences, NDSU

Introduction:

Historically, the wheat breeding programs at the public universities in the spring wheat region which include MN, ND, MT, and SD have played a major role in the wheat production by releasing well adapted and very competitive wheat cultivars. Among these wheat breeding programs, NDSU is well recognized for its well adapted and high quality germplasm and cultivars. While our goal is to maintain that hallmark germplasm/cultivars, more emphasis was made recently, in developing high yielding cultivars to meet our growers demand, particularly in the high inputs regions of the Western MN and Eastern ND regions. By combining NDSU resources and the support from the Minnesota Wheat Research and Promotion Council (MNWRPC), our efforts have bared fruits in 2007 when spring wheat cultivar 'Faller' was released by NDSU. Faller has been a major cultivar in the region. It has been the leading cultivar in MN from 2009 to 2012 and the second leading cultivar in ND from 2009 to 2013. Faller was truly, the first variety that combines high yield potential with relatively good quality attributes, challenging all other high yielding cultivars released by other breeding programs in the spring wheat region. Just two years after its release, Faller became the leading cultivar in MN in 2009. At a time, 30% of MN total wheat acreages were grown to Faller. In 2013, Faller was still grown on 17.27%, second only to the other NDSU cultivar 'Prosper' released jointly with the University of MN in 2011. Prosper was released to enhance the wheat production and improve incomes of wheat growers in MN and ND as did Faller. Indeed, just like Faller, Prosper, after just two years of its release, become the leading cultivar in MN in 2013. In 2014, Faller was planted on 20.7% of total MN wheat acreages followed by Faller with 13.5%. Combined together, the MN wheat acreage grown to both Faller and Prosper surpassed 35% in 2014. Demand for new adapted cultivars to the MN environments which combine high yield and good and "marketable" quality traits such as grain protein are needed and continues to be a major challenge to the wheat breeding programs. The MNWRPC is well aware of this important research and breeding components and appreciate the impact of new adapted cultivars on the MN wheat growers and the wheat industry. Therefore, the MNWRPC has funded this project since 2011. <u>Continuing support by the MNWPRC to our program will allow us to continue our efforts to release adapted cultivars to the MN wheat growers.</u>

Objectives

This project aims to continue developing superior spring wheat cultivars targeted to MN, particularly the Western wheat growing environments. These cultivars should possess the following traits:

- High yield potential.
- Good quality characteristics which allow premiums for wheat growers and sustainable competition on the international market. These traits include mainly protein content, milling and baking characteristics.
- High levels of resistances to dominant diseases such as leaf diseases including leaf and stem rusts, a continuous threat to wheat.
- Good resistance to Fusarium head blight (Scab), still a major disease for wheat in MN and the region.
- Resistance to leaf spotting diseases and bacterial leaf diseases that can be devastating in some years.

Research Activities and Prodecures

The funds provided by this project were used to expand our final testing of elite HRSW germplasm developed by our program to an additional two locations in the Western MN (Red River Valley) where wheat is dominant. These two locations were Alvarado and Wolverton, MN. Agronomic data including diseases reactions were collected on these advanced yield trials conducted in 2014 at the two MN locations and three other ND testing locations in the Red River Valley (Casselton, Prosper, and Langdon, ND). Unfortunately, in 2014, excess of rain has caused floods at the Wolverton site, which was lost. Therefore, only data from Alavardo site will be presented for 2014 research activities in MN. Currently, seed from this trial are being processed to be send to the quality lab to generate quality performance including grain characteristics, milling and baking data. These data are critical for selecting elite adapted lines further testing or potential cultivars release. In the years spanning this project, several research activities have been conducted by the NDSU spring wheat breeding program in order to achieve this goal. Although these activities have a multidisciplinary character, the wheat breeding program did coordinate them to make sure that the objectives of the project are being addressed efficiently and timely. Among these research activities we can list the following activities:

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1. Crosses and populations development:
About 200 new crosses were specifically made in 2014 to incorporate traits of economic values for wheat growers and industry in the Western MN and Eastern ND into our adapted germplasm. These crosses involved parental lines among the most grown cultivars and elite genotypes adapted to MN environments. These crosses were conducted in the Fall and Spring in greenhouse cycles. The F_1's generated by these crosses were (for the crosses made in Fall)/will (for crosses made in Spring) be planted in the greenhouse to generate the F_2 populations. The F_2 segregating populations generated from the F_1's are usually planted in field each summer. Breeding cycles have now progressed such that many of the new adapted parents have diseases (leaf diseases, FHB…etc.) resistances, high yield potential and quality. The key is to combine these important traits in one genotype. About 100-200 spikes are selected from the most promising F_2 population to be advanced for further generations' advancement and selections. Subsequently, five to 10 spikes from each selected F_3 lines are threshed and shipped to New Zealand or Arizona as head-rows for generation advancement and selection for some agronomic traits (lodging, height, maturity, shattering, and other plant type). Similar procedures is followed to advance and select this germplasm in further segregating generations until most genes are homozygous for desirable traits.

2. Diseases evaluation/screening:
Geramplasm planted in the field were subjected to screening for prevalent diseases in the field. In addition, rusts and Scab screening nurseries are installed in many locations including Prosper, Carrington, and Langdon, ND. Screening of elite material is also done in the greenhouse as well as by our colleagues in Dept. of Plant Pathology. These nurseries provide field screening for leaf diseases, FHB, bacterial blight,..etc resistances of germplasm coming from targeted segregating generations as well as advanced/ elite lines. In 2014, F_2 and following generations were screened for most prevalent diseases in the field and in the FHB screening nursery. Among the diseases screened for in the field, leaf diseases (rusts, and leaf spotting diseases), FHB, bacteria and insects (in some years) are the main stresses that are our breeding program is facing. Therefore, all breeding material planted in the jor ones. In addition to the filed screening, the advanced material is subjected to more scrutinized screening for rusts and FHB in specific diseases nurseries. These additional nurseries are installed in Fargo, Prosper, Carrington, and Langdon, ND. Furthermore, screening of elite material is also done in the greenhouse with emphasis on the new leaf rust race that has overcome the *Lr21* gene. This major gene has been used widely for decades to protect our germaplsm against leaf rust in the region. Among the cultivars that have this gene are Faller and Prosper. Fortunately, many other cultivars and germaplsm carry other genes that protect against this new race. In general, we screen the germaplsm included in the yield trials for the new race under filed condition.

3. Early generations and preliminary and intermediate yield trials evaluation/testing:
In 2014, the breeding program evaluated about 200 F_2 populations and 16,000 of F_3 and F_4 generations that were designed for the Eastern ND and Western MN. Similarly, about 1400, and 550 F_5 and F_6/F_7 lines were evaluated for disease resistances and agronomic traits in the preliminary yield trials (PYT) and intermediate trials (IYT), respectively. PYTs were conducted in non-replicated plots while IYTs have two replicates in randomized bloc design. Agronomic and disease notes were taken from the field and seed of these entries were evaluated for some quality traits in the laboratory (Dr S. Simsek). These lines were be advanced either to IYT (from PYT) or advanced yield trials (AYT) following cycle.

4. Screening and evaluation of advanced and elites lines:

a. MN Testing sites

As in past few years, with the support of the MNWRPC, the advanced yield trial including 75 lines and checks selected from previous yield trials was installed at two <u>extra locations in Western MN in 2014 as it we did in the previous 3 years.</u> The two locations were Wolverton (Southwest MN) and Alvarado (Northwest MN). These two locations are relatively contrasting sites of the Red River Valley where spring wheat is a major crop. These trials were conducted in randomized bloc design with 4 replicates.

b. ND Testing:

The same yield trial conducted in MN sites was tested in 2014 in several locations across ND with three locations in the Red River Valley. These locations are Casselton, Prosper and Langdon. The other yield trials including PYT, IYT, and AYTs were conducted in many sites in the Eastern parts of ND. Number of replicates and experimental design of these trials are similar to those conducted in MN.

5. Quality Evaluation:
Samples from plot for the 2014 elite yield trials installed at MN and ND and all other yield trials are sent to our quality laboratory for quality tests. Data on grain characteristics, milling, and dough and baking attributes will be generated for genotypes included in these trials. These data generated each year, are combined with the agronomic performance had allowed us to make decision whether we need further testing, seed increase, or discard lines. Lines for potential release are also included in these trials and data helped us making decision for final decision. This was certainly, the case of Faller, Prosper, and the 2013 released cultivar Elgin-ND.

6. Markers Assisted Selection (MAS):
The use of MAS based on known molecular markers for some quality and disease resistance traits is conducted in collaboration with the Genotyping Center at the USDA-

ARS at Fargo (Dr. Chao Lab.). As in the past, in 2014, DNA samples from about 1500 lines included in the yield trials will be sent to the USDA_ARS Fargo genotyping Center to determine the presence/absence of selected molecular marker in these lines. Particularly, molecular markers for FHB resistance located on chromosome 3BS (Sumai3), leaf diseases, grain protein content,…etc, will be utilized in the screening. The use of these markers is helpful in indicating the absence/presence of the genes of interest. This also helps us in planning our crosses to start combining and pyramiding different genes for some traits including FHB, and rusts.

7. Uniform Regional Nurseries (URN):
In 2014, the “traditional” URN was re-lunched again. The URN replaced the “Tri-state Cooperative Trial” (TCT) which included elite material from the three public (ND, MN, and SD) spring wheat breeding programs only and which was established for the first time in 2011. This trial was established to replace the URN that was historically conducted in the spring wheat region.

The 2014 URN included 31 genotypes (25 lines and 6 checks) from divers breeding programs. Our breeding program included five lines in these trials. The URN were conducted in five locations in ND including the Red river Valley at Prosper and Langdon.

Main Results

The weather conditions in 2014 were yet unusual. Due to heavy rains, the Woleverton location was flooded, therefore we lost it. Alavarado however, was overall good except for some lodging that occurred as a results of heavy rains that prevailed late in the season. Therefore, in this report only agronomic data collected at Alavarado are reported. Seed form this location along with other ND locations are being processed to be sent to the quality lab. for further analysis and generating data on milling and baking performance.

As in the past, the data on yield and other major agronomic and quality traits collected across both MN and ND locations during the advanced generations testing are vital for making decision for releasing cultivars or advancing elite germplasm for further testing. Grain yield is considered the top choice trait by growers for cultivar selection in the MN and eastern ND regions. Quality, particularly protein is also considered when choosing cultivars by growers. In this report, for the above reasons and because the quality data are not ready, we focus mainly on grain yield of lines grown in 2014. Hence, the yield data for the MN site ALavarado are represented in Figure 1 for 2014; and Figures 2 and 3 for 2013 (also reported in 2013 report). Yields levels at Alvarado were relatively high in both 2014 (Figure 1) and 2013 (Figure 2) seasons compared to those obtained at Wolverton (Figure 3) (2013 only). The overall average yield at Alvarado in 2014 was 61.6 bu/ac and the highest performing genotype was Faller with 76.8 bu/ac. Among the non-released lines, two had high yield, similar Faller, with higher test weight for one line. Quality data will reveal if the high yielding lines have better quality performance than Faller and Prosper.

In 2013, yields levels (Figures 2 and 3) –as reported in 2013 report- achieved at MN locations were high, particularly at Alavarado (Figures 2). This reflects the record yield achieved overall in the State of MN. The average yield trial was 88.3 and 57.3 at Alvarado and Wolverton, respectively. Faller was the highest yielding cultivar in both locations reaching the maximum yield levels of 100.1 and 79.6 bu/ac, followed by Prosper with 99.6 and 77.8 bu/ac at Alvarado and Woleverton, respectively (Figures 2 and 3). In the same trials, 27and 15 lines had yields between 91 1nd 100 bu/ac at Alvarado and more than 71 bu/ac at Wolverton. The yields of the recently released cultivar “Elgin-ND” across Alvarado and Wolverton were 96 and 74.5 bu/ac, respectively (Figures 2 and 3).

Major Achievements

Elite yield trials conducted since 2011 at MN and eastern ND generated valuable data for our breeding program. In 2014, samples from these trials will be analyzed for quality performance at the NDSU quality lab. and DNA samples from these genotypes will be sent to the USDA-ARS lab to be diagnosed for several molecular markers. The data generated from these trial allow us to identify potential lines for release or to advance for further testing in the future.

With the funding from the MNWRPC -which started even prior to 2011- our breeding program developed several cultivars that have contributed significantly to the MN wheat growers’ income. Among these cultivars, Faller, Prosper and recently Elgin-ND are millstones in our breeding program.

- **Elgin-ND:** This is the most recent released (2013) cultivar of our breeding program. Elgin-ND, in general has much higher yield than all other cultivars except Faller and Prosper. While Elgin-ND’ yield over many years is close to Faller yield, its protein level is significantly higher than both Faller and Prosper. The yields of Elgin-ND at Alavarado in 2014 was 66 bu/ac compared to 76.8 and 73.3 bu/ac for Faller and Prosper, respectively (Figure 1). Similarly, in 2013, Elgin-ND yields were also high (96 and 74.5 bu/ac) compared to Faller (100.1 and 79.6 bu/ac) and Prosper (99.6 and 77.8 bu/ac) at Alvarado and Woleverton, respectively (Figures 2 and 3). In 2012, across Alvarado and Wolverton, Elgin yields were respectively, 69.8 and 66 bu/ac compared to 74.9 and 64.1 bu/ac for Faller. In the same trial Prosper yields were 82.6 and 66.2 bu/ac, respectively. In ND (Table 1), Elgin-ND performed very well in ND across many years/locations from 20008-13. Particularly

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in Eastern ND environments which are similar to Western MN, Elgin-ND yield was close to both Faller and Prosper (Table 1).

- **Prosper:** In 2011 NDSU and the U of MN have jointly released the NDSU developed hard red spring wheat cultivar Prosper. It is a semi-dwarf variety with an early to medium-early maturity and has exceptionally high yield that equals Faller. It is moderately resistant/moderately susceptible to FHB and resistant to stem rust. Prosper was released to enhance the wheat production and improve incomes of wheat growers in MN and ND as did Faller. Indeed, just like Faller, Prosper, after just two years of its release, become the leading cultivar in MN in 2013 with 17.3% followed by Faller by 17.27%. Combined together, the MN wheat acreage grown to both Faller and Prosper surpassed 34.5% in 2013. In 2014, Prosper acreages increased to 20.3% while Faller had 13.46% of MN acreages. Both Prosper and Faller are also dominant in ND with 11.7 and 8.8% of ND 6 million acres. Their performance, particularly in Eastern ND was shown to be superior to all cultivars across several years/locations (Table 1).

- **Faller:** the 2007 release of Faller was a milestone in our NDSU wheat breeding program since it was the first high yielding released cultivar with relatively good quality attributes, challenging all other high yielding cultivars released by other breeding programs in the spring wheat region. Faller was mainly targeted to the Eastern ND and Western MN because of it very high yield and good disease package. Just two years after its release (2007), Faller became the leading cultivar in MN from 2009 to 2012. At a time 30% of MN total wheat acreages were grown to Faller. In 2013, Faller was still grown on 17.27% second only to Prosper, the other NDSU cultivar released in 2012. In 2014, Faller was still dominant in MN with 13.46% of MN acreages. Faller has been also very popular in ND and performs very well compared to the other leading cultivars including Glenn and Barlow (Table 1). Faller was the second leading cultivar in ND (up to 17.2% of ND 6 million acres) from 2009 to 2011. In 2014, it was still occupying 8.8% of the ND total wheat acreages.

Based on the above statistics, the impact of our breeding program on the MN wheat growers through the release of adapted and modern HRSW cultivars is substantial. NDSU cultivars released since 2007, including Faller and Prosper have played a major role in the wheat production in MN, the wheat industry in the US, and wheat export market internationally. It is estimated that Hundreds of millions of dollars may have been generated by these cultivars for the wheat business as a whole and for MN wheat growers, in particular. ***Continuing such impact in the future by releasing more adapted and highly performing cultivars remains our goal. To achieve this goal, the support from the MNWRPC is paramount.***

Table 1. Agronomic performance of Elgin-ND and HRSW checks in Eastern ND during 2008-2013 (32 environments).

No	Variety	Days Heading	Height	Lodge	Tomb stones	Leaf Disease	Test Weight	Grain Yield	Grain Protein
		days	inch	1-9	%	%	Lb/bu	Bu/ac	%
1	Barlow	53.5	33.5	2.2	1.9	9.7	60.9	67.9	14.7
2	Glenn	53.0	34.9	0.7	0.1	14.5	62.6	64.7	14.8
3	SY Soren	52.0	27.4	0.0	0.3	16.3	60.8	64.6	15.2
4	**Faller**	**56.5**	**33.3**	**1.9**	**0.2**	**12.0**	**60.2**	**76.7**	**13.8**
5	**Prosper**	**56.7**	**33.2**	**2.6**	**0.2**	**8.6**	**60.1**	**75.1**	**13.9**
6	Kelby	54.6	28.6	1.5	0.5	18.1	59.7	59.6	15.3
7	Brennan	55.4	28.6	1.9	1.3	21.2	59.6	62.1	15.3
8	RB07	54.1	31.3	1.7	0.2	24.7	59.8	68.8	14.6
9	Vantage	59.4	31.3	0.0	2.6	9.4	61.5	65.2	15.8
10	**Elgin-ND**	**53.9**	**35.1**	**3.0**	**0.6**	**12.3**	**59.9**	**71.4**	**14.8**
11	Velva	58.0	32.8	1.5	3.4	8.8	58.3	65.1	14.6
12	Linkert	53.1	27.5	0.0	0.9	13.8	60.8	60.4	15.6
13	Forefront	49.6	33.9	6.4	0.4	18.8	61.2	62.6	15.0
14	Advance	52.4	30.0	1.3	1.0	13.8	61.5	65.9	14.0

Figure 1: Frequency distribution of hard red spring lines in relationship with yield levels achieved at Alvarado, MN during 2014. ***NB: Bars for the checks Faller, Glenn, Barlow and Prosper represent yield in bu/ac.***

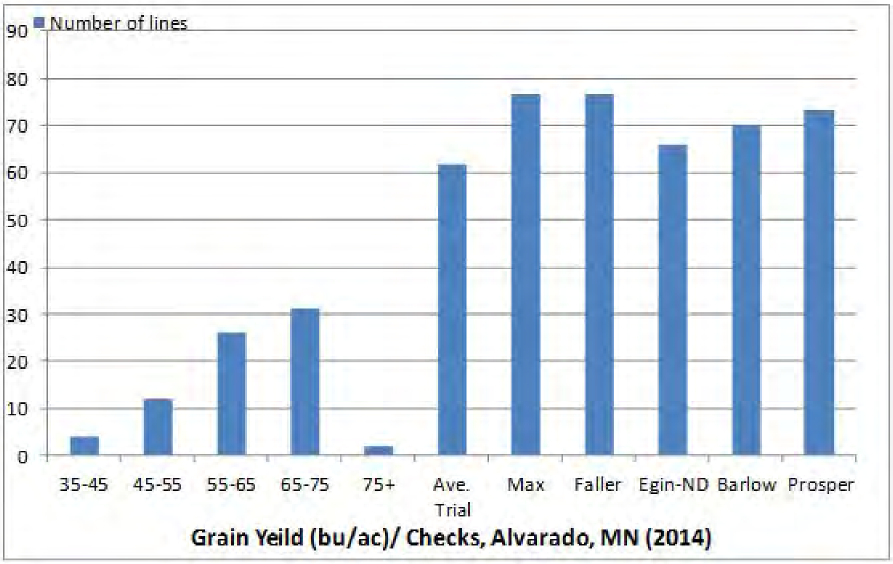


Figure 2: Frequency distribution of hard red spring lines in relationship with yield levels achieved at Alvarado, MN during 2013. ***NB: Bars for the checks Velva, Elgin-ND, Faller, Glenn, Barlow and Prosper represent yield in bu/ac.***

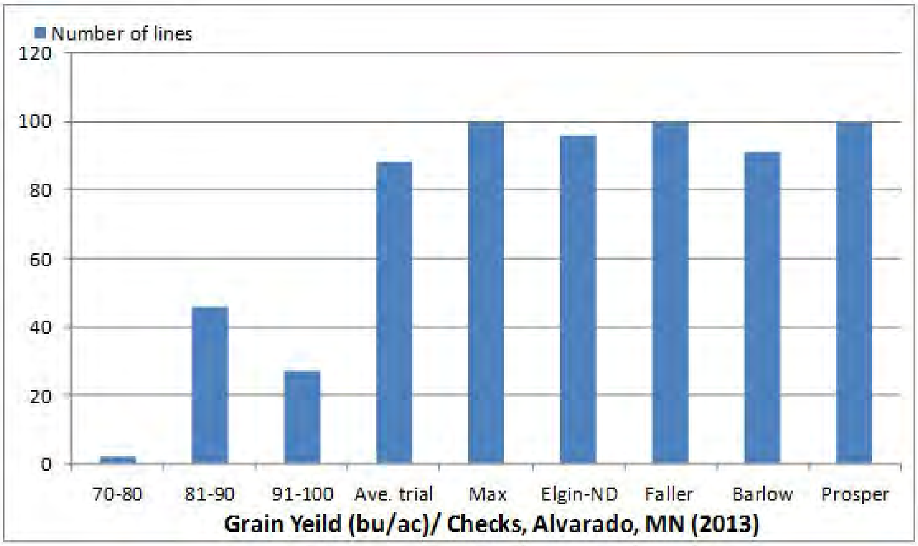
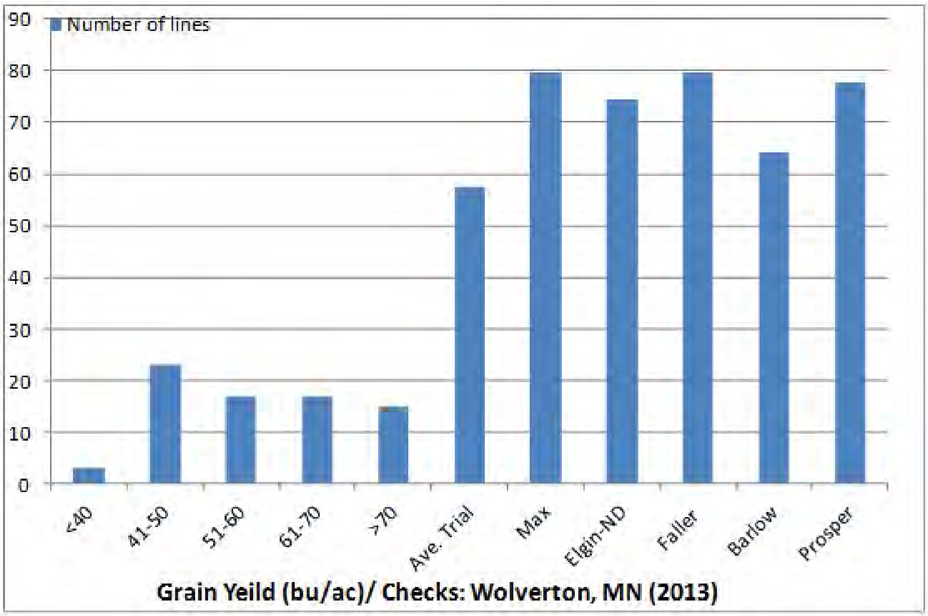


Figure 3: Frequency distribution of hard red spring lines in relationship with yield levels achieved at Wolverton, MN during 2013 (2 replicates only). ***NB: Bars for the checks Ave. trial, Max, Elgin-ND, Faller, Barlow, and Prosper represent yield in bu/ac.***



Optimum Seeding Rates for Diverse HRSW Varieties

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Research Questions

Yield of HRSW is affected by many agronomic practices starting with choice of the cultivar, the planting date, and seeding rate. Previous research has shown that optimum seeding rates differ for individual cultivars (Wiersma, 2004). This research project specifically explores the relationship between a set of genetic traits, including semi-dwarf stature and day length sensitivity, of individual cultivars, planting dates, and seeding rates, and to develop regression models that supersede individual cultivars and looks to explain how a group of genetically similar varieties respond to seeding rate.

Results

In both 2013 and 2014 the environment was atypical in that the accumulated growing degree days was behind the historical 30 year average, evidence of a cooler than normal growing season that proves hard red spring wheat response to seeding rate is not always as pronounced as what is expected (Figure 3). At the Kennedy North Dakota Agricultural Weather Network (NDAWN) station, which is just nine miles from the Hallock, MN field trial, there is evidence that the summer was cooler overall, especially at periods of grain fill. Table 2 has results of the seeding rate factor at all environments from 2014. Of the nine environments, four had a range in grain yield of less than 4 bu/ac across the five seeding rates. The other five locations had yield ranges of 5-8 bu/ac across five seeding rates. Within and across locations there were no significant variety by seeding rate interactions in 2014 and therefor no variety specific seeding rate response regressions can be developed. However, the single seed hill plots proved that cultivars have varying propensity to tiller. At Prosper, ND, averaged over all four planting dates as no significant interaction existed, the cultivar 'Sabin' had significantly higher stems per plant than any other cultivar (Table 3). Results from Prosper reiterate the importance of tillering when choosing a seeding rate for a specific cultivar. Contrary to Prosper, ND, results from Crookston, MN, show that with each successive planting date later into the season, the number of stems per plant decreased (Table 4). Two cultivars, 'Marshall' and 'Rollag' increased total number of stems at the second planting date compared to the first, but followed the general trend at the last two planting dates. Results confirm that as HRSW is planted later, a higher seeding rate should be considered as less tillers can be expected. Varieties and their genetic make-up, including semi-dwarf stature and day length sensitivity, influence this response. Results from stand counts and head counts leading to a total stems per plant calculation within the solid seeded trials showed a far smaller spread than in the hill plots, as expected, though six of nine environments had significant differences between cultivars (Table 5). Yield results from the planting date effect from the past two years with cooler than normal periods indicate that increasing seeding rate at later than optimal planting dates will not significantly increase or decrease yield (Table 6). Thus, the unpredictability of growing conditions, especially during critical growth periods, indicate the importance of erring on the side of increased seeding rate. Figures 1 and 2 begin to show the results that were intended from the hypothesis of this research. In 2013, at Crookston, MN, presence of the *Rht2* gene at the early planting date did not result in a yield decrease as seeding rate increased, while cultivars that did not have the Rht2 gene had a pronounced yield decrease at increased seeding rates above the optimum. In contrast to that result, when the Rht2 gene was present in a cultivar and the planting date was three weeks later than optimum, the yield curve broke into a large yield decrease after the 1.4 million seeding rate, mirroring the curve of cultivars without *Rht2*. Results begin to show that knowledge of the genetic makeup of a plant with respect to certain qualitative traits could impact seeding rate decisions.

Application/Use

Evidence from 2013 was that for many cultivars, increasing seeding rate up to the highest rate lead to significantly greater yield. Yields in the late planting date at the three locations highlighted in table 5 and 6 show varying results when increasing seeding rate. Evidence from the Crookston location in 2014 is that the highest seeding rate yielded greater than the four lower seeding rates in the late planting date while this trend was not seen in the early planting date. After two years of research the results do not allow us to recommend seeding rates through any genetic analysis of cultivars, however there is promise that this objective can be met.

Material and Methods

Six field locations were established in 2014 at Hallock, Crookston, Perley, Kimball, and Lamberton, MN and Prosper, ND. Locations were chosen to pair locations latitudinal, with Hallock and Crookston, Perley and Prosper, and Kimball and Lamberton being paired. Four field locations were established in 2013 at Hallock, Crookston, and Perley, MN and Prosper, ND. Locations were chosen to run down latitude lines with Hallock being the validation site for Crookston and Perley being the validation site for Prosper. Crookston (2013 and 2014), Prosper (2014), and Lamberton (2014) used a randomized complete block design (RCBD) with a split-split plot restriction with planting date as whole plot, HRSW cultivar as the split plot, and seeding rate as the split-split plot. Hallock (2013 and 2014), Perley (2013 and 2014), Prosper (2013), and Kimball (2014) were RCBD with a split plot restriction with HRSW cultivar as the whole plot and seeding rate the split plot. When planting date was a factor the first planting date would be as close to optimal as possible, and the second planting date three weeks later. The HRSW cultivar factor was twelve cultivars split into six groups of two from known genetic associations for *Rht1, Rht2*, and day length sensitivity (Table 1). The seeding rate factor had five levels at 600,000, 1,000,000, 1,400,000, 1,800,000, and 2,200,000 live seeds/acre planted. The data collected were stand count at Feekes 1-2, head count at Feekes 11, height, lodging, and grain yield components. Stand counts and head counts were measured from a 3 ft length in two adjacent rows, and used to verify seeding rates and determine the number of stems per plant. An additional trial with single seed hill plots was done at Crookston, MN and Prosper, ND in 2014. The trial was designed as a RCBD with a split plot with planting date as the whole plot and cultivar as the split plot. The same twelve cultivars from Table 1 were used, and there were four planting dates at each location, separated by approximately one week. Single seeds were space planted on a one foot spaced grid. Number of stems were counted at Feekes 11.

Economic Benefit to a Typical 500 Acre Wheat Enterprise

Table 7 shows the yield trend at all five seeding rates at Hallock in 2013. Though there was an interaction of cultivar during 2013, this data is averaged over cultivar to show the impact of seeding rate. The optimum seeding rate for maximum bet income with yield from Hallock, 2013, and seed costs taken into account, is the 1.4 million seeds per acre rate. The second most economical seeding rate was 1.0 million seeds per acre, while 0.6 million seeds per acre would net the lowest. If a farmer were to plant 500 acres with the math from table 7 holding true, planting at the optimum seeding rate of 1.4 million seeds per acre would net $8,618 more than the most uneconomical seeding rate of 0.6 million seeds per acre.

Recommended Future Research

From two years of research into the effect of planting date, seeding rate, and diverse HRSW cultivars it is evident that a third year of research will be needed to fully test the objectives of the research. The atypical growing conditions encountered in either year, especially 2014, limit our ability to meat the objectives of the research. Although some of the data, in particular Figure 1 and 2, strongly suggest that the genetic make-up of contrasting groups of cultivars influences their response to seeding rate and that this response therefor should be able to be predicted. In 2013 we had a spring wheat average yield at Crookston optimum planting date on May 10, 2013 of 91 bu/ac, while at the planting date almost three weeks later on May 28, 2013 averaged a higher yield at 95 bu/ac. In 2014 the seeding rate by cultivar interaction was not as expected, due to cooler than average temperature during grain fill which allowed wheat tillers to even out yield between seeding rates. While the seeding rate response curve in 2013 is more like what we would expect, we simply do not have a large enough data set to draw robust conclusions and develop the regression models. We will submit a proposal for continuation of this research for the 2015 season, where after, if funded, we will draw final conclusions on the potential of the ideas proposed in this research for choosing a seeding rate based on genetic components of the HRSW cultivar.

Table 1. The HRSW cultivars included in research and presence of day length sensitivity, Rht1, and Rht2 genes

Group	Cultivar	Day length Sensitivity	Rht1	Rht2
1	Albany	+	+	-
	Faller	+	+	-
2	Knudson	-	+	-
	Samson	-	+	-
3	Briggs	+	-	-
	Vantage	+	-	-
4	Sabin	-	-	-
	Oklee	-	-	-
5	Kelby	-	-	+
	Kuntz	-	-	+
6	Marshall	+	-	+
	Rollag	+	-	+

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Table 2. Effect of seeding rate on yield a 6 study locations, with 2 planting dates at 3 locations, 2014.

	Location								
Rate	**Hallock**	**Crookston PD 1**	**Crookston PD 2**	**Perley**	**Prosper PD 1**	**Prosper PD 2**	**Kimball**	**Lamberton PD 1**	**Lamberton PD 2**
Million seeds/ac	----------bu/ac----------								
0.6	76.9	71.3	64.5	88.1	64.8	44.2	83.8	71.6	58.4
1.0	81.8	75.2	67.2	89.8	65.9	49.1	83.5	75.2	61.5
1.4	81.8	73.2	67.9	90.7	66.4	48.9	82.6	78.1	63.7
1.8	82.0	74.2	67.9	88.8	66.5	49.8	80.7	78.0	65.7
2.2	82.3	73.9	70.5	88.7	65.7	49.0	81.2	79.5	63.8
Mean	80.9	73.5	67.6	89.2	65.9	48.2	82.4	76.5	62.6
Min	76.9	71.3	64.5	88.1	64.8	44.2	80.7	71.6	58.4
Max	82.3	75.2	70.5	90.7	66.5	49.8	83.8	79.5	65.7
Range	5.4	3.9	6.0	2.5	1.7	5.6	3.1	7.9	7.3
LSD (0.5)	1.5	NS	2.6	NS	NS	1.9	NS	2.2	3.3

Table 3. Effect of cultivar on total stems per plant, Prosper, ND, 2014.

Cultivar	Stems/plant
Sabin	43.9
Marshall	36.1
Albany	36.0
Knudson	33.9
Faller	31.7
Oklee	28.4
Kuntz	26.7
Vantage	25.8
Rollag	25.0
Briggs	24.2
Kelby	20.4
Samson	18.7
LSD (0.5)	6.2

Table 4. Effect of cultivar by planting date interaction on total stems per plant, Crookston, ND, 2014

Cultivar	23-May	30-May	6-Jun	23-Jun
	----------------stems/plant----------------			
Albany	34.3	25.8	8.5	3.7
Briggs	19.3	15.4	14.2	5.5
Faller	29.6	26.2	16.3	16.4
Kelby	14.3	13.2	11.5	6.5
Knudson	24.7	21.5	14.3	8.1
Kuntz	16.3	17.7	9.5	5.6
Marshall	14.7	24.2	13.5	7.9
Oklee	16.1	16.8	12.9	6.0
Rollag	11.1	19.8	13.9	5.4
Sabin	24.7	24.3	22.8	13.1
Samson	18.2	13.8	14.2	7.2
Vantage	20.8	20.0	10.6	4.4
Mean	20.4	19.9	13.5	7.5
LSD (0.05)	6.2	5.1	5.1	5.1

Table 5. Effect of cultivar on stems per plant at 6 study locations, with 2 planting dates at 3 locations, 2014.

Cultivar	Location								
	Hallock	Crookston PD 1	Crookston PD 2	Perley	Prosper PD 1	Prosper PD 2	Kimball	Lamberton PD 1	Lamberton PD 2
	---stems/plant---								
Albany	2.35	1.98	1.51	2.08	2.70	4.24	2.37	3.04	3.26
Briggs	2.35	2.04	1.66	2.40	2.93	3.56	2.46	2.78	3.39
Faller	2.47	2.02	1.45	1.99	2.53	2.73	2.43	3.03	3.60
Kelby	2.05	1.78	1.43	1.78	2.37	3.00	2.19	2.63	3.47
Knudson	2.45	2.04	1.82	2.24	2.66	3.20	2.45	3.33	4.19
Kuntz	1.71	1.65	1.54	1.70	2.37	3.77	2.12	2.52	3.04
Marshall	2.21	1.97	1.60	2.32	2.91	4.16	2.30	3.13	3.60
Oklee	2.28	1.69	1.46	1.75	2.18	2.49	2.12	2.80	3.12
Rollag	2.75	1.97	1.60	2.02	2.58	4.05	2.43	2.77	3.22
Sabin	1.93	1.74	1.25	1.92	2.30	2.58	1.96	2.77	2.52
Samson	1.96	1.94	1.44	1.83	2.01	3.13	2.61	2.58	2.85
Vantage	1.89	1.60	1.59	2.03	2.46	2.72	2.30	2.22	2.27
Mean	2.20	1.87	1.53	2.01	2.50	3.30	2.31	2.80	3.21
LSD (0.05)	0.33	0.26	0.23	0.30	0.73	0.68	NS	NS	NS

Table 6. Effect of planting date by seeding rate interaction averaged over HRSW cultivar on yield at Lamberton and Crookston, MN, 2014

Planting Date	Lamberton, MN 2014					
	600,000	1,000,000	1,400,000	1,800,000	2,200,000	LSD
	---bu/ac---					
Early	71.7	75.2	78.1	78.0	79.5	2.8
Late	58.4	61.5	63.7	65.7	63.8	4.0
	Crookston, MN 2013					
Early	88.6	92.6	92.9	91.3	90.8	NS
Late	91.0	94.8	97.0	95.5	96.2	NS
	Crookston, MN 2014					
Early	71.3	75.2	73.2	74.2	73.9	NS
Late	64.5	67.2	67.9	67.9	70.5	NS

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Figure 1. Effect of Rht2 gene on yield response to seeding rate in the early (optimal) planting date of May 10, Crookston, MN, 2013.

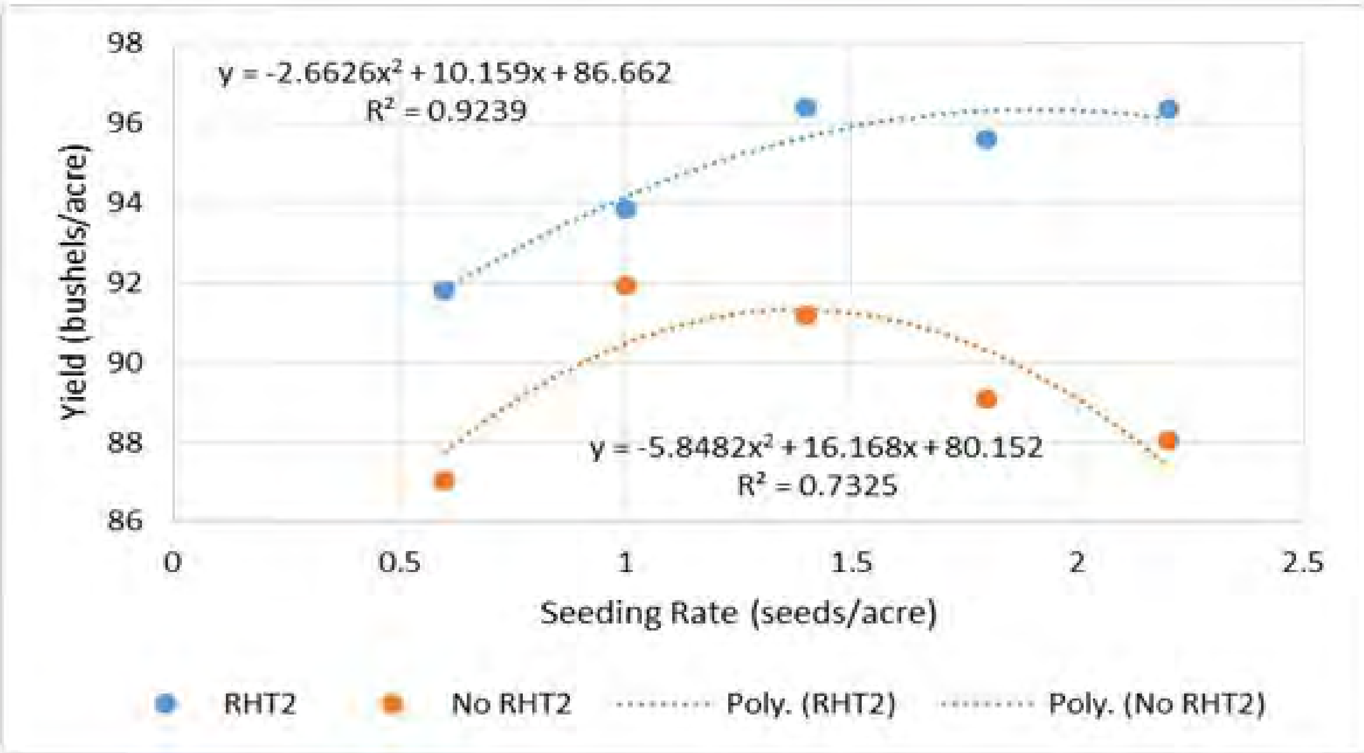

Figure 2. Effect of Rht2 gene on yield response to seeding rate in the late planting date of May 28, Crookston, MN, 2013

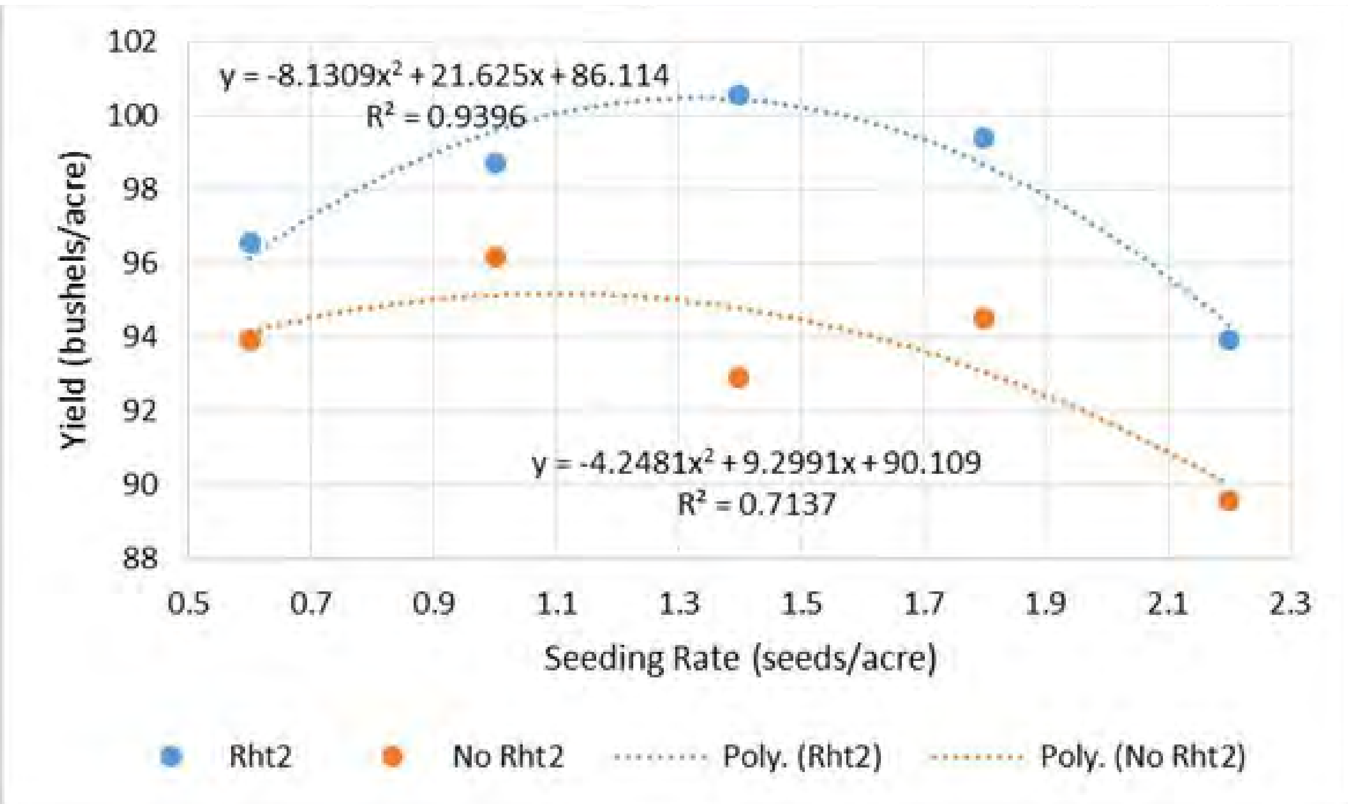

Figure 3. Accumulated growing degree days at the Kennedy, MN, North Dakota Agricultural Weather Network (NDAWN) for the 2014 dates growing season of the Hallock, MN trial and the 30 year average at Kennedy site.

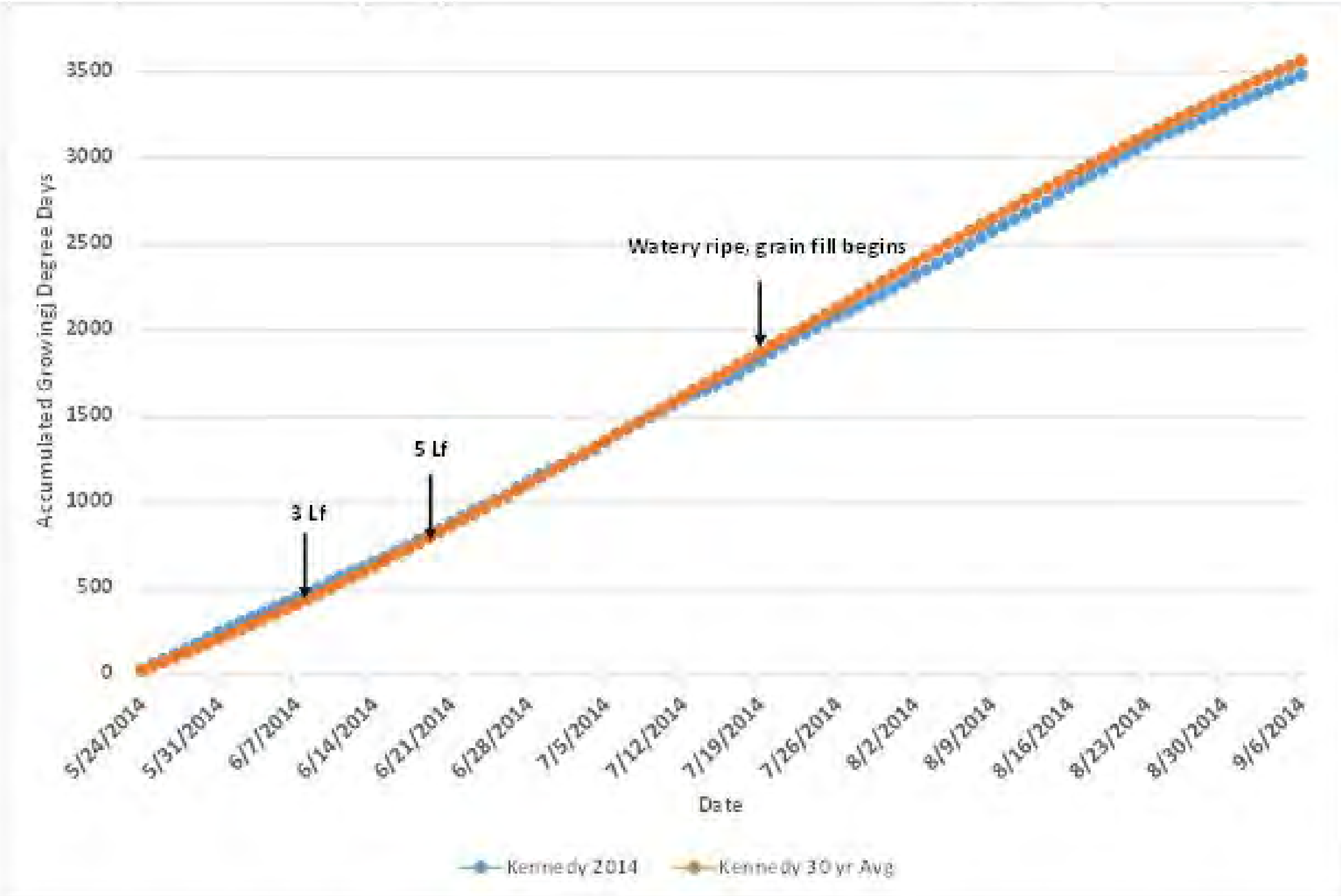

Table 7. Costs and benefits associated with seeding rate with yields from Hallock, MN, 2013

Seeding Rate	Seeding Rate	Seed cost [1]	Yield	Gross Income [2]	Net Income
Seeds/ac	**-Bushels/ac-**	**--$/acre--**	**-Bushels/ac-**	**----$/ac----**	**----$/ac----**
600,000	0.9	13.7	64.8	355.8	342.1
1,000,000	1.5	22.8	68.8	377.4	354.6
1,400,000	2.1	32.0	71.3	391.3	359.3
1,800,000	2.6	41.1	71.4	391.7	350.6
2,200,000	3.2	50.2	72.4	397.7	347.5
[1] Seed cost of $15.50 per bushel of HRSW. [2] December wheat price of $5.49					

References

Wiersma, J.J. 2002. Determining an optimum seeding rate for spring wheat in Northwest Minnesota. Online. Crop Management doi:10.1094/CM-2002-0510-01-RS.

Progress Report to Minnesota Wheat Research and Promotion Council on the Spring Wheat Protein Spread Project

Frayne Olson, Dept. of Agribusiness and Applied Economics, NDSU

Research

We have identified elevators in western Minnesota and eastern North Dakota that have price data for alternative spring wheat protein levels. Will be gathering this data over the next several weeks. We have also updated our existing protein spread information, which uses data from the USDA Agricultural Marketing Service for two major terminal markets.

A short presentation on spring wheat protein premiums/ discounts was included in NDSU Agricultural Lenders Conferences. The Agricultural Lenders Conferences provides updates on crop, livestock and biofuels outlook, an update on farm program changes and a review of farm financial performance. Approximately 400 agricultural lenders from North Dakota, Minnesota, South Dakota and Montana attended this year conference in 2014.

A review of research studies concerning post-anthesis application of nitrogen to enhance wheat protein levels is underway. A draft of the post-anthesis decision tool is being prepared.

Planning for the 2014/15 winter meeting season is underway, and we will coordinate with the Minnesota Wheat Research and Promotion Council to present preliminary results when they are available.

2014 Wheat, Barley and Oat Variety Performance in Minnesota - *Preliminary Report*

The 2014 growing season was in many ways a carbon copy of the 2013 season. Overall, the spring wheat pleasantly surprised most while the winter wheat, oats, and barley were a bit of a disappointment for some. While the barley crop was especially impacted by excess moisture earlier in the season, winter wheat and oats were severely affected by Fusarium head blight and crown rust, respectively.

After a brutally cold winter 2014 started much the same as 2013 with a cold and wet April. By the end of April only 9% of the oats, and 2% of the spring wheat and barley acreage had been seeded. This compares to a 5-year average of roughly 40% seeded for all three crops. Cool and wet conditions continued for much of May and June. Field work started in earnest in the third week of May and by May 29th, 67% of the spring wheat, 63% of the barley, and 85% of the oat acreage had been planted; a good week behind the 2013 pace and nearly 20% behind the 5-year average pace. By the third week of June nearly 60% of the State's topsoil and over half of the subsoil were rated as having a moisture surplus; a far cry from 2012 and 2013 drought conditions. Although the excess precipitation caused crop losses in individual fields , USDA's June yield prognosis had Minnesota's spring wheat yield predicted at 52 bushels per acre, only 1 bushel lower than in 2013 but still 2 bushels higher than 2012.

Early disease problems centered around tan spot and Septoria, especially in wheat following wheat. The delayed start in combination with the cool conditions allowed for an early epidemic to develop throughout the state and producers were encouraged to stop the tan spot and Septoria epidemic with the use of a fungicide at or before the 5-leaf stage (Feekes 5). Crown rust of oats was detected by the third week of June in central Minnesota and, with many of the oat varieties being moderate to very susceptible, ultimately caused substantial yield losses across the southern half of the state. Leaf rust of wheat and stem rust of oats were detected by the second week of July, but the diseases reached economic levels in only a few fields. Damages due to Fusarium head blight were severe in winter wheat and the earliest spring wheat, especially in southern and west central Minnesota. The later seeded spring wheat crop largely escaped damages due to FHB. Nonetheless, most spring wheat that has been delivered is being tested for the presence of deoxynivalenol or DON, underscoring the nervousness of the domestic and foreign buyers alike.

When harvest finally commenced producers were pleasantly surprised with the spring wheat grain yields. By August 24th only 22% of the spring wheat had been harvested which compared to 60% in 2013. Weather delays pushed harvest further back and fueled concerns about quality losses, in particular sprout damage. By September 15th only 75% of the spring wheat acreage had been harvested with much of the crop in Kittson, Roseau, Marshall, and Pennington counties still standing. The USDA placed the state's final average at 55 bushels per acre in their September summary, two bushels lower than the past two years. The adverse conditions for barley were reflected in the state's average yield of 52 bushels per acre, nearly a third less than the state's average in 2013.

The overall quality of the spring wheat crop is, with especially the vitreous kernels count and the grain protein content , below traditional levels for hard red spring wheat. Weathering as a result of the harvest delays explain the lower vitreous kernel count and slightly lower test weights. The grain protein content varies greatly between varieties and fields. This variability can generally be traced back to not just the varietal differences but also the differences in fertility management, especially with regard to N.

Spring wheat acreage remained the same at 1.2 million acres planted in 2014. Barley and oat acreage continued their decline with 75,000 and 230,000 planted acres, respectively.

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. The cooperator plots are handled so factors affecting yield and performance are as close to uniform for all entries at each location as possible.

The MAES 2014 Wheat, Barley, and Oat Variety Performance in Minnesota Preliminary Report 24 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.

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 2015 Directory', available through the Minnesota Crop Improvement Association office in St. Paul or online at http://www.mncia.org

INTERPRETATION OF THE DATA

The presented data are the preliminary variety trial information for single (2014) and multiple years (2012-2014) comparisons in Minnesota. The yields are reported as a percentage of the location mean, with the overall mean (bu/A) listed below. Two-year and especially one-year data are less reliable and should be interpreted with caution. In contrast, averages across multiple environments, whether they are different years and/or locations, provide a more reliable estimate of mean performance and are more predictive of what you may expect from the variety the next growing season. 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 due to 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 differentiate 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.

THE AUTHORS AND CONTRIBUTORS

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Matt Bickel, Robert Bouvette, James Cameron, Roger Caspers, Doug Holen, Dave Graftstrom, Matt Green, Mark Hanson, Tom Hoverstad, George Nelson, Steve Quiring, Susan Reynolds, Edward Schiefelbein, Galen Thompson, and Donn Vellekson supervised fieldwork at the various sites.

Special thanks are also due to all cooperating producers.

SPRING WHEAT

James Anderson, Jochum Wiersma, Susan Reynolds, Roger Caspers, Matt Green, Ruth Dill-Macky, James Kolmer, Matt Rouse, and Yue Jin.

Faller and Prosper combined maintained their share of nearly a third of Minnesota's spring wheat acres in 2014. WB-Mayville moved up to the 2rd most popular variety with 18%. The next three varieties, each with between 5-7% of the acres were SY-Soren, LCS Albany, and Rollag. LCS Iguacu, Prevail, SY-Ingmar, and WB9507 were varieties released in 2014 and their results have been added to the tables. Three varieties from Croplan Genetics, a new provider of HRSW genetics in the region, were also tested for the first time this year. Testing of Edge, Sabin, and Select was discontinued. The results of the state yield trials are summarized in Tables 1 through 7. The average yield across the six southern testing locations was 75 bu/A in 2014. This compares to an average of 65 bu/A in 2013 and a three-year average of 65 bu/A. The seven northern locations averaged 84 bu/A in 2013 compared to 89 bu/A last year and 83 bu/A for the three-year average.

Tables 4, 5, and 6 present the relative grain yield of tested varieties in 1, 2, and 3-year comparisons. LCS Albany, Faller, Prosper, and HRS3419 were the top yielders in the northern locations and LCS Albany topped the southern testing locations in 2014. Other varieties that yielded well statewide in 2014 were SY-Rowyn and LCS Iguacu. LCS Albany, Faller, and Prosper were the top yielders in the 3-year comparisons. Higher yielding cultivars tend to be lower in grain protein as is the case with these three varieties. In cooler, more-productive growing seasons, this may mean that grain protein percentage ends up below 14.0%. N fertility management is paramount to maximize grain yield and grain protein.

The varietal characteristics are presented in Tables 1, 2, and 3. Table 3 summarizes all the disease reactions for individual varieties. Varieties that are rated 4 or better are considered the best hedge against a particular diseases. Varieties that are rated 7 or higher are likely to suffer significant economic losses under even moderate disease pressure. Table 7 provides insight of how varieties respond to the use of fungicides. In Lamberton, Morris, Crookston, and Roseau the State Variety Trials are grown in duplicate. The duplicate trial is treated with fungicides at Feekes 5, 9, and 10.51 to eliminate, to the extent possible, any fungal pathogens that potentially can reduce grain yield and quality. Averaged across varieties over 3 years, the use of fungicide increased grain yield by 15 bushels per acre in the northern locations and 5 bu/A in southern locations. Individual varieties may have very different responses to fungicide, depending on their level of susceptibility to and intensity of fungal diseases. Use the information in Tables 3 and 7 to gain an understanding how individual varieties should be managed to reduce the yield losses caused by fungal pathogens such as tan spot, leaf and stripe rust, and FHB.

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 from their response to each of those diseases, the rating does not differentiate among them. 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. Tan spot was again widespread in 2014 and likely caused significant yield reduction in susceptible varieties. Control of leaf diseases with fungicides may be warranted, even for those varieties with an above average rating. Leaf rust was not a problem in 2014. However, growers should consider a variety's rating for leaf rust, and plan to use a fungicide if a variety is rated 5 or higher for either leaf or stem rust and disease levels warrant treatment.

Bacterial Leaf Streak cannot be controlled with fungicides. Variety selection of more resistant varieties is the only recommended practice at this time if you have a history of problems with this disease. Breaker, Forefront, Prevail, LCS Breakaway, SY Ingmar, and SY-Rowyn offer the best resistance while varieties like LCS Albany, RB07, Vantage, and WB-Mayville have a rating of 6 or 7, indicating that they are the most consistently affected by the disease.

Variety selection for 2015 continues to be a balance between yield potential, disease responses, and grain quality. Vigilance against FHB remains paramount as economic losses can quickly add up with varieties rated 6 or higher. Glenn, Forefront, and Rollag provide the best resistance against FHB. Forefront has good adaptation to southern locations and both Forefront and Rollag are competitive varieties for the northern locations. LCS Albany, Barlow, Breaker, Faller, RB07, and SY-Soren are all varieties with a rating of 4 for FHB. Combined, this group of varieties includes some of the top yielders (LCS Albany, Faller) and varieties with higher grain protein content such as Rollag, Barlow, and Glenn.

BARLEY

Kevin Smith, Ruth Dill-Macky, Jochum Wiersma, Brian Steffenson, and Ed Schiefelbein

The results of the state yield trials are summarized in Table 8. The average yield across the four testing locations (Morris, St. Paul, Stephen, and Roseau) was 103 bu/A in 2014. This is 11 bushels higher than the trial's average in 2013. The highest yields were recorded in Roseau and the lowest yields were recorded in Stephen (Table 8). Rasmusson was the highest yielding variety followed by Celebration, Innovation and Pinnacle based on the 3 year state averages. Agronomic characteristics are described in Table 9. Lacey, Rasmusson, Tradition, Pinnacle, and Stellar-ND are the most lodging resistant of the group. The two-rowed varieties Pinnacle and Rawson had the plumpest grain while Celebration was thinner than the other varieties. Grain proteins for the six-rowed varieties ran from 12.9% (Innovation) to 13.8% (Robust). While the two-rowed varieties Pinnacle and Rawson had 12.0% and 12.7% protein, respectively.

Table 10 describes the reaction of the currently grown varieties to the six major diseases in the region. Bacterial Leaf Streak (BLS) cannot be controlled by fungicides and there are only minimal differences in resistance among the current varieties. Conlon and Celebration have the best net blotch resistance while Quest and Conlon have the best FHB resistance among the varieties presented. The two-rowed varieties are a little more susceptible to spot blotch.

OATS

Jochum Wiersma, Roger Caspers, Ruth Dill-Macky, Matt Green

The results of the Minnesota Field Crops Trials for oats are summarized in Tables 12 through 14. The average yield across the five trial locations (Lamberton, Morris, Crookston, Stephen, and Roseau) was a 170 bu/a. This is substantially higher than 2013 and can partially be explained by a difference in protocol. Many of the oat varieties are moderately to very susceptible to crown rust (a crown rust rating >4). Consequently crown rust infections will affect the measured grain yield. As the goal of the trials is to measure yield potential rather than the susceptibility to crown rust it was decided to treat all yield trials with a fungicide when the flag leaf was fully extended (Feekes 9), the optimum time to control crown rust. Table 12 presents the relative grain yield of the tested varieties in 1 and 3 year comparisons. Deon, the latest University of Minnesota release, was the top yielding variety across the State in both the single and three year comparisons followed by Newburg, the 2011 release from North Dakota State University.

Agronomic characteristics and disease reactions are presented in Table 13 and 14, respectively. Relative maturity as measured by the number of days to heading, plant height, and resistance to lodging have been converted to a 1-9 scale to allow for easier interpretation of the data. Differences for all three characteristics are generally compressed in the southern half of the state or when seeding

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is delayed and protracted in the northern half of the State or when seeding early. Presenting averages of the actual data therefore can be misleading.

The disease ratings are based on inoculated screening nurseries for crown rust and smut on the University of Minnesota's St. Paul campus and for Barley yellow dwarf virus or red leaf of oats on the University of Illinois' Champaign Urbana campus. Consider most oat varieties to be moderately to very susceptible to crown rust. The use of a fungicide at Feekes 9 is warranted if crown rust is present in the lower canopy at that time and the variety has a crown rust rating of 4 and higher. Expect some yield losses due to crown rust with the most susceptible cultivars even when a fungicide application is made at Feekes 9 if conditions for crown rust remain favorable during the grain fill period. Therefore selecting moderately susceptible cultivars like Deon, Esker is still prudent.

Table 1. Origin and agronomic characteristics of hard red spring wheat varieties in Minnesota in single-year (2014) and multiple year comparisons.

Entry	Origin[1]	Days to Heading[2]	Height[2] (inches)	Straw Strength[3]
Advance	2012 SDSU	60.2	31.5	6
Barlow	2009 NDSU	56.8	32.8	6
Breaker	2008 WestBred	59.2	33.1	4
Elgin-ND	2013 NDSU	58.2	35.8	6
Faller	2007 NDSU	61.8	34.2	5
Forefront	2012 SDSU	55.9	35.7	5
Glenn	2005 NDSU	56.4	34.2	4
HRS 3361	2013 CROPLAN by WinField	59.6	31.2	3
HRS 3378	2013 CROPLAN by WinField	58.0	30.7	5
HRS 3419	2014 CROPLAN by WinField	63.0	30.7	2
Jenna	2009 Syngenta	62.3	31.3	4
Knudson	2001 Syngenta	59.9	31.6	5
LCS Albany	2009 Limagrain Cereal Seeds	61.1	31.2	5
LCS Breakaway	2012 Limagrain Cereal Seeds	56.9	29.8	4
LCS Iguacu	2014 Limagrain Cereal Seeds	60.8	30.8	4
LCS Powerplay	2012 Limagrain Cereal Seeds	58.7	30.8	5
Linkert	2013 MN	58.2	30.0	2
Marshall	1982 MN	63.1	32.2	4
Norden	2012 MN	59.6	31.0	3
Prevail	2014 SDSU	58.1	34.3	4
Prosper	2011 NDSU	61.8	34.6	6
RB07	2007 MN	58.2	31.7	5
Rollag	2011 MN	58.6	30.3	3
Samson	2007 WestBred	57.6	28.9	3
SY Ingmar	2014 Syngenta	59.4	31.2	4
SY-Rowyn	2013 Syngenta	56.3	29.4	5
SY-Soren	2011 Syngenta	58.0	29.6	4
Vantage	2007 WestBred	62.8	32.3	2
WB-Digger	2010 WestBred	58.4	32.2	5
WB-Mayville	2011 WestBred	56.4	30.9	3
WB9507	2013 WestBred	57.9	33.1	5
Mean		59.1	31.8	

[1] Abbreviations: MN = Minnesota Agricultural Experiment Station; NDSU = North Dakota State University Research Foundation; SDSU = South Dakota Agricultural Experiment Station. [2] 2014 data. [3] 1-9 scale in which 1 is the strongest straw and 9 is the weakest. Based on 2008-2014 data. The rating of newer entries may change by as much as one rating point as more data are collected.

Table 2. Grain quality of hard red spring wheat varieties in Minnesota in single-year (2014) and multiple-year comparisons.

Entry	Test Weight (lbs/bu)			Protein [1] %			Baking Quality [2]	Preharvest Sprouting [3]
	2014	2-Yr		2014	2-Yr			
Advance	60.9	61.1		13.6	13.4		Low–Medium	4
Barlow	60.5	60.5		14.5	14.6		Medium–High	2
Breaker	60.7	61.1		14.0	14.0		Medium–High	4
Elgin-ND	60.0	59.9		14.4	14.3		Medium–High	2
Faller	60.2	60.3		13.3	13.4		Medium	2
Forefront	60.9	60.9		14.6	14.5		Medium	4
Glenn	61.8	61.8		14.8	14.7		High	1
HRS 3361	59.5	–		13.9	–		–	–
HRS 3378	60.0	–		14.0	–		–	–
HRS 3419	59.9	–		12.9	–		–	–
Jenna	59.7	60.0		14.2	14.2		Medium	5
Knudson	59.6	59.8		13.4	13.5		Medium–High	2
LCS Albany	60.4	60.5		13.0	12.9		Low–Medium	5
LCS Breakaway	61.4	61.4		14.4	14.5		Medium	3
LCS Iguacu	61.2	61.2		12.6	12.7		–	2
LCS Powerplay	60.9	60.9		13.4	13.6		–	1
Linkert	60.3	60.4		14.9	15.0		High	2
Marshall	59.5	59.5		13.3	13.2		Low	2
Norden	61.4	61.7		13.9	13.9		Medium	1
Prevail	60.5	60.2		13.7	13.7		–	5
Prosper	60.4	60.3		13.4	13.5		Medium	2
RB07	60.2	60.3		14.2	14.3		Medium–High	2
Rollag	61.1	61.1		14.8	14.9		Low–Medium	1
Samson	58.0	58.8		14.2	14.1		Medium	5
SY Ingmar	60.9	–		14.4	–		–	–
SY Rowyn	61.1	60.8		13.7	13.7		–	4
SY Soren	60.6	60.6		14.4	14.5		Medium	1
Vantage	61.9	61.7		15.2	15.1		Medium	3
WB-Digger	58.5	59.0		13.9	13.8		Low–Medium	5
WB-Mayville	58.9	59.4		14.7	14.7		Medium–High	4
WB9507	58.9	–		13.7	–		–	–
Mean	60.3	60.5		14.1	14.1			
No. Environments	12	22		12	22			

[1] 12% moisture basis. [2] 2004-2013 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 3. Disease reactions1 of hard red spring wheat varieties in Minnesota in multiple-year comparisons (2012-2014).

Entry	Leaf Rust	Stem Rust[2]	Bacterial Leaf Streak[3]	Other Leaf Diseaes[4]	Scab
Advance	3	1	4	5	–
Barlow	4	1	4	4	4
Breaker	2	2	2	3	4
Elgin-ND	2	2	4	5	5
Faller	5	1	4	4	4
Forefront	2	4	3	4	3
Glenn	4	1	4	5	3
HRS 3361	–	3	4	4	–
HRS 3378	–	3	6	5	–
HRS 3419	–	1	6	3	–
Jenna	3	2	5	4	7
Knudson	2	3	4	3	6
LCS Albany	2	3	6	5	4
LCS Breakaway	4	2	3	5	5
LCS Iguacu	4	2	4	4	–
LCS Powerplay	5	1	5	5	5
Linkert	3	1	4	4	5
Marshall	8	1	6	7	7
Norden	2	1	4	4	5
Prevail	1	3	2	6	-
Prosper	5	2	4	4	5
RB07	2	2	6	6	4
Rollag	4	2	4	5	3
Samson	5	1	5	6	8
SY Ingmar	–	1	3	6	–
SY Rowyn	2	1	3	6	–
SY Soren	3	1	4	4	4
Vantage	6	3	7	6	5
WB-Digger	3	1	5	5	7
WB-Mayville	3	2	6	7	7
WB9507	–	3	6	3	–

[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] Bacterial leaf streak symptoms are highly variable from one environment to the next. The rating of newer entries may change by as much as one rating point as more data is collected.
[4] Combined rating of tan spot and Septoria spp.

Table 4. Relative grain yield of hard red spring wheat varieties in southern Minnesota locations in single-year (2014) and multiple-year comparisons (2012-2014).

	Benson			Kimball		LeCenter[1]		Lamberton			Morris			St. Paul			Waseca		
Entry	2014	2-Yr	3-Yr	2014	2-Yr	2014	2-Yr	2014	2-Yr	3-Yr	2014	2-Yr	3-Yr	2014	2-Yr	3-Yr	2014	2-Yr	3-Yr
Advance	100	102	102	97	99	77	96	106	111	108	106	110	109	86	107	100	82	102	101
Barlow	89	94	94	91	96	77	91	98	102	100	98	101	103	91	100	99	83	85	90
Breaker	100	97	97	97	98	83	95	99	100	100	99	100	101	104	107	104	94	95	99
Elgin-ND	90	94	93	94	95	74	88	102	102	102	101	101	99	98	98	100	75	87	88
Faller	107	108	106	108	100	122	110	106	105	107	107	106	103	111	106	107	98	97	97
Forefront	95	100	102	105	105	109	108	98	98	101	110	104	108	109	104	104	114	115	114
Glenn	96	93	93	88	97	90	89	92	93	94	101	98	96	81	87	87	79	83	77
HRS 3361	99	–	–	106	–	105	–	98	–	–	98	–	–	104	–	–	109	–	–
HRS 3378	99	–	–	94	–	82	–	100	–	–	84	–	–	83	–	–	120	–	–
HRS 3419	101	–	–	114	–	137	–	116	–	–	103	–	–	109	–	–	115	–	–
Jenna	96	102	103	106	103	99	109	101	101	106	106	103	107	111	104	110	111	105	117
Knudson	93	97	98	103	103	99	102	104	101	105	99	98	102	95	97	102	96	98	105
LCS Albany	108	110	111	112	107	98	116	118	115	121	111	111	115	119	114	119	134	132	134
LCS Break	100	102	102	98	99	99	106	93	96	91	97	98	102	84	98	97	84	92	93
LCS Iguacu	104	108	–	110	105	122	–	102	104	–	101	103	–	118	116	–	104	119	–
LCS PP	100	100	101	104	102	117	109	105	106	101	96	101	103	94	95	96	104	94	96
Linkert	92	93	94	99	101	96	104	92	93	95	88	90	90	88	90	95	101	95	102
Marshall	102	99	99	97	93	77	79	90	89	87	88	88	80	88	83	82	78	82	78
Norden	101	99	99	95	91	90	97	100	99	99	91	94	98	97	95	93	113	104	109
Prevail	107	105	101	104	105	118	106	95	101	100	114	111	112	114	111	110	126	134	119
Prosper	112	108	110	102	103	109	105	106	109	105	113	113	112	111	111	111	120	115	112
RB07	95	97	99	99	96	97	99	104	106	102	94	100	98	88	91	94	80	87	88
Rollag	100	95	98	99	97	86	96	95	94	91	94	93	93	97	88	90	83	83	84
Samson	93	97	100	92	97	91	111	92	96	98	87	93	96	94	94	99	100	105	107
SY Ingmar	113	–	–	106	–	131	–	102	–	–	106	–	–	102	–	–	94	–	–
SY Rowyn	108	105	–	106	110	120	–	103	107	–	118	115	–	103	104	–	119	106	–
SY Soren	99	99	100	101	100	96	104	107	102	104	105	100	100	98	97	101	94	94	100
Vantage	97	97	96	98	99	84	90	95	92	100	94	92	89	101	93	94	78	92	93
WB-Digger	97	103	107	94	99	94	104	92	101	99	87	98	98	97	100	103	71	89	101
WB-Mayville	99	102	103	90	98	107	114	87	88	95	82	85	90	99	97	103	80	89	97
WB9507	104	–	–	110	–	123	–	107	–	–	106	–	–	114	–	–	122	–	–
Mean (bu/A)	113.0	99.9	95.0	88.3	77.8	53.7	56.0	81.6	69.7	56.2	80.6	69.3	66.4	67.1	73.4	62.1	37.6	44.0	42.2
LSD (0.10)	8.5	7.7	7.2	4.9	7.3	9.5	10.7	7.6	5.7	4.2	8.0	8.1	6.5	4.7	7.3	5.2	6.5	6.0	5.5

[1] 2014 and 2014 data

Table 5. Relative grain yield of hard red spring wheat varieties in northern Minnesota locations in single-year (2014) and multiple-year comparisons (2012-2014).

	Crookston			Fergus Falls			Hallock			Oklee			Perley		Roseau			Stephen			Strathcona [1]	
Entry	2014	2-Yr	3-Yr	2014	2-Yr	3-Yr	2014	2-Yr	3-Yr	2014	2-Yr	3-Yr	2014	2-Yr	2014	2-Yr	3-Yr	2014	2-Yr	3-Yr	2014	2-Yr
Advance	101	100	101	91	97	99	104	101	102	96	96	93	105	104	90	95	95	95	97	96	101	96
Barlow	84	89	93	80	85	91	99	97	97	100	99	98	94	95	101	102	103	99	102	100	98	101
Breaker	99	100	96	95	96	99	98	97	99	90	93	94	96	98	98	103	103	96	100	101	101	97
Elgin-ND	99	101	103	99	99	100	106	101	99	96	99	98	99	100	97	101	102	103	106	102	94	95
Faller	123	118	116	115	114	108	114	112	110	110	110	107	106	105	103	109	109	108	109	108	108	98
Forefront	103	102	107	112	106	108	104	96	96	98	101	102	102	100	102	96	96	107	100	101	100	105
Glenn	85	87	90	81	88	89	99	91	90	97	96	93	93	94	98	94	90	96	97	95	101	94
HRS 3361	99	–	–	107	–	–	99	–	–	102	–	–	99	–	105	–	–	96	–	–	95	–
HRS 3378	89	–	–	80	–	–	98	–	–	92	–	–	103	–	94	–	–	97	–	–	97	–
HRS 3419	108	–	–	132	–	–	107	–	–	112	–	–	108	–	110	–	–	100	–	–	112	–
Jenna	99	100	103	112	112	112	97	98	100	100	102	102	98	101	102	101	106	101	97	102	100	106
Knudson	106	104	101	100	102	102	107	103	101	98	100	99	100	100	96	97	98	103	100	100	93	95
LCS Albany	116	113	111	116	121	121	108	110	112	115	112	116	101	99	105	112	114	112	109	110	109	111
LCS Breaker	85	89	89	77	87	93	98	99	99	103	98	103	98	99	97	93	97	97	92	97	98	99
LCS Iguacu	111	109	–	120	118	–	99	101	–	114	109	–	102	107	108	109	–	106	100	–	108	–
LCS Powerplay	97	102	106	104	101	101	100	103	102	102	104	107	94	97	107	108	107	98	105	105	106	101
Linkert	95	97	95	84	87	92	97	99	99	95	94	96	95	96	104	98	98	96	94	93	100	98
Marshall	92	96	95	88	96	92	98	99	96	82	90	90	100	99	90	95	94	96	100	96	91	88
Norden	96	99	99	96	97	96	99	98	97	101	101	101	98	99	92	96	98	101	100	100	100	101
Prevail	98	99	99	118	109	107	101	102	101	101	97	97	98	98	104	101	100	100	95	97	103	104
Prosper	116	112	107	116	113	109	112	109	109	111	112	111	107	108	107	107	110	105	113	110	107	99
RB07	102	101	100	98	98	98	96	101	100	98	97	99	102	101	100	98	98	102	99	98	98	99
Rollag	102	97	102	97	98	99	99	98	98	96	96	96	97	97	94	91	93	97	95	98	95	96
Samson	87	93	96	84	94	102	102	103	104	107	105	108	102	104	113	105	103	104	101	102	106	107
SY Ingmar	104	–	–	100	–	–	98	–	–	94	–	–	99	–	94	–	–	97	–	–	101	–
SY Rowyn	111	106	–	114	108	–	103	102	–	104	101	–	98	97	99	94	–	97	93	–	97	–
SY Soren	102	99	100	102	100	102	99	96	99	99	100	103	95	99	105	100	102	98	95	99	101	108
Vantage	93	92	93	100	103	98	93	95	94	95	95	94	99	99	93	98	95	90	101	100	102	101
WB-Digger	94	100	102	92	97	101	106	105	106	108	108	110	99	103	105	100	101	98	102	102	110	107
WB-Mayville	86	93	93	81	87	96	98	99	99	102	100	101	99	94	106	97	98	94	91	94	99	102
WB9507	111	–	–	116	–	–	112	–	–	109	–	–	107	–	103	–	–	112	–	–	99	–
Mean (bu/A)	94.7	91.2	81.3	78.4	82.4	78.2	87.8	101.0	97.3	93.5	86.1	84.9	82.1	86.8	87.7	79.4	78.1	60.4	79.0	78.3	89.9	80.1
LSD (0.10)	94.7	6.6	6.7	5.7	8.3	8.4	5.4	5.9	4.7	5.6	5.7	6.5	3.7		6.4	8.3	5.8	2.7	6.9	5.6	5.8	

[1] 2012 and 2014 data

Table 6. Relative grain yield of hard red spring wheat varieties in Minnesota in single-year (2014) and multiple-year comparisons (2012-2014).

	State			North			South		
Entry	**2014**	**2-Yr**	**3-Yr**	**2014**	**2-Yr**	**3-Yr**	**2014**	**2-Yr**	**3-Yr**
Advance	97	100	100	98	99	98	96	102	103
Barlow	93	96	97	95	96	97	91	96	97
Breaker	97	99	99	97	98	98	97	99	100
Elgin-ND	96	98	98	99	100	100	93	96	96
Faller	110	109	107	111	111	108	108	106	105
Forefront	104	102	103	103	100	102	104	104	106
Glenn	93	93	92	94	93	92	91	92	91
HRS 3361	101	-	-	100	-	-	102	-	-
HRS 3378	94	-	-	94	-	-	94	-	-
HRS 3419	111	-	-	111	-	-	112	-	-
Jenna	102	102	105	101	101	104	103	103	107
Knudson	99	100	101	100	100	100	98	100	102
LCS Albany	111	112	114	110	111	112	113	113	117
LCS Breakaway	94	96	98	94	94	97	95	98	99
LCS Iguacu	108	108	-	108	107	-	108	109	-
LCS Powerplay	101	102	103	101	103	104	102	101	101
Linkert	95	95	96	96	95	96	93	94	96
Marshall	91	93	91	92	96	94	91	90	87
Norden	98	98	98	98	98	99	97	97	98
Prevail	105	104	103	103	100	100	109	110	107
Prosper	110	110	109	110	110	108	110	110	109
RB07	98	98	98	100	99	99	95	97	97
Rollag	96	95	96	97	96	97	95	93	93
Samson	97	99	102	100	101	103	92	96	101
SY Ingmar	103	-	-	98	-	-	108	-	-
SY-Rowyn	106	104	-	103	100	-	110	109	-
SY-Soren	101	99	101	100	99	101	101	99	102
Vantage	95	96	96	96	98	97	94	94	95
WB-Digger	98	101	103	102	103	104	92	99	102
WB-Mayville	94	95	98	96	95	97	93	95	100
WB9507	109	-	-	108	-	-	110	-	-
Mean (bu/A)	79.8	79.3	74.6	84.3	86.9	83.1	74.6	70.6	64.8
LSD (0.10)	2.9	2.0	1.6	4.0	2.5	2.2	4.1	3.1	2.3
No. Environments	15	28	41	8	15	22	7	13	19

Table 7. Grain yield (bushels per acre) of hard red spring wheat varieties grown under conventional and intensive management.

	North						South	
	2014		2-Year		3-Year		2014	
Entry	Conv	Int	Conv	Int	Conv	Int	Conv	Int
Advance	87.0	105.3	83.1	99.4	78.1	92.4	85.9	91.8
Barlow	84.4	101.4	80.9	94.5	78.2	89.3	79.5	83.0
Breaker	89.8	103.7	86.6	97.4	79.0	90.3	80.3	84.8
Elgin-ND	89.6	102.6	86.2	96.9	81.9	90.1	82.4	86.3
Faller	103.1	117.1	97.1	106.9	89.8	99.3	86.3	90.3
Forefront	93.7	106.0	84.9	94.9	81.1	89.0	84.3	84.7
Glenn	83.2	99.5	77.0	90.7	72.0	83.3	78.5	85.4
HRS 3361	93.2	110.0	–	–	–	–	79.2	84.0
HRS 3378	83.4	103.2	–	–	–	–	74.7	81.6
HRS 3419	99.2	118.1	–	–	–	–	88.8	94.0
Jenna	91.4	102.2	85.6	95.6	83.2	91.2	84.0	85.4
Knudson	92.4	105.9	86.1	97.2	79.3	91.6	82.1	82.6
LCS Albany	100.7	111.0	95.7	105.7	89.7	98.0	92.7	87.1
LCS Breaker	83.2	104.4	77.6	93.1	74.1	88.2	76.9	87.9
LCS Iguacu	99.6	111.9	92.8	102.5	–	–	82.4	88.5
LCS Powerplay	92.9	110.9	89.5	102.8	85.0	96.6	81.7	85.9
Linkert	90.5	103.7	83.1	92.9	77.0	86.1	73.1	78.6
Marshall	83.1	105.7	81.3	96.6	75.5	89.5	72.2	82.2
Norden	85.7	103.0	83.3	96.9	78.5	90.1	77.1	84.0
Prevail	92.2	103.1	85.3	94.9	79.5	89.3	84.8	82.7
Prosper	101.8	115.5	93.5	104.9	86.5	99.5	88.7	90.0
RB07	92.3	108.9	84.7	98.2	79.0	91.1	80.3	84.0
Rollag	89.3	103.8	80.6	93.8	78.0	87.8	76.2	79.7
Samson	90.6	104.0	84.1	94.4	79.3	89.4	72.5	86.1
SY Ingmar	90.7	103.0	–	–	–	–	84.5	88.7
SY Rowyn	96.0	106.9	85.6	96.0	–	–	89.7	91.9
SY Soren	94.4	107.2	85.3	95.3	80.6	92.4	86.0	86.3
Vantage	85.0	95.4	80.7	91.5	75.2	86.3	76.4	82.6
WB-Digger	90.8	107.9	85.5	101.1	81.1	96.0	72.6	84.3
WB-Mayville	87.2	105.1	80.4	94.6	75.9	90.9	68.4	80.6
WB9507	97.6	110.4	–	–	–	–	86.2	92.9
Mean (bu/A)		106.3	85.2	97.3	79.9	91.2	80.9	85.7
LSD (0.10)		8.2	5.3	54.4	4.4	4.2	8.1	5.7
No. Environment		2	4	4	6	6	2	2

South				State					
2-Year		3-Year		2014		2-Year		3-Year	
Conv	Int	Conv	Int	Conv	Int	Conv	Int	Conv	Int
76.7	75.2	66.3	71.5	86.4	98.5	79.9	87.3	72.2	82.0
70.7	67.5	62.2	67.2	81.9	92.2	75.8	81.0	70.2	78.2
69.2	70.3	61.8	67.0	85.0	94.2	77.9	83.9	70.4	78.7
70.7	68.5	61.4	65.4	86.0	94.5	78.4	82.7	71.6	77.8
73.1	71.0	64.1	68.6	94.7	103.7	85.1	88.9	77.0	84.0
70.0	68.3	64.3	65.8	89.0	95.4	77.4	81.6	72.7	77.4
66.5	66.9	58.2	64.1	80.8	92.5	71.8	78.8	65.1	73.7
–	–	–	–	86.2	97.0	–	–	–	–
–	–	–	–	79.0	92.4	–	–	–	–
–	–	–	–	94.0	106.1	–	–	–	–
70.8	68.7	65.2	67.5	87.7	93.8	78.2	82.1	74.2	79.4
69.3	67.7	63.1	65.3	87.3	94.2	77.7	82.5	71.2	78.4
78.7	72.1	72.1	70.4	96.7	99.0	87.2	88.9	80.9	84.2
67.5	69.8	59.4	66.7	80.0	96.1	72.6	81.4	66.7	77.5
72.2	71.1	–	–	91.0	100.2	82.5	86.8	–	–
71.9	70.0	62.5	69.1	87.3	98.4	80.7	86.4	73.7	82.8
63.7	63.3	56.5	61.6	81.8	91.1	73.4	78.1	66.8	73.9
61.7	64.4	50.8	62.5	77.7	94.0	71.5	80.5	63.1	76.0
67.1	66.7	60.4	64.9	81.4	93.5	75.2	81.8	69.4	77.5
73.7	67.6	65.3	65.0	88.5	92.9	79.5	81.2	72.4	77.2
77.2	72.5	66.8	70.2	95.3	102.8	85.3	88.7	76.7	84.8
71.5	67.7	61.2	63.1	86.3	96.5	78.1	82.9	70.1	77.1
64.9	62.2	56.4	59.5	82.8	91.7	72.7	78.0	67.2	73.7
65.6	71.4	59.6	69.0	81.6	95.0	74.9	82.9	69.4	79.2
–	–	–	–	87.6	95.8	–	–	–	–
77.1	71.7	–	–	92.8	99.4	81.4	83.8	–	–
70.2	68.7	62.7	65.4	90.2	96.7	77.7	82.0	71.6	78.9
64.0	65.8	57.5	62.1	80.7	89.0	72.3	78.7	66.4	74.2
68.9	69.1	60.5	67.9	81.7	96.1	77.2	85.1	70.8	81.9
60.0	65.4	56.4	61.5	77.8	92.8	70.2	80.0	66.1	76.2
–	–	–	–	91.9	101.6	–	–	–	–
69.7	68.6	61.4	65.9	86.2	96.0	77.5	82.9	70.7	78.5
4.4	3.7	4.0	3.0	5.7	4.9	3.6	3.2	3.0	2.6
4	4	6	6	4	4	8	8	12	12

Table 8. Relative grain yield of barley varieties at several locations in Minnesota single-year (2014) and multiple year comparisons (2012-2014).

	Crookston	Morris		Stephen		St. Paul		Roseau		State Mean	
Entry	**2-Yr [1]**	**2014**	**2-Yr [2]**	**2014**	**3-Yr**	**2014**	**2-Yr [2]**	**2014**	**3-Yr**	**2014**	**3-Yr**
Celebration	105	116	101	109	104	106	103	106	99	109	104
Conlon	94	99	99	113	102	87	92	78	85	94	95
Innovation	103	92	107	97	96	131	120	95	101	104	104
Lacey	104	104	103	99	98	97	97	107	106	102	103
Pinnacle	105	104	103	97	105	97	100	113	108	103	104
Quest	98	106	106	91	100	111	112	107	103	104	100
Rasmusson	102	113	117	111	104	106	110	97	109	107	109
Rawson	101	71	81	93	99	86	94	98	101	87	94
Robust	98	92	88	99	94	96	91	109	100	99	96
Stellar-ND	100	97	92	99	100	89	90	91	93	94	96
Tradition	91	102	99	93	98	94	91	97	94	97	95
Mean (bu/A)	91	99	85	52	108	111	125	149	96	103	101
LSD (0.05)	10	11	11	12	9	19	11	14	9	10	4

[1] 2012 and 2013 data.
[2] 2013 and 2014 data.

Table 9: Relative grain yield of barley varieties in on-farm trials at Fergus Falls, Hallock, Oklee, Perley, Kimball and Strathcona, Minnesota.

Entry	2014 [1]	2-Yr [2]	3-Yr
Celebration	104	104	105
Conlon	89	91	92
Innovation	101	104	103
Lacey	105	106	104
Pinnacle	101	100	103
Quest	101	103	97
Rasmusson	111	110	110
Rawson	92	91	96
Robust	93	93	94
Stellar-ND	101	102	98
Tradition	103	101	99
Mean (bu/A)	113	110	109
LSD (0.05)	9	9	7

[1] Fergus Falls and Hallock sites were not harvested.
[2] Perley and Strathcona sites were not harvested.

Table 10. Agronomic characteristics of barley varieties, 2008-2014.

Entry	Type	Use	Days to Heading	Height (inches)	Lodging	Plump (%)	Protein (%)
Celebration	6-row	Malt	59	34	med.	84	13.6
Conlon	2-row	Malt	56	31	med.	95	13.0
Innovation	6-row	Malt	58	31	med.	95	12.9
Lacey	6-row	Malt	58	32	strong	94	13.2
Pinnacle	2-row	Malt	59	32	strong	97	12.0
Quest	6-row	Malt	58	33	med.	91	13.1
Rasmusson	6-row	Malt	58	30	strong	92	13.0
Rawson	2-row	Feed	58	32	med.	97	12.7
Robust	6-row	Malt	59	34	med.	91	13.8
Stellar-ND	6-row	Malt	58	32	strong	94	13.2
Tradition	6-row	Malt	59	32	strong	92	13.4
No. Environments			21	18	8	15	15

Table 11. Disease reactions of barley varieties in multiple year comparisons [1].

Entry	Fusarium Head Blight	Net Blotch	Speckled Leaf Blotch	Spot Blotch	Stem Rust [2]	Bacterial Leaf Streak
Celebration	7	3	9	4	1	5
Conlon	6	3	9	5	1	5
Innovation	8	4	9	2	1	6
Lacey	8	6	9	2	1	6
Pinnacle	9	6	9	4	1	6
Quest	5	5	9	3	1	6
Rasmusson	9	5	9	2	1	6
Rawson	8	5	9	3	1	3
Robust	8	5	9	2	1	6
Stellar-ND	9	6	9	2	1	7
Tradition	8	4	9	2	1	7
No. Environments						

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

Table 12. Agronomic and quality characteristics of oat varieties in single-year (2014) and multiple-year comparisons (2012-2014)

Entry	Breeder	Year of Release	Seed Color	Maturity [1]		Plant Height [2]		Lodging [3]		Test Weight (lbs/bu)		Grout (%)	Grain Protein %
				2014	3-Yr	2014	3-Yr	2014	3-Yr	2014	3-Yr	2-Yr	2014
AAC Justice	Ag Canada/UMN	2015	White	9	4	4	3	4	-	34.3	37.9	-	12.7
Badger	U of Wisconsin	2010	Yellow	1	1	1	1	3	3	32.5	36.6	70.9	13.4
Colt	SDSU	2010	White	1	2	3	3	5	4	35.4	39.8	73.3	14.9
Deon	U of Minnesota	2014	Yellow	8	9	6	6	1	2	34.7	38.7	72.7	14.0
Esker	U of Wisconsin	2006	Yellow	2	3	3	3	1	2	32.2	36.4	72.0	14.3
Goliath	SDSU	2013	White	9	7	9	9	5	-	36.3	40.3	-	14.4
Horsepower	SDSU	2012	White	3	3	2	1	4	3	36.1	39.6	71.9	13.5
Jury	NDSU	2012	White	8	5	8	8	6	-	35.4	39.2	-	13.4
Newburg	NDSU	2011	White	8	5	8	7	5	4	34.6	38.7	72.7	12.8
Rockford	NDSU	2008	White	7	7	6	6	3	3	36.4	39.9	72.1	13.9
Ron	U of Wisconsin	2014	Yellow	6	-	5	-	2	-	34.0	-	-	15.0
Saber	U of Illinois	2010	Yellow	2	2	2	2	1	2	35.2	38.9	73.6	14.4
Shelby 427	SDSU	2011	White	2	2	6	5	2	2	36.3	40.3	72.7	14.4
Souris	NDSU	2008	White	6	5	5	3	5	3	35.0	38.7	72.3	13.7
Tack	U of Illinois	2006	White	3	3	3	2	2	2	35.3	39.5	72.9	14.4
LSD(0.10)										0.9	0.9	1.8	0.6

[1] 1=earliest and 9=latest [2] 1=shortest and 9=tallest [3] 1=least prone and 9=most prone

Table 13. Relative grain yield of oat varieties in Minnesota in single-year (2014) and multiple-year comparisons (2012-2014).

	Lamberton		Morris		Crookston		Stephen		Roseau		State	
Entry	2014	3-Yr	2014	3-Yr	2014	3-Yr	2014	2-Yr [2]	2014	3-Yr [2]	2014	3-Yr
AAC Justice	85	-	91	-	109	-	119	-	112	-	105	-
Badger	104	100	78	80	92	90	66	87	93	92	91	95
Colt	88	87	63	91	56	67	69	79	79	78	66	85
Deon	116	103	119	110	114	114	119	115	107	106	114	110
Esker	115	106	101	104	96	106	99	101	93	91	99	107
Goliath	102	-	90	-	108	-	104	-	100	-	103	-
Horsepower	74	98	104	105	105	106	119	105	109	107	102	98
Jury	100	-	96	-	109	-	111	-	104	-	105	-
Newburg	100	106	108	115	111	108	104	108	112	113	110	105
Rockford	77	89	111	105	100	101	90	104	92	102	97	88
Ron [1]	115	79	100	110	96	-	88	-	94	-	99	102
Saber	96	109	111	103	91	96	97	104	96	84	96	103
Shelby 427	90	110	103	93	91	91	94	91	93	94	93	97
Souris	81	94	96	98	95	96	109	107	96	109	94	90
Tack	80	92	84	89	85	91	85	88	99	91	87	90
Mean (bu/A)	149	123	158	144	178	128	96	183	191	174	170	125
LSD(0.10)	17	14	20	12	14	9	11	10	14	10	11	7

[1] 2012 and 2014 data [2] 2013 and 2014 data

2014 North Dakota Hard Red Spring Wheat

Variety Trial Results for 2014 and Selection Guide - Preliminary Report

By Joel Ransom, Mohamed Mergoum, Senay Simsek, Maricelis Acevedo, Tim Friesen, Zhaohui Liu and Shaobin Zhong (NDSU Main Station); John Rickertsen (Hettinger Research Extension Center); Eric Eriksmoen (North Central Research Extension Center, Minot); Bryan Hanson (Langdon Research Extension Center); Glenn Martin (Dickinson Research Extension Center); Gautam Pradhan (Williston Research Extension Center); Blaine Schatz and Mike Ostlie (Carrington Research Extension Center).

Hard red spring (HRS) wheat was harvested from 6.19 million acres in 2014, up from 5.06 million acres in 2013. The average yield of spring wheat was 47.5 bushels/acre (bu/a), up slightly from the yield of 46 bu/a recorded last year.

Barlow was again the most popular HRS wheat variety in 2014, occupying 15.7 percent of the planted acreage, followed by Prosper (11.7), SY Soren (10.4), Faller (8.8), Glenn (8.2), and WB Mayville (4.4). SY Soren was released by Syngenta/AgriPro and WB Mayville was released by Monsanto/WestBred. All other varieties are NDSU releases.

Much of the spring wheat was planted later than is considered optimal due to a late and wet spring. However, temperatures were moderate during much of the growing season which helped the development of relatively high yield potential even in the late plantings. There were some reports of scab damage, and DON levels varied considerably depending on planting and flowering date and variety grown.

Successful wheat production depends on numerous factors, including selecting the right variety for a particular area. The information included in this publication is meant to aid in selecting that variety or group of varieties. Characteristics to consider in selecting a variety may include yield potential, protein content when grown with proper fertility, straw strength, plant height, reaction to problematic pests (diseases, insects, etc.) and maturity. Every growing season differs; therefore, when selecting a variety, we recommend using data that summarize several years and locations. Choose the variety that, on average, performs the best at multiple locations near your farm during several years.

Selecting varieties with good milling and baking quality also is important to maintain market recognition and avoid discounts. Hard red spring wheat from the northern Great Plains is known around the world for its excellent end-use quality. Millers and bakers consider many factors in determining the quality and value of wheat they purchase. Several key parameters are: high test weight (for optimum milling yield and flour color), high falling number (greater than 300 seconds indicates minimal sprout damage), high protein content (the majority of HRS wheat export markets want at least 14 percent protein) and excellent protein quality (for superior bread-making quality as indicated by traditional strong gluten proteins, high baking absorption and large bread loaf volume).
Gluten strength, and milling and baking quality ratings, are provided for individual varieties based on the results from the NDSU field plot variety trials. These ratings are applied to varieties grown for multiple years at seven NDSU Research Extension Centers across the state to provide producers and end users with end-use performance data. The wheat protein data often are higher than obtained in actual production fields but can be used to compare differences among varieties.

The agronomic data presented in this publication are from replicated research plots using experimental designs that enable the use of statistical analysis. These analyses enable the reader to determine, at a predetermined level of confidence, if the differences observed among varieties are reliable or if they might be due to error inherent in the experimental process. The LSD (Least Significant Difference) values beneath the columns in the tables are derived from these statistical analyses and apply only to the numbers in the column in which they appear. If the difference between two varieties exceeds the LSD value, it means that with 90 percent confidence (LSD probability 0.10), the higher-yielding variety has a significant yield advantage. When the difference between two varieties is less than the LSD value, no significant difference was found between those two varieties under those growing conditions.

NS is used to indicate no significant difference for that trait among any of the varieties at the 90 percent level of confidence. The CV stands for coefficient of variation and is expressed as a percentage. The CV is a measure of variability in the trial. Large CVs mean a large amount of variation that could not be attributed to differences in the varieties. Yield is reported at 13.5% moisture while protein content is reported at 12% moisture content.

Presentation of data for the entries tested does not imply approval or endorsement by the authors or agencies conducting the test. North Dakota State University approves the reproduction of any table in the publication only if no portion is deleted, appropriate footnotes are given and the order of the data is not rearranged. Additional data from county sites are available from each Research Extension Center at www.ag.ndsu.edu/varietytrials/spring-wheat.

2014 Variety Trials • North Dakota

Table 1. North Dakota hard red spring wheat variety descriptions, agronomic traits, 2014.

Variety	Agent or Origin [1]	Year Re-leased	Height (inch-es)	Straw Strength [2]	Days to Head [3]	Reaction to Disease [4] Stem Rust [5]	Leaf Rust	Leaf Spot [6]	Bact. Leaf Streak	Head Scab
Advance	SD	2012	32	6	64	R	MR/MS	M	MS	MS
Alpine [7]	AgriPro	2008	34	6	62	MS	S	MS	S	MS
Barlow	ND	2009	35	6	62	R	MS	MR	MS	M
Brennan	AgriPro	2009	30	4	62	R	MR	M	MS	MS
Brick	SD	2009	35	5	60	R	MS	MS/S	NA	MR
Duclair [8]	MT	2011	31	4	65	R	NA	NA	NA	NA
Elgin-ND	ND	2012	36	5	65	R	MS	M	MS/S	M
Faller	ND	2007	35	5	65	R	S	MR	MS	M
Forefront	SD	2012	37	5	61	R/MR	MR	MR	M	MR
Glenn	ND	2005	37	4	61	R	MS	M	M/MS	MR
HRS 3361	**Croplan**	**2013**	**33**	**3**	**65**	**NA**	**MS/MR**	**MR**	**NA**	**M**
HRS 3378	**Croplan**	**2013**	**32**	**4**	**64**	**NA**	**MR**	**M**	**NA**	**M**
HRS 3419	**Croplan**	**2014**	**32**	**2**	**68**	**NA**	**MR**	**MR**	**NA**	**MR**
Jenna	AgriPro	2009	32	4	66	R	MR	M	M/MS	M
Kelby	AgriPro	2006	30	4	62	R/MR	MR/MS	M	S	M
Kuntz	AgriPro	2007	31	4	65	NA	MS	MS	NA	M
LCS Albany	Limagrain	2008	32	5	67	NA	MR	MS	M	M
LCS Breakaway	Limagrain	2011	32	5	63	R	R	MS	MS	M
LCS Iguacu	**Limagrain**	**2014**	**33**	**3**	**66**	**NA**	**MS**	**M**	**M/MS**	**MR**
LCS Powerplay	Limagrain	2011	33	5	65	R	MS	MS	S	M
Linkert	MN	2013	31	2	63	R	MR/MS	M	MS	M
Mott [7]	ND	2009	36	3	66	R	MS	MS	MS	MS
MS Chevelle	**Meridian**	**2014**	**30**	**5**	**63**	**NA**	**R**	**NA**	**NA**	**M**
MS Stingray	Meridian	2013	35	NA	67	NA	MS	NA	NA	NA
ND901CL Plus [9]	ND	2010	36	4	60	MR	MS/MR	NA	NA	M
Norden	MN	2012	32	3	6	R	MR/MS	M	S	M
Pivot	WestBred	2010	27	3	67	NA	S	MR	NA	S
Prevail	**SD**	**2014**	**31**	**4**	**64**	**NA**	**MR**	**MS**	**NA**	**M**
Prosper	NDSU	2011	35	5	65	R	MS	M	MS	M
RB07	MN	2007	32	5	62	R	MS	MS	MS/S	MR
Rollag	MN	2011	32	3	63	R	MR/MS	MR	M	MR
Sabin	MN	2009	33	6	65	R	MR/MS	MS	NA	M
Samson	WestBred	2007	31	2	63	O	MR/MS	MS	MS	S
Select	SD	2010	35	6	60	R	MS	R/MR	S	MR
SY Ingmar	**Syngenta/ AgriPro**	**2014**	**31**	**4**	**64**	**NA**	**MR**	**M**	**M**	**M**
SY Rowyn	Syngenta/ AgriPro	2013	31	4	62	R	R	M	M	M

Table 1 continued...

SY Soren	Syngenta/ AgriPro	2011	30	4	63	R	R	M	S	M
SY Tyra [8]	Syngenta/ AgriPro	2011	31	5	62	R	R	MS	S	S
Vantage	WestBred	2007	32	2	67	MR	R	MS	MS/S	MS
Velva	NDSU	2011	35	4	63	R	R	M	S	MS
WB9507	**WestBred**	**2013**	**32**	**5**	**61**	**NA**	**MR**	**R**	**NA**	**MR**
WB9879CLP [9]	**WestBred**	**2012**	**33**	**4**	**64**	**NA**	**MS**	**MR**	**NA**	**MS**
WB Digger	WestBred	2009	34	6	63	MR	R	M	NA	MS
WB Gunnison	WestBred	2013	31	NA	65	NA	MS	MS	M	MS
WB Mayville	WestBred	2011	30	4	63	R	R	MS	S	S

[1] Refers to agent or developer: MN = University of Minnesota; MT = Montana State University; ND = North Dakota State University; SD = South Dakota State University; **Bold** varieties are those recently released, so data is limited and rating values may change. NA indicates insufficient information is available to make an accurate assessment.
[2] Straw Strength = 1 to 9 scale, with 1 the strongest and 9 the weakest. These values are based on recent data and may change as more data become available.
[3] Days to Head = the number of days from planting to head emergence from the boot averaged from several locations in 2010 and 2011.
[4] R = resistant; MR = moderately resistant; M = intermediate; MS = moderately susceptible; NA = Not adequately tested; S = susceptible.
[5] Fargo stem rust nursery inoculated with Puccinia graminis f. sp. Tritici races TPMK, TMLK, RTQQ, QFCQ and QTHJ.
[6] Leaf spot refers to the leaf fungal diseases such as tan spot and septoria. It does not include bacterial leaf streak.
[7] Hard white wheat.
[8] Solid stemmed or semisolid stem, imparting resistance to sawfly.
[9] CL = refers to a Clearfield variety, with tolerance to the Beyond™ family of herbicides.

Table 2. Analytical milling and baking data from field plot variety trials at Carrington, Casselton, Dickinson, Hettinger, Langdon, Minot and Williston, 2012 and 2013 (unless otherwise noted).

Variety	2014 N.D. Planted	OBS [1]	Test Weight	Protein 12% MB	Vitre-ous kernels	Falling Number	Farinograph Stability	Farino-graph Absorption	Loaf Volume	Mill and Bake Quality Rating
	(% area)		(lb/bu)	(%)	(%)	(sec-onds)	(minutes)	(%)	(cc)	(1-5 Stars) [2]
Advance	--	13	62.9	13.4	63	424	10.2	59.5	922	**
Barlow	15.7	13	62.5	14.9	80	403	11.2	66.0	981	***
Brennan	3.2	13	62.4	14.6	64	442	7.8	63.5	908	*
Elgin-ND	2.7	13	61.4	14.5	84	423	9.0	64.4	967	**
Faller	8.8	13	61.0	13.7	69	433	11.6	63.0	954	**
Forefront	--	13	62.3	14.2	60	429	10.7	61.1	966	***
Glenn [3]	8.2	13	63.9	15.1	89	407	13.8	65.2	983	*****
Jenna	1.1	13	61.3	14.0	55	440	8.7	62.9	928	**
LCS Break-away	--	7	63.8	14.8	84	447	6.5	64.2	913	*
Linkert	--	13	62.1	15.3	74	452	18.1	63.2	976	****
Norden	--	13	63.3	13.9	86	413	8.8	63.2	923	**
Prevail	--	10	61.5	13.8	62	398	9.1	60.7	915	**
Prosper	11.7	13	61.3	13.9	69	419	10.9	63.2	944	**
Rollag	1.5	13	62.6	14.8	70	522	7.2	65.9	877	*
Select	1.1	13	62.9	14.2	71	443	7.4	62.7	915	*
SY Soren	10.4	13	62.3	14.6	60	447	10.0	62.4	948	**
Vantage	1.9	13	63.1	15.7	87	358	11.4	64.0	943	***
Velva	1.3	13	61.2	14.1	75	412	10.0	63.2	921	**

Analyses conducted at the NDSU Hard Red Spring Wheat Quality Laboratory in Fargo, N.D. For footnotes, see bottom of Table 3

Table 3. Analytical milling and baking data from field plot variety trials at Dickinson, Hettinger, Langdon, Minot and Williston, 2013 (unless otherwise noted).

Variety	2014 N.D. Planted	OBS [1]	Test Weight	Protein 12 % MB	Vitreous Kernels	Falling Number	Farinograph Stability	Farinograph Absorption	Loaf Volume	Mill and Bake Quality Rating
	(% area)		(lb/bu)	(%)	(%)	(seconds)	(minutes)	(%)	(cc)	(1-5) [2]
Advance	--	7	63.7	13.1	63	425	9.5	60.2	908	**
Barlow	15.7	7	63.4	14.7	83	389	9.1	66.6	955	***
Brennan	3.2	7	62.9	14.6	67	432	7.8	64.3	896	*
Duclair	--	4	61.8	13.8	72	401	9.6	61.2	916	**
Elgin-ND	2.7	7	62.5	14.4	91	420	8.3	65.3	961	**
Faller	8.8	7	62.1	13.7	73	424	10.3	64.1	951	***
Forefront	--	7	62.9	14.2	62	425	10.3	62.1	956	***
Glenn [3]	8.2	7	64.6	15.0	93	388	11.7	65.7	981	*****
Jenna	1.1	7	62.0	13.7	53	436	8.5	63.4	914	**
Kelby	1.9	5	62.5	15.0	64	415	7.9	63.6	921	**
Linkert	--	7	63.0	14.8	73	449	17.1	63.8	959	****
Mott	2.9	6	62.9	14.4	78	386	9.3	62.5	903	***
Norden	--	7	64.2	13.6	83	421	8.7	64.3	901	**
LCS Albany	--	5	62.7	13.0	62	433	7.5	59.1	875	*
LCS Breakaway	--	6	64.1	14.7	82	450	6.3	64.2	909	*
LCS Powerplay	--	6	63.6	13.8	73	418	7.0	65.6	915	*
Prevail	--	7	61.8	13.8	62	387	8.0	61.5	915	**
Prosper	11.7	7	62.8	13.6	76	415	9.8	64.3	936	**
RB07	2.6	5	62.8	14.3	75	411	10.5	62.5	971	***
Rollag	1.5	7	63.5	14.7	75	521	6.7	67.1	863	*
Select	1.1	7	63.4	13.9	75	428	7.3	63.2	903	*
Steele-ND	1.7	6	63.6	14.5	72	408	8.3	64.9	958	***
SY Rowyn	--	7	62.7	13.6	63	443	21.9	61.0	929	****
SY Soren	10.4	7	63.1	14.4	66	425	9.4	63.2	941	***
Vantage	1.9	7	63.7	15.1	82	342	11.1	64.3	937	***
Velva	1.3	7	62.2	14.2	74	416	9.4	64.1	916	**
WB Mayville	4.4	5	62.5	14.7	66	474	10.9	65.7	942	***

Analyses conducted at the NDSU Hard Red Spring Wheat Quality Laboratory in Fargo, N.D.

[1] Observations

[2] Mill and Bake Quality Rating scale 1 to 5, with 1 being low and 5 being superior.

[3] Glenn is the current Wheat Quality Council check variety for comparing new experimental lines and newly released varieties.

Table 4. Yield of hard red spring wheat varieties grown at four locations in eastern North Dakota, 2012-2014.

	Carrington		Casselton		Prosper		Langdon		Avg. Eastern N.D.	
Variety	**2014**	**3 Yr.**	**2014**	**3 Yr.**	**2014**	**2 Yr.**	**2014**	**3-Yr.**	**2014**	**2/3 Yr.**
	------------(bu/a)------------									
Advance	88.9	60.2	90.3	78.7	83.8	69.4	84.9	87.5	87.0	74.0
Alpine	85.8	61.9	79.0	76.1	75.1	66.1	91.5	89.9	82.9	73.5
Alsen	85.4	61.7	74.6	69.2	72.0	60.3	--	--	--	--
Barlow	87.4	64.9	78.2	68.5	77.3	62.5	85.5	83.7	82.1	69.9
Breaker	85.8	61.3	89.4	75.5	82.4	67.9	83.1	85.6	85.2	72.6
Brennan	83.3	62.9	82.3	73.2	77.3	63.8	80.0	75.0	80.7	68.7
Duclair	75.5	--	83.9	--	75.0	--	--	--	--	--
Elgin-ND	93.2	66.8	88.5	76.1	78.8	67.4	90.1	88.6	87.7	74.7
Faller	110.9	72.4	101.2	82.5	92.0	73.3	95.5	97.5	99.9	81.4
Forefront	92.9	67.9	91.5	78.2	83.2	71.4	74.3	80.2	85.5	74.4
Glenn	87.6	61.3	76.5	66.5	77.2	67.7	75.8	78.3	79.3	68.5
Howard	94.2	67.1	86.8	75.8	79.9	65.3	--	--	--	--
HRS 3361	100.0	--	--	--	--	--	84.6	--	--	--
HRS 3378	85.6	--	--	--	--	--	87.1	--	--	--
HRS 3419	110.2	--	--	--	--	--	88.9	--	--	--
Jenna	100.0	69.1	87.8	80.0	77.6	67.2	87.0	85.4	88.1	75.4
Kelby	83.6	60.5	72.9	66.4	75.7	66.3	--	--	--	--
LCS Albany	106.5	67.5	93.7	--	77.9	--	95.2	93.0	93.3	--
LCS Breakaway	89.3	61.2	82.3	--	83.2	--	77.1	80.3	83.0	--
LCS Iguacu	94.5	--	94.6	--	85.2	--	90.6	--	91.2	--
LCS Powerplay	96.6	66.5	87.8	--	79.4	--	88.1	88.1	88.0	--
Linkert	92.3	65.5	83.8	--	77.5	--	81.7	77.7	83.8	--
Mott	97.2	66.0	89.5	74.3	80.1	63.0	--	--	--	--
MS Chevelle	102.6	--	81.0	--	81.7	--	91.2	--	89.1	--
MS Stingray	105.4	--	102.1	--	78.0	--	93.4	--	94.7	--
ND901CL Plus	83.3	60.7	78.9	67.3	76.3	63.8	--	--	--	--
Norden	96.3	64.0	83.7	74.6	78.5	64.0	80.5	80.9	84.8	70.9
Prevail	93.4	67.7	--	--	--	--	84.8	82.5	--	--
Prosper	105.2	69.4	89.9	76.1	90.1	74.5	92.9	95.4	94.5	78.9
RB07	92.2	63.7	90.6	75.9	79.2	67.6	88.3	86.1	87.6	73.3
Rollag	97.5	67.9	83.8	72.0	80.8	66.4	85.1	79.4	86.8	71.4
Samson	72.6	57.4	81.1	76.9	82.7	67.0	86.3	83.1	80.7	71.1
Select	94.8	66.6	80.9	72.3	83.0	61.7	77.3	79.8	84.0	70.1
Steele-ND	89.8	64.3	83.0	73.8	76.4	64.6	--	--	--	--
SY605 CL	82.9	59.2	82.6	72.5	85.5	70.4	--	--	--	--
SY Ingmar	90.9	--	89.6	--	76.1	--	86.8	--	85.9	--
SY Rowyn	93.1	64.5	93.1	--	87.0	--	87.0	86.8	90.1	--
SY Soren	89.9	63.5	83.1	74.6	74.3	65.2	85.1	80.8	83.1	71.0
SY Tyra	85.0	58.8	78.6	70.3	63.3	54.0	--	--	--	--
Vantage	92.3	61.9	82.2	70.7	70.0	54.4	81.4	78.0	81.5	66.3
Velva	90.2	59.1	86.3	75.3	70.5	58.8	92.6	87.9	84.9	70.3
WB Digger	94.8	66.6	95.2	80.7	80.1	67.6	90.3	89.5	90.1	76.1
WB Mayville	77.9	57.7	76.6	68.6	80.8	64.4	81.4	79.2	79.2	67.5
WB9507	104.8	--	--	--	--	--	86.8	--	--	--
Mean	91.3	63.9	84.9	73.8	78.2	65.0	85.7	84.2	86.5	72.4
CV%	5.6	--	4.9	--	8.1	--	5.6	--	--	--
LSD 0.10	6.0	--	4.9	--	7.4	--	5.5	--	--	--

Table 5. Yield of hard red spring wheat varieties grown at four locations in western North Dakota, 2012-2014.

	Dickinson		Hettinger		Minot		Williston		Avg. Western N.D.	
Variety	**2014**	**3 Yr.**	**2014**	**3 Yr.**	**2014**	**3 Yr.**	**2014**	**3 Yr.**	**2014**	**3 Yr.**
	---(bu/a)---									
Advance	88.1	67.4	89.0	80.6	67.1	60.5	38.0	33.0	70.6	60.4
Alpine	92.6	68.0	--	--	55.7	47.8	46.1	--	--	--
Barlow	91.1	69.3	80.1	73.3	62.2	55.8	36.3	35.0	67.4	58.4
Breaker	88.4	67.6	84.5	76.6	--	--	39.0	35.7	--	--
Brennan	84.9	66.2	80.4	76.7	54.1	49.2	41.3	37.5	65.2	57.4
Duclair	88.5	--	--	--	66.6	54.2	40.3	36.6	--	--
Elgin-ND	88.9	69.0	88.5	77.4	62.3	52.9	41.7	37.6	70.4	59.2
Faller	95.1	73.2	94.1	72.4	76.4	62.4	41.5	34.7	76.8	60.7
Forefront	80.0	64.3	85.2	75.3	55.8	49.2	45.0	40.2	66.5	57.3
Glenn	86.0	67.9	77.1	69.6	57.5	50.8	33.7	35.3	63.6	55.9
Howard	91.2	69.3	80.3	74.4	72.0	59.1	40.5	33.1	71.0	59.0
HRS 3361	83.9	--	88.2	--	56.6	--	38.0	--	66.7	--
HRS 3378	92.7	--	89.6	--	58.7	--	36.5	--	69.4	--
HRS 3419	69.8	--	97.9	--	67.7	--	41.9	--	69.3	--
Jenna	93.3	73.2	86.5	75.4	67.5	52.2	42.5	38..9	72.5	66.9
Kelby	81.3	61.4	--	--	54.9	47.9	37.8	36.4	--	--
LCS Albany	91.2	68.7	95.4	--	77.1	62.3	44.0	35.7	76.9	--
LCS Breakaway	88.9	66.6	86.4	--	63.1	55.8	37.1	36.3	68.9	--
LCS Iguacu	78.2	--	88.2	--	60.0	--	39.6	--	66.5	--
LCS Powerplay	92.2	72.5	82.9	--	65.0	58.6	40.9	40.1	70.3	--
Linkert	87.2	64.8	80.5	74.0	61.1	--	41.6	37.7	67.6	58.8
Mott	87.0	66.9	78.9	72.4	60.6	54.9	38.9	33.4	66.4	56.9
MS Chevelle	--	--	91.3	--	65.0	--	--	--	--	--
MS Stingray	87.4	--	95.9	--	75.1	--	--	--	--	--
ND901CL Plus	79.5	63.9	73.5	66.1	59.9	51.9	37.0	33.0	62.5	53.7
Norden	87.4	67.4	83.5	75.3	54.3	55.2	39.7	36.0	66.2	58.5
Prevail	85.3	63.1	87.2	79.2	74.1	57.9	43.3	--	72.5	--
Prosper	88.7	67.8	86.3	75.3	74.7	61.7	41.6	35.4	72.8	60.1
RB07	61.1	58.7	84.1	75.4	61.1	53.0	42.6	38.1	62.2	56.3
Rollag	86.5	65.6	84.2	76.2	63.2	56.1	40.2	--	68.5	--
Samson	87.6	70.3	90.1	79.9	65.0	53.7	41.5	37.4	71.1	60.3
Select	82.4	63.4	82.6	73.9	53.4	57.3	36.1	35.9	63.6	57.6
Steele-ND	79.9	63.9	80.9	73.5	69.3	58.0	41.3	33.9	67.9	57.3
SY605 CL	89.8	67.8	83.1	78.4	60.4	51.3	37.9	33.6	67.8	57.8
SY Ingmar	88.3	--	82.1	--	68.1	--	44.2	--	70.7	--
SY Rowyn	87.0	65.4	85.0	79.4	74.6	--	37.3	--	71.0	72.4
SY Soren	86.9	66.5	86.2	80.2	62.3	50.6	37.2	35.6	68.2	58.2
SY Tyra	90.8	68.7	85.7	78.1	56.7	53.7	41.2	36.2	68.6	59.2
Vantage	83.1	61.8	75.4	67.7	56.3	50.9	38.3	33.4	63.3	53.5
Velva	96.0	72.7	85.7	77.6	66.2	57.1	46.2	39.7	73.5	61.8
WB Digger	96.0	72.7	92.5	83.9	68.8	56.6	42.9	36.4	75.1	62.4
WB Gunnison	86.4	64.7	73.4	65.2	60.2	47.8	40.4	32.4	65.1	52.5
WB Mayville	93.2	67.9	79.7	73.0	66.6	52.9	40.4	34.8	70.0	57.2
WB9507	89.0	--	92.8	--	73.4	--	45.0	--	75.1	--
WB9879CLP	90.8	--	83.4	--	56.9	--	38.0	--	67.3	--
Mean	86.9	67.1	85.2	75.2	63.8	54.5	40.3	35.8	69.1	58.2
CV %	5.4	--	5.2	--	11.3	--	8.0	--	--	--
LSD 0.10	5.5	--	5.2	--	8.3	--	3.8	--	--	--

Table 6. Protein at 12 percent moisture of hard red spring wheat varieties grown at eight locations in North Dakota, 2014.

Variety	Carrington	Casselton	Prosper	Dickinson	Hettinger	Langdon	Minot	Williston	State Avg.
Advance	14.0	13.2	14.5	11.7	12.7	12.6	12.4	14.8	13.2
Alpine	14.9	13.5	14.2	12.6	--	12.9	12.8	13.9	13.5
Alsen	15.0	14.4	15.0	--	--	--	--	--	14.8
Barlow	14.6	13.5	14.8	12.5	13.8	13.9	14.4	15.5	14.1
Breaker	14.4	13.3	14.6	11.8	13.2	13.0	13.5	14.8	13.6
Brennan	14.4	14.3	14.3	12.5	12.5	13.8	14.7	15.5	14.0
Duclair	14.3	13.5	14.9	12.1	--	--	14.0	14.5	13.9
Elgin-ND	14.8	13.6	14.3	12.7	13.4	13.7	13.9	15.4	14.0
Faller	14.3	12.2	13.8	11.9	11.9	12.3	12.7	14.5	13.0
Forefront	14.7	14.1	14.4	12.7	13.2	13.8	13.5	14.4	13.9
Glenn	15.3	14.0	14.5	11.7	14.5	14.4	14.6	15.3	14.3
Howard	14.6	13.3	14.6	12.7	12.9	--	14.4	14.7	13.9
HRS 3361	14.3	--	--	11.7	11.7	13.5	13.8	15.4	13.4
HRS 3378	13.5	--	--	11.6	12.1	12.4	13.1	14.3	12.8
HRS 3419	13.5	--	--	11.6	11.8	12.3	11.5	14.2	12.5
Jenna	14.6	13.5	14.7	12.2	13.0	12.7	14.3	14.3	13.7
Kelby	14.4	14.4	14.9	13.8	--	--	13.7	15.3	14.4
LCS Albany	13.6	12.3	13.5	11.4	12.2	11.7	12.1	14.4	12.7
LCS Breakaway	15.0	13.9	14.8	12.3	13.5	13.7	14.5	15.2	14.1
LCS Iguacu	12.5	12.3	13.3	10.6	11.1	11.6	12.0	14.1	12.2
LCS Powerplay	14.2	12.8	13.9	12.4	12.4	13.4	13.9	14.8	13.5
Linkert	14.8	14.7	15.2	13.7	14.2	13.6	14.3	15.8	14.5
Mott	15.1	13.5	14.8	12.5	12.9	--	13.6	15.3	14.0
MS Chevelle	13.2	13.1	13.7	--	10.7	12.5	12.7	--	12.7
MS Stingray	12.2	11.3	12.7	11.0	10.5	10.7	10.9	--	11.3
ND901CL Plus	16.6	14.8	15.5	13.0	14.9	-	14.6	16.9	15.2
Norden	13.9	13.2	14.3	12.1	12.5	13.2	13.4	14.5	13.4
Prevail	14.1	13.0	14.4	12.9	12.2	13.3	13.8	14.5	13.5
Prosper	14.2	12.1	13.8	11.5	11.7	12.4	13.1	15.3	13.0
RB07	14.8	13.5	14.5	13.1	13.3	13.8	13.4	15.0	13.9
Rollag	15.2	13.9	15.2	13.2	13.7	14.1	14.0	15.4	14.3
Samson	13.6	13.4	14.2	11.9	11.8	12.5	13.0	14.5	13.1
Select	14.7	13.2	14.0	12.3	12.7	13.7	13.3	14.7	13.6
Steele-ND	14.6	13.5	14.2	12.7	13.6	--	14.2	14.8	13.9
SY605 CL	15.8	13.7	14.9	13.2	14.1	--	13.3	15.6	14.4
SY Ingmar	14.8	13.9	15.2	12.7	13.2	13.7	14.1	15.1	14.1
SY Rowyn	13.9	13.1	13.7	12.7	12.0	12.9	12.9	14.0	13.2
SY Soren	14.7	13.9	14.9	12.4	13.4	13.4	13.6	15.5	14.0
SY Tyra	13.7	12.5	14.1	11.9	11.8	--	13.2	14.3	13..1
Vantage	16.6	15.1	15.5	13.1	14.9	14.4	14.4	16.1	15.0
Velva	14.8	12.9	15.1	12.3	13.0	12.5	13.8	14.9	13.7
WB Digger	15.1	13.3	14.2	10.9	12.7	12.8	13.5	14.5	13.4
WB Mayville	14.8	14.1	14.3	12.0	13.2	13.6	14.1	14.3	13.8
WB9507	14.8	--	--	11.8	12.2	13.1	13.2	15.4	13.4
WB9879CLP	--	--	--	12.8	12.3	--	12.4	15.1	13.2
Mean	14.5	13.4	14.4	12.3	12.8	13.1	13.5	14.9	13.6
CV %	1.6	3.6	4.1	6.4	3.7	4.2	6.8	4.0	--
LSD 0.10	0.3	0.6	0.7	1.1	0.5	0.7	1.1	0.7	--

Table 7. Test weight of hard red spring wheat varieties grown at eight locations in North Dakota, 2014.

Variety	Carrington	Casselton	Prosper	Dickinson	Hettinger	Langdon	Minot	Williston	State Avg.
	(lb/bu)								
Advance	61.0	63.4	62.1	57.6	61.5	62.6	62.4	59.8	61.3
Alpine	57.9	61.0	60.8	55.9	--	61.1	60.0	60.2	59.6
Alsen	60.5	63.6	62.1	--	--	--	--	--	62.1
Barlow	60.9	62.4	61.9	57.4	60.9	62.9	61.1	60.5	61.0
Breaker	60.9	63.9	63.4	58.8	61.5	62.7	64.4	61.5	62.1
Brennan	60.3	62.2	61.4	55.9	60.0	62.5	59.7	61.3	60.4
Duclair	58.7	61.5	61.0	54.6	--	--	59.0	58.2	58.8
Elgin-ND	60.4	62.7	61.7	55.8	60.8	62.3	60.8	59.1	60.5
Faller	61.3	63.2	62.2	55.9	61.1	62.2	62.7	58.4	60.9
Forefront	60.4	63.1	62.0	57.1	61.2	62.1	60.6	61.0	60.9
Glenn	62.8	64.2	63.7	55.2	62.4	64.0	61.2	62.3	62.0
Howard	61.6	63.3	62.8	55.4	61.5	--	61.8	59.4	60.8
HRS 3361	60.9	--	--	55.9	60.1	61.3	60.7	59.2	59.7
HRS 3378	60.7	--	--	56.9	60.9	62.7	62.8	61.0	60.8
HRS 3419	60.4	--	--	54.9	60.2	60.0	60.5	57.3	58.9
Jenna	59.7	62.5	60.3	56.2	60.0	61.4	61.9	59.1	60.1
Kelby	60.2	62.5	61.5	56.8	--	--	60.4	61.4	60.5
LCS Albany	61.1	63.3	60.8	55.9	59.1	61.9	62.6	58.8	60.4
LCS Breakaway	61.2	63.3	63.0	58.0	62.2	62.9	63.7	61.5	62.0
LCS Iguacu	60.8	63.2	61.8	54.6	59.8	62.0	61.2	60.8	60.5
LCS Powerplay	61.3	62.7	62.9	56.5	60.8	62.4	61.4	60.5	61.1
Linkert	60.6	63.1	61.7	57.0	60.8	62.2	59.7	59.6	60.6
Mott	61.0	63.0	61.2	57.0	60.8	--	61.1	60.4	60.6
MS Chevelle	59.7	61.3	61.0	--	60.2	62.1	59.7	--	60.7
MS Stingray	59.9	61.6	59.7	54.4	58.7	60.1	62.3	--	59.5
ND901CL Plus	60.4	62.5	61.2	55.9	60.0	--	60.4	60.5	60.1
Norden	61.8	64.0	63.0	58.1	62.3	63.2	63.7	61.0	62.1
Prevail	60.1	62.3	61.7	56.0	61.0	61.9	61.1	59.5	60.5
Prosper	61.0	62.0	62.2	56.4	60.7	62.4	63.1	58.1	60.7
RB07	60.4	63.0	60.7	50.6	60.1	62.1	59.9	61.1	59.7
Rollag	61.7	63.5	62.6	57.5	61.6	63.0	61.5	60.4	61.5
Samson	56.9	61.1	61.2	54.0	59.2	60.9	59.4	59.7	59.1
Select	61.3	63.2	62.7	58.5	62.7	62.6	59.9	60.5	61.4
Steele-ND	60.7	62.4	62.7	58.2	61.3	--	61.4	59.7	60.9
SY605 CL	60.9	63.1	61.8	55.1	62.0	--	59.0	60.1	60.3
SY Ingmar	60.8	63.0	61.7	56.9	61.3	62.9	62.4	60.7	61.2
SY Rowyn	60.2	63.0	62.2	57.0	60.3	62.2	60.6	59.6	60.6
SY Soren	60.9	62.6	61.6	57.0	61.3	63.2	61.7	60.0	61.0
SY Tyra	59.6	61.2	61.1	56.2	60.4	--	60.6	61.5	60.1
Vantage	62.4	64.4	62.8	56.2	61.1	63.5	63.3	61.1	61.9
Velva	58.9	62.6	60.2	55.2	59.2	61.2	59.6	59.5	59.6
WB Digger	60.5	61.6	60.3	56.8	59.9	61.9	61.8	59.0	60.2
WB Mayville	58.4	61.0	61.6	55.5	59.6	61.4	61.1	60.8	59.9
WB9507	59.0	--	--	54.1	58.7	60.4	59.9	57.4	58.3
WB9879CLP	--	--	--	52.2	59.5	--	57.2	60.5	57.4
Mean	60.5	62.7	61.8	56.14	60.7	62.1	61.1	60.0	60.5
CV %	0.8	1.1	0.8	1.9	0.7	0.7	1.7	1.0	--
LSD 0.10	0.6	0.8	0.6	1.2	0.5	0.5	1.2	0.7	--

NOTES

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