

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

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Research Questions

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 with shorter, stronger straw.
 - 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.

Results

The funds provided by this project us to test our elite HRSW germplasm and selected varieties in Alvarado and Wolverton, MN. Agronomic data including diseases reactions are collected on these advanced yield trials conducted at the two MN locations and three locations in in eastern ND (Casselton, Prosper, and Langdon). Table 1. Provides data from three eastern ND locations across two years, 2013 and 2014. Faller and Prosper continue to be the top yielding varieties, but they have mean protein below 14.0%. Varieties having mean yield greater than 80 bu/ac and protein greater than 14% include Bolles, Elgin ND, and RB07.

In trials grown in MN in 2015, the trial at Wolverton was sown in early April into dry soil conditions. Emergence was uneven; however, precipitation received later in May and June resolved the situation. Growing conditions at Alvarado were favorable throughout the growing season. Mean yield at Alvarado and Wolverton was 61.8 and 67.2 bu/ac, respectively (Figures 1 and 2. Mean protein was 15.7 and 14.9 at Alvarado and Wolverton, respectively (Figures 3 and 4). In looking for lines/varieties that have yield and grain protein greater than Elgin-ND, nine lines were found in Alvarado and eight were found in Wolverton. Three lines were found that yield and protein greater than Elgin-ND at both locations. A change for the 2016 trials in Minnesota will be the addition of Bolles to the trial as a check.

Grain from both 2015 locations will be sent to the NDSU Wheat Quality Laboratory of Dr. Senay Simsek for milling

and baking evaluation. Additionally, seed from these trials will be shared with NDSU and USDA-ARS pathologists to determine their reaction to the common diseases that impact hard red spring production in the region.

Application and Use

Information from this research is used to identify improved varieties that are acceptable to growers in the wheat growing areas of Minnesota and acceptable those who use and process the harvested grain. NDSU varieties grown in Minnesota in 2015 included Prosper and Faller, which were grown on 16.6% and 12.2% of Minnesota's wheat acres, respectively.

Materials and Methods

1. Crosses and populations development:
About 170 new crosses were specifically made in fall 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 F₁'s generated by these crosses were either increased for another generation in the winter greenhouse to generate F₂ seed or crossed back to another parent to make three-way crosses. The F₂ segregating were grown in the field at Casselton and Prosper, ND. About 100-200 spikes were selected from the most promising F₂ population and this seed will be sown in Puerto Rico in November 2015 for generation advancement. In fall 2015, about 170 new crosses will be made to generate materials for the next cycle of breeding and evaluation.

2. Diseases evaluation/screening:
Germplasm 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 the Department of Plant Pathology and USDA-ARS. Diseases screened for include leaf and stem rust, FHB, and tan spot. A major goal of the program is to identify plants with resistance to the race of leaf rust that overcame the resistance previously provided by the gene LR21.

3. Early generations and preliminary and intermediate yield trials evaluation/testing:

In 2015, the breeding program evaluated about 170 F₂ populations and 16,500 F₃ and F₄ lines that were designed for the Eastern ND and Western MN. Similarly, about 1,500 F₄, 1500 F₅ and 600 F₆ or later lines were evaluated for disease resistances and agronomic traits in the preliminary yield trials (PYT) and intermediate trials (IYT), respectively. PYTs were evaluated in non-replicated plots while IYTs were evaluated in trials arranged as a randomized complete block designs with two replicates. Agronomic and disease notes are taken from the field and seed of these entries were evaluated for some quality traits in the laboratory (Dr S. Simsek). Promising lines will 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 grown at Alvarado and Wolverton, MN. Entries are assigned to plots using a randomized complete block design and each entry is replicated four times at each location.

b. ND Testing:

The same yield trial conducted in MN sites was tested in 2015 in several locations across ND with three locations in eastern ND. These locations are Casselton, Prosper and Langdon. The other yield trials including PYT, IYT, and AYT were conducted in many sites in the Eastern parts of ND. The number of replicates and experimental design of these trials are similar to those conducted in MN.

5. Quality Evaluation:

Grain samples from the 2015 from all of our trials grown in MN and ND will be sent to Dr. Simsek's 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 data so we can determine which lines to advance for further testing.

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 Dr. Shiaoan Chao. Dr. Chao is a scientist with the USDA-ARS in Fargo that oversees the genotyping center. DNA samples from about 1500 lines included in the yield trials will be sent to Dr. Chao's lab for genotyping with the markers associated with the QTL on chromosome 3BS for FHB resistance (FHB1) and the marker for the LR31 gene that confers resistance to the new race of leaf rust that is virulent on Faller and Prosper.

7. Uniform Regional Nurseries (URN):

We will be submitting new material from the breeding program to the URS in 2016. We will not have any restrictions on including data on our lines in any reports as has

been the case previously. Our breeding program included five lines in the URN and we will grow the trial at five locations in North Dakota, including Prosper and Langdon.

Economic Benefit to a Typical

500 Acre Wheat Enterprise

In 2014, the last year complete data are available, 66.5 million bushels of wheat was grown on 1.26 million acres. The farmgate value of this production was over \$368 million. Given that Prosper and Faller were grown on 35.2% of Minnesota's wheat acres in 2014, the value of the crop produced from these varieties two varieties was approximately \$126 million.

Related Research

I am going to use this section to update the Council on the hiring of a new hard spring wheat breeder at NDSU.

Dr. Mergoum resigned his position at NDSU on September 1, 2015 to take a job with the University of Georgia in Griffin, Georgia. A national search is ongoing at NDSU to fill the position, with University Distinguished Professor Dr. Elias Elias chairing the search. We are advertising at the Assistant/Associate Professor rank with the hope that a mid-career person with experience in wheat breeding will apply for the position. The search committee has been tasked to reach out to identify qualified candidates and inviting them to apply. The initial screening of applicants will begin on November 23. We have an aggressive timeline to fill this position. We will do phone interview of candidates in early December and invited the top individuals to campus in early January for on-campus interviews. We will keep stakeholder groups, including yours, informed of when these individuals will be on campus so you have the opportunity to meet with them and attend their seminars. For those that are unable to attend the seminars, we will have video recordings and we will provide a link so you can view them online. We hope to have the new breeder beginning their work at NDSU in early March. This timing would allow them to see their new breeding material in the field in Puerto Rico and Arizona.

In the interim until the new breeder is hired, I am working with the very qualified group of four technicians on the project. We selected materials to send to the off-season nurseries in New Zealand, Arizona, and Puerto Rico; and selected crosses to make in the fall greenhouse. Our goal for crossing this fall was to maintain our high yield and grain quality while incorporating genes for resistance to the new race of leaf rust, reduced plant height, and improved straw strength. We greatly appreciate the support provided by the MNWPRC to our program, which allows us to continue our efforts to develop and release improved cultivars for Minnesota growers.

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Recommended Future Research

- Baking and milling quality will be determined on grain harvested from the Alvarado and Wolverton, MN research sites in the Wheat Quality laboratory of Dr. Simsek.
- Reaction of entries to stem and leaf rust, tan spot, and FHB will be determined by NDSU and USDA-ARS scientists.
- Experimental lines currently in the breeding program with favorable agronomic performance, disease resistance, and end-use quality will be advanced to the next level of yield trials, including the trial that is grown at Alvarado and Wolverton, MN.
- New populations will be generated through crossing. We need to increase the frequency of the allele for leaf rust that confers resistance to the race of leaf rust that is virulent on Faller and Prosper.
- Bolles needs to be added as a check for the trials grown in MN in 2016.

Publications

Echeverry-Solarte, Morgan, A. Kumar, S. Kianian, S. Simsek, M.S. Alamri, E.E. Mantovani, P.E. McClean, E.L. Deckard, E. Elias, B. Schatz, S.S. Xu, M. Mergoum. 2015. New QTL alleles for quality-related traits in spring wheat revealed by RIL population derived from supernumerary x non-supernumerary spikelet genotypes. *Theor. Appl. Genet.* 128(5):893-912.

Jonathan T. Eckard, Karl D. Glover, Mohamed Mergoum, James A. Anderson and Jose L. Gonzalez-Hernandez. 2015. Multiple Fusarium head blight resistance loci mapped and pyramided onto elite spring wheat Fhb1 backgrounds using an IBD-based linkage approach. *Euphytica* 204:63-79.

Kumar, A., R. Seetan, M. Mergoum, V.K. Tiwari, M.J. Iqbal, Y. Wang, O. Al-Azzam, H. Šimková, M-C. Luo, J. Dvorak, Y.Q. Gu, A. Denton, A. Jilian, G.R. Lazo, and S.K. Kianian. 2015. Radiation hybrid maps of the D-genome of *Aegilops tauschii* and their application in sequence assembly of large and complex plant genomes. *BMC Genomics* 16(1):800.

Appendix:

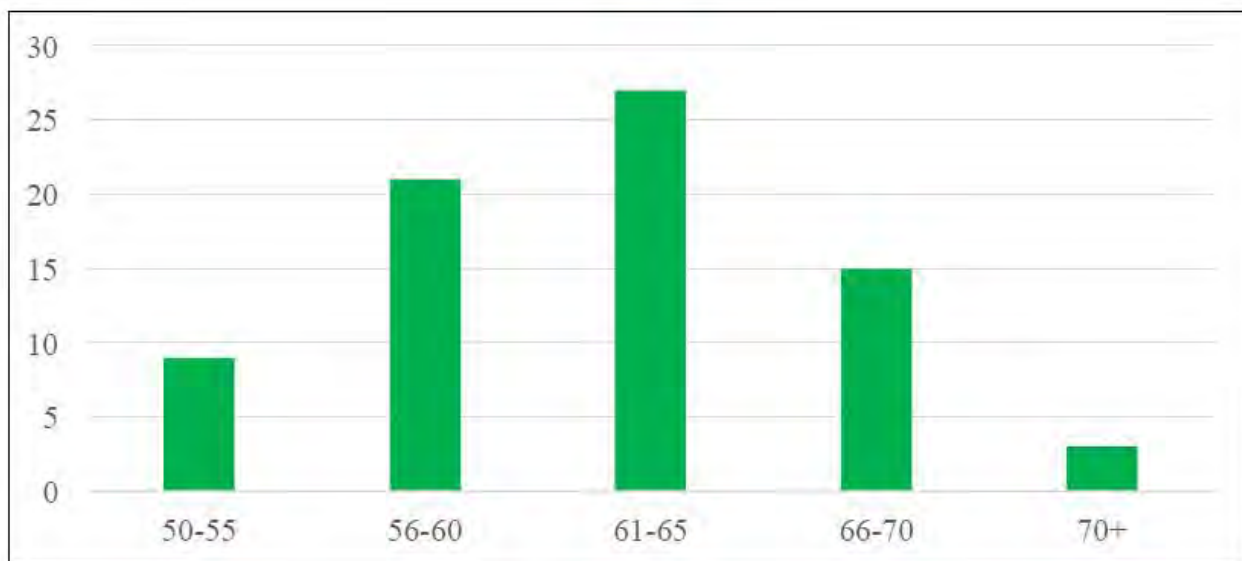


Figure 1. Frequency distribution of grain yield (bu/ac) for 75 hard red spring wheat lines grown in the NDSU yield trial at Alvarado, MN in 2015. Grain yield was 65.6 bu/ac for Elgin-ND, 66.4 bu/ac for Barlow, 74.8 bu/ac for Prosper, and 77.0 bu/ac for Faller.

Table1. Agronomic performance of selected varieties grown in Prosper, Casselton, and Langdon, ND (2013-2014)

Variety	Days to heading (days after 31 May)	Plant height (inches)	Foliar disease (%)	Test		
				Yield (bu/ac)	weight (lb/bu)	Protein (%)
Station years	6	6	1	6	6	6
Advance	52.4	31.7	4.6	81.3	62.8	13.3
Barlow	50.3	33.6	5.8	76.2	62.5	14.2
Bolles	54.3	33.0	16.3	81.1	62.1	15.0
Breaker	53.3	33.2	5.5	80.0	63.3	13.7
Brennan	51.6	29.1	12.6	74.7	62.0	14.3
Elgin	51.5	36.7	6.3	84.7	62.0	14.0
Faller	53.3	33.6	12.9	93.3	62.4	13.1
Forefront	49.3	36.6	6.7	79.0	62.3	14.3
Glenn	50.3	35.7	5.8	76.3	64.1	14.5
Jenna	54.7	32.2	12.3	84.2	61.4	13.7
LCS Breakaway	50.2	30.4	27.4	80.0	63.4	14.2
LCS Powerplay	51.7	32.8	10.3	83.6	62.6	13.4
Linkert	52.5	28.9	4.4	75.0	62.5	14.7
Norden	52.4	32.0	16.1	79.0	63.5	13.5
Prevail	51.1	34.1	15.8	81.2	61.9	13.6
Prosper	52.9	33.6	6.1	88.2	62.2	13.1
RB07	51.0	32.3	12.1	83.0	62.2	14.1
Rollag	51.7	30.4	13.2	76.8	63.0	14.6
Smason	51.5	31.1	16.4	81.1	61.2	13.7
Select	49.0	34.3	15.9	77.3	63.0	13.7
SY Rowyn	51.2	30.5	17.9	81.1	62.2	13.4
SY Soren	51.5	29.1	12.8	79.4	62.5	14.2
Vantage	55.4	31.7	8.5	74.7	63.2	15.1
Velva	54.6	33.9	6.4	81.1	61.0	13.7
WB Digger	53.3	33.1	13.5	84.3	61.2	13.6
WB-Mayville	50.7	29.1	35.1	73.7	61.4	14.4
Maximum	55.4	36.7	35.1	93.3	64.1	15.1
Minimum	49.0	28.9	4.4	73.7	61.0	13.1
Average	52.0	32.4	12.3	80.4	62.4	14.0

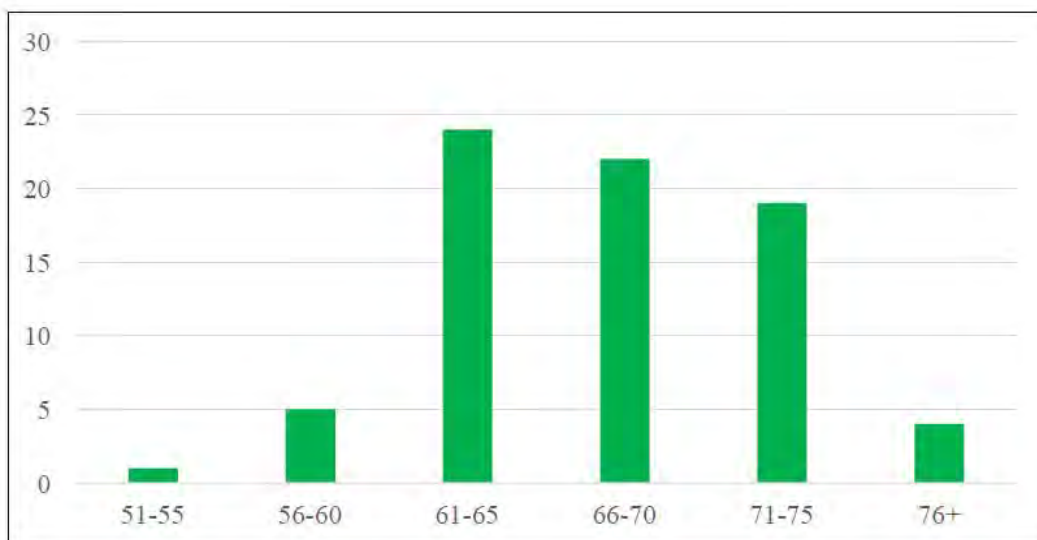


Figure 2. (left) Frequency distribution of grain yield (bu/ac) for 75 hard red spring wheat lines grown in the NDSU yield trial at Wolverton, MN in 2015. Grain yield was 69.1 bu/ac for Elgin-ND, 68.6 bu/ac for Barlow, 77.5 bu/ac for Prosper, and 78.2 bu/ac for Faller.

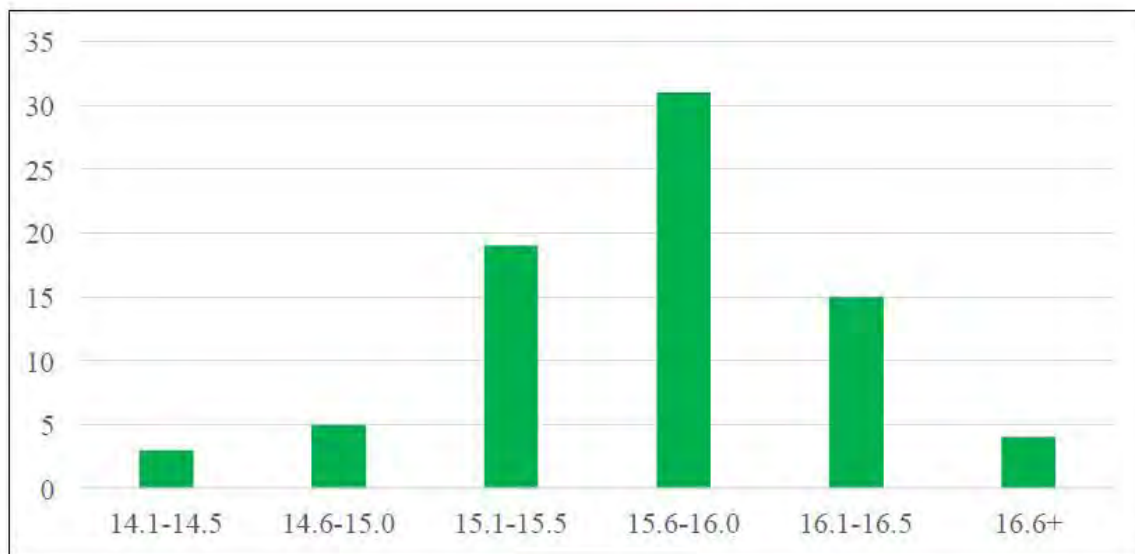


Figure 3. Frequency distribution of percent grain protein for 75 hard red spring wheat lines grown in the NDSU yield trial at Alvarado, MN in 2015. Grain protein was 14.9% for Elgin-ND, 15.2% for Barlow, 14.5% for Prosper, and 14.2% for Faller.

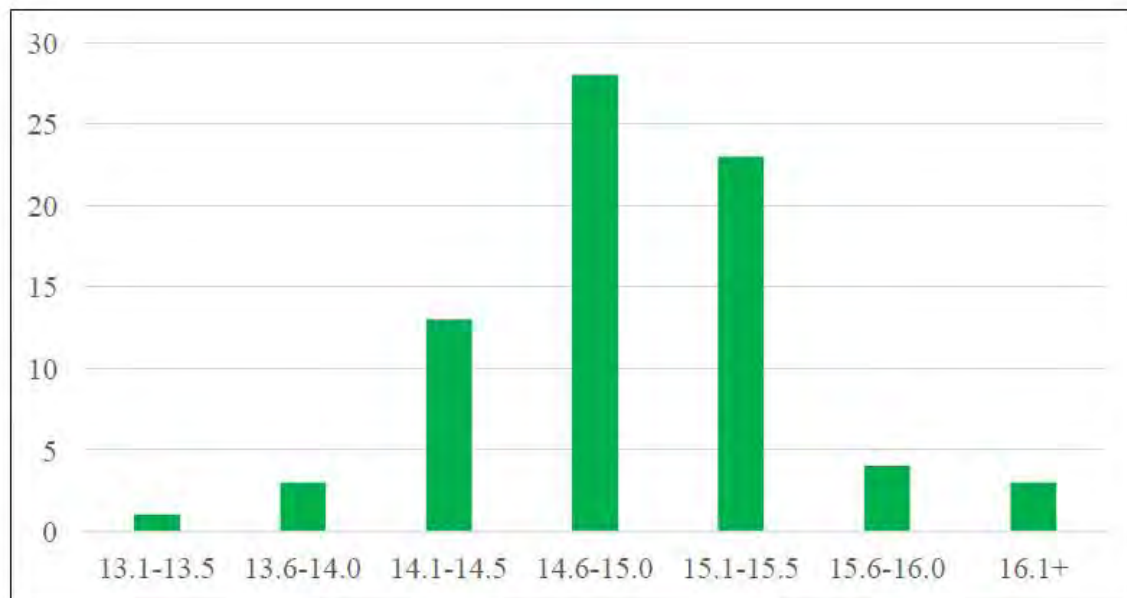


Figure 4. Frequency distribution of percent grain protein for 75 hard red spring wheat lines grown in the NDSU yield trial at Wolverton, MN in 2015. Grain protein was 15.1% for Elgin-ND, 15.0% for Barlow, 13.2% for Prosper, and 14.1% for Faller.