

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

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## 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 (MN-WRPC), our efforts have bore 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. [Continuing support by the MNWRPC to our program will allow us to continue our efforts to release adapted cultivars to the MN wheat growers.](#)

## 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 Procedures

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 Alvarado site will be presented for 2014 research activities in MN. Currently, seed from this trial are being processed to be sent 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:

*continued on page 106*

### 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:

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 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 germplasm against leaf rust in the region. Among the cultivars that have this gene are Faller and Prosper. Fortunately, many other cultivars and germplasm carry other genes that protect against this new race. In general,

we screen the germplasm 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 extra locations in Western MN in 2014 as it we did in the previous 3 years. 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 AYT 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 diverse 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 Wolvevorton location was flooded, therefore we lost it. Alavarado however, was overall good except for some lodging that occurred as a result of heavy rains that prevailed late in the season. Therefore, in this report only agronomic data collected at Alavarado are reported. Seed from 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 Wolvevorton (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 Wolvevorton, 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 Wolvevorton, respectively (Figures 2 and 3). In the same trials, 27 and 15 lines had yields between 91 and 100 bu/ac at Alvarado and more than 71 bu/ac at Wolvevorton. The yields of the recently released cultivar “Elgin-ND” across Alvarado and Wolvevorton 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 trials 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 milestones 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 Wolvevorton, respectively (Figures 2 and 3). In 2012, across Alvarado and Wolvevorton, 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 2000-13. Particularly

*continued on page 108*

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 its 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.

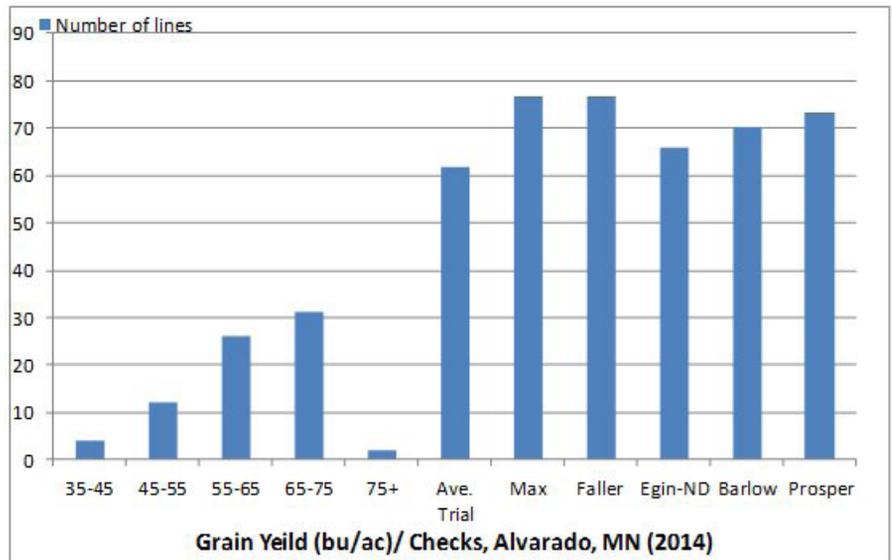
Based on the above statistics, the impact of our breeding program on the MN wheat growers through the release of adapted and modern HRSW cultivars is substantial. NDSU cultivars released since 2007, including Faller and Prosper have played a major role in the wheat production in MN, the wheat industry 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
<b>4</b>	<b>Faller</b>	<b>56.5</b>	<b>33.3</b>	<b>1.9</b>	<b>0.2</b>	<b>12.0</b>	<b>60.2</b>	<b>76.7</b>	<b>13.8</b>
<b>5</b>	<b>Prosper</b>	<b>56.7</b>	<b>33.2</b>	<b>2.6</b>	<b>0.2</b>	<b>8.6</b>	<b>60.1</b>	<b>75.1</b>	<b>13.9</b>
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
<b>10</b>	<b>Elgin-ND</b>	<b>53.9</b>	<b>35.1</b>	<b>3.0</b>	<b>0.6</b>	<b>12.3</b>	<b>59.9</b>	<b>71.4</b>	<b>14.8</b>
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

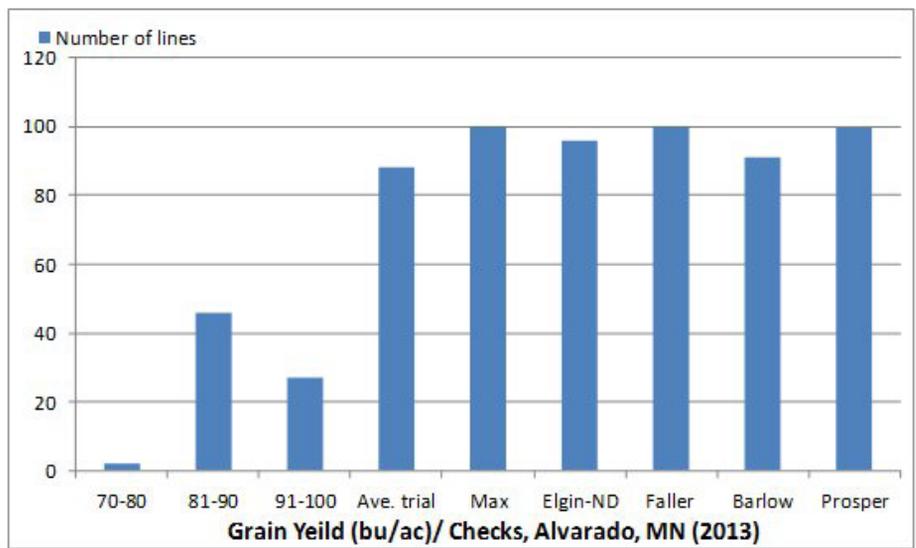
**Figure 1:** Frequency distribution of hard red spring lines in relationship with yield levels achieved at Alvarado, MN during 2014.

**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.**

