Developing South Dakota Winter Wheat Varieties with High Yield, Disease Resistance, and Excellent End-use Quality

South Dakota Wheat Commission

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Research Summary:

The objective of the breeding program at South Dakota State University is to rapidly develop high-yielding winter wheat varieties with excellent disease resistance and suitable end-use quality for the domestic and export markets. In 2013, a new hard red winter wheat variety 'Redfield' was released. Redfield is expected to be a replacement for cultivar Wesley. It is very similar in appearance to Wesley, with similar lodging resistance, higher yield potential, and higher test weight. Several advanced breeding lines with high yield potential and excellent disease resistance were also evaluated across South Dakota and in the northern part of the winter wheat growing region. The most promising of these lines are being increased for potential release. A new inoculated field nursery was implemented to evaluate resistance to bacterial leaf streak among advanced breeding lines. This is expected to lead to the development and release of new variety with improved tolerance to bacterial leaf streak. Dr. Rodrigo Dos Santos defended successfully his PhD dissertation. He evaluated the effect of starch characteristics on tortilla quality.

Introduction:

With 1.21 million acres planted and a production of 59.4 million bushels in 2014, winter wheat continues to be a crop of economic importance for South Dakota. To increase the profitability of South Dakota wheat producers, and to maintain South Dakota wheat production to its current level, it is essential to develop and release stable high-yielding varieties adapted to South Dakota's environment, resistant to prevalent diseases and pests, and with excellent end-use quality. The objective of the breeding program at South Dakota State University (SDSU) is to rapidly develop winter wheat varieties adapted to South Dakota that exhibit:

- high and stable yield,
- resistance to the prevalent bacterial, fungal, and viral disease pathogens,
- and excellent quality for bread, wheat flour tortillas, and other emerging end-use markets.

Description of Accomplishments:

The top 3, and 6 out of the top 10, highest yielding entries in the Northern Regional Performance Nursery in 2013 (Table 1) were developed by SDSU winter wheat breeding

program. One of those line SD06158 was released as 'Redfield' in the fall of 2013. Seed increase with intent to release has been initiated for three breeding lines (SD08200, SD09192, and SD10257-2). Experimental lines SD08200 and SD09192 were evaluated in the 2013 Wheat Quality Council (WQC) and exhibited good to excellent milling and baking quality. Members of WQC representing the US milling and baking industry awarded line SD09192 with the "Best of Show" award. In addition, line SD08200 and SD09192 have excellent leaf and stem rust resistance.

Table 1. Northern Regional Performance Nursery results for 2013

Entry	Line/selection	Grain Yield		Grain Volume Weight
		mean (kg/ha)	rank	(kg/hl)
1	Kharkof	3353	37	76.9
2	Overland	4342	4	76.7
3	Wesley	3923	21	75.0
4	Jerry	4013	17	74.7
5	Lyman	4316	5	76.7
6	N10MD2020	3575	33	76.1
7	N10MD2073	3515	34	74.8
8	NX10MD2216	3942	19	74.5
9	NX10MD2300	3745	31	74.7
10	NI07703	3447	35	73.0
11	NI09710H	4065	13	72.7
12	NI10712	3921	23	73.9
13	NI10718W	3895	24	74.2
14	NE10418	3737	32	75.5
15	NE10442	4044	14	75.8
16	NE10589	4147	9	75.4
17	NH10665	3954	18	75.9
18	NW10487	3748	30	74.0
19	NHH11569	4022	15	75.4
20	NE08499	4198	7	76.0
21	NHH09655	3866	26	74.0
22	LCH10-13	4015	16	77.6
23	LCH08-80	3864	27	74.8
24	LCH08-109	3363	36	72.6
25	SD06158	4292	6	75.9
26	SD07165	3941	20	75.0
27	SD07184	3858	28	76.5
28	SD08080	4123	10	76.3
29	SD08200	4108	11	76.6
30	SD09118	4358	3	77.2
31	SD09138	4152	8	76.9
32	SD09192	4361	2	75.5
33	SD10026-2	3887	25	75.7
34	SD10257-2	4386	1	77.4
35	BL11002	4087	12	74.8
36	MT08172	3761	29	72.6
37	MT0978	3923	22	73.9
	mean	3952.7		75.3
	cv (%)	11.5		
	l.s.d.	363		

The following nurseries were evaluated in the 2013-2014 growing season:

- **Crop Performance Trial (CPT):** 37 entries including 9 SDSU advanced breeding lines were planted at 16 South Dakota locations.
- **Advanced Yield Trial (AYT):** 30 entries planted at 6 South Dakota locations.
- **Preliminary Yield Trial (PYT):** 90 entries planted at 5 South Dakota locations.
- **Early Yield Trial (EYT):** 925 entries evaluated at 1 South Dakota location.
- **Headrows:** around 15000 rows evaluated at 1 South Dakota location.
- **F_3 populations:** 317 entries evaluated at 2 South Dakota locations.
- **F_2 populations:** 209 entries evaluated at 1 South Dakota locations.

Breeding lines from the PYT, AYT, and CPT, along with other regional nurseries, were evaluated for Fusarium head blight resistance in a mist-irrigated field nursery in Volga, SD.

New crosses were made in the fall and spring greenhouse growing season to develop new populations targeting the objectives of the breeding program. Plants at the F_1 stage were increased in Arizona.

Populations at the F_3 stage were grown in Castroville, Texas, where the natural pressure for leaf rust is very high. Individual spikes were selected from plants exhibiting leaf rust resistance.

In collaboration with Dr. Shaukat Ali, an inoculated field trial was implemented to evaluate bacterial leaf streak (BLS) resistance of advanced breeding lines (CPT and AYT). Results indicated that line SD09192 appears to exhibit some levels of resistance to BLS (Table 2).

Table 2. Ratings from the Bacterial Leaf Streak (BLS) inoculated field nursery in Brookings, 2014 for entries included in the CPT.

Entry	BLS ratings* (1-9)
Alice	8.7
Arapahoe	7.0
Brawl CL Plus	7.0
Byrd	8.0
WB-Cedar	7.3
Decade	7.7
Denali	7.3
Everest	6.3
Expedition	8.3
Freeman	6.0
WB-Grainfield	5.7
Ideal	8.0
Jagulene	8.0
Jerry	5.7
Lyman	5.7
WB-Matlock	6.3
Millenium	7.7
LCS Mint	6.3
Overland	6.7
WB-Redhawk	7.3
Robidoux	8.0
Redfield	6.7
Settler CL	7.3
T158	8.7
Wesley	8.7
SY Wolf	7.0
1863	6.7
NI08708	8.0
SD08080	7.0
SD08200	6.7
SD09113	6.3
SD09118	6.0
SD09138	6.7
SD09192	3.7
SD09227	7.7
SD10026-2	7.3
SD10257-2	8.0

*Average of 3 repetitions (1-9 scale: 1-2 are considered resistant; 3 is considered moderately resistant; 4 = moderately susceptible, and 5 and above are susceptible).

In collaboration with Dr. Padu Krishnan, two French interns (Elodie Payrau and Florianne Bouchet) evaluated several methods for their ability to predict loaf volume and end-use quality of winter wheat breeding lines. The two tests that yielded the highest correlation with loaf volume were maximum force measured by the Kieffer dough extensibity test (r=0.61) and an improved version of the traditional SDS sedimentation test developed by Seabourn et al., 2012 (r=0.57).

As part of the Winter Cereal Sustainability in Action initiative from Bayer Crop Science and Duck Unlimited, 62 doubled haploid lines were evaluated as plots, and 443 were evaluated as rows in the field. Selected lines were advanced to Preliminary or Early yield trials nurseries. In addition, 416 lines were increased in Arizona, and 327 were increased in the greenhouse. Parental lines used to develop those doubled-haploid lines were selected based on their winter hardiness and disease resistance.

Monsanto fellow, Rodrigo Dos Santos successfully completed is PhD. He evaluated how genetic differences in flour protein and starch characteristics relate to wheat flour tortilla quality. More specifically, he evaluated the effect of amylose level on wheat flour tortilla quality. Monsanto fellow Dalitso Yabwalo evaluated how kernel characteristics, such as length, width, shape, density, and packing efficiency relate to test weight. Yabwalo presented his research at the 2014 National Association of Plant Breeders (NAPB) annual meeting.

Projections:

The development of new winter wheat varieties adapted to South Dakota is expected to maximize South Dakota winter wheat producers' profit. New varieties with high and stable yield, improved disease resistance, and improved winter hardiness are expected to help producers maintaining stable grain yields, while limiting input costs. End use-quality will continue to be emphasized during the breeding process to insure that new released varieties meet the requirements of existing and emerging markets.