

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

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Research Summary:

Although production in 2012-2013 was significantly impacted by drought, winter wheat remains an important rotational crop for South Dakota producers. The development and release of new winter wheat varieties specifically adapted to environments across the state insures that producers maximize their economic return by growing varieties with improved yield, disease resistance and end-use quality. Our objective is to rapidly develop high-yielding winter wheat varieties with disease resistance and quality that is acceptable to domestic and export markets. The breeding program continues to successfully produce such varieties. In 2013, 'Redfield' winter wheat was released. Redfield is very similar to Wesley, one of the most widely grown varieties in South Dakota, but it exhibits higher grain yield potential and higher test weight compared with Wesley. Redfield is also less susceptible to scab than Wesley, and it has better than average overall baking quality. In addition to the release of Redfield, 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. As part of the Winter Cereal Sustainability in Action (WCSIA) initiative, a significant number of winter wheat doubled haploid lines were produced. Plans are to evaluate these lines in the field next season. The utilization of the doubled-haploid technology is expected to hasten the development of new varieties for South Dakota growers. Student research projects continue to produce valuable information for use by the breeding program. These results are important to designing new breeding strategies to improve breeding effectiveness in selecting for high and stable grain yield, disease resistance and end-use quality.

Introduction:

Winter wheat offers many advantages to producers in comparison to spring planted crops, including helping spread the cropping system workload, improving soil and water management, and providing a more wildlife-friendly alternative. It is therefore, important to rapidly develop and provide South Dakota winter wheat producers with high yielding varieties as quickly as possible. The objective of the winter wheat breeding program at South Dakota State University is to rapidly develop South Dakota winter wheat varieties that are:

- competitive and stable for grain yield;

- resistant to the prevalent races and biotypes of bacterial, fungal, and viral disease pathogens;
- accepted into both domestic and export quality markets

Description of Accomplishments:

The winter wheat breeding program continues to successfully develop new winter wheat varieties for South Dakota wheat producers:

- A new variety 'Redfield', tested as SD06158, was released to seed producers by the South Dakota Agricultural Experiment Station in September 2013. Redfield is adapted to South Dakota and the entire region where Overland and Wesley are currently produced (**Table 1**). Redfield is very similar in appearance to Wesley with the same lodging resistance, but with higher yield potential and higher test weight (**Table 2**). In addition, SD06158 exhibits better than average overall baking quality.
- Three advanced breeding lines (SD08080, SD08200, and SD09192) have performed very well in the 2013 South Dakota Crop Performance Trials (**Table 3**) and are going to be increased for seed with the potential of being released in the next coming years. Those three lines present high yield potential and a good level of resistance to disease races prevalent in South Dakota.

Table 1. NRPN agronomic comparison of Redfield to Wesley, Overland and Lyman, 2010 to 2013.

Year*	Variety	Grain Yield (kg/ha)	Yield Rank	Test Weight (kg/hl)	Plant height (cm)	Days to Heading (from 1/1)
2010	Redfield	4195	5	75.7	80	164
	Wesley	3966	14	71.4	78	161
	Overland	4319	1	73.4	87	163
2011	Redfield	4275	3	74.1	85	169
	Wesley	3944	14	71.2	82	166
	Overland	4430	1	73.9	90	168
2012	Redfield	4472	4	77.1	78	152
	Wesley	4214	22	75.2	74	148
	Overland	4659	2	77.8	84	150
	Lyman	4134	26	77.5	84	149
2013	Redfield	4124	16			
	Wesley	3871	26			
	Overland	4329	6			
	Lyman	3917	24			

*Data are averages across 14 locations with 34 entries in 2010; 12 locations with 29 entries in 2011; 16 locations with 34 entries in 2012; and 5 locations with 37 entries in 2013.

Table 2. South Dakota Crop Performance Trial (CPT) 2009 to 2013, 5-year average (data from Nathan Mueller).

Variety	East River		West River	
	Yield (Bu/A)	Test Weight	Yield (Bu/A)	Test Weight
Lyman	65.3	59.5	54.9	58.3
Overland	69.4	58.9	53.4	58.6
Redfield	65.3	58.3	53.2	58.2
Expedition	67.6	59.2	52.5	57.9
Wesley	63.6	56.8	51.5	56.8

Table 3. South Dakota Crop Performance Trial (CPT) average yield performance of promising advanced breeding lines in 2013.

Variety/Line	East River Average (Bu/A)	West River Average (Bu/A)
Expedition	57.7	46.4
Ideal	59.8	50.6
Lyman	65.0	54.0
Overland	61.8	51.3
Wesley	51.5	48.2
SY Wolf	60.6	52.8
Redfield	57.8	49.6
SD08080	65.9	51.0
SD08200	65.8	54.6
SD09192	61.1	53.2
CPT Average:	54.5	48.0

Utilizing an established and successful breeding methodology, the SDSU program included these nurseries:

- **Crop Performance Trial:** 36 entries including 8 SDSU advanced breeding lines were planted at 16 South Dakota locations.
- **Advanced Yield Trial:** 30 entries planted at 6 South Dakota locations + 1 Nebraska location.
- **Preliminary Yield Trial:** 90 entries planted at 5 South Dakota locations.
- **Early Yield Trial - HRWW:** 1171 entries evaluated at 1 South Dakota location.
- **Early Yield Trial - HWWW:** 220 entries evaluated at 1 South Dakota location.
- **Headrows:** 19160 rows evaluated at 1 South Dakota location.
- **F₃ populations:** 398 entries evaluated at 2 South Dakota locations.

Although some locations were abandoned due to extreme drought, breeding material with the best agronomic characteristics and disease resistance were advanced in the breeding program. In addition, new crosses were made and F₁ and F₂ populations were increased in Arizona. Breeding lines were also evaluated for Fusarium head blight resistance in a mist-irrigated field nursery in Volga, SD. In collaboration with Dr. Shaukat Ali, PYT, AYT and CPT breeding lines were evaluated for leaf rust, stem rust, and *Septoria nodorum* after

inoculation under greenhouse conditions. Lines were also evaluated for rusts, Fusarium head blight, tan spot, and bacterial leaf streak in the field.

Quality evaluations of breeding lines were performed using predictive methods, such as SDS sedimentation tests and mixographs. In collaboration with Dr. Padu Krishnan, a quicker and improved version of the traditional SDS sedimentation test (Seabourn et al., 2012) was evaluated as a method to screen hard winter wheat breeding lines for end-use quality. Advanced breeding lines were also evaluated at the USDA-ARS Hard Winter Wheat Quality Laboratory in Kansas. In addition, SD06158 (Redfield) and SD08080 were evaluated in the Wheat Quality Council (WQC) Trials, and both lines exhibited better than average overall baking quality.

As part of the WCSIA initiative, doubled haploid (DH) lines were produced; 505 DH lines will be evaluated in the field this coming season, while more than 800 lines are being increased and will be evaluated in the field the next season. Several improvements were implemented in producing DHs, and these have increased the efficiency of DH production.

Student Bradley Carsrud successfully completed his research and earned his MS degree. His research contributed to; 1) enhancing protocols for wheat seed staining to better differentiate between white and red kernels, 2) optimizing the use of a seed color sorter to sort kernels in segregating populations, and 3) enhancing selection for either red or white seeded wheat genotypes.

Monsanto fellow, Rodrigo Dos Santos is evaluating how genetic differences in flour protein and starch characteristics relate to wheat flour tortilla quality. He is analyzing the effect of high glutenin subunits and amylose level on wheat flour tortilla quality. In order to help breeders select for higher test weight, Monsanto fellow Dalitso Yabwalo is evaluating how kernel characteristics, such as length, width, shape, density, and packing efficiency relate to test weight. Preliminary results indicate that kernel density and packing efficiency have the highest positive contribution. Both Dos Santos and Yabwalo presented results from their research at the 2013 American Society of Agronomy annual meeting in Tampa, FL.

Projections:

Along with the new variety, Redfield, released in 2013, new high yielding, disease resistant varieties with acceptable end-use quality are expected to be released in upcoming years. New releases from the SDSU winter wheat breeding program are expected to benefit South Dakota wheat producers by maximizing their profits. The breeding program will continue to develop varieties with new sources of resistance to prevalent as well as emerging pests and diseases to the region. This is expected to help producers maintain stable grain yields, while limiting input costs. The breeding program will also emphasize developing varieties with enhanced end use-quality for existing and emerging markets to optimize producer options. Finally, producing doubled-haploids is expected to hasten the development of new varieties and provide producers with better genetic options in a more timely fashion.