2006 Project Report

Winter Wheat Breeding and Genetics

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CROP REPORT

The planting of the 2006 winter wheat crop started very slowly in September of 2005 due to dry conditions. Then it began to rain across most of the state. The Brookings area reported 8 inches of moisture. The exception to these conditions was Selby. The plots there were eventually lost due to a combination of wheat streak mosaic virus (WSMV) and drought conditions. After a mild winter, the Agricultural Statistics Service rated the winter wheat conditions in South Dakota on April 2, 2006 as 21% poor to very poor and 36% good to excellent. By the end of June 35 2006, those ratings changed to 61% poor to very poor and only 13% good to excellent. Our plots in Winner, Platte and Dakota Lakes were the most affected by the drought conditions of 2006. The Wall area had an average crop. Highmore was in very good condition but a hail storm just days before harvest reduced expected yields. Brookings had very good yields due in a large part to the 8 inches of fall rain in 2005.

Winter wheat production in 2006 was estimated at 41.4 million bushels, down 24 million bushels from 2005. Producers harvested 1.15 million acres (1.45 million planted acres) for a state average of 36 bushels/acre, which is 8 bushels lower than 2005. Overall, the excellent winter survival rate at most locations was due to a mild winter but the extreme drought conditions that developed, followed by above normal temperatures resulted in 75% of the crop being harvested by July 16th (5 yr average for that date is 23%).

In 2006, the winter wheat breeding program conducted testing at eight sites throughout South Dakota. These environments included Aurora and Brookings (Brookings Co.), Platte (Douglas Co.), Highmore (Hyde Co.), Selby (Walworth Co.), Winner (Tripp Co.), Wall (Pennington Co.), the Northeast Research Farm near Watertown (Codington Co.), Kennebec (Lyman Co.) and both irrigated and dryland environments at the Dakota Lakes Research Farm east of Pierre (Hughes Co.). Crop performance testing also was conducted at an additional nine sites west of the Missouri River in cooperation with John Rickertsen and Bruce Swan (SDSU West River Agricultural Research and Extension Center, Rapid City).

<u>BREEDING PROGRAM</u>

New Cultivars

<u>Release of 'Alice' wheat:</u> Alice hard white winter wheat was released to seed producers in 2006 because of its white grain color, earliness, excellent bread baking quality, good pre-harvest sprouting tolerance, and high yield performance in rainfed production systems in South Dakota and the northern Great Plains including Nebraska. Alice has been named to honor Alice Wright, administrative assistant for the South Dakota Wheat Commission for 23 years.

Alice was derived from the cross 'Abilene'/'Karl' made in 1992. Alice was developed using the bulk breeding method. The cross (coded X92103) was advanced to the F_3 generation as a bulk population. Seed harvested from the F_3 bulk was sorted for white kernel color in 1995. The bulk population of selected white kernels was coded X92103W and was grown in the greenhouse in spring 1996. Single heads were harvested from this selected F_4 bulk and planted in the field as head-rows in fall 1996. Alice was selected as an $F_{4:5}$ line in 1997. Alice was evaluated as SD97W609 in the South Dakota Early Yield Trial nursery in 1998, the South Dakota Advanced Yield Trial in 1999, in the South Dakota Crop Performance Testing (CPT) Variety Trial in 2000-2001 and 2003-2006, and in the Northern Regional Performance Nursery (NRPN) in 2003.

In 26 site-years of testing between 2003 and 2006 in the CPT, Alice was the earliest maturing cultivar (148 d to heading from 1 Jan.), similar to 'Wendy', 2 d earlier than 'Wesley', and 6 d earlier than 'Harding' ($LSD_{0.05}$, 1 d). Plant height obtained from 35 site-years of Alice (71 cm) is slightly taller than Wendy (68 cm) and Wesley (69 cm) and 15 cm shorter than Harding. The winter survival of Alice, as tested in six South Dakota locations in the very cold winter of 2001 was fair (51%), similar 'Rose' and 'Culver' (49%). No varietal differences for winter survival were observed during 2003 – 2006. Alice has a short coleoptile similar to Wesley and 'Trego' [70 mm, n = 14 observations; 117% of Wendy; 88% of Expedition; and 78% of Harding)]. Alice has the best pre-harvest sprouting tolerance among any hard white wheat cultivar tested in the CPT in Brookings, South Dakota between 2003 - 2006 (1.8 score; 1 = highly tolerant to 9 = highly susceptible; n = 8 observations), similar to 'Crimson' (1.8), better than Trego (2.6) and Wendy (4.2).

In 38 site-years of testing in the South Dakota CPT, grain yield of Alice (3602 kg ha^{-1}) was greater than Wendy (3557 kg ha^{-1}), Wesley (3553 kg ha^{-1}), Expedition (3532 kg ha^{-1}), Trego (3473 kg ha^{-1}), and 'Arapahoe' (3508 kg ha^{-1}), and was less than 'Millennium' (3769 kg ha^{-1}), ($LSD_{0.05}$, 99 kg ha^{-1}). In 38 site-years of testing in the CPT Alice had similar grain volume weight to Expedition (758 kg m^{-3}), higher than Wesley (736 kg m^{-3}) and lower than Millennium (767 kg m^{-3}) and Trego (764 kg m^{-3}) ($LSD_{0.05}$, 4.2 kg m^{-3}).

Alice was resistant to moderately resistant to stem rust races QFCS, RCRS, QTHJ, RTQQ, and TPMK and moderately susceptible to race TTTT in seedlings tests and moderately resistant to a composite of above races in adult plant tests conducted by the USDA Cereal Disease Laboratory, St. Paul, MN in 2003 and 2004. Alice is susceptible to the Great Plains biotype of Hessian fly based on seedling tests. Alice was found to be moderately susceptible (moderate mosaic and/or moderate stunting) to wheat soil-borne mosaic virus. Alice was tested in a blast-inoculated wheat streak mosaic virus (WSMV) nursery in Brookings, SD between 2000 and 2005. Yield losses of Alice, Wendy, and Trego, due to WSMV were 13.6%, 20.1%, and 29.0%. Plant stunting of Alice, Wendy, and Trego due to WSMV was 18.5%, 7.7%, and 20.9%. WSMV disease severity of Alice, Wendy, and Trego was 2.2, 2.4, and 2.0 (score; 0 = no symptoms; 1 = very mild symptoms, isolated small light green areas of mosaic, no stunting; 2 = mild symptoms, small areas of light green or yellow mosaic, short streaks, mild stunting; 3 = moderate symptoms, predominant yellow mosaic, extensive streaks, moderate stunting; 4 = severe symptoms, severe yellow mosaic, some necrosis, severe stunting; and 5 = severe symptoms, extreme yellowing, necrosis, very severe stunting, and plant death).

Composite milling and bread baking properties of Alice were determined during 2003 - 2005 cooperative baking tests conducted by the USDA-ARS Hard Winter Wheat Quality Laboratory in Manhattan, KS. Both milling and baking scores were very good. Relative to the check cultivars Wendy and Wesley, Alice had medium-sized kernels (28.9 vs. 27.5 and 29.7 mg, respectively). Flour extraction of Alice, Wendy, and Wesley was 674, 660, and 672 g kg^{-1}. Flour ash of Alice was lower (3.4 g kg^{-1}) than both Wendy (3.7 g kg^{-1}) and Wesley (3.8 g kg^{-1}). Flour protein of Alice (115 g kg^{-1}) was similar to Wendy and lower than Wesley (125 g kg^{-1}). In bread baking tests, flour water absorption and loaf volume of Alice (614 g kg^{-1}; 905 mL) were intermediate between Wendy (598 g kg^{-1}; 830 mL) and Wesley (631 g kg^{-1}; 932 mL). Alice had higher mixograph tolerance (4.3) than Wendy (0.7) but slightly lower than Wesley (5.0) (0 = unacceptable, 4 = acceptable, 6 = outstanding). Mixograph mix time for Alice (4.8 min) was intermediate between Wendy (3.2 min) and Wesley (7.0 min). Alice was evaluated in the Wheat Quality Council tests in 2004. Its bread baking quality was found to be better than all hard winter experimental lines and checks including 'Tandem' (PI 601817; Haley et al., 1998b). Alice has moderate grain polyphenol oxidase (PPO) levels [4.0, similar to Trego (4.1), higher than Wendy (3.4), but lower than 'NuFrontier' (5); 1-5 scale, lower is better].

Breeder seed of Alice originated from a composite of 200 $F_{10:11}$ head-rows selected in 2004 based on visual uniformity and white kernel color purity. Alice has been uniform for all morphological characters (such as maturity and plant height) during the last three generations of increase. Alice contains 0.05% of a purple-chaffed, tall hard red off-type and 0.28% of a tall white variant.

The South Dakota Foundation Seed Stocks Division (Plant Science Department, South Dakota State University, Brookings, SD) had Foundation seed of Alice available to seed producers for planting during fall 2006. Seed classes are Breeder, Foundation, Registered, and Certified. Alice will be submitted for U.S. Plant Variety Protection under P.L. 910577 with the certification option.

Release of 'Darrell' wheat: Darrell hard red winter wheat was released in 2006 to seed producers because of its good disease resistance and excellent yield potential in the northern Great Plains. Darrell has been named to honor Dr. Darrell Wells, the late former winter wheat breeder at South Dakota State University from 1962 to 1982.

Darrell was derived from the cross 2076-W12-11/'Karl 92'//NE89526. NE89526 is an experimental line from the University of Nebraska with the pedigree 'Lancota' selection /'Siouxland' //TX792729. 2076-W12-11 is an exotic parent with an unidentified pedigree. Darrell was developed by means of the bulk breeding method. The cross (coded XNE94031) was made by P. S. Baenziger at the University of Nebraska in 1995 and shared as an F_2 population in 1997. It was planted as an F_3 Bulk in South Dakota in 1997. Darrell was derived as an $F_{3:4}$ line selected in 1998. Darrell was evaluated as SD98102 in the South Dakota Early Yield Trial nursery in 1999, in the Preliminary Yield Trial in 2000, and in the Advanced Yield Trial in 2001. It was tested in the South Dakota Crop Performance Testing (CPT) Variety Trial between 2002 and 2006 and in the Northern Regional Performance Nursery in 2003 and 2004.

In 26 site-years of testing between 2003 and 2006 in the CPT, Darrell was a medium maturing wheat (152 d to heading from 1 Jan.) 4 d later than Expedition and 2 d earlier than Harding. Plant height obtained from 35 site-years of Darrell (80.6 cm) is similar to Tandem, slightly taller than Arapahoe (79.3 cm) and 5.3 cm shorter than Harding. The winter survival of Darrell, as tested in 5 South Dakota locations in the very cold winter of 2001, was good to excellent (68%) , similar to Alliance (72%) ($LSD_{0.05}$ 10%). Darrell has a medium-long coleoptile similar to Expedition (80 mm, n = 6 observations; 133% of Wendy and 89% of Harding). Darrell has good straw strength similar to Alliance and Expedition (1.8) and better than Arapahoe (2.2), Trego (2.2) and Tandem (3.1) (score; 0 = no lodging to 9 = severe lodging).

In 38 site-years of testing in the CPT, grain yield of Darrell (3692 kg ha^{-1}) was greater than Wendy (3557 kg ha^{-1}), Wesley'(3553 kg ha^{-1}), Expedition (3532 kg ha^{-1}), Trego (3473 kg ha^{-1}), and Arapahoe (3508 kg ha^{-1}), and was less than Millennium (3769 kg ha^{-1}), ($LSD_{0.05}$, 99 kg ha^{-1}). In 38 site-years of testing in the CPT, Darrell had similar grain volume weight to Expedition (758 kg m^{-3}), higher than Wesley (736 kg m^{-3}) and lower than Millennium (767 kg m^{-3}) and Trego (764 kg m^{-3}) ($LSD_{0.05}$, 4.2 kg m^{-3}).

Darrell is homogeneous for the 1AL.1RS wheat-rye translocation based on SDS-PAGE gel analysis. Darrell was resistant to stem rust races TTTT, TPMK, RTQQ, RCRS, QTHJ, and QFCS in seedlings tests and highly resistant to a composite of races in adult plant tests conducted by the USDA Cereal Disease Laboratory, St. Paul, MN in 2003 and 2004. Darrell likely carries *Sr6* and the undesignated stem rust resistance gene located on the 1AL.1RS translocation. Darrell is heterogeneous to the Great Plains biotype of Hessian fly based on seedling tests. Darrell was found to be moderately susceptible (moderate mosaic and/or moderate stunting) to wheat soil-borne mosaic virus. Darrell was tested in a blast-inoculated wheat streak mosaic virus (WSMV) nursery in Brookings, SD between 2002 and 2005. Yield losses of Darrell, Arapahoe, and Millennium, due to WSMV were 8.8%, 30.3%, and 24.2%. Plant stunting due to WSMV of Darrell, Arapahoe, and Millennium was 20.2%, 16.6%, 18.1%. WSMV disease severity of Darrell, Arapahoe, and Millennium was 1.9, 3.3, and 2.0 (score; 0 = no symptoms; 1 = very mild symptoms, isolated small light green areas of mosaic, no stunting; 2 = mild symptoms, small areas of light green or yellow mosaic, short streaks, mild stunting; 3 = moderate symptoms, predominant yellow mosaic, extensive streaks, moderate stunting; 4 = severe symptoms, severe yellow mosaic, some necrosis, severe stunting; and 5 = severe symptoms, extreme yellowing, necrosis, very severe stunting, and plant death). Darrell has the lowest *Fusarium* head blight disease severity rating (19%) among all cultivars tested under severe disease pressure in Brookings, South Dakota during the last three years, lower than Arapahoe (22%), Crimson (45%) and Jagalene (57%) ($P < 0.05$).

Composite milling and bread baking properties of Darrell were determined during 2003 - 2005 cooperative baking tests conducted by the USDA-ARS Hard Winter Wheat Quality Laboratory in Manhattan, KS. Darrell has acceptable milling and good baking quality. Relative to the check cultivars Millennium and Arapahoe, Darrell had similar kernel size (29.1 vs. 29.7 and 29.1 mg). Flour extraction of Darrell, Millennium, and Arapahoe was 665, 674, and 663 g kg^{-1}. Flour ash of Darrell was higher (3.9 g kg^{-1}) than both Millennium (3.6 g kg^{-1}) and Arapahoe (3.8 g kg^{-1}). Flour protein of Darrell (118 g kg^{-1}) was higher than both Millennium (112 g kg^{-1}) and Arapahoe (114 g kg^{-1}). In bread baking tests, flour water absorption and loaf volume of Darrell (625 g kg^{-1}; 875 L) were both higher than Millennium (614 g kg^{-1}; 855 L) and Arapahoe (616 g kg^{-1}; 822 L). Darrell had better mixograph tolerance (4.0) than both Millennium (3.0) and Arapahoe (3.3) (0 = unacceptable, 4 = acceptable, 6 = outstanding). Mixograph mix time of Darrell (5.4 min) was longer than Millennium (4.0 min) and Arapahoe (4.8 min). The Breeder Seed originated from a purification program in 2002 – 2003, 2003 – 2004, and 2004 – 2005 designed to remove off-types by rouging. Darrell contains 0.17% red chaff off-type and 0.15% tall white chaff variant.

The South Dakota Foundation Seed Stocks Division (Plant Science Department, South Dakota State University, Brookings, SD) had Foundation seed of Darrell available to seed producers for planting during fall 2006. Seed classes are Breeder, Foundation, Registered, and Certified. Darrell will be submitted for U.S. Plant Variety Protection under P.L. 910577 with the certification option.

Foundation Seed Increases

Foundation Seed of two lines (SD01W064 and SD96240-3-1) is being increased for potential release in 2007 and 2008. SD01W064 hard white winter wheat was developed from the cross RussianPI592033/NE92458//'Nekota'. It is in its third year of testing in the CPT Variety Trial. It was the highest yielding line in 2004 AYT, ranked 9th in 2005 CPT, and 19th in 2006 CPT. It has good baking and noodle quality based on preliminary testing. It has good resistance to stem, leaf, and stripe rusts, in addition to tan spot. It has been shown to possess the *Lr*34 gene that contributes to durable resistance to leaf rust. It is susceptible to scab. SD96240-3-1 was developed from the cross NE87513/USSR#67 and is in its third year of testing in the CPT. It has good resistance to stem and stripe rusts but it is moderately susceptible to leaf rust. It has poor baking quality and very high grain yield. It may be targeted for producers who are interested in high yielding, marginal quality wheat for feed and ethanol.

Regional Nurseries

The Northern Regional Performance Nursery (NRPN) was planted at Brookings, Winner, and the winter wheat stubble plots at Dakota Lakes (DLWWS). The NRPN consisted of four check varieties and 26 experimental lines from five public and private programs. Nine advanced experimental lines were included from the SDSU Winter Wheat Breeding Program. Average grain yield and other characteristics for 2006 NRPN are presented in Table 1. In addition to the NRPN, the Southern Regional Performance Nursery (SRPN) was planted at Brookings, Winner, and at Dakota Lakes on pea stubble (DLP). While the SDSU breeding program does not typically enter lines into the SRPN, evaluation of this nursery in South Dakota is important both as a means of germplasm exchange and in determining the range of adaptation of elite material from southern plains and western programs.

In addition to the regional yield nurseries, the Regional Germplasm Observation Nursery (RGON) was planted at Watertown and at Brookings in the mist-irrigated FHB disease nursery. Due to excessive early spring rain, the seed rottened at Brookings and the nursery was lost for the first time in the last six years. This nursery consisted of 286 entries from nine different breeding programs, including a periodic set of six checks, planted in double-row (3-foot long) plots with a single replication per entry. Thirty South Dakota advanced lines were entered into the 2006 RGON.

CPT Variety Trial

The CPT Variety Trial, under the overall coordination of Dr. Bob Hall. The trial included 30 entries, consisting of 18 released varieties (including new releases from other states), 10 advanced experimental lines from our program, and one experimental line each from Nebraska public breeding program and AgriPro. This trial was also grown at 13 other sites in South Dakota. Prior to cultivar release, promising elite lines must be grown in the CPT Variety Trial for three years to accurately measure the potential performance across a range of environmental conditions. Four of the 10 experimental lines from the breeding program evaluated in the 2006 CPT (Tables 2 and 3) were retained for further testing in 2007:

SD96240-3-1	NE87513/USSR#67
SD01058	XH1877/NE967430
SD98W175-1	KS84273BB-10/KSSB110-9//KS831374-141B/YE1110/3/KS82W418/SPN
SD01W064	RussianPI592033/NE92458//Nekota

Table 1. Grain yield, Agronomic and Disease Data for the 2006 NRPN in South Dakota

Trait†	Grain Yield					TW	HT	HT RED	HD	MAT	LD	ILAD	LR	FHB	SCR
	RANK £	bushels per acre				lbs/bu	inches	percent	relative days		scale of 1 to 9. 1 is best				
Locations¥	AVE	5,8	2	5	8	2,5,8	5,8	5 / 8	2,8	8	8	8	8	8	2,8
KHARKOF	28	41	11	28	49	59	37	45	7	4	7	9	4	2	7
HARDING	10	61	8	36	78	59	33	43	6	4	2	6	2	4	5
NUPLAINS	23	53	4	33	66	59	25	37	4	4	1	9	3	5	6
WESLEY	17	60	13	29	81	58	25	44	2	3	1	8	4	2	3
NX02Y4481	27	51	15	26	68	57	28	35	3	5	2	6	6	2	5
NW03Y2016	29	47	5	28	59	58	25	42	4	3	1	9	7	3	6
NW03Y2022	24	55	11	33	70	60	26	42	4	3	1	9	5	5	4
NW03Y2023	30	48	8	26	63	58	28	51	2	2	1	9	6	6	5
HV9W02-942R	3	63	17	35	82	58	24	43	1	3	1	4	1	4	4
NE01604	6	63	16	35	81	60	30	29	0	3	1	5	1	2	2
NE02528	22	58	12	32	75	59	27	41	1	3	1	9	3	3	4
NE02584	11	60	8	37	75	60	28	35	2	0	1	8	3	5	4
NE03458	20	57	14	33	75	59	27	39	1	3	1	9	5	5	4
NH03609	14	62	20	33	81	58	28	49	2	4	1	7	3	4	4
NH03614	5	62	5	36	79	58	28	47	3	4	1	7	3	4	5
NI03427	12	62	12	35	81	59	28	33	1	4	1	4	2	5	4
NI04430	19	60	4	32	78	56	27	46	3	5	1	6	2	4	4
NW03638	18	60	4	29	81	59	30	50	1	2	2	9	1	5	4
NW03681	1	65	15	36	84	59	30	42	3	4	1	7	2	2	4
98X0435-15	16	66	15	35	76	57	26	45	1	4	1	6	1	4	3
SD02279	21	58	16	33	75	58	33	49	6	7	3	1	2	2	4
SD02480	8	61	9	36	78	59	28	44	3	4	1	3	1	5	4
SD02286	26	54	17	29	71	58	32	51	3	4	3	8	4	2	3
SD02771	15	59	8	37	74	59	34	51	6	5	3	7	2	2	5
SD01058	9	62	7	35	81	58	30	46	3	5	1	8	1	5	5
SD96240-3-1	4	65	5	33	87	57	30	42	4	4	2	7	4	3	5
SD98W175-1	2	62	6	38	77	59	29	42	3	3	1	8	4	4	4
SD01W064	25	56	16	31	72	58	30	45	4	5	1	8	5	5	3
SD00151-7	7	61	4	38	76	59	34	49	6	5	1	9	3	5	5
NUDAKOTA	13	63	11	32	84	55	27	36	2	2	1	4	1	6	4
Mean		58	11	33	75	58	29	43	3	4	2	7	3	4	5
C.V. %		8	59	9	7	2					83		30	27	23
LSD (0.05)		6	13	6	9	1					1		2		2

¥ Locations: 2-Dakota Lakes Spring Wheat Stubble, 5-Winner, 8-Brookings
† GY-Grain Yield , TW-Testweight, HT-Height, HT RED-Height reduction (a measure of drought tolerance)
HD-Heading and MAT-Physiological Maturity (days relative to minimum for the nursery), LD-Lodging, LR-Leaf Rust
ILAD-Inverse of Leaf Area Duration (retention of green appearance of flag leaf),
FHB-Fusarium Head Blight (scale based on Index = severity * incidence in inoculated,misted nursery),
SCR-Agronomic beauty score
£ Relative average rank (based on the average of ranks for each location).
This measure removes the bias towards higher yielding locations.

Table 2. Grain Yield, Test Weight and Protein Data for the 2005 Crop Performance Testing (CPT) Variety Trial

	Grain Yield (bushels per acre)																TW¥		PRO¥	
LOCATION¶	BRK	NEF	PLA	HIM	DLP	WIN	WINT	MAR	OEL	BIS	STU	WALL	State	Rank Ave £	3-yr	3-yr rank ave £	State	3-yr	State †	3-yr
ALICE (W)	72	47	62	46	29	39	34	47	52	17	37	45	46	7	50	8	59.4	58.8	11.9	12.4
ALLIANCE	81	51	43	48	23	41	39	42	54	17	33	46	44	11	51	6	58.3	58.3	11.0	11.6
ARAPAHOE	82	50	46	45	28	35	33	45	52	17	30	42	43	23	49	14	58.6	58.4	11.8	13.0
CRIMSON	73	42	54	46	23	37	33	42	51	14	33	34	41	30	47	16	59.1	59.1	12.3	13.2
DARRELL	84	48	53	42	32	37	39	52	55	19	39	43	47	1	52	1	59.8	59.2	13.3	12.6
EXPEDITION	85	51	56	40	27	37	36	44	56	17	33	46	46	6	49	15	58.9	59.2	12.6	12.6
HARDING	71	45	46	49	24	37	37	40	52	18	33	42	42	27	50	7	59.2	58.8	12.5	13.1
HARRY	77	36	48	45	37	39	36	44	60	19	36	46	45	5			55.9		12.9	
HATCHER	78	50	55	46	24	38	35	55	62	12	38	41	46	9			59.2		11.6	
JAGALENE	65	42	51	44	24	41	36	42	57	16	38	42	43	19	51	5	59.9	59.1	11.7	12.2
JERRY	78	44	44	42	22	29	31	43	53	20	30	39	41	29	50	9	58.5	58.3	11.8	13.1
MILLENNIUM	79	44	57	42	33	31	37	43	56	19	32	41	45	15	53	2	59.3	59.6	13.0	12.4
NEKOTA	76	43	50	54	25	37	34	42	50	21	33	36	43	25	46	17	58.9	58.9	12.3	12.3
NUDAKOTA (W)	89	52	72	49	27	37	25	50	58	16	31	47	48	4			57.4		12.0	
NUFRONTIER (W)	66	40	54	50	25	38	35	46	57	11	35	44	43	17			59.6		12.3	
OVERLAND	85	52	53	32	31	38	35	44	52	13	28	46	45	16			58.9		11.7	
OVERLEY	81	68	69	26	25	30	27	41	54	17	29	46	46	20			60.1		12.6	
SD01058	79	46	61	50	27	40	37	51	55	14	35	44	47	3			59.2		12.4	
SD01122	63	36	56	52	33	28	33	45	52	18	29	43	42	24			58.3		13.2	
SD01W064 (W)	74	51	51	37	35	39	36	46	50	18	30	44	44	13			60.1		11.7	
SD02279	73	43	55	54	27	36	31	42	51	13	31	47	43	22			59.0		13.0	
SD02480	77	43	58	41	22	39	41	42	52	18	26	44	43	21			59.9		12.3	
SD96240-3-1	86	57	48	46	22	38	38	41	45	20	28	44	44	18			58.1		12.5	
SD97059-2	82	50	42	41	25	31	28	45	47	12	30	45	42	28	52	4	58.7	58.2	12.6	12.7
SD98W175-1	77	67	59	44	33	45	39	47	55	13	33	43	49	2			60.6		12.3	
TANDEM	65	48	47	45	25	36	36	44	51	16	35	45	42	26	49	13	60.1	59.9	12.8	12.9
TREGO (W)	72	47	48	51	27	38	38	53	54	17	36	40	45	10	49	11	59.7	59.7	11.5	12.1
WAHOO	78	44	49	44	27	35	33	45	61	16	36	48	45	14	52	3	57.8	57.7	12.0	12.5
WENDY (W)	80	49	49	34	32	38	39	48	49	19	33	46	45	8	49	12	59.3	59.4	12.1	12.7
WESLEY	81	53	49	52	30	34	31	48	52	17	34	42	45	12	49	10	57.0	57.2	12.3	13.1
Mean	77	48	53	45	27	37	35	45	54	16	33	43	44		50		59.0	58.8	12.3	12.3
CV %	9	23	23	13	36	9	12	13	8	20	13	11	17		15		2.7	2.9		
LSD (P<0.05)	9	16	17	12	14	5	5	8	6	7	7	7	3		2		0.7	0.5		

¶ Location abbreviations are for Brookings, Northeast Farm (South Shore), Platte, Highmore, Dakota Lakes Pea Stubble (Pierre), Winner, Winner Intensive (cooperator's management system including fertility and fungicides), Martin, Oelrichs, Bison, Sturgis, Wall, Statewide grain yield average, relative average rank (ranking of the average rank), Statewide 3-year average and rank.

† Protein information was obtained from BRK PLA HIM DLP WIN WALL

¥ Test weight in pounds per bushel, Protein in percent content of seed

£ Relative average rank (based on the average of ranks for each location). This measure removes the bias towards higher yielding locations.

Table 3. Agronomic and Disease Data for the 2006 Crop Performance (CPT) Variety Trial

Trait†	HT	HD	MAT	SCR	LD	FHB	ILAD	LR	YR
	inches	relative days		scale of 1 to 9, 1 is best					
Locations¥	1,5,6,8,9,15,17,18,19	1,6,7,8,9	8	1,6	8	8*	8	8	8
ALICE	24	0	0	2	2	4	8	2	1
ALLIANCE	25	2	2	4	2		8	5	1
ARAPAHOE	26	4	2	5	3	2	5	2	2
CRIMSON	27	6	4	6	1	4	4	1	1
DARRELL	27	4	5	3	1	1	6	3	2
EXPEDITION	25	1	1	3	3	4	8	3	1
HARDING	30	7	5	4	3	6	4	1	2
HARRY	25	5	5	3	2	4	7	2	1
HATCHER	23	3	2	4	1	6	7	2	1
JAGALENE	24	3	2	4	1	5	8	6	1
JERRY	28	6	4	5	2	6	6	1	1
MILLENNIUM	28	4	3	4	1	4	4	1	1
NEKOTA	24	1	1	5	2	4	9	4	5
NUDAKOTA	24	3	1	4	1	7	3	1	1
NUFRONTIER	26	3	4	2	3	6	7	2	1
OVERLAND	26	3	4	4	1	3	2	1	1
OVERLEY	26	0	0	2	2	4	3	2	1
SD01058	27	3	4	3	1	6	6	2	1
SD01122	28	6	6	5	2	8	6	2	1
SD01W064	27	4	4	1	1	6	5	2	1
SD02279	28	4	5	4	3	2	2	1	1
SD02480	25	4	1	5	1	3	4	1	1
SD96240-3-1	25	4	3	4	1		6	2	2
SD97059-2	26	4	5	3	2	2	4	2	1
SD98W175-1	25	3	3	3	1	4	6	1	1
TANDEM	26	4	3	6	5		6	3	2
TREGO	24	3	0	5	2	4	9	1	1
WAHOO	25	4	4	4	2	4	8	1	2
WENDY	23	1	0	3	1	4	9	4	
WESLEY	23	3	2	4	1		7	2	1
Mean	24	3	3	4	2	4	6	2	1
CV %		1		21	102	27			20
LSD (P<0.05)		1		1	2	4			1

¥ 1 = Dakota Lakes Pea Stubble, 5 = Winner, 6 = Wall, 7 = Northeast Farm, 8 = Brookings, 9 = Platte,

15 = Bison, 17 = Martin, 18 = Sturgis, 19 = Oehlrichs

* Misted, inoculated nursery. Alliance and Tandem were replaced with resistant Alsen (DI=32%) and susceptible Wheaton (DI=38%) checks.

† HT = plant height, HD = relative days to heading, MAT = relative days to physiological maturity,
SCR = general appearance score of plants at harvest time, LD = lodging,
FHB = Fusarium Head Blight (scale is based on disease index = severity * incidence, all plots having 100% incidence)
ILAD = effect of all disease and other environmental factors on loss of green appearance of flag leaf (inverse of Leaf Area Duration)
LR = Leaf Rust Symptoms, YR = Yellow (Stripe) Rust symptoms

Table 4. Grain Yield, Testweight and Agronomic Data for the 2006 Advanced Yield Trial (AYT)

Trait†	Grain Yield							TW	HT	HD	MAT	LD	ILAD	LR	YR	FHB	SCR
	RANK £	bushels per acre						lbs/bu	inches	relative days		scale of 1 to 9. 1 is best					
Locations¥	1,3,5,6,8		1	3	5	6	8	1,3,5,6,8	1,5,6,8	1,6,8	8	8	8	8	8	8	1,6
ALLIANCE	14	48	34	53	25	46	84	59	26	1	3	3	9	4	1		3
ARAPAHOE	20	48	21	58	36	45	79	58	28	2	3	4	6	1	1	4	5
CRIMSON	17	50	39	58	34	35	81	57	31	6	4	3	4	4	1	5	4
WESLEY	8	52	35	62	33	46	84	58	25	3	3	1	5	1	1	4	4
EXPEDITION	2	54	39	55	36	48	90	60	27	1	2	2	8	3	1	3	3
HARDING	19	49	29	61	32	45	78	58	29	6	6	2	2	1	1	6	5
JAGALENE	9	51	32	58	47	46	73	60	26	3	2	1	9	7	1	6	5
TANDEM	16	49	34	57	36	43	76	61	27	4	5	6	7	3	1		5
NE01604	40	46	24	50	34	39	81	58	28	3	3	3	4	2	1	4	5
TREGO	13	52	37	74	30	43	79	61	25	1	2	3	9	2	1	5	5
Wendy	11	49	32	47	35	46	87	60	23	0	0	1	9	3	1	5	5
SD02091	28	47	28	52	37	40	80	58	26	5	6	3	2	1	1	5	6
SD02279	5	54	43	65	32	45	85	58	29	6	6	5	2	1	1	4	4
SD02480	33	48	41	50	32	40	76	57	27	6	6	3	6	1	1	3	4
SD02286	42	46	31	49	32	38	77	57	30	6	6	5	1	1	1	3	4
SD02771	18	49	31	61	34	43	74	59	31	7	7	6	2	3	3	3	6
SD01058	6	52	29	64	40	43	86	59	29	3	6	1	5	1	1	2	5
SD01273	4	53	30	62	41	46	84	60	29	2	4	2	2	1	1	3	5
SD03018	21	47	26	41	45	45	80	61	30	3	2	5	3	1	1	5	4
SD03077	43	43	12	49	36	38	77	59	29	4	3	6	5	1	1	1	6
SD03113	34	47	36	56	34	34	77	57	34	10	6	2	1	1	1	4	4
SD03144	36	44	35	40	35	43	71	61	30	2	3	3	3	3	3	3	5
SD03171	12	50	37	48	36	41	90	60	26	4	4	2	5	1	1	5	5
SD03177	15	50	30	57	37	37	87	58	29	5	3	3	6	1	1	4	5
SD03178	23	49	24	49	35	41	94	58	29	0	2	4	4	2	2	5	4
SD03184	22	48	26	53	31	43	89	59	28	2	3	4	8	1	1	5	5
SD03188	10	52	38	56	33	41	94	57	28	4	6	2	6	1	1	4	6
SD00111-9	7	51	31	57	44	44	82	60	28	2	2	5	2	1	1	3	5
SD00151-6	25	47	16	52	41	38	88	58	27	3	1	4	3	1	1	5	5
SD00151-7	30	47	27	42	37	39	93	57	27	2	1	2	3	1	1	6	4
SD00151-8	27	49	24	46	40	38	97	57	27	3	4	2	1	1	1	6	4
SD00258-1	29	47	30	56	28	42	80	58	29	5	6	1	2	1	1	3	6
SD00265-3	3	52	36	56	40	43	86	60	32	5	5	3	4	1	1	3	5
SD98113-2-1	37	46	24	56	24	41	82	59	30	4	5	2	2	1	1	5	6
SD98W175-1-13	35	45	37	42	38	38	75	59	30	3	3	6	7	2	2	5	4
SD98W175-1-14	1	55	48	53	41	49	86	60	26	3	4	2	6	1	1	5	4
SD01W064-1	24	48	29	50	42	37	84	60	28	4	6	2	9	7	1	5	4
SD01W064-6	41	45	23	48	39	41	73	60	27	5	6	1	9	4	1	3	4
SD01W070-3	45	38	20	42	26	35	66	58	28	6	7	4	5	2	1	6	6
SD03W017	26	47	23	60	39	43	71	58	27	4	4	4	6	2	1	4	6
SD03W018	31	46	14	64	26	43	81	57	28	9	6	3	2	1	2	5	6
SD03W063	38	46	31	48	34	40	78	56	29	5	6	2	7	4	1	7	4
SD03W078	44	39	35	51	21	38	50	58	25	4	5	1	9	2	1	5	5
SD03W104	32	47	26	51	34	40	85	58	29	2	3	1	6	4	1	3	7
SD03W164	39	45	30	47	37	40	75	59	31	3	3	5	7	3	1	2	5
Mean		49	30	54	35	42	81	59	25	147	4	3	5	2	1	4	5
CV %		11	20	7	10	10	9	3	6.6	0		59				24	29
LSD (P<0.05)		4	11	8	6	7	12	1	1.8	1		2					3

¥ 1-Dakota Lakes Pea Stubble, 3-Highmore, 5-Winner, 6-Wall, 8-Brookings
£ Relative average rank (based on the average of ranks for each location).
This measure removes the bias towards higher yielding locations.
† GY-Grain Yield , TW-Testweight, HT-Height, HD-Heading and MAT-Physiological Maturity (days relative to Wendy)
LD-Lodging, LR-Leaf Rust, YR-Yellow (Stripe) Rust incidence, SCR-General Appearance at Harvest
ILAD-Inverse of Leaf Area Duration (retention of green appearance of flag leaf),
FHB-Fusarium Head Blight (scale based on Index = severity * incidence in inoculated,misted nursery)

Table 5. Grain Yield, Testweight, Agronomic and Disease Data for the 2006 Preliminary Yield Trial Red (PYTR)

Trait†	Grain Yield		TW	HT	HD	MAT	LD	ILAD	LR	YR	FHB	SCR
	RANK £	bu/acre	lbs/bu	inches	relative days		scale of 1 to 9, 1 is best					
Locations¥	1.5.6.8		1.5.6.8	1,8	1,6,8	6,8	8	8	8	8	8	8
ARAPAHOE	24	46	59	31	3	1	3	7	1	3	2	5
EXPEDITION	7	50	60	30	0	0	1	9	1	1	3	3
HARDING	26	45	58	32	6	3	1	7	6	6	3	3
JAGALENE	18	46	60	30	3	2	1	9	1	1	5	5
JERRY	38	45	58	32	8	4	3	5	1	1	4	4
MILLENNIUM	9	50	60	33	4	4	1	3	1	1	2	3
Wendy	8	48	60	27	1	0	1	9	1	1	3	3
TANDEM	15	47	61	31	4	3	4	6	1	1		5
TREGO	41	45	60	30	2	1	5	9	2	2		4
WESLEY	5	49	58	30	2	1	1	6	1	1	4	3
SD02134-1	4	49	56	34	7	3	1	2	1	1	7	3
SD02134-2	27	46	56	34	8	4	3	5	1	1	5	3
SD02372-5	20	47	59	32	6	5	1	5	1	1	3	4
SD02372-6	39	46	59	32	7	5	2	8	1	1	3	3
SD02413-4	13	48	59	34	7	3	4	7	1	1	3	4
SD02335-2	46	43	55	34	9	4	5	2	1	1	3	4
SD02396-2	22	46	58	30	4	2	1	7	1	1	5	3
SD02804-1	35	48	56	29	6	2	2	2	3	1	3	4
SD02399-1	29	45	58	31	5	2	1	6	1	1	5	2
SD02169-1	52	43	57	32	7	4	1	2	1	1	6	3
SD02370-2	53	41	58	32	6	4	4	7	1	1	3	4
SD02009-1	56	40	58	35	5	3	5	6	3	1	3	5
SD02009-3	58	41	58	30	3	2	3	8	2	1	4	4
SD02224-1	30	46	58	30	7	2	1	2	1	1	4	4
SD02357-2	17	47	57	33	4	1	2	5	1	1	3	3
SD02703-1	50	44	55	33	8	6	1	1	1	1	7	4
SD02110-4	59	41	55	33	6	1	6	9	2	1	5	6
SD02110-6	54	43	55	32	3	1	5	9	1	1	5	6
SD02644-1	44	44	59	31	6	1	5	7	1	1	5	4
SD02833-4	11	47	59	34	7	3	6	6	1	1	3	5
SD05004	1	53	58	33	6	3	1	5	1	2	5	3
SD05024	33	46	57	32	6	4	2	6	3	1	3	4
SD05048	31	45	59	30	3	1	4	8	3	1	2	4
SD05051	3	50	58	32	6	1	3	7	4	1	3	4
SD05074	37	46	57	30	5	2	1	6	2	1	3	3
SD05076	51	42	59	33	3	1	2	5	1	1	3	5
SD05089	49	44	59	30	5	2	2	5	4	1	5	5
SD05090	55	42	59	31	3	2	3	5	3	1	4	4
SD05093	60	37	57	31	6	4	3	5	1	1	5	4
SD05104	23	46	59	32	4	1	1	2	2	1	4	3
SD05118	2	50	58	30	6	2	3	2	1	1	4	4
SD05122	48	45	56	34	8	4	5	2	1	1	5	4
SD05127	45	44	60	33	2	2	4	3	1	1	5	5
SD05133	47	44	57	30	6	3	1	1	1	1	3	4
SD05142	28	45	57	32	6	2	6	4	1	1	3	3
SD05145	42	45	57	33	7	2	4	5	1	1	3	4
SD05146	34	43	58	34	7	2	7	5	1	1	3	5
SD05156	16	48	60	34	6	2	2	6	3	1	2	4
SD05160	40	46	60	37	5	1	3	4	4	1	3	2
SD05170	21	47	57	31	4	1	4	4	1	2	3	4
SD05171	6	50	57	35	7	3	5	3	1	1	4	3
SD05178	12	46	59	33	3	2	6	7	3	1	3	3
SD05179	14	50	61	35	5	2	3	1	1	1	4	3
SD05182	43	46	59	31	4	2	2	2	2	1	3	4
SD05190	57	41	59	30	4	1	2	5	1	1	3	4
SD05210	10	48	59	32	5	2	1	3	1	1	3	4
SD05215	19	47	59	33	3	2	5	9	3	1	2	3
SD05265	36	45	59	31	5	1	2	7	1	1	5	2
SD05280	32	45	59	28	4	2	1	6	2	1	5	4
SD05321	25	45	59	30	1	1	3	6	1	1	5	5
Mean		46	58	32	5	2	3	5	2	1	4	4
CV %		12	2	6	0.4		69				29	
LSD (P<0.05)		6	1	3	1		2					

¥ 1 Dakota Lakes Pea Stubble, 3 Highmore, 5 Winner, 6 Wall, 8 Brookings

£ Relative average rank (based on the average of ranks for each location).

† GY-Grain Yield , TW-Testweight, HT-Height, HD-Heading and MAT-Physiological Maturity (days relative to Expedition)
LD-Lodging, ILAD-Inverse of Leaf Area Duration (retention of green appearance of flag leaf),
LR-Leaf Rust, YR-Yellow (Stripe) Rust incidence, SCR-General Appearance at Harvest,
FHB-Fusarium Head Blight (scale based on Index = severity * incidence in inoculated,misted nursery)

Table 6. Grain Yield, Testweight, Agronomic and Disease Data for the 2006 Preliminary Yield Trial White (PYTW)

Trait†	Grain Yield						TW	HT	HD	MAT	LD	ILAD	LR	YR	FHB	SCR	SPROUTING	
	RANK £	bu/acre					lbs/bu	inches	relative days		scale of 1 to 9, 1 is best							
Locations¥	1.5.6.8		1	5	6	8	1.5.6.8	1,8	1,6,8	6,8	8	8	8	8	8	1,6,8	8 (2005)	8 (2006)
ARAPAHOE	23	47	34	34	32	88	58	32	4	1	3	7	1	1	6	5	1	3
EXPEDITION	10	54	52	46	31	87	60	34	1	1	2	9	3	1	6	7	2	3
HARDING	11	53	48	39	38	88	58	35	7	3	2	7	2	1	5	6	2	2
JAGALENE	7	54	56	49	42	67	60	31	3	1	1	9	4	1	3	7	1	1
WENDY	16	52	48	38	40	81	60	28	0	0	1	9	2	1	5	7	5	3
TREGO	12	53	46	44	39	82	60	31	2	1	2	9	3	1	4	7	3	3
WESLEY	15	53	46	43	36	85	57	29	3	1	1	7	2	1	4	7	1	2
SD05W012	3	55	43	48	43	87	59	29	2	1	2	3	1	1	7	8	4	4
SD05W018	4	56	45	51	39	90	60	32	5	3	1	3	1	1	2	7	3	4
SD05W027	18	51	47	39	38	82	60	30	5	1	1	6	1	2	6	8	1	4
SD05W030	1	56	49	47	43	85	60	29	4	3	2	2	1	1	5	6	3	3
SD05W038	26	47	41	39	34	75	60	33	4	1	1	2	1	1	6	6	2	
SD05W055	29	42	34	26	30	79	57	31	6	3	1	4	1	1	6	6	2	
SD05W066	14	53	43	48	39	82	60	30	6	4	1	4	1	1	4	6	3	4
SD05W081	22	48	29	42	39	83	60	28	3	4	1	2	2	1	7	6	2	4
SD05W108	13	52	42	43	41	83	58	29	6	4	1	3	1	1	4	6		4
SD05W113	30	40	22	32	32	73	58	30	7	2	1	2	1	1	6	7	2	
SD05W118	27	45	32	31	37	82	58	28	6	2	1	1	1	1	4	6	2	
SD05W121	24	49	42	37	38	79	60	29	4	1	6	7	3	1	4	6	1	
SD05W137	28	46	35	33	33	82	59	32	5	1	3	6	1	1	6	7	3	
SD05W138	8	54	45	42	42	87	60	28	4	0	1	9	1	1	5	6	3	
SD05W140	5	55	49	44	43	82	60	33	4	1	2	2	1	1	3	7	1	3
SD05W142	6	55	43	46	40	91	61	30	3	1	2	1	2	1	5	6	2	5
SD05W148	19	51	41	43	36	86	62	30	4	1	1	1	1	1	3	5	2	
SD05W157	20	50	42	35	38	85	58	30	5	1	1	7	1	1	2	7		
SD02W080-2	21	50	39	43	41	77	61	33	4	1	4	6	1	1	5	7	2	
SD05250	17	51	47	37	33	88	60	31	3	1	2	2	1	1	7	6	3	3
SD05257	2	56	46	44	43	91	58	33	4	1	3	6	2	1	5	7	2	2
SD05267	9	53	44	44	42	83	61	34	0	1	1	6	1	1	7	5	3	6
SD05270	25	47	31	41	36	81	59	30	6	0	2	7	1	1	4	4		
Mean		51	42	41	38	83	59	31	3	3	2	5	2	1	5	6		
CV %		11	15	14	9	8	2		0.6	0.2	103				20			
LSD (P<0.05)		6	13	12	7	13	1		1	1	1							

¥ 1-Dakota Lakes Pea Stubble, 5-Winner, 6-Wall, 8-Brookings

£ Relative average rank (based on the average of ranks for each location).

† GY-Grain Yield , TW-Testweight, HT-Height, HD-Heading and MAT-Physiological Maturity (days relative to Wendy)
LD Lodging, ILAD-Inverse of Leaf Area Duration (retention of green appearance of flag leaf),
SCR-General Appearance at Harvest, LR-Leaf Rust, YR-Yellow (Stripe) Rust incidence, SPROUTING-tolerance to preharvest sprouting,
FHB-Fusarium Head Blight (scale based on Index = severity * incidence in inoculated,misted nursery)

South Dakota Advanced Yield Trial (AYT)

The 2006 Advanced Yield Trial (AYT) was grown at seven sites in South Dakota. The AYT included 45 entries, consisting of 34 advanced experimental lines from our program and one line from Nebraska and ten checks. Eleven of the 34 experimental lines were whites.

The screening tests performed on entries in the AYT included WSMV field adult plant screening (Dr. Marie Langham, SDSU; data not shown), multiple-race seedling stem rust screening (data not shown), field FHB screening (data not shown), and field leaf rust screening (Table 4). The SDSU program also evaluated pre-harvest sprouting tolerance, PPO enzyme activity, coleoptile length, protein levels, and mixograph performance (data not shown). Based on field performance data and screening results, four lines were advanced to statewide yield trials (CPT) in 2007:

SD01273	KS95U589/NE967430
SD03171	89118RC1-X-9-3-3/TX96D2845//Expedition
SD0111-9	KS93U134/Arapahoe
SD98W175-1-14	KS84273BB-10/KSSB110-9//KS831374-141B/YE1110/3/KS82W418/SPN

Preliminary Yield Trial (PYT)

Separate Preliminary Yield Trial (PYT) nurseries were planted for hard red and hard white winter wheat in 2006. The nurseries were planted on dry land pea stubble at Dakota Lakes, on spring wheat stubble at Selby, on spring wheat stubble at Winner, on fallow at Wall, and on millet stubble at Brookings.

Selections for advancement to the 2007 AYT were based on grain yield, test weight, optimum plant height and maturity, straw strength, height reduction under dry conditions, agronomic performance, coleoptile length, disease leaf area duration, resistance to leaf and stem rusts, as well as predictive baking and milling quality. Pre-harvest sprouting tolerance and PPO activity were also weighted during the selections of lines from the PYT white nursery. No lines with leaf or stem rust susceptibility or poor leaf area duration were advanced. For the first time in the last six years, we failed to obtain reliable tan spot data in Winner and Selby or WSMV data in Winner due to severe drought in these two locations.

Early Yield Trial (EYT)

Separate Early Yield Trial (EYT) nurseries were planted for hard red (EYTR) and hard white (EYTW) winter wheat in 2006. With the exception of three lines in the EYTR and one line in the EYTW, all selections were from among the top 50% for grain yield. Two-thirds of the selections were among the top 20% for grain yield.

Selection was weighted on grain yield, drought tolerance, volume weight, optimum height and maturity, height reduction under drought, straw strength, agronomic performance, disease leaf area duration, leaf and stem rust resistance, as well as predictive milling and baking quality. In addition to these traits, PPO levels and pre-harvest sprouting tolerance were also weighted heavily for advancing EYTW lines to the 2007 PYTW.

Only lines with resistance or moderate resistance to stem and leaf rusts were selected for advancement. Most lines with poor green leaf duration due to disease severity were also discarded.

Head -row Nursery

The 2006 head-row nursery consisted of 24,147 rows, including periodic checks, originating from 306 different cross combinations. Of the 306, 101 were white and 149 were red populations. 53 white entries and 45 red entries were re-selections from the 2005 EYT nursery. Fifty heads were picked from each EYT plot for each entry. The other entries were obtained by picking 100 heads from each selected F_3 plot. Nineteen of the head-row populations contained QTL-tagged FHB parents.

Selections were based on relative date to maturity, pedigree and visual observation of plants prior to and at maturity. Conditions in the head-row nursery were suitable for selecting against FHB and leaf rust susceptibility. Heads of progeny of red/white crosses were threshed individually and evaluated for seed color before placing in the appropriate EYT nursery. White lines were screened for PPO before advancing to the EYT White nursery.

Early Generation Bulk Populations

a) F_3 Bulk Generation

The 2006 F_3 nursery of bulk populations was planted at Brookings and Dakota Lakes from seed of 535 F_2 bulk populations. The F_3 plots consisted of 243 red, 82 white, 137 red/white bulks, and 73 QTL-tagged FHB populations from crosses made in 2003. Of the white populations, 59 were from single crosses and 23 were from 3-way crosses. Of the red populations, 167 were from single crosses and 76 were from three-way crosses. Of the red/white populations, 94 were from single crosses and 43 were from 3-way crosses. The Dakota Lakes nursery was planted into winter wheat stubble and was severely affected by the drought of 2006 and consequently abandoned. Therefore all observations and head collections were performed at Brookings. Notes on overall appearance, disease leaf area duration, and relative maturation date were used, along with pedigree information, for selecting 220 of the 535 F_3 plots from which heads were picked for the 2007 Head-row nursery. For most plots, 100 heads were picked, with an attempt to obtain a diversity of plant types. About 20 – 50 heads were also picked from each 24 EYTR and 29 EYTW plots for the 2007 head-row nursery.

b) F_2 bulk Generation

The 2005 F_2 nurseries of bulk populations consisted of 700 entries from spring 2005 and fall 2004 greenhouse crossing cycles. Entries with adequate amount of seed (216 populations) were planted into 7-row plots in Brookings and Highmore, SD. Entries with insufficient seed to plant two locations (175 populations) were planted into 7-row plots at Highmore only. Entries with smaller amount of seed (4 – 24 g; 309) were planted into 4-row plots at Brookings only. The F_2 plots consisted of 336 red, 61 white, and 303 red/white bulk populations. Eight of the populations included FHB QTL-tagged parents. Of the 700 F_2 plots, 593 were advanced to the 2007 F_3 plots planted in Brookings and Dakota Lakes.

Greenhouse Crossing and Increase Program

The basic strategy of the greenhouse crossing program is to make adapted/adapted and adapted/un-adapted//adapted crosses (three-way crosses) with adapted winter wheat from our program and neighboring programs and un-adapted (e.g., spring wheat or other exotic germplasm) material with special desirable traits. Unique germplasm with resistance to FHB, WSMV, tan spot, Septoria, stem and leaf rusts, and hard white grain characteristics continue to be used in the crossing program. During 2006, 892 successful crosses were made during two greenhouse cycles (519 in the spring and 373 in the fall).

RESEARCH SUPPORT PROJECTS

Basic research support projects included inheritance studies on various biotic and abiotic stresses limiting yield and quality in South Dakota winter wheat.

Fusarium Head Blight:

'Darrell' hard red winter wheat (HRWW) was released in 2006. It has the lowest FHB severity rating among all cultivars tested in South Dakota during the last six years. It ranked top for yield in South Dakota Crop Performance Testing (CPT) Variety Trial in 2006 and had an exceptional three-year yield average. It had exceptional performance in the state of Nebraska in the Northern Regional Performance Nursery (NRPN) in 2003 and 2004. It has acceptable milling, good baking quality, and a good diseases package. 1,055 lines were dormant seeded in November 2005 in the mist-irrigated nursery in Brookings, SD. Due to excessive early spring rain, the seed failed to germinate and the nursery was lost for the first time in the last six years. A backup nursery consisting of 257 lines, including the NRPN, CPT, Advanced Yield Trial (AYT), and Preliminary Yield Trials (PYT) was transplanted in May 2006 and evaluated in July 2006. Four lines with promising FHB resistance were included in the 2007 CPT and 10 in the 2007 AYT. We included 15 experimental lines and checks in the 2006 Tri-state FHB Nursery (South Dakota, Nebraska, and Kansas). About 3,800 head-rows and 51 EYT entries with tagged FHB QTL sources were planted in the 2006 – 2007 season. Best lines out of the head-row nursery will be included in the EYT in 2008. Resistant lines will be entered into regional nurseries to facilitate development of varieties with broad adaptation to the northern Great Plains.

A six parent diallel was evaluated for FHB at $F_{4:5}$ generation in a mist-irrigated field in 2006. Diallel analysis showed highly significant ($P < 0.01$) general and specific combining ability effect, and the ratio of combining ability variance component was 0.68. The cross between parents 'ND2710' and 'BacUp' showed highly significant ($P < 0.01$) negative specific combining ability. Resistance source in ND2710 was derived from the Chinese variety, Sumai-3, and resistant source in BacUp was obtained from the Japanese variety 'Nuybay'. $F_{4:5}$ spring and winter population were developed from Nekota/ND2710, Nekota/BacUp, 2137/ND2710 and 2137/BacUp. Winter population were identified after cold treatment of seedlings (-7^0C for an hour). These spring and winter growth habit populations will be evaluated for FHB resistance using 3BS markers Xgwm493, Xgwm533, Xgwm397, XSTS3B-32 and XSTS3B-80 in 2007.

A mapping study is also underway where $F_{4:5}$ populations were derived from 'Jagalene'/'Tokai66' and Jagalene/SD97060 crosses and were evaluated for FHB resistance in the field in 2006. Disease index (%disease incidence * %disease severity/100) ranged from 11.1% to 90% and 33.3% to 90% in the Jagalene/Tokai66 and Jagalene/SD97060 populations, respectively. F_5 population was advance to F_6 in the greenhouse and F_6 populations will be evaluated for FHB in the field in 2007. Molecular mapping of the population will be done in 2007.

Stem rust

We have transferred several novel/under-utilized broad-spectrum stem rust resistance genes into selected adapted lines. Line derivation from these populations began in 2006. Research studies in coming years will focus on assessment of positive or negative effects of these genes with regard to yield, quality, or other agronomic traits. We are also building several populations for mapping markers associated with resistance of these sources in collaboration with Dr. Yang Yen, SDSU Molecular Biologist and Dr. Jeff Stein, SDSU Small Grains Pathologist. Our objectives are to: 1) to conduct a preliminary screen for the few existing markers linked with stem rust resistance genes, to assess the potential for using these markers in selection for the respective resistance genes, and 2) to search for molecular markers linked to the novel and under-utilized genes mentioned above. Resistance in most of these unique sources is believed to be conferred by a single major gene.

A segregating population from a cross between '2137' and CRL-Sr35 was made to develop a molecular marker for the stem rust resistant gene *Sr35*. Ninety-eight F2 plants were inoculated with a stem rust isolate of race QTH. Infection type and severity were evaluated 10 days after inoculation. Twenty-one microsatellite primer pairs developed previously from chromosome 3AL were used to determine polymorphism among parental lines and the F2 population. Chi square analysis indicated that resistance to stem rust was conferred by a dominant gene (_2=1.01, *P*=0.48). Only four primers (Xgwm155, Xgwm391, Xgwm497 and Xfca2076) revealed polymorphism and they were used for linkage analysis. Xgwm391 revealed a polymorphic fragment of 200 bp found only in the susceptible bulk and 2137. In contrast, Xcfa2076 amplified polymorphic fragments of 210 bp in the resistant bulk and CRL-Sr35. Chi square analysis revealed that the Xcfa2076 marker was associated with the *Sr35* resistance gene and no significant deviation from the expected ratio was observed (_2=0.78; *P*=0.4).

Clearfield Wheat

South Dakota Agricultural Experiment Station has signed a Material Transfer Agreement (MTA) with BASF Corporation to develop hard winter wheat with tolerance to the Beyond® herbicide. To accelerate progress in this area we will select among advanced germplasm at the University of Nebraska. We also obtained 50 F_3 bulks with tolerance to the Beyond® herbicide from the University of Nebraska. In the meanwhile, the two events that control resistance to the Beyond® herbicide are being incorporated into selected white and red genotypes using adapted germplasm from Nebraska to produce segregating populations containing the herbicide-tolerant events. These populations will be tested for herbicide tolerance by treating with the Beyond® herbicide in the greenhouse and field until resistance is confirmed. Marker assisted selection using sequences provided by BASF Corporation will be utilized. Selection for yield, stability, quality, disease and abiotic stress tolerance will also be practiced prior to line increase and release. We expect the release of such genotypes to have an impact in certain production areas in Southwestern South Dakota where jointed goat grass, a close wheat relative, is problematic in wheat-fallow rotations.

Heat stress

We are conducting this project in collaboration with the spring wheat breeding program at SDSU and the USDA-ARS, Plant Science and Entomology Research Unit in Manhattan, KS. The long-term goals of our program are to elucidate the mechanisms of heat tolerance in wheat and improve wheat performance under heat stress conditions. Our strategy includes use of wild wheat as a potential source of genes for improvement of heat tolerance in conventional wheat. Our joint programs recently obtained seeds of 109 genotypes of wild wheat from ICARDA. The heat tolerance in these genotypes is unknown but since they originate from hot and dry environments (Middle East, Asia, Africa, and Mediterranean) it is likely that many of them posses a high ability to tolerate heat stress. We plan to take advantage of these wild wheat genotypes and use them for improvement of heat tolerance in conventional wheat. To accomplish our long-term goals we plan to:

1. Investigate heat tolerance of the wild wheat genotypes and identify those genotypes that display the highest contrasting tolerance to heat stress.
2. Use wild wheat genotypes with highest tolerance to heat stress in our breeding program to: (a) introduce genes of importance to heat tolerance into conventional wheat backgrounds, and (b) create populations for QTL analysis/ genetic mapping by making crosses between genotypes that display contrasting tolerance to heat stress.
3. Develop molecular markers and QTLs for heat tolerance.

Near Infrared Reflectance (NIR) analyzer

The winter and spring wheat breeding programs obtained a FOSS 6500 Near Infrared Reflectance (NIR) analyzer, along with a computer and software that are required to operate the machine. The FOSS 6500 is the most widely used system of its kind in the USA. Several universities as well as some USDA wheat quality labs currently use THE FOSS 6500 where it is appropriate. It has a very broad wavelength range spectrum which covers both the near-infrared (1100 to 2500 nm) and the visible ranges of light (400 to 1100 nm). This allows an extensive array of materials, such as flour or whole grain, to be subjected to analysis. FOSS NIR Systems has developed a software package (winISI III) that is used to calibrate and operate their machines. Calibration takes place by first using standard analysis methods (i.e., wet lab, physical or chemical analysis, etc.) to obtain a dataset used for training purposes. Then grain or flour, as examples, are analyzed and the calibration software is used to build a model that will approximate the dataset used for training purposes. After a satisfactory model has been developed for any particular characteristic, samples can be analyzed with the NIR machine and data that are produced will mimic, or be highly correlated with, results from standard analysis procedures.

The FOSS 6500 will hopefully improve selection strategies within our breeding programs through the rapid and non-destructive analysis of milling and baking quality in thousands of early generation breeding lines. Program efficiency will thereby be increased through discarding materials with little potential. We are entirely cognizant that before we may predict milling and baking quality, etc. calibration models must be formulated. Fortunately, the software allows for calibrations to be shared from one unit to another. This may allow us to use calibrations derived by other programs.

Mixolab for Rheological and enzymatic analysis

We recently acquired a mixolab in collaboration with the Spring Wheat Breeding project and the department of Food Science and Hospitality at SDSU. It is a farinograph and a rapid visco analyzer combined in one instrument. It measures dough development time, protein weakening, starch gelatinization, enzymatic activity, and gel strength using one run of a sample. In addition, the mixolab obtains highly repeatable water absorption values. Dough properties evaluated by a mixograph or a farinograph are not always sufficient to predict bread-making properties. Some bread-making properties are not apparent until the dough is heated, when gluten proteins begin to denature. The mixolab has the capability of precisely controlling and ramping up the temperature after the kneading stage. In addition to the effect on proteins, the higher temperatures affect starch-pasting properties, which are important in assessing the suitability of flour for making noodles. Mixolab profiles will be used in studies of the effects of diverse glutenin and gliadin molecules on bread-making properties, and will be used for screening samples for both bread and noodle properties. Thirty-eight flour samples from the 2006 harvest were milled and evaluated in baking and mixograph tests at USDA-GMPRC in Kansas and will be analyzed on the mixolab.