2005-2006 Annual Progress Report
Winter Wheat Breeding and Genetics Program
Soil and Crop Sciences Department
Colorado State University

Introduction

Wheat breeding research at Colorado State University (CSU) is a cooperative effort involving multiple partners, including breeding program personnel, research and extension specialists at CSU and elsewhere, and farmer-cooperators who donate their time and land to assist with field testing activities. A critical component of this effort is the partnership that exists between the CSU Agricultural Experiment Station (CSUAES) and seed industry and wheat commodity groups in Colorado, including the Colorado Seed Growers Association (CSGA), the Colorado Wheat Administrative Committee (CWAC), the Colorado Association of Wheat Growers (CAWG), and the Colorado Wheat Research Foundation (CWRF). Without the excellent support from each of these groups, wheat breeding research at CSU would not be possible or, at the very least, would be severely curtailed.

The primary goals of the CSU Wheat Breeding and Genetics Program are to: a) **develop improved wheat cultivars and germplasm** adapted for the diverse production conditions in Colorado and the west central Great Plains and b) **conduct applied-basic research** to improve understanding of genetic and environmental factors that affect wheat yield and end-use quality. This report summarizes the activities of the breeding program and main areas of progress during the 2005-2006 season.

2005-2006 Site Conditions

In 2005-2006, the breeding program conducted field trials at six main locations in eastern Colorado (Akron, Burlington, Dailey, Julesburg, Sheridan Lake, and Walsh) in addition to the main location at the ARDEC research facility near Fort Collins. Overall, environmental conditions experienced at these locations where characterized by severe drought and high temperature stress that adversely affected both yield and quality.

Akron – good fall emergence and growth, very dry winter, warm spring with very limited moisture, severe drought stress from late spring through grain filling. All breeding trials were harvested.

Burlington – good planting conditions, crusting from rain after planting caused very uneven emergence. Adequate spring rains allowed stands to fill in some, though some trials remained problematic. Some trials with very poor emergence were abandoned.

Dailey – marginal planting conditions (no-till), spotty emergence, excellent fall precipitation, adequate spring rains though stands remained spotty and drought stress was evident by early June. Some minor freeze damage noted. All breeding trials were harvested.

Julesburg – very dry planting conditions, excellent fall emergence and fall growth following heavy October rains, dry winter and spring, very severe drought stress with wheat only 6" tall in places. Variety trial was harvested by all other trials were abandoned.

Sheridan Lake – marginal planting moisture (no-till), spotty emergence, good fall rains, dry and warm winter, adequate spring rains. All breeding trials were harvested.

Walsh – very dry planting conditions, good October rains immediately following planting, adequate emergence and fall growth, some minor crusting, very warm and dry winter, significant drought stress developed by early spring. Most yield trials were harvested though some had multiple missing plots due to non-uniformity of drought stress and Tordon spots.

Fort Collins (irrigated) – excellent fall stands and growth, significant drought stress from due to dry and warm winter and spring and inadequate and late irrigation. No significant disease or insect pressure. High temperature throughout grain filling also was a significant factor reducing yields and quality. Little significant lodging observed. All breeding trials were harvested.

Under the direction of CSU Extension Agronomist Dr. Jerry Johnson, the CSU Variety Testing Program evaluated check varieties and experimental lines at seven other dryland trial locations (UVPT – Bennett, Cheyenne Wells, Genoa, Lamar, Orchard, Sheridan Lake, and Yuma) and two other irrigated trial locations (IVPT – Haxtun and Rocky Ford). Overall, the various UVPT trial locations experienced significant high temperature and drought stress throughout the crop season. In spite of the low grain yields of the trials, all 11 UVPT locations were successfully harvested and incorporated into the statewide data summary. In addition to the Fort Collins IVPT, both Haxtun and Rocky Ford were successfully harvested though yields were reduced at Fort Collins due to drought stress and high temperatures and at Rocky Ford due to high temperatures and lodging.

There were generally no significant disease or insect problems in the trials in 2006. While not a problem in the trials, wheat streak mosaic virus (WSMV) was a significant problem in some areas of the state due to the mild conditions experienced in late summer and fall 2005 that provided ideal conditions for the wheat curl mite that transmits WSMV. Stripe rust, which had been so severe in 2005, was absent in 2006, significantly complicating selection to improve resistance to this disease. Aside from RWA that were observed at several locations, no other significant insect (bird cherry-oat aphid, greenbug) problems were noted.

Cultivar and Germplasm Development

Several field, laboratory, and greenhouse-based activities contribute to the overall breeding effort. The core of this effort can be likened to a “pipeline” with materials entering the pipeline at the beginning (e.g., new crosses), materials occasionally leaving the pipeline at the end (e.g., new cultivar or germplasm releases), and materials at all possible stages in between subject to various testing, screening, and selection activities. In addition to this central pipeline, we are currently involved in several supplementary activities or areas of emphasis that will also be described.

New Cultivar Releases

One new winter wheat cultivar was released in fall 2006. The new cultivar, named **'Ripper'** (denoting "something of uncommon worth"), is a hard red winter wheat with very high dryland yields, excellent drought and high temperature tolerance, and excellent milling and baking quality characteristics. In four years of statewide testing in the dryland Colorado Uniform Variety Performance Trial (UVPT), Ripper was the top yielding entry in the trials – about 7% (1.8 bu/a) higher than the next closest entry and 13% (3.2 bu/a) higher than Prairie Red. Ripper will be an excellent replacement for other stress tolerant, early-maturing cultivars in Colorado, particularly TAM 107 and Prairie Red, which tend to perform better in dry years yet have a marketing penalty due to their poor milling and baking quality.

Ripper was selected from the cross CO940606/TAM107-R2. CO940606 is an unreleased sib-selection of KS94WGRC29, a germplasm release from Kansas State University with the pedigree PI 220127/P5//TAM-200/KS87H66. TAM107R-2 is an unreleased sib-selection of Prairie Red. Ripper is a bearded (awned), white-chaffed, early maturing, semidwarf with heading date about one day later than Prairie Red and three days earlier than Hatcher. Plant height of Ripper is about one inch taller than both Prairie Red and Hatcher with most of this difference occurring in 2005 and 2006 when drought stress was most severe (i.e., suggesting that Ripper may maintain it's plant height better under drought stress conditions). Ripper has a medium-long coleoptile (similar to Prairie Red, slightly longer than Hatcher), good shattering

tolerance (similar to Prairie Red and Hatcher), and good straw strength (similar to Prairie Red, slightly better than Hatcher). Test weight of Ripper is slightly below average (similar to Jagger and Yuma) and grain protein content is slightly below average (similar to Prairie Red and Hatcher). Ripper is moderately resistant to prevalent races of stem rust, resistant to the virulent *Ug-99* race of stem rust identified in Africa, susceptible to both stripe and leaf rust, moderately susceptible to wheat streak mosaic virus, resistant to biotype 1 Russian wheat aphid (RWA), and susceptible to biotype 2 RWA. Comprehensive milling and baking quality evaluations (using Above, Ankor, and Hatcher as check entries) have shown that Ripper has superior values for both milling-related and baking-related variables compared to the check entries.

Detailed data on Ripper and other recently released varieties may be found at the home page of the CSU Wheat Breeding and Genetics Program (http://wheat.colostate.edu).

New Foundation Seed Increases

One new experimental line, designated as **CO01385-A1**, was advanced for Foundation Seed increase in fall 2006. Pending further yield and quality evaluations in 2006-2007, CO01385-A1 is targeted for release as a new cultivar in fall 2007. CO01385-A1 is a medium height, medium maturing hard red winter wheat with very high dryland and irrigated yields, high test weight, good resistance to both leaf and stripe rust, and above-average milling and baking quality characteristics. CO01385-A1 was derived from the cross Yumar/Arlin made in 1997, with initial line selection (CO01385) done in 2001 and a pure-line reselection done in Yuma AZ in 2003. CO01385-A1 has been the highest yielding entry averaged across two years of testing in the UVPT (21 location-years), with its yield 0.8 bu/a greater than Ripper, 1.7 bu/a greater than Bond CL, 2.9 bu/a greater than Hatcher, 3.7 bu/a greater than Keota, and 4.4 bu/a greater than Avalanche (the next five highest yielding lines in the UVPT on a two-year average). Test weight of CO01385-A1 was the third highest in the UVPT, about 1 lb/bu greater than the average of all entries, 0.3 lb/bu less than Danby and Trego, 0.2 lb/bu less than Avalanche, and 0.5 lb/bu greater than Prowers 99. In the irrigated IVPT, CO01385-A1 was also the highest yielding entry averaged across two years of testing (6 location-years). Yield has been 3.1 bu/a greater than TAM 111, 4.9 bu/a greater than Bond CL, and 9.2 bu/a greater than Hatcher (these are the next three highest yielding lines in the IVPT on a two-year average). Test weight of CO01385-A1 was the third highest in the IVPT, about 1 lb/bu above the average of all entries, 0.2 lb/bu less than Jagalene and NuGrain, 0.1 lb/bu greater than TAM 111, and 0.3 lb/bu greater than NuFrontier.

State Variety Trials

In 2005-2006, advanced experimental lines were tested in the dryland UVPT along with released cultivars and experimental lines from various public or private breeding programs (54 total entries). Excluding Ripper, a total of 25 experimental lines from our breeding program were tested in the 2006 UVPT, some being in their first, second, or third year of statewide testing. Of these experimental lines, 6 were non-*Clearfield** HRW lines, 5 were non-*Clearfield** HWW lines, 8 were *Clearfield** HWW lines, 2 were *Clearfield** HRW lines, and 3 were Biotype 2 RWA-resistant HRW lines (**Table 1**). Together with data from regional trials and breeding trials at other locations, selections were made for advancement of seven lines for further testing in the 2007 UVPT:

Entry	Pedigree	General Description
CO01385-A1	Yumar/Arlin	HRW, high yield and test weight, good quality
CO02W214	KS98HW423/KS96HW94	HWW, good yield, stripe rust resistant, lower sprout tolerance
CO02W237	KS98HW519/KS96HW94	HWW, good yield, stripe rust susceptible, good sprout tolerance
CO02W280	KS98HW521/KS98HW165	HWW, good yield, stripe rust resistant, lower sprout tolerance
CO03W238	KS01-5539/CO99W165	HWW *Clearfield** wheat, stripe rust susceptible, lower sprout tolerance
CO03W239	KS01-5539/CO99W165	HWW *Clearfield** wheat, stripe rust susceptible, lower sprout tolerance
CO03W269	KS01-5539/CO99W191	HWW *Clearfield** wheat, stripe rust susceptible, lower sprout tolerance

Table 1. Grain yield and test weight summary from the 2006 Dryland Variety Performance Trial (UVPT). Entries are ranked in descending order by grain yield. Lines marked in **BOLD** were advanced for further testing and seed increase.

ID	Akron	Arapahoe	Bennett	Burlington	Genoa	Julesburg	Lamar	Orchard	SLake	Walsh	Yuma	GY*	TW*	HT*
Ripper	30.7	15.0	34.7	13.1	30.5	4.8	28.8	42.3	36.5	24.7	44.7	27.8	55.2	19.7
CO03W239	**35.5**	**15.9**	**34.0**	**16.3**	**29.7**	**11.2**	**28.4**	**38.2**	**37.2**	**19.4**	**40.1**	**27.8**	**55.7**	**20.9**
NuDakota	39.7	16.3	35.3	19.8	28.9	8.5	24.6	40.3	29.6	21.0	41.9	27.8	54.4	20.0
Infinity CL	33.8	12.7	33.5	16.9	34.3	10.7	25.4	43.4	32.6	20.7	38.0	27.5	55.7	22.6
Goodstreak	27.3	17.0	35.8	18.7	27.5	10.5	21.5	46.5	43.9	14.0	38.3	27.4	56.6	23.3
Endurance	29.9	16.6	34.5	22.6	27.5	7.4	20.6	42.6	40.6	19.0	36.8	27.1	56.8	20.5
CO01385-A1	**31.8**	**14.7**	**33.8**	**18.0**	**27.5**	**12.3**	**19.9**	**44.5**	**33.3**	**18.6**	**42.6**	**27.0**	**56.6**	**21.7**
Harry	21.5	16.6	34.2	16.6	29.0	6.7	23.8	44.3	48.3	16.2	39.3	27.0	53.4	20.7
Keota	29.6	11.7	38.9	20.3	26.7	4.8	21.0	43.7	37.4	21.0	41.4	26.9	56.3	22.0
Hatcher	17.1	13.4	43.3	21.7	28.7	2.2	23.0	43.7	38.7	21.2	39.5	26.6	56.8	20.4
CO03637	29.7	13.9	32.8	15.0	30.7	12.1	26.9	38.6	39.9	20.2	31.2	26.5	54.9	20.5
Alliance	26.1	15.8	34.5	19.5	32.2	2.9	22.4	38.0	43.5	15.9	38.2	26.3	56.7	21.7
Avalanche	28.5	13.7	35.8	17.4	27.7	7.5	26.7	37.6	35.2	19.5	39.0	26.2	58.4	21.0
Yuma	23.2	16.6	34.9	19.0	27.5	6.4	23.1	42.6	36.2	20.8	38.0	26.2	55.4	20.3
Ankor	20.8	14.7	37.6	19.8	27.6	3.8	23.9	42.0	39.3	19.2	39.6	26.2	56.5	20.7
CO02W280	**33.1**	**15.1**	**34.0**	**13.9**	**28.7**	**12.9**	**20.4**	**44.4**	**36.0**	**14.0**	**35.6**	**26.2**	**56.8**	**22.5**
Trego	18.3	16.1	33.8	15.2	30.2	8.3	24.8	44.2	38.1	18.8	40.1	26.2	57.8	19.9
Jagger	34.9	10.0	31.1	22.0	27.2	13.6	23.4	36.3	31.7	18.3	38.5	26.1	55.9	22.2
Bond CL	19.3	15.4	36.8	14.0	24.8	10.9	28.3	41.9	32.9	17.7	43.8	26.0	53.1	22.2
CO03W262	26.0	16.6	35.0	15.5	27.8	6.0	22.9	34.8	38.2	20.0	43.0	26.0	54.9	22.2
Akron	20.3	16.1	35.4	19.0	26.8	4.1	23.6	41.4	39.4	22.0	35.6	25.8	56.2	20.6
CO01212	26.2	13.9	35.6	13.9	27.8	10.0	22.4	44.1	38.0	20.3	31.2	25.8	56.7	22.4
CO02W214	**31.2**	**15.7**	**33.7**	**13.8**	**29.3**	**10.7**	**18.0**	**41.1**	**35.0**	**16.5**	**37.5**	**25.7**	**56.4**	**22.3**
CO03W253	20.8	14.3	32.0	14.7	31.7	6.8	27.0	40.0	39.5	16.3	39.5	25.7	54.9	21.4
CO03W238	**30.4**	**11.4**	**35.5**	**18.2**	**27.0**	**10.6**	**24.4**	**36.0**	**37.0**	**17.8**	**33.1**	**25.6**	**55.6**	**21.7**
CO03W263	26.5	11.6	32.1	14.3	30.3	11.0	22.9	41.5	37.1	18.6	35.5	25.6	54.1	18.9
KS03HW6-6	20.3	13.8	34.1	13.3	30.1	7.5	24.9	42.4	50.3	9.0	35.3	25.5	55.0	20.0
Above	26.9	13.5	35.6	21.0	30.5	5.3	26.2	36.2	38.8	19.3	26.9	25.5	56.5	20.6
CO02W237	**34.8**	**11.7**	**32.9**	**13.7**	**27.4**	**9.6**	**21.6**	**37.4**	**37.0**	**16.5**	**37.5**	**25.5**	**57.0**	**21.5**
CO02322-A2	30.9	17.4	34.9	16.7	24.4	6.8	17.1	44.5	34.0	17.8	33.9	25.3	57.2	21.6
Danby	15.8	13.1	40.4	16.4	30.6	3.8	21.0	38.6	36.0	28.5	33.1	25.2	57.2	21.0
CO03621	19.8	13.5	35.3	15.7	28.6	8.9	25.4	37.9	33.3	17.1	40.6	25.1	55.1	21.5
CO01W171	13.8	17.1	37.8	17.7	26.3	3.8	22.6	41.3	39.1	17.8	38.6	25.1	57.4	21.3
CO01473	29.0	16.0	30.5	14.5	24.4	5.9	19.3	44.0	36.7	17.5	36.9	25.0	56.9	23.7
CO02320-A1	26.1	16.3	29.2	15.4	22.4	7.0	22.8	43.4	39.3	17.1	35.3	25.0	55.9	21.8
CO03W261	24.1	13.6	31.3	14.2	30.7	8.5	21.7	36.1	35.3	18.2	39.5	24.8	54.4	20.8
Prairie Red	27.3	10.4	30.3	19.6	28.9	6.0	25.5	36.7	30.7	20.6	35.0	24.6	55.6	20.4
Jagalene	28.4	14.2	32.2	19.0	28.2	4.3	20.9	34.1	33.0	20.1	35.6	24.5	57.2	20.9
NuHills	25.4	12.3	33.4	13.5	25.9	11.9	26.3	33.9	37.2	20.1	28.1	24.4	55.8	19.8
NuGrain	23.6	13.9	28.6	14.9	26.1	8.7	23.3	40.5	35.2	16.7	36.3	24.3	57.2	20.0
CO02265	18.3	14.9	38.0	18.5	24.3	8.2	21.3	42.3	31.8	17.2	32.3	24.3	56.3	21.5
TAM 111	17.6	11.7	35.9	18.8	28.4	4.2	22.8	43.0	34.3	15.6	34.8	24.3	56.6	22.2
CO01W172	16.9	17.6	33.0	15.8	27.2	5.4	21.7	39.1	35.7	17.4	36.4	24.2	57.9	22.4
Guymon	24.0	14.0	28.7	14.0	23.2	8.7	23.6	40.2	39.5	16.5	31.6	24.0	57.6	19.4
NuFrontier	27.7	15.3	31.3	12.5	25.0	13.8	17.1	28.3	37.7	17.0	37.8	24.0	55.9	19.8
CO02W040	32.5	12.2	31.5	16.1	23.8	7.4	21.2	36.7	28.9	17.0	35.6	23.9	56.1	22.1
CO03W269	**24.3**	**11.4**	**35.3**	**14.5**	**27.6**	**4.1**	**19.6**	**36.9**	**35.6**	**19.5**	**31.3**	**23.7**	**55.4**	**21.1**
Prowers 99	20.4	12.6	31.4	13.8	24.8	6.7	19.1	39.5	38.3	15.3	38.2	23.6	56.7	22.6
Postrock	24.3	13.0	32.0	20.3	20.5	5.4	23.5	36.0	29.2	18.3	34.9	23.4	56.9	21.0
RonL	14.6	13.2	32.1	10.1	26.5	8.6	24.3	37.1	35.5	20.4	30.3	23.0	56.2	18.5
CO03W267	19.4	11.9	32.5	13.4	25.8	3.8	24.2	33.0	30.5	18.0	37.1	22.7	56.8	21.9
CO03761	23.0	13.2	31.5	12.5	24.1	5.1	18.8	37.5	37.8	16.5	28.7	22.6	57.0	23.1
CO03765	24.1	11.9	31.2	11.8	27.2	8.9	14.9	32.2	34.6	13.6	28.1	21.7	54.8	22.5
CO03758	17.6	16.3	32.8	12.5	22.8	4.9	16.6	36.3	40.3	12.1	25.9	21.6	55.9	22.6
Average	24.9	14.1	33.9	16.3	27.4	7.6	22.5	39.6	36.7	18.0	36.0	25.2	56.1	21.3
LSD (0.05)	9.1	3.9	4.4	4.9	6.7	7.1	4.5	7.5	7.5	4.2	9.5	--	--	--

* Key to trait values: GY-average grain yield (bu/acre); TW-average test weight (lb/bu); HT-average plant height (inches).

As mentioned previously, many of the UVPT trial locations in 2006 were severely drought stressed and yields were generally low with very small numerical differences between the top and bottom of the trial. All locations were harvested, however, and the data were generally sound. With the exception of CO01385-A1, each of the lines retained for further testing and seed increase is a hard white wheat (HWW). All of these HWW were advanced for Breeder Seed increase in 2007 to enable a Foundation Seed increase and potential release in 2008. Our general goal with HWW these last few years has been to identify lines with yield comparable to or surpassing Avalanche (which has been the highest yielding HWW in the UVPT on two-, three-, and four-year averages) while improving baking quality and stripe rust resistance. In addition to these characteristics, we have also increased dramatically the numbers of samples that we are evaluating for pre-harvest sprouting tolerance. Preliminary data from these sprout tests suggest that some HWW (i.e., Avalanche, Trego, Danby, Aspen, and some of our new experimental lines) carry sprout tolerance that meets or even exceeds the sprout tolerance of many of the common HRW types in the trials or in production in Colorado. Among the lines discarded from further consideration were a group of 3 RWA biotype 2 resistant lines derived from crosses with a resistant Triticale. The resistance had been transferred to a Lamar wheat background, yet were found to be generally unadapted for dryland production and were at the bottom of the trials. Crosses have been made with these materials and populations are already in early generation population development.

Beginning with the 2007 UVPT, we collectively decided with the CSU Crops Testing Program (Dr. Jerry Johnson) to reduce the number of CSU experimental lines that are tested in the UVPT. The primary rationale for this change in our testing program is to improve the quality of the UVPT as a means to improve dryland variety recommendations for wheat producers in Colorado. Only lines targeted toward either Breeder or Foundation seed increase will be tested in the UVPT, and thus only two years of UVPT data will be available for a given line prior to release. To ensure that adequate yield data are available on experimental lines prior to release, two replications of the CSU Elite trial will now be grown at each of the dryland field testing locations in Colorado (7 at breeding program sites, 6 at Crops Testing sites = 13 total locations). We are confident that this change in our testing scheme will result in improved ability to make reliable variety recommendations to farmers as well as provide reliable data on experimental line performance to justify selection and release decisions.

As mentioned previously, the Irrigated Variety Trial (IVPT) was planted at three locations in Colorado and yield data were obtained from each of these locations (**Table 2**). No stripe or leaf rust was observed at any of the locations, though yields were reduced at Fort Collins due to both drought stress (resulting from inadequate spring precipitation and irrigation) and high temperature stress and at Rocky Ford due to high temperature stress and lodging. Of the experimental lines tested, CO01385-A1 was again near the top of the trial and on a two-year average (6 location-years), CO01385-A1 is the top yielding entry in the IVPT.

CSU Elite Nursery

In 2006, the CSU Elite was planted at each of our breeding locations in Colorado (Akron, Burlington, Dailey, Julesburg, Sheridan Lake, Walsh, and Fort Collins) as well as at several other locations in adjacent states (Amarillo TX, Goodwell OK, Colby KS, Healy KS, Ulysses KS, and Pierre SD). Between our locations in Colorado and locations in other states, the CSU Elite was planted at 13 total locations, 11 of which being dryland and 2 being irrigated. With the exception of Julesburg, each of the Colorado locations was successfully harvested.

With the 2006 CSU Elite (**Table 3**), we have implemented a new method for data analysis that serves to account for variability within replications and adjust yield data based on trends in the field. With this analysis, we have also implemented a process whereby grain yields within

Table 2. Grain yield and test weight summary from the 2006 Irrigated Variety Performance Trial (IVPT). Entries are ranked in descending order by average grain yield. Lines marked in **BOLD** were advanced for further testing and seed increase.

	Rocky Ford		Fort Collins		Haxtun		Average	
Entry	Grain Yield	Test Wt	Grain Yield	Test Wt	Grain Yield	Test Wt	Grain Yield	Test Wt
TAM 111	68.1	57.3	66.5	61.1	119.9	59.5	84.8	59.3
Keota	70.4	57.5	59.8	59.6	119.4	58.6	83.2	58.5
Platte	71.0	56.7	55.0	59.3	116.1	60.1	80.7	58.7
CO01385-A1	**57.2**	**57.8**	**60.6**	**61.8**	**122.8**	**58.0**	**80.2**	**59.2**
NI03427	60.5	58.3	66.2	60.6	111.8	59.8	79.5	59.6
Bond CL	60.6	56.6	44.8	54.4	133.0	57.2	79.5	56.1
Danby	56.5	58.1	55.3	56.6	118.8	60.5	76.9	58.4
CO03621	69.4	56.4	44.7	60.7	115.5	58.3	76.5	58.5
CO03637	71.6	55.3	42.5	54.2	113.0	57.2	75.7	55.6
CO01212	50.6	57.4	58.2	61.6	117.1	58.4	75.3	59.1
Ankor	58.1	56.1	50.7	58.6	115.4	57.6	74.7	57.5
CO03W269	**60.3**	**57.1**	**46.1**	**59.6**	**116.2**	**57.6**	**74.2**	**58.1**
CO03W267	63.4	57.0	45.9	59.3	112.4	58.4	73.9	58.2
CO03W261	62.5	55.3	43.2	56.2	114.2	57.4	73.3	56.3
CO02320-A1	58.6	55.9	43.3	59.4	116.0	57.6	72.7	57.6
CO03W253	55.2	56.3	44.3	53.2	117.1	59.0	72.2	56.2
NuGrain	64.9	57.5	46.1	60.8	105.4	59.8	72.2	59.4
Yuma	60.6	56.7	45.2	58.2	110.4	58.5	72.0	57.8
NuHills	66.6	57.7	47.4	53.6	101.9	59.2	72.0	56.8
CO02W237	**60.7**	**56.4**	**53.0**	**58.6**	**102.1**	**58.5**	**72.0**	**57.9**
Guymon	60.6	56.9	49.0	59.4	104.8	59.8	71.5	58.7
CO03W238	**66.6**	**56.0**	**43.4**	**57.3**	**104.3**	**57.4**	**71.4**	**56.9**
Jagalene	62.1	57.8	53.1	60.5	99.1	58.9	71.4	59.1
Prairie Red	59.2	56.7	44.6	60.0	109.9	58.7	71.2	58.5
Hatcher	54.2	56.9	47.3	59.8	111.4	58.3	71.0	58.4
CO03W263	54.8	54.8	39.7	55.6	118.2	56.9	70.9	55.8
CO02322-A2	60.6	57.3	46.6	60.5	102.9	59.4	70.0	59.1
NuFrontier	54.4	58.0	47.7	60.0	107.9	59.1	70.0	59.0
CO03W262	56.8	54.3	45.1	59.5	108.0	57.1	70.0	56.9
NuDakota	62.0	54.3	39.5	53.7	106.7	57.9	69.4	55.3
CO02W280	**52.8**	**56.7**	**48.4**	**59.2**	**105.0**	**59.7**	**68.7**	**58.5**
CO03W239	**61.0**	**56.0**	**45.6**	**59.6**	**99.3**	**57.9**	**68.7**	**57.9**
Antelope	58.3	56.4	43.1	58.2	103.6	57.9	68.3	57.5
CO02W040	52.6	56.7	52.1	58.8	98.4	58.1	67.7	57.9
CO02265	49.2	57.3	43.8	59.7	107.9	58.7	67.0	58.6
Postrock	60.9	56.9	50.9	60.6	86.5	59.1	66.1	58.9
NW98S097	47.6	57.2	43.9	59.3	98.5	59.2	63.3	58.6
NI02425	44.3	55.7	43.4	51.4	101.8	58.3	63.2	55.1
CO02W214	**47.2**	**56.2**	**40.9**	**56.0**	**101.0**	**58.6**	**63.0**	**56.9**
Wesley	47.6	55.7	41.1	55.1	92.1	57.8	60.2	56.2
Average	59.0	56.6	48.2	58.3	109.1	58.5	72.1	57.8

Table 3. Grain yield and test weight summary from check entries and experimental lines advanced from the 2006 CSU Elite Trial. Entries are ranked in descending order by average grain yield across 6 Colorado locations.

Entry	Ft Collins	Walsh	Sh Lake	Akron	Dailey	Burlington	Avg GY*	Avg TW*	HD*	HT*
CO03W239	83.6	10.5	38.5	24.8	34.9	12.5	34.1	56.3	141.8	20.7
CO01385-A1	83.2	9.4	35.6	29.6	32.3	12.9	33.8	58.0	144.5	22.2
CO03443	83.0	9.4	42.7	18.5	35.4	12.3	33.6	57.2	145.3	24.0
CO03W139	79.2	10.0	34.8	22.9	34.9	13.3	32.5	56.9	143.7	20.7
CO03064	77.5	10.2	39.2	19.4	34.4	13.3	32.3	55.6	144.5	24.5
Ripper	76.0	11.1	38.6	20.5	34.2	12.1	32.1	55.6	140.0	22.3
Bond CL	79.1	9.1	35.0	20.6	35.3	12.5	31.9	55.6	142.5	22.0
CO03W127	81.0	9.5	32.2	17.0	37.7	13.2	31.8	56.8	139.5	21.3
CO03W108	75.5	10.1	41.8	17.2	32.0	13.3	31.6	57.3	143.5	21.8
CO03W269	78.5	11.4	38.8	16.6	32.8	11.8	31.6	56.0	145.3	23.2
CO03W033	71.8	9.9	36.3	23.8	33.9	13.7	31.6	57.3	140.2	22.3
CO03W238	70.9	9.9	36.2	25.6	33.4	13.0	31.5	55.8	141.7	21.8
Hatcher	80.2	9.7	37.4	11.4	34.1	14.5	31.2	57.3	144.8	20.5
CO03W146	75.1	9.6	38.8	14.7	34.6	12.6	30.9	57.0	144.5	23.3
CO03W054	73.1	9.8	35.1	21.2	32.9	13.1	30.9	56.5	143.2	20.8
CO02W214	71.8	9.9	37.8	18.9	33.5	12.5	30.8	56.8	143.8	21.3
CO03W043	78.4	10.8	31.6	19.0	31.5	11.9	30.5	55.7	143.3	19.7
Jagalene	75.3	8.5	35.2	15.5	34.0	13.5	30.3	58.4	143.8	19.8
Danby	74.1	12.6	36.9	10.1	33.4	13.1	30.0	59.8	144.3	19.8
TAM 111	75.3	11.5	34.2	9.8	35.5	13.7	30.0	57.9	144.2	23.2
CO02W280	70.6	9.3	33.3	19.2	33.5	12.8	29.8	57.3	141.8	23.5
Ankor	75.6	10.7	34.8	10.9	32.9	12.5	29.6	56.5	144.8	21.3
Above	58.1	8.6	36.3	23.8	36.6	13.6	29.5	56.9	140.7	22.5
Avalanche	70.8	10.2	36.1	14.4	32.7	12.6	29.5	58.5	144.2	21.0
CO02W237	57.0	8.9	36.2	24.5	34.8	13.7	29.2	57.2	142.0	22.3
Mean	75.0	10.0	36.5	18.8	34.1	12.9	31.2	57.1	143.1	21.8
Model R^2 **	0.89	0.66	0.74	0.87	0.84	0.69				
% G Var **	55.2	15.5	32.8	45.5	11.7	6.2				

* GY-grain yield; TW-test weight; HD-heading date (days from Jan. 1); HT-plant height (inches).

** Model R^2 represents the ability of the statistical model used account for different sources of variability in the trial. A model R^2= 1.0 indicates perfect accounting for all sources of error.

** % G Var represents the percentage of the total variability in the trial explained by differences among entries (i.e., due to genetic differences among entries). A high value indicates a greater reliability of genetic differentiation among entries at that location.

each location are weighted according to the level of random variability at that location. The of this that the yield average across locations is weighted differentially according to the quality of the data. We have also implemented mixed model analyses for the CSU Elite which will allow us to perform multi-year and multi-location analyses on lines in this trial so that we use all available data on lines in selection and discard decisions. We are optimistic that these methods will improve the predictability of the data from our CSU Elite trials.

Grain yield data and relative variety rankings from the CSU Elite were generally in close agreement with data from the UVPT. Based on data from 6 locations in Colorado, as well as yield and other observations from the other locations, 16 experimental lines were retained for further testing and seed increase. Lines advanced to the UVPT have already been described. Of the remaining lines, 2 lines were HRW lines and 7 were HWW lines. It was encouraging to note that several of the HWW lines were higher yielding than the other HWW checks (Danby, Avalanche) and that some of these performed quite well in our pre-harvest sprouting tolerance tests. From the group of lines advanced from the 2006 CSU Elite, we will conduct extensive milling and baking quality evaluations during winter 2006-2007 in the CSU Wheat Quality Lab and the USDA-ARS Wheat Quality Lab. For several of these lines, reselections made in 2005 were advanced to a separate line reselection nursery for evaluation in 2006-2007. Pre-breeder seed increases of each of these lines and line reselections were planted at Fort Collins in fall 2006.

Advanced Yield Nursery (AYN)

In 2005-2006, the AYN was grown in three replications at all seven main breeding locations. The AYN was sub-divided into hard red (HRW), hard white (HWW), and *Clearfield** (both red and white types) sets to manage experimental error and seed mixing during harvest. For each subset, check entries were included for comparison. As with the CSU Elite, all three AYN trials at Julesburg were abandoned due to severe drought and visual non-uniformity in the field. At Burlington, due to poor stands and emergence from crusting after planting, data from the AYN HRW set were too variable for reliable interpretation. At Walsh, the AYN HWW set was situated in a poor spot in the field (with past bindweed patches and Tordon carryover) and data from this nursery were also too variable for reliable interpretation. Finally, due to Beyond herbicide damage in the *Clearfield** AYN at Fort Collins, where many of the lines were severely damaged, yield data were not recorded.

From the AYN, 49 total experimental lines were advanced for further testing in the 2007 CSU Elite (**Table 4**). Of this total, 13 were non-*Clearfield** HRW lines, 23 were non-*Clearfield** HWW lines, and 13 were *Clearfield** lines (8 HRW and 5 HWW). Thus, the relative proportion of HRW vs. HWW lines advanced at this stage of the program was 43% HRW and 57% HWW. Overall, strict selection was practiced for test weight in an overall effort to move test weight in our program in a more positive direction. Also, as already indicated, several *Clearfield** lines showed enough Beyond injury to warrant their elimination from the program in spite of superior yield performance at the other locations where Beyond was not applied.

Together with the other lines retained in the CSU Elite, and a set of key check entries, the size of the 2007 CSU Elite was increased to include 75 total entries (65 experimental lines and 10 key checks) with 2 replications rather than 3 replications as in the past. New trial design methodology implemented in fall 2006 will allow spatial analysis and adjustment methods to be used for these trials, which should increase the overall gain from our program by increasing trial precision and allowing us to test more lines. Also, as stated previously, the CSU Elite will now be planted at 13 locations in eastern Colorado and 7 locations in other states (20 locations), a very extensive level of experimental line testing at this stage in the program. We are confident that this new testing scheme will produce positive results for many years to come.

Table 4. Data summary for hard red, hard white, and *Clearfield** wheat experimental lines and check entries in the 2006 Advanced Yield nursery. Entries are ranked by average grain yield within grouping. †

Entry	Fort Collins	Walsh	Sh Lake	Akron	Dailey	Burlington	Avg GY	Avg TW
Hard red wheats (HRW)								
CO04092	81.6	11.5	35.6	23.4	26.8	--	35.8	57.8
CO04475	77.9	11.4	34.2	24.5	29.2	--	35.4	57.2
Hatcher	76.7	11.4	34.6	24.5	28.9	--	35.2	57.7
TAM 111	76.3	11.7	32.2	24.3	30.2	--	34.9	58.1
CO04344	76.5	12.0	34.1	24.5	27.4	--	34.9	56.6
CO04227	75.8	11.8	34.6	24.2	28.0	--	34.9	56.6
CO04393	75.1	11.6	34.8	23.0	29.3	--	34.8	57.5
CO04111	72.8	12.0	32.4	24.5	30.8	--	34.5	57.8
CO04448	72.6	11.8	33.2	25.4	28.7	--	34.4	57.1
CO04262	71.7	12.3	34.8	24.0	29.1	--	34.4	56.8
CO04447	72.5	11.5	32.5	25.2	29.8	--	34.3	57.2
Ankor	75.1	12.0	32.5	23.6	28.4	--	34.3	57.0
Ripper	69.4	11.5	34.3	26.0	29.2	--	34.1	56.0
CO04039	70.9	11.6	33.3	25.3	28.1	--	33.8	57.1
Jagalene	67.6	11.9	33.5	25.0	30.0	--	33.6	58.3
CO04113	57.7	11.3	33.9	24.4	29.0	--	31.2	58.4
CO04127	56.6	11.7	33.1	25.3	29.0	--	31.2	57.4
CO04025	56.2	11.4	32.7	24.5	29.5	--	30.9	58.0
Hard white wheats (HWW)								
CO04454W	81.9	--	37.8	30.2	26.3	18.5	38.9	57.2
CO04W164	81.0	--	37.7	30.2	26.4	18.6	38.8	56.8
CO04W135	73.3	--	36.3	36.1	26.8	18.5	38.2	56.1
CO04W038	79.1	--	40.4	26.3	26.4	18.8	38.2	57.9
CO04W075	79.0	--	36.9	28.6	26.6	18.1	37.9	57.1
CO04W188	79.3	--	40.9	22.9	26.5	18.2	37.6	57.0
CO04W061	80.7	--	38.0	25.7	26.3	16.9	37.5	57.3
CO04W128	75.3	--	40.7	28.6	26.1	16.2	37.4	58.4
CO04W281	76.6	--	37.4	27.6	26.9	17.5	37.2	58.3
CO04W097	75.1	--	36.9	29.1	26.3	18.4	37.2	56.1
CO04W029	74.3	--	36.7	30.0	26.8	18.0	37.2	57.1
CO04W014	71.0	--	36.8	31.0	26.7	20.0	37.1	57.4
CO04W205	70.6	--	35.3	32.5	26.1	20.5	37.0	56.1
CO04W119	77.5	--	36.6	27.0	26.3	17.6	37.0	57.8
CO04W028	66.6	--	39.5	32.7	26.4	19.6	36.9	57.0
CO04W216	66.7	--	35.7	36.3	26.5	18.7	36.8	57.0
CO04W095	73.4	--	37.2	27.6	26.2	19.5	36.8	56.9
Avalanche	72.1	--	33.9	31.5	26.3	18.1	36.4	58.0
CO04W179	75.0	--	37.1	24.9	26.5	17.9	36.3	57.2
CO04W051	72.9	--	36.3	28.0	26.3	16.4	36.0	56.3
CO04W210	66.4	--	36.0	32.2	26.4	18.3	35.9	56.0
CO04W010	72.8	--	37.6	24.2	25.8	18.4	35.8	56.4
NuFrontier	69.9	--	36.7	30.3	26.3	15.5	35.7	57.1
CO04W069	65.0	--	37.5	27.0	26.8	20.1	35.3	56.1
CO04W138	63.6	--	37.3	28.8	26.5	20.1	35.3	56.5
Platte	66.3	--	37.2	23.8	26.3	16.6	34.0	58.4
Danby	69.5	--	34.0	19.2	26.4	16.9	33.2	59.0
NuHills	53.4	--	35.8	27.5	26.3	16.3	31.9	57.7

Table 4. (continued)

Entry	Fort Collins	Walsh	Sh Lake	Akron	Dailey	Burlington	Avg GY	Avg TW
Clearfield* wheats								
CO04549	--	18.0	32.1	46.5	28.5	23.2	29.7	55.8
CO04553	--	17.2	37.9	38.9	30.4	23.6	29.6	55.8
CO04W320	--	17.3	32.0	41.1	30.6	25.7	29.3	55.8
CO04555	--	16.8	36.8	32.9	33.4	25.4	29.1	56.3
CO04499	--	17.7	38.2	36.8	30.8	21.8	29.1	56.4
CO04574	--	17.4	33.8	39.3	30.3	24.5	29.1	55.1
CO04544	--	16.6	34.0	38.4	32.6	22.9	28.9	55.5
CO04W323	--	17.6	34.1	38.3	30.8	23.2	28.8	56.1
CO04575	--	16.7	30.4	41.4	29.3	25.7	28.7	56.0
CO04551	--	17.7	29.9	41.7	27.2	26.0	28.5	55.5
Bond CL	--	15.9	28.8	40.7	33.2	22.2	28.2	54.1
AP502 CL	--	16.4	31.5	38.1	30.4	22.6	27.8	55.6
CO04W421	--	17.5	32.3	38.6	28.8	21.6	27.8	56.2
CO04W299	--	17.1	36.8	33.3	27.5	22.2	27.4	55.9
Above	--	16.9	31.6	36.6	29.1	22.4	27.3	56.5
Infinity CL	--	16.1	32.5	36.2	28.9	22.6	27.3	55.7
CO04W369	--	17.6	34.1	37.5	24.8	22.3	27.3	55.8
KS03HW6-6CL	--	17.1	30.1	29.6	28.0	23.8	25.7	56.2

In addition to continued yield testing, extensive milling and baking quality evaluations will be done on all of these materials during winter 2006-2007 in the CSU Wheat Quality Lab and the USDA-ARS Hard Winter Wheat Quality Lab (Manhattan KS). For each of these lines advanced to the CSU Elite Nursery, a headrow increase was planted at Fort Collins in fall 2006 for line purification and reselection in 2007 (where variability within the line persists).

Early-Generation Germplasm Development

In 2005-2006, we continued to aggressively emphasize early generation germplasm development efforts, from new line derivation down through the pipeline to the crossing program. Early-generation germplasm efforts at each phase in the pipeline are summarized as follows:

1) **F5 Preliminary Yield Nursery (PYN)**: Over 900 experimental lines were planted in seven groups of single-replication trials at four of our main breeding locations (Fort Collins, Burlington, Akron, Julesburg). Approximately 60% of these lines were hard red lines, and 40% were hard white lines. Based on grain yield, test weight, agronomic observations, small-scale quality data (on remnant bulk samples during winter 2005-2006), 140 of these lines were advanced to the 2006-2007 Advanced Yield Nursery (AYN), 50% in a HRW trial and 50% in a HWW trial. No single-gene Clearfield types were advanced from PYNs to the AYNs. As with the CSU Elite, the AYNs were planted in fall 2006 in a two-replication design that will allow spatial adjustment of yield trial data. To facilitate line reselection, we also planted a group of head selections from each of these lines at Fort Collins for reselection in 2007. Most of the HWW lines were subject to reselection by sampling heads at physiological maturity and running these through our intact head sprout testing procedure.

2) **F4 Headrows**: Over 31,000 headrows were grown at Fort Collins in 2005-2006. Approximately 21,000 of these were conventional HRW or HWW types, 5,500 were two-gene Clearfield* types, 3,500 were for reselection, and 1,000 were from populations derived from crosses with spring wheat types from CIMMYT. From visual observations and pedigree information, over 2200 headrows were hand harvested in July 2006. Grain from these headrow selections was visually inspected for kernel characteristics (color, shriveling, etc) and then subjected to a modified small-scale test weight test and whole-grain NIR. Based on visual observation, test weight, and whole-grain NIR estimates for grain protein content, wheat ash, and grain hardness, about 1040 lines were selected and advanced to the single replication PYN in fall 2006. Among this group, approximately 65% were HRW lines and 35% HWW lines. Two-gene *Clearfield** lines (both HRW and HWW) represented about 13% of the total entries. These *Clearfield** lines represent the most advanced of our two-gene *Clearfield** types. Included among the group of reselections advanced to the PYNs were a group of about 50 lines that had been brought through the sprout testing procedure the previous summer.

3) **F3 and F4 Bulks**: Approximately 435 F3 or F4 bulk populations were grown in 2005-2006. Of this set, 48 populations segregating for both the B-genome and D-genome *Clearfield** genes were grown only at Fort Collins and sprayed with 18 oz/a *Beyond* herbicide in spring 2006 to purify the populations for plants that carry both *Clearfield** genes. The conventional F3 & F4 bulk populations (387 total) were grown under both irrigation at Fort Collins and under dryland conditions at Akron. Among this set were a group of 130 HWW bulk populations obtained from the KSU breeding program at Hays KS. Based on yield, test weight, and visual observations of the bulk populations, about 25,000 non-*Clearfield** and 4,000 two-gene *Clearfield** head selections were made for advancement to the F4 headrow nursery in fall 2006. Many of the head selections were HWW selections as many of the bulk populations were crosses between white wheats or

originated from populations purified for HWW kernel color on the high-speed color sorter with the USDA-ARS in Manhattan KS.

4) **F2 Bulks**: Approximately 349 non-*Clearfield** F2 bulk populations and 49 two-gene *Clearfield** F2 bulk populations were grown at Fort Collins in 2005-2006. Of the non-*Clearfield** group, 194 were from single cross F1s and 155 were from three-way cross F1-derived populations selected in 2004. A total of 260 populations were advanced to the F3 and F4 bulk trial in fall 2006. For the *Clearfield** set, 35 populations were advanced to bulk testing following application of 18 oz/acre Beyond herbicide. In both groups, stringent selection among bulks was practiced for agronomic type and test weight prior to advancement. Also, we continue to sieve our F2 bulk samples to increase the frequency of larger-kernelled types in the bulk population.

5) **F1 Increase**: About 214 new single-cross F1 populations were increased at Fort Collins in 2005-2006. In addition to these single-cross F1s, a group of 557 three-way cross and backcross populations were planted in spring 2006 at Fort Collins. These new crosses included both Clearfield and non-*Clearfield** groups. From the non-*Clearfield** group, 229 populations were advanced to the F2 bulk nursery in 2006-2007. From the Clearfield* group, 81 populations were advanced for bulk testing in 2006-2007. In both groups, we continue to target development of HWW in our crossing program.

6) **Crossing**: Over 2100 new crosses were made in 2005-2006, split between crossing blocks in fall 2005 (1098 crosses) and spring 2006 (1147 crosses). Included among these crosses were three main types of materials: a) crosses targeted toward direct increase, bulk evaluation, and line development (961 crosses), b) crosses targeted only for backcrossing or three-way crossing (842 crosses), and c) crosses targeted for marker-assisted selection or germplasm introgression (180 crosses). Several new sources of germplasm were brought into the crossing program, including sources of adult-plant leaf and stripe rust resistance. With regard to HWW vs. HRW emphasis, we have completely discontinued making either HRW/HRW or HRW/HWW crosses, both of which yield very few if any HWW segregates in subsequent generations. Our strategy for utilizing desirable HRW types from our program and other programs is to use these as one of the first parents in a three-way cross with two other HWW parents.

Research Support Projects and Other Activities

Personnel Changes

In July 2006, two new Research Associates joined our program as a result of the departure of Sally Clayshulte in December 2005 and Bruce Clifford in May 2006. Emily Heaton came to us from the soybean breeding program at South Dakota State University. Prior to this, Emily completed a B.S. degree at CSU (while working in Dr. Pat Byrne's laboratory) and then her M.S. degree at North Carolina State University. Emily will be coordinating our molecular marker-assisted selection (MAS) and mapping activities. Hayley Miller came to us from the field crops entomology program at CSU. Hayley completed both her B.S. and M.S. degrees at CSU. Hayley will be managing our wheat quality testing efforts. Emily and Hayley enjoy both field and laboratory work and we are very excited about these new changes for our program.

New Russian Wheat Aphid Biotype Research

With the identification of a new, virulent biotype of RWA in Colorado in 2003, and additional virulent biotypes in 2004, we continue to be actively involved in several different research areas to address this problem. These activities have focused on continued germplasm screening, molecular marker identification for key resistance genes, and breeding line and population development. The following are the highlights of these activities:

- We completed the screening of 1,700 selections from the NPGS for resistance to RWA biotype 2. These selections had previously shown susceptibility to RWA biotype 1 in screenings done by the USDA-ARS lab at Stillwater OK. As we've identified many germplasm accessions with resistance to the new biotypes, we do not plan any new germplasm evaluations in the near future.
- In fall 2006, we planted a cooperative RWA biotype 2 resistance nursery at five of our breeding sites (Akron, Dailey, Walsh, Sheridan Lake, Fort Collins). This trial includes 8 resistant lines from the ARS program in Stillwater and 13 lines from our own program. All of these lines appear to carry the *Dn7* gene from the 2414-11 and Altus-034 accessions that we obtained from ARS-Stillwater in 2003. Based on yield and quality evaluations, we would hope to advance a subset of these lines for testing in fall 2007 and being seed increase of the most promising lines.
- We completed backcrossing of the Dn7 gene in 2414-11 into two elite HRW backgrounds from our program (CO00739 and CO00554). Both of these wheats were high yielding lines in 2003 but neither were released as Hatcher showed slightly superior performance. Backcross derivatives from these two groups were increased in our greenhouse in fall 2006. Seed samples from heads harvested separately were split, part of the sample was retained at CSU for RWA biotype 2 testing and part was sent to Yuma AZ for a seed increase. We would hope to advance a group of these line selections to multiple location testing in fall 2007. It is too early to project when a cultivar release might be made from these materials.
- Many new crosses and backcross populations have been developed using resistance sources identified. We have begun top-crossing several backcross-derived resistance sources with other susceptible wheats in our breeding program. Many of these populations are now going to the field.

Pre-Harvest Sprouting Tolerance Evaluation

Many hard white wheats have a predisposition to sprout in the head if wet conditions persist at harvest maturity. In 2005-2006, we continued to increase the number of samples evaluated in our sprout testing systems. For our kernel germination protocol, we implemented a "germination index" calculation which weights the kernels germinated according the day that they sprout (i.e., kernels sprouting after 1 day in the chamber are weighted greater in the calculation than those sprouting on the 6^{th} day in the chamber). With the intact head sprouting test, we continue to perform reselection within Preliminary and Advanced lines as a means to selectively identify sprout-tolerant segregates within heterogeneous lines. In this test, line reselections showing better sprout tolerance than the checks are dried, threshed, and planted in the headrow nursery in the fall. We are optimistic that this scheme will yield positive results with regard to improved sprouting tolerance in our breeding program. We have also been working to optimize several molecular markers reportedly associated with sprouting tolerance using the data from our own sprout tests to determine if the markers are predictive in our own germplasm.

USDA-CAPS Grant

Working collaboratively with Drs. Pat Byrne and Nora Lapitan, we continue to work on the USDA-CAPS grant secured by Dr. Jorge Dubcovsky at UC-Davis. We are nearing completion of our mapping population and planted a subset of this population at Fort Collins for phenotypic evaluation in 2006-2007. Marker mapping in the population is progressing well. As part of the grant, we will also be increasing our use of molecular marker assisted selection (MAS) through collaboration with the USDA-ARS Genotyping Center in Manhattan KS. We are initially focusing on topcross populations segregating for various glutenin alleles, stripe rust resistance (*Yr5* and *Yr15*), leaf and stem rust resistance (*Lr19/Sr25*, *Sr2*, *Sr24* sources), and the high grain protein content gene from tetraploid wheat. We continue to screen all parents entering our crossing

block with molecular markers and over the coming year we are planning to implement routine marker screening in both F1-topcross and single seed descent populations derived from F2 populations.

Wheat Variety Database

In August 2006, we launched a revised version of the Colorado Wheat Variety Database. The database had been available over the web since 2000, but it had become increasingly difficult to maintain over the web and internet security concerns had also become an issue. To alleviate these concerns, we modified the database such that users can now download a stand-alone version of the database over the Internet and install this on their own computer. Once installed, all functions of the database system are available from the user's computer without accessing the Internet/Web. The new Colorado Wheat Variety Database maintains the same functions as the previous version while providing several enhancements. The database allows users to search for wheat variety information, display variety trial results from all Colorado trial locations since 1990, create yield and test weight summaries averaged over years and trial locations specified by the user, and create head-to-head yield and test weight comparisons between two varieties of interest. Users interested in obtaining the database may download the database from the following link: "**http://wheat.colostate.edu/vpt.html**".

Graduate Student Research

Three graduate student research projects are currently underway in our breeding program. While we expect that these research projects will contribute vital information to help direct and focus breeding efforts, both the breeding project and the students benefit in many other ways though direct student involvement in the overall breeding program. Briefly, these include the following areas of research:

- Development and validation of near infrared reflectance (NIR) spectroscopy calibrations for whole-grain prediction of end-use quality characteristics (Joshua Butler). Josh began his Ph.D. dissertation studies (and his appointment as a research associate) in fall 2004 and has been working on development of a variety of whole grain NIR calibrations. Josh currently has a field study underway, planted at four of our field locations, to validate the results of selection based on three different whole grain calibrations. Josh hopes to complete his studies and defend his dissertation in spring 2008.
- Validation of the BYDV resistance and high grain protein content traits introgressed to several elite backgrounds as part of the IFAFS molecular marker grant (Jennifer Roth). Backcross derived near-isogenic lines have been developed following several generations of marker-assisted backcross selection. These lines were increased in Yuma AZ during winter 2005-2006 to allow us to plant yield trials at several locations in fall 2006. The objective of Jennifer's thesis study is to determine the direct and indirect effects of transfer of these segments to several elite backgrounds in our program. Jennifer hopes to complete her studies after summer 2007 and defend her thesis in fall 2007.
- RWA biotype 2 resistance gene mapping and gene transfer from *Triticum dicoccoides* (Ben Beyer). Ben has completed the development of a mapping population segregating for resistance to RWA biotype 2. He has screened bulks and the parents with many microsatellite markers and has identified a few that are showing linkage with the gene of interest. Further mapping is underway. Ben has also been working to transfer RWA biotype 2 RWA resistance from a tetraploid wheat (*Triticum dicoccoides*) to common wheat. In this study, Ben has developed selfed and backcross-derived lines that apparently carry the resistance from the tetraploid parents. Ben will be completing his studies and defending his thesis in fall 2007.

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