

**2003-2004 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 2003-2004 season.

2003-2004 Site Conditions

In 2003-2004, the breeding program conducted field trials at four main locations in eastern Colorado (Akron, Burlington, Julesburg, and Walsh) in addition to the main location at the ARDEC research facility near Fort Collins. Overall, environmental conditions experienced at these locations can be described as follows:

Akron – poor fall stands resulted from dry planting conditions and uneven soil moisture, stands failed to fill in with dry fall and spring conditions. Some winter injury noted. Very dry conditions in the spring. No significant disease or insect problems.

Burlington – excellent fall stand establishment, adequate winter precipitation. Some winter injury observed. Lack of subsoil moisture in the spring caused significant die-back with the onset of spring regrowth. Parts of trials that survived spring die-back rebounded with rains in April. Severe injury from early May freeze caused at least 80-90% yield loss. Trials were abandoned.

Julesburg – decent planting moisture, adequate plant stands in the fall. Dry fall and winter, minimal growth and tillering. Significant drought stress observed in the spring, very poor row cover and canopy development (except where variety trial was located). Late rains caused severe flush of weeds, some breeding trials were abandoned.

Walsh – decent planting moisture, adequate plant stands and growth in the fall. Fairly dry in early spring, good rains later in the spring. Freezes in mid April and early May did some damage. Significant Russian wheat aphid (RWA), mostly biotype 1, was observed throughout the nurseries. Plots were destroyed by a severe hailstorm just prior to harvest.

Fort Collins (irrigated) – excellent stands and growth in the fall. Uneven irrigation due to problems with the center pivot and water supply caused drought stress and uneven growth in the spring. Most trials had at least two good replications, although the Irrigated Variety Performance Trial (IVPT) was abandoned due to excessive drought-induced variability.

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, these UVPT trial locations were very disappointing as poor fall stands resulted in some trials being abandoned altogether (Genoa, Orchard) and other trials producing data that were deemed too variable for reliable variety comparisons (Lamar and Cheyenne Wells). Of the total of 11 UVPT locations, six locations were either not harvested or were not used for the overall variety summary. The two remaining IVPT locations were successfully harvested with very high yield averages: approximately 116 bu/acre at Haxtun and 90 bu/acre at Rocky Ford.

With the exception of some greenbug and resulting barley yellow dwarf virus infection at Rocky Ford, very little insect or disease pressure was observed at any of the testing locations. Russian wheat aphid (RWA) was observed at moderate levels at several trial locations, some of these being the original biotype ("biotype 1") and some being the new biotype ("biotype 2"). Leaf rust and stripe rust were observed at trace levels at some locations though, particularly in the case of stripe rust, at much lower levels compared to 2001 and 2003.

Over the last three years (2002, 2003, 2004 seasons), we have lost more than half of our dryland variety trial locations to poor stands, drought, hail, freeze damage, and other adverse environmental conditions. With concerns that this level of trial loss is negatively impacting the variety development process, the Variety Testing Program temporarily added two field locations in fall 2004 (Granada and Hudson) to test a reduced set of check varieties along with all of the experimental lines entered in the standard UVPT. We are hopeful that if we experience excessive trial loss again in 2005, these trial locations will provide the data necessary for making reliable experimental line selection or discard decisions in the breeding program.

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

Two new winter wheat cultivars were released in fall 2004. The first of these new cultivars, named '**Hatcher**' (after the late E.L. "Shug" Hatcher who farmed near Lamar, CO), is a high-yielding hard red winter wheat with good milling and baking properties and resistance to the original biotype of RWA. Hatcher is positioned primarily as a replacement for other CSU-bred varieties with RWA resistance, particularly 'Prairie Red' and 'Yumar'. Hatcher was selected from the crosses and backcrosses 'Yuma'/PI 372129//TAM-200/3/4*Yuma/4/KS91H184/'Vista', which is essentially a three-way cross between Yumar (50% parentage of Hatcher), KS91H184 (25% parentage of Hatcher), and Vista (25% parentage of Hatcher). Hatcher is an awned, white-chaffed, medium maturity, semidwarf hard red winter wheat. Hatcher has medium maturity, 144 days to heading from 1 January, 4 days later than Prairie Red and one day later than Yumar and 'Ankor'. Plant height of Hatcher is short (25.8 in), 0.6 in shorter than Prairie Red and 1.6 in shorter than Yumar and Ankor. Coleoptile length of Hatcher (73.6 mm) is less than Prairie Red (85.0 mm) and Ankor (77.4 mm) but longer than Yumar (62.9 mm). Shattering tolerance of Hatcher is good (3.6 score, 1=no shatter to 9=severe shatter, based on 3 observations), slightly lower than Ankor (2.7 score) but better than Prairie Red (4.1 score) and Yumar (4.2 score). On the basis of field evaluations under natural infection in Colorado and

cooperative evaluations through the USDA Regional Testing Program, Hatcher is moderately susceptible to stem rust, moderately susceptible to leaf rust, moderately resistant to stripe rust, and susceptible to both wheat streak mosaic virus and barley yellow dwarf virus. Hatcher is heterogeneous for resistance to the Great Plains biotype of Hessian fly and susceptible to greenbug. Resistance to RWA in Hatcher is conditioned by the *Dn4* resistance gene from the Yumar parent. Hatcher (originally tested as CO980607) was tested at 22 trial locations of the dryland Colorado Uniform Variety Performance Trial (UVPT) from 2001 to 2004. Grain yields of Hatcher (46.4 bu/a) were slightly lower than Trego (47.3 bu/a) but higher than all other entries tested including Ankor, Prairie Red, and Yumar. Test weight of Hatcher (58.1 lb/bu) was lower than Trego (59.7 lb/bu) but higher than Yumar (58.0 lb/bu), Ankor (57.5 lb/bu), and Prairie Red (57.4 lb/bu). In the Irrigated Variety Performance Trial (IVPT) (8 locations, 2002-2004), Hatcher (98.2 bu/a) had lower yield than Prairie Red (104.4 bu/a) and higher yield than Ankor (96.9 bu/a). The straw strength of Hatcher in these trials was only average (4.6 score, 1=erect to 9=flat, 3 observations), less than both Ankor (3.9 score) and Prairie Red (2.3 score). Hatcher was entered for testing in the 2003 and 2004 Southern Regional Performance Nursery (SRPN). Considering locations across the High Plains region, Hatcher was the 2nd highest entry both in 2003 (seven locations) and 2004 (five locations). Milling and bread baking characteristics of Hatcher were determined from three composite samples of grain from multiple locations in 2000, 2001, and 2002 and three single-location evaluations from 2001 (6 observations). Ankor and 'Prowers 99' were used as checks in these evaluations. Values for milling-related variables were generally superior to both Ankor and Prowers 99 while values for baking-related variables were generally intermediate between Ankor (average baking quality) and Prowers 99 (superior baking quality).

The second of the new cultivars released, named '**Bond CL**', is a high-yielding hard red winter wheat that combines resistance to the original biotype of RWA (biotype 1), excellent baking quality, and the *Clearfield** herbicide tolerance gene. *Clearfield** wheat is a non-transgenic (non-GMO) technology developed by BASF corporation that together with BEYOND™ herbicide enables growers to selectively control problematic winter annual grassy weeds, particularly jointed goatgrass, cheatgrass and downy brome, and feral rye. Bond CL is a doubled-haploid line developed using the wheat x maize hybridization method from the cross Yumar//TXGH12588-120*4/FS2 made in 1997 at Fort Collins, CO. Yumar (50% parentage of Bond CL) is a hard red winter wheat cultivar released by Colorado State University in 1997. TXGH12588-120*4/FS2 (50% parentage of Bond CL) is an herbicide-tolerant backcross derived line developed by Texas A&M University. Bond CL is a medium-early maturing, semidwarf hard red winter wheat. Average heading date of Bond CL is about 1.8 days later than Above and about 2.2 days earlier than Yumar. Plant height of Bond CL is medium-tall, about 2 inches taller than Above and about 1.5 inches taller than Yumar. Coleoptile length of Bond CL (78.5 mm) is less than Above (86.5 mm) but greater than Yumar (62.9 mm). Shattering tolerance of Bond CL is good (3.6 score, 1=no shatter to 9=severe shatter, 3 observations), slightly better than Above (4.3 score) and Yumar (4.8 score). On the basis of field evaluations under natural infection in Colorado and cooperative evaluations through the USDA Regional Testing Program, Bond CL has shown moderate susceptibility to stem rust, moderate susceptibility to leaf rust, susceptibility to stripe rust, and moderate susceptibility to wheat streak mosaic virus. In greenhouse seedling screening tests, Bond CL is resistant to greenbug biotype E, susceptible to the Great Plains biotype of Hessian fly, resistant to RWA biotype 1, and susceptible to RWA biotype 2. Bond CL (originally tested as CO00D007) was tested at 14 trial locations of the Colorado Dryland Uniform Variety Performance Trial (UVPT) during the 2002 (3 locations), 2003 (6 locations), and 2004 (5 locations) growing seasons. Grain yields of Bond CL (47.7 bu/a) were slightly lower than Above (48.4 bu/a) and greater than 'AP502 CL' (45.3 bu/a), the only two cultivars in the trials with tolerance to BEYOND™ herbicide. Compared to other entries, Bond CL was slightly lower yielding than Hatcher (48.1 bu/a) and TAM 111 (48.0 bu/a), but higher than all other entries in the trials. Average test weight for Bond CL (57.3 lb/bu) in these trials was less

than Above (58.2 lb/bu) and AP502 CL (57.7 lb/bu). Bond CL was tested at two trial locations of the Colorado Irrigated Variety Performance Trial (IVPT) in 2004. In these trials, Bond CL (112.9 bu/a) had lower grain yield than Yuma (114.6 bu/a) and higher grain yield than all other entries in the trials. The straw strength score strength of Bond CL in these trials was average (4.0 score, 1=erect to 9=flat scale, 3 observations), less than Yuma (1.7 score) and Prairie Red (2.0 score) and better than Ankor (5.0 score). Milling and bread baking characteristics of Bond CL were determined from multi-location composite grain samples from the Colorado UVPT in 2001 and 2002 with Above used a check in these evaluations. Values for milling-related variables of Bond CL were generally inferior to Above and values for baking-related variables of Bond CL were generally superior to Above.

State Variety Trials

In 2003-2004, advanced experimental lines were tested in the dryland UVPT along with released cultivars from various public or private breeding programs (46 total entries). As described in last year's report, a significant change was made in fall 2004 to the flow of germplasm through our breeding program. This change involved the establishment of a nursery (called the **CSU Elite Nursery**) that is intermediate to the Advanced Yield Nursery (AYN) and the first year of experimental line entry into the UVPT. Because of this change, fewer experimental lines (16 total) were tested in the 2004 UVPT. Of these experimental lines, three were *Clearfield** wheat lines, four were hard white wheat (HWW) lines with Biotype-1 RWA resistance, and nine were hard red wheat (HRW) lines in their first, second, or third year of statewide testing in the UVPT (**Table 1**).

As mentioned previously, the trials in 2004 were a big disappointment as trials at several locations were either not useful to enable reliable entry comparisons or were abandoned altogether. Data from five locations were sound, however, and, together with data from regional trials and breeding trials at other locations, selections were made for advancement of four lines for further testing in the 2005 UVPT:

Entry	Pedigree	Description
CO00016 †	CO940606/TAM107R-2	Early maturity, profuse tillering, good quality
CO00554 †	TAM 302/Akron//Halt	Lax head (~ Akron/Ankor), good row cover
CO00739 †	CO931111/CO910239//Halt	Tall semidwarf, good row cover
CO00796 †	Transvaal/Arlin/2/CO910424/Halt	Tall wheat (potential Prowers replacement)

† Line submitted for evaluation in the 2003-2004 Regional Performance Testing Program (Southern Regional Performance Nursery).

Of the experimental lines tested in the UVPT, the biggest disappointments were our hard white experimental lines (CO99W183, CO99W192, CO99W254, and CO99W329). None of these lines were even at the performance level of Avalanche and were thus discarded from further consideration. Of the four lines retained for further testing, CO00016 performed the best, second only to Jagalene in the trials. On a two-year average, however, CO00016 is the highest yielding entry in the trials with about 0.5 bu/a higher yield than Hatcher and 3 bu/a higher yield than Jagalene. The last line listed above, CO00796, is a tall wheat that has not been near the top of the trials but has been about 5 bu/a higher yielding than Prowers 99 in two years of testing in the UVPT. Continued testing in 2005 will determine the potential of this line as a tall wheat replacement for Prowers 99.

Small-scale seed increases of each of these lines retained for further testing were planted in fall 2004. Seed supply from any of these lines that perform well in 2005 should be adequate to enable Foundation Seed increase in 2005-2006 (for earliest possible release fall 2006). In addition to continued yield testing, extensive milling and baking quality evaluations will be done

Table 1. Data summary from the 2004 Dryland Variety Performance Trial (UVPT). Entries are ranked in descending order by grain yield. †

Entry	Yuma	Sh Lake	Julesburg	Bennett	Akron	Yield Avg	Test Wt	Height	Heading
Jagalene	45.3	50.4	53.7	51.4	69.6	54.1	58.0	24.8	140.7
CO00016 *	43.9	45.1	55.8	61.3	54.5	52.1	56.8	23.7	138.0
Above	45.0	43.4	49.9	57.6	61.1	51.4	56.6	22.8	137.7
Harry	41.3	49.0	46.7	52.3	66.9	51.2	54.3	25.0	143.7
Goodstreak	39.1	42.6	50.7	54.5	68.2	51.0	58.1	28.6	144.0
CO00554 *	38.2	47.0	52.9	55.0	60.3	50.7	56.9	24.7	141.0
Avalanche	44.5	50.7	44.0	56.0	57.9	50.6	58.2	25.3	142.7
Stanton	44.1	41.6	51.3	57.2	57.8	50.4	57.9	24.5	142.0
CO00739 *	34.7	46.7	53.3	56.9	60.1	50.3	56.5	24.9	141.3
TAM 111	40.9	46.9	46.1	52.4	65.0	50.2	57.7	25.3	142.3
W99-194	39.1	42.6	47.2	55.5	61.5	49.2	57.0	25.6	140.7
CO970547-7	37.5	30.8	59.2	61.7	56.2	49.1	57.6	25.4	138.7
Wahoo	37.7	47.4	47.1	53.9	59.2	49.1	56.4	24.7	143.0
Lakin	34.9	41.4	47.9	54.0	67.1	49.0	57.9	24.5	141.3
Yumar	31.0	40.0	48.3	57.6	66.6	48.7	57.2	24.8	141.7
AP502 CL	39.4	46.0	50.0	52.4	55.3	48.6	56.0	23.6	137.7
Bond CL	34.2	37.6	45.8	57.9	66.6	48.4	55.3	25.6	141.3
Yuma	31.6	38.6	50.4	54.6	66.8	48.4	56.4	23.8	141.3
Hatcher	40.8	41.7	44.2	54.7	60.0	48.3	57.1	22.5	141.0
Ankor	38.8	48.2	43.9	56.3	54.2	48.3	57.5	23.3	140.3
NuHills	43.2	44.0	46.4	50.4	56.4	48.1	57.0	23.3	140.0
Prairie Red	42.6	43.5	45.0	53.5	55.6	48.0	57.1	22.8	138.7
CO00796 *	33.8	38.8	51.0	55.1	60.7	47.9	57.2	27.0	142.0
Trego	37.3	48.8	37.5	54.1	60.7	47.7	59.3	23.0	141.7
Protection	34.1	38.1	54.2	52.6	59.1	47.6	55.3	26.8	138.3
CO99W183	37.9	33.9	53.5	55.4	56.1	47.4	54.4	23.6	140.0
NuFrontier	37.9	39.1	40.3	51.3	68.2	47.3	57.5	24.9	144.3
Jagger	41.5	38.5	56.1	48.0	52.5	47.3	56.6	23.4	138.3
CO99W192	33.0	41.3	43.2	51.8	65.3	46.9	54.7	24.3	143.0
Akron	42.4	40.5	43.6	55.0	52.1	46.7	57.1	23.3	141.3
CO00347	32.3	35.2	50.3	55.6	58.8	46.4	56.3	24.5	140.7
Alliance	26.9	35.9	49.1	55.8	64.0	46.4	56.3	24.6	140.7
CO00698	36.8	34.2	45.2	57.5	58.1	46.4	55.1	24.8	142.0
CO00345	37.0	30.8	52.8	52.5	57.3	46.1	57.3	24.6	139.3
CO991057	32.0	37.5	51.4	50.9	55.8	45.5	56.2	25.3	140.7
T81	35.2	43.7	46.5	50.8	51.3	45.5	57.5	23.5	138.7
Overley	36.7	41.1	54.4	50.6	42.9	45.1	57.1	24.8	138.3
Millennium	32.4	32.9	49.8	47.8	62.6	45.1	57.4	28.3	143.7
CO99W254	36.2	36.2	47.8	42.6	60.7	44.7	57.1	23.0	140.7
NuHorizon	34.3	44.0	39.2	49.8	51.2	43.7	58.0	22.2	142.7
Thunderbolt	30.3	34.2	46.7	48.0	55.7	43.0	58.8	25.1	142.0
CO99W329	25.8	30.3	50.0	51.8	55.0	42.6	56.9	22.4	138.0
Prowers 99	35.8	26.8	44.2	49.7	54.4	42.2	57.9	26.9	143.7
Halt	25.6	32.4	49.3	52.2	50.3	41.9	56.8	22.0	137.7
Arrowsmith	35.2	36.0	49.7	42.3	43.4	41.3	57.9	27.0	146.0
Antelope	28.5	32.2	45.2	51.6	47.4	41.0	56.6	24.2	142.7
Average	36.7	40.2	48.5	53.3	58.5	47.4	56.9	24.5	141.0
CV %	13.7	13.2	10.8	7.3	10.0				
LSD (0.05)	8.1	8.6	8.5	6.3	5.0				

† Key to trait values: yield – bushels/acre; test weight – pounds/bushel; heading – days from Jan. 1; height – inches.

* Line retained for further testing.

on these materials during winter 2004-2005 in the CSU Wheat Quality Lab, the USDA-ARS Hard Winter Wheat Quality Lab (Manhattan KS), and by various private-industry collaborators.

As mentioned previously, the Irrigated Variety Trial (IVPT) was planted at three locations in Colorado though the Fort Collins trial was abandoned due to excessive variability resulting from uneven irrigation. Very high yields were recorded at both remaining locations (**Table 2**), especially the Haxtun location where Yuma had a yield over 130 bu/a in each of the three replications. None of the trials experienced stripe rust as we've seen with more regularity in the irrigated trials the last few years. Of the experimental lines tested, few encouraging results were obtained. CO99W254 had performed very well in the irrigated trials in 2003 yet it's poor performance this year, coupled with confirmation of its inferior baking quality characteristics, resulted in this line being dropped from further consideration. CO00016 performed well in the irrigated trials in 2004 but is quite susceptible to stripe rust so it would not likely be positioned for irrigated conditions in the event that it moves toward release in 2006. While stripe rust was not an issue in 2004, we expect that it will continue to be an issue in Colorado particular for irrigated production conditions. Good sources of resistance are available in a variety of Great Plains germplasm sources, including lines from our own program, and we will continue to focus more on stripe rust resistance in our crossing program and, when favored by field infection, selection and advance decisions of experimental lines.

CSU Elite Nursery

As mentioned previously, the 2004 season was the first year of the new CSU Elite Nursery. The CSU Elite was planted at each of our breeding locations in Colorado (Akron, Burlington, Julesburg, Walsh, and Fort Collins) as well as at several other locations in adjacent states (Amarillo TX, Goodwell OK, Colby KS, Sidney NE, and Pierre SD). Testing of our materials by cooperators in other states serves two objectives. First, it allows us to see our materials under a broader range of production conditions and constraints than we might experience here in Colorado in a given year, allowing us to identify lines with broad adaptation and avoid lines with serious deficiencies that may not have appeared here in Colorado. Second, it allows our cooperators in other states to see our experimental lines before they reach the regional testing stage and use some lines in their crossing programs. To reciprocate, we also test the elite nurseries from the other cooperating programs at our testing locations here in Colorado. These include evaluation of the Texas and Oklahoma Elite Trials at Walsh, the Kansas Intrastate Nursery (KIN) at Burlington, and the Nebraska Intrastate Nursery (NIN) and South Dakota Advanced Yield Trial at Julesburg. We hope to continue this testing exchange in the future.

Based on data from all available locations (**Table 3**), considering irrigated trial data (Fort Collins, Goodwell OK), dryland trial data at Colorado locations only, and dryland trial data at all available locations, 12 experimental lines were advanced to the 2005 UVPT. In addition to these 12 lines, 4 line reselections from some of these lines were also advanced to the 2005 UVPT. In recent years, we have increased our emphasis on quality testing and we now have extensive quality evaluations on lines before we make the decision to advance them to the variety trial stage. This year was no exception, as several lines that performed well with regard to yield had significant quality flaws that could not be overlooked. From the group of lines advanced to the 2005 UVPT, we will conduct extensive milling and baking quality evaluations during winter 2004-2005 in the CSU Wheat Quality Lab and the USDA-ARS Hard Winter Wheat Quality Lab (Manhattan KS). A replicate set of experimental lines and check entries will also be sent to the USDA-ARS Western Wheat Quality Lab (Pullman WA) for bread baking and experimental Asian noodle testing. For each of these lines advanced to the UVPT, a headrow increase will be done in at Fort Collins in 2004-2005 for line purification and reselection (where variability within the line persists).

Table 2. Data summary from the 2004 Irrigated Variety Performance Trial (IVPT). Entries are ranked in descending order by grain yield.[†]

Entry	Haxtun			Rocky Ford		Avg Yield	Avg Test Wt	Height
	Grain Yield	Test Weight	Lodging Score	Grain Yield	Test Weight			
Yuma	133.5	57.5	1.7	95.8	55.9	114.6	56.7	34
Bond CL	130.7	57.6	4.0	95.0	55.1	112.9	56.4	38
CO991057	119.2	58.7	3.0	102.1	55.7	110.6	57.2	37
CO00016 *	117.0	57.2	2.0	100.9	54.9	109.0	56.1	35
Ankor	120.6	59.4	5.0	97.3	53.9	108.9	56.6	38
Prairie Red	109.1	56.9	2.0	106.0	55.2	107.6	56.1	34
Protection	122.2	57.6	3.3	92.9	54.3	107.5	56.0	35
Ok102	112.3	59.3	1.3	99.9	57.7	106.1	58.5	35
CO99W183	116.0	57.2	4.0	94.0	56.7	105.0	56.9	34
CO970547-7	113.8	58.7	5.0	93.4	56.2	103.6	57.5	33
NuHills	103.8	58.4	1.7	102.1	55.5	102.9	56.9	34
Overley	119.7	58.3	4.3	85.6	56.8	102.7	57.5	39
CO00345	116.8	58.5	4.0	87.9	57.6	102.4	58.0	34
CO00347	119.4	57.5	4.0	85.4	56.9	102.4	57.2	35
NuFrontier	111.7	56.2	2.3	92.2	57.4	101.9	56.8	38
Hatcher	118.4	59.0	5.0	84.8	57.0	101.6	58.0	37
CO99W192	112.8	58.4	4.7	90.3	51.1	101.5	54.8	35
CO99W254	111.0	55.9	1.3	91.5	56.9	101.2	56.4	34
CO00698	107.2	57.7	5.3	95.1	56.9	101.1	57.3	40
Dumas	113.8	58.2	1.0	88.2	58.0	101.0	58.1	35
Jagalene	119.9	59.0	1.7	81.5	57.0	100.7	58.0	37
Antelope	121.5	57.0	2.0	79.6	54.8	100.6	55.9	36
Nuplains	110.6	58.6	1.3	89.1	57.0	99.9	57.8	37
NuHorizon	121.6	60.3	1.0	77.4	56.4	99.5	58.3	35
CO99W329	114.8	55.2	3.3	82.8	56.3	98.8	55.8	33
Wesley	113.8	58.9	1.0	83.3	54.2	98.6	56.5	33
CO00739 *	115.9	57.8	3.0	80.0	55.4	97.9	56.6	37
CO00554 *	114.7	58.9	5.7	78.4	56.3	96.5	57.6	36
CO00796 *	104.1	59.1	3.3	81.8	57.4	92.9	58.3	38
Platte	107.8	61.0	1.0	77.2	53.2	92.5	57.1	33
Average	115.8	58.1	2.9	89.7	55.9	102.8	57.0	36
CV %	6.1			8.9				
LSD (0.05)	11.6			13.1				

[†] Key to trait values: yield: bushels/acre; test weight: pounds/bushel; height: inches; lodging score: 1=no lodging to 9=complete lodging scale.

* Line retained for further testing.

Table 3. Data summary from the 2004 CSU Elite Nursery. Entries are ranked in descending order by average dryland grain yield. †

Entry	Ft		Avg	Colby	Amarillo	Sidney	Pierre	Julesburg	Akron	Avg	Avg	HD	HT
	Goodwell	Collins	IRR							DRY	TW		
CO991350-A5	68.2	80.6	74.4	65.4	48.9	62.9	72.8	40.5	51.0	53.8	57.5	140.5	24.3
Above	67.4	73.5	70.5	66.6	53.9	64.9	64.3	40.8	40.7	53.4	57.9	138.8	23.9
Hatcher	68.9	83.5	76.2	59.6	37.9	74.0	81.2	36.2	57.9	53.1	59.4	141.8	23.6
CO980607-A3	64.0	73.0	68.5	62.6	42.2	60.9	66.5	40.3	51.7	51.5	59.2	141.3	23.3
CO991407-A2	70.3	72.4	71.4	52.9	43.6	69.8	67.5	40.3	47.7	50.9	59.7	139.5	21.6
CO991057-A1	75.8	81.0	78.4	50.0	49.0	62.7	71.4	39.6	49.5	50.2	58.6	142.3	23.7
CO980607-A1	69.3	74.1	71.7	59.6	42.7	56.7	61.1	41.1	49.5	49.9	59.0	141.0	24.4
CO01W189 *	56.6	82.4	69.5	56.6	28.6	75.0	75.1	41.0	48.0	49.8	58.7	143.3	24.0
CO00554 *	67.9	87.7	77.8	51.1	39.7	60.2	76.6	45.2	52.1	49.6	58.9	141.7	23.3
CO980630-A1	70.8	73.8	72.3	59.9	40.7	57.3	72.5	41.1	48.7	49.5	59.4	142.3	23.3
CO991407-A3 *	71.8	83.0	77.4	50.0	44.4	63.8	72.6	41.3	47.7	49.4	59.7	140.3	24.1
CO00016 *	72.6	77.2	74.9	61.7	29.4	73.4	69.5	40.9	40.9	49.3	57.8	141.5	22.4
CO01W172 *	66.0	63.1	64.5	51.8	29.4	76.2	66.0	38.3	48.2	48.8	59.5	142.2	23.6
CO00347	69.8	63.4	66.6	50.6	37.4	64.4	76.2	38.5	52.4	48.6	58.9	142.3	23.4
CO00739 *	54.4	95.8	75.1	46.2	35.1	60.6	61.9	45.4	55.7	48.6	58.3	141.8	25.6
Avalanche	62.0	79.6	70.8	47.8	38.2	62.5	64.0	42.3	50.9	48.3	59.1	142.5	23.9
Stanton	70.9	69.2	70.1	46.2	42.6	56.3	58.8	44.8	51.5	48.3	59.2	141.5	23.4
Jagalene	74.3	73.0	73.7	52.3	36.8	54.6	79.0	42.7	54.7	48.2	59.8	140.0	23.0
Bond CL	77.4	69.5	73.5	59.5	36.7	54.8	67.2	39.9	49.1	48.0	57.1	141.5	22.9
TAM 111	60.0	82.1	71.0	46.1	36.7	65.5	63.9	39.0	52.6	48.0	59.4	142.7	25.9
CO01W173 *	70.3	74.8	72.6	55.8	27.8	68.0	70.4	39.5	48.6	47.9	58.8	140.0	25.0
CO991325-8	76.9	70.6	73.7	55.2	31.6	66.0	62.4	39.5	47.3	47.9	57.0	143.0	22.9
CO991407-A9	70.2	71.1	70.6	51.4	38.5	64.0	76.3	38.6	47.1	47.9	59.3	140.2	23.0
CO99314-A1	72.1	60.3	66.2	56.8	46.8	49.6	55.5	38.7	46.7	47.7	59.0	137.8	21.6
CO01W171 *	65.9	67.8	66.8	52.3	27.2	64.7	77.7	38.9	53.7	47.4	59.2	143.3	23.3
CO01W191 *	65.9	82.3	74.1	51.1	26.0	65.4	79.6	36.3	54.6	46.7	59.4	144.0	24.1
CO991407-A13	70.3	86.0	78.1	44.1	38.2	66.5	70.7	41.0	43.2	46.6	59.1	138.2	22.6
CO00698	60.1	82.9	71.5	49.6	39.7	54.8	77.6	40.3	48.4	46.6	57.5	142.3	25.7
CO01W165	62.7	69.9	66.3	56.9	26.5	62.9	64.1	39.0	47.1	46.5	58.7	141.8	24.1
CO991057-A4 *	71.4	77.5	74.4	49.3	41.3	59.0	68.1	38.5	44.4	46.5	59.2	142.2	24.1
CO991407-A5	73.8	68.4	71.1	52.8	40.2	57.0	71.2	39.8	42.5	46.5	60.0	139.3	22.6
CO01W073	61.0	61.4	61.2	49.6	35.1	61.9	56.8	38.9	46.1	46.3	57.2	139.8	23.7
Trego	72.6	64.6	68.6	53.6	38.6	57.2	77.5	38.9	43.1	46.3	60.9	143.0	22.3
CO00345	71.8	72.8	72.3	52.8	36.6	55.4	70.2	42.4	43.9	46.2	58.8	139.2	24.1
CO991407-A10	71.2	82.9	77.0	46.0	36.4	61.8	70.6	40.1	44.7	45.8	58.7	137.8	25.0
Prairie Red	79.5	69.5	74.5	51.5	47.4	56.9	59.9	31.8	40.7	45.7	58.8	137.5	23.0
CO01434 *	64.4	76.3	70.3	48.9	31.6	60.3	70.5	39.3	47.2	45.4	58.6	143.0	24.9
CO01W190 *	69.7	75.3	72.5	52.3	28.3	63.5	74.3	37.1	46.0	45.4	59.6	141.2	25.7
CO00796 *	45.9	81.7	63.8	47.1	32.1	57.2	64.2	40.6	49.9	45.4	59.3	142.7	26.3
CO01473 *	62.1	53.8	57.9	42.3	32.5	56.3	69.9	36.3	58.6	45.2	59.6	142.8	23.7
CO01385 *	67.9	93.9	80.9	45.4	37.7	45.1	66.6	41.4	55.6	45.0	59.4	140.5	26.4
Ankor	81.8	79.0	80.4	52.3	33.3	50.7	61.9	41.2	46.1	44.7	59.3	141.7	24.7
CO01212 *	55.5	75.9	65.7	44.2	33.4	52.5	67.7	43.1	50.5	44.7	60.1	142.5	26.9
CO01252	66.8	78.8	72.8	51.2	45.5	50.7	61.6	37.1	38.4	44.6	59.5	136.3	21.9
CO01W097	26.5	75.0	50.7	52.5	33.5	51.7	55.8	37.9	46.6	44.4	58.0	142.2	23.7
CO01287	74.4	83.4	78.9	37.7	30.1	59.0	73.9	37.9	53.5	43.6	59.0	144.7	25.7
CO01242	71.0	74.5	72.7	43.4	30.5	58.5	57.9	35.5	47.1	43.0	56.7	140.3	24.1
CO01245	59.4	79.7	69.5	45.1	38.5	58.6	56.0	40.3	29.4	42.4	57.2	140.3	22.4
CO01W014	67.2	68.6	67.9	51.8	34.8	29.1	60.1	39.4	47.1	40.4	59.9	141.0	23.0
CO01433	62.3	68.2	65.2	40.8	28.0	43.5	73.8	36.9	48.3	39.5	58.8	143.7	23.4
Average	67.0	75.3	71.1	51.6	36.8	59.7	68.2	39.7	48.1	47.2	58.9		
CV (%)	12.5	11.6		10.9	6.6	17.4	11.5	9.3	8.9				
LSD (0.05)	16.8	14.1		11.3	4.9	20.9	15.7	6.0	7.0				

† Key to trait values: yield: bushels/acre; test weight (TW): pounds/bushel; heading (HD): days from Jan. 1; height (HT): inches

* Line retained for further testing.

Overall, data from the CSU Elite at the various locations were adequate for line selection purposes. As mentioned previously, we lost two dryland trial locations here in Colorado (Burlington, Walsh) and trials at our other two dryland locations were adversely affected by stand problems (Akron) or problems with weeds before harvest (Julesburg). Because of our continuing difficulties with dryland trial locations here in Colorado, in fall 2004 we chose to add two new dryland trial locations for testing of the CSU Elite and the Advanced Yield Nurseries (AYNs): Dailey and Sheridan Lake. At each location, we will have 600 total plots with replicated testing of the CSU Elite and the Advanced Yield Nurseries (AYNs). At Sheridan Lake, the Crops Testing Program will plant the trials and manage the alley-ways and the Wheat Breeding Program will harvest the trials. At Dailey, where we will be planting no-till into some prior crop residue, the Wheat Breeding Program will maintain the trials from planting through harvest. In "compensation" for this increased level of field testing, and the significant challenge that may result at harvest in good years when we don't lose trial locations, we will discontinue the Preliminary Yield Nursery (PYN) testing at the Walsh location. Over the years, the Walsh location is the one of our PYN testing locations (Akron, Burlington, Julesburg, and Fort Collins being the others) that is most often lost due to one reason or another. We are hopeful that these changes to our testing scheme will be a significant benefit to the program in the long term.

Advanced Yield Nursery (AYN)

In 2003-2004, the AYN was grown in three replications at all five main breeding locations. The AYN was sub-divided into hard red and hard white wheat groups to manage experimental error. For each subset, check entries were included for comparison. As with the CSU Elite, trials at Burlington and Walsh were lost completely and trials at Akron and Julesburg were adversely affected by different problems. Furthermore, the AYNs at Fort Collins were affected by the irrigation problems and the data were somewhat variable. From the AYN, 20 experimental lines were advanced to the 2005 CSU Elite Nursery (**Table 4**). Of this group, 8 lines are hard red lines and 12 are hard white lines. Between these two groups, emphasis was placed on yield as well as test weight and end-use quality evaluations done during the winter 2003-2004 in the CSU Wheat Quality Lab.

In addition to continued yield testing, extensive milling and baking quality evaluations will be done on all of these materials during winter 2004-2005 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 will be done in at Fort Collins in 2004-2005 for line purification and reselection (where variability within the line persists).

Early-Generation Germplasm Development

In 2003-2004, 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 new experimental lines were planted in seven groups of single-replication trials at all five main breeding locations. Approximately 80% of these were HRW lines while 20% were HWW lines. In addition to these lines, we also had a group of HWW *Clearfield** lines and a group of RWA biotype 2-resistant lines (derived from a resistant Triticale) in a single replication observation at Fort Collins only. Both of these sets had been advanced the previous year from a summer increase in the San Luis Valley. Based on grain yield, test weight, agronomic observations, small-scale quality data (on remnant bulk samples during winter 2003-2004 and samples tested following harvest in August 2004), 105 of these lines were advanced to the 2004-2005 Advanced Yield Nursery (AYN). To facilitate line reselection, we also planted a group of head selections from each of these lines at Fort Collins for reselection in 2005.

Table 4. Data summary for hard red and hard white wheat experimental lines in the 2004 Advanced Yield nursery. Entries are ranked by average grain yield within grouping.

Entry	Akron	Julesburg	Fort Collins	Average Yield	Dryland Avg Yield	Avg Test Wt	HD	HT
Hard Red Winter Wheats (HRW)								
CO02487	43.6	35.9	84.8	54.8	39.8	59.5	143.7	26.1
Ankor	41.0	30.2	89.0	53.4	35.6	59.2	142.0	24.9
Stanton	39.2	36.9	83.2	53.1	38.1	59.8	141.3	24.3
TAM 111	48.0	28.3	80.0	52.1	38.2	59.5	142.7	24.3
CO02213	39.1	34.4	82.3	51.9	36.7	61.0	142.2	25.1
Prairie Red	35.0	28.3	90.6	51.3	31.6	59.6	138.5	22.4
CO02322	36.6	38.8	78.5	51.3	37.7	59.5	140.8	23.4
CO02316	37.5	37.2	77.1	50.6	37.4	58.9	139.3	25.6
CO02440	39.7	23.5	87.6	50.3	31.6	59.5	144.0	23.9
CO02467	42.4	27.4	81.1	50.3	34.9	59.6	143.3	23.4
CO02320	36.5	33.0	80.5	50.0	34.8	58.8	143.0	27.3
Jagalene	41.6	32.3	73.9	49.2	36.9	59.5	140.0	25.0
CO02265	33.3	32.1	82.3	49.2	32.7	59.1	140.0	24.9
Average	39.5	32.2	82.4	51.3	35.8	59.5	142.4	24.6
CV (%)	12.2	14.1	10.3					
LSD (0.05)	7.6	7.1	12.7					
Hard White Winter Wheats (HWW)								
CO02W010	67.3	31.7	80.1	59.7	49.5	58.7	144.0	23.9
CO02W021	57.8	35.0	80.2	57.7	46.4	59.4	144.0	27.1
Lakin	61.1	32.0	79.7	57.6	46.5	59.6	140.7	26.6
CO02W180	66.4	32.9	73.3	57.5	49.7	58.9	143.5	27.1
CO02W192	58.9	37.6	73.7	56.7	48.3	59.3	143.0	24.6
CO02W185	55.1	38.2	75.6	56.3	46.7	59.5	141.2	25.6
Avalanche	60.0	26.3	76.1	54.1	43.1	60.2	143.2	25.9
CO02W183	56.4	31.7	74.3	54.1	44.0	59.9	143.7	25.1
CO02W214	55.9	38.0	67.5	53.8	47.0	58.5	142.5	25.6
CO02W283	64.5	32.0	64.0	53.5	48.3	58.9	142.3	23.6
NuFrontier	61.9	31.8	66.1	53.2	46.8	59.4	143.3	25.3
CO02W280	43.8	36.1	76.6	52.2	40.0	59.1	140.5	26.7
CO02W023	47.8	34.6	73.9	52.1	41.2	59.5	142.7	25.9
CO02W040	46.8	36.3	72.9	52.0	41.5	59.5	142.2	22.9
CO02W237	40.4	31.7	81.0	51.0	36.0	58.9	137.8	24.4
NuHills	50.9	28.1	71.7	50.2	39.5	60.0	139.3	24.6
Trego	48.9	23.7	75.8	49.5	36.3	60.8	143.2	23.0
Average	50.4	31.0	72.8	51.4	40.7	59.2	141.9	24.8
CV (%)	12.2	14.8	18.0					
LSD (0.05)	9.9	7.4	21.2					

[†] Key to trait values: yield: bushels/acre; test weight (TW): pounds/bushel; heading (HD): days from Jan. 1; height (HT): inches

- 2) **F4 Headrows:** Approximately 39,000 headrows were grown at Fort Collins in 2003-2004. Of this group, approximately 70% were HRW lines while 30% were HWW lines. From visual observations and pedigree information, and quality information from the remnant bulk grown in 2003, approximately 1600 of these were hand harvested in July 2004. Following small-scale quality screening in August (NIR protein and hardness, PPO), about 1040 lines were selected and advanced to the single replication PYN in fall 2004. Among this group of 1040 lines, approximately 56% were HRW lines, 44% were HWW lines, and 25% were single-gene *Clearfield** lines, whether HRW or HWW. Many of the HWW lines showed low polyphenol oxidase (PPO) content in the grain (associated with darkening of Asian noodle products) during quality screening in August.
- 3) **F3 Bulks:** Approximately 317 F3 bulk populations were grown in 2003-2004. Of this set of bulks, about 60 were bulk populations with the original single-gene *Clearfield** trait; these were sprayed with *Beyond™* herbicide in spring 2004 to selectively eliminate plants lacking the herbicide tolerance trait. The F3 bulk populations were grown under both irrigation at Fort Collins and under dryland conditions at Akron. Based on yield, test weight, and visual observations of the bulk populations at both locations, about 34,000 heads were selected from 114 populations for advancement to the F4 headrow nursery in fall 2004. From this group of 34,000, about 20% are HWW types and about 25% are *Clearfield** types (both HRW CL and HWW CL). Stringent selection among bulks, both in the conventional and *Clearfield** groups, was practiced for agronomic type and test weight prior to advancement.
- 4) **F2 Bulks:** Approximately 422 F2 bulk populations were grown at Fort Collins in 2003-2004. Of this total, about 21 were populations with single-gene *Clearfield** wheat parents in the pedigree; these were sprayed with *Beyond™* herbicide in spring 2004 to selectively eliminate plants lacking the herbicide tolerance trait. About 260 total populations were advanced to bulk testing in fall 2004. This group included 172 F2 bulk populations, 19 *Clearfield** F2 bulk populations, 16 F2 bulk populations obtained from the University of Nebraska in 2003, and 68 of the best F3 bulk populations (mostly HWW/HWW populations) which had been subjected to head selection in 2004. Stringent selection among bulks, both in the conventional and *Clearfield** groups, was practiced for agronomic type and test weight prior to advancement.
- 5) **F1 Increase:** About 555 new single-cross F1 populations were increased in Yuma AZ in 2004. In addition to these single-cross F1s, a group of approximately 659 three-way cross populations were planted in spring 2004 at Fort Collins. Among these three-way cross populations was a group of approximately 103 populations derived from crosses with two different spring wheat sources of the two-gene *Clearfield** wheat. Beginning in 2003-2004, we have altered our method of handling all of our three-way cross populations. This involves making the three-way cross in the fall greenhouse, planting the F1 populations in the spring at Fort Collins, selecting individual plants (by head selection) in the summer, evaluating the F1-derived F2 bulk population as a single row the following year, and then selecting among desirable bulk rows for inclusion into the bulk tests the following year. We hope that this method of handling three-way cross populations will allow us to identify unique and promising bulk populations and more effectively facilitate utilization of genetically diverse sources in our breeding program.
- 6) **Crossing:** Over 2000 new crosses were made in 2003-2004, split between crossing blocks in fall 2003 (1258 crosses) and spring 2004 (794 crosses). Included among these crosses were three main types of materials: a) crosses targeted toward direct increase, bulk evaluation, and line development (1185 crosses), b) crosses targeted only for backcrossing (408 crosses) or three-way crossing (154 crosses), and c) crosses targeted for marker-assisted backcrossing as part of the USDA-IFAFS grant funded program (242 crosses). Of the group targeted toward direct increase, approximately 70% were three-

way crosses (including a few backcrosses for *Clearfield** and RWA projects) and 30% were single crosses between elite parents. Special emphasis was made during both crossing cycles to utilize synthetic-derived germplasm sources from CIMMYT, transfer the *Lr19* gene from 'Agatha' and the *Rht8* gene from 'Mara' into several elite backgrounds using marker-assisted selection, and introgress through crossing and backcrossing both the two-gene *Clearfield** trait and several different sources of RWA biotype 2 resistance into our germplasm base. With regard to HWW vs. HRW emphasis, we have largely discontinued making either HRW/HRW or HRW/HWW crosses, both of which yield very few if any HWW segregates in subsequent generations.

Research Support Projects and Other Activities

New Russian Wheat Aphid Biotype Research

With the identification of a new, virulent biotype of RWA in Colorado in 2003, we have been actively involved in several different research areas to address this problem. Further research conducted in 2003-2004 by Frank Pears has shown that the new biotype (designated as "biotype 2") has rapidly spread to all major wheat growing areas in Colorado, being found in roughly equal proportions as the original biotype (designated as "biotype 1"). Of perhaps greater concern are recent data from the USDA-ARS group in Stillwater OK that suggest that additional, virulent biotypes may be present in the Great Plains region. While many unanswered questions remain, we have aggressively pursued the problem from several different perspectives. These activities can be summarized as follows:

Germplasm screening

- We completed the screening of a group of 761 accessions from the National Plant Germplasm System (NPGS). Crosses have been made and molecular marker mapping populations are currently under development using several of the most promising sources.
- We began the screening of a group of nearly 7,300 Iranian landrace selections from the NPGS. Many promising sources were identified in two rounds of screening (3018 accessions evaluated) in spring 2004. Some of these have been used in crosses for breeding purposes and for mapping population development. We will hopefully complete evaluation of this set in 2005 and will then evaluate all resistant accessions against RWA biotype 1.
- We evaluated a group of over 200 wheat-relative accessions (*Aegilops* and others) from the Wheat Genetics Resource Center in Manhattan KS. No resistance to biotype 2 was found in any of these accessions.

Resistance breeding

- We evaluated a set of 15 accessions derived from crosses and backcrosses between a resistant Triticale parent and Lamar winter wheat. These accessions have been under development for several years but increased attention has been focused on them since realizing that some carry excellent resistance to RWA biotype 2. Based on biotype 2 evaluations and yield and agronomic observations from a single replication grown at Fort Collins, we advanced five lines for testing in the 2005 AYN. We also planted an increase plot of each of these lines at Fort Collins to enable entry of one or more lines in the 2006 UVPT in fall 2005. As we are uncertain as to the chromosomal stability of the resistance, we hope to work with Dr. Kabwe Nkongolo over the coming year to determine if they are stable.
- Using the two most promising resistance sources identified last year, 2414-11 and CI2401, we have made many crosses and backcrosses to transfer RWA biotype 2

resistance in these lines to our germplasm base and several elite backgrounds. As 2414-11 is a winter wheat from Oklahoma we have greater flexibility using this source in our crossing program than the CI2401 source which is completely unadapted. Populations developed from these crosses, as well as with the *Dn7* source, will hopefully be ready to be planted in the field in 2005.

- We tested a set of 13 supposed RWA biotype 2 resistant breeding lines (in an Oklahoma type background) developed by the USDA-ARS group at Stillwater OK. These materials were grown in replicated trials at each of our five locations. The sources of resistance included PI140207, PI 366515 (the presumed source in the 2414-11 line), and the *Dn7* gene from the South African source. Two rounds of greenhouse screening with biotype 2 failed to identify the PI 140207- and PI 366515-derived lines as resistant while a few of the *Dn7*-based sources did show good resistance to RWA biotype 2. Unfortunately, field observations and yield data on these materials showed that they showed little, if any, promise as potential cultivar releases in Colorado.

Miscellaneous research

- We completed the field evaluation of a source of biotype 2 resistance (*Dn7*), comparing the benefits of this resistance with the *Dn4* source. We confirmed that in a spring wheat background, the *Dn7* gene is at least as effective as the *Dn4* gene in reducing infestation and yield loss from biotype 1 RWA. While we don't have data comparing the sources in a winter wheat background with biotype 2 RWA, we expect that the results would be similar.
- We continued a collaborative project between our group, Frank Peairs' group, Nora Lapitan's group, and the USDA-ARS Genotyping Center in Manhattan KS that aims to separate the *Dn7* gene from negative quality factors on the 1BL.1RS translocation that carries *Dn7*. Materials derived from crossing the *Dn7* source with special genetic stocks have been evaluated in the greenhouse for RWA resistance and in Nora Lapitan's lab for the presence/absence of the *sec-1* gene and the *Gli-1/Glu-3* genes. This project will continue in 2004-2005.

Clearfield* Qualification Trials

In 2003-2004, BASF Corporation instituted a requirement that all *Clearfield** wheat lines intended for cultivar release be evaluated in controlled field experiments to verify that their tolerance to Beyond™ herbicide is at least equivalent to Above winter wheat. This requirement stipulates that lines be evaluated over at least 6 environments in two years (i.e., total of 6 location/years) in replicated trials that include a control treatment, a 6 oz/acre treatment, and a 12 oz/acre treatment. Following conduct of the trials, data are submitted to BASF who then provide clearance that the line is worthy of release. As this requirement was brought to us after planting in fall 2003, we would not have the required two years of field data to justify release, which would have been problematic as we had two *Clearfield** lines under Foundation Seed increase. To deal with this problem, we developed a collaboration with other breeders in the Great Plains to evaluate each other's lines in qualification trials at each program's respective testing locations. This collaboration worked very well in 2004 and we expect to continue this in 2005 and subsequent years.

Graduate Student Research

Several graduate student research projects are currently underway or were completed in 2003-2004. 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 of geographic information systems (GIS) technology to improve variety recommendations and identify variety-specific production and quality zones (Federico Pardina-Malbrán). Using data from the Collaborative On-Farm Trials (COFT) in 2002 and 2003, coordinated by CSU Extension Agronomist Jerry Johnson, Federico developed maps of expected wheat yield and quality responses of several cultivars that may be useful to further delineate environments or production zones in Colorado. Federico successfully defended his M.S. thesis in summer 2004.
- Identification of RWA Biotype-B resistance sources and characterization of field protection provided by the *Dn7* RWA resistance gene (Meghan Collins). Meghan's greenhouse studies identified and confirmed biotype 2 RWA resistance among a group of biotype 1 resistant accessions from the NPGS while her field studies compared the *Dn4* and *Dn7* genes in a spring wheat background against artificial biotype 1 infestation (as previously described). Meghan successfully defended her M.S. thesis in fall 2004.
- Assessment of the agronomic potential of the gibberellic acid sensitive semidwarfing gene *Rht8* that does not reduce coleoptile length as other semidwarfing genes used in winter wheat programs in the Great Plains (Sally Clayshulte). The first year of Sally's field trials of recombinant inbred lines from two populations was done in 2004 and the second year was planted in fall 2004 for evaluation in 2005. A companion greenhouse study was initiated in 2004 to evaluate a large collection of cultivars from other Great Plains programs to determine the association between a molecular marker supposedly linked to the *Rht8* gene and other traits associated with *Rht8* (gibberellic acid sensitivity, plant height, and coleoptile length).
- Development and validation of near infrared reflectance (NIR) spectroscopy calibrations for whole-grain prediction of end-use quality characteristics in winter wheat (Joshua Butler). Josh began his Ph.D. dissertation studies in fall 2004 and is also employed as a Research Associate under the CSREES Special Grant. He will initially focus on development and validation of calibrations that will allow whole-grain, non-destructive estimation of test weight, kernel weight, and kernel diameter while at the same time providing estimates of grain hardness and wheat protein content. Joshua also will work to develop and validate calibrations for various measures of dough strength or starch properties.

USDA-IFAFS Project

We continue to work on backcrossing novel genes into our germplasm base through the multi-institutional grant effort funded by the USDA-IFAFS grant funding agency. The focus of this grant, entitled "Bringing Genomics to the Wheat Fields", is to utilize DNA marker technology as a means to transfer desirable quality and pest resistance traits into released varieties and elite experimental lines. Our program at CSU is one of 12 public wheat breeding programs involved in this effort, with Dr. Nora Lapitan serving as the lead investigator in our effort at CSU. When the program began three years ago, we chose recently released varieties or advanced experimental lines (e.g., Avalanche, Above, Ankor, CO970547 from CSU and Stanton and Lakin from KSU) as target parents to transfer or combine genes for wheat streak mosaic virus and barley yellow dwarf virus tolerance (from wheatgrass), high grain protein content (from wild durum wheats), and RWA resistance. As described in last year's report, we discontinued the efforts with RWA resistance following the identification of biotypes virulent on the genes that we were using. This part of the project was replaced with the two different major-gene sources of stripe rust resistance (*Yr5* and *Yr15*) that are currently being transferred to several different backgrounds. We have complete five cycles of backcross marker assisted selection for most of these materials and are planning on growing the backcross-derived populations in the field in 2005 to enable derivation of near-isogenic line (NILs).

Germplasm Introduction

In 2003-2004, we continued our long-term effort to systematically explore wheat germplasm from CIMMYT (in Mexico) and eastern European countries. The objective of this effort is to broaden the genetic diversity in our program in order to insure long-term genetic improvement primarily for yield under irrigated conditions and for stress tolerance under dryland conditions. Our strategy for using these sources is to evaluate them under field conditions in Colorado and then select among the larger group for the most promising sources for introgression. The crossing strategy that we are currently using is what we would call a "focused backcrossing" approach where two or three backcrosses are made with one or two of our elite backgrounds and segregating progenies are identified in field nurseries. We are hopeful that we will identify recombinants that maintain the desirable characteristics of our recurrent parents while transferring in desirable genes from the wheat germplasm sources.

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