2000-2001 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 staff 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 the various seed industry and wheat commodity groups in Colorado, including the Colorado Seed Growers Association (CSGA), the Colorado Wheat Administrative Committee (CWAC), 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.

The primary goals of the 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 basic research to improve understanding of genetic and environmental factors that affect wheat yield and end-use quality. The following report summarizes the various activities of the breeding program and main areas of progress during the 2000-2001 season.

2000-2001 Site Conditions

In 2000-2001, the breeding program conducted field trials at four main locations in eastern Colorado (Walsh, Burlington, Akron, and Julesburg) in addition to the main site located at the ARDEC research facility near Fort Collins. Overall, environmental conditions experienced at these locations were highly variable, complicating both evaluation and selection. At Burlington, timely planting and good moisture led to excellent establishment and fall growth, which, unfortunately, was followed by severe drought stress from jointing through harvest that significantly limited expression of yield differences. At Walsh, dry soil conditions in September delayed planting until late October (still in dry soil); poor fall emergence and growth, some of which occurring in spring, resulted in a high level of variability within the nurseries. At Akron, two inches of rain immediately after planting led to soil crusting and very poor emergence in preliminary and advanced generation breeding trials. At Julesburg, the variety trial (UVPT) was replanted in early October (following crusting after planting in mid-September) and abnormally cold temperatures beginning in early November limited fall growth. The Fort Collins breeding trial location was the lone bright spot among breeding trial locations with very high yields achieved as a result of favorable environmental conditions and optimal irrigation.

In cooperation with the CSU Variety Testing Program, under the direction of Dr. Jerry Johnson, varieties and experimental lines were also tested at six dryland trial locations (Bennett, Briggsdale, Cheyenne Wells, Genoa, Lamar, and Sheridan Lake) and two irrigated trial locations in Colorado (Haxtun, Rocky Ford). Growing conditions at many of the locations was very much similar to the four breeding locations, with problems caused by poor emergence and fall growth contributing to high levels of variability within the trials and generally low yields. The plots at Bennett and Rocky Ford were not harvested due to severe hailstorms prior to harvest while the Sheridan Lake location was not harvested due to very poor stands and soil blowing in the spring.

Virtually no virus (e.g., barley yellow dwarf, wheat streak mosaic) or insect (e.g, Russian wheat aphid, greenbug, Bird cherry-oat aphid) problems were observed at any of the wheat trial

locations. A high level of stripe rust infection was observed by mid-June at several locations (Akron, Fort Collins, Genoa, Haxtun, Julesburg, Lamar, and Walsh). Data were collected on stripe rust resistance of standard varieties and experimental breeding lines; in many materials that showed a very susceptible reaction, yields and test weights were adversely affected.

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 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 Releases

In 2001, one new winter wheat germplasm line and three new winter wheat cultivars were formally released. The germplasm line, **CO960293-2** (PI 222668/TAM 107//CO850034 pedigree), was released because of its combined resistance to wheat streak mosaic virus (WSMV) and Russian wheat aphid (RWA), both of which coming from the PI 222668 parent. The RWA resistance gene is different from those previously deployed in CSU cultivars and the recent Kansas State University release Stanton. Though distinct from the wheatgrass-derived WSMV resistance being deployed by several Great Plains breeding programs, it confers a high level of resistance (near-immunity) very similar to the wheatgrass source. We have used CO960293-2 extensively in recent crossing efforts to transfer the WSMV and RWA resistance to other backgrounds and combine its WSMV resistance with the wheatgrass WSMV resistance source.

Two of the new cultivars released, named **Above** and **AP502 CL**, are hard red winter wheat cultivars that carry non-transgenic tolerance to the new imidazolinone herbicide ***BEYOND™*** from BASF Corporation. The first publicly developed ***CLEARFIELD™*** winter wheat cultivars, Above and AP502 CL will allow selective control of winter annual grass (e.g., goatgrass, brome and cheat, and feral rye) and broadleaf weeds that are problematic in Colorado and other wheat production areas. The genetic backgrounds of Above and AP502 CL are very similar, each coming from backcross introgression of imidazolinone tolerance into germplasm adapted in the west-central Great Plains.

Above is an awned, white-glumed, early maturing (1.8 days later than TAM 107, 3.6 days earlier than Akron) semidwarf (0.5 inches taller than TAM 107, 1.2 inches shorter than Akron) hard red winter wheat. Above was derived from the cross TAM 110*4/FS2 made in 1996 at Amarillo, TX. The wheat germplasm line FS2 was developed by BASF Corporation (formerly American Cyanamid) through induced mutagenesis, with sodium azide and the French wheat cultivar Fidel, to obtain tolerance to the imidazolinone class of herbicides. Above was tested in Colorado Dryland Variety Performance Trials in 2000 and 2001. Above was tested in Colorado Dryland Variety Performance Trials in 2000 and 2001. Averaged over 15 trial locations (seven locations in 2000, eight locations in 2001), Above (41.8 bu/a) yielded less than Trego (45.1 bu/a), the same as Jagger and Alliance, and greater than Akron (40.9 bu/a), TAM 107 (39.9 bu/a), and TAM 110 (39.0 bu/a). Average test weight for Above (56.0 lb/bu) in these trials was less than Trego (59.0 lb/bu), TAM 107 (56.4 lb/bu), and Akron (56.3 lb/bu), the same as Jagger, and greater than TAM 110 (55.5 lb/bu). Above is resistant to stem rust, susceptible to leaf rust, and moderately susceptible to both wheat streak mosaic virus and Barley yellow dwarf virus. Above is resistant to greenbug and susceptible to Russian wheat aphid and the Great Plains biotype of Hessian fly. Milling and bread baking characteristics of Above were determined from

composite grain samples from unreplicated yield trials in 1999 and the Colorado Dryland Variety Performance Trials in 2000. Relative to the broadly adapted check cultivar TAM 107, Above had higher grain volume weight, kernel weight, and flour yield, with lower flour protein content and higher ash content. In bread baking tests, Above had lower bake water absorption, shorter Mixograph mixing time, lower loaf volume, lower crumb grain and texture score, and the same Mixograph tolerance score compared to TAM 107.

The second of the two ***CLEARFIELD™*** wheats, **AP502 CL**, is an awned, red-glumed, early maturing (similar to TAM 107, 5 days earlier than Akron) semidwarf (similar to TAM 107, 1 inch shorter than Akron) hard red winter wheat. AP502 CL was derived from the cross TXGH12588-26*4/FS2 made in 1996 at Amarillo, TX. The wheat germplasm line FS2 was developed by BASF Corporation (formerly American Cyanamid) through induced mutagenesis, with sodium azide and the French wheat cultivar Fidel, to obtain tolerance to the imidazolinone class of herbicides. TXGH12588-26, an unreleased experimental line from the Texas A&M University-Amarillo wheat breeding program, is a sister line to TAM 110. AP502 CL was tested in Colorado Dryland Variety Performance Trials in 2000 and 2001. Averaged over 15 trial locations (seven locations in 2000, eight locations in 2001), AP502 CL (40.1 bu/a) yielded less than Trego (45.1 bu/a), Jagger (42.4 bu/a), Alliance (42.3 bu/a), and Akron (40.9 bu/a), similar to TAM 107 (39.9 bu/a) and greater than TAM 110 (39.0 bu/a). Average grain volume weight for AP502 CL (55.3 lb/bu) in these trials was less than Trego (59.0 lb/bu), TAM 107 (56.4 lb/bu), Akron (56.3 lb/bu), Jagger (56.1 lb/bu), and TAM 110 (55.5 lb/bu). AP502 CL is resistant to stem rust, susceptible to leaf rust, and moderately susceptible to both wheat streak mosaic virus and Barley yellow dwarf virus. Above is resistant to greenbug and susceptible to Russian wheat aphid and the Great Plains biotype of Hessian fly. Milling and bread baking characteristics of AP502 CL were determined from composite grain samples from unreplicated yield trials in 1999 and the Colorado Dryland Variety Performance Trials in 2000. Relative to the broadly adapted check cultivar TAM 107, AP502 CL had higher test weight, the same kernel weight, lower flour yield and flour protein content, and higher ash content. In bread baking tests, AP502 CL had lower bake water absorption, shorter Mixograph mixing time, lower loaf volume, lower crumb grain and texture score and the same Mixograph tolerance score compared to TAM 107.

The third cultivar released to seed producers, named **Avalanche**, is an awned, white glumed, early maturing (4 days later than TAM 107, 1 day earlier than Akron, and 2 days earlier than Trego) semidwarf (1.1 inches taller than TAM 107, similar to both Akron and Trego) hard white winter wheat (HWW). Avalanche was selected from the cross KS87H325/Rio Blanco made in 1988 at Hays, KS and is a sister selection to Trego. Avalanche was tested in Colorado Dryland Variety Performance Trials from 1998-2001. Averaged over 35 trial locations between 1998-2001, Avalanche (50.8 bu/a) yielded less than Alliance (52.2 bu/a), similar to Akron (51.0 bu/a), and greater than TAM 107 (48.7 bu/a). In comparison with other hard white winter wheat cultivars available in Colorado, Avalanche has yielded less than Trego (51.6 versus 49.5 bu/a; 25 locations, 1999-2001) but greater than both Lakin (41.1 versus 38.9 bu/a; 15 locations, 2000-2001) and Nuplains (41.1 versus 37.6 bu/a; 15 locations, 2000-2001). Average test weight for Avalanche (58.7 lb/bu; 26 locations, 1999-2001) in these trials has been very high, slightly less than Trego (59.1 lb/bu) but greater than both Akron (57.1 lb/bu) and TAM 107 (56.9 lb/bu). Avalanche is resistant to stem rust, moderately susceptible to leaf rust, and moderately susceptible to both wheat streak mosaic virus and Barley yellow dwarf virus. Avalanche is susceptible to the Great Plains biotype of Hessian fly, greenbug, and Russian wheat aphid. Milling and bread baking characteristics of Avalanche were determined from composite grain samples from eight subregional production zones from the 1999 and 2000 USDA Southern Regional Performance Nurseries and from the 1999 and 2000 Colorado Dryland Variety Performance Trials. Relative to the broadly adapted check cultivar TAM 107, Avalanche had higher test weight, kernel weight, and flour yield with similar flour protein and ash contents. In

bread baking tests, Avalanche had better crumb grain and texture scores and slightly lower bake water absorption than TAM 107. Mixograph mixing time, mixograph tolerance score, and loaf volume were similar for Avalanche and TAM 107.

Breeder Seed Increases

In 2000-2001, eight advanced experimental lines were on Breeder Seed increase and simultaneous RWA-resistance purification in Yuma, Arizona. Five of these lines were RWA-resistant, backcross-derived versions of the popular variety Akron that were in their first year of testing in the state dryland variety trial (UVPT). The other three lines (CO950043, CO970498, and CO970547) were RWA resistant experimental lines that had performed well in variety trials in previous years and showed promise as potential replacements for RWA-resistant cultivars currently in production. Based on yield performance in dryland (UVPT, Table 1) and irrigated (IVPT, Table 2) state variety trials, and various milling and baking quality evaluations, two of the RWA-Akron lines (CO99508 and CO99534) and one of the other lines (CO970547) were retained for further variety trial testing and seed increase. Of the other lines on increase, both CO950043 and CO970498 were dropped from further consideration. While yield performance of CO950043 has been excellent in both dryland and irrigated trials, several independent baking quality evaluations (Wheat Quality Council, ConAgra Flour Milling, USDA-ARS) suggested that its overall baking quality was unacceptable. In addition to poor dryland yield performance in 2001, similar quality ratings for CO970498 were received.

Performance of the two RWA-resistant Akron lines, CO99508 and CO99534, was slightly less than that of Akron, although when disregarding dryland trials with less reliable data (e.g., Walsh and Lamar), the minor differences were not statistically significant. On the positive side, several independent milling and baking quality evaluations (e.g., USDA-ARS, Bay States Milling, ConAgra Flour Milling) also suggest that overall quality of these two lines is superior to that of Akron, a cultivar with a less-than-desirable baking quality reputation. Both of these lines are currently on Foundation Seed Increase (18 acres each) in Colorado to enable release of one line as an improved cultivar following testing (UVPT and IVPT) in 2002. Additional milling and baking quality evaluations are being done by the USDA-ARS quality lab during the winter 2001-2002 using seed remnants from several locations in 2001.

The remaining line on Breeder Seed increase, CO970547 (***Ike/Halt*** pedigree), again performed well statewide in dryland trials and was advanced for further testing. Based on a two-year average in the UVPT, CO970547 has been the highest yielding entry in the central and northeast Colorado locations, 1.5 bu/a better than Jagger and Enhancer and second only to Trego statewide. While CO970547 has excellent RWA resistance and above-average milling and baking quality ratings, it did not perform as well in the southeast Colorado locations where RWA resistance is of greatest concern. In an attempt to identify types within CO970547 that may show different adaptation patterns or perhaps a yield advantage over CO970547, seven pure-line headrow reselections were made from the headrow purification in Arizona. Seed harvested from the CO970547 headrow reselections was adequate to include each line in the replicated advanced yield trial (AYT) and a simultaneous strip-increase in Arizona for generation of Breeder Seed. If one or more of these reselections perform well in 2002, Breeder Seed quantities should be sufficient to increase in fall 2002 for potential release in 2003. The ability to conduct a concerted headrow reselection program, that exploits the phenomenal seed increase capabilities in Arizona, promises to be a significant benefit to the program in coming years.

In 2000-2001, 26 other CSU hard red experimental lines were included in the UVPT. Three of these lines were wheat-maize doubled haploid lines that combined resistance to RWA and BEYOND herbicide. One of these lines, CO99D726, yielded quite will in the UVPT but unfortunately exhibited unacceptable test weight patterns and was dropped from further

Table 1. Grain yield (bu/acre), test weight (lb/bu), and agronomic and disease reaction ratings from the 2001 UVPT.

Entry	Akron	Burl	JBurg	Genoa	Briggs	CWells	Lamar	Walsh	AVG	TW	HT	HD	SR
Trego	56.5	37.9	48.0	42.3	56.4	42.6	47.7	50.7	47.8	58.9	28.7	143.7	7
Jagger	56.1	38.8	43.9	52.4	65.0	35.4	34.4	47.1	46.7	57.0	28.7	137.3	1
Stanton	54.8	43.2	43.5	43.2	60.8	34.9	47.4	42.5	46.3	56.8	30.8	141.3	5
NuHorizon	55.6	33.4	42.9	47.4	56.3	39.1	44.0	45.9	45.6	58.8	26.7	143.3	2
Enhancer	60.7	36.3	48.7	47.6	52.5	40.4	41.3	36.8	45.5	56.7	28.8	140.3	2
CO99D726	57.8	34.8	43.9	37.6	57.9	36.6	49.6	42.7	45.1	55.1	28.6	142.7	5
CO980684	64.9	35.3	37.1	45.8	51.5	47.5	39.5	36.9	44.8	55.5	29.3	141.0	7
CO980376*	54.7	36.5	38.5	46.1	61.8	38.1	43.7	38.5	44.7	57.3	29.0	140.0	5
CO980719*	65.7	34.9	42.2	47.0	52.3	39.8	39.8	35.7	44.7	57.1	28.7	144.3	3
CO980630*	64.0	31.9	37.8	40.9	51.0	35.2	47.5	44.4	44.1	57.2	27.3	141.3	2
Alliance	45.1	34.3	41.8	41.3	65.1	35.8	48.9	39.4	44.0	56.1	29.0	142.7	2
CO950043	60.5	33.1	31.3	44.6	63.9	36.1	42.7	38.7	43.9	57.5	28.0	141.7	2
CO970547*	55.8	37.7	39.2	45.8	57.3	43.7	38.7	32.4	43.8	57.1	29.3	139.3	4
CO980829*	51.9	33.0	46.6	42.9	57.0	45.3	37.9	33.8	43.6	57.4	27.3	141.0	6
CO980607*	60.9	29.8	45.1	40.2	52.4	36.8	40.5	42.7	43.5	57.0	27.5	141.7	2
Akron	52.9	34.7	42.3	37.4	62.6	32.8	41.7	40.8	43.2	56.4	30.0	142.0	5
Yuma	54.0	41.7	44.1	36.0	56.3	36.1	40.3	36.2	43.1	56.0	28.0	141.3	4
CO980685	59.1	33.5	37.6	39.4	46.5	48.3	45.4	34.5	43.0	55.4	28.4	140.3	7
Golden Spike	51.6	29.3	41.0	45.2	51.6	31.8	46.6	47.0	43.0	55.2	31.8	149.7	2
CO980712	57.7	35.9	43.3	44.0	47.1	40.7	33.7	41.4	43.0	56.9	28.1	144.3	5
Halt	49.6	35.8	40.1	39.0	63.2	39.0	42.3	34.1	42.9	56.2	27.8	139.3	5
CO970531	50.0	36.3	41.5	41.9	50.6	35.7	42.5	43.9	42.8	55.5	29.8	141.0	4
CO980368	51.5	30.5	40.7	35.6	54.6	36.5	47.8	41.4	42.3	56.8	28.3	139.7	5
CO970943	63.9	31.3	35.9	43.1	56.6	31.8	40.9	33.7	42.2	56.4	28.9	139.7	5
CO970940	46.6	42.3	41.2	42.1	58.1	33.8	42.0	31.3	42.2	57.0	29.7	142.7	3
Above	45.3	35.2	46.5	35.6	56.1	35.2	41.3	40.4	41.9	55.5	27.7	140.3	7
NuFrontier	50.3	33.1	45.1	38.6	49.6	32.5	43.1	40.4	41.6	56.9	30.1	145.0	2
CO99508	48.9	37.5	38.7	40.1	54.8	38.2	36.4	38.1	41.6	56.3	29.7	141.7	8
Prowers 99	42.5	35.4	35.8	34.0	51.7	35.6	47.5	48.9	41.4	58.8	33.3	147.0	2
CO99534	47.2	35.0	39.6	35.0	56.9	39.6	39.9	37.3	41.3	56.9	28.6	141.7	6
Avalanche	47.3	33.8	39.0	37.9	52.8	38.7	39.7	40.9	41.3	57.7	28.4	141.7	6
CO980697	51.5	36.9	32.2	36.5	49.6	36.1	46.0	40.9	41.2	56.8	28.3	142.7	6
CO99509	46.0	33.1	39.0	39.8	58.6	38.8	40.2	32.9	41.0	57.2	29.6	142.7	8
CO980358	51.6	30.2	29.9	36.9	54.9	34.3	50.1	39.6	40.9	55.9	29.2	140.0	5
Yumar	46.4	36.2	42.4	36.1	53.1	33.6	41.1	36.9	40.7	57.1	29.1	142.0	6
Prairie Red	47.0	36.7	39.0	32.8	57.1	36.6	40.0	36.3	40.7	56.3	28.3	139.0	6
Kalvesta	52.1	41.0	37.6	32.1	51.9	40.3	35.3	31.9	40.3	57.1	27.2	140.0	6
CO970498	44.8	35.3	26.2	41.9	60.2	36.4	41.1	35.8	40.2	57.4	27.4	139.0	5
TAM 107	45.2	35.8	37.3	30.2	56.2	42.3	40.6	33.8	40.2	56.5	28.3	138.0	6
CO99577	42.3	37.1	37.2	37.7	54.9	41.7	32.7	35.0	39.8	56.9	28.6	141.7	8
CO970552	48.5	35.1	24.3	46.6	56.5	36.5	33.6	36.8	39.7	55.9	29.3	139.7	4
AP502 CL	50.8	29.6	41.2	32.7	57.2	32.3	38.2	34.1	39.5	55.2	26.7	138.3	8
CO980629	59.5	32.9	38.1	35.9	46.8	34.0	32.5	35.0	39.3	55.7	26.0	139.0	3
CO99D679	52.0	34.9	37.0	33.5	47.5	35.2	40.9	32.1	39.2	55.5	27.1	140.7	6
CO980704	48.2	34.1	32.6	33.9	45.7	39.2	43.5	34.8	39.0	56.6	29.0	144.0	8
Intrada	43.4	36.4	41.8	32.3	59.3	31.7	36.3	28.9	38.8	56.8	27.7	142.0	9
CO980459	46.8	31.0	36.7	35.1	54.2	38.0	37.6	30.3	38.7	56.6	26.7	141.7	5
Lakin	37.4	35.5	37.8	28.1	54.6	34.3	43.8	34.0	38.2	57.1	28.6	142.3	7
TAM 110	41.6	38.2	42.6	33.0	57.6	32.5	29.8	28.1	37.9	55.1	27.6	140.0	6
2137	31.3	32.9	37.4	33.7	53.9	34.4	42.8	36.2	37.8	55.7	28.8	142.0	7
CO99533	41.4	35.3	36.4	30.7	54.1	35.7	37.8	27.0	37.3	56.5	28.6	141.7	8
CO980454	51.4	29.6	37.1	35.7	50.2	32.1	29.7	32.5	37.3	56.4	28.7	141.7	4
Venango	42.8	33.4	36.2	27.9	47.9	34.1	35.8	39.3	37.2	58.1	27.7	144.3	9
CO99D695	38.3	32.1	38.7	29.7	52.0	38.1	34.1	25.9	36.1	54.2	27.8	141.0	5
Nuplains	29.0	35.8	30.7	32.1	56.6	31.5	41.0	28.3	35.6	55.8	28.6	147.0	7
CO980721	46.5	27.8	32.7	32.4	49.4	35.7	33.1	27.2	35.6	57.1	25.9	142.3	6
CO980424	36.5	32.8	31.5	28.6	52.0	28.1	35.9	29.6	34.4	54.0	29.4	144.3	7
Wichita	34.5	30.6	26.3	30.3	45.4	33.4	36.0	36.9	34.2	58.8	35.4	141.0	5
CO980779	38.6	29.2	31.7	24.2	43.8	41.9	30.5	28.7	33.6	54.5	27.4	143.0	7
CO980443	40.5	34.0	27.8	28.0	48.9	32.1	33.2	24.1	33.6	54.2	28.7	143.7	7

Notes: TW =test weight average over locations; HD=days to heading (from Jan. 1); HT=plant height (inches); SR= stripe rust reaction (1=resistant, 9=susceptible); * - line advanced for further testing.

consideration, along with the other two CLEARFIELD doubled haploid lines (CO99D679, CO99D695) that were in the trial.

Five of the remaining experimental lines performed well in the UVPT, as well as the IVPT at Fort Collins (Table 2), and were advanced for a second year of testing in the UVPT and IVPT. These five lines (CO980376, CO980719, CO980630, CO980829, and CO980607) were sent to Arizona for headrow increases to allow generation of pure Breeder Seed as well as line reselection as was done with CO970547. The addition of Fort Collins as an official IVPT location in 2001, coupled with testing of lines that are concurrently tested in the dryland UVPT, should hopefully lead to identification of lines that show exceptional yield performance under irrigation. This strategy was further advanced with addition of a site in the San Luis Valley (Center, CO) as an official IVPT location with fall 2001 planting.

Table 2. Grain yield (bu/acre) and test weight (lb/bu) from the 2001 IVPT.

	Fort Collins		Haxtun		Average	
Entry	Yield	Test Wt.	Yield	Test Wt.	Yield	Test Wt.
CO980607 *	131.2	62.0	--	--	--	--
NW97S278	122.8	62.5	96.7	64.5	109.7	63.5
CO980829 *	119.7	60.9	--	--	--	--
CO950043	119.4	60.9	84.8	62.7	102.1	61.8
CO980630 *	115.7	61.6	--	--	--	--
Enhancer	115.2	61.9	100.6	63.3	107.9	62.6
Wesley	114.4	60.5	102.0	63.3	108.2	61.9
Jagger	111.0	61.8	91.5	63.9	101.2	62.9
CO980376 *	110.2	61.6	--	--	--	--
CO970943	108.5	61.3	85.1	61.9	96.8	61.6
NuFrontier	108.4	62.1	87.4	64.0	97.9	63.1
CO970547 *	108.4	61.3	87.2	61.3	97.8	61.3
AP502 CL	106.8	60.3	81.3	59.2	94.1	59.7
CO980719 *	106.5	62.3	--	--	--	--
Yuma	104.2	61.3	81.5	63.1	92.9	62.2
CO970940	103.1	62.1	80.9	63.3	92.0	62.7
CO970498	102.6	61.8	72.9	62.2	87.7	62.0
Above	102.2	60.1	80.2	60.7	91.2	60.4
Yumar	101.7	61.0	76.4	61.0	89.0	61.0
NuHorizon	101.2	62.3	93.1	62.9	97.1	62.6
Prairie Red	100.0	60.3	74.0	61.7	87.0	61.0
Venango	96.7	61.2	84.1	64.2	90.4	62.7
Golden Spike	96.3	58.0	93.3	60.9	94.8	59.5
CO970531	96.1	59.4	91.5	62.1	93.8	60.8
Trego	95.1	62.1	83.3	64.0	89.2	63.0
Avalanche	94.3	60.8	86.3	63.5	90.3	62.2
CO970552	91.8	59.9	82.4	60.6	87.1	60.2
Akron	91.6	60.1	84.7	62.1	88.2	61.1
TAM 107	90.3	59.6	70.8	61.7	80.5	60.6
2137	86.4	59.9	79.4	62.3	82.9	61.1
Nuplains	85.5	60.7	75.2	63.2	80.3	62.0
Intrada	84.6	62.3	74.4	63.8	79.5	63.1
Lakin	82.0	59.8	78.8	60.7	80.4	60.3
Kalvesta	81.3	60.4	72.5	61.8	76.9	61.1
Platte	76.5	59.3	76.9	61.7	76.7	60.5

Notes: Entries are ranked according to grain yield performance at Fort Collins; lines with no Haxtun or over-location averages (--) were only tested at Fort Collins; * - line advanced for further testing.

Advanced Yield Nursery (AYN)

In 2001, two advanced yield nurseries were included among the breeding nurseries. The first of these was a “conventional” trial that included 10 check entries along with 70 hard red and 70 hard white experimental lines that had been advanced from preliminary yield trials in 2000. The second trial was a ***Clearfield™*** wheat trial that consisted of five check entries, five ***Clearfield™*** entries from Texas A&M-Amarillo, and 65 Clearfield entries from our own program. Of these 65 ***Clearfield™*** entries, 22 were developed via wheat-maize doubled haploid procedures and 43 were developed via single descent procedures.

Fifteen non-***Clearfield™*** entries were selected from advanced yield trials (Table 3) and entered in the 2002 UVPT; 11 of these are hard white and 4 are hard red types. The primary focus within this set of hard white germplasm is identification of lines that combine RWA resistance with good dual-purpose quality characteristics (breadmaking and noodle-making). Many of the hard whites in this group carry RWA resistance, either from Halt or sources from KSU-Hays that were used in crossing in 1996. Our quality improvement efforts have involved small-scale testing in our own laboratory, for both breadmaking and noodle color characteristics, along with comprehensive milling and baking tests at the USDA-ARS lab in Manhattan, KS. While many of the hard whites at this stage appear to have average or better breadmaking quality, only two of them (CO99W277 and CO99W329) have shown consistently desirable noodle color properties. Implementation of sprout tolerance tests in summer 2001 also identified a line (CO99W188) that appears to have excellent preharvest sprouting tolerance.

Table 3. Grain yield (bu/acre), test weight (lb/bu), and agronomic and RWA resistance reaction ratings from checks and selected entries in the 2001 AYN.

ID						Dryland				
	Akron	Burl	JBurg	Walsh	FC	Avg.	TW	HD	HT	RWA
CO99W081	54.4	31.0	26.7	45.4	91.9	39.4	56.5	147.6	31.4	R
CO99W076	55.0	22.5	32.7	32.1	95.7	35.6	56.7	147.6	31.9	R
CO99W078	49.6	23.3	27.4	41.4	88.6	35.4	56.4	147.6	31.0	R
CO99314	37.8	35.1	33.9	33.3	85.1	35.0	56.3	146.8	31.3	
CO99141	42.5	36.3	29.9	31.3	84.9	35.0	57.6	144.8	28.0	R
CO99W254	44.1	34.6	31.8	29.0	91.7	34.9	58.0	148.2	30.5	R
CO99W183	47.6	32.9	31.0	27.6	78.6	34.8	56.0	147.4	30.5	R
Jagger	44.2	30.8	30.4	33.5	79.7	34.7	56.1	145.8	28.8	
CO99148	47.6	26.3	27.4	37.2	93.5	34.6	57.1	145.6	29.5	R
Trego	34.8	33.1	30.8	37.0	82.9	33.9	57.8	149.6	30.1	
CO99W033	42.7	26.1	30.7	32.7	102.1	33.0	57.8	145.6	29.5	R
Prowers 99	43.0	22.9	29.6	35.5	80.8	32.8	58.2	151.6	33.9	R
CO99W277	36.1	30.4	29.3	34.1	80.9	32.5	56.4	150.8	33.5	R
CO99W188	41.2	23.7	29.7	32.8	83.2	31.9	56.2	148.2	30.0	R
Akron	35.1	31.8	31.2	29.1	71.7	31.8	56.6	149.2	32.3	
CO99W192	37.6	27.8	33.5	28.2	86.0	31.8	56.1	150.2	30.3	R
Alliance	29.7	30.7	30.9	35.4	73.9	31.7	55.8	149.2	32.3	
CO99W013	44.2	20.7	30.3	31.2	104.3	31.6	56.8	146.2	29.6	R
CO99177	36.8	36.3	29.7	22.4	77.1	31.3	56.0	146.6	29.9	R
Yuma	24.4	28.2	44.5	27.1	79.1	31.1	56.8	148.4	30.1	
Prairie Red	35.9	30.2	26.7	23.4	73.5	29.1	56.1	146.0	29.5	R
CO99W329	37.1	28.3	26.9	17.9	90.4	27.6	56.8	145.0	28.0	R
Halt	29.9	26.8	26.2	25.1	78.3	27.0	55.9	146.2	27.8	R
2137	21.9	28.9	27.6	25.6	69.9	26.0	56.2	149.4	29.9	
Platte	19.8	25.3	30.1	25.3	73.4	25.2	56.4	149.2	28.6	

Notes: TW =test weight average over locations; HD=days to heading (from Jan. 1); HT=plant height (inches); RWA= Russian wheat aphid resistance reaction (R=resistant, S=susceptible).

From the group of advanced ***Clearfield™*** experimental lines (Table 4), eight entries were selected and advanced to the 2002 UVPT. Of this group, five lines carry RWA resistance with an equal number (four each) of lines coming from doubled haploid (CO00D lines) breeding as came from single seed descent (CO99 lines) procedures. A primary focus within this set of materials, aside from incorporation of RWA resistance, has become identification of lines that have better test weight and baking quality than either Above or AP502 CL. While it has appeared to be somewhat difficult to recover high test weight from this limited set of germplasm, recovery of lines with improved baking quality characteristics appears to have been more successful. Breeder Seed increases of each of these eight lines is currently being done in Arizona to allow a larger seed increase of lines (at most two lines) that show significant improvements over Above in testing in 2002. Additional quality testing will be done on these lines, both during the winter and in between harvest and planting in 2002, to hopefully ensure that the next generation of ***Clearfield™*** wheats show measurable test weight and baking quality improvements.

Table 4. Grain yield (bu/acre), test weight (lb/bu), and agronomic and RWA resistance reaction ratings from checks and selected entries in the 2001 AYN ***Clearfield™*** Trial.

ID	Akron	Burl	JBurg	Walsh	FC	Dryland Avg.	TW	HT	HD	RWA
Alliance	46.4	29.5	41.3	38.7	83.1	39.0	55.9	30.8	148.3	
CO991057	49.9	31.5	41.4	32.6	96.1	38.8	57.0	30.8	145.5	
CO991132	49.3	30.5	41.6	32.4	80.3	38.4	55.7	29.0	144.3	
TX98A3952	41.3	27.0	48.0	32.2	70.2	37.1	56.7	27.5	145.8	
CO00D007	40.8	28.0	40.3	38.1	88.7	36.8	55.9	30.2	148.0	R
TX98A5423	40.9	34.5	35.6	34.0	91.3	36.2	55.9	28.8	145.0	
CO00D019	44.4	33.5	31.7	33.0	90.0	35.7	55.7	31.2	150.3	
AP502 CL	41.2	28.5	39.3	29.2	72.5	34.5	55.4	28.7	144.5	
Above	41.5	29.5	35.3	27.1	74.1	33.4	55.9	28.2	145.5	
CO991350	36.9	33.5	30.4	31.2	91.8	33.0	55.9	28.2	145.5	R
TX98A5424	42.4	21.5	41.2	25.7	85.4	32.7	56.3	28.3	144.8	
TX98A5421	42.2	28.5	33.8	26.0	81.3	32.6	56.5	28.7	144.5	
TX98A4611	43.9	21.5	36.5	27.2	83.4	32.3	56.1	28.7	144.5	
CO991407	30.3	34.0	36.4	26.1	82.5	31.7	57.0	27.8	144.0	R
CO00D011	24.1	36.0	33.2	32.8	103.6	31.5	57.1	28.5	149.5	R
CO00D032	27.5	26.5	36.7	31.1	84.8	30.4	55.6	27.3	147.5	R
TAM 110	38.5	27.5	35.9	19.1	84.1	30.2	56.3	28.3	145.0	
Yumar	25.5	29.0	39.7	26.6	78.7	30.2	57.1	27.7	146.3	R

Notes: TW =test weight average over locations; HD=days to heading (from Jan. 1); HT=plant height (inches); RWA= Russian wheat aphid resistance reaction (R=resistant, S=susceptible).

Preliminary Yield Nursery (PYN)

In 2000-2001, the PYN included 1040 experimental lines planted in a single replication trial at each our five main testing locations. The vast majority (950 lines, 91%) of these lines were hard red types due to the very limited number of hard white bulk populations in the field in summer 1999. Based on grain yield, agronomic data, RWA resistance, and small-scale end-use quality data, 130 of these lines were selected and planted in the 2002 AYN. The approximate percentage of hard white types advanced to the 2002 AYN was reflective of the percentage hard white types available in the PYN in 2001 (about 9%). This percentage of hard white types could change appreciable in coming years as many hard white headrows and bulk populations are now coming through the pipeline.

Early-Generation Germplasm Development

In 2001-2002, we continued the expansion early generation germplasm development efforts, both in terms of new line derivation and crossing. As plant breeding is often called “a numbers game”, where the probability of success is directly related to capacity to handle large numbers, it is expected that this expansion will enhance our ability to develop agronomically adapted wheat cultivars that combine high yield with good end-use quality characteristics. Early-generation germplasm efforts at each phase in the pipeline can be summarized as follows:

1) **Crossing**: over 900 crosses were made in 2000-2001, split between crossing blocks in fall 2000 and spring 2001. A primary focus of the crossing program was to expand the emphasis on crossing with hard white types originating from within our program (many with RWA resistance) and other breeding programs in the region. Many of our ***Clearfield*™** wheats were also used in crossing. Approximately 20% of the crosses were single crosses between two hard white parents (will produce only hard white types) while over 40% were single or three-way crosses with at least one hard white parent. We continue, however, to make a small number of crosses between hard red parents (where only hard red lines will result).

2) **F1 Increase**: Approximately 1100 F1 crosses were increased in the field in 2001, with about 43% of these coming from spring planting (at Fort Collins) of crosses made in the greenhouse in fall 2000. Seed from about 800 populations was sufficient to advance for planting in F2 bulk plots in fall 2001. Of this group of 800, about 15% were populations developed from crosses with ***Clearfield*™** wheats.

3) **F2 Bulks**: Approximately 460 F2 bulk populations were grown in the field in 2001. Of this total, about 60 were populations with ***Clearfield*™** wheat parents in the pedigree; these were sprayed in fall 2000 to selectively eliminate plants lacking the herbicide tolerance trait. About 345 populations (including all 60 ***Clearfield*™** populations) were advanced to F3 bulk plots in fall 2001.

4) **F3 Bulks**: Approximately 290 F3 bulk populations were grown in the field in 2001. In fall 2000, we planted these in Fort Collins, as usual, as well as at Akron for evaluation and observation under the more stressful, dryland conditions. Based on yield, test weight, and visual observations at both locations, about 30,000 heads were selected from 98 populations for advancement to the F4 headrow nursery in fall 2001. About 50% of these selections are hard white types, many of which originating from bulk populations obtained from the KSU-Hays breeding program in 1999.

5) **F4 Headrows**: Nearly 30,000 headrows were grown in 2000-2001. From visual observations, and small-scale quality screening done in August following headrow harvest, about 900 experimental lines were selected and advanced to preliminary yield tests in fall 2001. Of this group of 900 lines, about 120 (13%) are ***Clearfield*™** wheats reselected from lines tested in the advanced yield trials. Some of these lines (about 10%) also came from promising single seed descent populations identified in the field in 1999 and advanced through three generations in the greenhouse.

Research Support Projects and Other Activities

Graduate Student Research

Several graduate student research projects are currently underway. Briefly, these include the following important areas of research: determination of inheritance and chromosomal location of a new wheat streak mosaic virus (WSMV) resistance gene; assessment of environmental influence and genotype x environment interaction for key noodle quality

characteristics; identification of advantages and disadvantages of semidwarfing genes (of European origin) that that do not reduce coleoptile length. By summer 2002, three new graduate students will have joined the breeding program to work on other important areas of research. While we expect that these student projects will contribute vital information to direct the breeding program, the students also benefit by receiving a strong graduate training opportunity.

CIMMYT Germplasm Introduction

Beginning in fall 2001, we have begun a long-term effort to systematically explore the germplasm resources that are available to us through the International Maize and Wheat Improvement Center (CIMMYT) in Mexico. Germplasm from CIMMYT is being targeted for our breeding efforts because CIMMYT researchers appear to have made considerable progress in recent years with improvement of stress tolerance (high temperature and drought) in a spring wheat germplasm base that also shows good adaptation for high-input, irrigated production conditions. Materials will be brought through USDA-APHIS quarantine in the greenhouse in the fall and then planted under full- and limited-irrigation at ARDEC in the spring to identify accessions with promising adaptive characteristics. A limited number of these accessions will then be integrated into both spring and winter wheat crossing efforts.

USDA-IFAFS Project

A multi-institutional grant effort, coordinated through the Univ. of California-Davis, to the USDA-IFAFS grant funding agency was successful this past year. The focus of this grant, entitled “Bringing Genomics to the Wheat Fields”, proposes to utilize DNA marker technology as a means to transfer desirable quality and pest resistance traits into released varieties and elite experimental lines. CSU is one of 12 public plant breeding programs involved in this effort, with Nora Lapitan serving as our local collaborator. At CSU have chosen recently released varieties or advanced experimental lines (Avalanche, Above, RWA-Akron, CO970547, Stanton, and Lakin) as target parents to transfer or combine genes for wheat streak mosaic virus and barley yellow dwarf tolerance, high grain protein content, and Russian wheat aphid resistance. The duration of the project is four years, with the release of several improved varieties and germplasm anticipated at the end of the project.

Facilities and Equipment Improvements

In 2000-2001, several facilities and equipment improvements were realized. These improvements include: a new university greenhouse with improved climate control and increased space; a new plot planter with no-till openers, liquid starter fertilizer setup, and automatic seed distribution; a new seed cleaner/conditioner to assist with sample preparation for planting; a new ATV for field alleyway spraying and maintenance. We also recently purchased a new headrow planter that will be used for the first time in spring 2002. The Plant Science Renovation is also underway, the primary benefit for our program being a renovated and expanded wheat quality laboratory that will house the bread baking equipment from the Food Science Department. We are very excited about these important improvements and the positive impact that they promise to make to our program.

Program Contact

Dr. Scott Haley, Wheat Breeder
Soil and Crop Sciences Dept.
Colorado State University
Fort Collins, CO 80523
970-491-6483 (phone), -0564 (fax)
shaley@lamar.colostate.edu (email)
http://wheat.colostate.edu (web)