2001-2002 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. The following report summarizes the activities of the breeding program and main areas of progress during the 2001-2002 season.

2001-2002 Site Conditions

In 2001-2002, 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 were highly adverse for successful wheat test-plot research and selection:

Akron – timely planting with good soil moisture led to excellent stand establishment, fall growth, and spring re-growth. Sustained high temperatures and drought stress during spring and summer reduced yield (to about 70% of average) and limited the expression of yield differences among test entries.

Burlington - timely planting with good soil moisture led to good stand establishment and fall growth. Dry soil conditions during the winter, and moderately cold air and soil temperatures, combined to induce a low level of winter injury, particularly in materials with marginal adaptation. High temperatures and a nearly complete lack of spring and summer precipitation led to abandonment of all trials prior to harvest.

Julesburg – later planting than normal (October 1) led to reduced establishment and fall growth. Spring re-growth was accompanied by dry soil conditions that extended through to harvest and reduced yield (to about 75% of average) and limited the expression of yield differences among test entries.

Walsh - marginal soil moisture at planting (and extending through to harvest), combined with moderately cold soil temperatures during winter, led to poor stands, significant winter injury, excessive non-genetic field variation, and subsequent abandonment of most of the breeding trials (with the exception of the Dryland Variety Trial, UVPT) prior to harvest.

Fort Collins (irrigated) – timely planting and good soil moisture led to excellent establishment, fall growth, and spring re-growth. Delayed spring irrigation (first irrigation May 1), a severe spring freeze event (May 9), and a severe hailstorm two weeks prior to harvest collectively resulted in low and erratic yields.

In cooperation with the CSU Variety Testing Program, under the direction of CSU Extension Agronomist Dr. Jerry Johnson, varieties and experimental lines were also tested at six dryland trial locations (UVPT - Bennett, Briggsdale, Cheyenne Wells, Genoa, Lamar, and Sheridan Lake) and three irrigated trial locations in Colorado (IVPT - Haxtun, Rocky Ford, and Center in the San Luis Valley). Growing conditions at each of the UVPT locations was very much similar to the four main dryland breeding locations, with winter injury, spring freeze injury, high temperatures with dry winds, and severe drought stress complicating evaluation and selection. Only two of these six UVPT locations were harvested (Lamar and Bennett), although excessive non-genetic, field variation at Lamar made the data of very questionable value for selection and cultivar recommendation. The Genoa location was not harvested due to a severe hailstorm prior to harvest while the Briggsdale location was not harvested due to severe spring freeze injury. The Sheridan Lake and Cheyenne Wells locations were not harvested due to severe winter injury as a result of very dry soil conditions and moderately cold winter temperatures. Both the Rocky Ford and Haxtun IVPT locations were successfully harvested, although yields were reduced somewhat below optimum due to high temperatures and dry winds throughout spring and summer. The Center IVPT location, added in 2001-2002 as an official IVPT testing location, was abandoned in the spring due to a high level of winter injury.

Very little or no virus (e.g., barley yellow dwarf, wheat streak mosaic) or insect (e.g., Russian wheat aphid, greenbug, Bird cherry-oat aphid) pressure was observed at any of the wheat trial locations. A low level of stripe rust infection was observed at the Haxtun IVPT location, much lower than the epidemic observed in 2001. Leaf rust was observed at very low levels at both the Haxtun IVPT location and the Fort Collins-ARDEC irrigated location.

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 Releases

In August 2002, one new winter wheat cultivar was formally released. The new cultivar, named **Ankor**, was derived from the crosses and backcrosses Akron/Halt//4*Akron (≥ 94% Akron parentage) made between 1994 and 1998. Halt and Akron are cultivars released by CSU in 1994. Halt carries the *Dn4* gene, the source of Russian wheat aphid (RWA) resistance in Ankor. Ankor is an awned, white-chaffed, medium maturity, semidwarf hard red winter wheat. Ankor is medium maturing (144.8 days to heading from Jan. 1), about 3.5 days later than Prairie Red and similar to Akron. Plant height of Ankor is medium-short (30.1 inches), 1.7 inches taller than TAM 107 and similar to Akron. Coleoptile length of Ankor is slightly less than Prairie Red and similar to Akron. The straw strength of Ankor is good, slightly better than Akron based on limited evaluation and observation in the 2002 Irrigated Variety Performance Trial (IVPT). Ankor was tested in Colorado Dryland Variety Performance Trials (Colorado UVPT) during 2001 and 2002. Averaged over eight dryland trial locations in 2001, Ankor (41.6 bu a^{-1}) yielded less than Akron (43.2 bu a^{-1}) and greater than Prairie Red (40.7 bu a^{-1}). Averaged over three dryland trial locations in 2002, Ankor (33.7 bu a^{-1}) yielded more than Akron (33.2 bu a^{-1}) and less than Prairie Red (34.6 bu a^{-1}). Averaged over 11 locations in 2001 and 2002, Ankor (39.4 bu a^{-1}) yielded more than Prairie Red (39.0 bu a^{-1}) and less than Akron (40.4 bu a^{-1}). Test weight averages from dryland trials in 2001 and 2002 show that Ankor (56.8 lb bu^{-1}) has similar test weight to both Akron (57.0 lb bu^{-1}) and Prairie Red (56.8 lb bu^{-1}). Ankor was tested in Colorado Irrigated Variety Performance Trials (Colorado IVPT) during 2002. Averaged over three irrigated trial

locations in 2002. Ankor (78.9 bu a^{-1}) yielded more than Akron (69.5 bu a^{-1}), Prairie Red (73.2 bu a^{-1}), and Yumar (74.6 bu a^{-1}). Linear regression analysis of yield response from low yielding dryland to high yielding irrigated conditions suggests that Ankor may have a more favorable yield response at higher dryland and irrigated yield levels than Akron. On the basis of field evaluations in Colorado and cooperative evaluations through the USDA Regional Testing Program, Ankor has shown a similar response as Akron to prevalent diseases and insects in the west central Great Plains. Ankor is moderately resistant to stem rust, susceptible to leaf rust, and susceptible to both wheat streak mosaic virus and barley yellow dwarf virus. Ankor is susceptible to the Great Plains biotype of Hessian fly, susceptible to greenbug, and resistant to Russian wheat aphid. Milling and bread baking quality of Ankor was evaluated from multi-location grain composite samples collected in 2000 and 2001 and four individual-location grain samples collected in 2001. Relative to the recurrent parent Akron, Ankor showed very similar average values for key milling and baking quality traits. Based on summaries from the USDA Hard Winter Wheat Quality Database, Ankor appeared to show slightly better baking quality than Akron.

State Variety Trials

In 2001-2002, 31 advanced experimental lines were tested in the Dryland Variety Trial (UVPT). Of these lines, 8 were *Clearfield*™ wheat lines, 11 were hard white wheat (HWW) lines with Russian wheat aphid resistance, and 10 were hard red wheat (HRW) lines either in their first year or second year of statewide testing in the UVPT. Because of the overall lack of sound data from the UVPT, and "yield compression" among entries where the UVPT was successfully harvested (Table 1), decisions on experimental line retention and advance were extremely challenging. Because of this, selection intensity was relaxed slightly and more lines than normal were retained for further testing in the 2003 UVPT. Of the lines mentioned above, 8 HRW lines, 6 *Clearfield*™ lines (all HRW types), and 6 HWW lines were retained and advanced (19 total):

ID	Group	Pedigree	RWA
CO970547	HRW	Ike/Halt	R
CO980376 @ §	HRW	CO850034/T-57//5*TAM 107/3/NEWS02	R
CO980607 @ §	HRW	Yuma/T-57//TAM 200/3/4*Yuma/4/NEWS08	R
CO980630 @ §	HRW	Yuma/T-57//TAM 200/3/4*Yuma/4/NEWS08	R
CO99141 §	HRW	Ike/Halt	R
CO99177	HRW	Longhorn/Halt	R
CO99314 §	HRW	TX91V4931/Halt	S
CO00D007	HRW CL	Yumar//TXGH12588-120*4/FS2	R
CO00D011	HRW CL	Yumar//TXGH12588-120*4/FS2	R
CO991350	HRW CL	Yumar//TXGH12588-26*4/FS2	R
CO991407	HRW CL	Yumar//TAM 110*4/FS2	R
CO991057	HRW CL	Akron//TXGH12588-26*4/FS2	S
CO991132	HRW CL	Jagger//TXGH12588-120*4/FS2	S
CO99W183	HWW	KS92WGRC25/Halt	R
CO99W188	HWW	KS92WGRC25/Halt	R
CO99W192 §	HWW	KS92WGRC25/Halt	R
CO99W254	HWW	CO931029/Halt	R
CO99W277	HWW	CO931037/Halt	R
CO99W329	HWW	CO931091/Halt	R

@ Line submitted for evaluation in the 2002-2003 Wheat Quality Council (WQC) testing program.

§ Line submitted for evaluation in the 2002-2003 Regional Performance Testing Program (Southern Regional Performance Nursery).

Table 1. Grain yield (bu/acre), test weight (lb/bu), and agronomic ratings from entries in the 2002 UVPT.

Entry	Akron GY	Akron TW	Akron Shatter	JBurg GY	JBurg TW	Bennett GY	Bennett TW	AVG GY	AVG TW	Heading Date	Plant Height	RWA
CO99W192*	38.4	58.0	5.3	37.0	56.7	33.6	60.0	36.3	58.2	147	22	R
CO99534	37.8	59.1	3.7	35.6	56.4	35.2	60.9	36.2	58.8	145	22	R
Jagalene	38.6	61.3	7.0	34.0	58.6	34.5	61.4	35.7	60.4	146	23	S
CO99W188*	35.5	59.1	5.7	35.2	58.2	35.9	61.6	35.5	59.6	142	22	R
CO980376*	37.6	59.1	3.3	34.6	56.8	34.0	60.9	35.4	58.9	141	24	R
CO99W254*	33.5	59.2	5.7	41.4	57.7	31.0	61.9	35.3	59.6	142	22	R
TAM 111	37.8	59.1	4.0	34.5	56.4	32.6	62.1	35.0	59.2	147	24	S
CO970547*	40.5	59.5	7.0	34.8	57.4	29.4	62.5	34.9	59.8	142	23	R
CO99314*	41.2	58.0	5.3	33.3	56.9	30.1	61.7	34.8	58.9	141	23	S
Halt	38.3	58.4	6.0	34.9	56.3	30.9	60.9	34.7	58.5	142	22	R
Prairie Red	41.2	59.2	3.7	31.7	56.9	30.8	59.7	34.6	58.6	141	22	R
Above	44.1	59.7	2.7	35.6	56.9	23.9	61.2	34.5	59.3	142	22	S
CO980719	40.5	60.3	4.7	33.4	57.4	29.5	58.7	34.5	58.8	148	22	R
Trego	40.2	61.2	5.0	31.6	58.1	31.1	62.1	34.3	60.5	148	21	S
CO00D011*	41.1	57.7	4.0	30.8	56.6	30.2	61.2	34.1	58.5	150	21	R
CO980829	39.2	60.5	4.3	34.0	56.8	28.9	59.0	34.0	58.7	147	22	R
CO991350*	36.9	57.8	4.0	35.2	55.0	29.6	61.2	33.9	58.0	142	21	R
Lakin	37.2	59.4	5.7	34.8	56.8	29.6	62.1	33.9	59.4	147	24	S
CO00D019	35.7	55.6	4.0	32.2	54.9	33.3	60.2	33.7	56.9	150	21	S
CO980630*	40.1	59.9	5.7	31.6	57.2	29.4	62.4	33.7	59.8	148	21	R
CO991132*	39.0	58.7	4.0	36.1	56.3	25.8	60.1	33.7	58.4	141	25	S
Ankor	36.1	57.9	3.0	33.5	54.8	31.4	61.2	33.7	58.0	144	22	R
CO991407*	37.4	59.4	4.3	33.9	55.8	28.4	62.0	33.2	59.1	142	22	R
G970246	40.0	59.1	5.3	33.6	57.3	26.0	62.1	33.2	59.5	141	22	S
Akron	36.6	58.0	4.7	32.1	56.1	30.9	60.9	33.2	58.3	144	21	S
CO99W277*	35.4	59.2	4.7	36.1	56.3	28.1	62.2	33.2	59.2	143	23	R
CO99141*	39.5	60.5	3.7	35.3	58.3	24.1	62.0	33.0	60.3	140	23	R
CO99W183*	37.4	58.7	5.3	35.5	57.0	26.0	60.4	32.9	58.7	143	22	R
AP502 CL	36.4	57.1	3.0	33.4	56.6	28.4	60.2	32.7	58.0	141	22	S
CO991057*	36.6	58.4	4.7	32.3	56.6	29.2	62.1	32.7	59.1	142	22	S
Stanton	39.3	59.9	2.7	30.3	57.9	28.2	61.3	32.6	59.7	144	23	R
Alliance	35.5	58.5	5.0	32.3	55.7	29.8	62.3	32.5	58.8	145	21	S
Cutter	34.9	59.7	6.0	35.3	58.8	27.4	61.9	32.5	60.1	145	25	S
TAM 110	39.4	59.1	3.0	32.8	57.4	24.6	60.7	32.2	59.1	142	23	S
2137	34.0	58.3	4.3	32.1	54.7	30.4	61.9	32.2	58.3	146	22	S
CO99148	34.4	59.2	7.3	33.4	56.8	28.3	62.5	32.0	59.5	142	23	R
CO980607*	34.7	59.7	6.0	35.0	56.6	26.3	62.0	32.0	59.4	147	21	R
Prowers 99	36.8	58.9	3.3	31.1	57.0	27.5	62.9	31.8	59.6	150	24	R
Cisco	34.5	58.5	5.7	33.6	55.9	27.1	62.4	31.8	58.9	146	22	S
Jagger	38.1	60.0	5.0	31.7	56.7	25.3	60.4	31.7	59.0	141	25	S
Avalanche	38.7	60.2	5.0	32.0	57.4	24.0	64.0	31.6	60.5	146	23	S
CO00D007*	33.8	57.9	4.0	33.9	56.0	26.1	60.8	31.3	58.3	142	23	R
CO99W329*	30.5	59.1	5.0	41.5	57.2	21.1	63.3	31.0	59.8	140	22	R
Ok101	36.7	58.9	4.7	32.7	55.8	23.3	61.5	30.9	58.7	142	23	S
Yumar	34.7	57.8	4.3	32.6	56.9	25.1	61.1	30.8	58.6	146	21	R
Thunderbolt	35.0	60.0	7.0	33.5	57.2	23.8	62.3	30.8	59.8	147	22	S
CO99W076	31.2	59.3	7.0	35.1	58.1	25.6	60.0	30.6	59.2	142	24	R
G970447	31.3	57.7	4.7	31.8	54.9	28.7	61.3	30.6	58.0	144	20	S
CO99W013	34.9	58.6	6.7	34.5	57.5	22.1	61.8	30.5	59.3	142	22	R
Enhancer	32.5	57.7	6.0	32.3	55.1	26.2	62.0	30.3	58.3	145	24	S
CO99177*	30.0	59.1	5.0	37.7	57.4	22.8	60.8	30.2	59.1	142	23	R
Yuma	32.7	57.7	5.0	33.4	56.4	23.8	62.6	30.0	58.9	148	22	S
Venango	32.6	59.9	6.7	32.3	55.8	24.7	62.0	29.9	59.2	148	22	S
Dumas	33.4	59.6	4.3	33.6	56.9	22.4	62.3	29.8	59.6	146	22	S
CO99W033	35.6	58.5	5.3	28.8	57.2	25.0	61.2	29.8	59.0	142	22	R
CO00D032	28.7	56.1	4.7	33.2	55.4	26.9	61.2	29.6	57.6	143	20	R
G970209W	33.7	60.0	6.7	31.1	56.7	20.4	60.1	28.4	58.9	147	21	S
G970380A	27.5	57.9	5.3	30.5	56.2	25.9	60.7	28.0	58.3	141	22	S
CO99W081	25.0	60.0	7.0	32.3	58.0	23.6	59.8	27.0	59.3	142	20	R
CO99W078	25.0	59.6	5.7	33.3	57.9	21.7	59.5	26.7	59.0	143	22	R

Notes: GY=grain yield; TW=test weight; HD=days to heading (from Jan. 1); HT=plant height (inches); * - entry advanced.

Small-scale seed increases of each of the lines retained for further testing were planted in fall 2002. The HRW lines are being increased under irrigation at Fort Collins while the *Clearfield*™ and HWW lines are being increased in Yuma, Arizona, largely because of isolation needs (particularly for the HWW lines) and capabilities in Yuma. Seed supply from any of these lines that perform well in 2003 should be adequate to enable Foundation Seed increase in 2003-2004 (for earliest possible release fall 2004). In addition to continued yield testing, extensive milling and baking quality evaluations will be done on these materials during winter 2002-2003 in the CSU Wheat Quality Lab, the USDA-ARS Quality Lab (Manhattan KS), and by various private-industry collaborators.

As mentioned previously, the Irrigated Variety Trial (IVPT) was planted at four locations but only Haxtun and Rocky Ford provided useful yield data (Table 2). While none of the experimental lines were at the top, as was the case in 2001 (particularly with CO980607 and CO980630), we will of course continue to focus breeding and germplasm enhancement efforts toward irrigated wheat. Continued management of trials at ARDEC in Fort Collins for high yields and exploitation of high yielding germplasm from other production areas (e.g., CIMMYT-Mexico and Pacific Northwest materials) should help to achieve these objectives.

Table 2. Grain yield (bu/acre), test weight (lb/bu), and agronomic ratings from the 2002 IVPT.

	Haxtun		Rocky Ford		Fort Collins			Average*				
	GY	TW	GY	TW	GY	TW	Shatter	GY	TW	Lodging	Heading	Height
Platte	98.7	60.9	92.9	59.5	45.6	61.5	3.7	95.8	60.2	1.0	149	30
Prairie Red	90.1	58.7	99.7	57.9	29.7	58.9	5.3	94.9	58.3	3.0	144	31
Above	83.9	60.0	101.3	59.1	24.7	60.0	6.3	92.6	59.6	2.3	145	32
Yuma	93.1	58.3	92.1	57.2	50.6	60.0	4.0	92.6	57.8	1.7	149	31
Jagalene	89.8	60.0	95.1	59.7	45.0	61.5	6.3	92.4	59.8	2.3	149	33
Ok101	91.4	57.1	92.9	57.8	51.1	59.9	5.3	92.2	57.4	2.3	146	32
Avalanche	87.6	59.5	96.2	61.3	51.7	61.5	3.3	91.9	60.4	2.7	148	33
Lakin	92.9	60.4	90.4	59.2	41.3	61.3	4.5	91.6	59.8	3.3	148	34
Wesley	85.3	59.0	96.6	59.7	24.5	59.4	6.3	90.9	59.3	1.3	147	30
CO980607 *	85.2	59.2	95.2	58.9	51.8	61.2	4.3	90.2	59.0	4.3	147	33
Nuplains	85.7	60.8	93.2	59.7	45.4	61.6	5.3	89.5	60.3	2.0	150	33
TAM 111	86.7	59.5	91.4	58.9	51.1	61.3	3.7	89.0	59.2	2.3	149	34
Ankor	85.4	56.1	92.1	55.4	59.2	60.6	2.0	88.7	55.8	3.7	148	34
Antelope	88.7	59.3	85.0	58.5	54.2	61.0	4.7	86.8	58.9	1.7	149	34
CO980630 *	79.2	58.1	91.0	59.5	57.5	61.0	3.3	85.1	58.8	5.3	148	32
Trego	75.2	58.2	94.8	59.7	50.8	61.1	3.7	85.0	59.0	6.0	149	32
Yumar	85.7	59.6	83.3	56.6	54.8	60.9	3.7	84.5	58.1	2.0	148	32
Dumas	84.9	61.4	83.6	61.2	42.4	61.8	4.3	84.3	61.3	1.0	149	32
CO99534	77.8	57.0	88.1	57.6	55.9	60.7	2.0	83.0	57.3	4.3	148	34
CO980829	72.9	58.9	91.9	57.2	31.8	60.4	4.7	82.4	58.1	1.7	148	32
CO980376 *	69.1	60.3	95.3	58.4	46.6	60.7	3.7	82.2	59.4	5.3	148	33
Jagger	85.2	58.2	79.1	58.5	31.7	59.2	7.0	82.2	58.3	3.3	145	32
CO980719	74.3	55.1	88.5	57.3	47.8	61.3	7.7	81.4	56.2	7.0	149	33
2137	74.5	58.7	85.0	57.8	44.9	60.2	2.3	79.7	58.2	1.3	148	33
CDC Falcon	85.5	57.6	73.5	57.2	51.9	59.1	3.7	79.5	57.4	1.0	152	33
TAM 107	75.3	57.5	80.7	59.1	21.9	59.1	7.0	78.0	58.3	3.0	144	32
Akron	73.3	57.4	80.6	57.1	54.7	60.9	2.3	77.0	57.3	5.7	148	34
Venango	90.2	61.2	61.4	59.3	28.1	61.0	6.7	75.8	60.3	1.7	149	33
CO970547 *	68.3	59.9	81.8	59.9	41.0	60.4	4.3	75.0	59.9	4.7	146	33
Enhancer	69.4	59.4	68.2	58.2	50.6	60.0	2.7	68.8	58.8	7.3	147	33

Notes: Entries are ranked according to average yield across Haxtun and Rocky Ford; GY=grain yield; TW=test weight; HD=days to heading (from Jan. 1); HT=plant height (inches); LD=lodging score and Shatter=shattering score (1=none, 9=severe). * - line advanced for further testing.

Advanced Yield Nursery (AYN)

In 2001-2002, the Advanced Yield Nursery was grown in three replications at all five main breeding locations. The AYN included 10 check varieties, 129 experimental HRW lines, and 11 experimental HWW lines; none of the entries were *Clearfield*™ lines. Among the group of 129 HRW lines were a group of 15 reselections that had been made in 2001 from some of our more promising advanced lines. From the AYN, 20 experimental lines (listed in Table 3) were selected and advanced for statewide testing in the 2003 UVPT.

Table 3. Grain yield (bu/acre), test weight (lb/bu), and agronomic ratings from checks and selected entries in the 2002 AYN.

	Akron		Julesburg		Fort Collins		Average				
	GY	TW	GY	TW	GY	TW	GY	TW	Heading	Height	RWA
CO00580	43.9	58.2	34.6	56.9	55.7	59.9	39.2	57.6	148	25	R
CO00698	43.5	57.2	30.2	57.4	58.3	60.8	36.9	57.3	148	25	R
CO970547-7	43.3	59.8	29.9	58.2	44.9	61.2	36.6	59.0	146	25	R
CO00W015	47.1	60.1	25.5	58.6	56.9	61.8	36.3	59.3	145	26	
CO970547-2	43.2	59.1	29.2	57.6	41.4	60.4	36.2	58.3	145	24	R
CO00484	41.3	58.1	30.0	56.5	60.2	59.9	35.6	57.3	146	28	R
CO00480	36.4	57.1	34.8	57.0	48.4	60.6	35.6	57.0	148	25	R
CO00739	34.4	58.6	36.5	58.4	46.6	60.4	35.5	58.5	147	26	R
CO00583	41.5	59.9	29.2	57.5	29.8	61.5	35.3	58.7	144	26	R
CO980684-1	46.3	59.6	24.4	57.2	42.0	60.6	35.3	58.4	145	24	R
CO00554	36.9	59.9	33.2	58.5	51.3	60.5	35.1	59.2	147	26	R
CO00335	39.1	58.8	31.1	57.1	48.2	60.1	35.1	57.9	149	25	R
CO00345	39.3	60.2	30.1	58.6	32.4	62.1	34.7	59.4	144	24	
CO00523	37.6	56.5	31.8	57.1	51.2	59.6	34.7	56.8	147	25	R
Lakin	39.8	59.1	29.3	58.0	46.2	61.8	34.5	58.5	147	24	
CO00501	38.8	59.0	29.8	57.5	47.3	61.2	34.3	58.2	145	26	R
CO00016	40.2	59.4	27.9	58.2	37.7	60.6	34.1	58.8	145	23	R
CO970547	41.9	59.4	26.0	58.2	40.9	61.2	33.9	58.8	145	24	R
Prairie Red	39.1	58.9	28.3	57.6	39.0	60.8	33.7	58.2	144	22	R
Stanton	43.1	60.0	24.2	59.1	35.4	61.3	33.6	59.6	147	25	R
CO00347	35.9	59.4	31.2	58.9	47.1	60.7	33.6	59.1	145	24	
Alliance	40.8	59.1	26.1	56.8	32.8	61.1	33.4	58.0	148	23	
CO00582	37.4	60.0	29.4	58.4	46.2	61.4	33.4	59.2	143	26	
Jagger	39.9	59.9	26.0	57.9	30.6	60.7	32.9	58.9	145	25	
CO00579	40.2	56.7	25.4	56.1	45.6	59.4	32.8	56.4	147	25	
CO00796	32.3	57.9	28.0	57.6	63.0	59.8	30.2	57.7	148	28	R
Avalanche	39.5	60.9	20.6	59.2	57.0	61.8	30.0	60.0	148	23	
Trego	37.8	60.9	20.9	60.0	57.5	61.7	29.3	60.4	149	24	
Prowers 99	33.2	59.2	23.4	58.1	49.5	60.9	28.3	58.6	150	26	R
Akron	36.0	59.1	20.4	57.6	62.0	60.5	28.2	58.3	148	24	
Yuma	33.3	58.2	21.5	57.4	46.4	59.8	27.4	57.8	148	23	
Average	39.5	59.0	28.0	57.8	46.8	60.8	33.7	58.4			

Notes: Entries are ranked according to average yield across Akron and Julesburg, Fort Collins was excluded due to freeze and hail damage; GY=grain yield; TW=test weight; HD=days to heading (from Jan. 1); HT=plant height (inches); RWA= Russian wheat aphid resistance reaction (R=resistant, S=susceptible).

Included among the group of materials advanced were two reselections from CO970547, a RWA-resistant selection (from an Ike/Halt cross) that has shown superior performance in the UVPT since 2000. Breeder seed increases of these two lines, CO970547-7 and CO970547-2, were planted in fall 2002 to enable Foundation Seed increase in 2003-2004 (for earliest possible release in fall 2004). In addition to continued yield testing, extensive milling and baking quality evaluations will be done on all of these materials during winter 2002-2003 in the CSU Wheat

Quality Lab and the USDA-ARS Quality Lab (Manhattan KS). For each of these lines advanced to the UVPT, a headrow increase will be done in Yuma AZ in 2002-2003 for line purification and reselection.

Early-Generation Germplasm Development

In 2001-2002, 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)**: Approximately 895 new experimental lines were planted at all five main breeding locations planted in seven groups of single replication trials. The majority of these lines (632 lines, 71%) were HRW types. Based on grain yield, test weight, agronomic data, RWA resistance, small-scale quality data (on remnant bulk samples and samples tested following harvest in August 2002), 69 of these lines were selected and planted in the 2002-2003 AYN. To facilitate earlier line reselection, a small group of headrow selections made from each of these 69 lines will be grown in Yuma AZ in 2002-2003. To complement this group of PYN selections, a group of 65 line reselections (including HRW, HWW, and *Clearfield*™ lines) made in Yuma AZ from advanced lines were included among the lines advanced to the AYN.
2) **F4 Headrows**: Approximately 30,000 headrows were grown at Fort Collins in 2001-2002. From visual observations and pedigree information, and quality information from the remnant bulk in 2001, approximately 1800 of these were harvested in July 2002. Following small-scale quality screening in August (NIR protein, NIR hardness, SDS sedimentation), about 900 lines were selected and advanced to the single replication PYN in fall 2002. Among this group of 900 lines, approximately 40% are HWW types that were exposed to rigid selection in August 2002 for reduced polyphenol oxidase (PPO) content in the grain (associated with darkening of Asian noodle products).
3) **F3 Bulks**: Approximately 345 F3 bulk populations were grown in 2001-2002. The F3 bulk populations were grown under both irrigation at Fort Collins and the more stressful, dryland conditions at Akron. Based on yield, test weight, and visual observations at both locations, about 25,000 heads were selected from 137 populations for advancement to the F4 headrow nursery in fall 2002. From this group of 25,000, about 40% are HWW types and about 14% 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 791 F2 bulk populations were grown at Fort Collins in 2001-2002. Of this total, about 130 were populations with *Clearfield*™ wheat parents in the pedigree; these were sprayed with *Beyond*™ herbicide in fall 2001 to selectively eliminate plants lacking the herbicide tolerance trait. About 359 populations (including about 85 *Clearfield*™ populations) were advanced to F3 bulk plots in fall 2002. 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**: Approximately 1045 new crosses were increased in the field in 2002. Three environments were used for F1 seed increase: fall planting at Fort Collins (277 crosses), spring planting at Fort Collins (393 crosses), and spring transplanting of vernalized seedlings in the San Luis Valley (375 crosses). Although most of the fall-planted cross populations at Fort Collins were lost to a bad spot in the field, seed of about 796 populations from the spring and San Luis Valley increases was sufficient to advance for planting in F2 bulk plots in fall 2002. Of this group, about 17% were populations developed from crosses with *Clearfield*™ wheats.

6) **Crossing**: over 1600 crosses were made in 2001-2002, split between crossing blocks in fall 2001 and spring 2002. Included among these crosses were three main types of materials: a) crosses targeted toward direct increase, bulk evaluation, and line development (1175 crosses), b) crosses targeted only for backcrossing or three-way crossing (160 crosses), and c) crosses targeted for marker-assisted backcrossing as part of the USDA-IFAFS grant funded program (275 crosses). Of the group targeted toward direct increase, approximately 80% were single crosses between two elite parents and 20% were three-way crosses developed to broaden genetic diversity and introgress unique germplasm. With regard to HWW vs. HRW emphasis, approximately 30% of all single crosses were made between two HWW parents (will produce only HWW types) while 50% of all single crosses were made between one HRW parent and one HWW parent (will produce mostly HRW types).

Research Support Projects and Other Activities

Graduate Student Research

Several graduate student research projects are currently underway or were completed in 2001-2002. While we expect that these research projects will contribute vital information to direct breeding efforts, both the breeding project and the students benefit in many other ways though student involvement in the overall breeding program. 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 (Erin Ball, completed May 2002)
- evaluation of environment and genotype x environment interaction effects on Asian noodle quality characteristics (Aaron Brown)
- assessment of the breeding potential of gibberellic acid sensitive semidwarfing genes that do not reduce coleoptile length (Sally Clayshulte)
- development of geographic information systems (GIS) technology to improve variety recommendations and identify variety-specific production and quality zones (Federico Pardina-Malbrán)
- separation of the *Dn7* RWA resistance gene from deleterious, rye-derived wheat quality factors (Meghan Collins)
- characterization (inheritance, allelism, marker-tagging) of RWA resistance identified in Iranian landrace selections (Joshua Butler)

CIMMYT Germplasm Introduction

In 2001-2002, we began 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 have made considerable progress in recent years with, among other things, 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 from three global CIMMYT nurseries were brought through USDA-APHIS quarantine in the greenhouse in fall 2001 and planted at Fort Collins in the spring 2002 for observation. Entries showing desirable adaptive features were harvested and will be planted in spring 2003 for evaluation in dryland and irrigated spring wheat trials. Some of the more promising entries, including several originating from crosses with synthetic hexaploid wheats, have been 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 awarded in April 2001. 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 plant breeding programs involved in this effort, with Dr. Nora Lapitan serving as co-investigator in our effort at CSU. We have chosen recently released varieties or advanced experimental lines (e.g., Avalanche, Above, Ankor, CO970547, Stanton, and Lakin) 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. In summer 2002 we completed our first cycle of marker-assisted selection for the target traits and will be completing two more cycles in our fall 2002 and spring 2003 greenhouse cycles. 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 2001-2002, several facilities and equipment improvements were realized. These improvements include:

- completed installation of soil beds and movable benches in the new university greenhouse with improved climate control and increased space
- new, custom-built field plot planter with no-till openers, liquid starter fertilizer setup, and automatic seed distribution with a checkhead-cable system
- new Hege 1000 headrow tray planter with automatic seed distribution and a checkhead-cable system
- new trailer for hauling plot planters and plot combines
- new seed cleaner for small-lot seed conditioning
- new four-wheel ATV for field alleyway spraying and maintenance
- new linear/lateral-move sprinkler irrigation system at ARDEC in Fort Collins

In addition to the items outlined above, the Plant Science Building Renovation is nearing completion (targeted for December 2002), the primary benefit for our program (in addition to air-conditioned office space for the project leader) 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 all of these important improvements and the positive impact that they promise to make to our program.

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