Technical Report 2013 Wheat Field Days Edition

Agricultural Experiment Station

Colorado State University

College of Agricultural Sciences | Department of Soil & Crop Sciences | Extension

Crops Testing

Making Better Decisions

2012 Colorado Winter Wheat Variety Performance Trials

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Additional Wheat Information Resources on the Web

http://www.csucrops.com- Colorado State University Crop Variety Testing Program
http://wheat.colostate.edu - Colorado State University Wheat Breeding Program
http://wheat.colostate.edu/vpt.html - Colorado Wheat Variety Performance Database (CSU Wheat Breeding Program).
http://www.coloradowheat.org - Colorado Wheat Administrative Committee (CWAC), Colorado Association of Wheat Growers (CAWG), and Colorado Wheat Research Foundation (CWRF) website.

2012 Eastern Colorado Winter Wheat Variety Performance Trials

Jerry Johnson and Scott Haley

The Colorado State University Crops Testing and Wheat Breeding and Genetics programs provide current, reliable, and unbiased wheat variety information as quickly as possible to Colorado producers for making better variety decisions. CSU has an excellent research faculty and staff, a focused breeding program, graduate and undergraduate students, and dedicated agricultural extension specialists. However, wheat improvement in Colorado would not be possible without the support and cooperation of the entire Colorado wheat industry. On-going and strong producer support for our programs is critical for sustained public variety development and testing.

Our wheat variety performance trials and Collaborative On-Farm Test (COFT) represent the final stages of a wheat breeding program where promising experimental lines are tested under an increasingly broad range of environmental conditions. As a consequence of large environmental variation, Colorado State University annually conducts a large number of performance trials and on-farm tests. These trials serve to guide producer variety decisions and to assist our breeding program to more reliably select and advance the most promising lines toward release as new varieties.

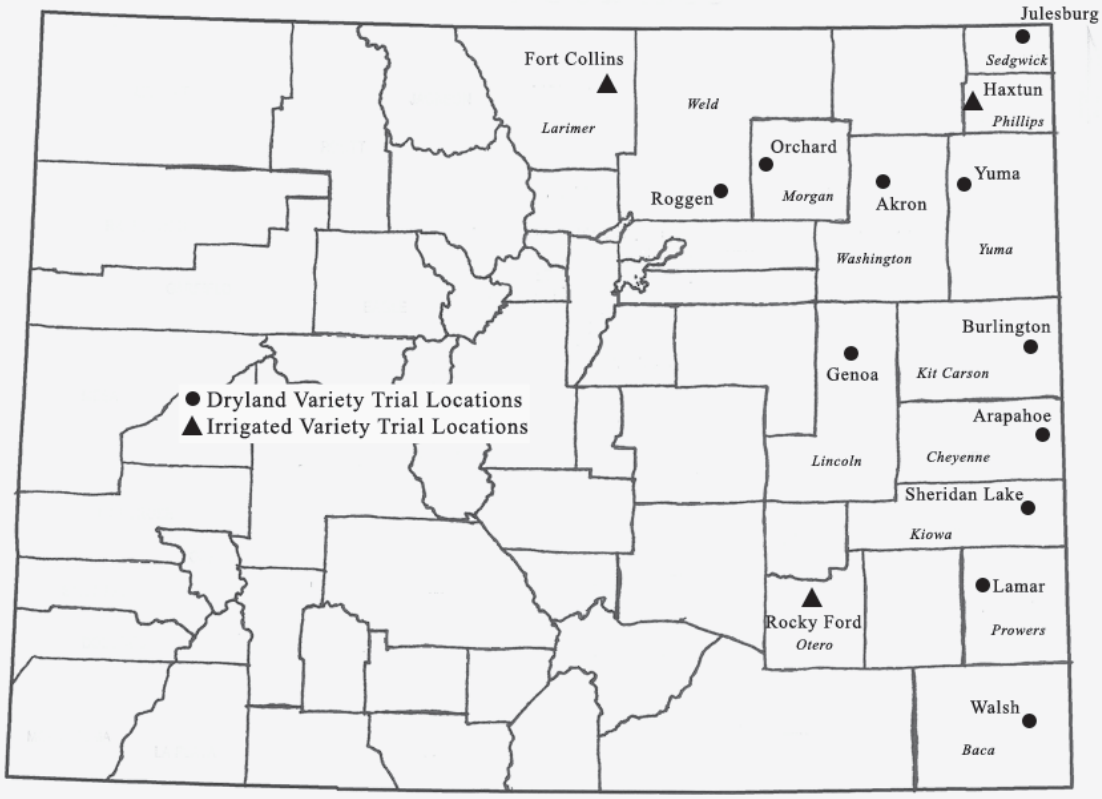
2012 Variety Performance Trials

There were excellent planting conditions at almost all dryland performance trial locations in fall 2011 resulting in good to excellent emergence and plant stands. The lone exception was Walsh, which suffered from extremely dry soil conditions at planting and poor fall stands resulted from deep planting. Low winter precipitation was received throughout eastern Colorado and all of the dryland trials suffered from spring drought except the Yuma and Julesburg trials, where the effects were less marked. High spring temperatures, particularly in March and April, were seen at all trial locations and resulted in above average cumulative growing degree-days and accelerated plant development. For example, at Akron there were 180% of normal cumulative growing degree-days from January through May but only 49% of average precipitation for the same period. The Roggen trial suffered more than other trials from drought and high temperatures which resulted in extreme intra-plot variation preventing reliable data analysis and interpretation. Windy conditions at all locations exacerbated the effects of drought and high temperatures. Stripe rust was observed at low levels at most locations but dry conditions in May reduced disease incidence and spread. Stripe rust was most evident at Genoa, where the higher altitude and cooler temperatures favored rust development, and at Julesburg where precipitation patterns were more favorable for stripe rust infection. All trials experienced above average growing degree-days that led to very early crop development and harvest. The Sheridan Lake trial received hail in early April and the trial at Walsh was destroyed by hail prior to harvest. Brown wheat mite damage was observed at Arapahoe and insecticide was applied to control the mites. There was a significant dryland root rot infection in the Burlington trial due to very lush early spring growth and subsequent drought stress conditions.

The Irrigated Variety Performance Trials (IVPT) at Rocky Ford and Haxtun were excellent. Due to continuing problems with the irrigation system, and an abnormally dry spring, the trial at Fort Collins had inadequate moisture from jointing until heading though irrigation frequency was improved during grain filling. All three trial locations had high spring growing degree-days resulting in early trial maturity. At Rocky Ford and Haxtun, above average growing degree-days contributed to high yields though stripe rust infection adversely affected the yield potential of susceptible varieties. While fungicide was not applied at Rocky Ford, it was applied at Haxtun but the flag leaves of susceptible varieties were lost before the fungicide controlled the disease. Lodging was significant at Haxtun and varieties without good straw strength were heavily lodged. Lodging did not occur at Fort Collins and was minimal at Rocky Ford.

There were 42 entries in the dryland performance trials (UVPT) and 32 entries in the irrigated performance trials (IVPT). All trials included a combination of public and private varieties and experimental lines from Colorado, Texas, Kansas, Oklahoma, Nebraska, and Montana. All dryland and irrigated trials were planted in a randomized complete block design with three replicates. Plot size was approximately 175 ft^2 and all varieties were planted at 700,000 viable seeds per acre for dryland trials and 1.2 million viable seeds per acre for irrigated trials. Yields are corrected to 12% moisture. Test weight information was obtained from a combine equipped with a Harvest Master measuring system.

2012 UVPT (Dryland) and IVPT (Irrigated) Trial Locations



Summary of 2012 Dryland Variety Performance Results

Variety Origin[a] and Release Year	Variety[b]	Market Class[c]	Yield[d]	Yield	Test Weight[d]	Plant Height[d]
			bu/ac	% trial average	lb/bu	in
CSU/PG 2011	Byrd	HRW	54.9	114%	61.1	28
CSU/PG 2012	Antero	**HWW**	54.6	113%	61.7	28
CSU exp	CO07W722-F5	**HWW**	52.6	109%	60.7	25
AP exp	SY Exp. 1029	HRW	52.4	108%	59.9	27
CSU exp	CO050233-2	HRW	52.0	108%	60.4	27
CSU exp	CO08263	HRW	51.7	107%	60.8	26
TX/W 2005	TAM 112	HRW	51.6	107%	61.8	28
CSU/PG 2006	Ripper	HRW	51.0	105%	60.1	27
CSU exp	CO08W218	**HWW**	51.0	105%	62.2	27
CSU/PG 2011	Brawl CL Plus	HRW	50.9	105%	62.1	29
TX/AGSECO 2010	TAM 113	HRW	50.9	105%	61.7	29
CSU/PG 2004/2011	CSU Blend12	HRW	50.4	104%	61.3	26
LG 2009	T158	HRW	49.8	103%	61.6	28
AP 2011	SY Wolf	HRW	49.1	102%	61.5	28
TX/AP 2002	TAM 111	HRW	49.1	101%	61.3	29
TX/CSU 2001	Above	HRW	49.0	101%	60.4	26
CSU/PG 2011	Denali	HRW	48.9	101%	62.0	28
CSU exp	CO08W454	**HWW**	48.8	101%	61.1	27
LG 2010	T163	HRW	48.6	100%	61.8	28
CSU/AGSECO 2004	Protection	HRW	48.6	100%	59.3	29
WB 2007	Winterhawk	HRW	48.6	100%	61.9	28
CSU exp	CO05W111	**HWW**	48.5	100%	61.2	28
NE 2008	Settler CL	HRW	48.4	100%	61.1	26
TX/SS 2006	TAM 304	HRW	48.2	100%	59.8	27
CSU/PG 2004	Hatcher	HRW	48.2	100%	61.1	26
CSU/PG 2007	Bill Brown	HRW	48.0	99%	62.0	26
NE 2010	Robidoux	HRW	48.0	99%	61.2	28
CSU exp	CO08346	HRW	47.7	98%	62.4	27
CSU exp	CO08W328	**HWW**	47.2	98%	62.2	28
WB 2008	Armour	HRW	46.6	96%	60.7	27
CSU/PG 2008	Thunder CL	**HWW**	46.3	96%	60.6	26
CSU/PG 2004	Bond CL	HRW	46.3	96%	58.4	28
KSU 2012	1863	HRW	46.2	95%	60.5	27
KSU 2011	Clara CL	**HWW**	46.0	95%	62.5	27
CSU/PG 2009	Snowmass	**HWW**	45.8	95%	60.8	29
NE 2010	McGill	HRW	45.8	95%	60.5	29
KSU 2009	Everest	HRW	45.6	94%	61.8	26
NE exp	NE05496	HRW	45.6	94%	60.8	26
CSU exp	CO08M011	HRW	45.5	94%	61.0	27
OK exp	OK05312	HRW	43.9	91%	61.9	27
NE exp	NE05548	HRW	43.6	90%	59.2	27
MT 2011	Judee	HRW	37.0	77%	60.5	26
		Average	**48.4**		**61.1**	**27**

[a]Variety origin codes: CSU=Colorado State University; TX/CSU=Joint release by Texas A&M and Colorado State Universities; WB=WestBred (Monsanto); AP=AgriPro (Syngenta); CSU/AGSECO=Colorado State release, marketed by AGSECO; TX/AGSECO=Texas A&M release, marketed by AGSECO; TX/W=Texas A&M release, marketed by Watley Seed Co.; TX/SS=Texas A&M release, marketed by Scott Seed Co.; CSU/PG=CSU release, marketed by CWRF under the PlainsGold brand; TX/AP=Texas A&M release, marketed by AgriPro (Syngenta); MT=Montana State University; KSU=Kansas State University; LG=Limagrain Cereal Seeds; NE=University of Nebraska; OK=Oklahoma State University.

[b]Varieties ranked according to average yield in 2012.

[c]Market class: HRW=hard red winter wheat; **HWW**=hard white winter wheat.

[d]The 2012 average yield, test weight, and plant height are based on nine 2012 trials.

Summary of 2-Yr Dryland Variety Performance Results

Variety Origin[a] and Release Year	Variety[b]	Market Class[c]	2-Year Average[d] Yield	Yield	Test Weight	Plant Height
			bu/ac	% trial average	lb/bu	in
CSU/PG 2011	Byrd	HRW	55.3	113%	60.4	29
CSU/PG 2012	Antero	**HWW**	54.7	112%	60.7	28
CSU exp	CO050233-2	HRW	51.3	105%	59.7	28
TX/W 2005	TAM 112	HRW	51.1	104%	61.1	28
CSU/PG 2006	Ripper	HRW	50.9	104%	59.2	26
CSU/PG 2011	Denali	HRW	50.2	102%	60.9	29
CSU/PG 2004	Hatcher	HRW	50.0	102%	60.2	26
TX/CSU 2001	Above	HRW	49.3	101%	59.5	27
CSU/PG 2007	Bill Brown	HRW	49.2	101%	60.8	26
AP 2011	SY Wolf	HRW	49.2	100%	60.2	28
NE 2008	Settler CL	HRW	49.2	100%	60.0	27
CSU/PG 2011	Brawl CL Plus	HRW	48.9	100%	60.8	28
CSU exp	CO05W111	**HWW**	48.7	99%	60.1	29
WB 2007	Winterhawk	HRW	48.5	99%	60.9	29
LG 2010	T163	HRW	48.5	99%	60.3	28
CSU/PG 2009	Snowmass	**HWW**	47.6	97%	59.9	29
NE 2010	Robidoux	HRW	47.3	97%	60.1	28
CSU/PG 2008	Thunder CL	**HWW**	46.5	95%	59.5	27
WB 2008	Armour	HRW	46.4	95%	59.5	26
CSU/PG 2004	Bond CL	HRW	46.4	95%	58.0	29
OK exp	OK05312	HRW	46.0	94%	60.8	27
NE 2010	McGill	HRW	45.7	93%	59.5	29
KSU 2009	Everest	HRW	45.5	93%	60.9	26
		Average	**49.0**		**60.1**	**28**

[a]Variety origin codes: CSU=Colorado State University; TX/CSU=Joint release by Texas A&M and Colorado State Universities; WB=WestBred (Monsanto); AP=AgriPro (Syngenta); TX/W=Texas A&M release, marketed by Watley Seed Co.; KSU=Kansas State University; NE=University of Nebraska; CSU/PG=CSU release, marketed by CWRF under the PlainsGold brand; LG=Limagrain Cereal Seeds; OK=Oklahoma State University.

[b]Varieties ranked according to average 2-year yield.

[c]Market class: HRW=hard red winter wheat; **HWW**=hard white winter wheat.

[d]The 2-year average yield, test weight, and plant height are based on six 2011 trials and nine 2012 trials.

Summary of 3-Yr Dryland Variety Performance Results

Variety Origin[a] and Release Year	Variety[b]	Market Class[c]	3-Year Average[d] Yield	Yield	Test Weight	Plant Height
			bu/ac	% trial average	lb/bu	in
CSU/PG 2011	Byrd	HRW	59.3	112%	60.3	30
CSU exp	CO050233-2	HRW	55.5	105%	60.0	29
CSU/PG 2011	Denali	HRW	55.2	104%	61.3	30
CSU/PG 2006	Ripper	HRW	53.9	102%	59.2	27
NE 2008	Settler CL	HRW	53.6	101%	60.3	28
CSU exp	CO05W111	**HWW**	53.5	101%	60.7	30
TX/W 2005	TAM 112	HRW	53.4	101%	60.9	29
CSU/PG 2004	Hatcher	HRW	53.3	100%	60.5	27
WB 2007	Winterhawk	HRW	53.0	100%	61.2	29
CSU/PG 2007	Bill Brown	HRW	52.9	100%	60.8	27
TX/CSU 2001	Above	HRW	52.4	99%	59.7	28
CSU/PG 2011	Brawl CL Plus	HRW	52.3	98%	61.0	29
CSU/PG 2009	Snowmass	**HWW**	51.8	98%	60.4	30
CSU/PG 2004	Bond CL	HRW	50.9	96%	58.2	30
WB 2008	Armour	HRW	50.9	96%	59.5	27
CSU/PG 2008	Thunder CL	**HWW**	50.8	96%	59.6	28
KSU 2009	Everest	HRW	49.8	94%	61.1	27
		Average	**53.1**		**60.3**	**29**

[a]Variety origin codes: CSU=Colorado State University; TX/CSU=Joint release by Texas A&M and Colorado State Universities; WB=WestBred (Monsanto); TX/W=Texas A&M release, marketed by Watley Seed Co.; KSU=Kansas State University; NE=University of Nebraska; CSU/PG=CSU release, marketed by CWRF under the PlainsGold brand.

[b]Varieties ranked according to average 3-year yield.

[c]Market class: HRW=hard red winter wheat; **HWW**=hard white winter wheat.

[d]The 3-year average yield, test weight, and plant height are based on nine 2010 trials, six 2011 trials, and nine 2012 trials.

2012 Collaborative On-Farm Test (COFT) Variety Performance Results

The objective of the 2012 COFT was to compare performance and adaptability of popular and newly released CSU varieties (Byrd, Brawl CL Plus, and Snowmass) with proven high-yielding varieties (Hatcher and Settler CL) and with a commercial variety (TAM 112) under unbiased, field-scale testing conditions. The COFT program is in its 14th year and much of Colorado's 2012 wheat acreage was planted to winter wheat varieties that have been tested in the COFT program. In the fall of 2011, thirty-five eastern Colorado wheat producers planted on-farm tests in Baca, Bent, Prowers, Kiowa, Cheyenne, Kit Carson, Washington, Yuma, Phillips, Sedgwick, Lincoln, Logan, Adams, and Weld counties. Each collaborator planted the six varieties in side-by-side strips (approximately 1.25 acres per variety) at the same seeding rate as they seeded their own wheat. Thirty-one viable harvest results were obtained from the thirty-five tests. The COFT results need to be interpreted based on all tests within a year and not on the basis of a single variety comparison on a single farm in one year. In addition to the overall 2012 COFT variety performance results, we have added a summary table of this year's COFT results grouped by geographic region to assist with variety comparisons.

Colorado extension wheat educators who conducted the COFT program in 2012:

Jerry Johnson – Extension Specialist-Crop Production, Fort Collins
Bruce Bosley – Extension Agronomist, Logan County
Wilma Trujillo – Extension Agronomist, Prowers County
Alan Helm – Extension Agronomist, Phillips County (no longer in CSU Extension)
Ron Meyer – Extension Agronomist, Golden Plains Area

2012 Collaborative On-Farm Test (COFT) Variety Performance Results

	2012 Varieties[a]																				
	Byrd			Brawl CL Plus			Hatcher			Settler CL			TAM 112			Snowmass			COFT Average		
County/Nearest Town	Yield[b]	Test Weight	Protein	Yield[b]	Test Weight	Protein	Yield[b]	Test Weight	Protein	Yield[b]	Test Weight	Protein	Yield[b]	Test Weight	Protein	Yield[b]	Test Weight	Protein	Yield[b]	Test Weight	Protein
	bu/ac	lb/bu	percent	bu/ac	lb/bu	percent	bu/ac	lb/bu	percent	bu/ac	lb/bu	percent	bu/ac	lb/bu	percent	bu/ac	lb/bu	percent	bu/ac	lb/bu	percent
Adams/Bennett	52.7	58.2	10.1	45.3	59.2	10.5	50.2	60.8	9.4	43.1	60.2	10.3	45.9	62.5	11.2	43.0	60.8	11.0	*46.7*	*60.3*	*10.4*
Adams/Last Chance	15.0	58.0	13.4	16.0	60.5	13.2	11.4	60.0	12.4	13.0	58.5	12.8	15.2	61.0	11.9	11.5	59.5	11.9	*13.7*	*59.6*	*12.6*
Baca/Two Buttes	9.3	57.7	17.1	13.5	57.6	17.5	7.0	60.0	16.1	10.2	56.6	17.5	11.0	58.8	17.3	6.5	58.7	17.7	*9.6*	*58.2*	*17.2*
Baca/Vilas	34.3	59.4	12.9	39.6	61.0	13.5	31.9	58.6	14.9	37.1	59.1	13.2	36.3	60.6	13.2	30.2	58.0	14.1	*34.9*	*59.5*	*13.6*
Bent/Lamar W	34.5	59.5	13.5	32.3	60.4	14.6	30.5	59.9	14.1	30.7	58.9	14.4	32.0	60.4	14.3	29.5	59.2	14.3	*31.6*	*59.7*	*14.2*
Cheyenne/Arapahoe	42.1	61.2	10.1	41.7	60.1	11.0	34.2	59.6	9.4	50.4	59.2	10.3	34.5	61.4	10.9	37.4	60.5	10.5	*40.1*	*60.3*	*10.4*
Cheyenne/Cheyenne Wells	32.3	59.6	14.5	28.2	60.4	15.1	31.6	62.0	13.9	29.8	59.0	14.6	29.6	60.8	15.0	29.6	58.7	15.3	*30.2*	*60.1*	*14.7*
Kiowa/Haswell	16.3	61.2	10.7	15.6	62.7	12.3	15.2	62.7	10.7	13.0	61.0	12.4	14.2	61.9	11.4	10.8	60.5	13.2	*14.2*	*61.7*	*11.8*
Kiowa/Towner	22.3	59.2	9.3	22.3	60.9	10.6	21.9	59.1	9.6	22.7	59.4	9.5	20.6	59.6	10.2	20.7	60.9	9.2	*21.8*	*59.9*	*9.7*
Kit Carson/Bethune	57.5	61.4	12.3	54.2	61.8	13.6	54.7	64.6	12.1	46.4	55.8	13.5	49.4	61.1	12.7	51.3	62.2	12.8	*52.3*	*61.2*	*12.8*
Kit Carson/Stratton	50.0	56.1	14.4	48.0	58.7	14.9	49.9	59.5	13.5	48.0	58.7	14.8	50.7	57.8	14.0	41.8	56.5	14.7	*48.1*	*57.9*	*14.4*
Lincoln/Arriba	64.9	62.0	11.8	60.2	65.5	12.1	62.1	63.0	11.0	58.0	63.0	12.2	59.0	62.5	12.4	56.7	62.5	11.5	*60.2*	*63.1*	*11.8*
Lincoln/Thurman	66.9	60.4	11.8	65.4	62.3	11.9	64.6	61.6	10.8	64.4	60.7	11.7	59.4	62.9	12.0	54.1	60.2	12.7	*62.5*	*61.4*	*11.8*
Logan/Leroy	56.7	60.5	10.6	53.4	61.5	10.6	50.5	60.5	10.1	50.7	61.0	10.3	53.1	59.0	10.1	49.0	60.0	10.0	*52.2*	*60.4*	*10.3*
Logan/Peetz	37.9	62.0	9.4	32.6	64.5	11.2	38.1	62.0	9.6	39.2	62.5	10.1	31.8	64.0	10.4	35.8	63.0	9.6	*35.9*	*63.0*	*10.1*
Logan/Sterling W	49.8	60.5	12.1	46.9	61.0	12.9	41.3	60.5	11.5	41.0	58.0	12.0	34.5	61.5	11.0	38.9	59.0	11.5	*42.1*	*60.1*	*11.8*
Phillips/Haxtun	40.7	54.8	12.5	43.5	58.0	10.9	44.1	57.5	11.9	43.2	55.5	11.7	40.1	56.2	11.7	33.2	53.4	13.8	*40.8*	*55.9*	*12.1*
Prowers/Bristol	49.2	59.0	12.0	40.0	57.9	14.2	41.0	58.9	12.5	39.2	55.4	14.2	48.5	60.9	13.0	42.4	56.9	12.8	*43.4*	*58.2*	*13.1*
Prowers/Lamar S	53.1	62.2	12.3	48.6	62.0	13.8	47.5	61.5	12.4	45.8	59.8	13.7	45.0	60.3	13.2	46.2	60.1	12.8	*47.7*	*61.0*	*13.0*
Prowers/Two Buttes N	17.2	56.0	15.4	16.5	58.0	15.4	13.8	55.0	14.5	16.5	54.0	16.2	17.0	57.0	15.6	13.8	55.0	16.8	*15.8*	*55.8*	*15.7*
Washington/Akron S	25.6	59.0	12.2	29.0	61.0	12.2	26.1	60.0	12.5	26.7	60.5	12.0	27.5	61.0	12.5	24.1	59.0	11.8	*26.5*	*60.1*	*12.2*
Washington/Akron W	33.5	59.1	15.6	33.4	60.2	15.4	35.5	60.0	14.3	32.6	60.4	14.9	32.3	58.5	14.8	28.7	58.0	14.8	*32.7*	*59.4*	*15.0*
Washington/Anton	10.4	58.0	10.2	9.6	59.0	9.9	9.6	59.0	10.6	10.7	57.5	11.4	9.2	58.0	11.4	9.4	59.0	12.0	*9.8*	*58.4*	*10.9*
Washington/Otis	58.3	61.5	12.0	57.6	61.5	12.3	52.0	61.0	12.6	49.0	61.5	12.2	49.0	63.0	12.0	45.6	61.0	12.5	*51.9*	*61.6*	*12.3*
Washington/Platner	52.9	60.0	11.9	53.9	62.5	11.8	52.5	61.5	11.2	47.5	61.0	12.3	47.3	60.5	13.0	46.9	60.0	13.1	*50.2*	*60.9*	*12.2*
Washington/Woodlin	39.6	58.5	10.4	38.5	60.0	11.7	39.9	59.5	10.0	36.6	59.0	10.7	36.7	60.5	10.8	32.5	58.5	10.4	*37.3*	*59.3*	*10.7*
Washington/Woodrow	53.2	62.0	9.5	49.4	62.5	12.6	49.9	63.5	11.1	49.4	62.5	10.8	47.6	62.0	10.3	43.7	63.5	11.0	*48.9*	*62.7*	*10.9*
Weld/Keenesburg	68.9	59.0	15.3	68.5	60.5	16.4	68.1	61.0	14.2	72.2	61.0	14.2	67.1	61.5	14.0	64.7	60.5	14.5	*68.2*	*60.6*	*14.8*
Weld/New Raymer	48.6	62.0	9.8	45.3	65.5	11.0	43.5	63.0	10.2	42.1	63.0	10.7	41.3	62.5	11.6	39.9	62.5	10.7	*43.4*	*63.1*	*10.7*
Weld/Prospect Valley	64.9	62.0	9.2	58.5	63.5	10.0	58.9	63.0	9.1	59.4	61.0	10.3	52.8	63.0	9.3	57.4	63.0	9.7	*58.7*	*62.6*	*9.6*
Yuma/Yuma	52.6	60.6	11.7	48.1	61.3	12.7	50.3	60.8	12.4	49.3	60.4	12.2	49.7	60.4	13.3	46.5	59.7	11.9	*49.4*	*60.5*	*12.4*
Average	**42.3**	**59.7**	**12.1**	**40.5**	**61.0**	**12.8**	**39.6**	**60.6**	**11.9**	**39.3**	**59.5**	**12.5**	**38.3**	**60.7**	**12.4**	**36.2**	**59.7**	**12.5**	**39.4**	**60.2**	**12.4**
Significance[c] yield	A			B			C			C			D			E					

LSD $_{(0.30)}$ for yield = 0.7 bu/ac

LSD $_{(0.30)}$ for test weight = 0.3 lb/bu

LSD $_{(0.30)}$ for protein = 0.2 percent

[a]Varieties are ranked left to right by highest average yield.

[b]Yield corrected to 12% moisture.

[c]Significance: Varieties with different letters are significantly different from one another.

2012 COFT Variety Performance Summary and Comparison by Region

2012 Overall (31)[a]				Trial Regions: South (10)[a,b]				Trial Regions: North (21)[a,b]			
Variety[c]	Yield[d]	Test Weight	Protein	Variety[c]	Yield[d]	Test Weight	Protein	Variety[c]	Yield[d]	Test Weight	Protein
	bu/ac	lb/bu	percent		bu/ac	lb/bu	percent		bu/ac	lb/bu	percent
Byrd	42.4	59.7	12.1	Byrd	31.1	59.5	12.8	Byrd	47.8	59.8	11.7
Brawl CL Plus	40.6	61.0	12.8	Brawl CL Plus	29.8	60.1	13.8	Brawl CL Plus	45.8	61.5	12.3
Hatcher	39.7	60.6	11.9	Settler CL	29.5	58.2	13.6	Hatcher	45.6	61.1	11.5
Settler CL	39.4	59.5	12.5	TAM 112	28.9	60.2	13.4	Settler CL	44.1	60.1	12.0
TAM 112	38.5	60.7	12.4	Hatcher	27.5	59.7	12.8	TAM 112	43.0	60.9	11.9
Snowmass	36.3	59.7	12.5	Snowmass	26.7	58.9	13.7	Snowmass	40.9	60.1	12.0
Average	**39.5**	**60.2**	**12.4**		**28.9**	**59.4**	**13.3**		**44.5**	**60.6**	**11.9**
$LSD_{(0.30)}$	0.7	0.3	0.2		1.3	0.4	0.3		0.8	0.3	0.2

[a]Number of locations included.

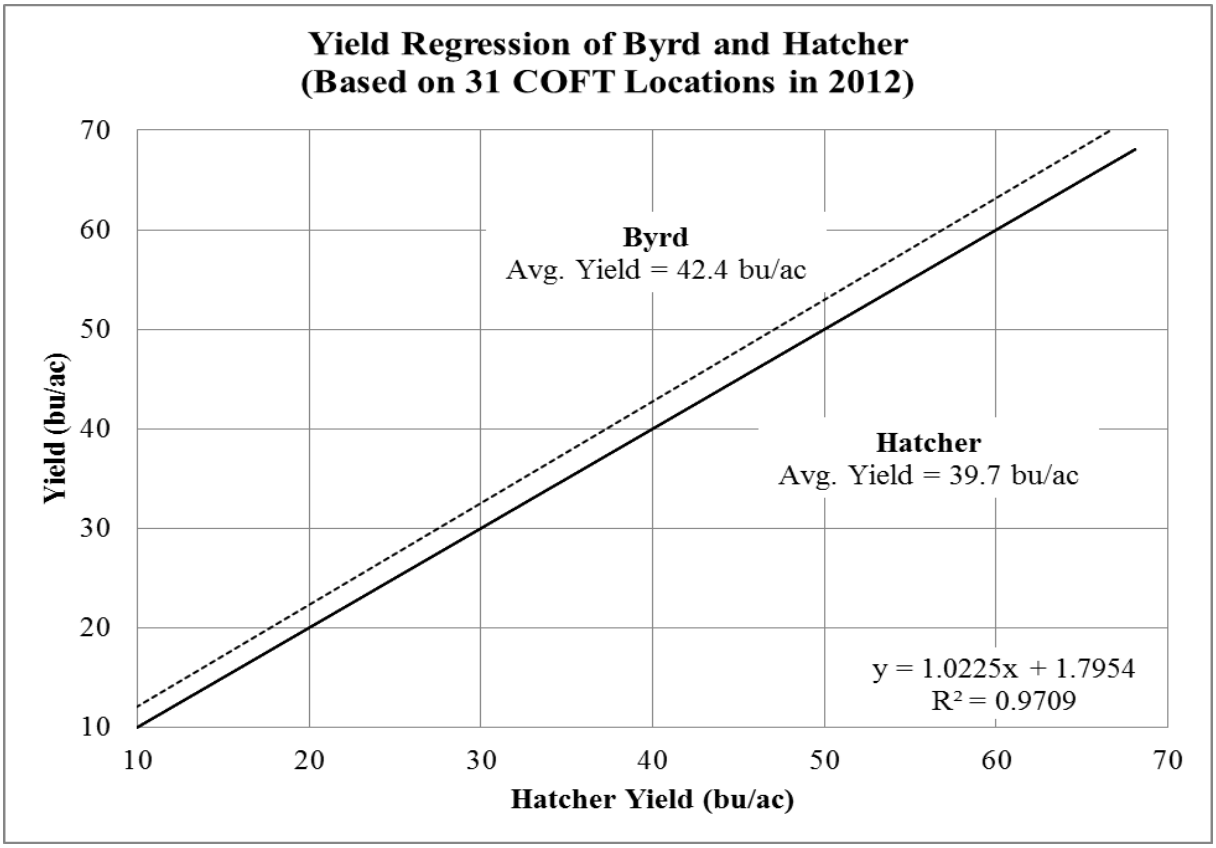
[b]Southern region includes trials located south of interstate-70, and northern region includes trials north of interstate-70.

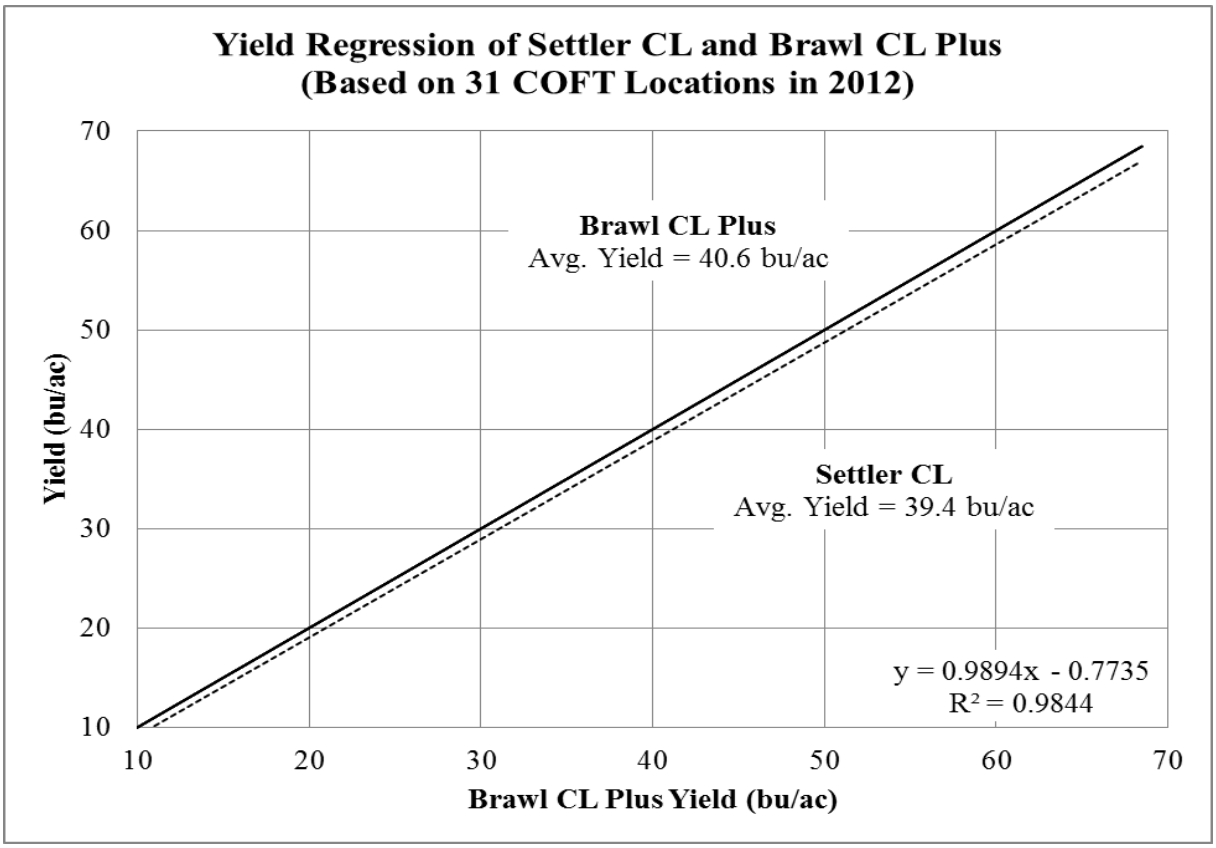
[c]Varieties are ranked by the highest average yield.

[d]Yield corrected to 12% moisture.

Yield Regressions to Compare Expected Performance of Varieties

The following linear regressions are based on 31 Collaborative On-Farm Test results in 2012. They can be used as a tool to help growers visualize the expected performance of each variety in low-to-high yielding environments. In the following regressions the lines do not cross over one another, meaning that the yield of Byrd would be expected to be higher than the yield of Hatcher over all yield environments. Similarly, the yield of Brawl CL Plus would be expected to be higher than Settler CL over all yield environments. Farmers can predict the yield of Byrd given the yield of Hatcher, which is shown on the first regression. The second regression can be used to predict the yield of Brawl CL Plus given the yield of Settler CL. The equation shown in the bottom right of each graph can be used to predict the expected yield of a variety, given a yield of the variety listed on the bottom (x-axis) of the graph. For example, in the first regression, the expected yield of Byrd = 1.0225 *(yield of Hatcher) + 1.7954 bu/ac. If the yield of Hatcher is 50 bu/ac then you would expect the yield of Byrd to be 52.9 bu/ac. The R^2 value of the regression is a statistical measure that represents how well a regression line fits the actual data points. R-squared values equal to 1.0 means the regression line fits the data perfectly. It is important to point out that the comparisons are expected to be more reliable when they include more results over multiple locations from different years. Additional testing of varieties might change the relationships portrayed in the following graphs.


Yield Regression of Byrd and Hatcher
(Based on 31 COFT Locations in 2012)
Byrd
Avg. Yield = 42.4 bu/ac
Hatcher
Avg. Yield = 39.7 bu/ac
y = 1.0225x + 1.7954
R² = 0.9709
Yield (bu/ac)
Hatcher Yield (bu/ac)
10
20
30
40
50
60
70


Yield Regression of Settler CL and Brawl CL Plus
(Based on 31 COFT Locations in 2012)
Brawl CL Plus
Avg. Yield = 40.6 bu/ac
Settler CL
Avg. Yield = 39.4 bu/ac
y = 0.9894x - 0.7735
R² = 0.9844
Yield (bu/ac)
Brawl CL Plus Yield (bu/ac)
10
20
30
40
50
60
70

Summary of 3-Yr Irrigated Variety Performance Results at Fort Collins

Variety Origin[a] and Release Year	Variety[b]	Market Class[c]	3-Year Average Yield	Yield	Test Weight	Plant Height	Heading	Lodging[d]
			bu/ac	% trial average	lb/bu	in	days from trial average	scale (1-9)[e]
CSU/PG 2011	Byrd	HRW	99.0	111%	60.4	37	0	3
CSU exp	CO050233-2	HRW	96.0	108%	59.1	37	1	1
CSU/PG 2006	Ripper	HRW	92.3	104%	59.1	36	-1	3
CSU/PG 2004	Hatcher	HRW	92.1	104%	59.8	36	0	2
NE 2008	Settler CL	HRW	90.6	102%	60.1	36	1	2
CSU/PG 2011	Denali	HRW	90.3	101%	61.4	37	2	2
WB 2008	Armour	HRW	88.4	99%	59.6	34	-3	2
CSU exp	CO05W111	**HWW**	87.2	98%	60.9	38	3	1
CSU/PG 2004	Bond CL	HRW	86.9	98%	58.2	37	-2	2
CSU/PG 2011	Brawl CL Plus	HRW	86.1	97%	60.5	37	-3	1
AP 2010	SY Gold	HRW	86.0	97%	60.2	36	-1	1
OK 2009	Billings	HRW	84.6	95%	60.2	37	0	1
CSU/PG 2008	Thunder CL	**HWW**	83.4	94%	60.2	35	0	1
CSU/PG 1991	Yuma	HRW	82.6	93%	59.2	34	-1	2
		Average	**89.0**		**59.9**	**36**		**2**

[a]Variety origin codes: CSU=Colorado State University; WB=WestBred (Monsanto); AP=AgriPro (Syngenta); CSU/PG=CSU release, marketed by CWRF under the PlainsGold brand; NE=University of Nebraska; OK=Oklahoma State University.

[b]Varieties ranked according to average 3-year yield at Fort Collins.

[c]Market class: HRW=hard red winter wheat; **HWW**=hard white winter wheat.

[d]Lodging scores based on 2011 trial data.

[e]Lodging scale: 1=no lodging, 9=severe lodging.

Summary of 3-Yr Irrigated Variety Performance Results at Haxtun

Variety Origin[a] and Release Year	Variety[b]	Market Class[c]	3-Year Average Yield	3-Year Average Yield	3-Year Average Test Weight	3-Year Average Plant Height	Lodging[d]
			bu/ac	% trial average	lb/bu	in	scale (1-9)[e]
CSU exp	CO050233-2	HRW	119.0	105%	61.6	36	2
WB 2008	Armour	HRW	117.1	103%	62.0	32	3
CSU/PG 2011	Brawl CL Plus	HRW	117.0	103%	62.8	36	2
CSU/PG 2011	Byrd	HRW	117.0	103%	63.2	37	5
OK 2009	Billings	HRW	116.3	103%	62.2	39	6
AP 2010	SY Gold	HRW	114.8	101%	61.0	36	3
NE 2008	Settler CL	HRW	113.3	100%	61.6	37	4
CSU/PG 2011	Denali	HRW	112.1	99%	61.6	38	5
CSU/PG 2004	Bond CL	HRW	111.9	99%	61.2	38	4
CSU exp	CO05W111	**HWW**	111.6	99%	61.6	39	3
CSU/PG 2008	Thunder CL	**HWW**	111.4	98%	62.1	35	4
CSU/PG 1991	Yuma	HRW	110.5	98%	61.5	36	4
CSU/PG 2006	Ripper	HRW	107.4	95%	60.3	35	3
CSU/PG 2004	Hatcher	HRW	105.6	93%	61.7	36	6
		Average	**113.2**		**61.7**	**36**	**4**

[a]Variety origin codes: CSU=Colorado State University; WB=WestBred (Monsanto); CSU/PG=CSU release, marketed by CWRF under the PlainsGold brand; AP=AgriPro (Syngenta); NE=University of Nebraska; OK=Oklahoma State University.

[b]Varieties ranked according to average 3-year yield at Haxtun.

[c]Market class: HRW=hard red winter wheat; **HWW**=hard white winter wheat.

[d]Lodging scores based on average of 2011 and 2012 trial data.

[e]Lodging scale: 1=no lodging, 9=severe lodging.

Summary of 3-Yr Irrigated Variety Performance Results Rocky Ford

Variety Origin[a] and Release Year	Variety[b]	Market Class[c]	3-Year Average Yield	3-Year Average Yield	3-Year Average Test Weight	3-Year Average Plant Height	Lodging[d]
			bu/ac	% trial average	lb/bu	in	scale (1-9)[e]
CSU exp	CO050233-2	HRW	97.9	109%	58.9	37	1
CSU/PG 2011	Byrd	HRW	97.2	108%	59.9	38	6
CSU exp	CO05W111	**HWW**	96.2	107%	59.5	40	3
NE 2008	Settler CL	HRW	95.7	106%	58.7	38	3
CSU/PG 2006	Ripper	HRW	93.6	104%	58.1	36	4
CSU/PG 2004	Bond CL	HRW	93.4	104%	58.2	38	2
CSU/PG 2011	Denali	HRW	92.7	103%	59.6	38	3
WB 2008	Armour	HRW	90.1	100%	59.9	33	4
OK 2009	Billings	HRW	89.7	100%	60.2	36	3
CSU/PG 2008	Thunder CL	**HWW**	87.2	97%	59.7	38	2
CSU/PG 2011	Brawl CL Plus	HRW	86.0	96%	60.0	37	1
CSU/PG 2004	Hatcher	HRW	81.6	91%	59.2	37	4
CSU/PG 1991	Yuma	HRW	80.9	90%	57.8	37	2
AP 2010	SY Gold	HRW	78.7	87%	58.9	38	3
		Average	**90.1**		**59.2**	**37**	**3**

[a]Variety origin codes: CSU=Colorado State University; WB=WestBred (Monsanto); CSU/PG=CSU release, marketed by CWRF under the PlainsGold brand; AP=AgriPro (Syngenta); NE=University of Nebraska; OK=Oklahoma State University.

[b]Varieties ranked according to average 3-year yield at Rocky Ford.

[c]Market class: HRW=hard red winter wheat; **HWW**=hard white winter wheat.

[d]Lodging scores based on average of 2010 and 2011 trial data.

[e]Lodging scale: 1=no lodging, 9=severe lodging.

Winter Wheat Variety Selection in Colorado for Fall 2012 Planting

Variety performance summary tables from CSU are intended to provide useful information to farmers, seed producers, and wheat industry representatives in Colorado and surrounding states. This section of the report is designed to provide guidance to farmers so they can weigh the advantages and disadvantages of different varieties and choose the variety that best fits their farm conditions.

- Producers should focus on multiple-year summary yield results when selecting a new variety. Over time, the best buffer against making poor variety decisions has been to select varieties based on three-year average performance and not on performance in a single year. Selection of a variety based upon performance at a single location in a single year has been consistently shown to be the poorest predictor of future yield results.
- Producers should consider planting more than one variety based on different maturity, plant height, disease or insect resistance, test weight, lodging, herbicide tolerance, coleoptile length, or end-use quality characteristics. These non-yield traits are useful to spread your risk due to the unpredictability of climatic conditions and pest problems.
- Producers should be aware that a new race of stripe rust emerged in 2010 and varieties that were resistant before are now susceptible. Although stripe rust was not a problem in 2011, farmers should remain aware of the potential for yield losses due to stripe rust in 2012.
- Producers should control volunteer wheat and weeds to avoid the negative effects of a green bridge that could lead to serious virus disease infections vectored by the wheat curl mite (wheat streak mosaic virus, High Plains virus, Triticum mosaic virus) or aphids (barley yellow dwarf virus).
- Producers should soil sample to determine optimum fertilizer application rates. In the absence of soil sampling, grain protein levels should be monitored closely. If protein levels in a field fall below 12%, nitrogen fertilizer was likely insufficient to meet demands for yield and yield was lost (consult http://tinyurl.com/c88u3x2).

Many new varieties possessing multiple valuable traits and with high yield potential are currently in the breeding and selection process. However, the ten dryland wheat varieties emphasized here are based on their order of relative performance for the past three years and the specific traits they possess.

Dryland Production Conditions

Settler CL – This 2008 Nebraska release is a HRW Clearfield® winter wheat that has performed well in 4 years of testing and has good test weight. It is later maturing, medium height, and is moderately susceptible to leaf rust and moderately resistant to stripe rust.

CSU Blend09 – A 50:50 blend of Hatcher and Ripper and first entered into CSU Dryland Variety Trial (UVPT) in 2009.

Snowmass – HWW CSU released in 2009 is a medium-maturing, taller semidwarf with excellent test weight and milling and baking quality. It has excellent resistance to wheat streak

mosaic virus, stripe rust, and moderate sprouting tolerance. Snowmass has relatively poor straw strength and will not be recommended for high-yield irrigated conditions. It is being handled in the CWRF ConAgra Mills Ultragrain® Premium Program for hard white wheat (HWW).

Ripper – An early maturing HRW 2006 CSU release that is high yielding, taller than Hatcher, excellent baking quality, and a medium long coleoptile. It has relatively lower test weight, and is susceptible to both leaf and stripe rust. Ripper has shown extremely stable yields, being in the top three of the three year yield averages from 2005 – 2010 and 4th in 2011.

Hatcher – This medium maturing, high yielding 2004 CSU HRW variety was planted on more Colorado wheat acres in the fall of 2008, 2009, and 2010 than any other variety. It has good stress tolerance, good test weight and moderate resistance to stripe rust. Hatcher is also relatively short and develops a "speckling" condition on the leaves in the spring in the absence of any apparent disease. Hatcher remains a highly recommended HRW wheat variety based on its yield record, test weight, stress tolerance, and resistance to stripe rust.

Bill Brown – CSU HRW release (2007) can be compared to Hatcher and Ripper: it is similar in maturity to Hatcher and later maturing than Ripper. Like Ripper, it is slightly taller than Hatcher. It has good resistance to stripe rust like Hatcher, which is much better than Ripper, and also very good resistance to leaf rust (unlike Hatcher and Ripper). It has superior test weight to Hatcher and other varieties, especially Ripper (low) and better baking quality than Hatcher but not quite as good as Ripper. Bill Brown is susceptible to stem rust, which is a much greater concern under irrigated conditions. Like Hatcher, Bill Brown tillers aggressively and recovers well from poor stand conditions.

Winterhawk – This WestBred release (2007) is medium maturing, medium tall, longer coleoptile with good stripe rust resistance. It has good test weight and good baking quality but is susceptible to both leaf and stem rust. It has been high yielding in our variety and COFT trials.

TAM 112 – A HRW 2005 release from Texas A&M and marketed by Watley Seed Company has good dryland adaptation and is distinguished by excellent wheat streak mosaic virus tolerance (or resistance to its vector, the wheat curl mite), a medium-long coleoptile, early maturity, and good test weight and baking quality. It is susceptible to leaf and stripe rust and has poor straw strength.

Above – This CSU Clearfield HRW (2001) release and both Ripper and TAM 112, are the earliest maturing varieties in the 2011 trials. On a 3-year average, Above is the second highest yielding Clearfield variety. It has average test weight and is susceptible to leaf and stripe rust and has relatively poor baking quality.

Bond CL – A medium maturing taller 2004 HRW CSU release with high yields and good baking quality in addition to the Clearfield trait. It has lower test weight and is susceptible to stripe rust.

Irrigated Production Conditions

Four irrigated wheat varieties to consider based on the order of relative performance for three years. The most important variety selection criteria for irrigated varieties are yield, straw strength, and stripe rust resistance.

Settler CL – This 2008 Nebraska release is a HRW Clearfield winter wheat that has performed well in four years of testing and has good test weight. It is medium height, and is moderately susceptible to leaf rust and moderately resistant to stripe rust.

Armour – A Westbred release (2008) first entered in CSU trials in 2009. Early maturing short semidwarf, with prolific tillering, good leaf and stripe rust resistance, and good straw strength.

Ripper – An early maturing HRW 2006 CSU release that is high yielding and has excellent baking quality. It has relatively lower test weight, and is susceptible to both leaf and stripe rust. Like Bond CL, it may show significant lodging in very high yielding conditions.

Bond CL – A medium maturing taller HRW CSU release (2004) with high yields, average straw strength, but susceptible to stripe rust. It has lodged significantly in some high yielding irrigated trials. It has low test weight that is more manageable and less of a concern in irrigated conditions.

Description of winter wheat varieties in eastern Colorado trials.

Name, Class, and Pedigree	Origin	RWA*	HD	HT	SS	COL	YR	LR	WSMV	TW	MILL	BAKE	Comments
1863 Hard red winter KS940786-6-4/Karl92//Cutter	KSU 2012	S	6	4	--	2	5	7	--	3	3	3	KSU-Manhattan release (2012). First entered into CSU Variety Trials in 2012. Medium height and medium maturing, good test weight, intermediate reaction to stripe rust, moderately susceptible to leaf rust. Good quality characteristics.
Above Hard red winter TAM 110*4/FS2	CSU-TX 2001	S	4	5	3	9	9	9	5	7	4	7	CSU/Texas A&M release (2001), marketed by PlainsGold. Single-gene Clearfield* wheat. Early maturing semidwarf, excellent dryland yield in CO. Leaf and stripe rust susceptible. Marginal baking quality.
Antero Hard white winter KS01HW152-1/TAM 111	CSU 2012	S	5	5	4	6	2	8	--	3	4	6	CSU release (2012), marketed by PlainsGold. High dryland and irrigated yield, medium height and maturity, good test weight, good straw strength. Good resistance to prevalent races of stripe rust.
Armour Hard red winter B1551-WH/KS94U326	Westbred 2008	S	1	1	3	8	6	5	7	8	4	5	Westbred release (2008). Early maturing short semidwarf, heavy tillering, good leaf rust resistance, moderate susceptibility to new races of stripe rust. Lower test weight.
Bearpaw Hard red winter DMS/Rampart//Pronghorn/3/2*Rampart	MT 2011	S	--	--	--	2	--	--	--	--	--	--	Montana State University release (2011). First entered in CSU Variety Trials in 2013. Carries solid stem trait conferring some protection against wheat stem sawfly damage.
Bill Brown Hard red winter Yumar/Arlin	CSU 2007	R*	5	3	4	3	6	2	7	3	6	3	CSU release (2007), marketed by PlainsGold. High test weight, good leaf rust resistance, moderate susceptibility to new races of stripe rust. Very susceptible to stem rust. Good baking quality, short coleoptile.
Billings Hard red winter N566/OK94P597	OK 2009	S	7	4	6	6	2	2	--	8	1	2	Oklahoma State release (2009). First entered into CSU Irrigated Variety Trials in 2010. Good leaf and stripe rust resistance. Below average yield in CSU irrigated variety trials.
Bond CL Hard red winter Yumar//TXGH12588-120*4/FS2	CSU 2004	R*	6	6	5	4	8	6	8	8	6	3	CSU release (2004), marketed by PlainsGold. Single-gene Clearfield* wheat. Slightly later, slightly taller than Above. Good dryland yield, high irrigated yields, good baking quality. Low test weight, leaf and stripe rust susceptible.
Brawl CL Plus Hard red winter Teal 11A/Above//CO99314	CSU 2011	S	4	5	2	8	5	4	--	2	3	2	CSU release (2011), marketed by PlainsGold. Two-gene Clearfield* wheat. Excellent test weight, straw strength, milling and baking quality. Early maturity, medium height, long coleoptile. Intermediate reaction to stripe rust.
Byrd Hard red winter TAM 112/CO970547-7	CSU 2011	S	5	5	4	7	5	6	--	5	3	2	CSU release (2011), marketed by PlainsGold. High yield, excellent drought stress tolerance and quality. Medium height, maturity, coleoptile length. Average test weight and straw strength. Intermediate reaction to stripe rust.

Russian wheat aphid resistance (RWA), heading date (HD), plant height (HT), straw strength (SS), coleoptile length (COL), stripe rust resistance (YR), leaf rust resistance (LR), wheat streak mosaic virus tolerance (WSMV), test weight (TW), milling quality (MILL), and baking quality (BAKE). Rating scale: 0 - very good, very early, or very short to 9 - very poor, very late, or very tall. * RWA rating denotes resistance to the original biotype (biotype 1) of RWA. All available cultivars are susceptible to the new biotype of RWA.

Description of winter wheat varieties in eastern Colorado trials.

Name, Class, and Pedigree	Origin	RWA*	HD	HT	SS	COL	YR	LR	WSMV	TW	MILL	BAKE	Comments
Clara CL Hard white winter KS03HW154(TREGO/CO960293)/KS03HW1(FIDEL/97HW150//97HW349/3/TGO)	KSU 2011	S	6	5	6	4	4	--	2	2	4	4	KSU-Hays release (2011). First entered in CSU Variety Trials in 2012. Single-gene hard white Clearfield* wheat. Carries same WSMV resistance as RonL and Snowmass. Moderate resistance to stripe rust, excellent test weight.
CSU Blend12 Hard red winter Hatcher-Byrd Blend	CSU 2004/2011	--	--	--	--	--	--	--	--	--	4	2	50:50 blend of Hatcher and Byrd. First entered into CSU Dryland Variety Trial (UVPT) in 2012.
Denali Hard red winter CO980829/TAM 111	CSU 2011	S	7	7	3	8	6	8	7	2	4	5	CSU release (2011), marketed by PlainsGold and KWA in Kansas. High yields, excellent test weight. Medium tall, medium-late, medium coleoptile length. Average straw strength and quality. Moderate susceptibility to stripe rust.
Everest Hard red winter HBK1064-3/KS84063-9-39-3-4W//VBF0589-1/IL89-6483	KSU 2009	S	5	2	--	7	8	3	7	3	3	7	KSU-Manhattan release (2009). First entered into CSU Variety Trials in 2010. Good leaf rust and barley yellow dwarf virus resistance. Susceptible to new races of stripe rust. Marginal baking quality.
Freeman Hard red winter KS92-946-B-15-1=(ABI86*3414/JAG//K92)/ALLIANCE	NE 2012	S	3	4	--	3	--	--	--	--	8	5	Nebraska release (2012), first entered in CSU Variety Trials in 2013.
Gallagher Hard red winter OK93P656-(RMH 3299)/OK99711	OK 2012	S	5	3	6	2	3	2	--	5	5	5	Oklahoma State release (2012), first entered in CSU Variety Trials in 2013.
Hatcher Hard red winter Yuma/PI 372129//TAM-200/3/4*Yuma/4/KS91H184/Vista	CSU 2004	R*	6	2	6	6	3	7	8	4	4	3	CSU release (2004), marketed by Plainsgold. Medium maturing semidwarf. Good test weight, moderate resistance to stripe rust. Excellent High Plains yield record, good milling and baking quality. Develops “leaf speckling” condition.
Iba Hard red winter OK93P656-(RMH 3299)/OK99621	OK 2012	S	5	3	6	8	3	1	--	2	2	5	Oklahoma State release (2012), first entered in CSU Variety Trials in 2013.
Judee Hard red winter (Vanguard/Norstar//Judith dwf, 93X312E14)/3/ NuHorizon	MT 2011	S	9	2	--	--	3	--	--	4	4	3	Montana State University release (2011), first entered in CSU Variety Trials in 2012. Carries solid stem trait conferring some protection against wheat stem sawfly damage. Very late maturing, very low yield in 2012 CSU dryland trials.
LCS Mint Hard red winter Overley/CO980829	Limagrain 2011	S	5	5	--	3	3	6	--	3	2	2	Limagrain release (2011). First entered in CSU Variety Trials in 2013, previously tested under experimental designation CO050175-1. Moderately resistant to stripe rust, good test weight, good milling and baking quality.

Russian wheat aphid resistance (RWA), heading date (HD), plant height (HT), straw strength (SS), coleoptile length (COL), stripe rust resistance (YR), leaf rust resistance (LR), wheat streak mosaic virus tolerance (WSMV), test weight (TW), milling quality (MILL), and baking quality (BAKE). Rating scale: 0 - very good, very early, or very short to 9 - very poor, very late, or very tall. * RWA rating denotes resistance to the original biotype (biotype 1) of RWA. All available cultivars are susceptible to the new biotype of RWA.

Description of winter wheat varieties in eastern Colorado trials.

Name, Class, and Pedigree	Origin	RWA*	HD	HT	SS	COL	YR	LR	WSMV	TW	MILL	BAKE	Comments
McGill Hard red winter NE92458/Ike	NE 2010	S	6	6	8	1	6	--	--	7	5	4	Nebraska release (2010). First entered in CSU Variety Trials in 2011. Medium maturity, medium height. Lower test weight, poor straw strength. Intermediate reaction to new races of stripe rust.
Protection Hard red winter Jagger//TXGH12588-120*4/FS2	AGSECO/CSU 2004	S	3	7	3	4	7	9	5	8	4	6	CSU release (2004), marketed by AGSECO. Single-gene Clearfield* wheat. Lower yield relative to Bond CL in CSU Variety Trials. Taller plant stature, susceptible to stripe rust. Low test weight.
Ripper Hard red winter CO940606/TAM107R-2	CSU 2006	R*	2	4	4	9	9	9	7	8	4	4	CSU release (2006), marketed by PlainsGold. Excellent stress tolerance, high dryland yields in Colorado, good baking quality. Very good recovery from stand reduction. Leaf and stripe rust susceptible, lower test weight.
Robidoux Hard red winter NE96644/Wahoo (sib)	NE 2010	S	5	3	6	7	4	--	--	5	5	3	Nebraska release (2010). First entered in CSU Variety Trials in 2011. Medium maturity, medium short. Moderate resistance to stripe rust.
Settler CL Hard red winter N95L164/3/MILLENNIUM SIB//TXGH125888-120*4/FS2	NE 2008	S	8	5	3	5	6	8	7	6	3	4	Nebraska release (2008). Single-gene Clearfield* wheat. Good dryland and irrigated yield in CSU Variety Trials. Later maturing, medium height. Moderately susceptible to new races of stripe rust.
Snowmass Hard white winter KS96HW94//Trego/CO960293	CSU 2009	S	7	6	8	5	6	6	2	4	6	2	CSU release (2009), marketed by PlainsGold. Hard white winter wheat (HWW). Medium-maturing, medium-tall. Good WSMV resistance, moderately susceptible to stripe rust, moderate sprouting tolerance. Grown under contract with ConAgra.
SY Gold Hard red winter W95-301/W98-151	Agripro 2010	S	4	5	5	2	7	2	6	3	5	5	Agripro release (2010). First entered in CSU Variety Trials in 2009. Good leaf rust resistance, susceptible to stripe rust. Good milling quality, lower baking quality. Best adapted in Northeast Colorado.
SY Wolf Hard red winter W99-331/97x0906-8	Agripro 2010	S	6	4	3	5	4	4	--	5	4	4	Agripro release (2011). First entered in CSU Variety Trials in 2011. Good milling quality, poor baking quality. Good resistance to tan spot and septoria, moderate resistance to stripe rust and leaf rust.
T153 Hard red winter T136//T81/KS93U206	Limagrain 2008	S	3	3	--	7	--	--	--	4	7	6	Limagrain release (2008). First entered in CSU Variety Trials in 2013.
T154 Hard red winter T88/2180//T811	Limagrain 2008	S	2	2	--	5	--	--	--	3	--	--	Limagrain release (2008). First entered in CSU Variety Trials in 2013.

Russian wheat aphid resistance (RWA), heading date (HD), plant height (HT), straw strength (SS), coleoptile length (COL), stripe rust resistance (YR), leaf rust resistance (LR), wheat streak mosaic virus tolerance (WSMV), test weight (TW), milling quality (MILL), and baking quality (BAKE). Rating scale: 0 - very good, very early, or very short to 9 - very poor, very late, or very tall. * RWA rating denotes resistance to the original biotype (biotype 1) of RWA. All available cultivars are susceptible to the new biotype of RWA.

Description of winter wheat varieties in eastern Colorado trials.

Name, Class, and Pedigree	Origin	RWA*	HD	HT	SS	COL	YR	LR	WSMV	TW	MILL	BAKE	Comments
T158 Hard red winter KS93U206/2*T81	Limagrain 2009	S	2	5	5	3	2	7	--	4	3	5	Trio (Limagrain) release (2009). First entered in CSU Variety Trials in 2012. Good stripe rust resistance, top dryland yields on a three-year average in Western KS trials.
T163 Hard red winter 93WGRC27/T811	Limagrain 2010	S	3	4	8	4	3	--	4	6	3	2	Trio (Limagrain) release (2010). First entered in CSU Variety Trials in 2011. Some plants carry resistance to wheat streak mosaic virus. Moderate resistance to stripe rust. Poor straw strength.
TAM 111 Hard red winter TAM-107//TX78V3630/CTK78/3/TX87V1233	TX 2002	S	6	7	3	8	5	8	7	2	4	5	Texas A&M release (2002), marketed by Agripro. Medium maturing, taller wheat. Good test weight, good straw strength, good irrigated yield. Leaf rust susceptible, intermediate reaction to stripe rust.
TAM 112 Hard red winter U1254-7-9-2-1/TXGH10440	TX 2005	S	2	4	7	7	7	7	3	2	4	2	Texas A&M release (2005), marketed by Watley Seed. Good test weight, good quality, excellent wheat streak mosaic virus tolerance. Susceptible to leaf and stripe rust, poor straw strength.
TAM 113 Hard red winter TX90V6313/TX94V3724	AGSECO 2010	S	5	5	8	3	2	2	--	3	4	5	Texas A&M release (2010), marketed by AGSECO. First entered in CSU Variety Trials in 2012. Good leaf and stripe rust resistance, good test weight. Poor straw strength.
TAM 304 Hard red winter TX92U3060/TX91D6564	Scott Seed 2006	S	4	2	2	7	8	2	--	5	6	4	Texas A&M release (2006), marketed by Scott Seed Co. First entered in CSU Variety Trials in 2012. Good straw strength, susceptible to stripe rust, lower test weight.
Thunder CL Hard white winter KS01-5539/CO99W165	CSU 2008	R*	4	4	3	7	3	5	4	6	5	2	CSU release (2008), marketed by PlainsGold. Single-gene HWW Clearfield* wheat. Good straw strength for irrigation. Excellent quality, moderate stripe rust resistance, moderate sprouting susceptibility. Grown under contract with ConAgra.
WB-Cedar Hard red winter TAM 302/B1551W	Westbred 2010	S	2	2	1	5	2	5	7	7	3	5	Westbred release (2010). First entered in CSU Variety Trials in 2011. Hard red sister selection to Aspen hard white wheat. Good stripe rust resistance, excellent straw strength for high-input irrigation. Lower test weight.
WB-Grainfield Hard red winter G982231/G982159//KS920709W	Westbred 2012	S	6	5	--	2	--	--	--	6	--	--	Westbred release (2012). First entered into CSU Trials in 2013.
Winterhawk Hard red winter 474S10-1/X87807//HBK736-3	Westbred 2007	S	5	5	5	8	5	7	7	2	2	4	Westbred release (2007). Medium maturing, medium tall, long coleoptile. Intermediate reaction to new races of stripe rust, susceptible to leaf rust, very susceptible to stem rust. Good test weight, good quality.

Russian wheat aphid resistance (RWA), heading date (HD), plant height (HT), straw strength (SS), coleoptile length (COL), stripe rust resistance (YR), leaf rust resistance (LR), wheat streak mosaic virus tolerance (WSMV), test weight (TW), milling quality (MILL), and baking quality (BAKE). Rating scale: 0 - very good, very early, or very short to 9 - very poor, very late, or very tall. * RWA rating denotes resistance to the original biotype (biotype 1) of RWA. All available cultivars are susceptible to the new biotype of RWA.

Description of winter wheat varieties in eastern Colorado trials.

Name, Class, and Pedigree	Origin	RWA*	HD	HT	SS	COL	YR	LR	WSMV	TW	MILL	BAKE	Comments
Yuma Hard red winter NS14/NS25//2*Vona	CSU 1991	S	6	3	3	1	5	5	6	6	5	3	CSU release (1991). Medium maturity, semidwarf, short coleoptile, good baking quality characteristics. Moderate resistance to stripe rust. Good yields especially under irrigation.

Russian wheat aphid resistance (RWA), heading date (HD), plant height (HT), straw strength (SS), coleoptile length (COL), stripe rust resistance (YR), leaf rust resistance (LR), wheat streak mosaic virus tolerance (WSMV), test weight (TW), milling quality (MILL), and baking quality (BAKE). Rating scale: 0 - very good, very early, or very short to 9 - very poor, very late, or very tall. * RWA rating denotes resistance to the original biotype (biotype 1) of RWA. All available cultivars are susceptible to the new biotype of RWA.

CSU Wheat Breeding and Genetics Program Update 2013

Scott Haley
Department of Soil & Crop Sciences

Introduction

The primary goal of the CSU Wheat Breeding and Genetics Program is to develop and release improved wheat cultivars and germplasm adapted for the diverse production conditions in Colorado and the High Plains region. Over 50 years of continuous activity at CSU we have developed a germplasm base uniquely adapted for the High Plains region and have brought many new cultivars to the market to address production and marketing constraints facing Colorado's wheat producers.

We are fortunate to receive generous funding support from CSU (Colorado Ag Experiment Station) and from the Colorado wheat industry through the Colorado Wheat Administrative Committee (CWAC) and the Colorado Wheat Research Foundation (CWRF). The funding we receive, enhanced considerably with the CWAC assessment increase in 2007, supports several different activities focused on wheat cultivar development. The following descriptions of these activities highlight our progress over the last few years, particularly since the CWAC assessment increase in 2007.

Breeding Program Core

The primary goal of our breeding program is the development and release of improved wheat cultivars adapted for Colorado and the High Plains region. At the present time, our focus is split between hard red winter wheat (HRW), hard white winter wheat (HWW), and *Clearfield*® wheat in both HRW and HWW classes.

- In fall 2012, CO07W245 was released as 'Antero'. Antero is a HWW cultivar derived from the cross KS01HW152-1/TAM 111 made in 2003. Antero is medium height and medium maturing, and has a medium-length coleoptile, good straw strength, and excellent test weight. Antero is resistant to stripe rust, moderately resistant to stem rust and wheat soilborne/wheat spindle streak mosaic virus, moderately susceptible to barley yellow dwarf and wheat streak mosaic viruses, and susceptible to leaf rust and all biotypes of Russian wheat aphid. In two years of testing (2011 and 2012) in the dryland CSU Uniform Variety Performance Trial (UVPT), Antero was the second highest yielding entry in the trials, similar to Byrd HRW, 9.4% higher than Hatcher HRW, and 14.9% higher than Snowmass HWW. In the 2012 Colorado Irrigated Variety Performance Trial (IVPT), Antero was also the second highest yielding entry across three trial locations. Antero has shown excellent milling properties and good baking properties in tests conducted in the CSU Wheat Quality Lab. Pre-harvest sprouting tolerance of Antero is similar to Snowmass HWW, which is similar to Hatcher HRW wheat (and superior to Thunder CL and Platte HWW).
- In fall 2012, five HRW and seven HWW experimental lines were advanced for Breeder seed production to enable potential release in fall 2014. All of these lines have shown good field performance (but none surpassing Byrd or Antero), good test weight, stripe rust resistance, and average or better milling and baking quality.
- CWRF royalty funds and our partnership with ConAgra are providing for a significant expansion of experimental line development (both HRW and HWW) through the use of doubled haploid (DH) breeding technology. With CWRF funding, we are also exploring the development of DHs at CSU.
- In fall 2012, we planted over 16,000 yield trial plots across 14 trial locations in Colorado, in addition to three dryland CSU Elite Trial locations in Kansas (in collaboration with KSU) and one under irrigation in Nebraska (in collaboration with a private company). We also planted

over 30,000 headrows, over 1,000 early-generation (F2-F4) populations (including 91 two-gene *Clearfield*® populations), and over 1,400 new cross combinations at Fort Collins in fall 2012 and spring 2013.

Genomic Selection

The basic objective of this program is to conduct research focused on implementation of "genomic selection" (GS) in the CSU Wheat Breeding Program. Our motivation originates from successes achieved with GS in other breeding systems, especially its use in the dairy industry where it has been used quite successfully to predict the merit of prospective young bulls prior to costly and time-consuming trait evaluation. If successful, the value of GS in wheat breeding will be realized through shortening of the breeding cycle time (in conjunction with doubled haploid technology) and increased rates of genetic improvement over time for yield, quality, and other traits of interest.

Selected activities, highlights, and accomplishments of our program are as follows:

- Dr. Eric Storlie joined our breeding program as a Research Scientist in August 2012 to lead our program's efforts in GS. Eric brings considerable experience in wheat breeding/genetics and wheat quality research and had most recently led a wheat GS project in France. We are extremely fortunate to have been able to bring somebody with Eric's skills to CSU.
- In 2010, we assembled a group of genotypes (n=400) from our breeding program to form our initial "training panel" for GS model development. In 2012-2013, we are further building our training panel through addition of 1,900 genotypes to the panel. Some of these genotypes (30%) were breeding program discards from prior years while most (70%) are current genotypes that are also under field-testing in 2013.
- In 2012, we completed our first attempt at conducting dense, genome-wide marker analysis using "genotyping by sequencing" (GBS) technology. We have optimized protocols for GBS obtained from the Jesse Poland Lab (USDA-ARS, Manhattan KS) and are currently conducting GBS on the set of 1,900 genotypes mentioned above. We expect to have the GBS on these materials completed by June 2013.
- Using historical data on our initial GS training panel (n=400), and the GBS markers obtained on the panel, we explored GS model development using several statistical models. Estimates of accuracy for grain yield ranged between r=0.45 and 0.60, results that compare well with cross-validation results for yield reported in the literature.
- In addition to standard prediction methods, we are testing the use of another method of measuring accuracies based on ranks to determine if the models predict stable, high-yielding genotypes with greater precision. If so, it will be possible to isolate these genotypes and rapidly and preferentially advance them toward further crossing and seed increase.

DNA Marker-Assisted Selection

The objectives of this program are to apply DNA molecular marker-assisted selection (MAS) as a tool in selection for traits of interest in the breeding program. On a limited basis, we would hope to be able to identify and validate our own markers for new traits, yet this activity was curtailed greatly with the re-assignment of a research associate (Rebecca Kottke) to provide technical support for the TILLING project.

Selected activities, highlights, and accomplishments of our program are as follows:

- Since inception of this program in 2008, a major part of our overall marker effort had been implementation of a rapid generation advance scheme ("single seed descent", SSD) for line development. We initiated four sets of SSD populations since 2008, with each set involving growing three generations (F2-F4) in the greenhouse and DNA marker assays for key traits

for selection. Line selections from the first set started in 2008 were selected for advanced yield trials in 2012. Selections from subsequent SSD sets will be working their way through our pipeline in coming years.

- In 2012, we greatly expanded routine marker testing of preliminary lines, including those developed via SSD in prior years. In 2012, we expanded the number of preliminary lines developed in our program (1013 in 2011 vs. 1815 in 2012) and we continued this expansion in 2012-2013. We have also significantly increased our use of doubled haploid technology for line development (via HPI, funded by ConAgra Mills and CWRF royalties).
- We are working to align next-generation DNA sequence data, obtained via genotyping by sequencing (GBS), with known DNA marker sequences for key genes. A set of preliminary lines will be tested with both GBS and conventional tests in spring 2013 for this purpose. We have also succeeded in adapting a new marker analysis method known as KASP for screening for target traits. These markers will primarily be targeted toward TILLING-derived traits for which we have DNA sequence information.

TILLING for Novel Trait Development

The objective of this program is to develop and validate novel traits in wheat using advanced, functional genomics-based techniques, such as TILLING or other technologies. TILLING (Targeted Induced Local Lesions In Genomes) has shown promise in wheat for novel trait development using mutation induction rather than transgenics (GM). Therefore, TILLING-derived traits are non-GM and may provide new and beneficial technologies for wheat. Our current trait emphases include drought stress tolerance, herbicide resistance, insect resistance, and human health related traits.

Selected activities, highlights, and accomplishments of our program are as follows:

- In 2012, we sought and received approval to promote Dr. Harish Manmathan to a Special Research Assistant Professor position. Since joining our program in 2010, Harish has done an excellent job in leading this effort, demonstrating a keen capacity to master the challenges specific to wheat and develop novel approaches to meet our objectives.
- We have succeeded in integrating next-generation DNA sequencing with TILLING in a novel technique called "TILLING-by-Sequencing" (TBS). Mutations in all three genomes of eight different genes (24 total mutations) were identified using TBS and are currently being confirmed.
- In 2013, we are conducting research to extend the TBS technology (i.e., DNA sequencing and bioinformatics) to identify native mutations in a variety of candidate genes that may already exist in CSU Wheat Breeding Program germplasm. This procedure, known as "Eco-TILLING", will exploit the genotyping by sequencing (GBS) marker information already being generated for use in genomic selection (GS) in the breeding program.
- Mutations identified in genes related to high amylose (developed by UC-Davis) and drought stress tolerance (developed at CSU) continue to be transferred to elite wheat germplasm for trait validation and potential commercialization. KASP marker technology, together with doubled haploid (DH) breeding technology, will be used to accelerate these efforts.

Russian Wheat Aphid Resistance

The objectives of this program are to incorporate Russian Wheat Aphid (RWA) resistance into breeding program germplasm and ultimately develop improved varieties carrying RWA resistance. Appearance of several virulent RWA biotypes since 2003, combined with lower RWA incidence in recent years and inexpensive chemical control options, has led to RWA resistance occupying a lesser position among our breeding objectives. We continue to address RWA resistance, however,

as uncertainties exist with regard to the future importance of RWA in Colorado and the economics of wheat production and chemical control options. All of our RWA resistance breeding effort is done in close collaboration with Frank Peairs and his team (BSPM Department).

Selected activities, highlights, and accomplishments of our program are as follows:

- In 2012, one experimental line tested in the Advanced Yield Nursery was advanced to the 2013 CSU Elite Trial. This line (CO10091) is a hard red winter wheat with the pedigree Altus-034/Bond CL//TAM 111. CO10091 performed well in the 2012 AYN and a decision to advance this line for further testing will be made after harvest in 2013.
- In 2012, 31 lines in the Preliminary Yield Nursery carried a source of RWA biotype 2 resistance in the pedigree. Based on yield and other evaluations, only four of these lines were advanced to the 2013 Advanced Yield Nursery. Screening of these lines in the insectary showed that only three of these four lines carried RWA biotype 2 resistance.
- In 2012, several headrow populations derived from crosses with various RWA resistance sources were tested in the field at Fort Collins. From these populations, 85 line selections were made and advanced for testing in the 2013 Preliminary Yield Nursery. Screening with RWA biotype 2 in the insectary has identified 69 selections that carry resistance. In 2013, we will carefully evaluate these lines for their potential for advancement.
- In fall 2012 we completed backcrossing of a modified version of the *Dn7* gene into Byrd and Antero and in spring 2013 we will conduct RWA biotype 2 screening on segregating progenies from the last backcross.
- We have completed backcrossing of different RWA biotype 2 resistance sources into a Yuma background to develop materials for future biotype monitoring. We also completed transfer of the modified source of *Dn7* to a Bill Brown background with the objective of characterizing the effect of the modified *Dn7* source on yield and other quality characteristics.

End-Use Quality Improvement

The objectives of this program are to conduct end-use quality evaluations on experimental lines in our breeding program and those collected from the state dryland (UVPT) and irrigated (IVPT) variety trials. We are also engaged in several other research areas that are not focused directly on line selection but are complementary to the quality improvement efforts in the breeding program.

Selected activities, highlights, and accomplishments of our program are as follows:

- Comprehensive milling and baking quality evaluations are done annually at several stages of our breeding program. Our overall strategy in breeding line evaluation is to properly characterize experimental lines in order to properly inform the line selection and seed increase decision-making processes.
- Comprehensive quality evaluations (as described above) are done on selected locations of the state dryland (UVPT) and irrigated (IVPT) variety trial program every year. These evaluations are also used to develop milling and baking quality scores that are reported in the "Variety Characteristics Table" in the *Making Better Decisions* booklet.
- In 2012-2013, we determined NIR protein content from every plot of five locations of the CSU Elite Trial (750 total samples). Our objective is to begin to use "grain protein deviation" (protein content adjusted for grain yield) as a measure of nitrogen use efficiency (NUE).
- In 2012, quality-related research activities included evaluation of near-isogenic line (NIL) selections for different glutenin alleles in a 'Ripper' background and genomic selection model development for end-use quality (including pre-harvest sprouting tolerance). These research projects will form the basis for a PhD dissertation of graduate student Jessica Cooper.

'Antero' (CO07W245) Hard White Winter Wheat

Colorado State University Wheat Breeding Program

General

- Pedigree - KS01HW152-1/TAM 111; cross made 2003
  (KS01HW152-1 = Trego/Betty sib)
- Characteristics

Chaff color	white	Stripe Rust	resistant
Awns	awned	Leaf Rust	susceptible
Plant height	medium	Stem Rust	moderately resistant
Maturity	medium	Powdery mildew	unknown
Coleoptile length	medium	Hessian Fly	heterogeneous
Straw strength	very good	RWA (biotype 1 and 2)	susceptible
Test weight	excellent	WSBMV/WSSMV	moderately resistant
Sprout tolerance	good (~Hatcher)	BYDV, WSMV	moderately susceptible

Field Performance

Antero has been tested in Colorado and Western Kansas in the CSU Elite Trial since 2010. Data from these trials are summarized below; entries are ranked by the three-year dryland average (**bold**).

Entry	2010	2011	2012	2 Year Avg	3 Year Avg	TestWt Avg	NE CO	SE CO	Irrig CO	Western KS
Byrd	62.1	55.8	59.3	57.8	**59.2**	59.6	63.8	51.0	114.4	61.8
Antero	**64.7**	**56.6**	**52.8**	**54.4**	**57.7**	**60.0**	**63.1**	**48.1**	**119.2**	**66.2**
Hatcher	57.4	55.6	50.5	52.7	**54.2**	59.5	58.2	46.9	106.1	65.9
Denali	60.2	52.5	50.3	51.3	**54.1**	60.2	59.3	44.9	113.4	64.6
Ripper	56.5	53.3	52.8	53.0	**54.1**	58.2	58.4	46.4	106.0	55.2
Brawl CL Plus	57.1	51.5	52.8	52.2	**53.8**	60.5	60.0	42.6	104.2	67.3
Bill Brown	59.4	52.3	50.1	51.0	**53.7**	60.0	58.1	45.9	108.2	60.9
TAM 112	56.5	48.9	52.4	50.9	**52.7**	60.0	57.4	44.3	104.1	58.6
Winterhawk	57.2	49.4	50.6	50.1	**52.4**	60.3	58.2	42.0	115.1	66.7
Above	51.7	52.2	51.4	51.7	**51.7**	59.1	57.4	41.5	102.3	57.4
Thunder CL	53.8	50.1	48.8	49.3	**50.8**	58.6	57.1	39.4	107.0	57.1
CO05W111	58.9	48.5	45.7	46.9	**50.8**	59.4	55.4	42.3	111.6	58.5
Snowmass	51.5	52.7	46.4	49.1	**49.9**	59.6	54.4	41.6	105.0	54.5
Average	57.5	52.3	51.1	51.6	**53.5**	59.6	58.5	44.4	109.0	61.1
Locations	9	8	11	19	**28**	28	18	10	5	8

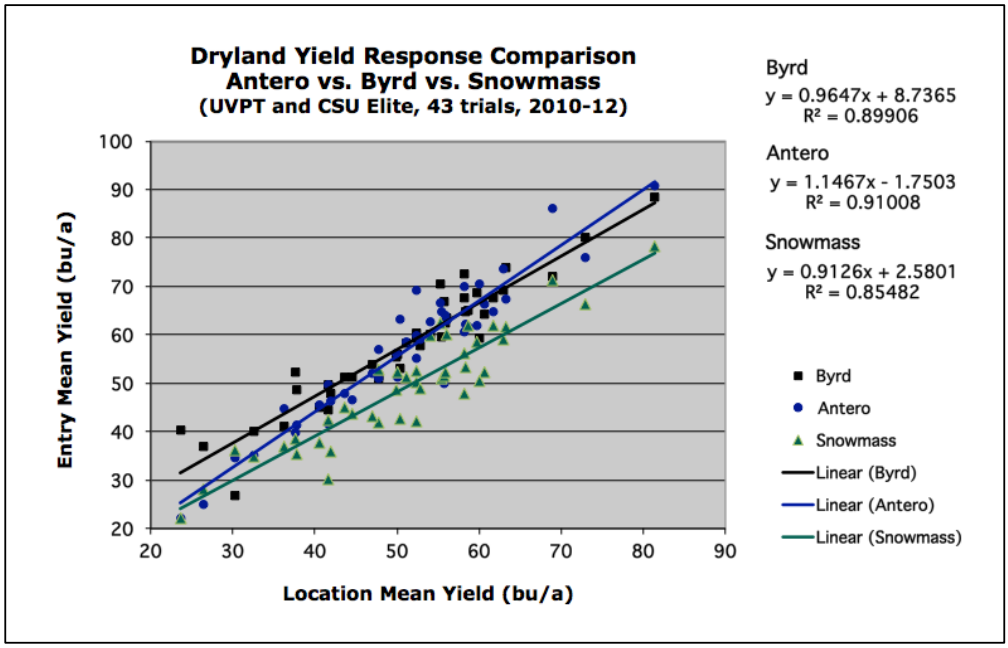
Antero was tested in the Colorado Dryland Uniform Variety Performance Trial (UVPT) in 2011 and 2012. Data from these trials are summarized at right; entries are ranked by the two-year dryland average (**bold**).

Antero was also tested in the Colorado Irrigated Variety Performance Trial (IVPT) in 2012. Antero performed well-above average at both Haxtun and Rocky Ford as well as the limited-irrigation trial at Fort Collins. Data from these trials may be found at:

http://csucrops.com

Entry	2011 Yield	2012 Yield	Average Yield	NE Yield	SE Yield	Average TestWt
Byrd	56.0	54.9	**55.4**	59.2	47.6	60.4
Antero	**54.8**	**54.6**	**54.7**	**59.8**	**44.4**	**60.7**
TAM 112	50.3	51.6	**51.1**	55.6	42.0	61.1
Ripper	50.6	51.0	**50.9**	54.8	43.1	59.2
Denali	52.1	48.9	**50.2**	54.9	40.7	60.9
Hatcher	52.8	48.2	**50.0**	53.4	43.3	60.2
Above	49.7	49.0	**49.3**	53.8	40.3	59.5
Bill Brown	51.0	48.0	**49.2**	53.1	41.4	60.8
SY Wolf	49.2	49.1	**49.2**	55.5	36.6	60.2
Settler CL	50.3	48.4	**49.1**	53.7	40.0	60.0
Brawl CL Plus	45.8	50.9	**48.9**	54.0	38.6	60.8
CO05W111	48.9	48.5	**48.7**	53.0	39.9	60.1
Winterhawk	48.4	48.6	**48.5**	53.2	39.1	60.9
T163	48.2	48.7	**48.5**	52.8	39.9	60.3
Snowmass	50.2	45.8	**47.6**	50.8	41.1	59.8
Robidoux	46.4	47.9	**47.3**	51.4	39.2	60.1
Thunder CL	46.8	46.3	**46.5**	50.9	37.7	59.5
Armour	46.2	46.6	**46.4**	50.9	37.5	59.5
Bond CL	46.5	46.3	**46.4**	50.4	38.2	58.0
McGill	45.5	45.8	**45.7**	50.4	36.2	59.5
Everest	45.3	45.6	**45.5**	50.4	35.7	60.9
Average	49.3	48.8	**49.0**	53.4	40.1	60.1
Locations	6	9	**15**	10	5	15

Regression of entry mean yield for Antero, Byrd, and Snowmass on location mean yield of 43 replicated, dryland trials in Colorado from 2010 to 2012.



Antero was tested in the 2012 Southern Regional Performance Nursery (SRPN). Averaged across 25 trial locations, Antero was the second highest yielding entry in the trial.

End-Use Quality

Antero has been evaluated in comprehensive milling and baking quality tests in the CSU Wheat Quality Laboratory since 2009. Byrd was included in these tests as an excellent quality HRW check and Snowmass and Thunder CL were included as excellent quality hard white wheat (HWW) checks.

Trait (unit of measurement)	Samples	Antero	Byrd	Snowmass	Thunder CL
SKCS kernel weight (mg) †	29	31.0	26.8 *	30.3 ns	28.8 *
SKCS kernel diameter (mm)	29	2.71	2.52 *	2.71 ns	2.63 *
SKCS kernel hardness (score)	29	63.7	67.3 *	77.9 *	68.8 *
Test weight (lb/bu)	16	60.4	59.4 *	59.3 *	58.7 *
NIR wheat ash (%)	29	1.42	1.44 *	1.47 *	1.46 *
Flour extraction (%)	17	69.8	71.4 *	66.5 *	68.5 *
NIR flour ash (%)	25	0.42	0.42 ns	0.46 *	0.41 *
Polyphenol oxidase (L-Dopa)	15	0.53	0.51 ns	0.57 ns	0.52 ns
Grain color (Minolta L*)	15	58.0	56.4 *	58.7 *	60.0 *
Wheat protein content (%)	28	12.3	12.4 ns	12.5 ns	13.0 *
Mixograph mixing time (min)	24	4.4	6.3 *	7.3 *	4.8 *
Mixograph tolerance (score) ‡	16	2.7	5.0 *	5.7 *	4.1 *
Bake mix time (min)	16	4.1	6.2 *	7.7 *	4.6 *
Bake absorption (%)	16	61.5	63.0 *	63.7 *	63.4 *
Loaf volume (cc)	16	850	1054 *	976 *	1009 *
Crumb grain (score) ‡	16	2.9	4.6 *	5.4 *	4.3 *
Milling Rating		Excellent	Excellent	Good	Good
Baking Rating		Good	Excellent	Excellent	Excellent

† Single kernel characterization system (SKCS).

‡ Mixograph tolerance and crumb grain scores: 0=very poor, 6=very good.

* Value significantly different from Antero based on a paired t-test at the 5% probability level; ns=not significant.

Graduate Students of CSU's Wheat Research Programs

Among the most important products of CSU's wheat research programs are the graduate students who receive training and experience here. These are the teachers, researchers, and administrators who will guide wheat improvement and discovery over the next several decades, in public and private sectors, in the U.S. and abroad. Our current batch of grad students is a diverse and well qualified group. Summaries of their research projects are listed below.

Steve Becker, Ph.D. (Pat Byrne advisor): Using synthetic hexaploid wheat to improve drought tolerance of Great Plains cultivars

Drought stress is an increasing concern for many wheat breeding programs and producers in the U.S. Great Plains. The aim of Steve's research is to improve the drought tolerance of adapted cultivars by crossing them with synthetic hexaploid wheat lines. One parent of these synthetic wheats is Aegilops tauschii, a wild wheat; thus, these lines recapture some of the diversity found in the wild and combines it into a form that can be directly crossed with bread wheat. Beneficial drought tolerance traits such as increased deep root growth and extraction of more soil moisture from deeper depths have been found in some synthetic lines. DNA marker analysis of these synthetic lines will identify novel and useful genomic diversity that can be targeted for introgression into adapted cultivars. Locally adapted synthetic-derived germplasm is currently being developed by backcrossing selected synthetic lines to the elite cultivars 'Hatcher' and 'Goodstreak'. Testing these new materials in preliminary yield trials in Colorado and Nebraska has identified increased yield potential in some crosses. After receiving his Ph.D., Steve would like to return to a breeding position in the seed industry.

Craig Beil, M.S. (Phil Westra advisor): Quantifying gene flow from wheat to jointed goatgrass

Craig's research was prompted by the concern that gene transfer from transgenic (or GMO) wheat to jointed goatgrass could have negative environmental effects. Field trials were conducted during two field seasons and supplemented with greenhouse studies to determine fertility and backcrossing rates of wheat x jointed goatgrass first generation backcross (BC1) plants. Pollination by jointed goatgrass led to the production of second generation backcross plants (BC2) in both growing seasons, providing the first direct estimate of a backcrossing rate of BC1 plants pollinated by jointed goatgrass under field conditions. Craig is currently examining the chromosome composition of BC2 plants by using a chromosome visualization technique known as genomic in situ hybridization (GISH). Identification of differences in chromosome retention or translocation of wheat genome sequences into jointed goatgrass may provide insight into the environmental safety of transgenic wheat. Although there are currently no approved transgenic wheat varieties, these may be on the market within 10 years. After completing his M.S., Craig plans to pursue a Ph.D. in plant breeding.

Jessica Cooper, Ph.D. (Scott Haley advisor)

Jessica's project concerns improving end-use quality in wheat. Quality is an important trait for wheat production but is very complex to measure. To improve the efficiency of breeding for quality traits, it is helpful to have genetic markers or tags to tell us that a certain quality gene is present or absent in the plant. Genomic selection will do this on a massive scale, using thousands of genetic markers across the wheat genome. Jessica will use this marker information along with phenotypic data to create predictive models for quality. Wheat lines with good predictive scores based on this model will be advanced or used as parent lines in the development of new varieties. Besides decreasing the time it takes to produce better varieties for the farmer, exploring this genomic data will help us understand gene functions and interactions behind quality traits important in the milling and baking industry. After receiving her Ph.D., Jessica would like to work as a plant breeder in the seed industry.

Hung Dao, Ph.D. (Pat Byrne advisor): Validating end-use quality genes on wheat chromosomes 6B and 7B

Hung Dao is funded by the government of Vietnam to study agricultural biotechnology at CSU. The goal of his dissertation research project is to validate genes for grain protein and other end-use quality traits that were first detected in research by a previous graduate student, Walid El-Feki. The initial research found favorable genes on chromosomes 6B and 7B in a doubled haploid mapping population of the cross Platte x CO940610. Hung's work will attempt to confirm the effects of those genes in recombinant inbred line and backcross populations of the same cross. He will also attempt to identify specific 'candidate genes' in those chromosome regions that might be responsible for the observed effects. If the genes are validated and candidate genes are identified, they may be useful in wheat breeding and for further study of the genes' functions and effects. After completing his degree, Hung will return to Vietnam to work in a university or government ministry.

Erena Edae, Ph.D. (Pat Byrne and Scott Haley, co-advisors): Identifying chromosome regions and genes that contribute to drought tolerance in spring wheat

Erena's dissertation project is focused on identification of chromosome regions and genes that contribute to wheat productivity under drought stress. Erena conducted field studies on 294 diverse spring wheat lines under moisture stress and irrigated conditions at Greeley, CO and at Melkassa, Ethiopia. Through application of statistical procedures that relate DNA markers with field agronomic data, he identified several chromosome regions that affect wheat performance under drought conditions. Erena also examined DNA sequences of five genes hypothesized to contribute to drought tolerance, and compared sequence variations to field performance. He found that specific sequence changes within the selected genes were associated with yield and yield-related traits of wheat. If confirmed in further experiments, these genes and chromosome

regions may be useful in wheat breeding programs to improve productivity under limited soil moisture. Funding for Erena's studies was provided by Monsanto's Beachell-Borlaug International Scholars Program. After graduation, Erena plans to pursue a career in public sector plant breeding research.

Sarah Grogan, Ph.D. (Pat Byrne advisor): Evaluating canopy spectral reflectance as an indicator of drought tolerance

Sarah's project focuses on evaluating drought tolerance in winter wheat. Her research is part of the USDA-funded Triticeae Coordinated Agricultural Project (TCAP), which is characterizing and integrating breeding responses to complex traits like water- and nitrogen-use efficiency that are affected by a changing climate. She is evaluating 300 winter wheat varieties and advanced lines contributed by breeding programs across the Great Plains for drought tolerance traits. This includes measuring canopy spectral reflectance (CSR), a novel approach to evaluating secondary traits based on the amount of light reflected from the canopy at key wavelengths in the near infrared spectrum. CSR has the potential to be used by breeders as a high-throughput evaluation method. She will combine her measurements with DNA marker data contributed by TCAP collaborators to identify genes associated with yield under water stress. After graduation, Sarah would like to find a position that includes teaching, and has completed requirements for a teaching certificate from The Institute for Learning and Teaching at CSU.

Sue Latshaw, Ph.D. (Scott Haley advisor): Improving nitrogen use efficiency of wheat

Sue joined the CSU Wheat Breeding Program to explore the genetics of nitrogen use efficiency (NUE) among CSU breeding lines. Plant processes that contribute to NUE are broadly divided into three component traits: nitrogen uptake from the soil, its assimilation into the crop canopy, and its utilization for producing yield. Her research objective is to assess the variation for NUE and these component traits in a set of 399 CSU breeding lines, to find rapid and accurate ways to measure these traits during the growing season, and to develop predictions for breeding values for NUE from DNA sequences of the breeding lines. These methods could be applied in the breeding program so that new varieties with improved NUE, higher yields, and high grain protein would be introduced on an accelerated schedule. Her professional goal is to work as a plant breeder in academia or the seed industry.

Wahid Mahmoud Awad, Ph.D. (Pat Byrne advisor): Determining root traits that improve wheat's ability to tolerate drought stress

Wahid's dissertation research is part of the multi-state Triticeae Coordinated Agricultural Project, known as TCAP. Among the goals of this project is to combine trait data with DNA marker data to discover genes that improve yield under drought stress conditions. Wahid is investigating a hard winter wheat association mapping population of 300 Great Plains cultivars and advanced lines. The population will be evaluated in multiple environments differing in soil moisture, and the relationship among root architecture, water use efficiency, and yield will be determined. Wahid has also been growing wheat plants in 1-meter long plastic tubes in the greenhouse to quantify differences in root length, diameter, and biomass in drought-stressed plants. After identifying chromosome regions associated with root traits, Wahid will investigate candidate genes in those regions that may be responsible for the traits. After receiving his degree, Wahid will return to a faculty position at the University of Cairo, Egypt.

Wheat Quality Evaluations from the 2012 CSU Dryland & Irrigated Variety Trials

John Stromberger, Scott Haley, and Jerry Johnson
Department of Soil & Crop Sciences

Introduction

End-use quality maintenance and improvement is an important objective of virtually all wheat breeding programs. Grain buying and end-use industries have become increasingly sophisticated in both domestic and export markets and, while wheat producers are seldom rewarded for improved functional quality, technological advancements promise to increase the ability of the trade to identify and source good quality and thus discount poor quality.

Breeding for improved quality is very challenging. Quality is a function of variety interacting with climate and agronomic practices. Colorado climatic conditions are highly variable and unpredictable which slows down breeding progress. Also, quality is measured by many traits and many genes are involved, further complicating breeding. Most experimental quality tests only approximate average quality needs of product manufacturers and don't match specific requirements of different wheat product types and processes. For hard winter wheat, high grain protein content is an important criterion for improved quality but is often associated with lower yields (and vice versa). Finally, wheat quality testing must accommodate the reality of large sample numbers and small sample sizes that are typical of all wheat breeding programs. Despite these challenges, standard testing methodologies have been developed that are consistent, repeatable, and can be done in our laboratory on large numbers of small samples. These analyses provide reliable assessments of functional quality characteristics for a broad array of potential product types and processes.

Our objective with providing quality data and summaries for entries in the Colorado variety trials is to fully characterize the quality of public and private trial entries that are currently or have the potential to be marketed in Colorado. We hope that these data and ratings will be included among the criteria by which wheat producers make their variety selection decisions. At the very least, we encourage producers to carefully consider avoiding varieties that have lower wheat quality when other agronomically acceptable varieties with better quality are available.

Testing Methodology

In 2012, grain samples were collected from four dryland (UVPT) variety trial locations (Akron, Lamrar, Orchard, Yuma) and two irrigated (IVPT) variety trial locations (Fort Collins, Rocky Ford). Preliminary small-scale quality analyses were carried out to determine suitability of the samples for full-scale analyses. Criteria for sample suitability included grain protein values not too far below or above 12% grain protein content, sound grain free of visual defects, and good discrimination among samples at a location for experimental dough mixing properties. In this process of sample selection, two of the dryland locations (Akron, Yuma) and one of the irrigated locations (Fort Collins) were excluded from further analyses beyond protein content.

Using standard testing protocols, quality tests were done in the CSU Wheat Quality Laboratory on variety trial samples from the remaining locations. These tests, reported in the attached tables, include the following:

Milling-Related Traits

- Test weight: obtained by standard methodology on a cleaned sample of the harvested grain.
- Grain protein and ash content: obtained by prediction using whole-grain near-infrared reflectance spectroscopy (NIRs) with a Foss NIRSystems 6500. Both grain protein and ash are reported on a standard 12% moisture basis. High grain protein percentage is associated

with higher water absorption of flours and higher loaf volumes in the bakery. Grain ash represents the remaining weight of a grain sample following incineration in a high-temperature oven. Millers prefer low wheat ash (values < 1.6%) as this tends to result in low-ash flour following milling and products with improved color properties.

- Single kernel characterization system (SKCS): the Perten SKCS 4100 provides data on kernel weight and hardness of a grain sample. From 100-300 kernels are analyzed to provide an average and a measure of variability (standard deviation, STD) for each trait. Millers prefer a uniform sample with heavier (>30 grams/1000 kernels) kernels for improved milling performance. Hardness should be representative of the hard winter wheat class (60-80 hardness units).
- Flour yield: obtained using a modified Brabender Quadrumat Milling System. Flour yield represents the percentage of straight grade flour obtained from milling a grain sample (approximately one pound). In general, millers prefer high flour extraction percentage with low flour ash values. Due to variation among different milling systems, valid comparison of values from different mills and establishment of a single target value is not possible.

Baking-Related Traits

- Mixograph mixing time and tolerance: obtained using a National Manufacturing Computerized Mixograph. The Mixograph measures the resistance of a dough during the mixing process. Bakers generally prefer flours with moderate mixing time requirements (between 3 and 6 minutes) and good tolerance to breakdown of the dough with overmixing (subjective score >3). Some varieties with exceptionally long mixing times (i.e., Snowmass, Thunder CL) may not compare favorably with other varieties in conventional evaluations but have unique characteristics that merit handling in an identity-preserved program such as with the CWRF ConAgra Mills Ultragrain® Premium Program.
- Pup loaf bake test: using a 100-gram straight-dough test, data on bake water absorption, mixing time, loaf volume, and crumb characteristics are obtained. In general, bakers prefer higher water absorption (> 62%), high loaf volume (> 850 cubic centimeters), and a higher crumb grain score and crumb grain color (score > 3). The crumb grain and color scores are subjective assessments of the color and size, shape, and structure of the small holes in a slice of bread.

Composite Scores

Because none of the traits measured can be used alone to represent overall milling or baking quality, development of a composite score may be used as a means to differentiate and characterize quality of different samples. The development of a composite score also has the advantage of "smoothing" out differences in environmental conditions from year to year and utilizing all of the data generated on the samples from year to year.

Composite scores are generated through a two-step process. First, each trait is ranked from high to low (or "good" to "bad") at individual locations and a score from 1=good to 9=bad is assigned to each variety for each trait. Second, these individual-trait scores are used to generate a composite score that weights the trait scores by the relative importance of that trait to overall milling or baking quality. The weights that we have used are similar to those developed by the USDA-ARS Hard Winter Wheat Quality Laboratory for the Wheat Quality Council evaluations. These weights are as follows:

Milling – test weight 30%, grain protein content 10%, kernel weight 20%, grain hardness 10%, flour yield 20%, grain ash content 10% (100% total)

Baking – bake absorption 20%, Mixograph mixing time 20%, Mixograph tolerance 20%, loaf volume 20%, crumb color 10%, crumb grain 10% (100% total)

Wheat Milling and Baking Quality Data - 2012 Lamar

* Value in **bold** indicates superior value, value in *italics* indicates inferior value.

Entry	Test Weight	Grain Protein	SKCS Weight	SKCS Hardness	Flour Yield	Grain Ash	Bake Absorption	Mixograph Mix Time	Mixograph Tolerance	Loaf Volume	Crumb Color	Crumb Grain	**Milling Score**	**Baking Score**
1863	59.1	**12.6**	22.9	*81.0*	66.9	**1.35**	61.3	**4.14**	3	770	3	3	**3**	**3**
Above	58.2	**13.3**	24.4	*81.5*	67.1	*1.63*	**64.2**	3.11	3	770	4	3	**3**	**3**
Antero	59.2	11.6	24.8	80.0	66.6	1.56	*58.4*	6.04	3	*725*	4	*2*	4	*7*
Armour	**60.1**	*10.9*	25.3	*81.1*	67.8	**1.47**	*58.5*	5.83	3	820	4	4	**2**	5
Bill Brown	59.9	11.6	22.6	*91.3*	*64.6*	1.60	59.3	**4.47**	4	*720*	3	*2*	6	4
Bond CL	*57.4*	12.5	*20.6*	79.6	*64.4*	1.61	**63.2**	3.70	4	835	4	3	*8*	**1**
Brawl CL Plus	**60.4**	**12.7**	25.0	*83.9*	**68.8**	*1.62*	**62.5**	**4.11**	4	**915**	4	4	**1**	**1**
Byrd	58.7	*10.8*	*21.0*	*84.1*	67.1	1.56	*57.3*	*7.61*	**5**	830	4	4	5	6
Clara CL	**60.2**	**13.4**	23.2	*86.7*	66.5	*1.62*	61.5	3.71	3	850	4	4	**3**	**3**
CO050233-2	*57.2*	12.5	23.0	*81.1*	65.9	*1.63*	**62.3**	*2.49*	3	745	3	*2*	6	6
CO05W111	58.8	12.0	22.3	*80.8*	*65.1*	**1.43**	61.4	3.57	4	780	3	3	4	4
CO07W722-	*57.5*	11.7	23.0	*93.1*	*64.6*	1.53	59.2	5.95	4	*700*	4	3	*8*	5
CO08263	59.5	*10.5*	*21.1*	*81.3*	67.7	1.51	*57.2*	**5.26**	4	735	*2*	4	5	5
CO08346	**60.4**	12.2	*21.9*	*86.2*	65.6	1.56	61.3	**4.13**	4	835	4	4	4	**2**
CO08W218	60.1	**12.6**	23.3	*88.8*	66.5	**1.45**	**62.3**	**3.97**	4	830	**5**	4	**3**	**2**
CSU Blend12	59.2	12.1	22.8	79.0	67.0	1.54	61.1	**4.98**	4	**875**	4	4	4	**1**
Denali	59.5	11.6	24.7	79.6	66.7	1.59	**62.2**	**4.16**	4	740	3	3	4	**3**
Everest	**60.4**	11.7	23.1	*87.9*	67.6	*1.63*	60.5	**3.91**	4	735	3	3	4	4
Hatcher	58.9	12.3	24.8	*81.4*	66.1	1.52	60.4	**4.59**	4	775	4	3	4	**2**
Judee	57.8	**13.2**	24.7	78.4	67.2	1.58	**63.2**	**5.11**	4	**945**	4	4	**3**	**1**
McGill	57.7	11.9	24.9	74.8	67.5	1.57	60.3	**4.56**	4	780	4	3	4	**2**
NE05496	*57.1*	11.7	22.9	77.8	66.7	1.54	60.2	5.38	**5**	**890**	**5**	**5**	6	**1**
NE05548	*55.7*	**14.7**	23.6	74.8	**68.3**	*1.65*	**65.1**	**4.20**	4	**910**	3	*2*	6	**1**
OK05312	**60.7**	**12.6**	23.6	*87.5*	**68.6**	1.54	61.5	3.18	3	*720*	4	3	**1**	5
Protection	*56.4*	**12.6**	23.1	*84.6*	**68.5**	1.51	61.4	**4.11**	3	755	*2*	3	5	4
Ripper	58.1	11.3	**27.4**	78.0	66.5	1.51	59.5	**3.93**	3	780	3	3	4	4
Robidoux	58.9	11.6	23.4	79.8	66.7	**1.47**	59.3	**5.24**	4	795	**5**	3	4	**3**
Settler CL	58.7	**12.6**	24.5	78.2	67.8	*1.71*	61.4	**4.39**	4	**875**	**5**	4	4	**1**
Snowmass	57.7	11.7	22.8	*87.7*	*63.0*	1.58	60.1	*8.00*	**6**	800	4	**5**	*7*	4
SY Exp. 1029	58.8	12.3	23.3	*81.5*	66.0	*1.64*	**62.3**	**3.96**	4	**910**	3	4	4	**1**
SY Wolf	59.5	*11.0*	24.5	78.7	**68.0**	1.51	*57.7*	**4.71**	*2*	745	4	3	**3**	5
T158	59.1	*10.8*	**26.3**	77.3	**68.4**	1.54	*57.4*	**4.80**	*2*	775	4	*2*	**3**	5
T163	59.5	11.2	**26.5**	74.9	**69.2**	1.48	*58.4*	**4.45**	3	840	**5**	4	**3**	**3**
TAM 111	59.3	*11.0*	**26.5**	*80.2*	66.5	1.57	59.7	**3.94**	3	755	4	3	4	4
TAM 112	**60.3**	*10.5*	**26.3**	*89.0*	*62.9*	*1.66*	60.5	**4.40**	4	*685*	4	3	5	4
TAM 113	**60.7**	*10.3*	25.0	*82.3*	67.1	1.50	*56.3*	**4.09**	4	*720*	4	4	**1**	5
TAM 304	58.4	*10.4*	23.7	*89.3*	66.0	**1.45**	*58.4*	*6.40*	4	780	4	4	5	5
Thunder CL	57.7	*11.0*	*21.8*	*86.1*	*64.6*	**1.48**	*58.4*	**5.29**	**5**	805	4	3	*7*	**3**
Winterhawk	59.0	*11.0*	25.4	*81.7*	**69.0**	1.52	*58.6*	**4.40**	4	760	**5**	4	**2**	**3**
Average	58.9	11.8	23.8	82.3	66.7	1.55	60.4	4.62	3.7	795	3.8	3.4		
Minimum	55.7	10.3	20.6	74.8	62.9	1.35	56.3	2.49	2	685	2	2		
Maximum	60.7	14.7	27.4	93.1	69.2	1.71	65.1	8.00	6	945	5	5		

Wheat Milling and Baking Quality Data - 2012 Orchard

* Value in **bold** indicates superior value, value in *italics* indicates inferior value.

Entry	Test Weight	Grain Protein	SKCS Weight	SKCS Hardness	Flour Yield	Grain Ash	Bake Absorption	Mixograph Mix Time	Mixograph Tolerance	Loaf Volume	Crumb Color	Crumb Grain	**Milling Score**	**Baking Score**
1863	**61.5**	11.1	26.3	*83.1*	68.8	**1.34**	**59.5**	2.87	3	750	3	3	**3**	4
Above	*58.4*	10.9	27.1	*84.8*	68.5	*1.50*	**59.4**	2.85	3	*675*	3	*2*	*7*	5
Antero	60.9	10.8	**30.3**	74.8	69.5	1.44	56.8	**4.25**	*2*	695	4	3	4	4
Armour	60.4	*9.4*	27.3	74.6	69.6	1.39	*55.4*	**4.57**	3	*675*	3	3	5	6
Bill Brown	60.5	**11.8**	25.9	*90.5*	70.0	1.46	**60.2**	**4.75**	4	830	4	3	5	**1**
Bond CL	59.0	*9.7*	*25.5*	76.0	*67.4*	1.41	*56.4*	3.20	4	700	4	3	*7*	5
Brawl CL Plus	**61.7**	10.3	29.1	*81.4*	**70.4**	1.40	58.6	**3.58**	4	**855**	**5**	**5**	**1**	**1**
Byrd	60.3	**12.1**	27.3	78.7	**72.0**	1.40	**60.5**	5.05	**5**	**950**	**5**	4	**2**	**1**
Clara CL	61.3	10.6	28.3	*85.4*	*68.1*	1.46	*56.5*	**3.65**	3	745	4	3	4	4
CO050233-2	*58.0*	**11.4**	27.1	*80.9*	68.9	*1.50*	58.5	*2.40*	3	725	4	*2*	5	5
CO05W111	60.1	10.2	*25.5*	79.5	*67.7*	**1.34**	57.5	**4.26**	4	815	3	3	5	**2**
CO07W722-	59.8	*9.8*	**30.0**	*87.3*	*67.3*	1.39	57.7	**4.65**	4	*640*	4	4	5	4
CO08263	60.1	10.2	*23.9*	*84.1*	70.0	1.41	57.5	**4.67**	4	755	4	3	5	**3**
CO08346	61.0	**12.3**	*25.8*	79.4	*68.0*	1.40	**60.6**	**4.40**	3	**960**	**5**	4	4	**1**
CO08W218	60.7	**12.0**	**30.0**	78.9	70.3	**1.34**	**60.5**	**4.64**	4	**865**	4	4	**2**	**1**
CSU Blend12	60.2	**11.4**	26.8	78.8	**71.2**	1.40	**59.3**	*6.16*	4	**900**	**5**	**5**	**3**	**2**
Denali	60.9	10.2	29.0	73.5	69.0	1.44	*56.6*	**3.76**	*2*	730	3	3	4	5
Everest	60.7	11.0	26.4	*81.9*	69.6	*1.49*	**59.7**	**3.67**	3	755	4	3	4	**2**
Hatcher	60.3	10.4	29.1	73.3	70.3	1.35	58.1	5.24	3	810	**5**	3	4	4
Judee	60.0	10.9	26.4	*84.3*	68.2	1.38	57.4	5.11	*2*	830	4	4	5	4
McGill	60.0	9.9	28.2	78.7	68.8	1.42	*56.5*	**3.89**	*2*	*680*	3	3	5	5
NE05496	59.4	10.5	26.5	*80.4*	68.7	1.36	58.4	5.21	3	785	4	4	5	4
NE05548	*58.7*	10.9	27.2	78.2	**71.1**	*1.49*	57.4	4.91	*2*	790	4	3	4	4
OK05312	60.8	10.1	27.0	*82.1*	70.1	1.35	*56.5*	**3.54**	*2*	695	4	*2*	**3**	5
Protection	*58.1*	10.5	27.4	*81.0*	**71.4**	1.43	*56.5*	3.15	*2*	*625*	3	*2*	4	*7*
Ripper	59.1	10.8	**29.6**	80.0	**71.2**	1.42	**59.4**	**3.48**	4	800	4	4	**2**	**1**
Robidoux	60.9	10.2	27.2	79.2	69.2	1.40	57.6	**3.84**	4	750	**5**	4	4	**2**
Settler CL	60.4	10.1	27.4	*81.2*	69.9	*1.51*	*56.6*	**4.77**	4	725	3	*2*	4	5
Snowmass	*58.8*	**12.7**	27.5	*88.0*	*67.9*	1.48	**62.4**	*8.00*	**6**	**920**	**5**	**5**	6	**1**
SY Exp. 1029	61.2	10.3	27.7	*80.8*	69.3	1.44	57.4	3.12	3	770	4	4	**3**	4
SY Wolf	**61.5**	*9.7*	29.0	79.2	68.7	1.45	*55.5*	**4.20**	*2*	*675*	*2*	3	**3**	6
T158	60.6	9.9	29.2	*81.0*	69.9	1.40	*56.6*	2.99	*2*	725	4	4	**3**	6
T163	61.0	10.8	**29.5**	78.2	70.0	1.39	57.5	**3.57**	3	**845**	**5**	**5**	**2**	**2**
TAM 111	60.4	9.9	28.3	*80.5*	68.3	1.40	*55.4*	**3.40**	*2*	*645*	4	3	4	6
TAM 112	60.9	9.9	28.1	*89.5*	*66.4*	1.46	58.6	**3.66**	4	735	4	4	*7*	**2**
TAM 113	**61.8**	*9.4*	28.3	75.8	68.6	1.41	*55.4*	5.47	3	750	4	4	4	6
TAM 304	59.9	10.2	*25.7*	*91.4*	*66.8*	1.39	57.4	3.25	4	800	4	4	*7*	**3**
Thunder CL	59.7	10.1	26.0	*82.6*	69.3	**1.32**	57.7	**4.84**	3	815	**5**	4	4	**3**
Winterhawk	60.1	*9.3*	29.1	73.4	68.7	1.36	*55.5*	*0.79*	3	*620*	3	3	5	*9*
Average	60.2	10.6	27.6	80.8	69.2	1.41	57.8	4.10	3.2	764	3.9	3.4		
Minimum	58.0	9.3	23.9	73.3	66.4	1.32	55.4	0.79	2	620	2	2		
Maximum	61.8	12.7	30.3	91.4	72.0	1.51	62.4	8.00	6	960	5	5		

Wheat Milling and Baking Quality Data - 2012 Rocky Ford

* Value in **bold** indicates superior value, value in *italics* indicates inferior value.

Entry	Test Weight	Grain Protein	SKCS Weight	SKCS Hardness	Flour Yield	Grain Ash	Bake Absorption	Mixograph Mix Time	Mixograph Tolerance	Loaf Volume	Crumb Color	Crumb Grain	**Milling Score**	**Baking Score**
Antero	60.8	*8.7*	33.3	63.1	70.7	1.38	*54.3*	*1.40*	3	*600*	3	3	5	*8*
Armour	61.7	**11.6**	34.1	77.0	**71.8**	1.39	56.3	**3.15**	*1*	810	4	4	**2**	**3**
Billings	**62.5**	10.8	**38.1**	73.8	69.6	1.46	55.5	2.65	*2*	*655*	**5**	3	**1**	5
Bond CL	60.0	10.1	30.8	69.4	69.3	1.40	55.5	**3.23**	*2*	725	**5**	3	5	4
Brawl CL Plus	61.2	**12.1**	*30.7*	*84.7*	71.4	1.50	**59.2**	**3.45**	3	**990**	4	4	5	**1**
Byrd	*59.2*	*9.5*	32.0	*58.8*	**73.5**	1.42	55.3	4.41	4	**835**	4	4	6	**3**
Clara CL	60.4	**11.1**	*29.9*	*81.0*	*69.2*	*1.52*	56.3	4.48	*2*	**820**	4	4	*7*	**3**
CO050233-2	59.6	10.2	32.2	68.6	70.1	*1.59*	55.6	2.80	*2*	725	4	3	5	5
CO05W111	60.1	9.7	*27.5*	75.4	70.1	1.38	56.3	**4.15**	4	735	4	3	6	**3**
CO07W722-	61.7	10.9	31.2	*81.0*	69.4	**1.34**	**57.3**	4.83	3	695	4	3	4	4
CO08263	61.7	9.8	*27.5*	74.5	**72.1**	1.40	*54.2*	**3.31**	*2*	*625*	3	3	4	6
CO08346	61.9	10.0	32.3	74.4	69.4	*1.54*	56.4	**3.92**	*2*	**815**	**5**	4	4	**2**
CO08W218	61.1	*9.5*	**37.7**	65.4	69.7	**1.36**	56.4	4.79	3	715	4	3	**3**	4
Denali	61.1	10.6	32.3	66.2	71.5	1.45	*54.3*	**3.51**	*2*	*670*	4	3	4	5
Hatcher	60.1	10.0	34.3	64.2	69.5	1.39	55.2	2.47	3	710	4	3	5	5
McGill	60.2	9.8	*29.3*	75.6	70.3	1.46	55.4	**3.85**	*2*	725	4	3	6	4
Ripper	60.3	10.6	31.8	75.9	70.9	**1.33**	56.6	**3.05**	3	775	4	4	**3**	**3**
Robidoux	60.9	*9.5*	32.1	63.5	70.4	1.45	*54.4*	5.04	*2*	*650*	4	3	5	*7*
Settler CL	60.3	10.3	**35.1**	63.7	71.3	1.50	56.5	4.68	3	810	4	4	4	**3**
SY Gold	60.1	10.4	32.4	71.0	69.6	1.50	55.4	**3.13**	*2*	*600*	4	3	4	6
SY Wolf	60.7	11.0	*29.0*	*83.8*	69.4	*1.57*	56.3	**3.98**	*2*	**820**	3	3	*7*	**3**
T158	60.1	9.9	34.3	65.3	**71.7**	1.47	*54.6*	**3.06**	*2*	740	4	4	**3**	5
T163	60.1	**11.2**	33.7	68.7	70.4	1.42	**57.5**	**4.05**	3	**890**	**5**	**5**	**3**	**1**
TAM 112	62.0	10.4	**36.5**	74.3	69.5	*1.57*	**57.6**	**3.60**	4	765	**5**	**5**	**3**	**1**
TAM 113	61.5	10.4	**34.7**	64.7	70.8	*1.52*	55.2	**3.55**	*1*	755	4	4	4	4
TAM 304	60.6	9.9	31.4	74.4	69.3	1.38	56.3	**3.92**	3	695	**5**	4	5	**3**
Thunder CL	61.2	10.2	32.5	74.9	**72.1**	1.43	56.7	**3.94**	4	**840**	**5**	**5**	**3**	**1**
WB-Cedar	61.6	**11.3**	**37.3**	67.3	70.1	1.47	**58.6**	**3.25**	*2*	720	4	3	**2**	**2**
Yuma	60.7	9.7	31.5	75.7	*69.2*	**1.36**	55.4	2.72	3	*670*	**5**	4	5	5
Average	60.8	10.3	32.6	71.6	70.4	1.45	56.0	3.60	2.6	744	4.2	3.6		
Minimum	59.2	8.7	27.5	58.8	69.2	1.33	54.2	1.40	1	600	3	3		
Maximum	62.5	12.1	38.1	84.7	73.5	1.59	59.2	5.04	4	990	5	5		

Grain Protein Content and Grain Yield at Four UVPT Locations, 2012

	Grain Protein						Grain Yield					
Entry	**Akron**	**Lamar**	**Orchard**	**Yuma**	**Average**	**Rank**	**Akron**	**Lamar**	**Orchard**	**Yuma**	**Average**	**Rank**
1863	16.0	12.6	11.1	16.0	14.0	6	48.3	39.9	49.5	65.5	50.8	24
Above	14.8	13.3	10.9	15.8	13.7	8	54.5	45.8	47.0	62.7	52.5	17
Antero	15.6	11.6	10.8	16.0	13.5	17	58.6	48.0	56.1	66.4	57.3	3
Armour	16.1	10.9	9.4	16.0	13.1	30	47.9	43.4	42.4	63.1	49.2	35
Bill Brown	15.4	11.6	11.8	15.0	13.4	19	52.3	43.5	44.9	59.8	50.1	28
Bond CL	15.5	12.5	9.7	15.3	13.3	23	49.7	41.4	49.2	54.2	48.6	36
Brawl CL Plus	16.2	12.7	10.3	15.0	13.6	16	57.1	41.7	52.3	63.6	53.7	9
Byrd	15.1	10.8	12.1	14.6	13.2	28	58.2	51.2	55.4	64.3	57.3	2
Clara CL	15.8	13.4	10.6	15.9	13.9	7	44.3	41.8	46.5	56.6	47.3	39
CO050233-2	15.6	12.5	11.4	14.9	13.6	11	52.8	42.2	54.3	62.4	52.9	16
CO05W111	16.1	12.0	10.2	14.2	13.1	29	52.6	40.6	50.8	59.6	50.9	22
CO07W722-F5	15.0	11.7	9.8	14.8	12.8	37	58.0	51.6	55.1	65.2	57.5	1
CO08263	15.3	10.5	10.2	16.4	13.1	31	49.8	50.6	51.7	60.4	53.1	15
CO08346	15.1	12.2	12.3	16.3	14.0	4	48.7	44.8	49.5	57.3	50.1	29
CO08M011	15.1	12.6	12.4	14.2	13.6	12	45.3	40.3	46.7	54.7	46.8	41
CO08W218	14.8	12.6	12.0	13.0	13.1	32	53.2	43.9	46.9	68.6	53.2	14
CO08W328	16.2	12.1	11.9	13.0	13.3	20	49.0	42.7	50.3	64.4	51.6	19
CO08W454	15.9	13.6	11.3	13.5	13.6	13	50.3	42.1	52.2	56.0	50.2	27
CSU Blend12	14.0	12.1	11.4	13.8	12.8	39	50.6	43.7	51.4	57.8	50.9	23
Denali	15.4	11.6	10.2	14.1	12.8	38	51.5	40.4	56.4	66.9	53.8	8
Everest	15.9	11.7	11.0	15.8	13.6	15	48.0	44.9	45.6	60.3	49.7	31
Hatcher	14.1	12.3	10.4	13.5	12.6	42	49.4	45.2	45.4	58.4	49.6	33
Judee	17.1	13.2	10.9	16.0	14.3	2	34.7	31.7	43.3	45.3	38.8	42
McGill	16.0	11.9	9.9	16.0	13.5	18	50.3	40.2	50.0	58.6	49.8	30
NE05496	15.0	11.7	10.5	15.9	13.3	21	50.4	41.4	44.3	55.0	47.8	38
NE05548	17.1	14.7	10.9	17.2	15.0	1	48.4	36.2	46.1	57.2	47.0	40
OK05312	14.9	12.6	10.1	14.7	13.1	33	45.7	39.8	49.6	57.6	48.2	37
Protection	15.5	12.6	10.5	16.1	13.7	9	54.7	44.9	46.8	66.4	53.2	13
Ripper	14.9	11.3	10.8	14.4	12.8	36	51.3	53.2	50.1	62.9	54.4	7
Robidoux	15.1	11.6	10.2	16.0	13.2	27	51.9	44.9	51.7	65.2	53.4	12
Settler CL	15.6	12.6	10.1	16.1	13.6	10	51.7	41.2	53.5	57.8	51.1	21
Snowmass	15.8	11.7	12.7	15.7	14.0	5	51.2	45.1	48.6	52.4	49.3	34
SY Exp. 1029	17.1	12.3	10.3	16.2	14.0	3	52.8	46.5	55.2	63.0	54.4	6
SY Wolf	16.2	11.0	9.7	16.0	13.3	24	50.4	37.4	52.8	60.4	50.3	26
T158	15.0	10.8	9.9	17.2	13.2	25	52.2	47.2	51.4	63.1	53.5	11
T163	14.7	11.2	10.8	16.2	13.2	26	50.9	43.5	48.6	59.1	50.5	25
TAM 111	16.5	11.0	9.9	16.9	13.6	14	52.3	40.6	52.0	61.0	51.5	20
TAM 112	16.2	10.5	9.9	15.2	13.0	35	56.9	48.3	50.6	65.6	55.4	4
TAM 113	15.4	10.3	9.4	16.1	12.8	40	56.6	47.9	50.9	64.8	55.1	5
TAM 304	15.6	10.4	10.2	16.9	13.3	22	52.1	45.6	51.3	59.3	52.1	18
Thunder CL	14.7	11.0	10.1	14.8	12.6	41	50.6	41.4	45.9	60.8	49.7	32
Winterhawk	15.4	11.0	9.3	16.1	13.0	34	53.9	46.1	51.2	63.5	53.7	10
Average	15.5	11.9	10.6	15.4	13.4		51.2	43.6	49.8	60.6	51.3	
Maximum	17.1	14.7	12.7	17.2	15.0		58.6	53.2	56.4	68.6	57.5	
Minimum	14.0	10.3	9.3	13.0	12.6		34.7	31.7	42.4	45.3	38.8	

Correlation Between Average Grain Protein and Average Grain Yield

2012 -0.44 Conclusion - grain protein and grain yield are negatively correlated (but not as strong as in 2011)

2011 -0.68 Conclusion - grain protein and grain yield are negatively correlated

Grain Protein Content and Grain Yield at Two IVPT Locations, 2012

	Grain Protein				Grain Yield			
ID	Fort Collins	Rocky Ford	Average	Rank	Fort Collins	Rocky Ford	Average	Rank
Antero	14.0	8.7	11.4	32	66.5	124.0	95.3	4
Armour	15.7	11.6	13.7	1	56.2	116.3	86.3	20
Billings	15.1	10.8	12.9	7	61.1	119.7	90.4	14
Bond CL	13.6	10.1	11.9	28	60.2	121.4	90.8	10
Brawl CL Plus	15.0	12.1	13.5	2	66.6	109.4	88.0	17
Byrd	14.5	9.5	12.0	24	73.3	117.9	95.6	3
Clara CL	15.5	11.1	13.3	4	54.2	121.8	88.0	18
CO050233-2	14.5	10.2	12.3	19	67.9	125.0	96.5	1
CO05W111	14.8	9.7	12.2	20	60.2	127.7	94.0	5
CO07W722-F5	14.8	10.9	12.8	8	63.9	115.0	89.5	15
CO08263	14.5	9.8	12.2	21	62.7	122.9	92.8	8
CO08346	14.7	10.0	12.4	18	61.7	104.2	83.0	25
CO08M011	14.4	10.6	12.5	15	57.3	130.5	93.9	6
CO08W218	14.3	9.5	11.9	26	64.3	106.4	85.4	22
CO08W328	15.6	10.7	13.2	6	61.1	102.8	82.0	26
CO08W454	14.0	9.5	11.8	30	69.2	123.6	96.4	2
Denali	14.5	10.6	12.5	12	60.8	111.3	86.1	21
Hatcher	14.1	10.0	12.1	22	55.5	113.4	84.5	23
McGill	15.1	9.8	12.4	16	51.8	105.0	78.4	31
Ripper	14.5	10.6	12.6	11	63.4	117.5	90.5	13
Robidoux	14.5	9.5	12.0	25	66.1	120.9	93.5	7
Settler CL	14.5	10.3	12.4	17	60.5	120.8	90.7	12
SY Gold	15.0	10.4	12.7	9	67.3	91.2	79.3	30
SY Wolf	15.9	11.0	13.4	3	61.8	100.0	80.9	28
T158	13.7	9.9	11.8	29	64.8	112.9	88.9	16
T163	13.9	11.2	12.5	13	58.1	101.9	80.0	29
TAM 112	15.0	10.4	12.7	10	68.9	115.3	92.1	9
TAM 113	14.6	10.4	12.5	14	62.2	110.8	86.5	19
TAM 304	13.9	9.9	11.9	27	68.8	112.6	90.7	11
Thunder CL	13.9	10.2	12.1	23	58.0	109.1	83.6	24
WB-Cedar	15.2	11.3	13.2	5	49.6	113.2	81.4	27
Yuma	13.6	9.7	11.6	31	56.4	100.4	78.4	32
Average	14.6	10.3	12.5		61.9	113.9	87.9	
Maximum	15.9	12.1	13.7		73.3	130.5	96.5	
Minimum	13.6	8.7	11.4		49.6	91.2	78.4	

Correlation Between Average Grain Protein and Average Grain Yield

2012 -0.33 Conclusion - grain protein and grain yield are negatively correlated

Farmers Have a New Tool to Fight Feral Rye

Brawl CL Plus Takes Clearfield® Weed Control to the Next Level

Glenda Mostek

Since the introduction of the Clearfield® system, wheat farmers have turned to Beyond® herbicide to control problematic grassy weeds in their fields and now PlainsGold is excited to offer a new two-gene Clearfield winter wheat – Brawl CL Plus. This new PlainsGold variety combines yields comparable with Hatcher with improved weed control when used with Beyond herbicide.

Brawl CL Plus is a two-gene Clearfield variety, that provides a greater degree of tolerance to Beyond herbicide, compared to single-gene varieties. This improves the effectiveness of broad-spectrum weed control, including problematic winter annual grassy weeds. Brawl CL Plus is the first publicly-developed two-gene Clearfield winter wheat that permits the use of methylated seed oil (MSO) in the tank mix with Beyond herbicide to increase the effectiveness of the herbicide, particularly on feral rye, which is tougher to control once it starts to tiller and develop.

Brawl CL Plus, developed by Colorado State University (CSU), will be available from PlainsGold seed growers in Colorado, Wyoming, Nebraska, Kansas, and Montana for planting this fall.

Wheat contains three different genomes from ancestral species. Above (and other CL wheat varieties) carry a single gene on the D genome. As a two-gene Clearfield wheat variety, Brawl CL Plus carries this gene and an additional gene is carried on the B genome, which gives it greater crop safety than single-gene Clearfield wheat varieties.

Brawl CL Plus has dryland yields comparable to the popular variety Hatcher and single-gene Clearfield wheat varieties Above and Bond CL. It has excellent test weight, (higher than Above and Bond CL); good straw strength, (similar to Above and Thunder CL); medium-tall plant stature, (slightly taller than Hatcher and Ripper); a heading date two days earlier than Hatcher, (similar to Above); medium-long coleoptile, good fall stand establishment, good stripe rust resistance, good milling, and exceptional bread baking quality characteristics.

PlainsGold
GENETICS YOU CAN TRUST

Research on Brown Wheat Mite, Russian Wheat Aphid, and Wheat Stem Sawfly

Frank Peairs
Department of Bioagricultural Sciences and Pest Management

Brown wheat mite

Traditionally brown wheat mite has been a sporadic pest of wheat, with widespread damage limited to periods of drought. For unknown reasons, possibly due to changes in production practices, this pest has become a more consistent and widespread problem over the past few years. Research priorities include mass rearing, infestation methods, host range, and resistance screening techniques.

Brown wheat mites often spend part of their life cycle on noncultivated cool season grasses, as do most other wheat pests. The suitability of these hosts is an important aspect of their field biology. Seven cool season grasses were compared to winter wheat for host suitability by Sheri Hessler, a graduate student in our department. The mites increased on all species, with downy brome, crested wheatgrass and intermediate wheatgrass being the most similar to winter wheat. Meadow brome, Russian wild rye, smooth brome and mountain brome were less suitable. Field studies support that several of these species can serve as important sources of reinfestation for winter wheat. Such studies improve our knowledge of brown wheat mite field ecology as well as our techniques for plant infestation and damage evaluation, which will be necessary for screening for resistance once mass rearing methods have been developed.

The main obstacle to mass rearing is that brown wheat mites produce dormant, oversummering eggs after a certain amount of time in cultivation. The oversummering eggs will not hatch for several months, which stops mite production. Ms. Hessler has found that photoperiod is an important environmental cue for breaking egg dormancy and exposing the dormant eggs to brief periods of light during the night hastens hatching. However, the viability of the prematurely hatched eggs seems to be reduced compared to those that went through a complete dormant period. Photoperiod might also be used to prevent mites from producing dormant eggs in the first place, but less progress has been made with this approach. Photoperiod manipulation seems to be the key to breaking or preventing egg dormancy, however, much needs to be learned before we are able to efficiently mass-rear brown wheat mites for plant resistance screening and other studies.

A treatment timing study again showed the effectiveness of early treatment of brown wheat mite in terms of reducing mite abundance. However, yield differences were not observed. It is very difficult to measure insect and mite effects on yield unless the timing, level and uniformity of the infestation can be controlled. This is another example of our need to be able to efficiently mass-produce brown wheat mites.

Russian wheat aphid

We have found Russian wheat aphids on noncultivated grasses in montane environments throughout the past several growing seasons. We are currently biotyping 80 clones collected

from higher elevations as well as from eastern Colorado locations. We have found a number of distinct biotypes in each environment; however, they generally have virulence patterns similar to either Biotype RWA1 or Biotype RWA2. Clones with virulence patterns similar to Biotype RWA1 have been found in both montane and prairie environments, indicating the wheat varieties with *Dn4* resistance still may have some value in controlling Russian wheat aphid. No virulence to plants with the *Dn7* gene has been confirmed. Russian wheat aphid biotypes are a serious problem for the wheat breeding program. We are trying to determine the origin of new biotypes, and it seems likely that montane environments are one important source.

We are in our third year of evaluating the effectiveness of resistant varieties with the *Dn7* source of resistance against Russian wheat aphid biotype RWA2. Results from the first two years suggest that this source provides highly effective resistance against this biotype.

Wheat stem sawfly

The wheat stem sawfly, *Cephus cinctus* Norton, long considered a severe pest of wheat in Montana, North Dakota and the Prairie Provinces, has been found damaging winter wheat along Highway 14 in Weld County, CO, starting in 2010. While this insect is native to Colorado, sawfly populations capable of damaging winter wheat were previously unknown here.

Since the beginning of the last century the sawfly has spread south out of Canada into the northern Great Plains spring wheat. It has become more abundant on winter wheat and damage to winter wheat has spread into southeastern Wyoming, the Nebraska Panhandle, and Colorado.

Because it is unknown how far into Colorado this problem will spread, we started surveying eastern Colorado wheat in 2012. The results of the 2012 survey showed that sawfly damage in winter wheat was found to the Kansas border and as far south as Cheyenne County. Since this is the first time such a survey has been conducted, there is no baseline survey information for comparison. However, based on the lack of prior damage reports, this seems to represent a range expansion for damage to winter wheat in eastern Colorado.

We are evaluating a variety of wheat stem sawfly management approaches, including chemical control, biological control, pheromone traps, and sawfly resistant (solid stem) varieties. We are monitoring the sawfly at several locations near New Raymer and Byers to get a better understanding of its field biology under Colorado conditions.

How to Calibrate Your Drill to Plant Seeds per Acre

Jerry Johnson and Sally Sauer
Department of Soil & Crop Sciences

There are advantages to planting seeds per acre instead of pounds per acre due to the potentially large difference in seed size among seed lots. A farmer planting 35 pounds per acre could be planting 350,000 seeds per acre or 630,000 seeds per acre depending on the number of seeds per pound. Another advantage of planting seeds per acre is that you know how many seeds were planted per linear foot of row so stand counts can be taken after emergence to determine what percent of planted seed actually emerged. Actual stands often turn out to be much lower than expected – even under seemingly good planting conditions. You don't have to know how many seeds per pound of seed to be able to plant seeds per acre.

The following table will assist you in calibrating your drill to plant seeds per linear row foot (seeds per acre).

STEP 1: (see table) estimate your percent emergence rate based upon your planting conditions. Emergence rate is not the germination percentage of your seed, but rather what percent of seed planted will actually emerge. A guideline is provided to help you determine your estimated emergence rate, which ranges from very poor to excellent planting conditions.

STEP 2: (see table) determine desired plant population depending on the date of planting. For example, if planting in early September, you might want 500,000 plants per acre to avoid having too many plants and tillers the next spring that might exhaust available soil moisture. Plants emerging in early September will tiller profusely. If planting in mid-late October you might want to have 1,100,000 plants per acre as tillering will be greatly reduced.

STEP 3: (see table) find the row spacing for your drill and read across to the column you found in STEP 1 to find the number of seeds per linear foot. Set your drill accordingly.

Note that drills will need to be recalibrated if planting conditions improve (it rains) or become worse (hot and dry) or if your planting season is extended to a later date requiring a heavier seeding rate. We are interested in your experience. Send me and/or Sally an email message or feel free to call either of us with comments or questions.

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Sally Sauer (970) 491-1914 or Sally.Sauer@colostate.edu

Planting Rate in Seeds Per Linear Foot of Row

			Step 1: **Planting Conditions and Farmer Estimated Emergence Rate**					
	Step 2:	***Step 3:***	**Very Poor**	**Poor**		**Average**	**Excellent**	
Seeding Date	**Desired Plant Population**	**Row Spacing**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**
	plants/acre	**inches**	**seeds/linear foot of row**					
Late Aug.	**300,000**	**6.0**	9	7	6	5	4	4
	300,000	**7.5**	11	9	7	6	5	5
	300,000	**10.0**	14	11	10	8	7	6
	300,000	**12.0**	17	14	11	10	9	8
Early Sept.	**500,000**	**6.0**	14	11	10	8	7	6
	500,000	**7.5**	18	14	12	10	9	8
	500,000	**10.0**	24	19	16	14	12	11
	500,000	**12.0**	29	23	19	16	14	13
Mid-Sept.	**700,000**	**6.0**	20	16	13	11	10	9
	700,000	**7.5**	25	20	17	14	13	11
	700,000	**10.0**	33	27	22	19	17	15
	700,000	**12.0**	40	32	27	23	20	18
Late Sept./Early Oct.	**900,000**	**6.0**	26	21	17	15	13	11
	900,000	**7.5**	32	26	22	18	16	14
	900,000	**10.0**	43	34	29	25	22	19
	900,000	**12.0**	52	41	34	30	26	23
Mid/Late Oct.	**1,100,000**	**6.0**	32	25	21	18	16	14
	1,100,000	**7.5**	39	32	26	23	20	18
	1,100,000	**10.0**	53	42	35	30	26	23
	1,100,000	**12.0**	63	51	42	36	32	28

Table can also be accessed at: www.tinyurl.com/d2hbpgb

Importance of Variety Selection and Short- and Long-Term Benefits of Purchasing Certified Seed

Rick Novak
Department of Soil and Crop Sciencs

The annual survey of the Colorado Ag Statistics Service indicated that 2.2 million acres of winter wheat were planted in Colorado in the fall of 2012. This was 200,000 less acres planted to winter wheat than in 2011. However, there has been a continuing trend of farmers increasing their purchases of Colorado Certified seed as the graph on the following page indicates. The first certified seed that a farmer often purchases is for a newly released variety. Farmers often rely on their past experinces while at the same time they consult other informational resources to make more informed and educated decisions with regards to their seed purchase decisions. Farmers have experienced increases in grain yields over time as a result of continued research and development of new wheat varieties. As the cost of an average farming operation continues to increase, better management decisions can make significant differences in the bottom line at the end of the year.

There are many reasons why farmers purchase certified seed regularly and it is worthwhile to recognise these benefits. It is important to identify the short- and long-term benefits of using certified seed every year.

The short-term benefits for farmers purchasing certified seed are the following:

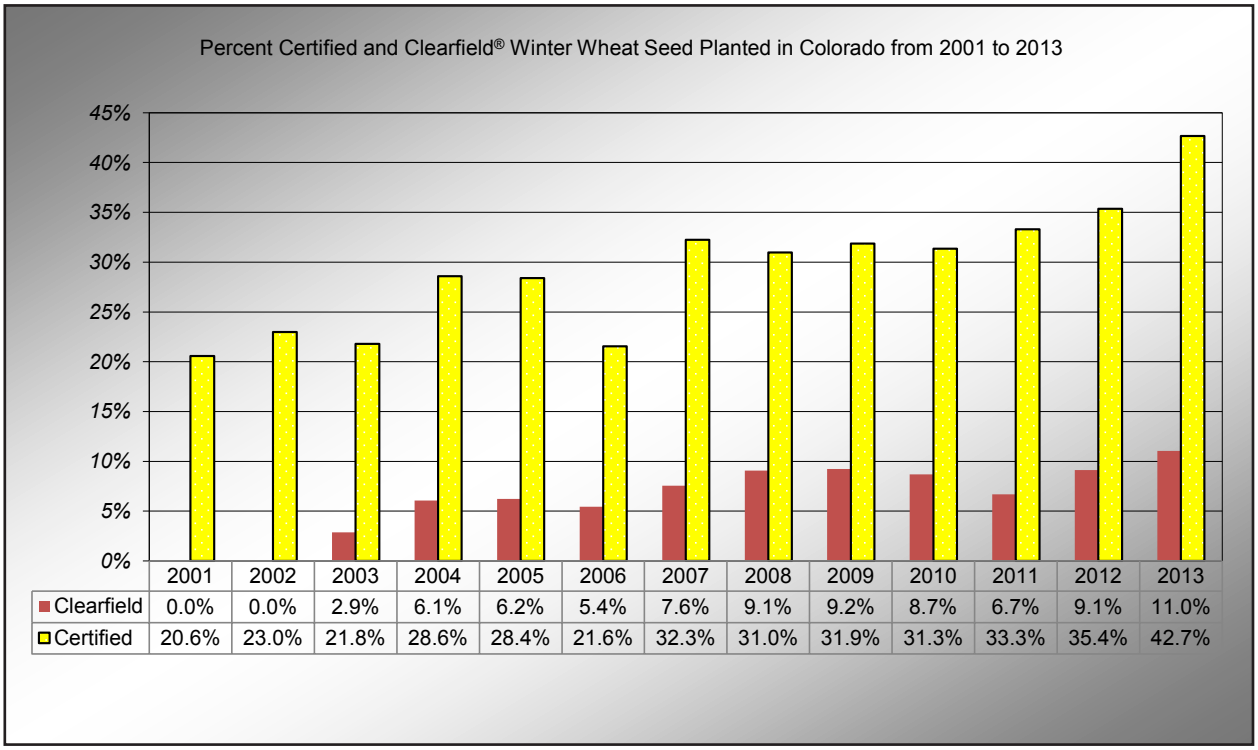
1. Farmers are able to maintain grain sales and reduce their risk.
2. Farmers do not have to transport, store, handle, and condition the grain intended for seed.
3. Farmers do not have to be concerned about purity, weeds, and germination of their seed.
4. Farmers are able to purchase a more desireable variety with superior agronomic traits.
5. Farmers are able to purchase the most productive varieties available.
6. Farmers are able to purchase seed that has been field inspected for weeds and genetic purity.
7. Farmers will receive a seed tag providing documented verification of the purity and germination.
8. Farmers have the option in many cases to have seed treatment applied to their purchased seed.
9. Farmers are able to save time and labor and purchase the exact amount of seed required.
10. Farmers are given the opportunity to grow Identity Preserved varieties for specialty markets.
11. Farmers often will experience an increase in their productivity by using certified seed.

There are long-term benefits of certified seed as well:

1. Farmers have experienced an increase in average grain yields over a number of years.
2. Farmers have witnessed breeding programs making large investments in plant varietal development.
3. Farmers have captured value from Identity Preserved program products in the market place.
4. Farmers have seen several new technologies adapted in varietal development.

Purchasing certified seed provides the needed funding that supports research and varietal development for the future. The development of new varieties generally took 10-12 years in the past, but with the implementation of new technologies in the area of wheat breeding, such as double-haploid and marker-assisted selection, the timeline of bringing new varieties to the farmer is being reduced. Each time a farmer makes a decision to purchase Certified seed they are also supporting research and varietal development that will benefit them in the future.

In August, the university and private wheat breeding teams will be presenting their trial results during the wheat planting decision meetings. If you are growing wheat or just interested in wheat as a crop, mark your calendar and attend a wheat planting decision meeting in your area. This is one of the best ways for you to become informed about wheat varieties. The first-hand experience of attending a meeting along with a review of trial results after harvest will help you make informed variety selection decisions. As a farmer, use field trial information as another tool in your toolbox to help you achieve a successful farming operation!



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Clearfield	0.0%	0.0%	2.9%	6.1%	6.2%	5.4%	7.6%	9.1%	9.2%	8.7%	6.7%	9.1%	11.0%
Certified	20.6%	23.0%	21.8%	28.6%	28.4%	21.6%	32.3%	31.0%	31.9%	31.3%	33.3%	35.4%	42.7%

Effects of Drought on Wheat Diseases and Stripe Rust Management

Ned Tisserat
Department of Biological Sciences and Pest Management

Drought and Diseases. *Fusarium crown rot*, also referred to as dryland foot rot is promoted by drought, especially in the fall. The fungus can infect the wheat crown under a wide range of soil moisture conditions (even moist conditions that favor seed germination). However, subsequent drought may predispose the young root system to colonization by the fungal pathogen. Unfortunately, we may see substantial crown rot in fields where the wheat came up, but then more or less stopped growing because of dry conditions.

Look for scattered pockets of yellow, stunted plants following green-up. Damaged plants are usually concentrated on wind-prone hills or rocky areas in the field. Brown/red discoloration of the crowns and lower stems will be evident and the root system will be much reduced. Affected plants will tiller poorly and will develop small heads and may be killed outright.
The disease can be avoided or reduced by planting good quality seed (germination >92%) into a firm seedbed (a loose seedbed will promote the disease). Seed treatments have been used to prevent infection by the *Fusarium* in the fall, although the benefits of this treatment are debated. There isn't a lot that can be done once the infection process has started. Fungicides applied for foliar diseases (like stripe rust) in the spring are not likely to alter the development of Fusarium crown rot.

Virus diseases transmitted by curl mites (e.g. wheat streak mosaic and Triticum mosaic) can also be indirectly impacted by heat and drought. Virus infected plants are not efficient water users and suffer even more during drought. On the other hand, drought tends to reduce many of the fungal foliar pathogens like stripe and leaf rust. These pathogens rely on prolonged periods of leaf wetness for infection and their epidemics are slowed by dry conditions, even if they are present in a field. That means foliar fungicides may not be needed.

Managing Stripe Rust with fungicides.

Stripe rust has become a serious problem for wheat producers in Colorado. Prior to1999, stripe rust was largely confined to the Pacific Northwest because its development is favored by cool temperatures. However, a new race of the pathogen was found in the Great Plains around that time that was more adapted to our spring weather patterns. Since then, we have experienced a number of stripe rust outbreaks. Fortunately, stripe rust resistance genes were already present or bred into many popular wheat varieties. However, new races of stripe rust emerged in 2010 and again in 2012 and many varieties that were resistant are now susceptible. Farmers should

refer to the *Description of Winter Wheat Varieties in Colorado Performance Trials* (page 21) for updated information on variety susceptibility. It is not possible to forecast which stripe rust races will predominate in a given year, so varieties rated as moderately susceptible to susceptible should be considered at risk.

Another management strategy for stripe rust-susceptible varieties is fungicide use. There are many different fungicides labeled for stripe rust control and these provide very good to excellent control when applied prior to infection. Consult the *North Central Regional Committee on Management of Small Grain Diseases* (NCERA-184) fungicide efficacy chart (http://tinyurl.com/c3bxugn) for details on these fungicides. In general the fungicides belong to one of two classes based on mode of action; the triazoles and the strobilurons. Some fungicides are mixtures of these two products.

Fungicides typically have their greatest efficacy if they are applied two to three weeks or less before infection. Typically in Colorado, rust infections start to develop around the time the flag leaf emerges, and if stripe rust is present in the region this is good time to make an application. Earlier applications (i.e. at jointing) aren't warranted if stripe rust has not yet made it to our state. In fact, these very early sprays will not prevent stripe rust development during flowering or grain filling because there is little fungicide residual left in the plant. The rule of thumb is to wait as long as possible before making an application, but not so long that a high level of infection has already occurred. Also remember that there are harvest restrictions for these fungicides that limit their application after flowering or 30 days before harvest.

There are many factors in addition to varietal resistance/susceptibility to consider before making fungicide applications. They include the presence of the disease in the region (for inoculum), a weather forecast that is favorable for disease development, market prices, expected yield levels, and fungicide and application costs. Therefore the decision can be a difficult one. We at CSU, in collaboration with colleagues throughout the nation, monitor stripe rust development each spring and then try to provide a periodic synopsis of the potential for damage via email to producers. If you would like to receive these email updates please contact Ned Tisserat (Ned.Tisserat@colostate.edu).

High Grain Yield and High Grain Protein for Colorado Winter Wheat

Susan Latshaw and Scott Haley
Department of Soil & Crop Sciences
Merle Vigil
USDA-ARS, Central Great Plains Research Station

On this 50th anniversary year for the CSU Wheat Breeding Program, we can look back and see the great strides made in winter wheat variety improvement for Colorado. The Colorado State University Wheat Breeding Program has released over 35 improved varieties since its inception in 1963. The higher yielding varieties have resulted from improved adaptation to the tough climatic conditions of Colorado's eastern plains. These high yield adaptations were demonstrated over the last several years—in 2010, when 60% of the Colorado crop was planted to CSU wheat varieties, growers achieved a new high yield record of 45 bushels per acre (CWRF). In the drought year of 2012, yields remained higher than expected, averaging 34 bushels per acre despite the extremely dry conditions. Looking ahead, several new variety releases promise startling advances—Byrd (2011 release) has topped dryland state variety trials for three straight years, producing 11% greater yield than Colorado's #1 variety, Hatcher. A revolutionary variety released in 2009, Snowmass (HWW), provides growers with a 30-90 cent per bushel price premium through the CWRF ConAgra Mills Ultragrain® Premium Program. The premium increases with higher grain protein.

Growers want high yielding wheat with adequate grain protein for maximized pricing at the elevator. Domestic and export end-users want grain protein suitable for product manufacturing. The high performing varieties of this era may require management adjustments for optimal yield and grain protein concentration to meet both wheat grower and end-user requirements.

N application to prevent low grain protein concentration and to promote high yields

Due to inadequate soil nitrogen (N) availability (caused by either low soil N levels or inadequate fertilizer N application), yields and grain protein are reduced. Grain protein concentration below 11% is recognized as an indicator of N deficiency stress for the wheat crop (Goos et al., 1984). There are several tools for determining fertilizer application rates. Economically optimal N fertilizer rates were modeled for dryland production, accounting for grain prices, yields, and input costs in a wheat-fallow rotation, but did not include factors for protein discounts and premiums (Vigil, 2007). Recommendations generated in that report for an average precipitation year were 20 to 35 lb N/ac at current market prices, although these would likely be higher with the market prices today. To increase grain protein concentration by one percentage point, it takes approximately 20 to 30 pounds of applied N fertilizer (Davis and Westfall, 2009).

In our 2011 field study at Akron, CO, as yield increased in response to N, grain protein also increased for the varieties Snowmass and Byrd (Figure 1). This was contrary to the common observation of a negative relationship between yield and protein content. Yields of Byrd were greater than Snowmass, but their N responsiveness for grain protein was similar --25 lb N/ac was inadequate to achieve 11% protein, while 50 lb N/ac was sufficient. In 2012, under very dry conditions, yields were low and did not respond to applied N, but protein showed a linear

response to applied N. Protecting high yields and grain protein concentration requires adequate N supply for these modern varieties.

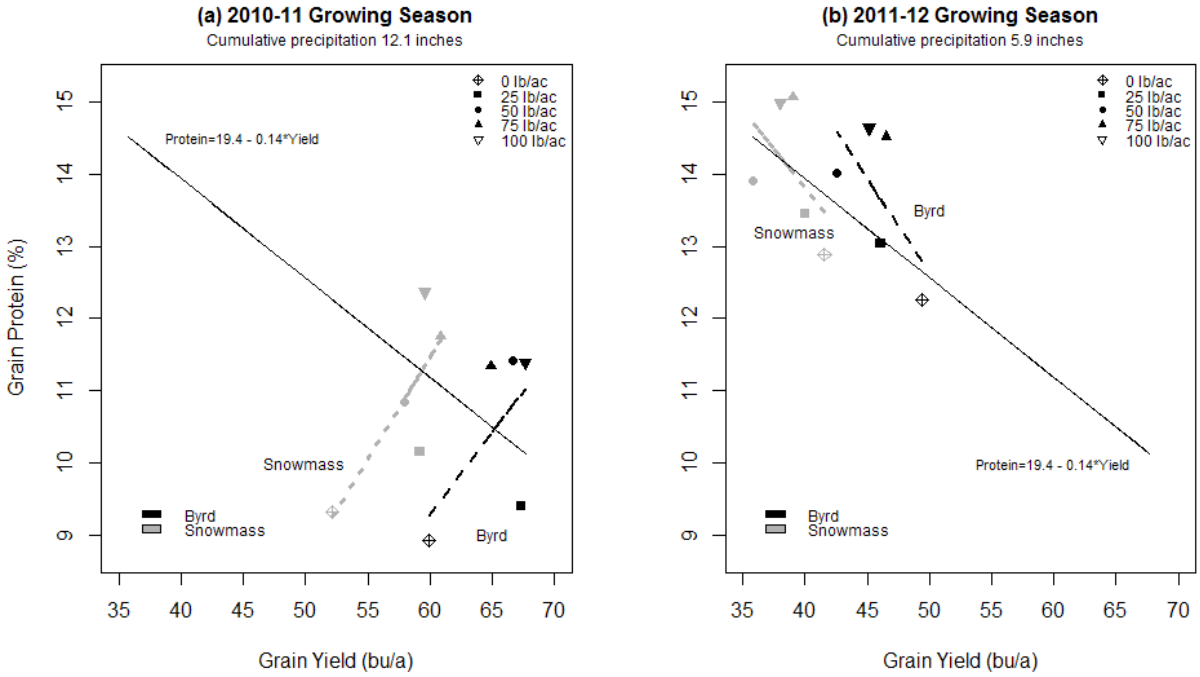


Figure 1. Nitrogen fertilizer rate effects on grain yield and grain protein concentration for varieties Snowmass and Byrd in (a) 2010-11 and (b) 2011-12. Data are adjusted means (n=3 and n=4, respectively). The overall regression of grain protein on grain yield for all data over both seasons is plotted in each box. Regression lines for each cultivar within a season are included. For 2010-11: protein = -5.55 + 0.28 yield (Snowmass) and protein = -4.26 + 0.23* yield (Byrd). For 2011-12: protein = 22.4 - 0.21* yield (Snowmass) and protein = 25.6 - 0.26* yield (Byrd).*

Genetic Improvement to Prevent Low Grain Protein

Several recent studies report on genetic factors that have either independent or antagonistic effects on grain yield and grain protein across environments, offering evidence that the negative association between the traits can be modified through breeding. Screening methods are being implemented in the CSU Wheat Breeding Program to meet this objective. If these efforts are successful, varieties may be developed that maintain high yields and relatively higher protein, even at low or moderate levels of N fertilization.

References

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Goos R.J., Westfall D.G., Ludwick A.E. (1984) Grain Protein Content as an Indicator of Nitrogen Fertilizer Needs in Winter Wheat in Eastern Colorado. Colorado State University Extension Service.
Vigil M. (2007) Optimal Nitrogen Fertilization of Dryland Wheat. (http://tinyurl.com/chg6v2b) High Plains Ag Lab Research Update pp. 20-23.

Weed Research on Kochia, Feral Rye, and Jointed Goatgrass

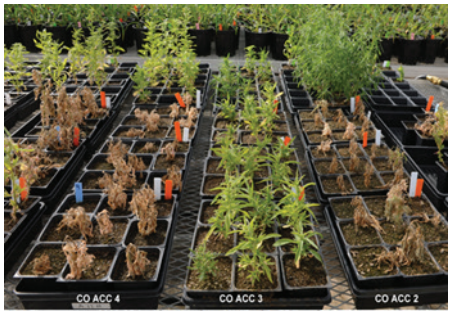
Phil Westra and Dale Shaner
Department of Bioagricultural Sciences and Pest Management

Glyphosate Resistant Kochia

We collected over 100 random samples of kochia from eastern Colorado where complaints of glyphosate resistant kochia have increased over the past 2 years. Kochia resistance threatens reduced-till farming from the southern plains all the way into Canada. Our Colorado kochia

sampling has been done in 2011 and again in 2012. Often the resistant kochia can be seen as a meandering streak through an otherwise weed free field.

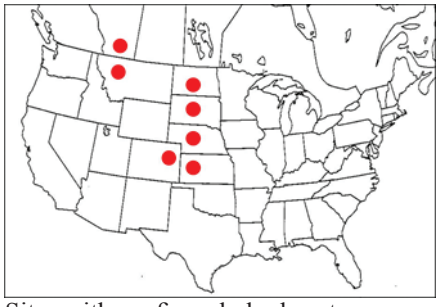
In our greenhouse testing, some kochia plants survive up to 6 pounds of Roundup per acre. The photo (right) shows 2 kochia lines (CO ACC 2 and CO ACC 4) totally killed by glyphosate while line 3 is unaffected.



Three random 2011 CO kochia accessions 4 weeks after treatment with .75 lb/ac glyphosate: untreated control in background; ACC 3 is 100% resistant- 27 plants. Greenhouse photo March, 2012.

Molecular research has confirmed that glyphosate resistant kochia plants have many more copies of the EPSPS gene and this allows them to survive high rates of glyphosate. We will need to develop other herbicides to control kochia in various crops including Roundup Ready crops.

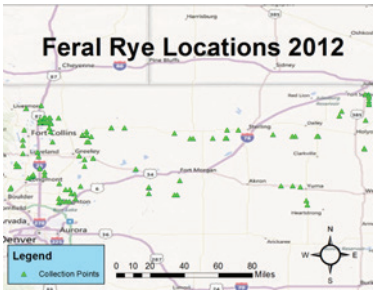
Although glyphosate resistant kochia samples continue to come into our lab at CSU, we find that in random samples, most kochia populations are still controlled by labeled glyphosate rates. There is pretty strong evidence, however, that growers are now applying higher glyphosate rates to deal with this issue; a more common rate now appears to be 1.25 pounds per acre as opposed to the 0.75 pound rate which would be the normal rate.



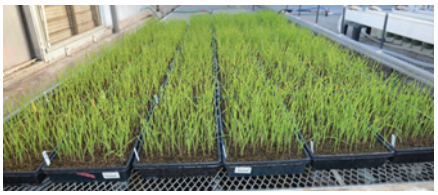
Sites with confirmed glyphosate resistant kochia.

Screening Feral Rye Response to Beyond Herbicide

The goal of this experiment was to identify resistant accessions of feral rye throughout the state of Colorado, and from this data perform an ALS assay to look at this as one of the possibilities for the mechanism of resistance. We used several teams of students in July 2012 to collect feral rye seed from 111 sites in eastern Colorado. Each site was geo-referenced and a minimum of 150 ml of seed was threshed from each accession. Seeds were planted in rows in greenhouse flats filled with commercial potting soil, and then watered and fertilized to promote good germination and growth.



Once the plants reached a height of close to 4 inches, we applied Beyond herbicide (imazamox) at 3 oz/acre, 6 oz/acre, and 12 oz/acre. The highest labeled rate in the field for control of feral rye with imazamox is 6 oz/acre. After spraying and allowing them to regrow for about a week, we cut all of the plants an inch from the soil surface, and the resistant plants quickly showed re-growth. After allowing them adequate time for regrowth (about 1 month), we sprayed all of the treated flats with the 6 oz/acre rate in order to eliminate any susceptible biotypes that survived the initial treatment.



After identifying possible resistant accessions, we performed an ALS assay to determine the inhibitory effect of imazamox on the resistant plants. Several feral rye accessions survived 12 oz/acre of imazamox, suggesting they would not be controlled by a field rate of the herbicide. This research, with a large number of feral rye accessions from eastern Colorado, shows a wide range of responses to a given rate of Beyond herbicide. Some are controlled by 3 oz/acre of Beyond, while others are not controlled by 12 oz/acre. Ongoing research will attempt to further characterize the reasons for these differences.

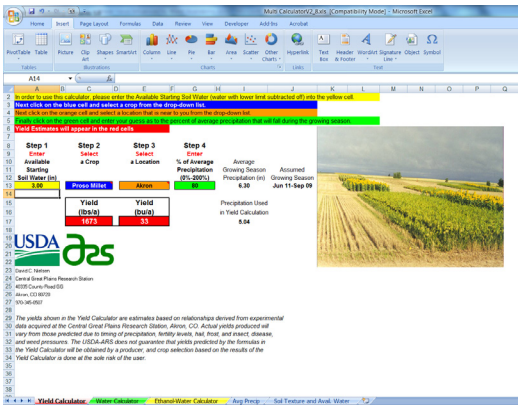
Gene Flow from Wheat to Jointed Goatgrass

Craig Beil used Genomic In Situ Hybridization to paint each genome of wheat and jointed goatgrass a different fluorescent color. It will help us characterize the amount of DNA that is exchanged in gene flow between wheat and jointed goatgrass. We have shown that by planting BC1 wheat x jointed goatgrass hybrids in the field where there is a good jointed goatgrass pollen source, fertile BC2 plants can be generated, although at a low frequency. This small genetic bridge helps move hybrids containing wheat germplasm back towards a jointed goatgrass phenotype where the new plants could contain novel wheat genes that provide an advantage to the jointed goatgrass.

Winter Wheat Yield Response to Available Water

David C. Nielsen
USDA-ARS, Central Great Plains Research Station

Dryland winter wheat yields in eastern Colorado can vary greatly from year to year and are primarily limited by available water supplies. Yields increase linearly with water use. It is a function of how much water is available as soil water that can be extracted by the roots and how much precipitation falls during the growing season.



Wheat yields increase at an average rate of 4.7 bu/acre per inch of water use after the first 5 inches of water use (including stored soil water). For example, if a wheat crop received 10 inches of precipitation from planting to harvest and used 6 inches of stored soil water, that would amount to 16 inches of water use. Following the first 5 inches of water use the remaining 11 inches of water use would generate a yield of 4.7 × 11 = 52 bu/a.

This water use/yield relationship has been incorporated into an Excel-based spreadsheet calculator (MultiCalculator, available at http://tinyurl.com/cjqn6er) which can also calculate expected yields for 17 other crops at 15 Great Plains locations in Colorado, Nebraska, and Kansas. The Yield Calculator (red tab at the bottom of the spreadsheet) requires the user to pick the desired crop and location from drop-down lists and to input an estimate of available soil water at planting and the expected percentage of average growing season precipitation. The table below shows the expected winter wheat yields for 8 locations in eastern Colorado under nine combinations of three different available soil water contents at planting (4, 6, and 8") and three levels of growing season precipitation (80, 100, and 120% of average).

The expected yields range from 23 bu/a at La Junta with 4" of available soil water at planting and 80% of average precipitation to 80 bu/a at Wray with 8" of available soil water at planting and 120% of average precipitation.

Available Soil Water at Planting	4"			6"			8"			Average
% of Average Precipitation	80%	100%	120%	80%	100%	120%	80%	100%	120%	Precip (in)
Location	Wheat Yield (bu/a)									
La Junta	23	31	38	33	40	47	42	50	57	7.7
Briggsdale	26	34	42	36	44	52	45	53	61	8.4
Fort Morgan	28	36	44	37	45	54	46	55	63	8.8
Limon	30	39	48	40	49	57	49	58	67	9.5
Lamar	33	43	52	42	52	62	52	62	71	10.2
Akron	34	44	54	44	54	64	53	63	73	10.6
Stratton	37	48	59	47	58	68	56	67	78	11.4
Wray	39	50	62	49	60	71	58	69	80	11.9

It is important to remember that the yield estimates given in the table assume that available water supply is the controlling factor for wheat yield, and does not consider yield reductions that may occur due to poor plant stands, inadequate N fertility, insect predation, weed competition, disease problems, hail, wind, frost, harvest losses, or precipitation timing effects.

Getting an estimate of available soil water at planting requires taking a soil sample, weighing that sample before and after drying in an oven, calculating the percent water, and then subtracting off a lower limit of water availability (e.g., about 8% for a silt loam soil). Method details are available at http://tinyurl.com/dywyzdh.

Dr. Perry Miller, Montana State University, demonstrates the use of the soil probe.

An alternative method is to push a special soil probe constructed from a 3/8" rod with a somewhat larger ball or auger welded to the end (available at http://tinyurl.com/d3c69mu). After inserting the rod as far as it will go into the soil, the user removes it from the soil and measures the insertion depth and multiplies that depth by the water-holding capacity of the soil type being sampled (e.g., 2"/ft for a silt loam). The MultiCalculator referenced above contains a more detailed list of available water contents related to soil texture on the Soil Texture and Avail. Water tab at the bottom of the spreadsheet.

An alternative to probing the soil is to keep track of precipitation events and use the Precipitation Storage Efficiency Calculator (also available at http://tinyurl.com/cjqn6er). This calculator determines the estimated precipitation storage efficiency and stored soil water over the 14-month fallow period in a wheat-fallow system under either conventional tillage or no-till production practices using relationships determined at Akron, CO. The value of stored soil water that the calculator returns to the user could be used as an estimate of available soil water that could be extracted by the wheat during the growing season.

When Will My Winter Wheat Flower?

Greg McMaster
USDA-ARS, Great Plains Systems Research

Knowing when to expect your wheat crop will reach a specific growth stage is important for many reasons. The window for applying herbicides is increasingly being based on the growth stage, or number of leaves that have appeared. The effectiveness of managing practices such as spring application of N fertilizer or limited irrigation strategies can be improved when timed to specific growth stages. However, when winter wheat reaches a growth stage depends on factors such as weather (heat and drought) or variety (early or late maturity). Fortunately, much research has studied the timing for reaching a growth stage as a function of the environment (called phenology), and we can predict wheat growth stages quite accurately.

What is PhenologyMMS?

Until recently, most phenological information has been used by scientists and in detailed crop simulation models. To facilitate the accessibility of this information, USDA-ARS has developed a computer program (PhenologyMMS) that is available to farmers and consultants for predicting crop growth stages. This program uses historical weather data for certain locations in eastern Colorado. After setting a few inputs such as planting date for a particular year, it will predict the date of seedling emergence and subsequent growth stages; first tiller appearance, jointing, beginning of booting, heading, flowering, and maturity. The user can run the model under irrigated or dryland conditions. The growth stage predictions can be based on a "generic" winter wheat variety, for early, medium, or late maturing varieties, or for some specific varieties of wheat.

Basic science behind PhenologyMMS.

PhenologyMMS simplifies assumptions used in more detailed phenology computer simulation models, but is still based on temperature as the most important factor controlling phenology. The standard approach for representing temperature is to calculate the growing degree-days (GDD) required to progress from one growth stage to the next. We use the following steps to calculate GDD:
Calculate the average temperature for today (in Centigrade °C):

Tavg = (Maximum daily temperature + Minimum Daily Temperature) / 2

Calculate the GDD for today:

GDD = Tavg – base temperature (We use 0°C for the base temperature)

Finally, add up each day's GDD until enough are accumulated to reach the next growth stage. An important note here is that if today is colder than the base temperature (giving a negative number), then skip today. The base temperature is the lowest temperature where the wheat plant will develop, although obviously very slowly.

One important feature of PhenologyMMS is that the effect of water stress on the timing of growth stages is also considered. This is done to more accurately reflect what is generally known; such as seeds will germinate sooner when there is a lot of soil water, or grain filling is shortened by hot and dry conditions. The user chooses the general conditions of water stress (for example irrigated fields or high rainfall locations resulting in little water stress) or "significant" water stress (such as dryland fields or low rainfall years). The user can change these conditions for different periods of the growing season.

What can I do with PhenologyMMS?

One of the most common uses of PhenologyMMS is to select a weather file for a location, and then change the conditions or inputs and see how it changes the timing of different growth stages. For instance, explore how changing the planting date and amount of soil water in the seedbed zone (optimum to planted in dust) will alter the timing of specific growth stages in the same, or different, years. The table below is an example of running the program to predict certain growth stages for one planting date at five locations in eastern Colorado under irrigated or dryland conditions and based on historical weather data.

Average simulated dates for a "generic" wheat variety to reach certain growth stages under optimal (i.e., irrigated) and stressed (i.e., dryland) conditions in eastern Colorado[1].

		Average expected date						
		2 Leaves	Jointing		Anthesis or Flowering		Maturity	
Location	# Yrs	Irrigated	Irrigated	Dryland	Irrigated	Dryland	Irrigated	Dryland
Walsh, CO	12	Oct 6	Apr 7	Apr 7	May 14	May 10	Jun 21	Jun 9
Rocky Ford, CO	28	Oct 8	Apr 14	Apr 14	May 18	May 14	Jun 25	Jun 13
Stratton, CO	19	Oct 8	Apr 21	Apr 21	May 27	May 23	Jul 3	Jun 22
Akron, CO	29	Oct 10	Apr 28	Apr 27	Jun 2	May 29	Jul 9	Jun 28
Fort Collins, CO	30	Oct 14	May 1	May 1	Jun 5	Jun 1	Jul 13	Jul 1

[1] Initial inputs assumed a 15 September planting date, optimal soil water at planting, 5 cm seeding depth, and a 0°C base temperature. Locations are arranged in order of increasing latitude and the number of historical years of weather data used for each location is indicated.

How do I get PhenologyMMS? Download from the Web at: http://tinyurl.com/cfkys9a, select "software" (left side), and scroll down through the list to "PhenologyMMS". It is recommended that all default download options are used, and this will provide an icon on the desktop. Double clicking on this icon will start the program.

Note: PhenologyMMS is being improved and updated continually. Please call (970-492-7340) or e-mail (greg.mcmaster@ars.usda.gov) with comments or suggested improvements.

Harvest Bigger Returns with the

CWRF ConAgra Mills Ultragrain® Premium Program

Colorado Wheat Research Foundation (CWRF) is proud to continue the long-standing partnership with ConAgra to offer wheat growers premiums for select hard white winter wheat varieties. The demand for hard white wheat continues to grow as consumers look for the health benefits of whole grain products from hard white wheat varieties.

A Powerful Pair of Hard White Wheat Varieties

Snowmass

Snowmass hard white winter wheat is the flagship variety in the CWRF ConAgra Mills Ultragrain® Premium Program. Snowmass is in high demand with millers and bakers because of its unparalleled milling and baking quality. In addition to the price and protein premium, Snowmass features good dryland yields with good test weights, excellent wheat streak mosaic resistance and medium-tall plant height for increased crop residue.

Thunder CL

Thunder CL is another PlainsGold hard white winter wheat variety. Thunder CL is a one-gene Clearfield® hard white winter wheat variety that is tolerant to Beyond™ herbicide for broad-spectrum weed control, including problematic winter annual grassy weeds. In addition, Thunder CL combines good yields, good stress tolerance, good disease resistance, good test weights and superior milling and baking qualities.

How can you join the program?

1. Contact your local seed grower
Snowmass and Thunder CL can be purchased directly from local PlainsGold seed growers right in your area. They'll also help you with necessary paperwork to enroll in the program.

Snowmass Seed Growers:

Anderson Wheat Farms, Haxtun 970-774-4143
Brooks Seeds, Walsh (719) 523-4473
Cooksey Farms, Roggen 303-849-5214
CSF Farms, Seibert 970-664-2281
Jim Dolezal, Julesburg 308-289-5445
Dry Creek Seed Company, Genoa 719-763-2367
Eagle Farms, Holyoke 970-854-5328
Johnston Family Farms, Erie 303-591-8830
Kochis Farms, Matheson 719-775-2596
Mertens Brothers, Inc., New Raymer 970-437-5358
Pachner Agri-Enterprises, Akron, 970-554-0645
Progressive Farms, Byers 720-244-6775
Gary Rafert, Amherst 970-854-2607
Sand Creek, Inc., Sheridan Lake 719-729-3367
Wagers Seed, Woodrow 970-842-2022
Wickstrom, Inc., Orchard 970-768-1384
Randy Wilks, Burlington 719-346-7314

Thunder CL Seed Growers:

Cooksey Farms, Roggen 303-849-5214
Frank Fry, Grand Junction 970-858-7181
Johnston Family Farms, Erie 303-591-8830
Ryan Weaver, Burlington 719-346-7779

2. Join the Program
After you talk to your local seed grower, they will help you finalize all the necessary contracts to join the program, including:
• Grain Pricing Schedule with ConAgra Mills detailing the contract terms.
• Wheat Seed Agreement with CWRF that requires the planting of certified seed and the delivery of all production to ConAgra.
• Clearfield® Wheat Stewardship Grower Agreement with BASF (for Thunder CL)

3. Earn premiums of 30–90 cents/bushel*
All Snowmass and Thunder CL wheat grown under the premium program is eligible for a minimum premium of 30 cents per bushel, regardless of protein levels. Additional bonuses of up to 60 cents per bushel are available for protein levels starting at 12.2% up to 15%. That means wheat with 15% protein will earn you a premium of 90 cents/bushel. Here's how it breaks out:

Protein Level	Base Premium	Additional Premium	Total Premium		Protein Level	Base Premium	Additional Premium	Total Premium
12.2%	$0.30	$0.03	$0.33		13.8%	$0.30	$0.42	$0.72
12.4%	$0.30	$0.06	$0.36		14.0%	$0.30	$0.45	$0.75
12.6%	$0.30	$0.14	$0.44		14.2%	$0.30	$0.48	$0.78
12.8%	$0.30	$0.17	$0.47		14.4%	$0.30	$0.51	$0.81
13.0%	$0.30	$0.25	$0.55		14.6%	$0.30	$0.54	$0.84
13.2%	$0.30	$0.28	$0.58		14.8%	$0.30	$0.57	$0.87
13.4%	$0.30	$0.36	$0.66		15.0%	$0.30	$0.60	$0.90
13.6%	$0.30	$0.39	$0.69					

NEW for 2012/13 - After harvest, you will receive a $2/bushel rebate from ConAgra Mills on your certified seed purchase of Snowmass or Thunder CL.

Delivery Points
Wheat raised under the CWRF ConAgra Mills Ultragrain® Premium Program must be grown under contract, and delivered to one of the following delivery points:

Colorado
Anton – Anton Coop
Amherst – Grainland Coop
Arriba – Flagler Coop
Bennett – Roggen Coop
Brush – Roggen Coop
Burlington – Stratton Equity Coop
Commerce City/Denver – ConAgra
Flagler – Flagler Coop
Fort Morgan - Wildcat Dairy
Genoa – Flagler Coop
Haxtun – Grainland Coop
Holyoke – Grainland Coop
Hugo – Flagler Coop
Nunn – Roggen Coop
Peetz – Peetz Coop
Pierce – Roggen Coop
Roggen – Roggen Coop
Springfield - Elkhart Coop
Stratton – Stratton Equity Coop
Wildcat Dairy – Roggen Coop

Nebraska
Lodgepole – Frenchman Valley Coop
Dix – Frenchman Valley Coop

Kansas
Coolidge – Scoular Co.
Colby – Cornerstone Ag

Additional delivery points pending

For more information about participating in the CWRF ConAgra Ultragrain® Premium Program for hard white wheat, contact the Colorado Wheat Research Foundation at (970) 449-6994 or visit www.plainsgold.com.

*Premium program for 2012/13. The program for 2013/14 may differ.

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