Technical Report Wheat Field Days Edition- 2016

Colorado State University

Agricultural Experiment Station

College of Agricultural Sciences Department of Soil & Crop Sciences Extension

Making Better Decisions

2015 Colorado Winter Wheat Variety Performance Trials

Crops Testing

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Additional Resources on the Internet:
Colorado State University Crop Variety Testing Program: www.csucrops.com
Colorado State University Wheat Breeding Program: www.wheat.colostate.edu
Colorado Wheat Variety Performance Database: www.ramwheatdb.com
Colorado Wheat Administrative Committee (CWAC), Colorado Association of Wheat Growers (CAWG), and Colorado Wheat Research Foundation (CWRF): www.coloradowheat.org

Variety Performance in the 2015 Eastern Colorado Winter Wheat Trials

Jerry Johnson and Scott Haley

Colorado State University faculty, staff, and students work tirelessly throughout the year to provide current, reliable, and unbiased wheat variety information to Colorado producers. We are fortunate that farmers really support research in Colorado; research support has kept public variety testing alive and well. Farmer support for public variety testing is our hope for the future. Our work in Colorado is possible due to the support and cooperation of the entire Colorado wheat industry, especially support from the Colorado Wheat Administrative Committee (wheat assessment) and the Colorado Wheat Research Foundation (seed royalties). We have to test under a broad range of environmental conditions to best determine expected performance of new varieties. That is why we have 11 dryland variety performance trials, three irrigated variety performance trials, and 30 on-farm variety tests each year.

We have a uniform variety testing program, meaning that all varieties are tested in all test locations. There were 44 varieties and experimental lines in each of the 11 dryland trials. The three irrigated trials each had 32 varieties and the ~30 collaborative on-farm tests (COFT) each had six varieties. The trials included a combination of public and private varieties and experimental lines from Colorado, Texas, Kansas, Oklahoma, Nebraska, Wyoming, and Montana. Seed companies with entries in the variety trials included WestBred (Monsanto), AgriPro (Syngenta), Limagrain Cereal Seeds, AGSECO, Adaptive Genetics, and Watley Seed Company. There were entries from five marketing organizations: PlainsGold (Colorado), Husker Genetics (Nebraska), the Crop Research Foundation of Wyoming, Oklahoma Genetics, and the Kansas Wheat Alliance. All dryland and irrigated trials were planted in a randomized complete block design with three replicates. Plot sizes were approximately 175 ft^2 (except the Fort Collins IVPT, which was 80 ft^2) and all varieties were planted at 700,000 seeds per acre for dryland trials and 1.2 million seeds per acre for irrigated trials. Plot sizes for the COFT ranged from 0.5 to 1.5 acres per variety for the six varieties for three to nine total acres and seeding rates conform to the wheat seeding rate of the collaborating farmer. Yields were corrected to 12% moisture. Variety trial test weight information was obtained from a Harvest Master weighing system on the plot combine.

General Growing Season Comments

The 2014-2015 growing season can be characterized by two primary factors:

1. Enormous variation in temperatures
2. Rain (Stripe rust!)

The summer of 2014 was relatively cool and wetter than normal, contributing to over-summering of insect pests that caused significant virus problems in many areas (barley yellow dwarf virus and wheat streak mosaic virus). The fall was much warmer than normal and set some records. Planting conditions were good with some exceptions in the Southeast. There was very lush growth in some variety trials due to moisture and favorable temperatures. We generally had high temperatures during the month of October. On November 10 things got cold, with record low temps on November 13 (November 12-17 was very cold). Eastern Colorado experienced very cold temps again in late January, down to -20°F. There was widespread snow in early February. Very warm temperatures occurred around February 11 and set some records. Eastern Colorado experienced a very dry winter in general. On March 16, the temperatures warmed into the low 80s. There was good statewide precipitation around April 16-19, and again from April 25-27. Stripe rust was found at Roggen on April 30. There were widespread cool and cloudy conditions during the week of May 3. It was very cold the nights of May 9 and 10, which caused extensive freeze damage in some areas north of I-70. On May 20 many locations saw air temperatures in the upper 20s, causing freeze damage to headed wheat plants in some fields. The month of May was really wet, with some areas receiving 12 inches or more of precipitation. We saw high temperatures from mid-June up until harvest.

Significant winter injury was noted at several locations (Burlington, Akron, and Yuma) with less winterkill at other locations (Arapahoe, Julesburg, and Orchard). Winter injury appeared to be associated with drought tolerance, and presumably, root growth. Varying degrees of winterkill occurred from near 100% loss to burned tips of leaves. Many fields suffered winterkill on more than one event. Very high precipitation and cool temperatures in the month of May created very good conditions for the spread of stripe rust and other fungal pathogens that are very atypical for eastern Colorado (i.e., *Stagnospora* glume blotch, and *Fusariam* head blight).

General Growing Conditions in Southeast Colorado - Wilma Trujillo

For the first time in several years, southeastern Colorado wheat producers planted into adequate moisture. Rains in August restored farmers' hope after continuous losses from drought. This led to an increase in the wheat acreage planted in 2014. While adequate topsoil moisture provided a better seed bed for farmers to drill into, the subsoil moisture profile was still low.

The weather conditions have been the biggest challenge for producers in this area. Although the planting conditions were positive, a successful crop still depends on weather conditions during the entire growing season. The fall months were characterized by wet and warm conditions. Precipitation was slightly above the 30-year normal. October was unusually warmer than it has been in previous years. Precipitation and warm temperatures were beneficial for wheat germination and emergence. Some concerns were expressed regarding warm temperatures leading to advanced growth of early planted wheat and its high water use. November started with frigid weather conditions across Southeastern Colorado. There were some concerns expressed over winterkill. During December and most of the winter months, producers remained concerned about wheat conditions, as a consequence of hard freezes, particularly in areas where advanced growth of the crop was observed. The weather patterns with cold temperatures also brought snow that helped insulate and protect the crop from excessive winterkill.

Wheat began breaking dormancy in early March. As warm temperatures and dry conditions prevailed, moisture stress was observed in several locations across Southeastern Colorado. During April, dry conditions persisted and dry pockets in wheat fields became more pronounced where no replenishing moisture events occurred. As dry conditions prevailed, outbreaks of army cutworms, pale western cutworms, and false wireworms significantly affected a large percentage of wheat fields. Severity of the insect pressure ranged from minor to severe. May was characterized by widespread precipitation events. May 2015 is considered to be the wettest month on record for Southeastern Colorado. Accumulated precipitation ranged from 5.64 inches at Walsh to 9.25 inches at Eads. Also, May was marked by cooler temperatures. The wet and cool conditions were favorable for the development of stripe rust. Damage to wheat from stripe rust depended on the variety and the amount of inoculum present. June started with strong thunderstorms and localized hail associated with several storm systems. The abundance of heat and moisture generally improved wheat conditions. However, persisting stripe rust and other fungal diseases were still observed where surplus soil moisture and cool temperatures occurred in greater frequency.

Harvest activities gradually began in the last week of June. In early July, producers made significant progress in harvesting wheat in the midst of scattered precipitation. In Southeastern Colorado, wheat harvest was wrapped up by the third week of July. Yield ranged from 10 bu/ac to 84 bu/ac throughout Southeastern Colorado. Test weight also varied from 54 lb/bu in poor fields to 62 lb/bu in good fields. Many wheat producers reported higher yields than expected. Yield variability could be attributed to the weather pattern during the growing season, selection of adapted wheat varieties, and pest and disease control timings.

General Growing Conditions in the Central High Plains of Colorado - Ron Meyer
With the 2015 wheat harvest complete, a look back at the wheat growing season can be characterized as one of extremes. The extreme variances in both air temperatures and precipitation made the wheat growing season more than challenging. In September of 2014 conditions were dry early but quickly improved for planting operations. Beneficial moisture created good conditions for crop establishment. From October through March, winter precipitation totals were only 86% of normal. A challenge for the 2015 crop was widely fluctuating air temperatures. A long, warm fall was abruptly changed on November 13 when the low air temperature recorded at Burlington was -8.5°F. This temperature swing caused winter damage to some wheat fields. February was almost as brutal as on February 7 the high temperature at Burlington was 78°F but by February 23rd the low temperature was -5°F.

Precipitation recorded from April through May was well above normal. The Burlington area received 192% of normal amounts for the two months. Sixteen days of precipitation in May made for both good wheat growing conditions and disease-promoting environments. The wet weather was perfect for stripe rust. This fungal disease arrives from the south on strong wind currents. New stripe rust races are continually evolving and varieties that are resistant one year can be totally susceptible in another year. The best strategy for control is to pay attention to updates on stripe rust development in the southern Plains and, if conditions warrant, be ready to apply fungicides, which many producers did. The farmers who treated fields were rewarded with excellent yields – some dryland fields yielded 102 bu/ac and an average of 70 bu/ac was not uncommon. Long-term average dryland wheat yield in the Burlington area is 33 bu/ac.

The 2014-15 wheat growing season will be remembered as challenging but one of the better yielding years on record.

General Growing Conditions in the North Central High Plains of Colorado - Dennis Kaan
The fall of 2014 saw plenty of moisture and good growing conditions. Producers who started planting in early September planted into good soil moisture conditions. Heavy rain storms occurred in the middle of September, causing localized flooding and soil crusting. As a result, some producers had to replant acreages. The remainder of September and October were

seasonable. The week of November 10 saw a decline in temperature from seasonal conditions to below zero temperatures. The dramatic change in temperatures caused freeze damage and winter kill conditions. After this initial surge of cold air, temperatures returned to normal averages for the remainder of the winter. Northeast Colorado also experienced normal precipitation for the winter months.

At the first of May, an above-average precipitation pattern began that produced rainfall amounts equal to average monthly totals. The above-average precipitation was accompanied by cooler temperatures, slowing plant growth. The above-average precipitation and cool temperatures allowed many different plant diseases to spread rapidly throughout Northeast Colorado in the month of May. Many producers had to apply fungicides to maintain favorable yield potential. June and July returned to seasonal precipitation and temperature conditions. Harvest did not begin in earnest until the second week in July in Northeast Colorado. Some producers were working to finish wheat harvest at the first of August.

Dryland Variety Performance Trials - Southeast Locations

Arapahoe, Cheyenne County: Planted 9/16/14. Trial received hail on two separate storm events. The second hailstorm on June 11 caused significant damage. Lost trial. Results could not be reported. GPS: 39.014, -102.316

Lamar, Prowers County: Planted 9/15/14 and harvested 6/30/15. Good moisture at planting, survived winter well, had significant drought stress symptoms in early April. Cutworms were present. Stripe rust was present in the trial and surrounding field, but not significant, so no fungicide was applied. Trial was sprayed to control brown wheat mites and cutworms. GPS: 37.7799, -102.5473

Sheridan Lake, Kiowa County: Planted 9/15/14 and harvested 6/30/15. Had good stands in spring, no winter injury. Received good spring moisture, although it came late. Barley yellow dwarf virus was widespread in trial. Brown wheat mite and army cutworms were present. Did not spray fungicide for stripe rust. Had low levels of rust initially, then received 3 inches of rain over 6-day period in May and rust levels increased significantly. GPS: 38.565, -102.4358

Walsh, Baca County: Planted 9/18/14 Trial received severe hailstorm June 11. Trial lost. No results. GPS: 37.4346, -102.3193

Dryland Variety Performance Trials - Northeast Locations

Akron, Washington County: Planted 9/18/14 and harvested 7/14/15. Good emergence and very lush growth until November freeze. Below-freezing temperatures were registered on May 9 and May 10. Very wet month of May, over 6 inches of rain. Severe freeze damage noted on May 28 with lots of sterile and partially sterile heads, and some purpling of the heads. There were many Russian wheat aphids present. Stripe rust was not controlled early enough and caused significant damage before a fungicide was applied around June 1. GPS: 40.1526,-103.1357

Burlington, Kit Carson County: Planted 9/16/14 and harvested 7/7/15. Rain delayed planting and stands were not as good as hoped but there was very lush fall growth. Dry conditions in late fall followed by a November freeze caused severe damage in the trial. Trial received 7 to 8 inches of rain from mid-April through mid-June. Stripe rust was beginning to appear by May 27, and the stripe rust infection was considered severe by June 4. Trial was sprayed for stripe rust on June 5. GPS: 39.188, -102.299

Genoa, Lincoln County: Planted 9/20/14 and harvested 7/23/15. Very good planting conditions and emergence. In early November there were uniform stands and 5 tillers/plant. No evidence of winterkill in early April, but trial looked pale green. Freeze damage in early-maturing varieties and stripe rust present. Pale green color was more noticeable by late April. In mid-May, yellow and purple/blue stems were visible in many varieties. Tested plant samples for virus infections and none found. Most likely cause of yellowing was N deficiency and possibly P deficiency related to cold temperatures. Slight hail damage from storm on June 5. By mid-June plants had regained green color but were stunted from the lack of N. Total spring rainfall was 8.78 inches. GPS: 39.2733, -103.485

Julesburg, Sedgwick County: Planted 9/22/14 and harvested 7/16/15. Good planting conditions. Very lush fall growth. Some winter injury observed by March 12. Below-average precipitation by early April. Rainfall very good thereafter, 2.5 inches in April, 6.8 inches in May, and more in June. Small hail reported May 17, but didn't cause much damage. May 28 visit showed wheat looking great, soil very wet, and very little stripe rust on flag leaves. Fungicide was not applied and stripe rust was present- it was most likely a factor influencing yield on the most susceptible entries. GPS: 40.9005, -102.2288

Orchard, Morgan County: Planted 9/23/14 and harvested 7/27/15. Poor emergence in some plots that persisted throughout the season. Good soil moisture in January. Some winter injury occurred on varieties that showed severe winter injury at other locations. Approximately 14 inches of rainfall in spring. A stripe rust infection observed on May 18 was severe by May 28, leading to loss of up to 80% of the flag leaf of some varieties. Fungicide applied on May 22 helped to control further development of the stripe rust. Bad infestation of wheat stem sawfly causing extensive lodging and broken stems in much of the trial. GPS: 40.511, -104.071

Roggen, Weld County: Planted 9/23/14 and harvested 7/16/15. Good planting conditions followed by rain. Good winter survival of all entries, even the ones that showed injury elsewhere. Wheat was lush in early April and needed moisture. There was severe spring freeze damage in earlier varieties from the May 9 and May 10 freeze. A few Russian wheat aphids found. On May 26, wheat was wet, mostly headed, with epidemic stripe rust levels even though the trial had been sprayed. Some entries had no flag leaf left. Trial received 12.5 inches of rain from third week in April through the end of May. GPS: 40.0716, -104.2817

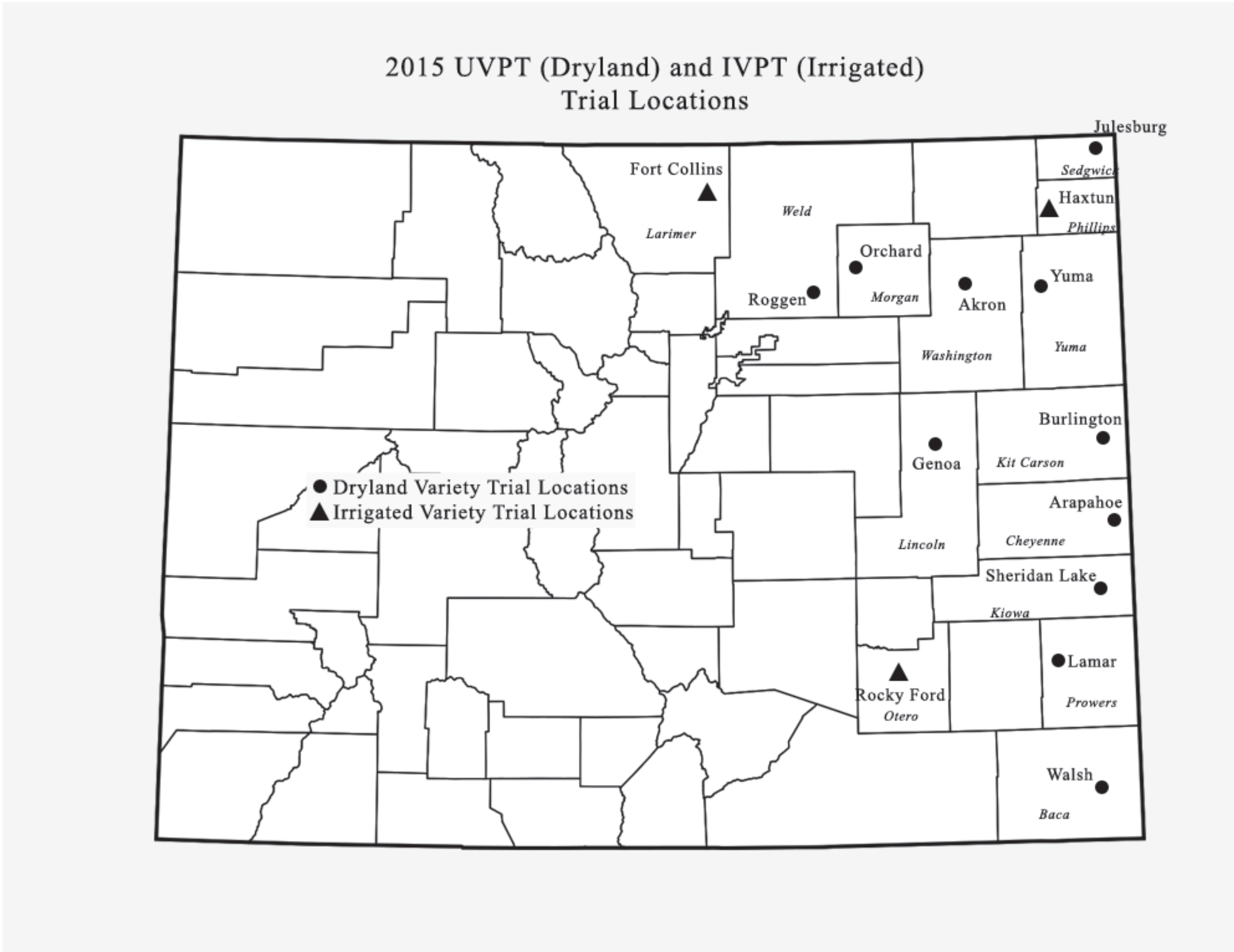
Yuma, Yuma County: Planted 9/22/14 and harvested 7/17/15. Very moist planting conditions. Erratic plant stands. November freeze damage and severe winter injury. Sprayed two times for stripe rust (early May and early June). On May 28 wheat looked better, though still poor stands, some stripe rust found lower on the canopy but nothing on flag leaves. By early June, leaf rust was beginning to appear and stripe rust had fully infected flag leaves of susceptible varieties. GPS: 40.1858, -102.6614

2015 Irrigated Variety Performance Trials

Fort Collins, Larimer County: Planted 9/22/14 and harvested 7/22/15. Good planting conditions, fall growth, and winter survival. Severe spring freeze damage occurred in early May which devastated early maturing varieties. Stripe rust was significant but not as serious as the stripe rust infections at Akron or Burlington. Insecticide (Vesper) was applied on May 18 for control of severe Russian wheat aphid infestation. No fungicide was applied. GPS: 40.653, -104.999

Haxtun, Phillips County: Planted 10/16/14 and harvested 7/20/15. The field was worked several times to get corn stalks broken up. Very late date of planting. Rough planting surface due to corn residue. Erratic plant emergence, much less than what was desired for irrigated wheat. Significant winterkill from the weather change in November (from 70°F to -10°F in one day!). Fungicide application was made relatively early (mid-to-late April) and significant stripe rust was apparent on susceptible entries by early June. GPS: 40.406, -102.607

Rocky Ford, Otero County: Planted 9/30/14. Trial lost to severe early season lodging. Results could not be reported. GPS: 38.039, -103.693


2015 UVPT (Dryland) and IVPT (Irrigated)
Trial Locations
Julesburg
Sedgwick
Haxtun
Phillips
Fort Collins
Larimer
Weld
Orchard
Roggen
Morgan
Akron
Yuma
Washington
Yuma
Burlington
Genoa
Kit Carson
Dryland Variety Trial Locations
Irrigated Variety Trial Locations
Arapahoe
Lincoln
Cheyenne
Sheridan Lake
Kiowa
Lamar
Rocky Ford
Otero
Prowers
Walsh
Baca

Summary of 2015 Dryland Variety Performance Results

Variety[b]	2015 Individual Trial Yield[a]									2015 Multi-Location Average				
	Akron	Burlington	Genoa	Julesburg	Lamar	Orchard	Roggen	Sheridan Lake	Yuma	Yield	Yield	Stripe Rust	Test Weight	Height
	bu/ac									bu/ac	% of avg	score (1-9)[c]	lb/bu	in
Joe	**90.2**	**89.1**	46.7	**88.0**	27.4	114.3	**89.2**	**86.7**	100.3	81.3	133%	1	60.7	33
CO11D1767	**81.5**	**92.1**	**50.9**	**85.3**	31.8	**118.0**	**83.7**	69.4	102.4	79.4	130%	1	57.2	33
Antero	71.5	**89.4**	**50.0**	80.8	36.5	**120.8**	63.2	**74.7**	103.3	76.7	126%	2	58.5	33
SY Monument	**75.3**	85.8	41.9	79.7	29.6	110.9	**76.5**	60.1	**106.8**	74.1	121%	2	58.8	32
CO11D1539	59.4	86.4	**49.4**	79.3	36.9	111.3	63.1	**77.7**	90.9	72.7	119%	3	58.4	33
Oakley CL	**75.0**	78.2	47.2	65.6	25.6	109.5	73.5	**85.6**	89.7	72.2	118%	1	57.6	31
CO11D1236	65.2	79.3	41.9	76.0	**37.3**	108.5	65.7	66.7	**106.1**	71.9	118%	7	59.0	34
Ruth	64.5	72.5	38.3	79.5	*21.2*	**122.1**	53.4	68.3	104.1	69.3	114%	3	59.8	33
CO11D1306W	65.9	72.9	38.4	75.1	34.4	108.0	70.8	60.8	95.6	69.1	113%	6	59.2	33
TAM 114	68.5	72.2	**47.7**	82.3	24.5	92.4	55.9	65.5	104.2	68.1	112%	2	58.9	33
Denali	57.6	67.4	38.8	76.8	29.9	107.8	67.1	55.9	**105.0**	67.4	110%	8	58.5	35
WB-Grainfield	58.4	80.7	35.1	**82.9**	22.1	96.9	58.7	74.1	90.1	66.6	109%	2	58.9	33
CO11D1353	38.0	70.7	41.8	73.4	**38.2**	93.2	**73.6**	69.5	88.5	65.2	107%	6	56.8	34
CO11D446	34.6	**92.2**	46.0	**87.3**	28.9	87.5	37.9	74.2	98.0	65.2	107%	3	58.9	31
CO11D1298	52.1	66.8	30.0	70.2	34.5	108.9	70.5	45.9	104.9	64.9	106%	6	56.5	33
Winterhawk	44.1	66.3	38.4	70.5	26.4	109.1	56.7	62.1	**107.5**	64.6	106%	4	58.4	33
LCS Mint	45.6	72.7	41.1	54.3	34.0	**117.2**	63.0	68.8	83.8	64.5	106%	4	57.6	34
SY Wolf	54.6	59.6	42.9	62.8	26.4	102.8	69.2	61.4	88.9	63.2	104%	3	56.7	32
Avery	34.6	73.3	31.3	70.9	**37.0**	107.1	53.6	62.1	87.2	61.9	101%	7	57.2	35
TAM 204	53.4	72.8	30.5	66.5	26.6	99.2	63.5	67.7	72.7	61.4	101%	2	55.3	30
KanMark	36.2	77.1	42.0	66.4	25.3	102.9	55.7	57.2	88.9	61.3	100%	6	58.6	28
Sunshine	38.2	72.5	41.0	72.9	23.2	101.3	35.3	67.4	99.4	61.2	100%	4	57.1	31
LCS Pistol	51.3	78.5	36.8	72.9	*19.6*	*79.1*	47.8	64.6	95.5	60.7	99%	6	57.8	32
Cowboy	42.4	63.5	32.4	67.2	27.7	102.5	65.3	48.4	89.5	59.9	98%	8	56.2	33
Byrd	30.1	75.1	28.0	68.4	33.4	104.1	43.1	62.3	93.4	59.8	98%	7	58.0	34
LCH13DH-5-59	38.6	66.7	29.8	73.6	32.9	101.2	50.1	*39.6*	103.1	59.5	98%	7	57.0	36
CO11D1397	30.0	74.2	28.2	66.5	**37.9**	92.7	53.2	56.3	93.8	59.2	97%	8	56.9	31
Snowmass	35.6	70.1	31.4	65.8	27.3	98.3	43.6	58.0	101.3	59.0	97%	8	56.9	34
Settler CL	32.2	62.8	28.8	68.0	25.7	104.1	40.2	58.1	101.0	57.9	95%	7	55.6	31
Hatcher	39.0	64.9	46.6	63.5	26.3	93.9	48.4	65.4	71.8	57.8	95%	5	56.0	33
T158	43.5	70.0	35.2	72.1	23.2	*82.5*	43.6	61.2	82.4	57.1	94%	2	57.8	31
TAM 113	39.3	65.3	36.8	53.0	28.8	*81.9*	63.7	65.3	*64.6*	55.4	91%	4	56.6	32
Gallagher	41.0	66.8	32.5	57.8	24.5	94.5	38.9	58.3	79.3	54.8	90%	4	55.1	29
CO11D1316W	27.9	59.9	29.0	54.2	31.8	98.1	62.3	51.7	70.4	53.9	88%	8	53.8	33
Iba	30.5	61.9	39.3	*50.3*	27.4	87.1	52.4	66.7	*69.4*	53.9	88%	6	57.5	29
TAM 112	31.7	65.0	23.7	63.6	30.3	97.5	29.5	56.4	83.8	53.5	88%	7	59.9	31
MTS1024	40.1	*51.6*	31.8	63.5	*18.5*	106.7	62.2	*32.6*	*59.7*	51.9	85%	4	53.5	32
Brawl CL Plus	30.9	65.5	31.0	62.5	*17.8*	87.2	*26.8*	59.5	83.9	51.7	85%	6	58.3	32
Above	21.9	61.2	22.6	52.4	23.7	97.4	35.1	50.9	77.7	49.2	81%	7	56.1	30
Akron	*18.1*	*54.1*	23.6	*49.0*	26.3	92.5	38.4	52.3	80.4	48.3	79%	8	55.4	33
CO11D1174	*16.2*	60.1	*19.1*	51.6	29.4	93.1	*24.5*	43.4	83.0	46.7	77%	8	52.5	31
Prairie Red	22.2	61.3	*21.4*	54.5	24.6	*85.3*	29.1	46.2	*67.5*	45.8	75%	8	56.4	30
Ripper	*16.9*	*51.3*	*14.8*	*49.3*	22.2	103.8	*24.0*	*40.6*	80.4	44.8	73%	9	53.8	30
Bearpaw	*8.6*	*48.2*	*18.7*	*43.7*	24.7	93.3	*26.1*	*24.1*	92.2	42.2	69%	7	52.2	32
Average	**44.4**	**70.2**	**35.3**	**67.5**	**28.2**	**100.6**	**53.4**	**60.1**	**89.6**	**61.0**		**5**	**57.1**	**32**
[d]LSD (P<0.30)	5.1	4.5	4.5	4.6	3.3	9.2	4.6	5.7	6.0					

[a]Top four yielding varieties in each location are in bold and bottom four yielding varieties in each location are in italics.

[b]Varieties ranked according to multi-location average yield in 2015.

[c]Stripe rust score: 1 equals no stripe rust and 9 equals severe stripe rust infection.

[d]If the difference between two variety yields equals or exceeds the LSD value then they are significantly different with less than 30% probability that the difference is due to random error.

Summary of 2-Year (2014-2015) Dryland Variety Performance Results

Variety[b]	Brand/Source	Market Class[c]	2-Year Average[a]			
			Yield	Yield	Test Weight	Plant Height
			bu/ac	% trial average	lb/bu	in
Antero	PlainsGold	**HWW**	69.5	120%	59.4	30
SY Monument	AgriPro Syngenta	HRW	65.4	113%	59.9	29
Oakley CL	Kansas Wheat Alliance	HRW	65.1	113%	59.0	28
Denali	PlainsGold	HRW	63.3	110%	60.7	30
Avery	Colorado State Univ. exp.	HRW	63.0	109%	59.7	31
CO11D446	Colorado State Univ. exp.	HRW	62.0	107%	60.3	27
WB-Grainfield	WestBred Monsanto	HRW	60.6	105%	60.4	30
SY Wolf	AgriPro Syngenta	HRW	60.5	105%	58.3	28
Byrd	PlainsGold	HRW	60.1	104%	60.0	30
Cowboy	Crop Res. Foundation of WY	HRW	60.0	104%	59.2	29
Winterhawk	WestBred Monsanto	HRW	60.0	104%	60.8	30
LCS Mint	Limagrain	HRW	59.9	104%	59.9	30
Sunshine	PlainsGold	**HWW**	58.8	102%	58.2	28
LCS Pistol	Limagrain	HRW	58.4	101%	59.4	28
Settler CL	Husker Genetics	HRW	58.3	101%	57.7	28
Snowmass	PlainsGold	**HWW**	57.7	100%	59.2	31
Hatcher	PlainsGold	HRW	57.5	100%	58.4	29
KanMark	Kansas Wheat Alliance	HRW	57.3	99%	60.3	25
T158	Limagrain	HRW	55.6	96%	59.5	27
TAM 113	AGSECO	HRW	55.1	95%	58.6	28
Gallagher	Oklahoma Genetics	HRW	54.6	95%	57.0	27
Iba	Oklahoma Genetics	HRW	54.3	94%	59.3	27
TAM 112	Watley Seed	HRW	54.1	94%	61.3	28
Brawl CL Plus	PlainsGold	HRW	53.5	93%	59.9	29
Above	PlainsGold	HRW	51.8	90%	58.1	28
Akron	Colorado State Univ.	HRW	51.6	89%	58.5	30
Ripper	PlainsGold	HRW	50.6	88%	57.4	27
Prairie Red	PlainsGold	HRW	50.1	87%	58.1	27
Bearpaw	Montana State Univ.	HRW	46.1	80%	57.0	28
		Average	**57.8**		**59.2**	**28**

[a]The 2-year average yield and plant heights are based on nine 2015 and nine 2014 trials. Test weights are based on six 2015 and eight 2014 trials.

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

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

Summary of 3-Year (2013-2015) Dryland Variety Performance Results

			3-Year Average[a]			
Variety[b]	Brand/Source	Market Class[c]	Yield	Yield	Test Weight	Plant Height
			bu/ac	% trial average	lb/bu	in
Antero	PlainsGold	**HWW**	57.8	120%	58.6	28
Oakley CL	Kansas Wheat Alliance	HRW	54.1	112%	58.4	26
Denali	PlainsGold	HRW	52.6	109%	59.7	29
Byrd	PlainsGold	HRW	50.8	105%	58.8	28
WB-Grainfield	WestBred Monsanto	HRW	50.7	105%	58.9	28
LCS Mint	Limagrain	HRW	50.6	105%	59.4	29
Winterhawk	WestBred Monsanto	HRW	50.3	104%	59.9	28
SY Wolf	AgriPro Syngenta	HRW	50.2	104%	58.0	27
Settler CL	Husker Genetics	HRW	49.2	102%	56.9	26
Hatcher	PlainsGold	HRW	47.7	99%	57.8	27
Snowmass	PlainsGold	**HWW**	47.3	98%	57.8	29
T158	Limagrain	HRW	47.0	97%	58.3	26
Iba	Oklahoma Genetics	HRW	46.2	96%	58.6	25
TAM 113	AGSECO	HRW	46.2	96%	57.8	27
TAM 112	Watley Seed	HRW	46.1	95%	59.8	27
Gallagher	Oklahoma Genetics	HRW	45.9	95%	56.7	25
Brawl CL Plus	PlainsGold	HRW	45.8	95%	58.9	28
Above	PlainsGold	HRW	44.2	92%	57.2	26
Ripper	PlainsGold	HRW	43.5	90%	56.6	26
Bearpaw	Montana State Univ.	HRW	38.7	80%	56.8	26
		Average	**48.2**		**58.2**	**27**

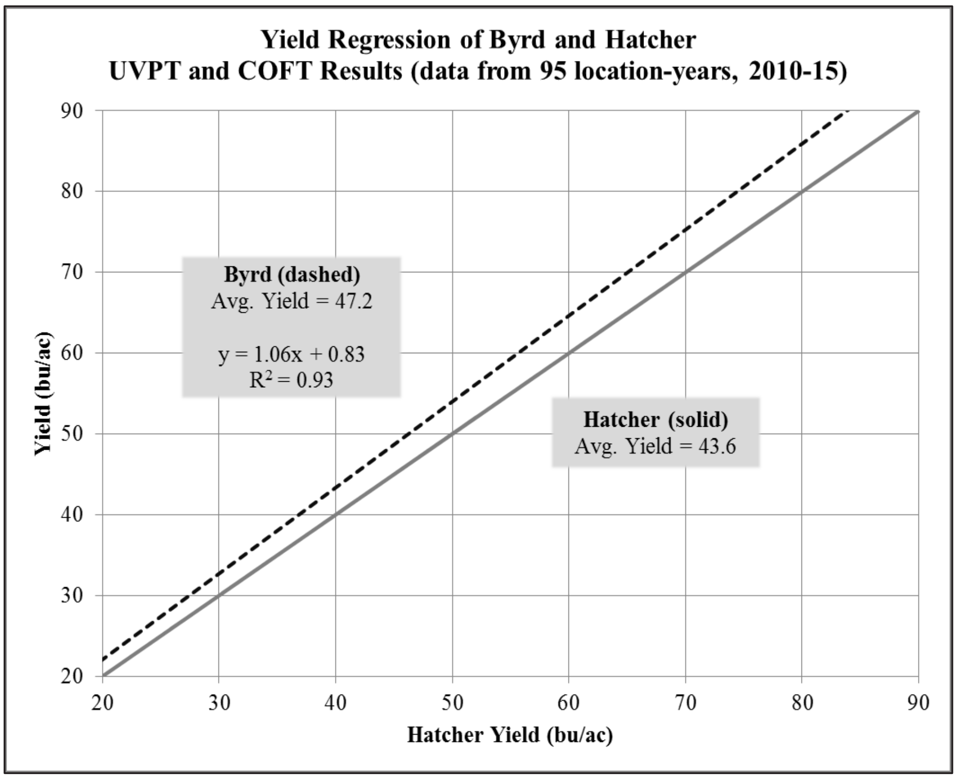
[a]The 3-year average yield is based on nine 2015, nine 2014, and seven 2013 trials. Test weights are based on six 2015, eight 2014, and five 2013 trials. Plant heights are based on nine 2015, nine 2014, and six 2013 trials.

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

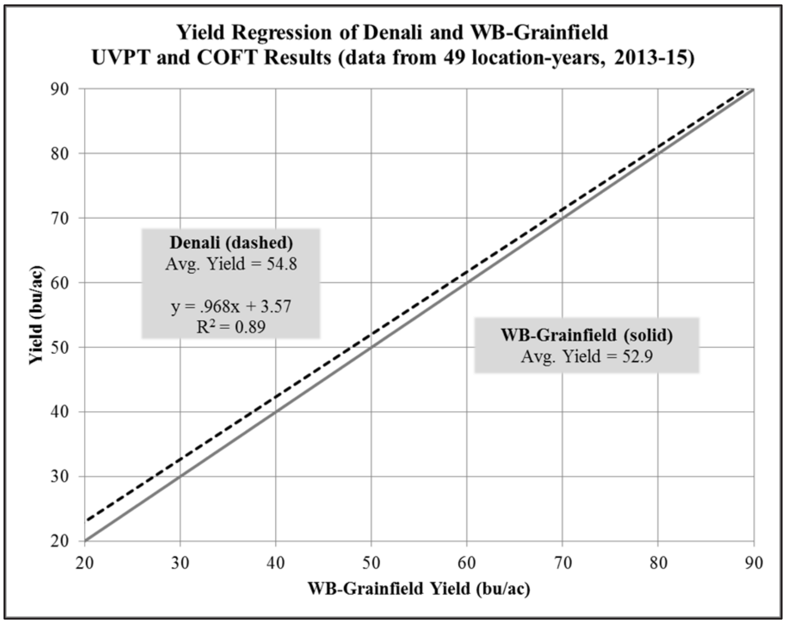
[c]Market class: HRW=hard red winter wheat; **HWW**=hard white winter wheat.

The Relative Performance of One Variety by Comparison to Another Variety

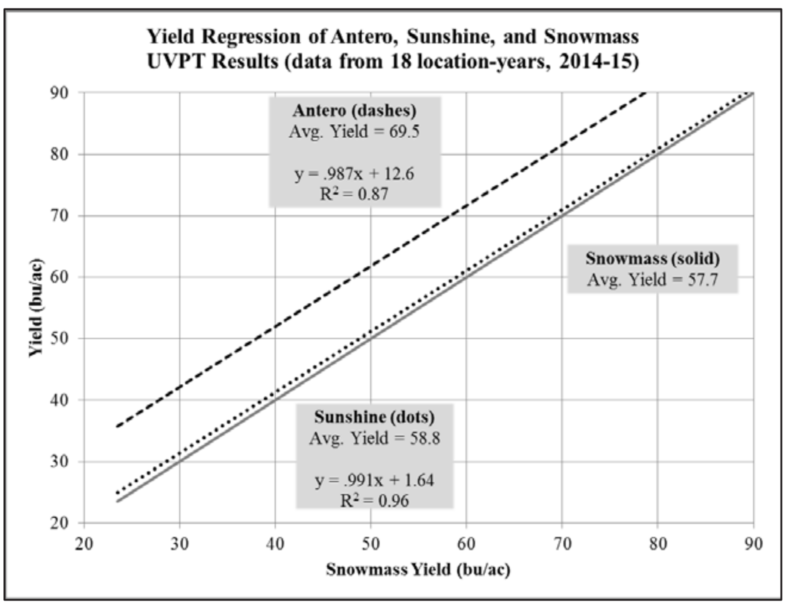
The following regressions are intended for use by the reader to be able to compare the predicted performance of one variety relative to another using results from multiple Dryland Variety Performance Trials and Collaborative On-Farm Test results over the past six years (2010 through 2015). They are a tool to help growers visualize these relationships. The equation shown in each graph can be used to predict the yield of a variety given a yield of the variety listed on the bottom (x-axis) of the graph. The R^2 value of the regression is a statistical measure that represents how well a regression line fits the actual data. An R^2 value 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.



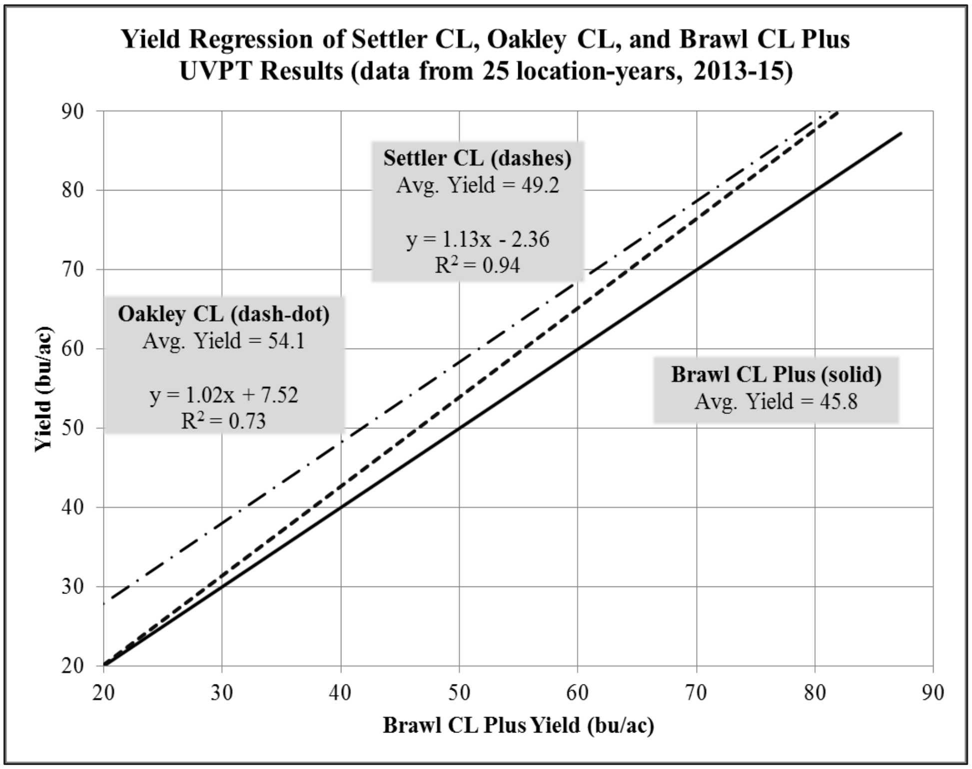
In the graph above of Byrd and Hatcher, the regression line of Byrd (dashed) is above Hatcher at range of yield levels shown. Byrd is predicted to yield somewhat higher than Hatcher in lower yielding environments and much higher than Hatcher in high-yield environments. If Hatcher yielded 30 bu/ac, then we would predict Byrd to yield 32.6 bu/ac. If Hatcher yielded 80 bu/ac, then we would predict Byrd to yield 85.6 bu/ac.



The graph above shows the comparison of two hard red varieties, Denali and WB-Grainfield. At low yield levels, Denali is predicted to have a higher yield than WB-Grainfield, while at higher yield levels, their yields are predicted to be very similar. When WB-Grainfield yields 22 bu/ac, Denali is predicted to yield 25 bu/ac, and at a WB-Grainfield yield of 80 bu/ac, Denali is predicted to yield 81 bu/ac.



This graph shows a comparison among three hard white winter varieties, Antero and Sunshine over Snowmass. There is not a substantial predicted difference in yield between Snowmass and Sunshine. Antero is predicted to be much higher yielding (by 11 or 12 bu/ac) than either Snowmass or Sunshine at all yield levels.



The final graph shows a comparison among three Clearfield varieties, Settler CL, Oakley CL, and Brawl CL Plus. Clearly, Oakley CL will be higher yielding than Brawl CL Plus by approximately 8 bu/ac across all yield environments. However, Brawl CL Plus is a two-gene Clearfield variety and Oakley CL is only a single-gene Clearfield variety. Brawl CL Plus is intended to be used to clean up difficult-to-control winter annual grasses like volunteer rye that could not be controlled in Oakley CL wheat. Control of volunteer rye can be extremely important for some farmers—more important than the yield losses they may suffer from planting Brawl CL Plus instead of other varieties. Settler CL is predicted to yield lower than Oakley CL at very low yields, and about the same as Oakley CL at high yield levels.

2015 Collaborative On-Farm Test (COFT) Variety Performance Results

Jerry Johnson, Bruce Bosley, Wilma Trujillo, Dennis Kaan, Ron Meyer, and Sally Sauer

The objective of our on-farm testing program is to compare the performance of wheat varieties that are of most interest to Colorado farmers. In 2015, six varieties were included: Byrd (popular HRW), Brawl CL Plus (herbicide tolerant HRW), Denali (HRW), Snowmass (extremely high quality HWW), Sunshine (newly released high quality HWW) and WB-Grainfield (new HRW from WestBred). Varieties in the COFT program are tested under farm field-scale conditions with farmer equipment. Colorado State University Extension Specialists oversee all aspects of the program. The COFT program is in its 19th year and the majority of Colorado's winter wheat acreage is planted to varieties that have been tested in the program. On-farm testing leads to more rapid replacement of older inferior varieties and wider and faster adoption of improved varieties.

In the fall of 2014, over thirty eastern Colorado wheat producers received seed of the six varieties and planted them in side-by-side strips under the same conditions as the wheat in the rest of the field. Twenty-four viable harvest results were obtained. Failed tests were due to drought conditions and hail. In 2015, there were extremes in yield across Colorado. The highest yielding strip was over 100 bu/acre while the lowest recorded yield this year was 15 bu/acre. Yields were affected by winterkill, spring freeze, stripe rust infections, winter drought, viruses, Russian wheat aphid, cutworm, and losses to brown wheat mite.

The varieties tested in COFT this year fit different farmer needs. For those looking for control of winter annual grasses, Brawl CL Plus is the obvious choice even though its yield this year was lower than the past few years. Farmers wanting to grow white wheat with exceptional quality should be growing Snowmass or Sunshine. The statistically different yield this year among the three remaining varieties (Byrd, Denali, and WB-Grainfield) can be seen in the COFT table. In past years under normal conditions (drought), Byrd and Denali have been higher yielding than WB-Grainfield in the variety performance trials. Byrd and Denali are moderately susceptible to stripe rust while WB-Grainfield is moderately resistant. WB-Grainfield is early maturing, Byrd is medium maturing, and Denali is later maturing. WB-Grainfield generally has higher test weight and protein. Don't select a variety to plant based upon the results from a single on-farm test. It is very important to use results from multiple years and multiple locations.

We should not be lulled into complacency by the good precipitation received in 2015. It should not be forgotten that drought is the major yield-determining factor in eastern Colorado. You can't spray for drought.

2015 Collaborative On-Farm Test (COFT) Variety Performance Results

2015 Varieties[a]

County/Nearest Town	Denali			WB-Grainfield			Byrd			Sunshine			Snowmass			Brawl CL Plus			COFT Average		
	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 N	47.7	62.3	9.1	48.2	62.5	9.6	46.2	61.2	9.0	47.8	61.0	8.6	40.4	61.5	8.8	35.2	64.5	11.1	*44.2*	*62.2*	*9.4*
Adams/Prospect Valley	47.4	59.6	9.4	49.5	59.5	9.5	49.4	57.4	9.5	59.1	57.6	8.8	50.7	59.2	9.9	36.8	56.2	10.6	*48.8*	*58.3*	*9.6*
Arapahoe/Deer Trail	16.6	53.4	11.3	14.6	53.5	12.6	21.9	53.5	10.0	17.1	54.5	10.8	18.6	52.5	10.9	18.7	54.0	10.1	*17.9*	*53.6*	*10.9*
Baca/Pritchett	59.3	64.4	9.5	54.2	63.7	11.0	65.2	62.6	9.4	61.5	62.6	10.4	53.5	62.6	9.8	54.3	63.2	11.3	*58.0*	*63.2*	*10.2*
Baca/Vilas	57.1	60.9	10.9	43.4	58.3	13.0	48.4	60.5	11.6	52.3	59.4	11.2	51.3	60.5	12.5	49.1	60.3	11.7	*50.3*	*60.0*	*11.8*
Bent/Lamar	31.2	60.2	13.0	25.3	60.8	13.5	27.5	59.0	13.7	29.5	60.1	14.1	31.7	58.3	13.2	22.2	60.0	15.1	*27.9*	*59.7*	*13.7*
Cheyenne/Cheyenne Wells	21.1	58.1	13.1	19.5	57.1	13.4	24.8	58.2	13.0	20.8	57.2	13.9	25.8	57.4	13.7	16.2	55.9	14.5	*21.3*	*57.3*	*13.6*
Crowley/Olney Springs	35.9	58.6	10.9	24.4	57.8	11.7	27.2	59.0	12.1	32.6	58.3	10.8	39.8	58.7	11.0	27.1	58.4	12.5	*31.2*	*58.5*	*11.5*
Kit Carson/Bethune	43.4	52.6	10.5	41.2	60.5	12.7	41.4	57.8	11.5	40.6	56.6	12.3	32.2	63.0	12.5	44.8	56.1	13.5	*40.6*	*57.8*	*12.2*
Kit Carson/Bethune N	68.7	58.3	10.6	56.8	59.3	10.9	64.2	58.5	10.2	58.0	56.2	12.0	67.2	61.1	10.1	58.6	57.8	11.5	*62.3*	*58.5*	*10.9*
Kit Carson/Burlington N	85.4	61.4	11.0	100.6	63.0	10.5	88.6	61.0	11.1	89.3	62.8	11.6	75.8	62.4	10.8	83.9	59.0	12.5	*87.3*	*61.6*	*11.3*
Lincoln/Arriba	64.4	60.9	9.9	60.8	59.4	10.7	47.5	54.8	9.9	49.3	57.5	10.5	42.7	51.9	9.8	28.9	54.9	13.0	*48.9*	*56.6*	*10.6*
Morgan/Orchard	78.3	59.6	-	69.1	59.6	-	77.1	59.4	-	62.6	59.7	-	72.2	59.4	-	59.5	59.0	-	*69.8*	*59.5*	-
Otero/Manzanola	46.0	57.1	9.5	42.8	55.9	11.0	58.3	58.1	9.7	57.8	58.2	-	56.4	57.2	10.7	51.3	57.4	10.9	*52.1*	*57.3*	*10.4*
Phillips/Haxtun	87.8	60.0	10.2	79.1	61.0	10.5	85.0	61.0	9.7	89.0	60.5	10.0	64.9	60.0	10.6	72.9	60.0	12.1	*79.8*	*60.4*	*10.5*
Prowers/Lamar S	29.5	57.1	10.2	26.7	57.8	11.4	32.6	58.2	11.3	26.8	58.2	11.3	31.7	58.2	10.7	27.9	57.4	11.8	*29.2*	*57.8*	*11.1*
Washington/Akron	48.1	55.0	9.3	45.7	57.0	10.9	32.1	53.0	10.8	35.3	56.0	11.6	26.0	51.0	10.1	21.6	53.0	13.5	*34.8*	*54.2*	*11.0*
Washington/Akron S	58.2	55.0	10.9	77.3	59.0	12.6	58.9	57.0	11.9	55.9	57.0	12.5	57.9	55.0	11.3	46.3	58.0	13.9	*59.1*	*56.8*	*12.2*
Washington/Central	65.2	-	-	67.0	-	-	61.1	-	-	68.6	-	-	50.7	-	-	46.5	-	-	*59.9*	-	-
Weld/Keenesburg	75.3	58.3	9.9	89.6	59.7	11.2	68.0	58.7	11.1	72.2	59.5	10.9	66.0	56.5	10.4	55.0	60.3	12.8	*71.0*	*58.8*	*11.0*
Weld/New Raymer SE	60.0	58.7	9.6	57.2	58.5	9.4	69.0	59.5	8.7	58.0	58.8	9.3	57.5	58.8	10.1	68.7	57.6	8.9	*61.7*	*58.7*	*9.3*
Weld/New Raymer SW	106.5	60.5	10.9	98.3	61.0	11.7	104.8	60.5	11.4	97.2	60.0	11.2	96.0	60.0	11.0	64.8	60.0	14.2	*94.6*	*60.3*	*11.7*
Weld/Roggen	83.4	60.0	10.8	78.1	58.8	11.7	73.2	59.4	12.1	65.3	58.3	12.6	69.5	57.7	10.5	52.6	57.5	13.0	*70.4*	*58.6*	*11.8*
Yuma/Yuma	55.6	61.8	9.1	57.6	60.9	9.0	49.9	59.3	9.4	48.5	60.4	9.9	41.9	60.8	9.6	46.5	61.9	10.8	*50.0*	*60.9*	*9.6*
Average	**57.2**	**58.9**	**10.4**	**55.3**	**59.3**	**11.3**	**55.1**	**58.6**	**10.8**	**54.0**	**58.7**	**11.2**	**50.9**	**58.4**	**10.8**	**45.4**	**58.4**	**12.2**	***53.0***	***58.7***	***11.1***
Yield Significance[c]	A			A,B			B			B			C			D					

LSD $_{(P<0.30)}$ for yield = 2 bu/ac

LSD $_{(P<0.30)}$ for test weight = 0.4 lb/bu

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

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

[b]All yields are corrected to 12% moisture.

[c]Yield and test weight significance: varieties with different letters have yields or test weights that are significantly different from one another.

Summary of 2-Year (2014-2015) Irrigated Variety Performance Results at Fort Collins

			2-Year Average					
Variety[a]	Brand/Source	Market Class[b]	Yield	Yield	Test Weight	Plant Height	Heading	Lodging
			bu/ac	% trial average	lb/bu	in	days from trial average	scale (1-9)[c]
Denali	PlainsGold	HRW	108.7	117%	62.0	35	2	3
LCS Mint	Limagrain	HRW	108.1	117%	62.0	36	1	2
Avery	Colorado State Univ. exp.	HRW	105.3	114%	60.7	35	-1	5
Antero	PlainsGold	**HWW**	105.3	114%	61.0	36	1	4
Cowboy	Crop Res. Found. of WY	HRW	104.5	113%	61.3	34	3	5
SY Wolf	AgriPro Syngenta	HRW	100.5	109%	60.2	34	2	3
Byrd	PlainsGold	HRW	94.6	102%	60.2	35	-2	4
Hatcher	PlainsGold	HRW	93.3	101%	59.6	34	1	4
Iba	Oklahoma Genetics	HRW	90.6	98%	60.0	34	1	2
Oakley CL	Kansas Wheat Alliance	HRW	90.2	98%	60.9	35	2	4
KanMark	Kansas Wheat Alliance	HRW	90.1	97%	60.6	31	1	2
CO11D446	Colorado State Univ. exp.	HRW	90.0	97%	58.8	32	-4	4
Thunder CL	PlainsGold	**HWW**	87.8	95%	60.6	34	-1	2
LCS Pistol	Limagrain	HRW	87.1	94%	59.9	33	-3	3
WB-Cedar	WestBred Monsanto	HRW	83.9	91%	57.9	29	-6	1
Brawl CL Plus	PlainsGold	HRW	81.1	88%	60.3	33	-2	1
Yuma	CO State Univ.	HRW	80.4	87%	58.7	33	-1	3
T158	Limagrain	HRW	79.7	86%	59.4	33	-2	2
Sunshine	PlainsGold	**HWW**	76.9	83%	59.0	32	-3	1
		Average	**92.5**		**60.2**	**34**		**3**

[a]Varieties ranked according to average 2-year yield at Fort Collins.

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

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

Summary of 3-Year (2013-2015) Irrigated Variety Performance Results at Fort Collins

			3-Year Average					
Variety[a]	Brand/Source	Market Class[b]	Yield	Yield	Test Weight	Plant Height	Heading	Lodging[c]
			bu/ac	% trial average	lb/bu	in	days from trial average	scale (1-9)[d]
Antero	PlainsGold	**HWW**	98.0	115%	61.3	34	0	4
Denali	PlainsGold	HRW	94.1	110%	61.9	33	3	3
Byrd	PlainsGold	HRW	90.3	106%	60.7	33	-1	4
SY Wolf	AgriPro Syngenta	HRW	89.2	105%	60.4	32	2	3
Hatcher	PlainsGold	HRW	85.7	101%	60.0	30	1	4
Iba	Oklahoma Genetics	HRW	83.0	97%	60.5	32	1	2
Thunder CL	PlainsGold	**HWW**	83.0	97%	60.8	32	-1	2
WB-Cedar	WestBred Monsanto	HRW	80.6	95%	58.3	28	-5	1
T158	Limagrain	HRW	79.3	93%	59.8	30	-2	2
Brawl CL Plus	PlainsGold	HRW	78.0	91%	60.7	32	-2	1
Yuma	CO State Univ.	HRW	76.5	90%	59.2	31	0	3
		Average	**85.2**		**60.3**	**32**		**3**

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

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

[c]Lodging scores based on 2014 and 2015 data.

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

Summary of 2-Year (2014-2015) Irrigated Variety Performance Results at Haxtun

Variety[a]	Brand/Source	Market Class[b]	2-Year Average Yield	Yield	Test Weight	Plant Height	Lodging[c]
			bu/ac	% trial average	lb/bu	in	scale (1-9)[d]
CO11D446	Colorado State Univ. exp.	HRW	98.6	112%	59.1	33	7
Antero	PlainsGold	**HWW**	96.8	110%	56.5	36	5
SY Wolf	AgriPro Syngenta	HRW	96.1	110%	54.4	32	1
WB-Cedar	WestBred Monsanto	HRW	95.2	109%	59.8	29	2
Denali	PlainsGold	HRW	94.9	108%	58.4	38	4
Sunshine	PlainsGold	**HWW**	92.8	106%	56.9	34	4
Oakley CL	Kansas Wheat Alliance	HRW	91.6	104%	55.7	35	7
LCS Pistol	Limagrain	HRW	89.7	102%	56.2	33	8
KanMark	Kansas Wheat Alliance	HRW	89.6	102%	58.0	31	1
Byrd	PlainsGold	HRW	87.7	100%	57.8	35	7
T158	Limagrain	HRW	86.6	99%	56.0	32	8
Cowboy	Crop Res. Found. of WY	HRW	86.3	98%	55.4	36	5
Brawl CL Plus	PlainsGold	HRW	85.6	98%	57.4	34	4
Avery	Colorado State Univ. exp.	HRW	84.0	96%	56.8	35	7
Hatcher	PlainsGold	HRW	81.9	93%	56.8	33	7
Thunder CL	PlainsGold	**HWW**	79.2	90%	55.3	36	3
Iba	Oklahoma Genetics	HRW	77.4	88%	54.5	33	3
LCS Mint	Limagrain	HRW	77.0	88%	55.9	36	5
Yuma	CO State Univ.	HRW	76.0	87%	56.6	34	4
		Average	**87.8**		**56.7**	**34**	**5**

[a]Varieties ranked according to average 2-year yield at Haxtun.

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

[c]Lodging scores based on 2014 data.

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

Summary of 3-Year (2013-2015) Irrigated Variety Performance Results at Haxtun

			3-Year Average				
Variety[a]	Brand/Source	Market Class[b]	Yield	Yield	Test Weight	Plant Height	Lodging[c]
			bu/ac	% trial average	lb/bu	in	scale (1-9)[d]
Denali	PlainsGold	HRW	108.2	110%	58.9	37	4
Antero	PlainsGold	**HWW**	105.6	108%	57.5	36	4
WB-Cedar	WestBred Monsanto	HRW	103.6	106%	60.4	29	2
SY Wolf	AgriPro Syngenta	HRW	103.1	105%	56.1	32	1
T158	Limagrain	HRW	98.6	101%	57.8	32	5
Byrd	PlainsGold	HRW	98.5	100%	58.3	35	5
Brawl CL Plus	PlainsGold	HRW	96.7	99%	59.1	34	2
Iba	Oklahoma Genetics	HRW	92.9	95%	56.2	34	3
Hatcher	PlainsGold	HRW	91.8	94%	57.8	33	6
Yuma	CO State Univ.	HRW	91.1	93%	58.1	35	3
Thunder CL	PlainsGold	**HWW**	88.5	90%	56.7	35	2
		Average	**98.1**		**57.9**	**34**	**3**

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

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

[c]Lodging scores based on 2013 and 2014 data.

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

Winter Wheat Variety Selection in Colorado for Fall 2015 Planting

It is not possible to accurately predict which variety will perform best in each field every year. However, there are some selection guidelines that improve the ability to select superior varieties. The variety performance summary tables in this report provide useful information to farmers for improving variety selection. Other guidelines that improve variety selection are below. Most producers know that they should plant more than one variety.

- Producers should focus on multi-year and multi-location yield summary results when selecting a new variety. Recently, Scott Haley has elegantly shown that statistically, the best predictor of future performance is results from three-year multi-location summaries.

- Producers should pay attention to ratings for maturity, plant height, coleoptile length, disease and insect resistance, and end-use quality characteristics. Refer to the Description of Winter Wheat Varieties in Eastern Colorado Dryland and Irrigated Trials (2016) for variety-specific information. There are descriptions in this table for all of the varieties found in the current variety trials.

Some other factors that influence the success of a wheat crop that should not be neglected:

- Producers should be aware of current ratings for stripe rust resistance as well as the potential of new races of stripe rust to develop unexpectedly (as occurred in 2010 and 2012). If variety resistance/susceptibility, market prices, expected yield levels, and fungicide and application costs warrant an application, farmers should consult the North Central Regional Committee on Management of Small Grain Diseases (NCERA-184) fungicide efficacy chart. Regular updates to this chart can be found on the CSU Wheat Breeding Program "Wheat Links" page (wheat.colostate.edu/links.html).

- Producers should plant treated seed for protection against common bunt (stinking smut) and other seed-borne diseases. Information on seed treatments is available from Michigan State University and Kansas State University at: tinyurl.com/hv5m9js and tinyurl.com/jgeznub

- Producers should control volunteer wheat and weeds to avoid loss of valuable soil moisture and to avoid creating 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 vectored by aphids (barley yellow dwarf virus).

- Producers should soil sample to determine optimum fertilizer application rates. Sampling should be done prior to planting. Information on fertilizing winter wheat is available from Colorado State University Extension at: bit.ly/1K7pMGA

- Producers should plant seeds per acre and not pounds per acre. Different varieties and seed lots can vary widely in seed size. Refer to the How to Calibrate Your Drill available online at csucrops.com (click on the winter wheat tab) or directly at the following link: bit.ly/1MS5Hdh

Dryland Variety Performance – 2015

Many new varieties possessing multiple valuable traits and superior dryland or irrigated yields are currently available. The six top yielding varieties described in greater detail below are based on their rank in three-year average dryland yield performance.

Antero – A hard white wheat (HWW), released in 2012, and marketed by PlainsGold. It is very high-yielding and has the highest three-year average dryland yield two years in a row. It was also the top-yielding variety in the 2014 COFT. It has medium height and maturity, good drought stress tolerance, good test weight, good stripe rust resistance, and moderate sprouting tolerance (similar to Hatcher). For the 2016 crop, a grower premium will not be offered by Ardent Mills for Antero grown in Colorado.

Oakley CL – A medium-maturing hard red wheat (HRW) single gene Clearfield variety released in 2013 by Kansas State University-Hays and marketed by Wildcat Genetics. This variety with medium height and average test weight has very good stripe rust resistance. It has good milling and baking characteristics, and good WSMV resistance.

Denali – A medium-late-maturing HRW variety marketed by PlainsGold for production in Colorado and marketed in Kansas by Wildcat Genetics. It is photoperiod sensitive, which can cause late heading in years with abnormally warm early spring temperatures (as in 2012). It is medium-tall, has excellent test weight and average milling and baking quality, and is moderately susceptible to current races of stripe rust.

Byrd – A medium-maturing, medium-height, high-yielding HRW, marketed by PlainsGold. Byrd was the top-yielding variety across the dryland locations in 2010, 2011, and 2012 and second to Antero in 2013 and 2014. It was the top yielder in the 2012 and 2013 COFT. Byrd has excellent drought stress tolerance, average test weight, and excellent milling and baking qualities. Byrd carries a gene for resistance to the wheat curl mite (vector of wheat streak mosaic virus) and is moderately susceptible to current races of stripe rust.

WB-Grainfield – An early-maturing, tall, hard red variety released from WestBred Monsanto in 2012. It has good resistance to current races of leaf and stripe rust. It has average test weight and good milling characteristics. It was also one of the top-yielding varieties in this year’s COFT.

LCS Mint – A 2011 hard red release that is marketed by Limagrain Cereal Seeds. It is a medium-maturing and medium-tall variety with moderately good resistance to current races of stripe rust and excellent test weight. It has excellent milling and baking characteristics.

Variety Selection for Irrigated Production Conditions at Haxtun and Fort Collins

The most criteria for irrigated variety selection are yield, straw strength, and stripe rust resistance. Under limited-irrigation conditions, drought stress tolerance can also be important.

The top five yielding varieties at each irrigated variety trial location based on a three-year average are shown below. Variety selection recommendations are not included for Rocky Ford as trials could not be harvested for yield for different reasons in the past two years.

Haxtun

Denali – See dryland description above. It has above-average straw strength and moderate susceptibility to stripe rust.

Antero – See dryland description above. It has very high yields under dryland and irrigated conditions, average straw strength, and good resistance to stripe rust.

WB-Cedar – An early-maturing HRW, marketed by WestBred Monsanto. It has good leaf and stripe rust resistance and excellent straw strength for high-input irrigated conditions. It has below-average winterhardiness.

SY Wolf – A medium-maturing HRW, marketed by AgriPro Syngenta. It has a very broad disease resistance package, with good protection for leaf spotting diseases (tan spot and *Septoria*), leaf rust, and moderate resistance to stripe rust. Very good straw strength and good milling and baking quality.

T158 – A medium-early-maturing and medium height HRW variety, marketed by Limagrain Cereal Seeds. Average straw strength, excellent drought tolerance, moderately susceptible reaction to leaf rust, and good stripe rust resistance.

Fort Collins

Antero – See descriptions above.

Denali – See descriptions above.

Byrd – See dryland description above. It has average straw strength and a moderately susceptible reaction to stripe rust.

SY Wolf - See descriptions above.

Hatcher - A medium-maturity HRW, marketed by PlainsGold. It has good test weight and moderate resistance to stripe rust. It is relatively short and develops a “speckling” condition on the leaves in the spring in the absence of disease. Has below-average straw strength.

Description of Winter Wheat Varieties in Eastern Colorado Dryland and Irrigated Trials (2015 and 2016)

Name, Class, and Pedigree	Origin	RWA*	HD	HT	SS	COL**	YR	LR	WSMV+	TW	MILL	BAKE	Comments
Above Hard red winter TAM 110*4/FS2	CSU-TX 2001	S	3	5	3	8	8	9	5	7	4	6	CSU/Texas A&M release (2001), marketed by PlainsGold. Single-gene Clearfield wheat. Early maturing semidwarf. Leaf and stripe rust susceptible. Marginal baking quality.
Akron Hard red winter TAM 107/Hail	CSU 1994	S	5	6	5	4	9	9	9	5	6	3	CSU release (1994). Vigorous growth, closes canopy early in spring and competes well with weeds. Leaf and stripe rust susceptible. Lower yields relative to more recent wheat releases, entered as historical check.
Antero Hard white winter KS01HW152-1/TAM 111	CSU 2012	S	4	6	5	6	2	7	6	4	3	6	CSU release (2012), marketed by PlainsGold. Medium height and maturity, good test weight, average straw strength, good resistance to stripe rust. Moderate sprouting tolerance.
Avery Hard red winter TAM 112/Byrd	CSU 2015	S	4	5	4	7	6	7	7+	5	4	3	CSU release (2015), marketed by PlainsGold. Doubled haploid-derived line, similar to Byrd with higher yield potential, larger kernels and slightly improved quality. Carries wheat curl mite resistance from TAM 112 parent. Intermediate reaction to stripe rust.
Bearpaw Hard red winter DMS/Rampart//Pronghorn/3/2*Rampart	MT 2011	S	9	2	3	2	7	--	--	5	6	5	Montana State University release (2011). First entered in CSU Variety Trials in 2013. Carries solid stem trait conferring protection against wheat stem sawfly damage. Short plant stature, late maturing.
Brawl CL Plus Hard red winter Teal 11A/Above//CO99314	CSU 2011	S	2	6	2	8	5	5	8	3	4	3	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 to reaction to both stripe rust and leaf rust.
Byrd Hard red winter TAM 112/CO970547-7	CSU 2011	S	4	5	4	7	7	7	7+	5	3	3	CSU release (2011), marketed by PlainsGold. Excellent drought tolerance and quality. Average test weight and straw strength. Moderately susceptible to stripe rust. Carries wheat curl mite resistance from TAM 112 parent.
Cowboy Hard red winter CO980829/TAM 111	WY-CSU 2011	R*	8	6	6	3	7	7	7	4	4	5	CSU release (2011), marketed by Crop Research Foundation of Wyoming. Sister selection to Denali, but slightly shorter, lower straw strength, and 1 lb/bu lower test weight. Similar disease reaction and quality (except RWA biotype 1 resistant).
Denali Hard red winter CO980829/TAM 111	CSU 2011	S	7	7	4	7	7	7	6	2	4	6	CSU release (2011), marketed by PlainsGold and Wildcat Genetics in Kansas. Excellent test weight. Medium tall, medium-late, medium-long coleoptile. Good straw strength and average quality. Moderate susceptibility to stripe and leaf rust.
Doublestop CL Plus Hard red winter N91D2308-13/OK03908C//OK03928C	OK 2013	S	5	5	3	8	3	3	6	3	3	3	Oklahoma State release (2013), first entered in CSU Variety Trials in 2016. Two-gene Clearfield wheat. Good leaf and stripe rust resistance, good test weight, good milling and baking quality.

Column Key - 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: 1 - very good, very resistant, very early, or very short to 9 - very poor, very susceptible, 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 biotypes of RWA.
** Coleoptile length ratings range from 1=very short (~ 50 mm or ~2 in) to 9=very long (~100 mm or ~4 in). Coleoptile lengths should be interpreted for relative variety comparisons only.
+ WSMV ratings for Byrd, TAM 112, and Avery are based on mechanical WSMV inoculation and do not take into account their resistance to the wheat curl mite vector of WSMV.

Description of Winter Wheat Varieties in Eastern Colorado Dryland and Irrigated Trials (2015 and 2016)

Name, Class, and Pedigree	Origin	RWA*	HD	HT	SS	COL**	YR	LR	WSMV+	TW	MILL	BAKE	Comments
Gallagher Hard red winter Duster/OK99711	OK 2012	S	7	5	6	4	4	3	7	6	5	5	Oklahoma State release (2012), first entered in CSU Variety Trials in 2013. Good leaf disease resistance (leaf and stripe rust resistance). May show physiological leaf spotting in cool spring conditions.
Hatcher Hard red winter Yuma/PI 372129//TAM-200/3/4*Yuma/4/KS91H184/Vista	CSU 2004	R*	6	2	7	4	5	7	8	4	5	4	CSU release (2004), marketed by PlainsGold. Medium maturing semidwarf. Good test weight, moderate resistance to stripe rust, good milling and baking quality. Develops "leaf speckling" condition.
Iba Hard red winter OK93P656-(RMH 3299)/OK99621	OK 2012	S	6	3	5	6	5	2	8	3	4	6	Oklahoma State release (2012), first entered in CSU Variety Trials in 2013. Good stripe rust resistance, good test weight, good quality.
Joe Hard white winter KS04HW101-3(98HW423/98HW170)/KS04HW119-3(TREGO*2/CO960293)	KSU 2015	S	7	6	6	5	1	2	2	4	4	4	KSU-Hays release (2015), first entered in CSU trials in 2015. Hard white wheat. Good leaf and stripe rust resistance, straw strength, test weight, and High Plains adaptation. Intermediate pre-harvest sprouting tolerance.
KanMark Hard red winter PRL/2*PASTOR//G980129W/3/KS970104-3-13	KSU 2014	S	5	2	2	5	6	2	6	2	3	2	KSU-Manhattan release (2014). First entered into CSU Variety Trials in 2014. Medium maturity, short semidwarf. Good test weight, good straw strength, good quality. Intermediate reaction to stripe rust, good resistance to leaf rust.
LCS Chrome Hard red winter Not Disclosed	Limagrain 2016	S	5	5	2	5	2	1	--	3	6	4	Limagrain release (2016), first entered in CSU Variety Trials in 2016. Medium maturing, medium height, good straw strength and test weight. Good resistance to stripe rust and leaf rust.
LCS Jet Hard red winter Not disclosed	Limagrain 2015	S	7	3	2	--	2	--	--	7	7	4	Limagrain release (2015), first entered in CSU Variety Trials in 2015. Primary area of adaptation in Pacific Northwest, extending down into southern Idaho. Good quality, straw strength, stripe rust resistance. Marginal winterhardiness.
LCS Mint Hard red winter Overley/CO980829	Limagrain 2011	S	4	7	4	4	4	8	5	2	2	3	Limagrain release (2011), first entered in CSU Variety Trials in 2013, previously tested in 2010 under experimental designation CO050175-1. Moderate resistance to stripe rust, good test weight, good milling and baking quality.
LCS Pistol Hard red winter T158/T157	Limagrain 2014	S	3	5	4	5	5	6	7	5	7	7	Limagrain release (2014), first entered in CSU Variety Trials in 2014. Intermediate reaction to stripe rust, good leaf rust resistance. Broad adaptation.
MTS1024 Hard red winter MT02113*4/MTS0359	MT EXP	S	5	2	2	4	4	--	--	6	7	2	MT State experimental, first entered into CSU trials in 2015. Potential release in Wyoming in 2016. Carries solid stem trait conferring some protection against wheat stem sawfly damage. Higher yielding than other MT solid stem lines tested.

Column Key - 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: 1 - very good, very resistant, very early, or very short to 9 - very poor, very susceptible, 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 biotypes of RWA.

** Coleoptile length ratings range from 1=very short (~ 50 mm or ~2 in) to 9=very long (~100 mm or ~4 in). Coleoptile lengths should be interpreted for relative variety comparisons only.

+ WSMV ratings for Byrd, TAM 112, and Avery are based on mechanical WSMV inoculation and do not take into account their resistance to the wheat curl mite vector of WSMV.

Description of Winter Wheat Varieties in Eastern Colorado Dryland and Irrigated Trials (2015 and 2016)

Name, Class, and Pedigree	Origin	RWA*	HD	HT	SS	COL**	YR	LR	WSMV+	TW	MILL	BAKE	Comments
Oakley CL Hard red winter Above/Danby//KS03HW10	KSU 2013	S	6	5	7	6	1	4	2	4	3	3	KSU-Hays release (2013), first entered in CSU Variety Trials in 2013. Single-gene hard red Clearfield wheat. Good test weight, good stripe rust resistance, carries same WSMV resistance as Clara CL and Snowmass.
Prairie Red Hard red winter CO850034/PI372129//5*TAM 107	CSU 1998	R*	4	3	3	8	9	9	5	7	5	4	CSU release (1998), marketed by PlainsGold. Biotype 1 RWA-resistant version of TAM 107. Good stress tolerance, poor end-use quality, leaf and stripe rust susceptible. Lower yields relative to more recent wheat releases, entered as historical check.
Ripper Hard red winter CO940606/TAM107R-2	CSU 2006	R*	2	5	4	8	9	9	7	8	5	4	CSU release (2006), marketed by PlainsGold. Early-maturing, long coleoptile. Excellent drought stress tolerance, good baking quality. Very good recovery from stand reduction. Leaf and stripe rust susceptible, lower test weight.
Ruth Hard red winter OK98697/Jagalene//Camelot	NE 2015	S	5	5	4	5	3	6	7	3	3	5	Nebraska release (2015), first entered in CSU Variety Trials in 2015. Medium height, medium maturity, medium length coleoptile. Good stripe rust resistance and good test weight.
Settler CL Hard red winter N95L164/3/MILLENNIUM SIB//TXGH125888-120*4/FS2	NE 2008	S	7	4	2	6	7	8	7	6	3	4	Nebraska release (2008). Single-gene Clearfield wheat. Later maturing, medium height. Moderately susceptible to stripe rust.
Snowmass Hard white winter KS96HW94//Trego/CO960293	CSU 2009	S	6	8	8	4	6	6	2	6	6	2	CSU release (2009), marketed by PlainsGold in CWRF-Ardent Mills Ultragrain Premium Program. Hard white wheat. Medium-maturing, medium-tall. Good WSMV resistance, moderately susceptible to stripe rust, moderate sprouting tolerance.
Sunshine Hard white winter KS01HW152-6/HV9W02-267W	CSU 2014	S	5	5	4	8	5	8	--	6	3	1	CSU release (2014), marketed by PlainsGold in CWRF-Ardent Mills Ultragrain Premium Program. Hard white wheat. Excellent quality, good sprouting tolerance and straw strength, intermediate reaction to stripe rust.
SY Monument Hard red winter BC991149-11/00x0090-4	Agripro 2014	S	7	6	4	6	2	1	7	5	4	1	Agripro release (2014). First entered in CSU Variety Trials in 2014. Good drought tolerance, winterhardiness, quality, and resistance to both leaf and stripe rust.
SY Sunrise Hard red winter BC98337-10-53/CDC Falcon//NE03458	Agripro 2015	S	7	2	1	5	2	3	7	2	3	8	Agripro release (2015), first entered in CSU Irrigated Trials in 2015. Short semidwarf with good straw strength, winterhardiness, drought tolerance, stripe rust resistance, test weight. Stewardship Agreement requires no saved seed. Certified seed only.
SY Wolf Hard red winter W99-331/97x0906-8	Agripro 2010	S	7	5	3	4	3	1	6	3	3	6	Agripro release (2011). First entered in CSU Variety Trials in 2011. Good resistance to tan spot, septoria, leaf rust, and stripe rust. Best performance in Colorado trials under irrigation and in the I-70 corridor counties and further north.

Column Key - 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: 1 - very good, very resistant, very early, or very short to 9 - very poor, very susceptible, 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 biotypes of RWA.

** Coleoptile length ratings range from 1=very short (~ 50 mm or ~2 in) to 9=very long (~100 mm or ~4 in). Coleoptile lengths should be interpreted for relative variety comparisons only.

+ WSMV ratings for Byrd, TAM 112, and Avery are based on mechanical WSMV inoculation and do not take into account their resistance to the wheat curl mite vector of WSMV.

Description of Winter Wheat Varieties in Eastern Colorado Dryland and Irrigated Trials (2015 and 2016)

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	8	5	4	3	6	Trio (Limagrain) release (2009). First entered in CSU Variety Trials in 2012. Good stripe rust resistance. Medium early maturity, excellent tolerance to drought, covers ground quickly in fall.
TAM 112 Hard red winter U1254-7-9-2-1/TXGH10440	TX 2005	S	2	4	7	5	7	7	5+	3	4	2	Texas A&M release (2005), marketed by Watley Seed. Early maturing semi-dwarf. Good test weight, good quality. Moderately susceptible to stripe rust. Carries resistance to wheat curl mite for protection from wheat streak and other mite-vectored viruses.
TAM 113 Hard red winter TX90V6313/TX94V3724	TX 2010	S	7	3	8	3	4	3	7	5	4	4	Texas A&M release (2010), marketed by AGSECO. First entered in CSU Variety Trials in 2012. Good leaf and stripe rust resistance. Poor straw strength and winterhardiness.
TAM 114 Hard red winter TAM 111/TX98A0050	TX 2014	S	6	6	4	8	2	4	7	2	4	1	Texas A&M release (2014), marketed by AGSECO. First entered in CSU trials in 2015. Good resistance to leaf, stripe, stem rust, and Hessian fly. Good test weight and quality characteristics.
TAM 204 Hard red winter TAM 112/3/Mason/Jagger//Pecos	TX 2014	S	4	3	2	5	2	6	3	7	6	8	Texas A&M release (2014), marketed by Watley seed. First entered in CSU trials in 2015. Awnless for grazing/dual purpose. Good resistance to stripe rust. Carries wheat curl mite resistance from TAM 112 parent.
Thunder CL Hard white winter KS01-5539/CO99W165	CSU 2008	R*	4	4	3	7	4	5	4	6	5	3	CSU release (2008), marketed by PlainsGold in CWRF-Ardent Mills Ultragrain Premium Program. Single-gene hard white Clearfield wheat. Good straw strength for irrigation. Excellent quality, moderate stripe rust resistance, moderate sprouting susceptibility.
WB-Cedar Hard red winter TAM 302/B1551W	Westbred 2010	S	2	2	1	5	3	5	7	7	3	7	Westbred release (2010). First entered in CSU Variety Trials in 2011. Hard red selection from Aspen HWW. Good stripe rust resistance, excellent straw strength for high-input/full irrigation. Very drought susceptible, lower test weight.
WB-Grainfield Hard red winter G982231/G982159//KS920709W	Westbred 2012	S	2	7	4	2	2	3	7	5	3	6	Westbred release (2012). First entered into CSU Trials in 2013. Early maturing tall semi-dwarf. Good leaf and stripe rust resistance, lower test weight, shorter coleoptile.
WB4303 Hard red winter PFAU/WEAVER/3/MASON/JGR//PECOS/4/FARMEC	Westbred 2015	S	5	3	1	--	6	2	4	6	2	2	Westbred release (2015), first entered in CSU Variety Trials in 2016. Medium short, medium-early, good straw strength, good quality. Moderately resistant to stripe and leaf rust. Best adapted for irrigated production conditions.
WB4458 Hard red winter KS940786-7//G982163/G982002	Westbred 2012	S	4	5	1	--	5	5	7	7	6	6	Westbred release (2012), first entered in CSU Variety Trials in 2016. Medium height, medium-early. Good straw strength, winter hardiness, shatter resistance. Good drought and acid soil tolerance. Intermediate reaction to stripe and leaf rust.

Column Key - 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: 1 - very good, very resistant, very early, or very short to 9 - very poor, very susceptible, 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 biotypes of RWA.
** Coleoptile length ratings range from 1=very short (~ 50 mm or ~2 in) to 9=very long (~100 mm or ~4 in). Coleoptile lengths should be interpreted for relative variety comparisons only.
+ WSMV ratings for Byrd, TAM 112, and Avery are based on mechanical WSMV inoculation and do not take into account their resistance to the wheat curl mite vector of WSMV.

Description of Winter Wheat Varieties in Eastern Colorado Dryland and Irrigated Trials (2015 and 2016)

Name, Class, and Pedigree	Origin	RWA*	HD	HT	SS	COL**	YR	LR	WSMV+	TW	MILL	BAKE	Comments
WB4721 Hard red winter Not Disclosed	Westbred 2016	S	4	5	1	--	3	2	4	1	3	3	Westbred release (2016), first entered in CSU Variety Trials in 2016. Medium height, medium-late maturity. Good test weight, winterhardiness, drought tolerance, straw strength, and quality. Good resistance to stripe and leaf rust.
Winterhawk Hard red winter 474S10-1/X87807//HBK736-3	Westbred 2007	S	4	7	5	8	4	7	7	2	2	4	Westbred release (2007). Medium maturing, medium tall, long coleoptile. Intermediate reaction to stripe rust, susceptible to leaf rust, very susceptible to stem rust. Good drought tolerance, test weight, and quality.
Yuma Hard red winter NS14/NS25//2*Vona	CSU 1991	S	6	3	3	1	8	5	6	6	5	4	CSU release (1991). Medium maturity, semidwarf, short coleoptile, good baking quality characteristics. Susceptible to stripe rust. Long-term check for irrigated conditions.

Column Key - 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: 1 - very good, very resistant, very early, or very short to 9 - very poor, very susceptible, 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 biotypes of RWA.

** Coleoptile length ratings range from 1=very short (~ 50 mm or ~2 in) to 9=very long (~100 mm or ~4 in). Coleoptile lengths should be interpreted for relative variety comparisons only.

\+ WSMV ratings for Byrd, TAM 112, and Avery are based on mechanical WSMV inoculation and do not take into account their resistance to the wheat curl mite vector of WSMV.

Wheat Quality Evaluations from the 2015 CSU Dryland and Irrigated Variety Trials

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Introduction

End-use quality maintenance and improvement is an important objective of virtually all wheat breeding programs. Grain milling and product manufacturing 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 discount poor quality in the market place.

Breeding for wheat end-use quality is relatively complex in comparison to many breeding objectives. Quality is a function of variety interacting with climate and agronomic practices and Colorado's harsh and variable climatic conditions often negatively impact quality. Quality assessment is commonly done through evaluation of multiple traits with many underlying genetic factors controlling their expression. Most experimental quality tests only approximate average quality needs of product manufacturers and don't exactly 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 generally 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 on large numbers of relatively 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 CSU Dryland and Irrigated 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 the data and resulting ratings will be included among the criteria by which wheat producers choose their varieties. 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 2015, grain samples were collected from four dryland (UVPT) variety trial locations (Akron, Julesburg, Yuma, and Roggen) and two irrigated (IVPT) variety trial locations (Fort Collins, Haxtun). Preliminary small-scale quality analyses were carried out to determine sample suitability for full-scale analyses, with criteria including grain protein not too far below or above 12% grain protein content, sound grain free of visual defects, and good discrimination among samples at a given location for experimental dough mixing properties. In this process of sample selection, the Roggen dryland location was excluded from analyses beyond protein content with the primary issue being protein values well below the level required for meaningful dough mixing and baking quality evaluations. During sample processing we also realized that the Haxtun location was severely infected by Fusarium head blight, though we proceeded to analyze the samples.

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

<u>Milling-Related Traits</u>

- Test weight: obtained by standard methodology on a cleaned sample of the harvested grain.
- Grain protein and protein recovery: obtained using near-infrared reflectance spectroscopy (NIRs) with a Foss NIRS™ DA1650 Feed and Forage analyzer. Grain protein is reported on a

standard 12% moisture basis. High grain protein content is associated with higher water absorption of flours and higher loaf volumes in the bakery. Protein recovery represents the numerical difference between grain and flour protein content and a lower value is most desirable by the milling industry.

- 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 value and a measure of variability for each trait. Millers prefer a uniform sample with heavier (>30 grams per 1000 kernels, or >15,133 seeds per pound) 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 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 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 over-mixing (subjective score >3). Some varieties with exceptionally long mixing times (i.e., Snowmass, Sunshine) 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 Ardent 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 higher crumb grain and crumb color scores (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 has proven useful as a means to differentiate and characterize overall 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 depending on the optimal orientation of the 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%, protein recovery 10%, kernel weight 20%, grain hardness 10%, flour yield 20% (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 - 2015 Akron

* **Bold** indicates superior value, underlined indicates inferior value.

Entry	Test Weight	Grain Protein	SKCS Weight	SKCS Hardness	Flour Yield	Protein Recovery	Bake Absorption	Mixograph Mix Time	Mixograph Tolerance	Loaf Volume	Crumb Color	Crumb Grain	**Milling Score**	**Baking Score**
Above	53.5	12.7	25.7	66.9	69.8	**-0.4**	62.5	2.98	3	870	3	3	4	5
Akron	50.6	13.1	21.7	65.2	68.0	-1.6	**64.3**	3.78	4	875	3	3	8	**3**
Antero	**58.6**	11.8	**30.3**	60.4	**73.2**	-0.6	61.4	4.26	3	780	3	2	**2**	6
Avery	51.0	12.8	21.3	63.7	70.5	-1.1	63.2	3.25	4	905	2	2	6	5
Bearpaw	49.7	**14.0**	23.7	71.3	69.6	-0.9	64.2	4.05	3	905	2	3	7	4
Brawl CL Plus	54.0	**14.1**	24.9	66.9	71.6	-0.7	**65.0**	4.35	4	895	2	2	**3**	**3**
Byrd	52.6	13.3	23.3	60.4	72.3	-0.8	63.4	4.39	**5**	890	2	3	5	4
CO11D1236	55.5	11.6	29.0	53.6	**75.0**	-0.6	60.7	4.83	4	750	2	2	**3**	7
CO11D1306W	**58.7**	12.2	27.7	63.6	72.5	-1.1	61.8	3.55	4	765	3	2	**3**	6
CO11D1397	50.4	12.8	21.3	60.6	67.3	-1.0	62.5	**5.98**	**5**	935	3	4	9	**2**
CO11D1539	57.4	12.9	**31.5**	61.7	72.0	-1.3	62.6	3.39	3	925	**5**	4	**3**	4
CO11D1767	56.2	12.3	27.9	61.8	**73.8**	-0.9	62.5	3.97	3	790	2	2	**3**	6
CO11D446	55.6	**14.2**	26.6	57.3	71.1	-0.8	**65.1**	**5.52**	**5**	880	3	2	4	**2**
Cowboy	54.3	12.7	27.6	61.3	70.2	-1.2	61.7	3.51	3	795	1	2	4	7
Denali	57.2	12.2	26.2	59.6	71.9	-1.7	61.3	2.53	3	735	1	1	5	9
Gallagher	55.1	13.6	25.4	74.9	70.2	-1.0	63.6	4.51	4	825	2	3	5	5
Hatcher	55.6	12.8	25.4	67.6	71.3	-1.7	61.4	3.80	3	810	3	3	5	6
Iba	54.7	13.1	23.1	69.4	71.1	-1.1	61.7	3.76	2	840	2	3	5	6
Joe	**58.5**	12.8	28.6	68.8	71.4	**-0.1**	62.4	3.96	2	855	3	2	**2**	5
KanMark	56.4	13.6	23.5	72.7	**73.0**	-0.8	**64.4**	5.06	**5**	**975**	3	4	**3**	**1**
LCS Mint	54.5	12.2	23.9	69.1	72.2	-0.5	61.1	4.86	4	860	3	2	4	5
LCS Pistol	57.0	13.6	26.5	59.9	68.8	-0.6	63.0	3.11	1	840	3	2	4	7
MTS1024	51.2	13.2	23.3	69.0	70.5	-0.6	64.0	**5.62**	**5**	925	4	3	5	**2**
Oakley CL	**57.9**	13.4	**30.9**	75.1	72.7	-0.8	63.8	4.09	4	**950**	**5**	**5**	**2**	**2**
Prairie Red	51.7	13.1	26.1	68.0	68.8	**-0.3**	**64.5**	4.13	4	**990**	4	3	5	**2**
Ripper	52.0	13.4	25.6	62.2	69.9	-0.7	**64.4**	3.62	3	845	2	2	5	5
Ruth	**57.8**	12.8	27.9	66.9	72.8	-1.2	61.6	3.75	3	850	4	3	**2**	5
Settler CL	54.5	13.5	26.4	61.8	72.0	-1.1	63.3	4.55	4	810	3	2	4	5
Snowmass	51.0	12.9	26.2	68.5	68.9	-0.9	63.2	**5.59**	**5**	940	3	3	6	**2**
Sunshine	57.5	13.8	**29.4**	61.7	72.4	-0.7	**64.3**	4.58	**5**	**980**	**5**	4	**1**	**1**
SY Monument	57.5	12.8	**30.4**	73.5	**73.5**	**-0.4**	**64.4**	**7.15**	**6**	**975**	**5**	**5**	**1**	**1**
SY Wolf	55.7	**14.3**	27.1	71.1	71.1	-1.4	62.3	5.07	**5**	860	2	2	4	4
T158	**58.5**	**14.8**	**32.3**	65.7	72.3	-1.6	62.2	3.54	2	860	3	3	**1**	6
TAM 112	54.5	12.8	27.7	64.3	68.8	**-0.4**	64.2	3.63	4	**965**	4	4	4	**3**
TAM 113	56.5	12.4	26.4	67.9	72.1	-0.5	62.5	3.23	3	875	3	3	**3**	5
TAM 114	57.5	13.7	28.9	63.8	72.5	-1.0	**65.3**	**6.40**	**5**	**1075**	4	4	**1**	**1**
TAM 204	55.2	13.4	23.8	69.4	71.0	-1.1	61.6	2.34	1	715	2	1	5	9
WB-Grainfield	55.9	13.3	26.8	72.2	71.4	-0.5	64.2	3.59	3	800	2	2	4	5
Winterhawk	55.2	13.5	26.6	67.0	72.2	-1.0	63.4	3.69	3	855	2	2	**3**	5
Average	55.1	13.1	26.4	65.8	71.3	-0.9	63.1	4.20	3.6	871	2.9	2.7		
Minimum	49.7	11.6	21.3	53.6	67.3	-1.7	60.7	2.34	1	715	1	1		
Maximum	58.7	14.8	32.3	75.1	75.0	-0.1	65.3	7.15	6	1075	5	5		

Wheat Milling and Baking Quality Data - 2015 Julesburg * **Bold** indicates superior value, underlined indicates inferior value.

Entry	Test Weight	Grain Protein	SKCS Weight	SKCS Hardness	Flour Yield	Protein Recovery	Bake Absorption	Mixograph Mix Time	Mixograph Tolerance	Loaf Volume	Crumb Color	Crumb Grain	**Milling Score**	**Baking Score**
Above	57.4	12.0	31.1	59.8	72.7	-0.7	59.6	3.83	2	900	3	3	5	6
Akron	57.0	12.3	29.9	52.5	73.1	-1.0	60.8	4.95	**5**	955	**5**	**5**	4	**2**
Antero	58.3	11.2	31.0	44.3	**75.5**	-1.0	58.0	4.10	2	945	2	2	**3**	7
Avery	57.6	10.9	30.9	44.5	**74.8**	-0.6	59.7	5.25	**5**	950	**5**	4	4	**3**
Bearpaw	53.6	11.7	25.5	59.1	73.4	**-0.5**	58.9	4.43	2	855	3	3	8	7
Brawl CL Plus	56.6	**12.6**	29.5	51.1	73.2	**-0.1**	62.9	4.66	3	970	3	4	4	**3**
Byrd	57.5	12.0	30.6	47.2	**76.3**	-1.2	60.7	4.90	**5**	945	**5**	4	**3**	**2**
CO11D1236	57.5	12.0	**34.4**	42.2	**75.4**	-1.2	59.8	4.56	4	840	3	3	**3**	5
CO11D1306W	**58.7**	10.9	29.5	54.3	73.5	-0.5	60.6	3.56	3	760	4	3	4	6
CO11D1397	57.4	11.5	30.5	48.5	72.7	-0.9	61.3	5.31	4	985	4	4	5	**3**
CO11D1539	57.3	11.6	33.6	43.9	72.1	-1.1	61.8	3.38	4	835	3	3	6	5
CO11D1767	57.1	12.0	30.4	54.6	73.6	-1.3	60.9	3.74	3	790	3	3	4	6
CO11D446	57.5	11.7	33.6	44.9	**74.6**	-1.3	62.7	5.17	**5**	945	**5**	4	4	**2**
Cowboy	56.9	11.3	31.0	50.0	73.2	-1.0	61.4	**5.53**	3	775	2	3	4	5
Denali	**58.8**	11.3	33.8	39.3	73.8	-1.1	58.6	3.34	2	675	3	2	4	9
Gallagher	56.4	**12.8**	29.9	62.2	73.0	-1.0	62.7	4.27	4	860	2	2	6	4
Hatcher	56.8	12.4	33.3	47.7	73.9	-1.2	61.7	4.58	4	840	4	3	**3**	4
Iba	57.0	**13.1**	30.5	53.1	73.8	-1.6	61.7	3.78	3	890	3	3	4	5
Joe	58.5	11.5	32.2	51.1	71.7	**-0.4**	62.8	4.48	4	875	4	3	4	**3**
KanMark	58.2	12.3	31.2	57.8	**75.0**	**-0.2**	**63.6**	5.06	**5**	**1090**	4	4	**2**	**1**
LCS Mint	57.0	12.2	32.1	50.3	73.9	-1.1	61.6	4.07	3	960	3	3	4	4
LCS Pistol	57.4	12.3	27.0	47.7	69.8	-0.7	58.6	2.65	1	800	3	2	7	9
MTS1024	54.0	12.2	28.0	61.2	73.2	-0.9	60.8	5.29	**5**	955	4	4	8	**2**
Oakley CL	**58.7**	**12.7**	33.1	63.9	72.8	-1.2	61.7	5.11	4	**1025**	4	4	4	**2**
Prairie Red	56.9	**13.1**	33.6	55.8	72.2	-0.8	62.7	3.59	3	**1050**	**5**	4	4	**3**
Ripper	55.3	**13.1**	29.0	54.9	72.9	-1.4	62.5	3.27	3	815	2	1	6	6
Ruth	58.3	11.7	32.4	50.2	73.8	**-0.5**	61.4	3.86	4	820	4	3	**3**	5
Settler CL	57.4	12.3	32.5	49.1	74.1	-0.8	61.4	4.34	4	895	4	4	4	**3**
Snowmass	56.9	11.7	**37.2**	50.6	73.7	-0.7	**63.8**	**7.52**	**5**	**1055**	4	4	**2**	**1**
Sunshine	57.1	12.2	**34.7**	43.7	73.2	-0.9	**63.9**	4.32	4	**1025**	4	4	4	**1**
SY Monument	57.9	12.2	34.2	57.1	73.2	-1.2	**63.8**	**5.56**	**5**	**1010**	**5**	4	4	**1**
SY Wolf	58.1	12.1	32.7	53.7	73.2	-0.8	58.7	4.88	2	855	3	3	**3**	7
T158	58.6	12.0	**35.7**	46.3	73.7	-0.5	59.9	3.47	3	940	4	3	**2**	5
TAM 112	58.5	12.4	**34.6**	50.4	72.4	**-0.3**	**63.1**	4.16	4	**1040**	**5**	4	**2**	**2**
TAM 113	57.4	12.4	30.5	56.3	73.3	-0.5	**63.0**	3.50	3	990	4	4	4	**3**
TAM 114	58.4	11.9	31.5	48.5	72.8	**-0.5**	62.9	**6.53**	**5**	**1040**	4	4	**3**	**1**
TAM 204	57.7	**13.0**	28.2	58.3	72.2	-0.7	61.1	2.41	1	825	1	1	6	8
WB-Grainfield	**58.7**	11.8	**34.8**	56.5	73.5	-0.7	61.9	3.88	3	865	4	3	**2**	5
Winterhawk	**59.9**	11.2	**34.5**	51.6	73.5	-0.6	60.9	5.05	4	890	**5**	**5**	**1**	**3**
Average	57.4	12.0	31.8	51.6	73.4	-0.8	61.4	4.42	3.5	911	3.6	3.3		
Minimum	53.6	10.9	25.5	39.3	69.8	-1.6	58.0	2.41	1	675	1	1		
Maximum	59.9	13.1	37.2	63.9	76.3	-0.1	63.9	7.52	5	1090	5	5		

Wheat Milling and Baking Quality Data - 2015 Yuma

* **Bold** indicates superior value, underlined indicates inferior value.

Entry	Test Weight	Grain Protein	SKCS Weight	SKCS Hardness	Flour Yield	Protein Recovery	Bake Absorption	Mixograph Mix Time	Mixograph Tolerance	Loaf Volume	Crumb Color	Crumb Grain	**Milling Score**	**Baking Score**
Above	54.7	12.3	31.3	52.3	69.7	-0.7	60.9	3.47	3	850	4	3	5	5
Akron	54.3	12.0	27.1	61.1	69.6	-0.8	61.9	4.84	4	975	**5**	4	8	**3**
Antero	55.9	11.5	31.3	41.4	72.5	-1.4	60.7	4.55	3	790	4	3	5	5
Avery	54.8	12.1	26.4	49.6	**73.6**	-0.9	62.7	4.68	**5**	960	4	4	4	**3**
Bearpaw	53.6	11.8	26.4	53.6	73.0	**-0.5**	60.2	4.65	4	820	3	3	5	5
Brawl CL Plus	54.6	**13.4**	28.7	49.7	72.7	-0.9	60.6	3.56	2	990	**5**	4	4	5
Byrd	54.1	12.6	26.1	51.6	**74.2**	-1.2	**63.8**	5.25	**5**	**1010**	4	4	4	**1**
CO11D1236	56.5	11.8	30.7	41.7	**74.6**	-1.2	62.2	4.43	**5**	820	2	2	**3**	4
CO11D1306W	55.5	12.7	28.7	45.4	70.4	-1.5	62.1	5.10	4	850	4	3	5	4
CO11D1397	56.5	11.5	28.7	45.0	71.5	-1.0	63.1	**5.92**	**5**	900	4	**5**	4	**1**
CO11D1539	54.5	12.3	**33.1**	38.5	71.1	-1.5	61.3	4.12	3	905	3	3	6	5
CO11D1767	54.4	12.2	28.7	51.4	71.9	-1.6	61.0	3.19	3	750	2	2	5	7
CO11D446	54.9	12.7	31.9	42.1	**73.6**	-1.0	**64.0**	**5.35**	**5**	975	4	3	4	**2**
Cowboy	54.3	12.2	27.5	50.8	70.6	-1.6	62.9	3.69	3	825	2	3	5	5
Denali	56.5	11.9	30.6	47.6	72.2	-1.0	60.7	3.56	2	835	2	2	4	7
Gallagher	54.1	13.1	28.5	63.2	70.0	-1.1	62.9	3.70	3	860	2	2	6	5
Hatcher	54.0	11.5	25.4	59.0	71.2	-0.7	60.9	3.35	3	800	3	3	7	6
Iba	56.5	12.2	28.6	45.4	72.4	-1.0	60.1	4.21	2	840	2	2	4	7
Joe	55.4	12.9	29.1	45.4	71.0	-1.5	62.0	3.82	4	875	4	3	5	4
KanMark	56.4	12.3	30.5	53.9	72.9	**-0.6**	**64.1**	4.76	**5**	**1100**	**5**	**5**	**3**	**1**
LCS Mint	56.1	11.8	29.8	47.6	71.8	-0.7	60.9	3.86	4	860	4	3	**3**	4
LCS Pistol	56.4	12.3	30.1	44.7	68.2	-0.9	59.8	2.60	1	835	4	3	5	8
MTS1024	50.6	13.1	24.9	59.1	70.6	-0.8	**64.0**	4.87	4	945	4	4	8	**3**
Oakley CL	55.4	**13.6**	31.2	58.6	71.9	-0.8	**63.8**	4.07	4	930	**5**	4	4	**2**
Prairie Red	56.1	**14.7**	32.8	58.0	71.2	-2.2	**63.8**	3.01	3	**1030**	**5**	**5**	4	**3**
Ripper	53.0	13.0	29.0	50.7	71.3	-0.7	**65.0**	3.68	3	900	2	2	5	4
Ruth	55.0	11.5	28.2	52.4	71.4	**-0.6**	60.9	3.54	3	870	3	3	4	5
Settler CL	**57.4**	12.9	**37.5**	43.8	73.0	-1.2	63.1	5.04	**5**	955	**5**	4	**1**	**1**
Snowmass	56.0	12.0	**34.4**	55.1	73.2	-0.9	**64.7**	**6.47**	**6**	**1015**	**5**	**5**	**3**	**1**
Sunshine	56.2	12.1	31.4	47.8	71.7	-1.0	62.3	**5.80**	**5**	**1025**	**5**	4	**3**	**1**
SY Monument	56.0	12.5	33.0	51.2	**73.9**	-0.9	**64.2**	**6.62**	**5**	**1010**	**5**	4	**2**	**1**
SY Wolf	56.6	**13.3**	30.1	51.1	72.3	-1.7	59.0	4.61	2	875	3	3	**3**	7
T158	56.8	**14.4**	**37.0**	47.1	72.3	-2.2	62.1	3.27	2	815	3	3	**1**	6
TAM 112	56.4	12.0	29.8	56.1	70.9	**-0.4**	62.8	3.49	3	**1000**	**6**	**5**	4	**2**
TAM 113	56.4	12.8	30.4	53.3	72.6	-1.0	**63.7**	3.31	3	995	**5**	4	**3**	**3**
TAM 114	55.1	12.5	29.1	50.5	72.3	-1.3	62.7	**5.60**	**5**	**1130**	4	4	4	**1**
TAM 204	54.2	12.7	25.1	53.4	69.6	-1.0	60.9	2.99	1	810	3	2	7	8
WB-Grainfield	**57.4**	11.9	32.9	51.7	**73.5**	**-0.6**	60.8	3.84	3	835	4	3	**1**	5
Winterhawk	**58.0**	12.4	**35.8**	47.1	**73.7**	-1.3	61.0	3.89	3	940	**5**	**5**	**1**	4
Average	55.4	12.5	30.1	50.5	71.9	-1.1	62.1	4.28	3.5	910	3.8	3.4		
Minimum	50.6	11.5	24.9	38.5	68.2	-2.2	59.0	2.60	1	750	2	2		
Maximum	58.0	14.7	37.5	63.2	74.6	-0.4	65.0	6.62	6	1130	6	5		

Wheat Milling and Baking Quality Data - 2015 Fort Collins

* **Bold** indicates superior value, underlined indicates inferior value.

Entry	Test Weight	Grain Protein	SKCS Weight	SKCS Hardness	Flour Yield	Protein Recovery	Bake Absorption	Mixograph Mix Time	Mixograph Tolerance	Loaf Volume	Crumb Color	Crumb Grain	**Milling Score**	**Baking Score**
Antero	**60.3**	11.6	35.3	50.5	**73.4**	-1.6	59.0	3.10	2	805	4	4	**2**	5
Avery	57.9	11.3	30.1	53.0	72.3	-0.9	61.0	**4.80**	4	920	4	4	4	**2**
Brawl CL Plus	58.8	**15.5**	28.7	72.5	70.9	-1.9	**64.7**	3.08	2	950	3	4	5	4
Byrd	58.5	12.7	28.1	62.9	**73.5**	-0.8	63.0	4.47	4	**1065**	**5**	4	4	**1**
CO11D1236	58.0	10.9	31.5	42.6	**74.4**	-1.2	59.0	4.21	3	725	2	2	4	6
CO11D1306W	58.8	10.6	35.2	43.8	72.3	-1.5	58.0	3.77	3	685	2	2	5	7
CO11D1397	58.7	11.2	28.2	50.8	72.0	-1.4	60.7	**5.88**	**5**	915	3	4	5	**2**
CO11D1539	59.6	11.6	**36.8**	52.0	71.6	**-0.4**	61.9	3.19	3	925	4	4	**2**	4
CO11D1767	58.4	10.9	**36.0**	58.4	70.9	**-0.7**	59.7	3.37	3	745	2	2	**3**	6
CO11D446	56.4	11.3	25.2	57.7	71.2	-1.1	59.8	**5.82**	**5**	915	3	4	6	**2**
Cowboy	57.3	11.6	30.8	52.6	71.6	-1.0	60.7	4.43	3	905	3	3	5	4
Denali	**60.7**	10.4	31.6	55.0	72.0	-1.1	58.8	3.35	3	715	4	2	**3**	6
Hatcher	57.9	12.0	32.4	51.7	71.2	-1.0	61.8	3.46	3	875	3	3	4	5
Iba	59.5	10.8	33.3	43.6	**74.2**	-1.0	58.9	3.70	3	800	3	3	4	5
KanMark	58.5	12.1	24.7	74.3	72.2	-1.1	62.7	4.16	4	**1015**	**5**	**5**	6	**2**
LCS Jet	53.8	12.1	30.2	57.4	72.0	-0.8	**63.9**	4.64	4	860	2	3	6	**3**
LCS Mint	**60.5**	11.0	34.3	48.5	**73.7**	-0.9	59.8	**4.84**	4	865	**5**	**5**	**2**	**3**
LCS Pistol	58.1	**15.0**	28.2	57.6	65.5	-2.4	61.4	1.87	0	790	3	3	6	8
Oakley CL	60.0	11.0	**39.2**	56.1	72.1	-1.1	61.1	3.54	3	845	**5**	4	**2**	4
Sunshine	57.7	**15.3**	30.2	61.4	70.1	-2.2	**67.7**	**4.81**	**5**	**1045**	4	4	6	**1**
SY Sunrise	**60.1**	13.1	**37.8**	46.8	71.3	-1.5	60.1	2.12	1	685	3	2	**2**	7
SY Wolf	59.4	12.8	**36.0**	56.5	72.8	-1.3	59.8	2.92	0	915	3	4	**2**	7
T158	59.0	**14.2**	**36.0**	62.6	70.4	-1.4	60.8	2.11	0	725	3	3	4	8
TAM 114	59.1	13.7	25.3	72.7	69.9	-1.3	**65.8**	4.19	4	**1075**	3	**5**	7	**1**
Thunder CL	59.2	**14.6**	35.1	56.4	71.8	-1.8	63.8	3.24	1	**1025**	4	4	**3**	**3**
WB-Cedar	57.4	13.9	31.1	64.1	69.8	**-0.6**	62.8	2.58	1	855	4	4	5	5
Yuma	55.8	12.6	26.8	60.2	68.8	-1.5	**63.8**	2.67	3	890	3	3	8	4
Average	58.5	12.4	31.8	56.4	71.6	-1.2	61.5	3.72	2.8	872	3.4	3.5		
Minimum	53.8	10.4	24.7	42.6	65.5	-2.4	58.0	1.87	0	685	2	2		
Maximum	60.7	15.5	39.2	74.3	74.4	-0.4	67.7	5.88	5	1075	5	5		

Wheat Milling and Baking Quality Data - 2015 Haxtun

* **Bold** indicates superior value, underlined indicates inferior value.

Entry	Test Weight	Grain Protein	SKCS Weight	SKCS Hardness	Flour Yield	Protein Recovery	Bake Absorption	Mixograph Mix Time	Mixograph Tolerance	Loaf Volume	Crumb Color	Crumb Grain	**Milling Score**	**Baking Score**
Antero	53.8	12.6	**29.9**	51.1	71.0	-1.3	61.6	3.77	3	840	1	1	**3**	6
Avery	53.1	12.2	25.3	60.4	71.3	**-0.6**	61.9	**4.89**	3	870	4	3	4	**3**
Brawl CL Plus	53.1	**14.3**	28.0	56.3	70.2	-1.2	**64.6**	2.91	3	**935**	1	1	**3**	4
Byrd	53.2	12.8	25.0	57.4	**72.7**	-1.1	62.6	**4.96**	**5**	**975**	4	3	**3**	**1**
CO11D1236	50.5	12.6	25.6	57.3	70.2	-0.9	62.9	4.52	**5**	855	1	1	6	4
CO11D1306W	52.3	12.4	23.9	66.1	69.3	-1.1	60.9	**4.72**	4	840	3	3	6	4
CO11D1397	51.9	12.2	24.5	53.3	68.4	-1.4	60.7	**5.45**	3	890	4	4	7	**3**
CO11D1539	52.0	13.3	28.2	57.7	70.7	-1.5	60.8	4.02	3	820	1	1	4	6
CO11D1767	**54.4**	12.6	27.2	69.4	**71.9**	-1.3	60.8	3.56	2	820	1	0	**3**	7
CO11D446	53.3	12.8	26.2	63.2	**71.7**	**-0.5**	**63.8**	**5.63**	**5**	**935**	3	1	**2**	**1**
Cowboy	51.4	12.0	25.1	61.0	69.2	**-0.9**	61.7	3.89	3	855	1	1	5	6
Denali	**54.8**	11.9	26.8	59.8	70.3	-1.0	60.6	3.19	3	855	1	1	**3**	6
Hatcher	52.5	13.4	26.5	60.8	70.1	-1.8	60.6	3.31	2	800	2	1	4	7
Iba	53.2	13.2	27.3	61.1	71.1	-1.5	59.8	3.06	2	780	1	0	**3**	8
KanMark	**54.5**	**14.4**	26.9	66.1	**72.3**	-1.6	**63.5**	3.57	2	**965**	3	3	**2**	**3**
LCS Jet	47.8	**14.8**	26.0	67.4	68.6	-1.6	**64.6**	3.92	3	865	3	2	7	4
LCS Mint	50.6	13.2	26.8	58.7	69.3	-1.4	61.9	3.68	2	810	2	3	6	6
LCS Pistol	52.7	14.0	26.9	50.2	67.1	-1.7	61.7	2.62	1	760	2	1	7	8
Oakley CL	52.7	**14.4**	26.0	71.7	70.5	-1.4	62.9	4.05	3	905	4	3	5	**3**
Sunshine	**55.2**	13.7	**29.4**	46.1	**72.0**	-1.9	**64.7**	3.98	4	**980**	2	2	**2**	**2**
SY Sunrise	53.2	12.5	**29.0**	56.1	70.8	**-0.9**	59.8	2.55	1	700	1	1	**3**	9
SY Wolf	**55.4**	**14.3**	**29.7**	69.8	71.1	-1.8	60.8	3.46	0	805	2	2	**1**	7
T158	52.5	13.3	**29.0**	57.2	70.9	-1.1	61.9	2.85	2	730	2	2	**3**	8
TAM 114	53.5	11.9	24.9	66.1	70.4	**-0.8**	61.0	**4.81**	**5**	**980**	**5**	4	4	**1**
Thunder CL	50.6	13.3	26.2	61.8	70.2	-1.2	62.5	3.50	2	900	1	1	5	6
WB-Cedar	54.3	**14.4**	**32.0**	57.3	71.7	-1.6	60.5	2.59	1	770	1	1	**1**	9
Yuma	51.4	12.9	26.4	58.7	69.4	-1.2	**63.7**	2.89	3	865	3	3	5	5
Average	52.7	13.2	27.0	60.1	70.5	-1.3	62.0	3.79	2.8	856	2.2	1.8		
Minimum	47.8	11.9	23.9	46.1	67.1	-1.9	59.8	2.55	0	700	1	0		
Maximum	55.4	14.8	32.0	71.7	72.7	-0.5	64.7	5.63	5	980	5	4		

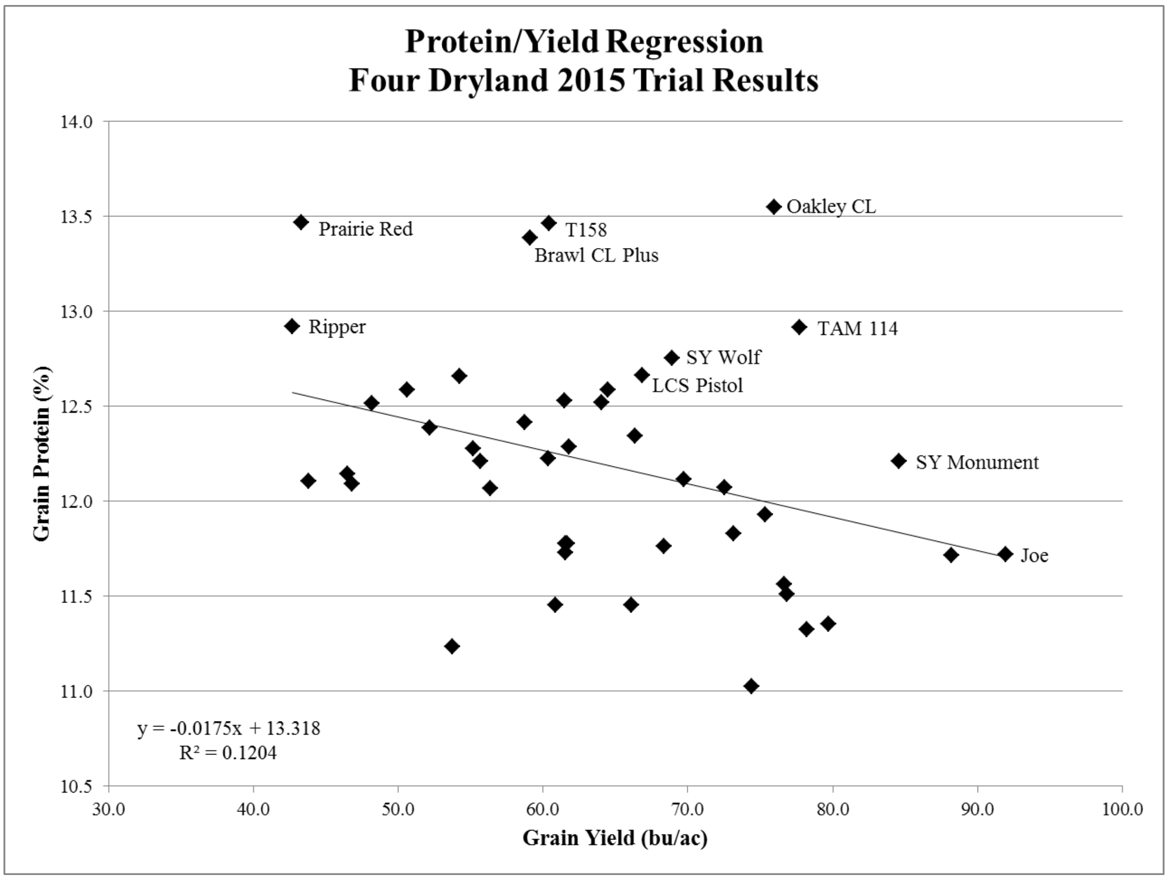
New Assistant Professor of Agricultural Systems Science

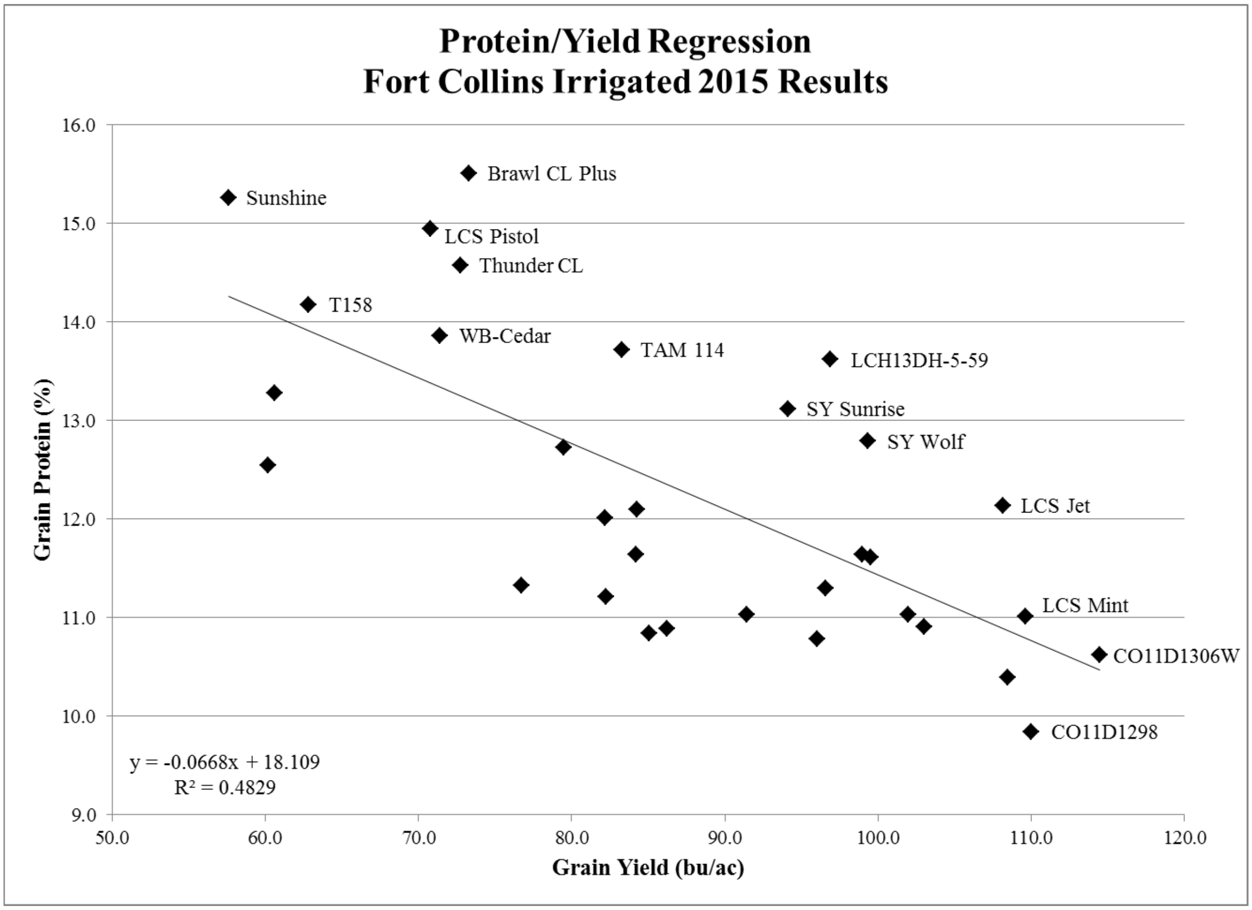
My name is Steve Fonte and I'm a new Assistant Professor of Agricultural Systems Science in the Department of Soil and Crop Sciences at CSU. I arrived in Colorado last August, and come most recently from the University of California at Davis, but have also worked at Oregon State University and the International Center for Tropical Agriculture, in Colombia. I specialize in soil biology and fertility (specifically soil organic matter and nutrient management), but I've also collaborated with a number of multidisciplinary teams working to understand how different management options affect yield, water and nutrient use efficiency, soil health, and a range of ecosystem services that contribute to the long-term productivity and sustainability of agricultural systems. My research has brought me in contact with producers from around the world, from subsistence farmers in Uganda, Central America, and Peru to large-scale commercial operations in California and Colombia. Thus, I've worked with crops including corn, beans, tomatoes, rice, cabbage, potatoes, forages, and wheat. While my experience with wheat is not extensive, I'm learning fast. I look forward to working with many of you in developing the research questions that will guide my future work at CSU and in experimenting with new options to increase wheat yields and sustainability throughout the region.

The Relationship between Grain Yield and Protein Content in the 2015 Wheat Variety Performance Trials

Jerry Johnson and Sally Sauer

The following graphs are based on four dryland and one irrigated variety performance trials in the 2014/2015 growing season. They show the relationship between grain yield and protein. In general, as yield increases, the protein content decreases. The R^2 value is a statistical measure of how well yield is related to grain protein, or how well the data fits the line. Here, the R^2 values are low and it is difficult to make conclusions concerning the true relationship of grain yield to protein content. However, the graphs can be used to identify varieties with high and low protein content in 2015. Additional testing of varieties might change the relationships portrayed in the graphs. It is also important to note that, in addition to yield, available nitrogen in the soil, growing conditions, and other environmental factors can impact grain protein content.




Protein/Yield Regression
Fort Collins Irrigated 2015 Results
Grain Protein (%)
Grain Yield (bu/ac)
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
Brawl CL Plus
Sunshine
LCS Pistol
Thunder CL
T158
WB-Cedar
TAM 114
LCH13DH-5-59
SY Sunrise
SY Wolf
LCS Jet
LCS Mint
CO11D1306W
CO11D1298
y = -0.0668x + 18.109
R² = 0.4829

Perspectives on Wheat Variety Trials and Wheat Variety Trial Data

Scott Haley
CSU Wheat Breeder
Soil and Crop Sciences Department, CSU

Introduction

The Colorado State University (CSU) Crops Testing Program, under the leadership of Dr. Jerry Johnson, conducts winter wheat variety performance trials each year throughout Colorado. These trials are carried out as a service to the wheat industry to provide unbiased and reliable information to crop producers to assist with variety selection decisions. Together with the CSU Collaborative On-Farm Testing (COFT) program, variety trials serve to accelerate the adoption of improved varieties and – equally important – help foster the demise of inferior varieties. Thus, these trials provide immense economic benefits to the entire wheat industry in Colorado.

A fundamental reality – and complication – of all crop breeding and crop variety testing activities is what's commonly referred to as "*genotype-by-environment interaction*", or *GxE*, where G refers to the variety and E refers to anything that involves the environment (i.e., geography, climate, soil type, diseases/insects, fertility, management, etc). The concept of GxE is based largely on the inconsistency in grain yield (or other traits) that is observed when different varieties are tested in different years or locations. In a practical sense, this inconsistency across years or locations complicates selection in breeding programs and development of sound variety recommendations from crop variety trial data.

Proper use of data from wheat variety trials is essential to improve variety selection decisions by producers. Given the reality of GxE in variety testing, a common practice in Colorado and elsewhere is to present multiple-year, multiple-location averages of variety performance. This is most often reported as the "three-year average" with the assumption that this is the best predictor of future variety performance. While the "three-year average" has been in use for many years, very little evidence has been made available to document that this is really better than other possible ways to interpret the data, such as using a single trial location or a single year of trial data. The objective of this report is to provide tangible evidence that the "three-year average" is really the best available predictor of future variety performance.

Methodology

All of the grain yield data from CSU dryland variety trials from 1990 to 2015 was assembled to examine the predictability of dryland wheat variety trials in Colorado. This dataset included the High Moisture Variety Trial (HMVT) and Low Moisture Variety Trial (LMVT) from 1990 to 1999 and the Uniform Variety Performance Trial (UVPT) from 2000 to 2015. This enormous dataset included 22,392 total observations across 26 years, 25 trial locations, 220 unique year-location combinations, and 219 different varieties (released varieties and experimental lines). Most of the location/year combinations included three field replications though some trials only had two replications due to some problem that occurred with the trial (i.e., drought, winter injury, poor emergence, weed infestation, wayward combine or sprayer, etc).

This dataset was subjected to a comprehensive statistical analysis in order to:

1) determine the proportion of the total variation in the data that was due to years, locations, varieties, and all the possible interactions among these.
2) use these estimates to illustrate the effect of the numbers of years of testing and trial locations on variety predictability, or what's known as "broad sense heritability" in the plant breeding world.

3) estimate the correlation of yields at a given location with yields of the same varieties in the next three years at that location based on that single location only, the region-wide (northeast, southeast) three-year average, and the statewide three-year average.

Results

In the first part of the analysis, all of the sources of variation in the data going back to 1990 were estimated. A pie chart of these results is shown below in **Figure 1**. The most interesting revelation was that roughly 75% of all the variation in the data was due to effects that had nothing to do with the varieties, such as year, location, and their interaction (*dark green portion*). Only 25% of total trial variation was due to variety and interactions of the variety with years and locations. Another key finding was that the variety x year variation (*light blue slice*) was much larger than the variety x location variation (*pink slice*), which confirmed that year-to-year variation is a much more important part of the GxE for grain yield in Colorado.

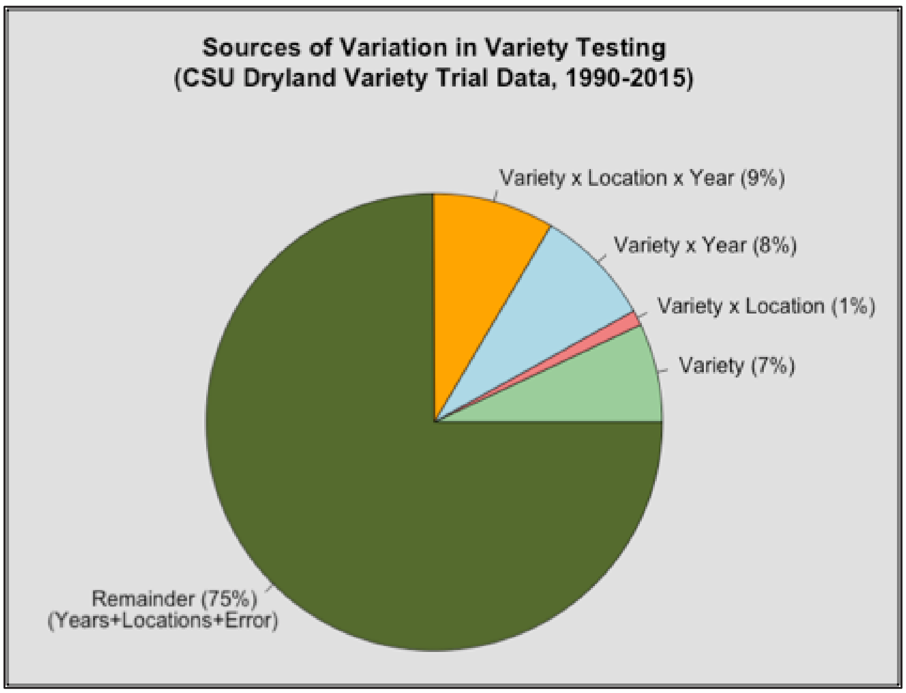


Figure 1 – Sources of variation estimated from CSU Dryland Variety Trial data (1990-2015).

In the second part of the analyses, the components of total trial variation related to variety effects (the 25% shown above) were used to illustrate the effect of the number of years of testing and trial locations on predictability. This is shown in **Figure 2**. The most striking observation was that the lowest level of predictability observed was with a single year of testing, regardless of the number of trial locations available in that year. Predictability did increase with increasing years of testing, but even with four years of testing and 20 locations in each year the predictability of variety performance was only about 70%.

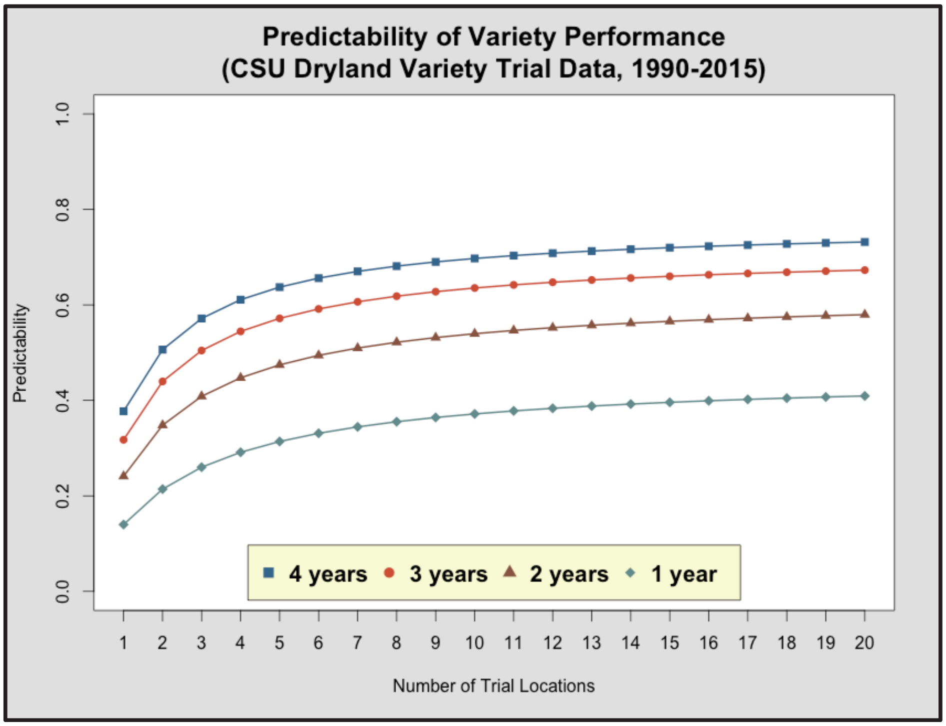


Figure 2 – Predictability of variety performance for grain yield estimated from CSU Dryland Variety Trial data (1990-2015).

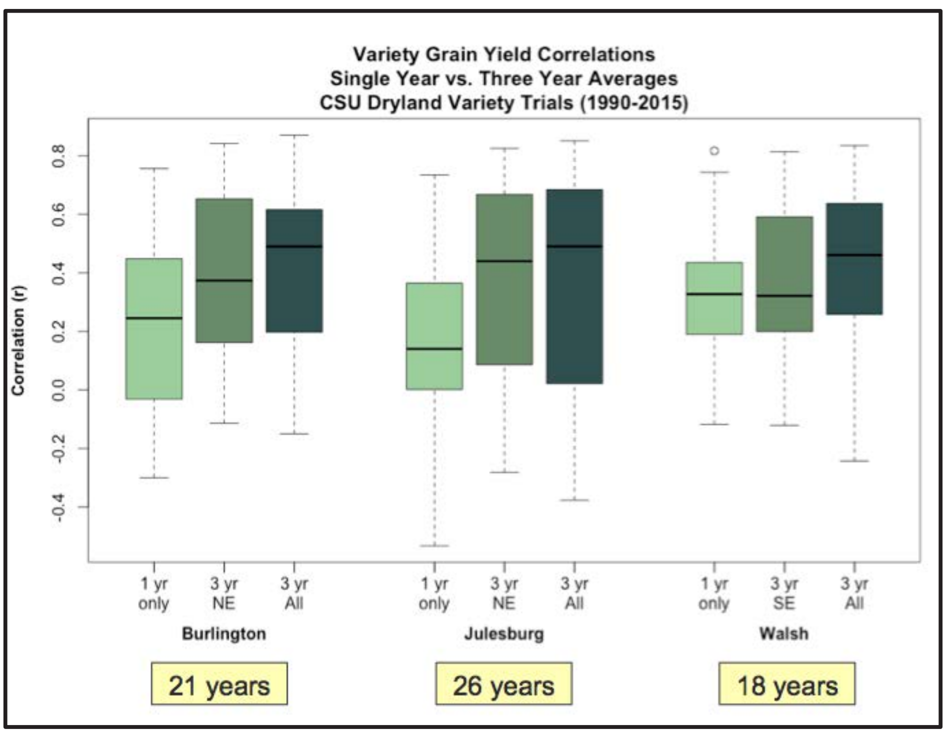


Figure 3 – "Box-plot" graph depicting the correlation of variety performance between years at three locations in Colorado. The horizontal line within each colored box shows the average of all the correlations.

One interesting observation was that zero or even negative correlations were quite common. The lowest correlation observed (-0.53 for 1990 vs. 1992 at Julesburg) showed that the top variety in 1990 ('Yuma') was 17th out of 19 in 1992 and the lowest variety in 1990 ('Jules') was 1st out of 19 in 1992. While this specific example may have been easily explained, it does reinforce that extreme year-to-year variability is common and variety predictability is imperfect.

The last part of the analysis involved calculating the correlation of yields from one year at one location with each of the next three years at the same location. This is shown in **Figure 3**. In each case, the lowest average correlation was observed when a single location-year of data (*light green* box) was used as the predictor. For Burlington and Julesburg, a higher correlation was observed when the current region-wide average ("3 yr NE"; *medium green* box) was used as the predictor, though at Walsh ("3 yr SE") this was equivalent to using a single year of data as the predictor. Most importantly, in each case, the current statewide three-year average (*dark green* box) was the best predictor of yields of the same varieties in subsequent years.

Summary and Conclusions

- Crop breeding and variety testing programs virtually everywhere must deal with the confounding effects of genotype-by-environment interaction (GxE). The presence of GxE reduces progress ("genetic gains") in breeding and complicates variety recommendations.
- The majority of the trial variation for grain yield was variation that did not involve the varieties in any way – and thus is not controllable. Year-to-year variation and GxE variation involving years are the most significant source of variation in these experiments.
- Predictability did improve with increased years of testing and locations but predictability is still imperfect due to extreme year-to-year climatic variability in Colorado. Producers should plant multiple varieties to hedge risks from unpredictable climatic conditions.
- The **worst** predictor of what will happen in a following year at a given trial location was what happened this year at that same location. A **better** predictor was generally the current region-wide three-year average. The **best** predictor was the current statewide three-year average.
- Producers should strive to use all available data to assist with the variety selection process. A handy and powerful database resource is available for desktop or handheld computers to enable generation of custom data summaries. This is available at – ramwheatdb.com.

Acknowledgements

The generous support of the Colorado Wheat Administrative Committee (CWAC) and Colorado Wheat Research Foundation (CWRF) is gratefully acknowledged.

Keeping the Farm on the Farm When the Wind Blows

Cassandra Schnarr and Meagan Schipanski

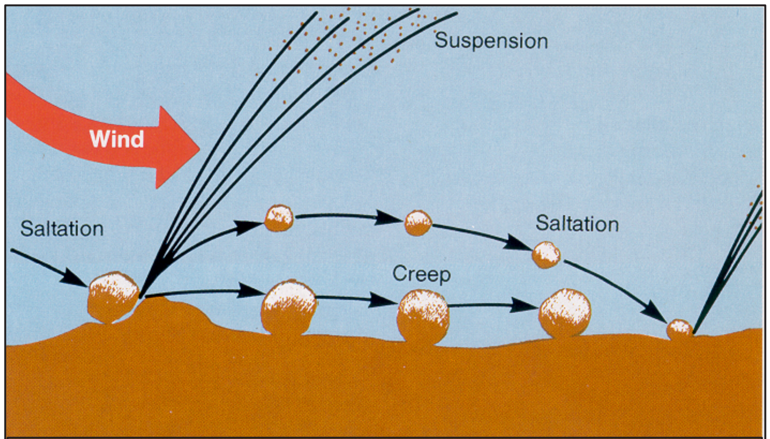
The fundamental asset of a farm is the soil, and an essential goal of the farmer is to hold onto that soil. Erosion can result in lost organic matter, topsoil, surface residues, soil fertility and moisture capacity – reducing crop yields. The evidence of water erosion in your fields is easy to see – rills progressing over time into gullies, and sediment building up in ditches. Wind erosion is a more stealthy threat. Every April, when snow cover can be sporadic and the young wheat or last year's residues do not provide full cover for the soil, the eastern plains of Colorado see their fiercest winds. When you see a dust cloud in the air, that farmer is losing about five tons of soil per acre to wind erosion, according to John Tatarko of the USDA-ARS Wind Erosion Unit.

Thanks to the foresight of previous CSU researchers, Gary Peterson and Dwayne Westfall, we have three long-term research sites in eastern Colorado, referred to as the Dryland Agroecosystems Project (DAP). These no-till sites – located near Sterling, Stratton, and Walsh – have 30 years of rotation history, providing information on everything from water use efficiency to comparative crop profitability. Some of the key factors that influence soil erodibility include residue cover, soil aggregate size, and soil aggregate stability. Previous research at the DAP sites found that reducing fallow frequency increased surface residues and water stable soil aggregates that are important for reducing water erosion (Ortega et al. 2002; Shaver et al. 2002). Our research is focused on the question, 'what is the effect of rotation intensity on soil wind erosion after 30 years? Will soil from systems with fewer fallow periods be able to hold together when the wind blows?'

Limited spring residue cover following corn in a no-till crop rotation near Stratton, Colorado, may leave this soil vulnerable to wind erosion.

Graduate student Cassandra Schnarr is leading the effort that involves collecting soil samples and testing for aggregate stability in collaboration with the USDA-ARS Wind Erosion Unit. The samples are crushed with a Soil Aggregate Crushing Energy Meter to determine the strength of the aggregates from the different rotation systems. Other samples are sent through a sieve system to be divided into size classes. Stronger and larger aggregates will be the most resistant to wind destruction.

The influences of cropping system intensity on wind erosion susceptibility, especially under no-till management, are not well examined. This research will give producers another piece to the puzzle of the complex interactions among crops, water, and soil. Better-informed decisions lead to higher profitability and the conservation of a vital resource for future generations of Colorado producers.



The size and strength of soil aggregates affects how easily they can be carried away by the wind.

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Shaver, T.M., Peterson, G.A., Ahuja, L.R., Westfall, D.G., Sherrod, L.A. and Dunn, G., 2002. Surface soil physical properties after twelve years of dryland no-till management. *Soil Science Society of America Journal*, 66(4):1296-1303.

Aphids that Attack Winter Wheat

Frank Peairs

Ten species of aphids can be found infesting winter wheat and other small grains in Colorado. While they vary in abundance and economic significance, all of them can reach levels where treatment is required.

Aphids can affect the wheat crop in several ways. All species feed on the plant and weaken it by sucking sap from the phloem. Most species are capable of transmitting plant viruses, primarily Barley Yellow Dwarf Virus. Greenbug is phytotoxic and capable of killing small plants, in addition to being a virus vector. Russian wheat aphid and western wheat aphid cause rolling and discoloration of leaves.

There are several management approaches for aphids in winter wheat. Adjusting planting dates can help reduce infestations, although effective dates can vary by location and year. Generally, later planting in the fall and early planting of spring grains are most commonly recommended. Control volunteer wheat and barley. Although many grass species help aphids survive the summer, volunteers are the most important source of infestation for the new crop in the fall. Try to have a three week volunteer-free period prior to emergence of fall seedlings.

Produce a healthy, stress-free crop. Aphids often get their start in stressed fields or stressed portions of fields and cause relatively more damage to stressed plants. Test the soil and fertilize accordingly. Plant certified, treated seed. Select a variety that is well adapted to local growing conditions.

Naturally-occurring biological control often can be effective. Insecticide use can disrupt biological control, so use insecticides only according to accepted treatment guidelines.

Aphid-resistant varieties are highly effective. A number of varieties resistant to greenbug or Russian wheat aphid have been released. However, this approach has been limited by the development of biotypes capable of overcoming the resistance.

Given the sporadic nature of aphid infestations, judicious use of insecticides is often a reasonable option. Available insecticides are listed in the High Plains Integrated Pest Management Guide, http://wiki.bugwood.org/HPIPM:Main_Page. Field biology and treatment guidelines for each aphid also are found in the Guide.

Use the key on the next page to determine which aphid or aphids you are dealing with. This key requires observations of aphid cornicles, which are tubular structures found at the rear of the aphid, and antennae. In some aphids the cornicles are easily observed, while in others they are greatly reduced in size. You will need to observe the cornicles and antennae through a 10X hand lens before you go through the key.

Field Key to Important Wheat Aphids

1. A. Cornicles long and tubular in shape. Go to 2.
   B. Cornicles very short and rounded. Go to 8.

2. A. Body greenish, yellowish or pinkish. Go to 3.
   B. Body dark, chocolate brown. ***Rusty plum aphid.***

3. A. Red coloration on abdomen. Go to 4.
   B. No red coloration on abdomen. Go to 5.

4. A. Antennae with five segments and long fine hairs. ***Rice root aphid.***
   B. Antennae with six segments and short antennal hairs. ***Bird cherry-oat aphid.***

5. A. Cornicles relatively long, almost reaching the tip of the abdomen. Go to 6.
   B. Cornicles relatively short, shorter than the distance to the tip of the abdomen. Go to 7.

6. A. Cornicles all black. ***English grain aphid.***
   B. Cornicles black just at the tips. ***Rose grass aphid.***

7. A. Cornicles dusky. ***Corn leaf aphid.***
   B. Cornicles black just at the tips. Usually with a darker green stripe on back. ***Greenbug.***

8. A. Shiny brown to black aphid, spiny appearance under magnification. ***Hedgehog grain aphid.***
   B. Spindle-shaped gray to green aphids, usually associated with tightly rolled and discolored leaves. Go to 9.

9. A. When viewed from side, a single projection from the tip of the abdomen. Waxy, gray appearance. ***Western wheat aphid.***
   B. When viewed from side, a double projection from the tip of the abdomen. Greenish appearance. ***Russian wheat aphid.***

Soil pH and Phosphorus Fertilizer

Jessica G. Davis

In the past, it has been safe to assume that most Colorado farm ground has a neutral or alkaline pH. However, in recent years, there have been an increasing number of documented cases of soil acidity in wheat-growing areas of Colorado. In particular, sandy soils with long histories of application of ammonia-based fertilizers tend to be the worst hit. Soil acidity has also begun to appear in heavier-textured soils; but higher clay contents tend to buffer soil pH, so it takes longer to see pH levels decline in heavier-textured soils than in sandy, low organic matter soils.

There are many causes of soil acidity, but the likely culprit in agricultural parts of Colorado is application of ammonia-based fertilizers year after year. When ammonium converts to nitrate in soils, hydrogen ions are released, contributing to increased soil acidity (and lower soil pH). Anhydrous ammonia is commonly used on wheat ground, and urea converts to ammonium before being used by plants. The most common liquid fertilizer (urea ammonium nitrate or UAN) contains both urea and ammonium which contribute to soil acidification, but ammonium sulfate is the most acid-forming of all of the nitrogen fertilizers.

<u>Aluminum Toxicity</u>

Soil acidity affects plant nutrients in many ways. When soil pH drops below 5.5, concentrations of aluminum in soil solution go up, and aluminum toxicity can become a problem. In particular, aluminum toxicity causes root deformities to occur. Roots tend to get thick and club-like on the ends, root branching diminishes, and root tips turn brown or black and die off. Of course, when the roots aren't healthy, the whole plant isn't healthy! Water and nutrient uptake will decline when roots are damaged, and the entire plant will suffer.

Below you can see the effects of soil pH on wheat roots. These photos were taken in the Holyoke area and are courtesy of Dave Green with Servi-Tech. So this is not just a problem back East, but something we need to be aware of in Colorado, too.

pH 5.6

pH 4.8

pH 4.5

Phosphorus

In addition to the effect of pH on aluminum, soil pH also has an important impact on plant availability of soil phosphorus. Ideally, a pH of about 6-7 optimizes phosphorus availability. Usually, in Colorado, we are concerned about soil pH being too high and too much calcium in high pH soils binding phosphorus so plants can't take it up. When soil pH is too low, this also reduces phosphorus availability to plants, and in these cases, iron and aluminum are the culprits binding phosphorus so plants can't take it up.

So be sure to pull soil samples from your fields regularly so you can monitor what is happening with your soil pH. As pH levels decline, particularly if they drop below 5.5, it is critically important to bring the pH back up to 6.5 with limestone or other liming materials. And as you evaluate soil pH, pay special attention to soil phosphorus levels. Sometimes crops don't respond to nitrogen fertilizer as we would expect, because a phosphorus deficiency is limiting growth.

If your crop needs phosphorus, banding P fertilizer at planting will reduce binding of the phosphorus to soil minerals and increase the effectiveness of the fertilizer. Banding P with N (as 10-34-0, for example) has been shown to optimize seedling health and get your wheat crop off to a good start.

2015 Wheat Variety Decision Tree for Dryland Production

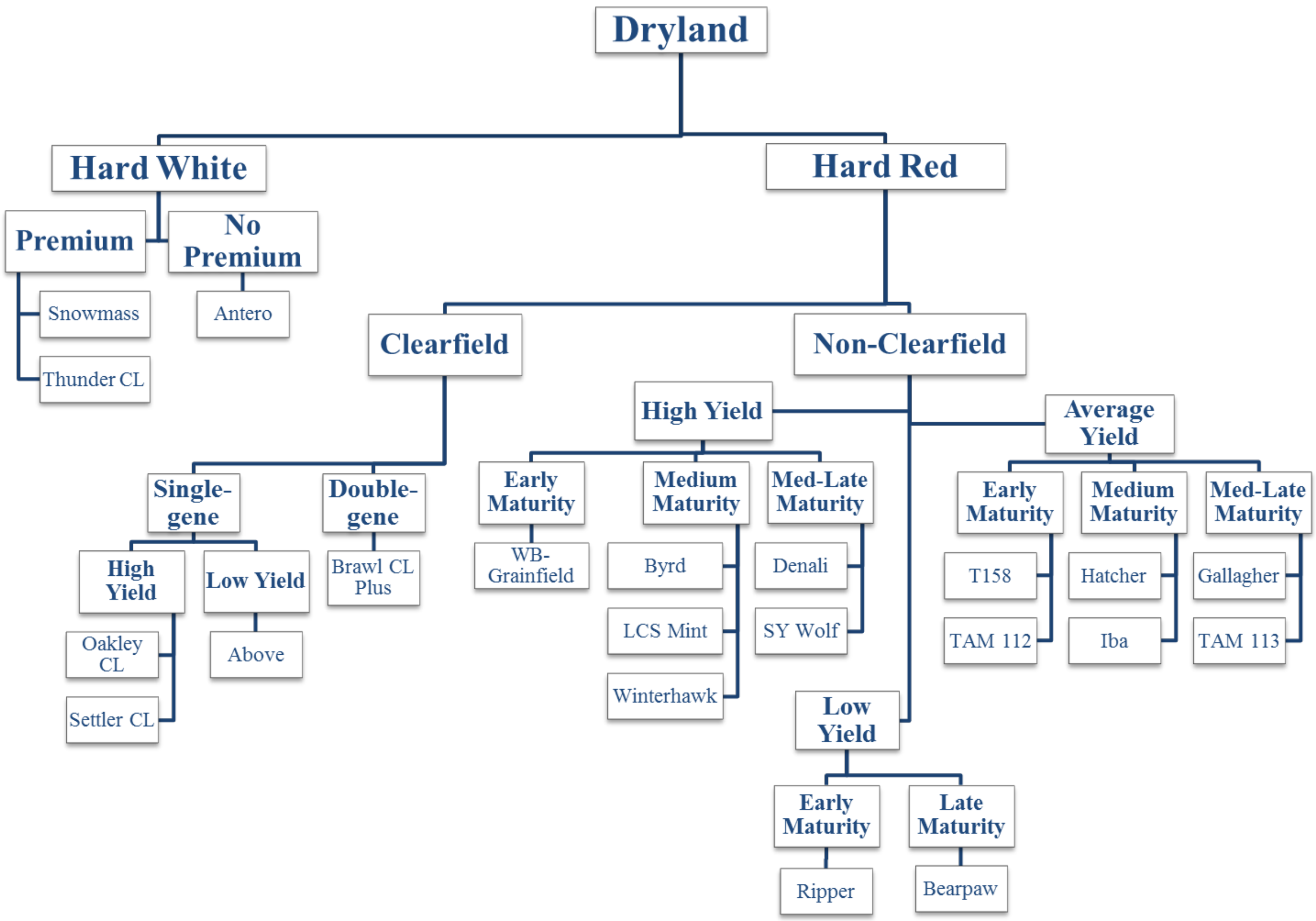
Jerry Johnson and Sally Sauer

The decision tree on the following page will help you make variety selection decisions based on some important characteristics. All of the varieties shown in the decision tree have been tested in our trials for three years, across multiple locations. The yield groups (high, average, and low) were based on the three-year (2013-2015) dryland performance results. Varieties considered high-yielding in the decision tree had a three-year average yield above 100%, or the trial average yield (48.2 bu/ac). Varieties considered average-yielding had a yield between 95 and 100% of the trial average (45.8 to 48.2 bu/ac), and low yield varieties were less than 95% of the trial average (less than 45.8 bu/ac).

The first decision is whether you are going to plant hard red or hard white winter wheat. For farmers choosing to grow hard white wheat, you can decide whether you want to get into a premium program (CWRF Ardent Mills Ultragrain® Premium Program) that can pay an extra $.40 to $.85 a bushel. Or, you can forego the premium program and plant Antero – a high-yielding white wheat adapted to the Great Plains.

If you decide to plant hard red winter wheat, there are substantially more options, and therefore some more decisions to be made. The first decision is whether you are going to plant a Clearfield variety or not. This may be an easy decision for some farmers. One of the Clearfield varieties, Brawl CL Plus, is a double-gene Clearfield variety. This means the herbicide Beyond can be mixed with methylated seed oil to make it more potent on some of the more intractable winter annual grasses, and especially volunteer rye. Brawl CL Plus has excellent test weight, is early-maturing, and has an intermediate to reaction to both stripe rust and leaf rust. There are two high-yielding single-gene Clearfield wheat varieties: Oakley CL and Settler CL. Oakley CL was the second-highest-yielding variety on a three-year average in our trials. It has good test weight, and good stripe rust and wheat streak mosaic virus resistance. Settler CL is a later maturing, medium height variety and is moderately susceptible to stripe rust.

Among the non-Clearfield, high-yielding varieties, WB-Grainfield is the only early-maturing variety and is a tall semi-dwarf. It has good leaf and stripe rust resistance. For the high-yielding medium-maturing varieties, there are three options: Byrd, LCS Mint, and Winterhawk. This should be a category of primary importance for selection of a variety as the varieties are high-yielding and stable. Byrd has excellent drought tolerance, average test weight, and is moderately susceptible to stripe rust. LCS Mint has good test weight and is moderately resistant to stripe rust. Winterhawk has good drought tolerance and test weight, and has an intermediate reaction to stripe rust. The last group of high-yielding non-Clearfield varieties is medium-to-late maturity varieties Denali and SY Wolf. Denali was third from the top for yield in the 2015 three-year summary and has excellent test weight. SY Wolf has very good test weight, is resistant to leaf rust, and is moderately resistant to stripe rust.


Dryland
Hard White
Premium
Snowmass
Thunder CL
No Premium
Antero
Hard Red
Clearfield
Single-gene
High Yield
Oakley CL
Settler CL
Low Yield
Above
Double-gene
Brawl CL Plus
Non-Clearfield
High Yield
Early Maturity
WB-Grainfield
Medium Maturity
Byrd
LCS Mint
Winterhawk
Med-Late Maturity
Denali
SY Wolf
Low Yield
Early Maturity
Ripper
Late Maturity
Bearpaw
Average Yield
Early Maturity
T158
TAM 112
Medium Maturity
Hatcher
Iba
Med-Late Maturity
Gallagher
TAM 113

Managing the Wheat-mite-virus Complex in the High Plains

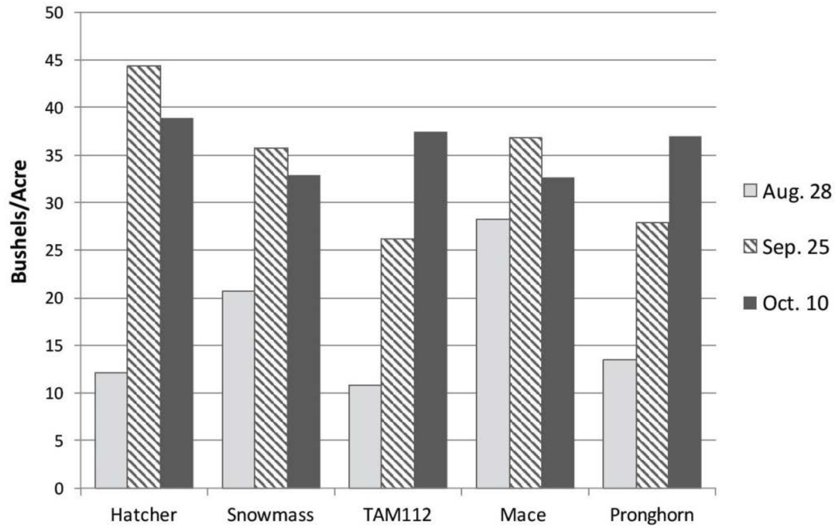
Kirk Broders

The Great Plains region of the U.S. from Montana south to Texas produces over 1 billion bushels of wheat annually or 50% of U.S. wheat production. A disease complex of three viruses transmitted by the wheat curl mite, most notably wheat streak mosaic virus, is the primary disease that impacts wheat throughout the western Great Plains. Colorado State University is part of a five-year, six-state grant (MT, NE, CO, KS, OK, TX) that is looking at improving our ability to predict when the risks from this disease are greatest and how best to manage those risks.

Problems from this disease complex occur when the wheat curl mite that transmits the viruses is able to over-summer in significant numbers. However, the mite cannot survive away from green plants for more than a day or two at the most; therefore, the mite needs a 'green bridge' to be able to survive until the new wheat crop emerges in the fall. In the central High Plains, the greatest 'green bridge' risk results when pre-harvest hail causes pre-harvest volunteer wheat. The mites quickly carry the viruses to the volunteer wheat and attempt to ride out the summer. The mite and viruses can also survive on some other grasses present through the summer. Corn is the most significant risk for mite-virus over-summering. Mite populations can establish on the corn and carry the viruses through corn and move to the new wheat crop in the fall. Damage around corn fields will be variable but will depend on how green the corn stays (irrigated corn is at a greater risk than dryland). Significant August rains can improve the condition of dryland corn and extend its 'greenness' further into the fall when it can overlap with wheat emergence. The severity of this spread will depend on the extent of this corn-wheat overlap and on the fall weather conditions (e.g., greater risk with a warm fall). Even though the risk of disease from adjacent corn is not as extreme as from pre-harvest volunteer wheat, the border effects from mite and virus spread can be significant. Virus risk around these areas can be managed by avoiding early planting in these areas to minimize overlap. Growers might also consider using resistant varieties. Few commercial varieties have strong resistance to this virus complex, but a few newer varieties do carry virus resistant genes (e.g., Snowmass, RonL, Oakley CL, Clara CL, and Mace).

Research completed near Akron, CO, has demonstrated that the most reliable strategy for controlling virus infection is to plant between September 15 and October 15. Keep in mind this is a general rule and may vary from year to year. This will allow for the corn to adequately dry down and reduce the wheat curl mite population, while still allowing the wheat ample time to germinate and establish prior to the onset of colder temperatures. Evidence from our research indicates that even the most resistant varieties (Snowmass and Mace) show a yield penalty when planted early (before September 1) in areas of high wheat curl mite and virus pressure (Figure 1). However, they perform much better than susceptible varieties (Hatcher and Pronghorn) at the earliest planting date. In contrast, all varieties performed significantly better when planted after September 25th. In fact, the susceptible varieties Hatcher and Mace performed as well or better than the resistant cultivars when planted in late September, indicating there was very limited virus pressure after September 25.

Figure 1. Impact of planting date on yield of 5 wheat varieties planted next to corn with high levels of wheat curl mite and wheat streak mosaic virus pressure. Snowmass, TAM112, and Mace are resistant varieties; Hatcher and Pronghorn are susceptible to virus infection.



Growers should scout fields for the presence of wheat streak mosaic virus symptoms (Figure 2) in May in order to know which fields will be most prone to fall infection. In areas with known wheat curl mite-transmitted virus pressure, growers should make sure to eliminate volunteer wheat and weeds after harvest and wait until late September to plant. This is particularly important in areas that are adjacent to or near corn fields as this represents a significant source of inoculum.

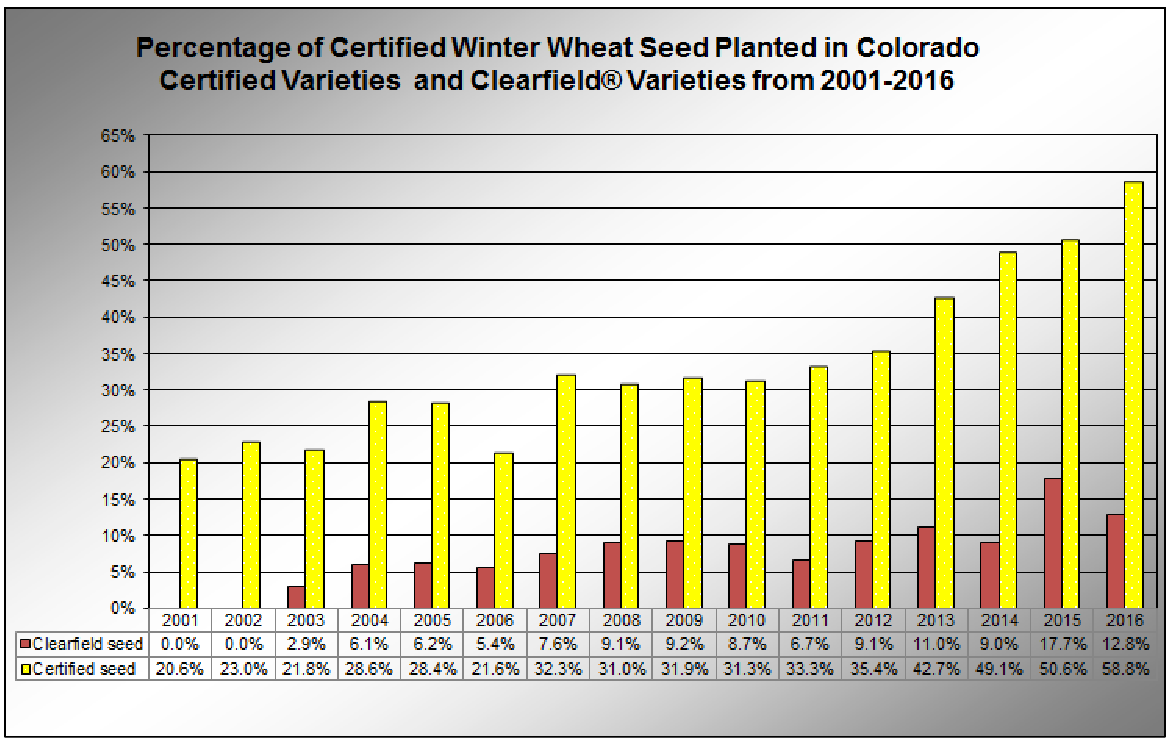
Figure 2. Symptoms of severe wheat streak mosaic virus (WSMV) infection on wheat. Photo courtesy of Dr. Mary Burrows, Montana State University, Bugwood.org

Making a Sound Decision – Plant Certified Seed

Rick Novak

Weather conditions from a previous year often impact decisions made with respect to planting and variety selection. We need to remind ourselves that agronomic decisions and variety selections should be based on information from three years of variety trial results. Variety selection decisions only occur once a year and with planting just a few months away, this would be a good time to gather information to help with this decision-making process. Generally, better informed and educated growers make better, more calculated variety selection decisions. So why not get started on your 2016 wheat variety selection decision plans today.

The annual survey of the Colorado Ag Statistics Service indicated that 2.25 million acres of winter wheat were planted in Colorado in the fall of 2015. This is about 275,000 less acres planted to winter wheat than in 2014. There has been a consistent trend of increasing purchases of Colorado certified seed by farmers in Colorado as the graph below indicates.



Many farmers currently purchase a portion or all of their seed as certified seed every year. The real success of the certified seed program is that certified seed planted has increased from about 20% to 58% in 16 years. In the past five years, usage has dramatically increased from 35% up to 58%. Various factors have influenced the use of certified seed despite the cost: new and improved varieties, increase in the frequency of new variety releases, seed availability, and many others.

There are many reasons to purchase certified seed, but purchasing certified seed regularly is simply a very sound management practice. I would like to review a couple of the more important benefits that result from purchasing certified seed.

1. You do not have to be concerned about purity, weeds, and germination of the seed you plant.
2. You will have the option to have seed treatment applied to the purchased seed.
3. You can save time and labor and purchase the exact amount of seed required for planting.
4. You are able to purchase a desirable, higher yielding variety with superior agronomic traits.
5. You are provided an opportunity to grow identity-preserved varieties for specialty markets.
6. You will experience an increase in average grain yields over time with new and improved varieties.

Purchasing certified seed provides the needed funding that supports research and varietal development for the future. The development of a new variety can take up to ten years, but with the implementation of new wheat breeding technologies, such as doubled haploid and genetic marker-assisted selection, the timeline of bringing new varieties to the market has been reduced significantly. In 2016, we will also hear about more significant improvements coming soon for wheat, such as hybrids and new herbicide tolerant wheat technologies. As a result of the increase in certified wheat seed use in recent years, there has been a direct funding increase in research and development for the crop. Therefore, each time that a farmer makes a decision to purchase certified seed the action encourages stronger support for research and variety development.

Field Days and other plot tours provide each of us with a first-hand opportunity to ask questions, gather information, and review the previous season with experts. Please become familiar with and informed about all the options that you have when making your variety selections and agronomic decisions for this fall!

Potential for Harvest Weed Seed Control in Colorado

Neeta Soni, Todd Gaines, Scott Nissen, and Phil Westra

Key Points:

- Harvest weed seed control (HWSC) methods destroy weed seeds collected at grain harvest, providing an additional option to diversify weed management
- HWSC methods work best if the maturity of the weed species coincides with grain harvest, and if a majority of weed seed is retained on the plants and harvested, so some weed species are good targets and others are not
- HWSC methods integrate well with conservation tillage and residue retention for dryland farming, because only the chaff fraction leaving the combine is targeted and the bulk of the residue is retained in the field as straw
- Over time, HWSC methods combined with herbicides can drive the weed seed bank to almost zero in a field
- The main HWSC methods include chaff carts, narrow windrow burning, chaff baling, and the Harrington Seed Destructor; visit www.ahri.uwa.edu.au/spoiled-rotten for details

Herbicides and crop rotation are the major methods for winter annual grass weed control in Colorado wheat fields. Weeds can respond quickly to evolve herbicide resistance or to adapt to cultural practices such as tillage and crop rotation. Integrated weed management programs are critical to sustainably manage weeds and protect crop yields, and diversity in weed control methods is vital to ensure sustainability. We are currently investigating a new method for integrated weed management that could provide non-chemical control of winter annual grass weeds in wheat. Harvest weed seed control (HWSC) involves methods to capture and destroy weed seeds at the same time that the crop is being harvested, greatly reducing the dispersion of weed seeds in the field from harvesting equipment. When added to a weed management program, HWSC can reduce weed pressure for next season, substantially deplete the weed seed bank in the soil, and delay weed species adaptation to our current weed control practices.

We investigated whether there is potential for Colorado wheat growers to use HWSC as an integrated method for annual winter grass control. Problematic weeds such as feral rye, jointed goatgrass, and downy brome have a similar growth habit and maturity as wheat. If the seeds produced on these species do not shatter prior to wheat harvest, then the weed seeds are collected at wheat harvest by the combine. Some of these seeds go into the combine bin (and can result in dockage if present at high levels), and many seeds are returned back to the field in the chaff fraction. This provides an opportunity to capture and destroy the weed seeds present in the chaff using one of several HWSC methods. Researchers working in Australian wheat fields have reported successful cases where it was possible to destroy 80-95% of weed seed (major species include annual ryegrass, brome, and wild radish) using any one of multiple HWSC methods in grain crops. Existing HWSC methods used in Australia include direct baling of chaff (bales can then be used as feed); chaff carts (chaff piles are later burned to destroy the weed seeds); narrow windrow burning (chaff is concentrated in a windrow and later burned to destroy the weed seeds); and the Harrington Seed Destructor, a machine either pulled behind the combine or integrated in the combine to crush weed seeds in the chaff and return all residue to the field.

In the summer of 2015, we conducted a field survey in eastern Colorado. Our objective was to determine the proportion of total feral rye, jointed goatgrass, and downy brome seed that was retained in the harvested wheat canopy and the proportion of weed seed shattered from the plant at harvest and found on the ground. In addition, we compared heights between weed species and wheat. Twenty-one wheat fields were sampled 1-4 days before harvest. In total we sampled 14, 6, and 7 locations containing feral rye, jointed goatgrass, and downy brome, respectively. Our results indicated that depending on the weed species, about 75 to 90% of the weed seed was found in the section of the wheat canopy that is harvested by the combine (Figure 1). Average plant height of downy brome and feral rye was similar or taller than wheat, while jointed goatgrass was on average 12 inches shorter than wheat. Therefore, downy brome and feral rye are more likely to be harvested by the combine than jointed goatgrass, depending on the grower's harvest height preference.

Results from this survey showed that HWSC methods have potential as an integrated non-chemical weed control method in Colorado for winter annual grass weeds. The majority of winter annual grass seeds can be captured at wheat harvest and Colorado wheat growers have the opportunity to substantially reduce the weed seed bank in the soil over time. To validate our findings we are repeating this field survey in summer 2016. **Please contact PhD student Neeta Soni (neeta.soni@colostate.edu) if you have a potential sample site (feral rye, jointed goatgrass, or downy brome) and would like to participate in the survey.**

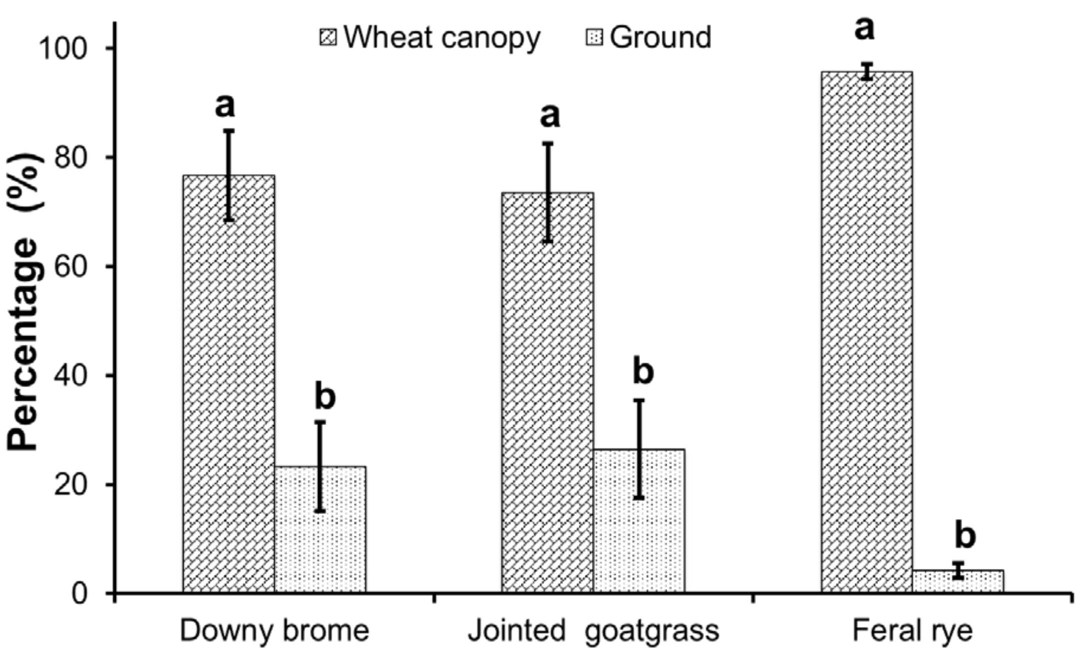


Figure 1. Percentage of total weed seed in the wheat canopy, versus the percentage of seed on the ground at time of wheat harvest. Winter annual grasses retain most of their seeds on the plant in the wheat canopy at wheat harvest. The letters 'a' and 'b' indicate statistically significant differences.

PlainsGold Supports Public Wheat Breeding

Byrd. Brawl CL Plus. Hatcher. Snowmass. Antero. Denali. To winter wheat farmers in the High Plains of Colorado, Kansas and Nebraska, these six varieties are legends for their reliability, yield and quality. And now, new varieties like Sunshine and Avery will become part of wheat farmers' success. The wheat breeding program at Colorado State University (CSU) that developed them—and certainly the wheat farmers who supported the program individually and through the state checkoff—put a spotlight on this great public wheat-breeding program. The CSU wheat-breeding program has released more than 30 improved wheat varieties since 1963. The program delivered the first publicly-developed, two-gene Clearfield wheat, which was released in 2011 under the name Brawl CL Plus. This was preceded by the launch in 2001 of the first ever Clearfield wheat in the U.S., Above, and the first variety resistant to the Russian wheat aphid in 1995 – Halt. Surprised? You aren't alone. International powerhouses in corn and soybeans such as Monsanto and Syngenta have purchased regional wheat breeding companies in the past few years. The Colorado Wheat Research Foundation (CWRF) takes ownership of the CSU-developed varieties and markets them under the PlainsGold® brand. Royalties from seed sales are then reinvested into variety development at CSU, as well as testing and marketing. This collaboration between CWRF and the university is unique and many other states try to use this as a model for their own programs.

PlainsGold varieties are exclusively from the CSU wheat breeding program, and tested extensively in Colorado and surrounding states. All PlainsGold varieties have consistently performed well in the unique, and often difficult, wheat growing conditions prevalent across the High Plains region. Plus, many varieties have unique traits such as herbicide tolerance and premium quality for additional incentives for growing specific varieties. According to information supplied by PlainsGold, "Our unique approach to wheat variety development is based on a firm foundation of field-testing. All PlainsGold varieties are tested in one of the country's strongest field-testing programs comprising more than 50 locations."

"The CSU wheat breeder has consistently made advances in wheat genetics ahead of most other research programs," said Dan Anderson, CWRF chairman. "These advances, combined with one of the largest trial programs in the country, ensure wheat farmers of having quality choices with the data they need to select a variety that aligns with their individual production goals." Despite strong competitive pressure in Colorado and the High Plains, PlainsGold varieties are planted on the majority of winter wheat acreage in Colorado. More than 68 percent of wheat acres in Colorado are currently planted to PlainsGold varieties. Now, PlainsGold is expanding into more states, including Kansas, Nebraska, Wyoming, Montana, South Dakota and Texas.

Acknowledgments

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The authors are thankful for the cooperation and selfless contributions of land, labor, and equipment made by the following Colorado wheat farmers who consent to having winter wheat variety performance trials conducted on their farms: John and Jensen Stulp (Lamar, Prowers County), Burl Scherler (Brandon, Kiowa County), Dennis and Matt Campbell (Arapahoe, Cheyenne County), Randy Wilks (Burlington, Kit Carson County), Jim Carlson (Julesburg, Sedgwick County), Steve Boerner (Haxtun, Phillips County), Cooksey Farms (Roggen, Weld County), Ross Hansen (Genoa, Lincoln County), Wickstrom Farms(Orchard, Morgan County), and Bill and Steve Andrews (Yuma, Yuma County). We recognize valuable assistance provided by the CSU Extension agents who work with eastern Colorado wheat producers in all aspects of the COFT program. We are very thankful for the efforts and sacrifices made by Colorado wheat producers who contributed time, land, and equipment to the success of the Collaborative On-Farm Test program. We thank Syngenta Crop Protection for their generous donation of seed treatment product so that all varieties are able to be treated.

Colorado State University is very grateful to the Colorado Wheat Administrative Committee for printing this report.

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