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Agricultural Experiment Station

Colorado State University

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

Making Better Decisions

2019 Colorado Winter Wheat Variety Performance Trials

Crops Testing

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Additional Resources on the Internet

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

Overview of 2018-2019 Eastern Colorado Winter Wheat Trials

Jerry Johnson and Sally Jones-Diamond

Colorado State University researchers provide current, reliable, and unbiased wheat variety information to Colorado producers. Support of our research keeps public variety testing thriving in Colorado. Farmer support of 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 and trait royalties).

We test under a broad range of environmental conditions to best determine expected performance of new varieties. We have a uniform variety testing program, meaning that all dryland varieties are tested in all eleven dryland test locations and all irrigated varieties are tested in all three irrigated trials. There were 38 varieties including experimental lines in each of the 11 dryland trials. The three irrigated trials each had 24 varieties. The variety trials included a combination of public and private varieties and experimental lines. Seed companies with entries in the variety trials included AgriMaxx Wheat, AgriPro Syngenta, Dyna-Gro Seed, Limagrain Cereal Seeds, and WestBred Bayer. There were entries from the Colorado marketing organization, PlainsGold.

All dryland and irrigated trials were planted in a randomized complete block design with three replicates. Plot sizes were approximately 150 ft^2 (except the Fort Collins irrigated trial, 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 0.15 to 2.2 acres per variety in side-by-side strips and seeding rates conformed to the seeding rate used by the collaborating farmer. Yields were corrected to 12% moisture. Variety trial plot weight, test weight, and grain moisture content information was obtained from a Harvest Master H2 weighing system on a plot combine.

General Growing Conditions in Southeast Colorado - Kelly Roesch

As is typical in the Southeast Area we received some moisture from the monsoon season in July that was followed by a hot and dry August. Some of the area received moisture in early September which allowed for good conditions for those producers who were willing to plant early. The wheat that was planted later was for the most part planted into dry conditions. Rain received in the last week of November got the crop started and wheat stands across the area looked good going into winter.

The winter brought more snow and cooler temperatures than have been experienced recently. As the wheat broke dormancy in the spring moisture remaining from the snow and rain combined with warmer temperatures had the wheat crop looking excellent.

A cold front on May 22nd brought temperatures in the 26-28°F range for several hours. Damage to the wheat depended on what growth stage it was in. Fields in the pollination stage suffered the worst damage. Lower lying portions of the fields had more damage than the hilltops.
June and July continued to bring good moisture and growing conditions. Very little virus or rust presence was noted.

Yields ranged from 15-90+ bu/acre across the area depending on the extent of freeze damage. Protein levels were mixed however, with the higher yields there was still a lot wheat with protein at 10 or below. Yields for the area as a whole were generally averaging in the 50 bu/acre range.

General Growing Conditions in Northwest High Plains of Colorado - Wilma Trujillo
2019 was another challenging year for wheat producers. Most producers in Adams, Morgan, Logan, Southwest Washington and Weld counties planted in adequate soil moisture from late September to mid-October. Germination and stand establishment were adequate.

In general, normal conditions prevailed during the fall. September was characterized by dry and warm conditions. October and November were slightly wetter and cooler than normal. Warm and dry conditions predominated in December and January. Winter snowfall was sporadic and somewhat slightly below normal. The snow blizzards in mid-March and mid-April provided significant moisture. The mid-May snow-storm brought not only heavy rain/snow mix, but also freezing temperatures. May turned out to be exceptionally cooler than normal. Lower temperatures delayed the jointing and boot stages for about three weeks. June started with localized hail associated with several thunderstorm systems.

Stripe rust was present in most of the area, but dry conditions in June stopped further development of the disease. Other fungal (tan spot, leaf rust and cephalosporium stripe) and bacterial (bacterial streak) diseases were observed in the area. Damage to wheat from these diseases ranged from very low to mild depending on wheat variety.

Harvesting activities gradually began in the first week of July. In mid-July, producers made significant progress in harvesting wheat in the midst of scattered precipitation. Wheat harvest was wrapped up by the first week of August.

Yield ranged from the mid 30's to low 70's bu/ac across the area. Yield variability could be attributed to the weather pattern during the growing season, hail storms, selection of adapted wheat varieties, presence of the wheat stem sawfly and fertilization management. Grain protein content was highly variable, ranging from 7% to above 12%. Test weight varied from 58 lb/ac to 63 lb/ac.

General Growing Conditions in Northeast Colorado - Dennis Kaan and John Spring
Wheat planting in Washington, Yuma, Logan, Phillips, and Sedgwick counties for the 2019 crop ranged from optimal (latter-half of September) to later than normal (early-to-mid October). Seedbed conditions were generally dry over good subsoil moisture for earlier planted wheat, and mostly into adequate soil moisture for later planted. Stand establishment was adequate. Temperatures were relatively mild from September through January, but drier than usual. Fall growth and tillering was much less than usual going into winter dormancy. Unusually cold temperatures occurred in February and March, but generally were accompanied by snow events, and stand loss was not widespread across the region. Cold spring temperatures continued into April, delaying green-up and jointing by approximately 3 weeks relative to normal timing. Several late frosts further slowed spring growth but did not result in widespread damage.

The dry conditions observed over the winter reversed in April, and greater than average precipitation combined with lower than average temperatures for much of the remaining wheat growing season. Good moisture and mild temperatures did create favorable growing conditions for late tillering and development, and a good-to-excellent crop by maturity.

Despite concerns posed by cool, wet weather, stripe rust did not appear with any severity across the region until well after flag leaf emergence, or even heading. Late infestations of leaf and stripe rust did occur in susceptible varieties, but generally had minimal impacts on yield. While present across the region, viral diseases had minor effects as well. Background levels of tan spot and bacterial leaf streak were also observed, but with minimal yield loss. Cephalosporium stripe was unusually severe and resulted in appreciable yield losses in susceptible varieties in some fields across the area. Due to cold temperatures and slow early growth reducing the ability of wheat to withstand generally safe herbicides, unusual cases of severe crop injury resulted from spring applications of the Group 2 herbicides Beyond, PowerFlex, Osprey, and Olympus. While relatively isolated, in fields where such injury was observed yield losses ranged from severe to nearly complete loss. The area with wheat stem sawfly damage continued to expand relative to prior year observations, but the degree of loss was generally low. Hail damage was normal to light across the region.

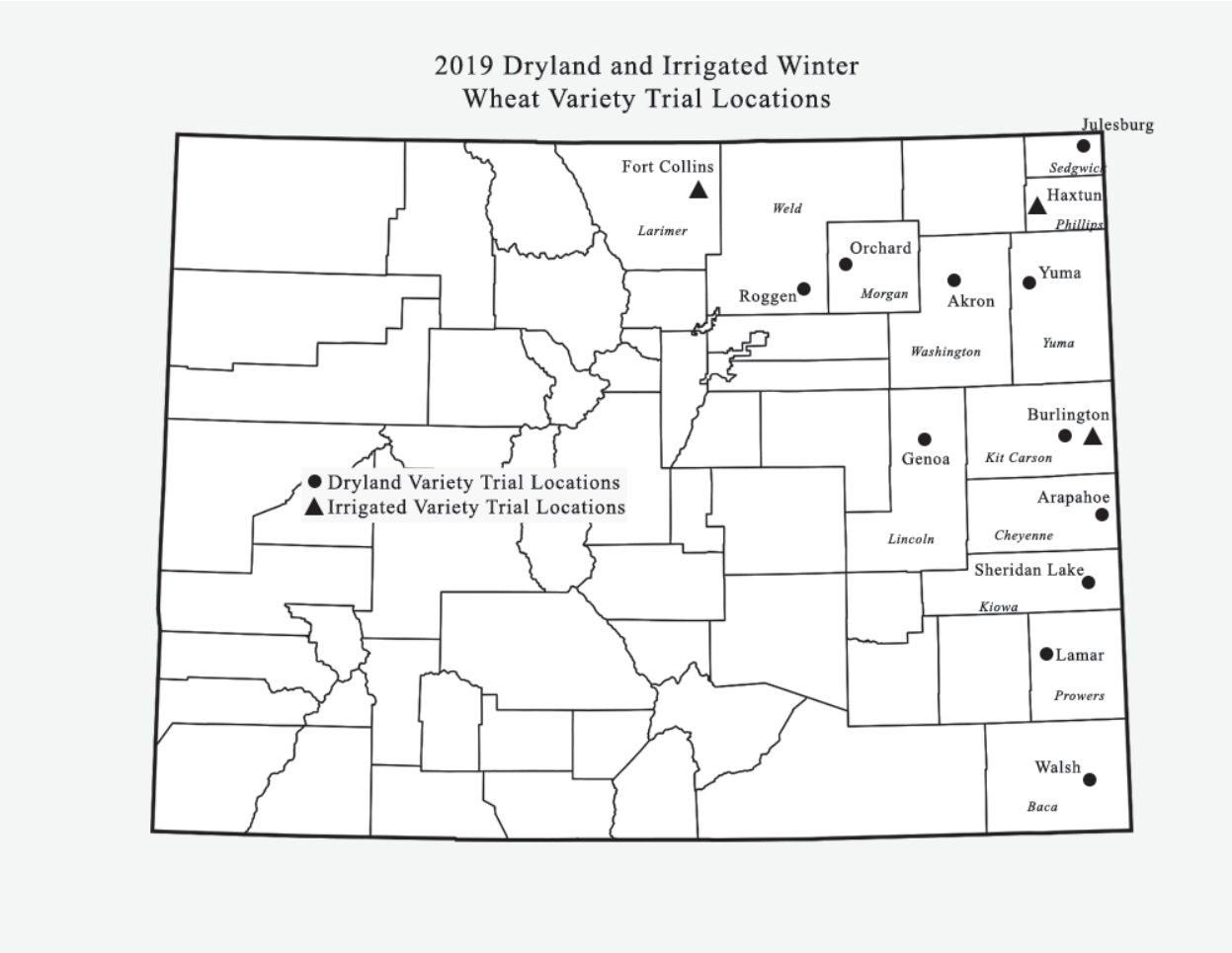
Harvest did not begin in earnest until after the 4th of July and was not fully finished until August. Yields ranged from 40 to over 90 bu/ac across the area, with 60 to 70 bu/ac typical. Test weights were good to high, with most ranging from 60 to 64 lb/bu. Under-application of N fertilizer for yield level continued to result in low protein levels, with 9 to 10% typical. Where adequate N fertilizer was applied for yield potential, protein reached adequate levels of 11.5 to 12% or above.

General Growing Conditions in East Central Colorado - Ron Meyer

The 2019 wheat production season from east-central Colorado can be described as another successful season. Timely fall moisture enabled very good wheat stands along the I-70 corridor. Snow cover followed during the winter season, which further added to adequate soil moisture levels. Finally, better-than-average spring moisture allowed deep soil moisture to accumulate when the winter wheat crop began the journey to yield. In addition, air temperatures were cooler than normal which favors wheat production. As a result, reported wheat yields that were double long-term averages were common. Dryland wheat yields from many farms averaged 70 bushels per acre while some producers averaged more than 90 bushels per acre across the whole farm. As a result of very good yields, protein levels were again low. Better nitrogen fertilizer management is assisting protein levels, however, as yields increase protein tends to drop. This was the case locally, as well.

Stripe rust was evident early but did not proliferate and only a few fields were treated with a fungicide. I believe a combination of low rust spore populations, resistant wheat varieties, and lower humidity caused a failure to thrive for rust populations.

These exceptional wheat yields continue the trend and makes the last four wheat crops in this area better than our long-term average.


2019 Dryland and Irrigated Winter
Wheat Variety Trial Locations
Julesburg
Sedgwick
Fort Collins
Larimer
Weld
Haxtun
Phillips
Orchard
Morgan
Roggen
Akron
Yuma
Yuma
Washington
Burlington
Kit Carson
Genoa
Dryland Variety Trial Locations
Irrigated Variety Trial Locations
Arapahoe
Cheyenne
Lincoln
Sheridan Lake
Kiowa
Lamar
Prowers
Walsh
Baca

2019 Dryland Wheat Trial Management and Characteristics

2019 Dryland Wheat Trial Management and Characteristics

		Akron	Arapahoe	Burlington	Genoa	Julesburg	Lamar	Orchard	Roggen	Sheridan Lake	Walsh	Yuma
	Average Yield (bu/ac)	67	104	100	72	54	53	48	73	60	90	86
Location	**GPS Coordinates (Lat/Long)**	40.1493	39.0015	39.2852	39.3516	40.8356	38.0026	40.4817	40.0727	38.5345	37.4312	40.1907
		-103.1373	-102.2461	-102.2795	-103.5093	-102.3429	-102.6135	-104.1099	-104.3019	-102.4712	-102.3104	-102.6611
	County	Washington	Cheyenne	Kit Carson	Lincoln	Sedgwick	Prowers	Morgan	Weld	Kiowa	Baca	Yuma
Soil	**Soil Type**	Rago Silt Loam	Keith-Richfield silt loam	Kuma-Keith silt loam	Weld silt loam	Keith-Kuma silt loams	Wilid silt loam	Briggsdale clay loam	Weld loam	Wiley loam	Wiley loam	Haxtun sandy loam
	Sand-Silt-Clay %	29-50-21	29-52-19	29-54-17	31-50-19	31-50-19	39-44-17	51-26-23	31-44-25	41-40-19	21-60-19	49-32-19
	Soil Organic Matter	1.5 %	1.6 %	1.9 %	2.0 %	1.6 %	1.1 %	1.2 %	1.4 %	1.3 %	1.7 %	1.4 %
	Soil pH	6.3	7.9	7.5	7.2	6.3	8.1	7.6	7.6	7.4	7.9	7.3
	Soil Nutrients at planting (N-P lb/ac)	111-15	166-7	182-10	123-20	102-27	80-5	70-5	82-10	87-10	137-11	117-18
Management	**Applied Fertilizer in Season (N-P-K lb/ac)**	8-28-0	73-46-0-7S-0.5Zn	92-49-0	62-38-0-1S	23-28-0-1Zn	45-36-0	59-37-0-2S-0.25Zn	8-28-0	54-28-0-8.25S	56-20-0	37-28-0-2S
	Tillage	No-Till	Verticle Tillage	Tilled	2x Tilled	No-Till	No-Till	No-Till	No-Till	No-Till	Tilled	Min-Tilled
	Previous Crop 2017/2018	Proso millet/ Chemfallow	Corn/ Chemfallow	Corn/ Chemfallow	Oil Sunflowers/ Fallow	Corn/ Fallow	Wheat/ Chemfallow	Proso Millet/ Chemfallow	Corn/ Fallow	Grain Sorghum/ Chemfallow	Wheat/ Fallow	Proso Millet/ Fallow
Development	**Planting Date**	3-Oct-2018	13-Sep-2018	13-Sep-2018	18-Sep-2018	2-Oct-2018	12-Sep-2018	2-Oct-2018	1-Oct-2018	12-Sep-2018	18-Sep-2018	19-Sep-2018
	Harvest Date	26-Jul-2019	16-Jul-2019	17-Jul-2019	18-Jul-2019	30-Jul-2019	8-Jul-2019	29-Jul-2019	25-Jul-2019	12-Jul-2019	8-Jul-2019	13-Jul-2019
	Heading Date (Avg)	4-Jun-2019	26-May-2019	28-May-2019	2-Jun-2019	8-Jun-2019	16-May-2019	9-Jun-2019	5-Jun-2019	20-May-2019	19-May-2019	30-May-2019
	Days from Planting to Heading (Avg)	244	255	257	257	249	246	250	247	250	243	253
Envrionment	**Biotic Stress**	Minor sawfly, trace stripe rust, tansy mustard present in May	Some WSMV noted mid-May	Sprayed for stripe rust June 1	-	Tan Spot, Cephalosporium stripe, WSMV, stripe rust present	-	Severe sawfly	Low level stripe rust noted June; sprayed for rust in June	-	Minor leaf and stripe rust, barley yellow dwarf virus, tan spot	Low levels stripe and leaf rust
	Abiotic Stress	Freeze - possible* Some lodging	-	-	Freeze- minor*	Freeze - suspected**	Freeze - severe*	Freeze - moderate* Slight hail damage in June	Freeze - moderate*	Freeze - severe*	-	Leaf rolling mid-May indicated drought stress 2.8" rain late May
	Total Rain: April 1 to Harvest	9.25 in	6.99 in	7.56 in	8.22 in	7.46 in**	5.76 in	8.42 in	7.4 in	9.07 in	6.89 in	5.97 in
	Last Spring Freeze Dates	**May 22:** 2 hr < 30 F Temp to 29 F	No Freeze Events	No Freeze Events	**May 22:** 2 hr < 30 F Temp to 29 F	**May 22:** Suspected**	**May 19:** 15 min <31 F Temp to 30.6 F **May 22:** 3 hr < 30 F Temp to 28.2 F	**May 22:** 1 hr < 30 F Temp to 28.5 F	**May 22:** 1hr < 30 F Temp to 28.7 F	**May 22:** 3 hrs < 30 F Temp to 28 F	No Freeze Events	No Freeze Events

*Freeze severity estimated from Kansas State Wheat Freeze Damage Publication (https://www.sunflower.k-state.edu/agronomy/docs/c646_Whole_Wheat_Freeze_Publication.pdf)
**Weather station limited data: Missing rain prior to May 17, missing Temp - May 22 midnight to 6:20 am
WSMV: Wheat streak mosiac virus

Irrigated Variety Performance Trials

Fort Collins, Larimer County: Planted 9/13/2018 and harvested 7/25/2019. Timely fall planting with fall moisture. Uniform emergence and good stands and fall growth. Ample spring precipitation, very lush growth and very high yield potential observed by late May. Cool spring temperatures led to late date of heading, about 8 days later than the 10-year average for the site. Pea-sized hail on June 4 caused minor damage. Damaging hail occurred on June 5, causing 20-30% damage, which was more severe on earlier entries. Severe stripe rust in the field effectively controlled with fungicide, but a later leaf rust infection was noted on susceptible entries. Lodging observed in some entries. Trial received 150 lb/ac of N and 30 lb/ac of P. GPS: 40.6529, -104.999

Haxtun, Phillips County: Planted 10/4/2018 and harvested 8/7/2019. Trial planted after corn silage harvest into tilled corn residue. Planted about 1.25" deep. Trial was irrigated in fall after planting. Good growth in spring and trial received hail damage from a storm at the end of May and again at the end of June. Trial was sprayed in mid-June with fungicide. Trial received 117 lb/ac N in the spring. GPS: 40.405, -102.6063

Burlington, Kit Carson County: Planted 10/3/2018 and harvested 7/17/2019. Planted into tilled corn residue about 1.25" deep. Plants looked good, albeit small in mid-May. Limited-irrigation applied during the season (4" total) and the late date of planting contributed to low yield. Wheat streak mosaic virus symptoms were severe in the trial by mid-May and significantly affected grain yield. Trial received 110 lb/ac of N and 40 lb/ac of P, no fungicide or insecticides were applied. GPS: 39.21465, -102.13837

Summary of 2019 Dryland Winter Wheat Variety Performance Results

	2019 Individual Trial Yield[a]											2019 Multi-Location Average			
Variety[b]	Akron	Arapahoe	Burlington	Genoa	Julesburg	Lamar	Orchard	Roggen	Sheridan Lake	Walsh	Yuma	Yield	Yield	Test Weight	Heading[c]
	bu/ac											bu/ac	% of avg	lb/bu	days from avg.
CO15D098R	**73.7**	**118.1**	**111.2**	**81.3**	57.5	58.5	52.3	**82.1**	62.7	91.7	**96.3**	80.5	110%	62.2	0
Antero	71.1	112.3	**109.5**	**78.5**	57.4	**66.3**	52.0	78.9	64.5	96.9	**95.8**	80.3	110%	61.1	-1
Sunshine	**73.2**	103.9	**107.4**	76.7	57.2	**66.3**	52.7	76.5	66.9	**101.8**	90.2	79.3	108%	61.3	-1
Langin	**74.6**	110.6	**109.7**	72.9	56.6	54.1	43.8	77.9	64.4	**99.7**	**95.1**	78.1	107%	60.5	-3
Byrd CL Plus	69.0	111.6	105.3	**77.1**	49.7	60.0	58.3	77.1	65.2	96.0	89.6	78.1	107%	60.8	0
Avery	68.9	110.8	103.7	76.3	51.9	59.3	51.0	77.3	61.1	**101.4**	92.2	77.6	106%	60.3	1
Whistler	64.1	112.4	96.8	74.3	57.3	**65.5**	46.6	79.4	70.5	98.4	84.7	77.3	106%	60.3	2
Guardian	66.2	113.6	95.6	**77.7**	40.2	**66.8**	44.2	75.9	**78.9**	90.9	86.4	76.0	104%	61.8	1
Snowmass 2.0	64.8	108.5	**107.4**	68.5	55.5	**66.2**	45.9	76.8	65.0	86.8	88.6	75.8	104%	61.3	-1
CO13D1479	67.4	106.6	105.1	73.1	57.5	59.1	47.1	75.1	62.7	89.6	87.3	75.5	103%	61.2	1
Breck	67.3	112.2	103.8	69.0	58.8	61.4	42.9	72.3	59.4	94.0	89.3	75.5	103%	62.6	0
Crescent AX	66.8	108.2	102.5	74.2	52.1	50.1	56.9	76.1	59.9	90.8	91.7	75.4	103%	61.7	-1
WB4595	69.2	98.3	100.6	75.9	60.7	54.2	55.0	77.0	62.6	92.8	82.7	75.4	103%	62.2	1
Denali	61.3	107.9	**108.6**	74.1	57.3	59.2	46.4	70.5	62.8	90.5	89.3	75.3	103%	61.9	2
Monarch	65.3	108.1	106.2	74.5	55.8	59.6	40.5	73.5	60.6	90.7	91.6	75.1	103%	61.1	1
Canvas	68.7	105.4	101.5	75.1	51.6	61.8	40.4	72.2	69.4	89.8	86.2	74.7	102%	61.8	1
CO13D0346	64.3	107.4	98.9	69.4	60.2	43.9	47.4	72.4	66.5	93.7	**93.4**	74.3	102%	60.6	-1
Byrd	63.5	113.0	97.0	69.6	46.3	61.6	46.3	72.2	63.4	94.5	89.6	74.3	101%	60.7	-1
WB4462	**72.8**	101.9	103.5	**77.2**	**62.6**	42.6	55.4	73.5	46.7	87.1	86.1	73.6	101%	62.0	-1
WB4792	64.6	97.1	95.9	75.5	57.1	55.8	46.2	74.0	62.9	89.7	89.0	73.4	100%	61.7	3
Fortify SF	**72.3**	108.4	93.2	70.5	51.2	50.2	59.4	75.2	58.4	81.8	85.5	73.3	100%	61.4	0
SY Monument	65.6	102.6	103.6	68.1	58.2	57.1	50.0	73.2	49.4	89.3	84.9	72.9	100%	60.5	2
WB-Grainfield	67.4	109.1	103.3	66.0	59.6	42.9	43.0	69.2	51.8	92.5	88.7	72.1	99%	61.6	-3
SY Rugged	69.1	101.9	96.4	70.7	**65.6**	47.3	46.0	70.1	55.0	87.7	80.0	71.8	98%	61.1	-1
Hatcher	70.7	100.8	94.2	74.7	41.6	48.2	48.1	77.4	62.5	88.0	80.7	71.5	98%	60.7	0
CO15SFD092	69.5	107.2	98.1	63.1	50.5	42.1	53.0	74.2	51.6	86.2	85.8	71.0	97%	61.2	-1
LCH15ACC-7-7	63.8	98.4	101.3	72.5	58.4	41.3	43.0	67.8	58.5	81.5	91.6	70.7	97%	61.5	-3
SY Wolverine	64.9	101.3	101.9	68.0	45.4	52.1	36.5	69.7	56.3	94.5	87.0	70.7	97%	60.7	-1
SY Wolf	63.6	98.5	99.2	69.7	56.2	49.6	44.4	72.6	50.6	90.3	81.4	70.6	96%	61.2	2
AM Eastwood	71.0	93.1	95.2	62.9	57.0	44.5	45.2	68.5	48.2	85.9	87.1	69.0	94%	61.1	-1
Spur	67.5	-	81.4	74.0	60.2	-	**66.8**	71.8	-	-	76.8	68.7	94%	58.8	4
Incline AX	55.7	98.5	90.8	**78.0**	41.6	**65.8**	41.1	68.5	59.9	85.2	69.8	68.6	94%	59.6	2
Long Branch	64.2	96.6	91.6	69.3	44.8	51.0	39.1	72.3	58.3	85.9	81.7	68.6	94%	60.8	0
Brawl CL Plus	64.5	95.8	94.2	61.7	51.6	37.2	57.6	66.1	49.2	84.9	84.4	67.9	93%	62.1	-2
SY Legend CL2	61.1	96.9	95.5	66.7	61.9	45.1	37.9	68.3	52.1	83.9	75.6	67.7	93%	61.4	-1
WB4418	64.7	95.8	97.4	71.5	58.6	31.0	47.1	65.5	47.3	90.6	71.1	67.3	92%	60.4	-1
Snowmass	57.8	95.3	90.7	65.9	36.7	53.6	34.3	73.0	64.9	81.0	75.9	66.3	91%	61.3	0
LCS Valiant	60.0	90.1	99.0	67.7	47.5	35.2	45.1	67.3	49.5	81.7	84.3	66.1	90%	61.4	-1
Average	**66.6**	**104.3**	**99.9**	**71.9**	**53.9**	**53.2**	**47.6**	**73.2**	**59.5**	**90.2**	**86.0**	**73.2**		**61.2**	**5/27/2019**
[d]LSD (P<0.30)	3.2	4.2	5.0	4.5	3.6	3.0	5.0	2.5	3.5	2.7	2.9				

[a]Varieties in the top LSD yield group in each location are in bold.

[b]Varieties ranked according to average yield across eleven trials in 2019.

[c]Varieties with positive values headed later than the trial average and varieties with negative values headed earlier than the multi-location trial averages.

[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.

Rank of Variety Yield in 2019 Dryland Trials

	2019 Multi-Location Average		2019 Individual Location Rankings										
			Arapahoe	**Burlington**	**Walsh**	**Yuma**	**Roggen**	**Genoa**	**Akron**	**Sheridan Lake**	**Julesburg**	**Lamar**	**Orchard**
		Avg Yield (bu/ac)	104.3	99.9	90.2	86.0	73.2	71.9	66.6	59.5	53.9	53.2	47.6
Rank	Varieties Ranked By Yield												
1	CO15D098R	80.5	CO15D098R	CO15D098R	Sunshine	CO15D098R	CO15D098R	CO15D098R	Langin	Guardian	SY Rugged	Guardian	Spur
2	Antero	80.3	Guardian	Langin	Avery	Antero	Whistler	Antero	CO15D098R	Whistler	WB4462	Antero	Fortify SF
3	Sunshine	79.3	Byrd	Antero	Langin	Langin	Antero	Incline AX	Sunshine	Canvas	SY Legend CL2	Sunshine	Byrd CL Plus
4	Langin	78.1	Whistler	Denali	Whistler	CO13D0346	Langin	Guardian	WB4462	Sunshine	WB4595	Snowmass 2.0	Brawl CL Plus
5	Byrd CL Plus	78.1	Antero	Sunshine	Antero	Avery	Hatcher	WB4462	Fortify SF	CO13D0346	CO13D0346	Incline AX	Crescent AX
6	Avery	77.6	Breck	Snowmass 2.0	Byrd CL Plus	Crescent AX	Avery	Byrd CL Plus	Antero	Byrd CL Plus	Spur	Whistler	WB4462
7	Whistler	77.3	Byrd CL Plus	Monarch	Byrd	LCH15ACC-7-7	Byrd CL Plus	Sunshine	AM Eastwood	Snowmass 2.0	WB-Grainfield	Canvas	WB4595
8	Guardian	76.0	Avery	Byrd CL Plus	SY Wolverine	Monarch	WB4595	Avery	Hatcher	Snowmass	Breck	Byrd	CO15SFD092
9	Snowmass 2.0	75.8	Langin	CO13D1479	Breck	Sunshine	Snowmass 2.0	WB4595	CO15SFD092	Antero	WB4418	Breck	Sunshine
10	CO13D1479	75.5	WB-Grainfield	Breck	CO13D0346	Byrd CL Plus	Sunshine	WB4792	WB4595	Langin	LCH15ACC-7-7	Byrd CL Plus	CO15D098R
11	Breck	75.5	Snowmass 2.0	Avery	WB4595	Byrd	Crescent AX	Canvas	SY Rugged	Byrd	SY Monument	Monarch	Antero
12	Crescent AX	75.4	Fortify SF	SY Monument	WB-Grainfield	Denali	Guardian	Hatcher	Byrd CL Plus	WB4792	CO13D1479	Avery	Avery
13	WB4595	75.4	Crescent AX	WB4462	CO15D098R	Breck	Fortify SF	Monarch	Avery	Denali	CO15D098R	Denali	SY Monument
14	Denali	75.3	Monarch	WB-Grainfield	Guardian	WB4792	CO13D1479	Whistler	Canvas	CO15D098R	Antero	CO13D1479	Hatcher
15	Monarch	75.1	Denali	Crescent AX	Crescent AX	WB-Grainfield	CO15SFD092	Crescent AX	Spur	CO13D1479	Whistler	CO15D098R	CO13D0346
16	Canvas	74.7	CO13D0346	SY Wolverine	Monarch	Snowmass 2.0	WB4792	Denali	CO13D1479	WB4595	Denali	SY Monument	CO13D1479
17	CO13D0346	74.3	CO15SFD092	Canvas	WB4418	CO13D1479	Monarch	Spur	WB-Grainfield	Hatcher	Sunshine	WB4792	WB4418
18	Byrd	74.3	CO13D1479	LCH15ACC-7-7	Denali	AM Eastwood	WB4462	CO13D1479	Breck	Avery	WB4792	WB4595	Whistler
19	WB4462	73.6	Canvas	WB4595	SY Wolf	SY Wolverine	SY Monument	Langin	Crescent AX	Monarch	AM Eastwood	Langin	Denali
20	WB4792	73.4	Sunshine	SY Wolf	Canvas	Guardian	Snowmass	LCH15ACC-7-7	Guardian	Crescent AX	Langin	Snowmass	Byrd
21	Fortify SF	73.3	SY Monument	LCS Valiant	WB4792	Canvas	SY Wolf	WB4418	SY Monument	Incline AX	SY Wolf	SY Wolverine	WB4792
22	SY Monument	72.9	WB4462	CO13D0346	CO13D1479	WB4462	CO13D0346	SY Rugged	Monarch	Breck	Monarch	Long Branch	SY Rugged
23	WB-Grainfield	72.1	SY Rugged	CO15SFD092	SY Monument	CO15SFD092	Long Branch	Fortify SF	SY Wolverine	LCH15ACC-7-7	Snowmass 2.0	Fortify SF	Snowmass 2.0
24	SY Rugged	71.8	SY Wolverine	WB4418	Hatcher	Fortify SF	Breck	SY Wolf	Snowmass 2.0	Fortify SF	Crescent AX	Crescent AX	AM Eastwood
25	Hatcher	71.5	Hatcher	Byrd	SY Rugged	SY Monument	Canvas	Byrd	WB4418	Long Branch	Avery	SY Wolf	LCS Valiant
26	CO15SFD092	71.0	SY Wolf	Whistler	WB4462	Whistler	Byrd	CO13D0346	WB4792	SY Wolverine	Brawl CL Plus	Hatcher	SY Wolf
27	LCH15ACC-7-7	70.7	Incline AX	SY Rugged	Snowmass 2.0	Brawl CL Plus	Spur	Long Branch	Brawl CL Plus	SY Rugged	Canvas	SY Rugged	Guardian
28	SY Wolverine	70.7	LCH15ACC-7-7	WB4792	CO15SFD092	LCS Valiant	Denali	Breck	CO13D0346	SY Legend CL2	Fortify SF	SY Legend CL2	Langin
29	SY Wolf	70.6	WB4595	Guardian	AM Eastwood	WB4595	SY Rugged	Snowmass 2.0	Long Branch	WB-Grainfield	CO15SFD092	AM Eastwood	LCH15ACC-7-7
30	AM Eastwood	69.0	WB4792	SY Legend CL2	Long Branch	Long Branch	SY Wolverine	SY Monument	Whistler	CO15SFD092	Byrd CL Plus	CO13D0346	WB-Grainfield
31	Spur*	68.7	SY Legend CL2	AM Eastwood	Incline AX	SY Wolf	WB-Grainfield	SY Wolverine	LCH15ACC-7-7	SY Wolf	LCS Valiant	WB-Grainfield	Breck
32	Incline AX	68.6	Long Branch	Brawl CL Plus	Brawl CL Plus	Hatcher	Incline AX	LCS Valiant	SY Wolf	LCS Valiant	Byrd	WB4462	Incline AX
33	Long Branch	68.6	Brawl CL Plus	Hatcher	SY Legend CL2	SY Rugged	AM Eastwood	SY Legend CL2	Byrd	SY Monument	SY Wolverine	CO15SFD092	Monarch
34	Brawl CL Plus	67.9	WB4418	Fortify SF	Fortify SF	Spur	SY Legend CL2	WB-Grainfield	Denali	Brawl CL Plus	Long Branch	LCH15ACC-7-7	Canvas
35	SY Legend CL2	67.7	Snowmass	Long Branch	LCS Valiant	Snowmass	LCH15ACC-7-7	Snowmass	SY Legend CL2	AM Eastwood	Hatcher	Brawl CL Plus	Long Branch
36	WB4418	67.3	AM Eastwood	Incline AX	LCH15ACC-7-7	SY Legend CL2	LCS Valiant	CO15SFD092	LCS Valiant	WB4418	Incline AX	LCS Valiant	SY Legend CL2
37	Snowmass	66.3	LCS Valiant	Snowmass	Snowmass	WB4418	Brawl CL Plus	AM Eastwood	Snowmass	WB4462	Guardian	WB4418	SY Wolverine
38	LCS Valiant	66.1	-	Spur	-	Incline AX	WB4418	Brawl CL Plus	Incline AX	-	Snowmass	-	Snowmass

Table illustrates the stability of variety performance across the 2019 dryland trial locations. Follow any variety (top 11 are color-coded) from the left multi-location average column across to the right to see how each variety ranked at each location. Locations are listed left to right by decreasing average yield by location.

* Spur was entered but not reported at Arapaho, Walsh, Sheridan Lake and Lamar where Spur is ommitted from the rankings and locations have only 37 enteries.

Summary of 2-Yr (2018 and 2019) Dryland Variety Performance Results

			2-Year Average[a]				
Variety[b]	Brand/Source	Market Class[c]	Yield	Yield	Test Weight	Test Weight	Plant Height
			bu/ac	% trial average	lb/bu	% trial average	in
Antero	PlainsGold	**HWW**	75.4	109%	60.4	100%	34
CO15D098R	Colorado State University Exp.	HRW	74.8	108%	61.7	102%	35
Langin	PlainsGold	HRW	74.7	108%	60.3	99%	31
Sunshine	PlainsGold	**HWW**	73.6	106%	60.2	99%	32
Whistler	PlainsGold	HRW	72.8	105%	59.6	98%	34
Avery	PlainsGold	HRW	72.2	104%	60.1	99%	33
Snowmass 2.0	PlainsGold	**HWW**	72.2	104%	60.9	100%	32
Byrd CL Plus	PlainsGold	HRW	71.9	104%	60.3	99%	34
Breck	PlainsGold	**HWW**	71.8	104%	62.1	102%	33
Monarch	PlainsGold	**HWW**	71.2	103%	60.7	100%	31
CO13D1479	Colorado State University Exp.	**HWW**	70.5	102%	60.9	100%	33
Guardian	PlainsGold	HRW	70.5	102%	61.7	102%	33
Denali	PlainsGold	HRW	70.4	102%	61.4	101%	34
Canvas	PlainsGold	HRW	70.2	101%	61.2	101%	31
Crescent AX	PlainsGold	HRW	69.9	101%	61.2	101%	33
SY Monument	AgriPro Syngenta	HRW	69.3	100%	60.0	99%	32
Byrd	PlainsGold	HRW	69.3	100%	60.5	100%	33
WB4462	WestBred Bayer	HRW	69.0	100%	61.3	101%	35
WB-Grainfield	WestBred Bayer	HRW	68.0	98%	60.7	100%	33
Fortify SF	PlainsGold	HRW	67.7	98%	61.0	101%	33
Hatcher	PlainsGold	HRW	67.2	97%	60.4	100%	32
SY Rugged	AgriPro Syngenta	HRW	67.1	97%	60.0	99%	30
Long Branch	Dyna-Gro Seed	HRW	66.8	97%	60.0	99%	32
SY Wolf	AgriPro Syngenta	HRW	66.3	96%	60.7	100%	31
WB4418	WestBred Bayer	HRW	66.2	96%	60.0	99%	30
CO15SFD092	Colorado State University Exp.	HRW	65.6	95%	60.8	100%	31
Brawl CL Plus	PlainsGold	HRW	65.3	94%	61.4	101%	33
AM Eastwood	AgriMaxx Wheat	HRW	64.9	94%	60.5	100%	28
Incline AX	PlainsGold	HRW	64.4	93%	58.9	97%	32
Snowmass	PlainsGold	**HWW**	63.9	92%	61.0	101%	33
SY Legend CL2	AgriPro Syngenta	HRW	63.7	92%	60.8	100%	31
		Average	**69.2**		**60.7**		**32**

[a]The 2-year average yield and test weight are based on 20 trials (eleven 2019 and nine 2018 trials). Plant heights are based on 19 trials (ten 2019 and eight 2018 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-Yr (2017, 2018, and 2019) Dryland Variety Performance Results

Variety[b]	Brand/Source	Market Class[c]	3-Year Average[a] Yield	Yield	Test Weight	Test Weight	Plant Height
			bu/ac	% trial average	lb/bu	% trial average	in
Langin	PlainsGold	HRW	75.5	108%	60.2	100%	31
Antero	PlainsGold	**HWW**	74.7	107%	60.1	100%	34
Whistler	PlainsGold	HRW	74.6	107%	59.3	98%	34
Snowmass 2.0	PlainsGold	**HWW**	73.2	105%	60.6	100%	32
Avery	PlainsGold	HRW	72.6	104%	60.1	100%	34
Canvas	PlainsGold	HRW	72.1	103%	61.0	101%	31
Sunshine	PlainsGold	**HWW**	72.1	103%	59.8	99%	32
Breck	PlainsGold	**HWW**	71.9	103%	61.9	103%	33
Byrd CL Plus	PlainsGold	HRW	71.8	103%	59.9	99%	34
Guardian	PlainsGold	HRW	71.7	103%	61.5	102%	33
Monarch	PlainsGold	**HWW**	71.3	102%	60.5	100%	31
Byrd	PlainsGold	HRW	71.1	102%	60.4	100%	33
CO13D1479	Colorado State University Exp.	**HWW**	70.4	101%	60.4	100%	33
Denali	PlainsGold	HRW	68.9	99%	60.7	101%	34
WB-Grainfield	WestBred Bayer	HRW	68.0	97%	60.6	100%	33
SY Monument	AgriPro Syngenta	HRW	67.5	97%	59.6	99%	32
WB4462	WestBred Bayer	HRW	67.3	96%	61.0	101%	35
SY Rugged	AgriPro Syngenta	HRW	66.8	96%	59.7	99%	30
Hatcher	PlainsGold	HRW	66.1	95%	60.0	99%	32
SY Wolf	AgriPro Syngenta	HRW	65.9	94%	60.3	100%	31
Snowmass	PlainsGold	**HWW**	65.8	94%	60.6	101%	34
Brawl CL Plus	PlainsGold	HRW	64.7	93%	60.9	101%	33
Incline AX	PlainsGold	HRW	62.9	90%	58.0	96%	32
		Average	**69.9**		**60.3**		**33**

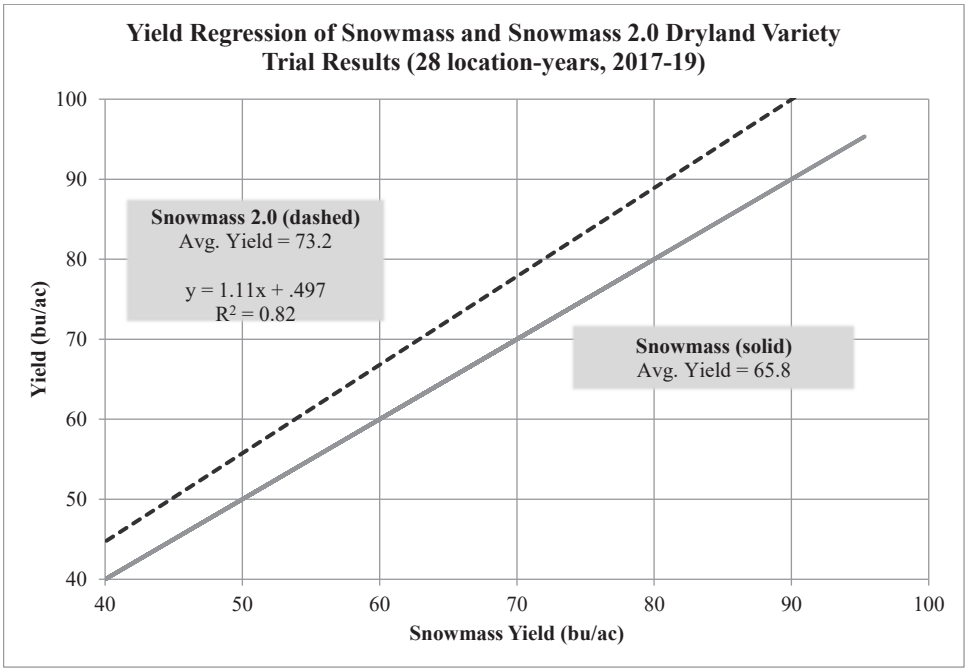
[a]The 3-year average yield and test weights are based on 28 trials (eleven 2019, nine 2018, and eight 2017 trials). Plant heights are based on 26 trials (ten 2019, eight 2018, and eight 2017 trials).

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

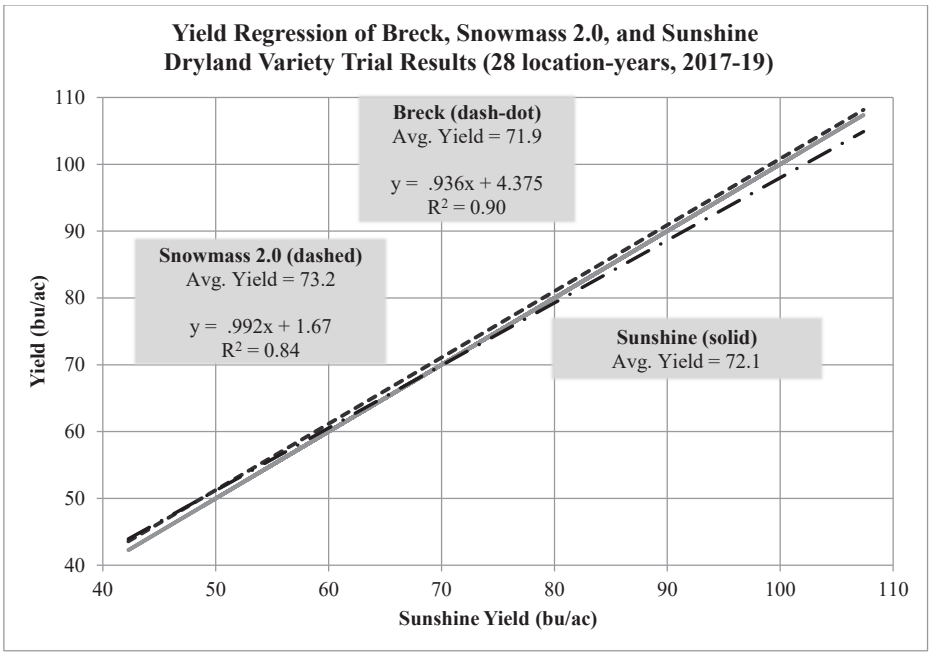
[c]Market class: HRW=hard red winter wheat; **HWW**=hard white winter wheat.

Head-to-Head Yield Comparisons

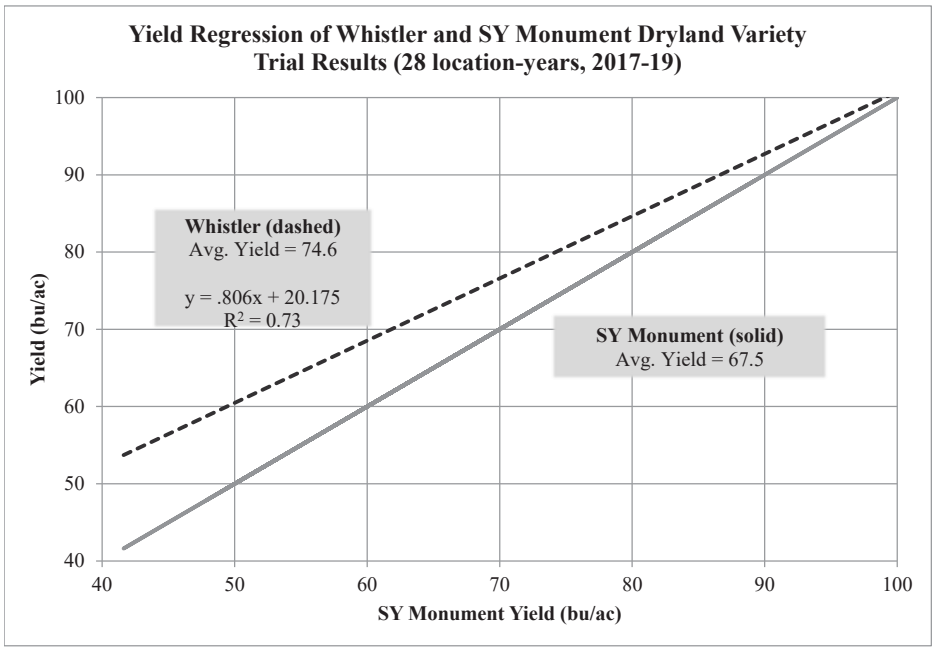
These regressions are used to compare the predicted performance of one variety relative to another variety. The regressions use results from multiple Dryland Variety Performance Trials results over the past three years (2017 through 2019). These (or any other) yield comparisons can be made online at ramwheatdb.com, which uses the Dryland Variety Performance Trial data. 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 results over multiple locations from different years.



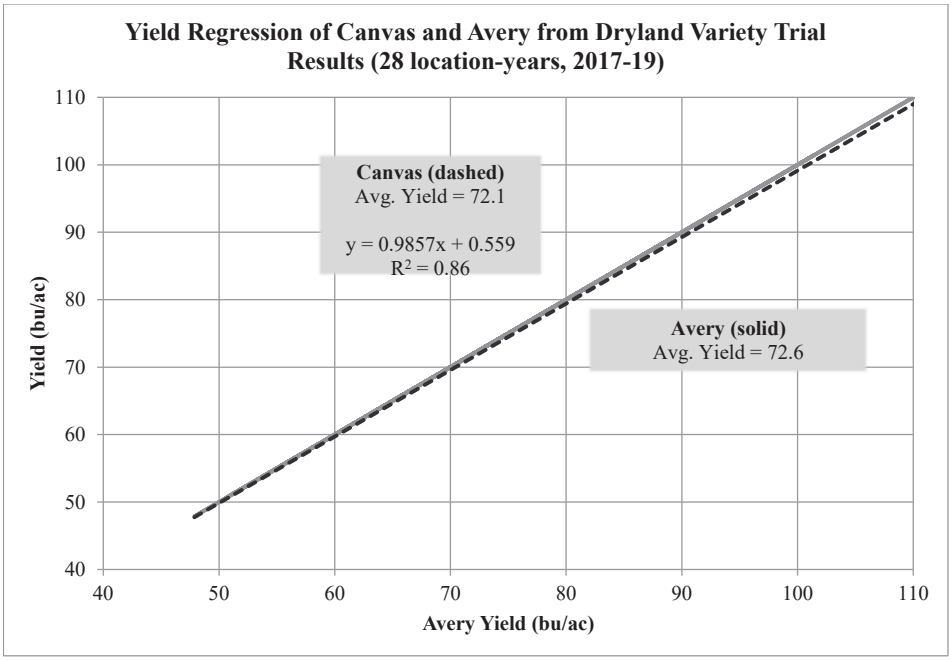
The first graph compares two hard white wheat varieties with a premium at harvest. Snowmass and Snowmass 2.0 (new release). Across all of the yield levels shown, Snowmass 2.0 is expected to yield higher than Snowmass, and the difference is greater at higher yield levels. If Snowmass yielded 60 bu/ac, it is predicted that Snowmass 2.0 would yield 67.1 bu/ac.



The graph above compares three hard white wheat varieties that generally bring a premium at harvest for high quality: Snowmass 2.0, Sunshine, and Breck. The trend is for Snowmass 2.0 to yield higher than Sunshine at all yield levels, and higher than Breck at yield levels above 60 bu/ac.



The above graph compares two medium-late maturity wheats, SY Monument and Whistler. Across all of the yield levels shown, Whistler is expected to yield higher than SY Monument, and the difference is greater at lower yield levels. If SY Monument yielded 60 bu/ac, it is predicted that Whistler would yield 68.5 bu/ac.



The final graph above compares two medium maturity, high-yielding varieties, Avery and Canvas. The regression line of Canvas (dashed) is at or below the Avery line at all yield levels shown and is consistently expected to yield similarly to Avery.

2019 Collaborative On-Farm Test (COFT) Variety Performance Results

Jerry Johnson, Sally Jones-Diamond, Kelly Roesch, Wilma Trujillo, Dennis Kaan,
Ron Meyer, John Spring, and Roger Tyler

In the fall of 2018, thirty eastern Colorado wheat producers received seed of the five or 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. The objective of our on-farm testing program is to compare the performance of wheat varieties that are of most interest to Colorado farmers under farmer conditions. Five varieties were included in all tests and sixteen tests also included Snowmass 2.0. HRW varieties were Byrd, Avery, Langin, and Long Branch. HWW varieties were Breck, and Snowmass 2.0 if seed was available. Colorado State University Extension agents oversaw all aspects of the program. The COFT program is in its 23rd 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. The varieties tested in COFT this year fit different farmer needs and readers are encouraged to study the tables in the Description of Winter Wheat Varieties in Eastern Colorado and the Dryland Decision Tree for more information.

Summary of 2019 COFT Variety Results (24 tests included)

Variety	Yield[a]	Test Weight	Protein
	bu/ac	lb/bu	percent
Langin	65.8	59.8	10.2
Avery	64.5	60.0	9.9
Byrd	63.1	60.3	10.1
Breck	62.3	62.2	10.5
Long Branch	60.3	59.9	10.3
Average	**63.2**	**60.4**	**10.2**
$LSD_{(0.30)}$	1.2	0.3	0.1

[a]Yield corrected to 12% moisture.

Summary of 2019 COFT Variety Results with Snowmass 2.0 (16 tests included)

Variety	Yield[a]	Test Weight	Protein
	bu/ac	lb/bu	percent
Langin	67.6	59.9	10.3
Avery	65.9	59.9	10.1
Byrd	64.7	60.5	10.2
Snowmass 2.0	64.0	60.2	10.6
Breck	63.4	61.9	10.6
Long Branch	62.7	59.8	10.5
Average	**64.7**	**60.4**	**10.4**
$LSD_{(0.30)}$	1.3	0.4	0.2

[a]Yield corrected to 12% moisture.

2019 Collaborative On-Farm Test (COFT) Variety Performance Results

2019 Varieties (ranked left to right by highest yield)

	Langin			Avery			Byrd			Breck			Long Branch			COFT Average		
County/Nearest Town	Yield[a]	Test Weight	Protein	Yield[a]	Test Weight	Protein	Yield[a]	Test Weight	Protein	Yield[a]	Test Weight	Protein	Yield[a]	Test Weight	Protein	Yield[a]	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
Adams/Bennett N	44.1	61.2	10.7	60.3	62.6	9.3	56.3	62	8.7	57.5	63.5	9.3	-	-	-	*54.5*	*62.3*	*9.5*
Adams/Prospect Valley	36.2	60.1	7.7	36.9	60.0	7.8	33.0	60.0	7.5	33.2	63.7	8.0	37.7	61.1	8.1	*35.4*	*61.0*	*7.8*
Baca/Pritchett	49.9	57.0	6.6	44.7	58.9	6.8	43.6	58.4	6.6	44.2	61.3	6.9	44.2	59.2	6.8	*45.3*	*59.0*	*6.7*
Baca/Vilas	80.8	58.1	9.0	80.1	58.1	9.2	80.5	58.8	9.0	77.1	60.0	10.0	71.1	58.0	9.7	*77.9*	*58.6*	*9.4*
Baca/Walsh	87.6	58.9	-	84.5	59.2	-	83.3	58.9	-	79.7	61.9	-	75.2	58.5	-	*82.1*	*59.5*	-
Bent/Lamar	59.0	59.3	11.3	54.6	59.6	11.3	60.3	59.5	11.3	56.5	61.6	11.2	54.6	58.4	12.3	*57.0*	*59.7*	*11.5*
Kiowa/Eads	46.6	58.7	9.6	47.8	59.6	9.7	45.7	58.9	10.9	40.8	62.3	11.8	38.3	59.7	10.5	*43.8*	*59.8*	*10.5*
Kiowa/Haswell	62.0	62.4	8.2	65.0	61.8	8.4	57.4	61.2	8.4	65.9	65.0	8.9	60.0	62.4	8.6	*62.1*	*62.6*	*8.5*
Kit Carson/Bethune	51.4	59.1	10.6	57.9	59.4	10.9	49.8	62.6	12.2	46.9	60.3	11.0	37.7	59.7	12.8	*48.8*	*60.2*	*11.5*
Kit Carson/Burlington N	90.2	64.3	11.4	79.3	66.2	11.0	79.1	66.3	12.0	87.0	64.6	10.9	80.0	62.7	11.6	*83.1*	*64.8*	*11.4*
Kit Carson/Stratton	85.5	61.7	9.6	81.4	59.8	9.7	82.4	60.2	9.5	77.4	63.7	10.2	70.6	60.0	10.2	*79.5*	*61.1*	*9.8*
Logan/Leroy	72.8	59.2	10.9	73.4	58.2	10.9	70.1	59.3	11.2	68.7	59.4	11.9	71.6	57.9	11.3	*71.3*	*58.8*	*11.2*
Morgan/Orchard	53.6	58.6	13.0	51.7	56.9	12.5	52.8	59.3	11.7	54.0	58.3	12.8	49.3	56.7	11.4	*52.3*	*58.0*	*12.3*
Phillips/Haxtun	94.7	57.2	12.9	84.1	57.7	12.7	89.3	59.9	13.0	89.1	57.5	13.1	88.3	57.7	12.8	*89.1*	*58.0*	*12.9*
Phillips/Holyoke	93.6	62.4	9.0	90.9	63.5	8.7	87.9	62.7	8.7	84.3	64.9	9.3	86.8	63.4	8.9	*88.7*	*63.4*	*8.9*
Prowers/Holly	93.2	60.5	9.9	77.7	60.1	8.5	75.5	60.5	9.1	75.5	62.3	9.9	71.4	59.5	8.9	*78.7*	*60.6*	*9.3*
Prowers/Lamar	21.9	57.6	14.6	35.7	59.9	12.9	30.9	59.8	13.8	37.5	62.1	13.4	30.5	59.9	12.9	*31.3*	*59.9*	*13.5*
Sedgwick/Julesburg	77.1	61.0	9.2	83.6	62.4	8.5	81.1	62.0	8.9	80.8	65.5	9.2	73.7	63.0	9.2	*79.2*	*62.8*	*9.0*
Sedgwick/Julesburg S	60.8	60.8	8.1	60.7	61.7	8.1	57.8	61.8	8.5	54.0	64.7	8.2	56.9	62.3	8.1	*58.0*	*62.3*	*8.2*
Washington/Akron	66.2	56.8	10.6	61.2	55.8	10.9	61.4	57.2	10.4	62.2	59.2	10.8	60.7	57.3	10.9	*62.4*	*57.3*	*10.7*
Washington/Akron S	58.9	58.6	11.1	55.1	57.4	10.6	54.4	60.4	10.6	48.5	62.2	12.0	55.5	60.0	10.7	*54.5*	*59.7*	*11.0*
Weld/New Raymer SE	57.0	62.5	11.0	51.9	63.3	10.5	51.2	62.1	10.4	50.8	64.8	11.2	50.6	62.4	10.0	*52.3*	*63.0*	*10.6*
Weld/Roggen	71.3	59.3	10.2	68.8	57.1	10.6	67.8	56.3	11.5	70.6	61.2	11.6	69.2	57.7	11.6	*69.5*	*58.3*	*11.1*
Yuma/Yuma	64.9	58.8	8.7	60.4	60.2	8.3	61.4	59.4	8.6	52.7	62.3	9.0	53.8	60.7	8.9	*58.6*	*60.3*	*8.7*
Average	**65.8**	**59.8**	**10.2**	**64.5**	**60.0**	**9.9**	**63.1**	**60.3**	**10.1**	**62.3**	**62.2**	**10.5**	**60.3**	**59.9**	**10.3**	***63.1***	***60.4***	***10.2***
Yield Significance[b]	A			B			C			C			D					

LSD $_{(P<0.30)}$ for yield = 1.2 bu/ac

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

LSD $_{(P<0.30)}$ for protein = 0.1 percent

[a]All yield and protein data are corrected to 12% moisture.

[b]Yield significance: varieties with different letters have yields that are significantly different from one another.

2019 Wheat Variety Decision Tree for Dryland Production

Jerry Johnson and Sally Jones-Diamond

The decision tree on the following page helps Colorado growers make variety selection decisions based on important traits. Under each variety name are the scores, YR for stripe rust and WSMV for wheat streak mosaic virus, with '1' being very resistant and '9' being very susceptible.

HWW

In addition to high yields in high and low yielding conditions, Antero has good test weight, moderate sprouting tolerance and fair straw strength. Monarch, a 2018 release, is a viable non-premium dryland wheat variety choice but is mainly targeted for irrigated conditions with good stripe rust resistance, excellent straw strength, and excellent yields. Snowmass 2.0, Sunshine, and Breck are in the Ultragrain Premium Program. Snowmass 2.0, expected to replace Snowmass, is better for yield, grain protein deviation, and straw strength. Sunshine has excellent quality, good sprouting tolerance and straw strength but is susceptible to viruses. Breck, is a high-yielding variety with good sprouting tolerance, and straw strength. It also has very high test weight and low polyphenol oxidase (PPO) activity for improved whole grain bread and noodle quality.

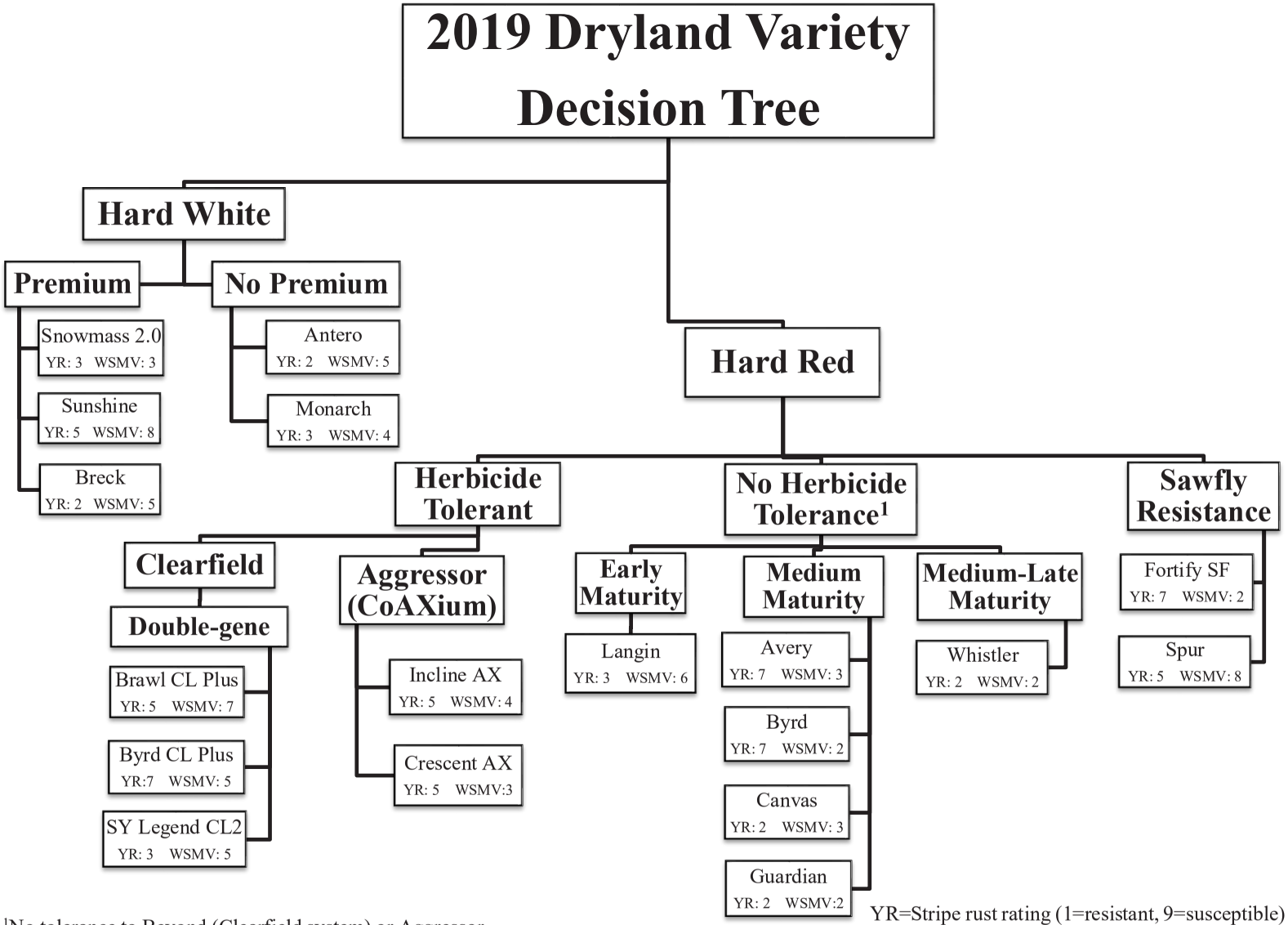
HRW

There are more choices for growers planting a two-gene Clearfield® variety. Brawl CL Plus, Byrd CL Plus and SY Legend CL2 (latter two are 2018 releases) are recommended for good control of winter annual grasses. Brawl CL Plus has good test weight, quality, grain protein content, and is early-maturing but has below-average yield. Byrd CL Plus is among the top yielding varieties in 2019 trials and very similar to the familiar Byrd parent. SY Legend CL2, from Agripro Syngenta, provides weed control and has good overall disease tolerance while yielding 92% of 2019 trial yield average.

The new CoAXium® Wheat Production System based on Aggressor® herbicide, a different class of compounds from Beyond, is an option for excellent control of winter annual grasses. Incline AX provides good weed control but has lower test weight and yield. Crescent AX (2018), is much higher yielding than Incline AX yet retains excellent control of winter annual grasses.

Although there are no wheat stem sawfly resistant varieties, there are some varieties that exhibit acceptable yield in the presence of strong sawfly pressure: Fortify SF has above trial average yields in 2018 and 2019. Spur, a 2016 Montana release marketed by Agripro Syngenta, was highest yielding in the Orchard trial this year in the face of very heavy sawfly infestation.

Most producers will plant high-yielding HRW varieties. The recommended early-maturing HRW variety is Langin (2016 release) from CSU, which is a top yielder. For the high-yielding, medium-maturing varieties, there are four recommendations: Avery, Byrd, Canvas, and Guardian. Byrd is well-known and Avery is similar to Byrd with a higher yield potential, larger kernels, slightly improved quality, and above-average test weight. Like Byrd, Avery carries wheat curl mite resistance. Canvas (2018 release) is better yielding than Byrd with a complete package of disease resistance and other traits. Guardian (2019) also has a good disease resistance package and good quality. The recommended high-yielding medium-to-late maturity HRW variety is a newcomer, Whistler, which has excellent yield and good stripe rust and WSMV resistance.



[1]No tolerance to Beyond (Clearfield system) or Aggressor (CoAXium system) herbicides

YR=Stripe rust rating (1=resistant, 9=susceptible)

WSMV=Wheat streak mosaic virus rating (1=resistant, 9=susceptible)

Summary of 2019 Irrigated Variety Performance Results

Variety[b]	2019 Individual Trial Yield[a]			2019 Multi-Location Average				
	Burlington	Fort Collins	Haxtun	Yield	Yield	Test Weight	Height	Lodging
	bu/ac			bu/ac	% of avg	lb/bu	in	score (1-9)[c]
CO13D0346	**90.6**	81.2	84.3	85.4	112%	60.2	30	3
Guardian	**91.6**	89.7	73.8	85.1	112%	61.6	28	4
Monarch	68.8	**94.0**	**90.8**	84.5	111%	59.5	32	1
WB4303	63.0	**98.0**	86.0	82.3	108%	57.5	28	1
Breck	74.7	79.4	**92.3**	82.1	108%	60.9	32	2
WB4792	66.1	**97.5**	81.4	81.7	107%	59.8	34	1
Crescent AX	80.7	86.4	76.4	81.2	107%	60.8	35	6
WB4595	71.3	86.3	85.3	81.0	106%	61.3	30	1
Denali	66.7	84.4	86.7	79.3	104%	59.6	30	1
Canvas	77.6	83.2	75.4	78.7	103%	60.5	30	1
CO15D098R	78.2	75.3	81.2	78.2	103%	60.6	32	5
Snowmass 2.0	73.0	79.9	81.4	78.1	103%	59.7	30	4
SY Wolverine	68.1	**93.7**	72.3	78.0	103%	59.4	25	1
Sunshine	73.4	78.0	79.9	77.1	101%	59.9	28	5
Long Branch	62.9	86.9	79.1	76.3	100%	58.8	28	6
SY Wolf	64.0	85.0	77.6	75.5	99%	59.1	30	1
SY Sunrise	69.4	76.4	71.1	72.3	95%	60.1	26	1
AM Eastwood	57.2	76.8	73.4	69.1	91%	58.9	26	1
WB4418	57.1	82.0	65.9	68.4	90%	58.3	29	1
WB4699	51.6	81.0	70.0	67.6	89%	57.8	28	1
WB-Grainfield	51.8	71.0	77.7	66.8	88%	60.4	32	3
Brawl CL Plus	67.0	64.3	67.6	66.3	87%	60.6	31	1
WB4269	42.7	84.0	71.7	66.1	87%	59.4	28	1
Thunder CL	42.3	76.7	74.3	64.4	85%	59.5	33	1
Average	**67.1**	**83.0**	**78.2**	**76.1**		**59.8**	**30**	**2**
[d]LSD (P<0.30)	3.6	4.5	4.6					

[a]Varieties in the top LSD yield group in each location are in bold.

[b]Varieties ranked according to multi-location average yield in 2019.

[c]Lodging score: 1 equals no lodging and 9 is severe lodging.

[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 (2018 and 2019) Irrigated Variety Performance Results

Variety[b]	Brand/Source	Market Class[c]	2-Year Average[a] Yield	Yield	Test Weight	Test Weight	Plant Height
			bu/ac	% trial average	lb/bu	% trial average	in
WB4303	WestBred Bayer	HRW	89.0	108%	57.1	96%	30
Monarch	PlainsGold	**HWW**	87.7	107%	59.3	99%	32
Guardian	PlainsGold	HRW	86.9	106%	61.2	102%	31
Breck	PlainsGold	**HWW**	85.8	104%	60.9	102%	33
CO15D098R	Colorado State University Exp.	HRW	85.3	104%	60.5	101%	34
Crescent AX	PlainsGold	HRW	84.8	103%	60.8	102%	34
Denali	PlainsGold	HRW	84.7	103%	59.6	100%	32
Canvas	PlainsGold	HRW	84.7	103%	60.5	101%	30
Snowmass 2.0	PlainsGold	**HWW**	83.5	102%	59.5	100%	32
Long Branch	Dyna-Gro Seed	HRW	82.8	101%	58.6	98%	31
SY Wolf	AgriPro Syngenta	HRW	82.7	101%	59.0	99%	31
Sunshine	PlainsGold	**HWW**	82.2	100%	59.6	100%	31
SY Sunrise	AgriPro Syngenta	HRW	79.8	97%	60.2	101%	28
WB4418	WestBred Bayer	HRW	79.7	97%	58.7	98%	30
WB-Grainfield	WestBred Bayer	HRW	76.7	93%	60.1	101%	33
Brawl CL Plus	PlainsGold	HRW	75.2	92%	60.7	102%	32
AM Eastwood	AgriMaxx Wheat	HRW	74.0	90%	59.0	99%	28
Thunder CL	PlainsGold	**HWW**	73.2	89%	59.2	99%	33
		Average	**82.2**		**59.7**		**31**

[a]The 2-year average yield and test weight are based on five trials (three 2019 and two 2018 trials). Plant heights are based on four trials (two 2019 and two 2018 trials).

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

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

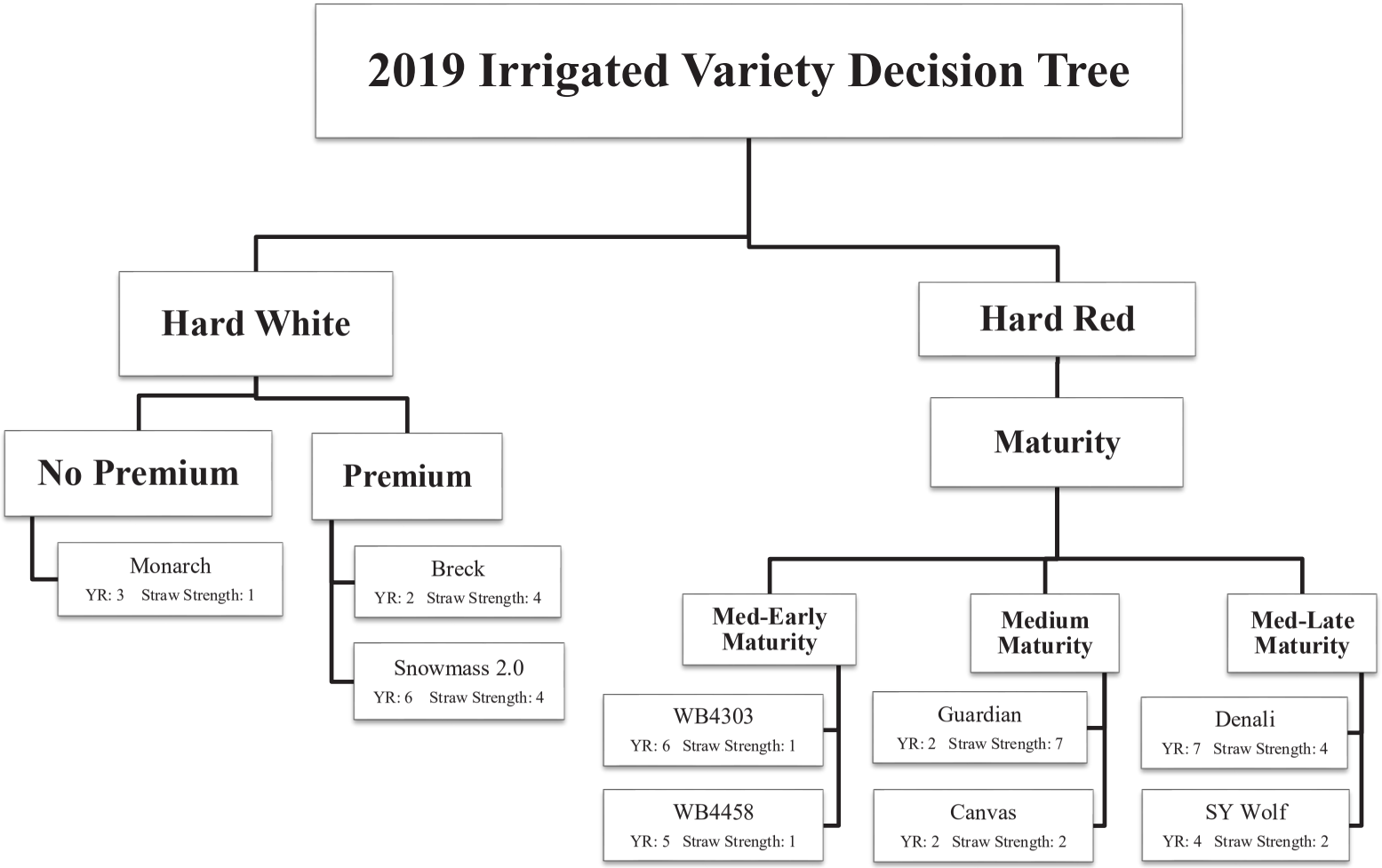
Summary of 3-year (2017, 2018, and 2019) Irrigated Variety Performance Results

Variety[b]	Brand/Source	Market Class[c]	3-Year Average[a] Yield	Yield	Test Weight	Test Weight	Plant Height
			bu/ac	% trial average	lb/bu	% trial average	in
Monarch	PlainsGold	**HWW**	95.6	110%	59.0	100%	33
Guardian	PlainsGold	HRW	93.4	107%	60.4	102%	34
WB4303	WestBred Bayer	HRW	91.7	105%	56.4	96%	31
Snowmass 2.0	PlainsGold	**HWW**	91.1	104%	59.0	100%	33
Breck	PlainsGold	**HWW**	90.1	103%	60.2	102%	34
Canvas	PlainsGold	HRW	89.5	102%	59.3	100%	32
Denali	PlainsGold	HRW	88.8	102%	59.2	100%	32
SY Wolf	AgriPro Syngenta	HRW	88.2	101%	58.3	99%	33
SY Sunrise	AgriPro Syngenta	HRW	84.7	97%	59.7	101%	29
Sunshine	PlainsGold	**HWW**	84.5	97%	58.3	99%	32
Brawl CL Plus	PlainsGold	HRW	81.0	93%	59.7	101%	33
WB-Grainfield	WestBred Bayer	HRW	79.3	91%	59.6	101%	34
Thunder CL	PlainsGold	**HWW**	77.4	89%	58.6	99%	34
		Average	**87.3**		**59.1**		**32**

[a]The 3-year average yield and test weight are based on eight trials (three 2019, two 2018, and three 2017 trials). Plant heights are based on five trials (two 2019, two 2018, and one 2017 trial).

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

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



Straw Strength (1=very good, 9=very poor)

YR = Stripe rust rating (1=resistant, 9=susceptible)

Important Variety Selection Considerations

It is not possible to accurately predict which variety will perform best in each field every year. However, there are some selection guidelines to improve the ability to select superior varieties. The variety performance summary tables and decision trees in this report provide useful information to farmers for improving variety selections. Other guidelines that improve selections are below.

Focus on multi-year and location yield summary results when selecting a variety – use results from the three-year variety performance trials and from the collaborative on-farm tests.

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 (2019) for variety-specific information.

Use the wheat variety database, a great resource, at http://ramwheatdb.com/ to aid in variety selection. Head to head comparisions are easily made between varieties at http://ramwheatdb.com/

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

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 wheat mosaic virus, and triticum mosaic virus) or vectored by aphids (barley yellow dwarf virus and cereal yellow dwarf virus).

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

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

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/2Kn8egF

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

Description of Winter Wheat Varieties in Eastern Colorado Dryland and Irrigated Trials (2019)

Name/Class/Pedigree	Origin	HD	HT	SS	COL**	YR	LR	SR	WSMV+	TW	PRO++	MILL	BAKE	Comments
AM Eastwood Hard red winter Not Disclosed	AgriMaxx 2017	4	1	2	4	3	7	--	4	5	4	4	4	AgriMAXX release (2017). First entered into CSU Variety Trials in 2018. Early maturing, medium-short, good winterhardiness, good straw strength. Moderately resistant to stripe rust, moderately susceptible to leaf rust, moderately resistant to WSMV. Good test weight and milling and baking quality.
Antero Hard white winter KS01HW152-1/TAM 111	CSU 2012	5	6	7	5	2	7	2	5	4	5	4	6	CSU release (2012), marketed by PlainsGold. Medium height and maturity, good test weight, fair straw strength, good resistance to stripe rust. Moderate sprouting tolerance.
Avery Hard red winter TAM 112/Byrd	CSU 2015	6	7	4	6	7	7	8	3	6	6	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. Moderately susceptible to stripe rust.
Brawl CL Plus Hard red winter Teal 11A/Above//CO99314	CSU 2011	2	6	2	9	5	6	7	7	3	1	3	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 reaction to both stripe rust and leaf rust. Certified seed only.
Breck Hard white winter Denali/HV9W07-482W//Antero	CSU 2017	5	6	4	7	2	5	2	5	1	1	2	3	CSU release (2017), marketed by PlainsGold in CWRF-Ardent Mills UltraGrain Premium Program. Good stripe rust resistance, sprouting tolerance, straw strength, grain protein deviation, and quality. Very high test weight, lower polyphenol oxidase (PPO) activity for improved whole grain bread and noodle quality. Certified seed only.
Byrd Hard red winter TAM 112/CO970547-7	CSU 2011	4	6	7	6	7	6	8	2	5	6	4	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.
Byrd CL Plus Hard red winter CO06072/4*Byrd	CSU 2018	5	7	5	4	7	5	8	5	5	6	5	5	CSU release (2018), marketed by PlainsGold. Two-gene Clearfield wheat in Byrd background. Highly similar to Byrd with exception of tolerance to Beyond herbicide. Certified seed only.
Canvas Hard red winter Denali/Antero//Byrd	CSU 2018	6	3	2	6	2	6	2	3	2	4	3	3	CSU release (2018), marketed by PlainsGold. Hard red winter, medium maturing, medium-short, good straw strength. Good stripe rust and carries wheat curl mite resistance from Byrd parent. Good test weight and milling and baking quality.
Crescent AX Hard red winter (AF28/Byrd)//(AF10/2*Byrd)	CSU 2018	3	5	2	6	5	6	--	3	3	8	3	3	CSU release (2018), marketed by PlainsGold. Carries non-GMO *Axigen* herbicide tolerance trait. Approximately 66% Byrd and 34% Hatcher parentage. Much improved yield and test weight relative to Incline AX. Intermediate reaction to stripe rust and carries wheat curl mite resistance from Byrd parent. Certified seed only.
Denali Hard red winter CO980829/TAM 111	CSU 2011	8	7	4	6	7	6	3	3	3	6	4	7	CSU release (2011), marketed by PlainsGold and Kansas Wheat Alliance 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.

Column Key - heading date (HD), plant height (HT), straw strength (SS), coleoptile length (COL), stripe rust resistance (YR), leaf rust resistance (LR), stem rust resistance (SR), wheat streak mosaic virus tolerance (WSMV), test weight (TW), protein (PRO), milling (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/long.

** 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 are based on field evaluations in Colorado under pressure from wheat curl mite transmitted viruses. Scores may reflect both resistance to the wheat curl mite and resistance to mite-transmitted viruses.
++ PRO ratings represent "grain protein deviation" (relative grain protein level accounting for differences in grain yield).

Description of Winter Wheat Varieties in Eastern Colorado Dryland and Irrigated Trials (2019)

Name/Class/Pedigree	Origin	HD	HT	SS	COL**	YR	LR	SR	WSMV+	TW	PRO++	MILL	BAKE	Comments
Fortify SF Hard red winter Byrd/Bearpaw//Byrd	CSU 2019	4	6	9	6	7	7	8	2	4	7	4	5	CSU release (2019), marketed by PlainsGold. Medium height, medium maturity. Carries wheat curl mite resistance from Byrd parent and semi-solid stem trait for partial resistance to the wheat stem sawfly. Certified seed only.
Guardian Hard red winter Antero/Snowmass//Byrd	CSU 2019	6	5	7	5	2	3	2	2	2	1	3	3	CSU release (2019), marketed by PlainsGold. Medium height, medium maturity. Excellent resistance to WSMV due to combination of resistance to wheat curl mite and the virus itself. Good combined resistance to all three rusts, good test weight, good milling and baking quality, high grain protein deviation. Certified seed only.
Hatcher Hard red winter Yuma/PI 372129//TAM-200/3/4*Yuma/4/KS91H184/Vista	CSU 2004	6	4	7	5	5	7	3	6	6	7	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.
Incline AX Hard red winter (AF28/Byrd)//(AF10/2*Byrd)	CSU 2017	9	4	4	6	5	6	--	4	9	7	7	4	CSU release (2017), marketed by PlainsGold. Carries non-GMO *Axigen* herbicide tolerance trait for winter annual grassy weed control. Approximately 66% Byrd and 34% Hatcher parentage. Good quality, good straw strength. Lower test weight. Certified seed only.
Langin Hard red winter CO050270/Byrd	CSU 2016	2	3	7	4	3	5	8	6	4	6	5	3	CSU release (2016), marketed by PlainsGold. Early maturing semidwarf. Good test weight, stripe rust resistance, and quality. Medium coleoptile. Carries wheat curl mite resistance from Byrd parent. Very high yield potential for irrigation, but straw strength requires use of growth regulator.
LCS Valiant Hard red winter NI03418/Camelot (sel.)	Limagrain 2018	4	5	5	6	6	5	7	8	4	--	4	3	Limagrain release (2018), first entered in CSU Variety Trials in 2019. Medium-early maturing, good drought stress tolerance. Good Hessian fly and stem rust resistance and end-use quality. Supplies will be limited in 2019.
Long Branch Hard red winter Not Disclosed	Dyna-Gro 2016	4	5	2	7	3	3	--	--	8	6	6	7	Dyna-Gro release (2016). First entered into CSU Variety Trials in 2018. Medium-late maturing, medium-tall with very good straw strength, good winterhardiness, and moderate resistance to stripe rust.
Monarch Hard white winter CO07W722-F5/Snowmass//CO07W722-F5	CSU 2018	6	3	1	5	3	5	2	4	4	8	5	4	CSU release (2018), marketed by PlainsGold. Hard white winter with excellent straw strength and very high irrigated yield potential. Good stripe rust resistance. Quality more similar to Breck, but very low PPO. Certified seed only.
Snowmass Hard white winter KS96HW94//Trego/CO960293	CSU 2009	6	7	9	4	6	6	2	3	5	7	5	2	CSU release (2009), marketed by PlainsGold in CWRF-Ardent Mills Ultragrain Premium Program. Hard white wheat. Medium-maturing, medium-tall, poor straw strength. Good WSMV resistance, moderately susceptible to stripe rust, moderate sprouting tolerance. Certified seed only.
Snowmass 2.0 Hard white winter CO07W722-F5/Snowmass//Brawl CL Plus	CSU 2018	4	4	4	5	3	5	1	3	4	4	4	1	CSU release (2018), marketed by PlainsGold in CWRF-Ardent Mills Ultragrain Premium Program. Hard white winter with quality profile very similar to Snowmass but low PPO and better grain protein deviation. Good stripe rust and wheat streak mosaic virus resistance. Good straw strength, good test weight. Certified seed only.

Column Key - heading date (HD), plant height (HT), straw strength (SS), coleoptile length (COL), stripe rust resistance (YR), leaf rust resistance (LR), stem rust resistance (SR), wheat streak mosaic virus tolerance (WSMV), test weight (TW), protein (PRO), milling (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/long.

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+ WSMV ratings are based on field evaluations in Colorado under pressure from wheat curl mite transmitted viruses. Scores may reflect both resistance to the wheat curl mite and resistance to mite-transmitted viruses.
++ PRO ratings represent "grain protein deviation" (relative grain protein level accounting for differences in grain yield).

Description of Winter Wheat Varieties in Eastern Colorado Dryland and Irrigated Trials (2019)

Name/Class/Pedigree	Origin	HD	HT	SS	COL**	YR	LR	SR	WSMV+	TW	PRO++	MILL	BAKE	Comments
Spur Hard red winter MT02113*4/MTS0359	MT-CRFW-Agripro 2016	9	4	4	8	5	4	--	8	9	6	7	2	MT State release (2016), marketed by Crop Research Foundation of Wyoming and Agripro. First entered into CSU trials in 2015. Late maturity, average leaf and stripe rust resistance, very susceptible to mite-transmitted viruses. Carries solid stem trait conferring some protection against wheat stem sawfly damage.
Sunshine Hard white winter KS01HW152-6/HV9W02-267W	CSU 2014	2	4	3	7	5	6	2	8	6	2	3	2	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. Very susceptible to mite-transmitted viruses. Certified seed only.
SY Legend CL2 Hard red winter Agripro Exp/AP503 CL2 sib	Agripro 2018	4	4	5	2	3	3	--	5	4	4	5	4	Agripro release (2018), first entered in CSU trials in 2018. Two-gene Clearfield wheat. Good overall disease tolerance. Stewardship Agreement requires no saved seed. Certified seed only.
SY Monument Hard red winter BC991149-11/00x0090-4	Agripro 2014	8	5	4	4	2	2	2	8	5	4	5	1	Agripro release (2014). First entered in CSU Variety Trials in 2014. Good drought tolerance, winterhardiness, and resistance to both leaf and stripe rust. Excellent end-use quality. Very susceptible to mite-transmitted viruses.
SY Rugged Hard red winter Greer/Doans	Agripro 2017	6	1	4	5	2	3	3	8	6	2	4	3	Agripro release (2016), first entered in CSU Variety Trials in 2017. Dryland adapted, good stripe rust resistance, good milling and baking quality. Very susceptible to mite-transmitted viruses.
SY Sunrise Hard red winter BC98337-10-53/CDC Falcon//NE03458	Agripro 2015	7	1	1	4	3	4	2	8	3	3	4	7	Agripro release (2015), first entered in 2015 CSU Irrigated Trials. Short semidwarf, very good straw strength, winterhardiness, drought tolerance, stripe rust resistance, test weight. Marginal baking quality, very susceptible to mite-transmitted viruses. Stewardship Agreement requires no saved seed. Certified seed only.
SY Wolf Hard red winter W99-331/97x0906-8	Agripro 2010	8	5	2	5	4	2	2	6	6	2	4	6	Agripro release (2011). First entered in CSU Variety Trials in 2011. Good resistance to tan spot, septoria, leaf and stripe rust, and bacterial leaf streak. Best performance in Colorado trials under irrigation and in the I-70 corridor counties and further north. Very good straw strength.
SY Wolverine Hard red winter Undisclosed	Agripro 2019	4	3	2	6	4	2	--	4	3	--	3	6	Agripro release (2019), first entered in CSU trials in 2019. Good overall disease resistance, good straw strength. Similar to SY Wolf in reaction to Wheat Streak.
Thunder CL Hard white winter KS01-5539/CO99W165	CSU 2008	4	4	1	6	4	5	4	9	6	7	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. Very susceptible to mite-transmitted viruses. Certified seed only.
WB-Grainfield Hard red winter G982231/G982159//KS920709W	Westbred 2012	2	6	4	2	2	4	2	8	4	5	4	6	Westbred release (2012). First entered into CSU Trials in 2013. Early maturing tall semi-dwarf. Good leaf and stripe rust resistance, shorter coleoptile. Very susceptible to mite-transmitted viruses.

Column Key - heading date (HD), plant height (HT), straw strength (SS), coleoptile length (COL), stripe rust resistance (YR), leaf rust resistance (LR), stem rust resistance (SR), wheat streak mosaic virus tolerance (WSMV), test weight (TW), protein (PRO), milling (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/long.

** 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 are based on field evaluations in Colorado under pressure from wheat curl mite transmitted viruses. Scores may reflect both resistance to the wheat curl mite and resistance to mite-transmitted viruses.
++ PRO ratings represent “grain protein deviation” (relative grain protein level accounting for differences in grain yield).

Description of Winter Wheat Varieties in Eastern Colorado Dryland and Irrigated Trials (2019)

Name/Class/Pedigree	Origin	HD	HT	SS	COL**	YR	LR	SR	WSMV+	TW	PRO++	MILL	BAKE	Comments
WB4269 Hard red winter KS98W0512-2--4//HV9W02-846R/HV9W96-1271R-1	Westbred 2016	1	3	3	6	2	2	2	7	3	--	3	3	Westbred release (2016), first entered in CSU trials in 2019. Medium-short plant height, early maturity, very high tillering, with good straw strength. Very good Fusarium Head Blight tolerance, so target irrigated acres following corn. Grower Agreement required, no saved seed. Certified Seed Only.
WB4303 Hard red winter PFAU/WEAVER/3/MASON/JGR//PECOS/4/FARMEC	Westbred 2015	4	1	1	6	6	3	1	8	9	3	6	4	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. Low test weight. Best adapted for irrigated production conditions. Very susceptible to mite-transmitted viruses.
WB4418 Hard red winter XA4402	Westbred 2017	4	3	1	2	4	4	--	5	6	4	8	5	Westbred release (2017), first entered in CSU trials in 2018. Medium short plant height, medium maturity, with excellent straw strength. Average to above average fungal and viral disease package. Grower Agreement requires no saved seed. Certified seed only.
WB4462 Hard red winter TAM 203//P25R47/Hitch	Westbred 2015	4	8	4	5	7	3	--	8	3	3	2	5	Westbred release (2015), first entered in CSU trials in 2017. Western adapted variety with a taller plant stature and medium maturity. Good winter hardiness and drought tolerance, moderately susceptible to stripe rust. Very susceptible to mite-transmitted viruses.
WB4595 Hard red winter Undisclosed	Westbred 2018	5	5	3	4	4	4	--	5	2	--	5	5	Westbred release (2018), first entered in CSU trials in 2019. Medium plant height, medium maturity, with very good drought tolerance and standability, so a good fit for either irrigated or dryland acres. Very good fungal and viral disease package. Grower Agreement required, no saved seed. Certified Seed Only.
WB4699 Hard red winter Undisclosed	Westbred 2018	6	2	2	3	4	3	--	5	5	--	5	5	Westbred release (2018), first entered in CSU trials in 2019. Short plant height, very high tillering with very good straw strength. Improved Fusarium Head Blight tolerance, so target irrigated acres following corn. Very good fungal and viral disease package. Grower Agreement required, no saved seed. Certified Seed Only.
WB4792 Hard red winter Undisclosed	Westbred 2018	7	6	3	3	4	2	--	5	4	--	4	4	Westbred release (2018), first entered in CSU trials in 2019. Medium plant height, medium-late maturity, good drought tolerance and straw strength. Very good fungal and viral disease package, good milling and baking quality. Grower Agreement required, no saved seed. Certified Seed Only.
Whistler Hard red winter CO08W218/Snowmass//Byrd	CSU 2018	9	7	9	5	2	6	1	2	7	5	5	3	CSU release (2018), marketed by PlainsGold. Hard red winter, later maturing, tall, marginal straw strength. Good stripe rust resistance and carries wheat curl mite resistance from Byrd parent. Very good milling and baking quality.

Column Key - heading date (HD), plant height (HT), straw strength (SS), coleoptile length (COL), stripe rust resistance (YR), leaf rust resistance (LR), stem rust resistance (SR), wheat streak mosaic virus tolerance (WSMV), test weight (TW), protein (PRO), milling (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/long.

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Perspectives on Wheat Variety Trials and Wheat Variety Trial Data
(Reprinted from the *2016 Making Better Decisions Report*)

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.

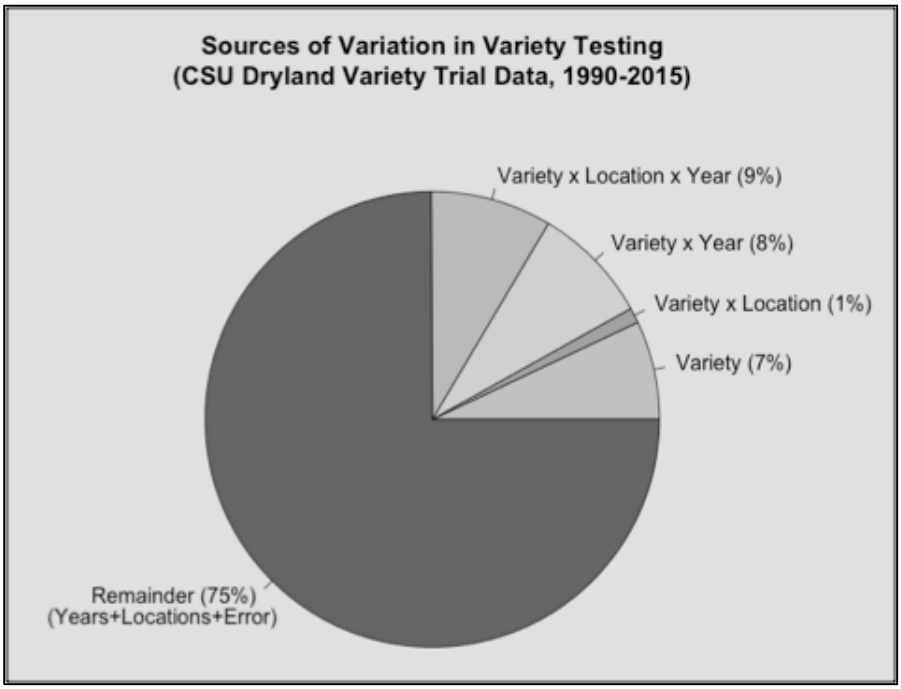

Figure 1 –Sources of variation estimated from CSU Dryland Variety Trial data (1990-2015).

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%.

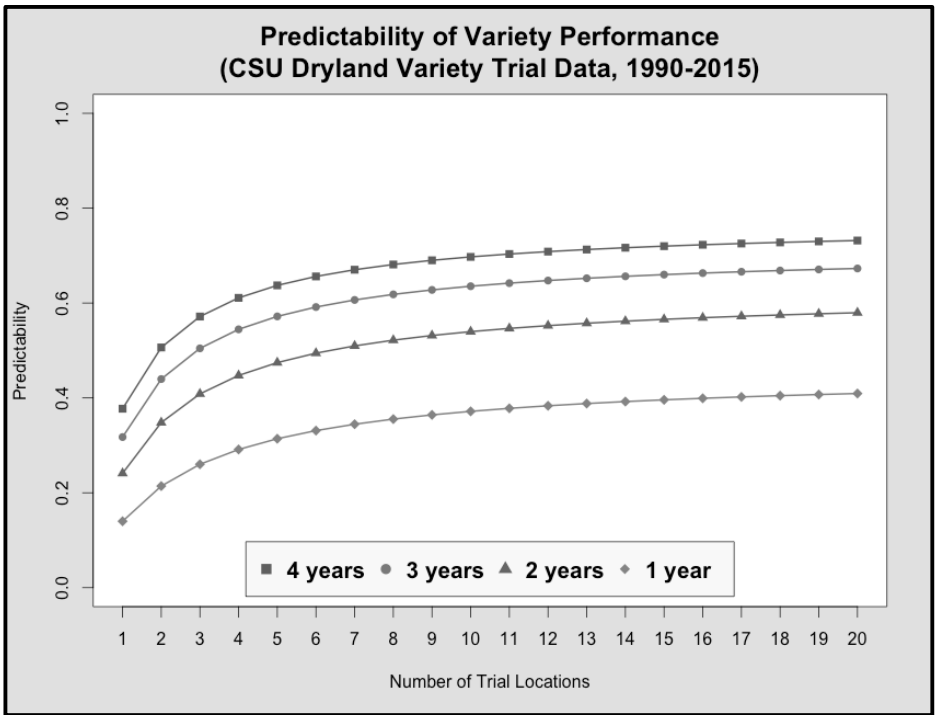

Figure 2 – Predictability of variety performance for grain yield estimated from CSU Dryland Variety Trial data (1990-2015).

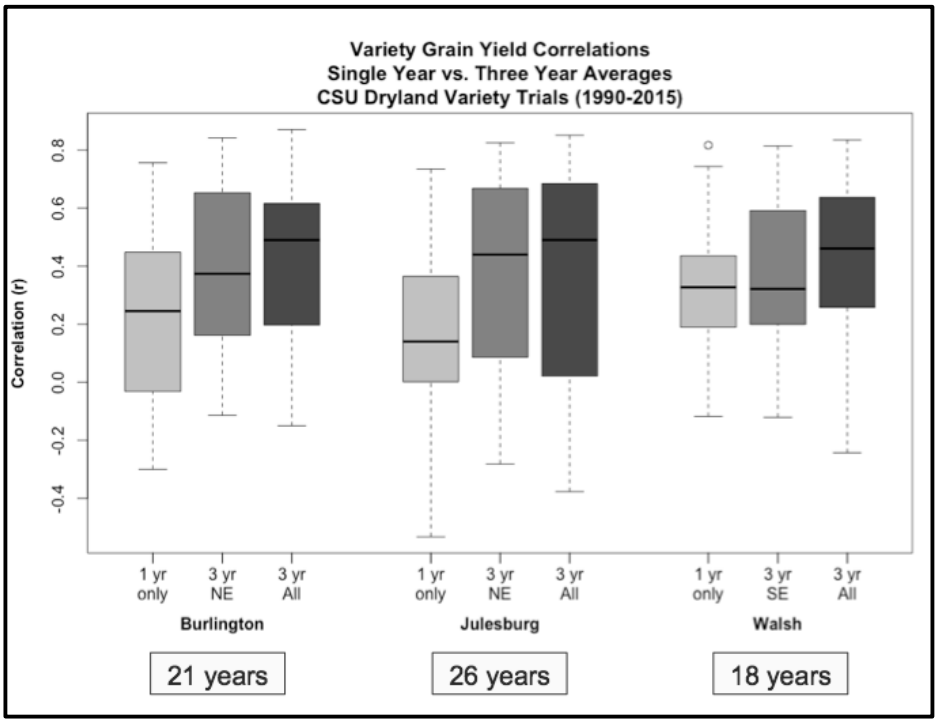

Figure 3 – "Box-plot" graph depicting the correlation of variety performance between years at three locations in Colorado. The horizontal line within each colored box shows the average of all the correlations.

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.

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.

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.

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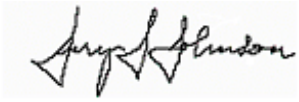

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