

# Agricultural Experiment Station

College of Agricultural Sciences

Department of Soil & Crop Sciences

Extension

## Making Better Decisions



## 2023 Colorado Winter Wheat Variety Performance Trials



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### **Additional Resources**

Colorado State University Crop Variety Testing Program: [www.csucrops.org](http://www.csucrops.org) and on Twitter with the handle [@CSUCrops](https://twitter.com/CSUCrops)

Colorado State University Wheat Breeding Program: [www.agsci.colostate.edu/wheat/](http://www.agsci.colostate.edu/wheat/)

Colorado Wheat Variety Performance Database: [www.wheattrials.com](http://www.wheattrials.com)

Colorado Wheat Administrative Committee (CWAC), Colorado Association of Wheat Growers (CAWG), and Colorado Wheat Research Foundation (CWRF): [www.coloradowheat.org](http://www.coloradowheat.org)

# Overview of 2022-2023 Eastern Colorado Winter Wheat Trials

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. Our work in Colorado is possible due to the support and cooperation of the entire Colorado wheat industry, the Colorado Wheat Administrative Committee, the Colorado Wheat Research Foundation, seed companies who enter varieties, and Colorado farmers who donate their resources and time to host wheat variety trials.

The Eastern Colorado winter wheat trials are conducted under a broad range of environmental conditions to best determine expected performance of new varieties. We have a regional uniform variety testing program, meaning that dryland varieties entered in our northeast region are tested across our seven test locations in northeast Colorado, and varieties entered in our southeast region are tested across our six test locations in southeast Colorado. All irrigated varieties are tested in all three irrigated trials across northeast Colorado. In the dryland trials, there were 46 varieties tested, including experimental lines across the two regions of the 13 total dryland trial locations. The three irrigated trials had 23 varieties each. The variety trials included a combination of public and private varieties and experimental lines. Seed companies with entries in the variety trials included AgriPro Syngenta, CROPLAN by WinField United, Limagrain Cereal Seeds, and Meridian Seeds. There were entries from the Colorado marketing organization PlainsGold, the Kansas Wheat Alliance, the University of Nebraska-Lincoln, and Crop Research Foundation of Wyoming.

All dryland and irrigated trials were planted in a randomized complete block design with three replicates. Plot sizes were approximately 150 ft<sup>2</sup> (except the Fort Collins irrigated trial, which was 80 ft<sup>2</sup>). 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 Collaborative On-Farm Tests ranged from 0.20 to 1.5 acres per variety in side-by-side strips with seeding rates conforming to the seeding rate used by the collaborating farmer. Yield was corrected to 12% moisture. Variety trial plot weight, test weight, and grain moisture content information were obtained from a HarvestMaster H2 GrainGage™ weigh system on a plot combine. Protein content was corrected to 12% moisture and obtained using a FOSS Infratec™ NOVA grain analyzer.

## General Conditions Affecting the 2022 Colorado Wheat Crop

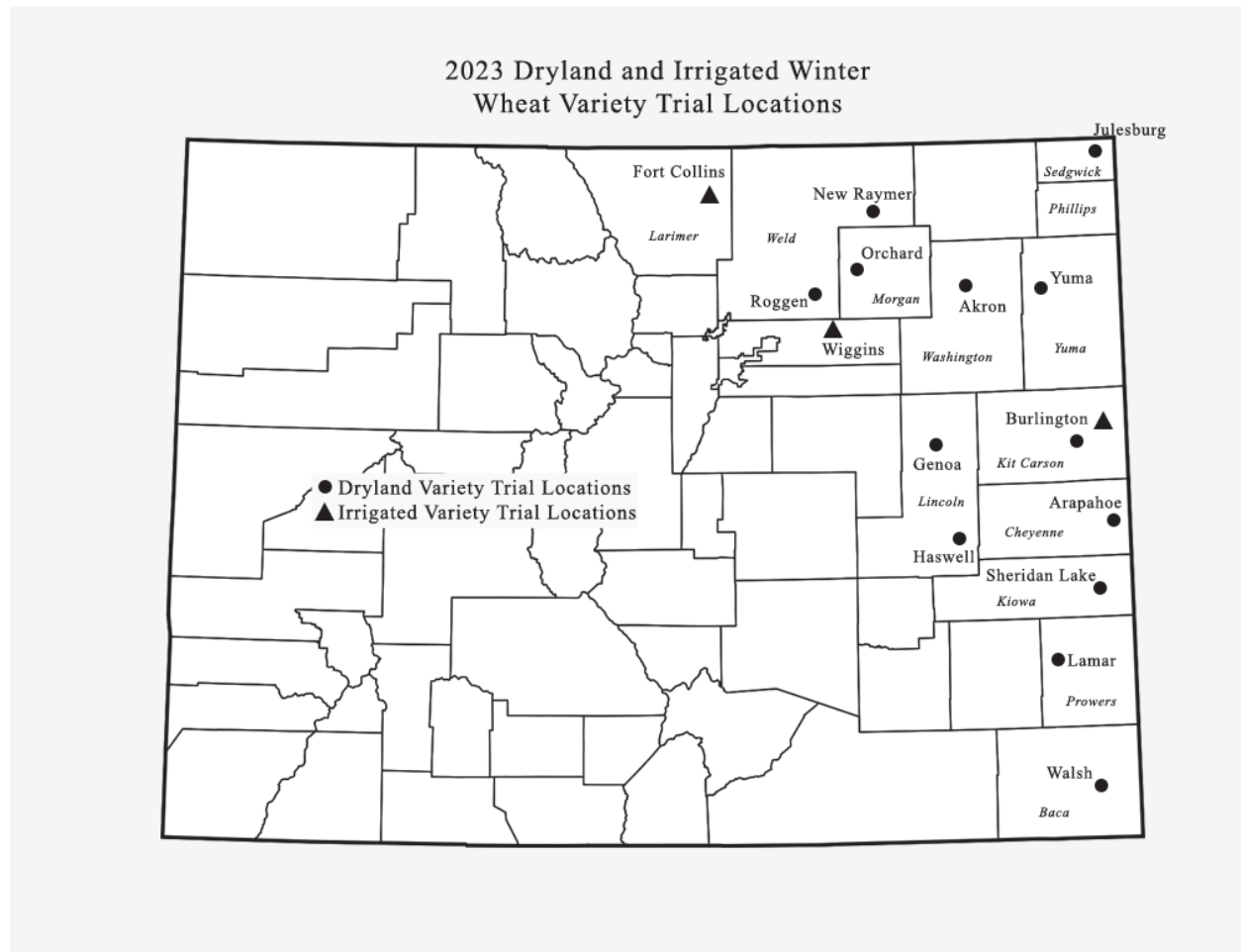
Sally Jones-Diamond and Ron Meyer

Fall 2022 was drier than normal in east-central and northeast Colorado. Rainfall received in September allowed for most wheat to be planted into adequate moisture. However, soil moisture conditions quickly deteriorated throughout eastern Colorado, especially in Sedgwick and Phillips counties in the northeast. Temperatures in the fall were above average and precipitation was well below normal. Most of northeast Colorado was experiencing moderate to exceptional drought conditions during the planting season and through the fall. Baca County in southeast Colorado moved from abnormally dry conditions at planting into extreme drought conditions by mid-November. Winter precipitation helped improve drought conditions for most of eastern

Colorado. Frequent and heavy rains from the spring through harvest pulled the region out of the drought. With the rain came isolated hail events which destroyed or severely damaged wheat fields for a number of producers.

Stripe rust disease became an issue starting in June and July, when frequent precipitation and high humidity favored the spread of the disease. Many growers sprayed fungicides if the crop was not yet in the grain-fill period. Brown wheat mite infestations ranged from low levels in east-central Colorado to high levels in southeast Colorado that required chemical control. Wheat Stem Sawfly (WSS) was widespread across many northeast Colorado counties, albeit at lower numbers than previous seasons. Some producers swathed their wheat to avoid lodging and decrease harvest losses. Some wheat in east-central and northeast Colorado showed lodging due to high moisture and wind (which usually shows up first) combined with wheat stem sawfly cutting.

Wheat yields in northeast Colorado were above average while yields south of I-70 were recorded at below normal levels. Some wheat fields south of I-70 were abandoned due to the early drought conditions which resulted in poor stands.



# 2023 Wheat Trial Management and Characteristics

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Dryland Locations													Irrigated Locations				
	Akron	Arapahoe	Burlington	Genoa	Haswell	Julesburg	Lamar	New Raymer	Orchard	Roggen	Sheridan Lake	Walsh	Yuma	Burlington	Fort Collins	Wiggins	
<b>Average Yield (bu/ac)</b>	88	-	91	54	15	66	-	57	56	77	37	48	63	77	117	97	
<b>GPS Coordinates (Lat/Long)</b>	40.151038, -103.141808	38.911339, -102.31567	39.31518, -102.258	39.359785, -103.510437	38.632886, -103.265932	40.83667, -102.373352	38.012394, -102.63239	40.57115, -103.8973	40.481426, -104.07898	40.7075, -104.28144	38.53187, -102.43544	37.43116, -102.31043	40.186218, -102.65899	39.4107331, -102.15088	40.652947, -104.9992	39.9953, -104.10392	
<b>County</b>	Washington	Cheyenne	Kit Carson	Lincoln	Lincoln	Seigwick	Prowers	Weld	Morgan	Weld	Kiowa	Baca	Yuma	Kit Carson	Larimer	Adams	
<b>Soil Type</b>	Rago silt loam	Wiley complex	Kuma and Keith silt loams	Weld silt loam	Bacild silt loam	Rago and Kuma silt loams	Marvel silt loam	Olney fine sandy loam	Plainer sandy loam	Weld loam	Wiley loam	Wiley loam	Plainer loam	Norka silt loam	Fort Collins loam	Truckton sandy loam	
<b>Soil Organic Matter</b>	1.6%	1.9%	2.0%	1.8%	1.9%	1.8%	1.6%	-	1.6%	1.5%	1.4%	-	1.4%	2.1%	-	1.1%	
<b>Soil pH</b>	6.2	8	7.8	7.7	7.4	7.3	7.6	-	7.1	7.4	7.6	-	7.2	8.1	-	7.8	
<b>Soil Nutrients at planting (N-P-K lb/ac)</b>	134 - 38	129 - 6	125 - 28	121 - 20	89 - 14	46 - 20	75 - 22	-	82 - 60	111 - 24	87 - 12	-	76 - 34	108 - 10	-	64 - 14	
<b>Applied Fertilizer in Season* (N-P-K lb/ac)</b>	70 - 0 - 0	-	12 - 41.5 - 0	-	-	6 - 22 - 0	-	-	8.7 - 30 - 0	16 - 55.5 - 0	-	-	14 - 47.5 - 0	5 - 16 - 0	-	54 - 30 - 0	
<b>Tillage</b>	No-Till	No-Till	Tilled	Tilled	Sweep Plow 1x	No-Till	No-Till	No-Till	No-Till	No-Till	Tilled	No-Till	No-Till	Tilled	Tilled	Tilled	
<b>Previous Crop</b>	Proso Millet	Sunflower	Corn	Sunflower	Corn	Corn	Fallow	Corn	Proso Millet	Fallow	Corn	Fallow	Fallow	Corn	Dry Bean	Dry Bean	
<b>Planting Date</b>	9/29/2022	9/26/2022	9/26/2022	9/20/2022	9/5/2022	9/27/2022	9/5/2022	9/26/2022	9/27/2022	9/15/2022	9/5/2022	9/21/2022	9/19/2022	10/17/2022	9/29/2022	10/18/2022	
<b>Harvest Date</b>	8/5/2023	-	7/13/2023	7/27/2023	7/17/2023	7/26/2023	-	7/31/2023	7/29/2023	7/19/2023	7/14/2023	7/17/2023	7/17/2023	7/27/2023	8/9/2023	7/28/2023	
<b>Biotic Stress</b>	Wheat Stem Sawfly Stripe Rust	-	Wheat Stem Sawfly	Wheat Stem Sawfly	-	Wheat Stem Sawfly Stripe Rust	-	Wheat Stem Sawfly	Wheat Stem Sawfly	Wheat Stem Sawfly	-	Stripe Rust	Wheat Stem Sawfly	Wheat Stem Sawfly	-	Wheat Stem Sawfly	
<b>Abiotic Stress</b>	-	Drought	-	Hail	Drought and Hail	-	Hail	Drought and Hail	-	-	Winter Kill	Hail	Hail	-	-	-	
<b>Total Rain: January 1 to Harvest</b>	19.2"	-	13.2"	18"	12.3"	15"	-	18.7"	19.1"	19.1"	14.5"	11.1"	15.4"	17.9"	17.1"	20.5"	
<b>GDD (Jan 1 - Harvest, 32°F base)</b>	4,014	-	3,367	3,611	3,671	3,770	-	3,795	3,749	3,490	3,719	4,274	3,338	3,908	4,115	3,847	
<b>General Comments</b>	Planted about 2" deep into excellent moisture. Excellent fall emergence and stands, although field was dry in mid-October. Wheat stem sawfly was present at moderate levels, but lodging was due to high yield. Stripe rust was observed at low levels late in the season - trial was not sprayed.	Trial lost due to severe drought and poor stands. Excellent fall emergence and stands, although field was dry in mid-October. Wheat stem sawfly was present at low levels, but lodging was due to high yield. Stripe rust was observed at low levels late in the season - trial was not sprayed.	Planted about 2" deep into filled corn residue. Excellent fall emergence. Trial had lush spring growth. Wheat stem sawfly was present at low levels, but lodging was due to high yield.	Planted 2" deep into good moisture and sandflower residue. Dry conditions in fall, emergence and stands were above average. Wheat stem sawfly present but minimal lodging was observed at harvest. Minor hail damage received in July.	Planted 2" deep into excellent moisture and corn residue. Fall emergence and stands were average with some areas of spotty emergence. Wheat stem sawfly present but minimal lodging was observed from a hail event in early July.	Planted 2" deep into excellent moisture and corn residue. Fall emergence and stands were average with some areas of spotty emergence. Wheat stem sawfly present but minimal lodging was observed from a hail event in early July.	Planted 1.5" deep into good moisture and heavy corn residue. Very dry conditions in fall, emergence and stands were average with some areas of spotty emergence. Wheat stem sawfly present but minimal lodging was observed at harvest.	Trial lost due to severe hail damage in June.	Planted about 1.5" deep into good moisture. Very good fall emergence, although field was dry in mid-October. Wheat stem sawfly was present at moderate levels. Trial had minor hail damage in mid-July.	Planted about 2" deep into good moisture and rillet residue. Very good fall emergence, although field was dry in mid-October. Trial had lush spring growth. Wheat stem sawfly was present at low levels, but lodging was due to high yield.	Planted about 2" deep into good moisture and wheat residue. Very good fall emergence. Trial had lush spring growth. Wheat stem sawfly was present at low levels, but lodging was due to high yield.	Planted 1.5" deep into excellent moisture and corn residue. Fall emergence was very good. Trial showed winterkill in some varieties in early spring. Some field soil variation apparent in spring.	Planted 2" deep into moisture. Fall emergence was acceptable and good fall growth. Trial received minor damage from two small hail events in June and a high wind event in early July. There was moderate to heavy stripe rust observed. Minor hail damage in July.	Planted 1.5" deep into excellent moisture and heavy residue. Fall emergence and growth was good. Trial showed winterkill in some varieties in early spring and slow green-up due to residue. Wheat stem sawfly present but minimal lodging was observed. Minor hail damage in July.	Planted about 1.5" deep into good fall emergence and very late to green-up in late planting date. Trial irrigated late to green-up in the spring due to late planting date. Wheat stem sawfly was present at low levels, but lodging was due to high yield.	Planted about 1.5" deep into deep. Field had one inch of water applied immediately after planting. Good fall emergence and very late to green-up in the spring due to late planting date. Wheat stem sawfly was present at low levels, but lodging was due to high yield.	Planted about 1.5" deep into deep. Field had one inch of water applied immediately after planting. Good fall emergence and very late to green-up in the spring due to late planting date. Wheat stem sawfly was present at low levels, but lodging was due to high yield.

\* 8 and 28 lb/ac of N and P were applied at planting as starter by Crops Testing  
Dashes denote missing information, N/A means not applicable

# Summary of 2023 Dryland Winter Wheat Variety Performance Results

Brand/Source	Market Class	Variety <sup>a</sup>	2023 Multi-Location Average				2023 Individual Trial Yield <sup>b</sup>										
			Yield <sup>b</sup>	Yield	Test		Akron	Burlington	Genoa	Julesburg	New			Sheridan			
					Weight	Protein <sup>c</sup>					Raymer	Orchard	Roggen	Lake	Walsh	Yuma	
			bu/ac	percent of average	lb/bu	percent	days from average	bu/ac									
PlainsGold	HWW	Monarch	<b>76.3</b>	111%	57	10.5	0	<b>101.5</b>	<b>103.0</b>	60.5	70.5	81.0	97.5	83.5	43.5	54.5	<b>71.0</b>
PlainsGold	HWW	Snowmass 2.0	72.5	105%	57	10.7	-1	96.0	101.5	54.0	69.5	71.0	<b>103.0</b>	81.5	35.5	53.0	62.0
CROPLAN	HRW	CP7017AX	72.4	105%	58	10.6	0	93.0	97.0	53.0	<b>72.0</b>	81.5	96.0	77.5	41.0	51.0	65.5
Frenchman Valley Coop	HWW	Valley	72.0	104%	57	11.0	0	<b>99.0</b>	<b>103.0</b>	44.5	<b>73.0</b>	75.0	92.0	81.0	38.0	46.0	67.0
PlainsGold	HRW	Crescent AX	70.2	102%	58	11.0	-1	90.5	99.5	60.0	63.0	77.5	97.5	76.0	31.0	46.0	59.0
PlainsGold	HRW	Whistler	69.7	101%	56	10.2	1	76.0	75.0	62.0	68.0	<b>90.0</b>	89.0	81.0	<b>48.5</b>	53.5	67.0
PlainsGold	HRW	Amplify SF	69.6	101%	57	11.3	0	88.0	85.5	58.5	68.0	80.0	89.0	78.0	36.0	45.0	64.0
PlainsGold	HRW	Avery	69.6	101%	56	10.0	1	86.5	91.0	53.5	63.5	81.5	95.0	79.0	32.0	54.5	64.5
PlainsGold	HWW	Sunshine	69.2	101%	57	11.0	-1	<b>97.5</b>	91.0	58.5	66.0	80.5	87.0	75.0	31.0	49.0	62.5
PlainsGold	HRW	Byrd	69.2	100%	57	10.3	0	84.5	90.5	56.0	67.5	78.0	93.5	79.0	33.5	47.0	61.5
Meridian Seeds	HRW	MS Maverick	68.1	99%	57	11.2	0	<b>98.5</b>	81.0	55.0	68.0	76.0	89.0	73.0	36.5	53.5	60.0
PlainsGold	HRW	Byrd CL Plus	68.1	99%	56	10.5	0	89.0	91.0	56.5	67.0	77.0	92.5	78.0	34.5	37.0	61.5
PlainsGold	HRW	Kivari AX	67.9	99%	55	10.2	0	85.5	75.0	56.0	66.5	81.0	85.5	81.5	37.5	52.0	65.0
PlainsGold	HRW	Canvas	67.7	98%	57	11.1	0	76.0	87.5	46.0	69.5	83.5	86.5	77.0	40.0	55.0	60.0
PlainsGold	HWW	Breck	67.4	98%	58	10.6	0	82.5	77.0	53.5	61.5	74.0	91.5	73.0	38.5	<b>60.5</b>	63.0
PlainsGold	HRW	Guardian	66.7	97%	58	11.0	0	76.5	85.5	53.0	60.0	79.5	94.0	80.0	36.0	50.5	57.5
PlainsGold	HRW	Langin	66.6	97%	56	10.9	-2	77.0	88.5	62.0	60.5	71.0	94.5	83.0	31.5	36.0	61.0
PlainsGold	HRW	Brawl CL Plus	66.4	96%	57	11.6	-1	96.0	95.0	50.5	59.0	71.5	90.5	70.0	32.0	45.5	57.0
Limagrain	HRW	LCS Steel AX	66.1	96%	58	11.0	-2	84.0	<b>107.0</b>	56.5	59.0	65.5	88.0	74.0	33.0	45.0	58.0
PlainsGold	HRW	Hatcher	65.5	95%	56	10.6	0	78.0	84.5	55.5	59.0	74.0	83.0	74.5	37.5	51.5	58.5
PlainsGold	HWW	Windom SF	64.3	93%	57	10.6	-1	84.0	64.5	52.5	68.5	<b>87.5</b>	72.5	68.0	40.0	47.5	61.5
PlainsGold	HRW	Fortify SF	63.2	92%	57	10.5	0	73.5	74.5	47.5	61.0	76.0	96.0	74.0	32.0	34.5	67.5
Limagrain	HRW	LCS Atomic AX	59.7	87%	57	11.0	-1	80.0	100.0	48.0	65.0	57.5	84.5	75.5	21.5	10.5	56.0
PlainsGold	HRW	Ray	54.2	79%	52	11.7	6	58.5	60.5	41.5	46.0	68.0	77.5	66.0	33.5	42.0	52.5
<b>Experimentals</b>																	
Colo. State University exp.	HRW	CO19410R	<b>75.6</b>	110%	58	10.9	1	<b>98.0</b>	100.0	<b>69.0</b>	66.5	85.5	95.0	78.5	40.0	54.0	<b>71.5</b>
Colo. State University exp.	HRW	CO19393R	<b>73.5</b>	107%	57	10.8	0	92.0	101.0	58.5	67.0	83.0	95.0	<b>87.5</b>	43.0	45.0	63.5
Colo. State University exp.	HRW	CO20D108R	73.0	106%	57	10.8	1	86.5	99.0	53.0	66.5	82.0	90.5	82.0	39.5	56.5	67.0
Colo. State University exp.	HWW	CO18D007W	73.0	106%	57	10.4	0	<b>97.0</b>	93.0	53.5	67.0	70.0	<b>102.0</b>	82.0	40.5	54.0	68.5
Colo. State University exp.	HRW	CO19D087R	72.3	105%	56	10.9	-1	86.5	<b>107.0</b>	56.5	70.0	76.5	96.0	82.5	40.5	54.0	58.5
Colo. State University exp.	HRW	CO19D304R	71.9	104%	56	10.6	1	84.0	92.5	54.5	68.0	<b>90.0</b>	91.5	79.5	<b>45.5</b>	<b>58.0</b>	64.5
Colo. State University exp.	HRW	CO18D297R	71.9	104%	58	11.1	0	94.5	98.0	62.0	67.5	67.0	<b>100.0</b>	78.5	41.0	48.0	64.5
Colo. State University exp.	HWW	CO19S129W	71.7	104%	57	10.6	0	96.5	<b>103.0</b>	49.5	69.5	82.5	88.0	74.5	38.5	47.0	65.0
Colo. State University exp.	HWW	CO19S135W	70.6	103%	57	10.6	-1	96.5	<b>103.5</b>	53.5	70.5	77.0	94.0	82.0	31.5	39.5	66.5
Colo. State University exp.	HWW	CO19S085W	70.3	102%	57	11.4	0	90.0	94.0	55.5	65.5	78.5	95.0	79.5	38.0	49.0	61.0
Colo. State University exp.	HRW	CO18042RA	68.3	99%	57	10.5	1	88.5	96.0	61.0	62.5	74.5	84.5	78.5	35.0	42.0	59.5
Colo. State University exp.	HRW	CO19S053R	68.2	99%	57	10.5	0	77.5	84.5	57.0	64.0	<b>87.0</b>	92.0	77.5	37.0	49.5	63.5
Colo. State University exp.	HRW	CO18035RA	68.1	99%	56	11.1	-2	91.5	85.0	56.5	63.0	79.0	88.5	80.5	35.0	43.5	63.0
Colo. State University exp.	HRW	CO200037R	66.8	97%	57	11.0	1	83.5	90.5	50.5	64.5	76.0	87.0	72.0	36.0	52.5	60.5
		<b>Average</b>	<b>68.9</b>	<b>100%</b>	<b>57</b>	<b>10.8</b>	<b>0</b>	<b>87.0</b>	<b>91.0</b>	<b>55.0</b>	<b>65.5</b>	<b>77.5</b>	<b>91.0</b>	<b>77.5</b>	<b>36.5</b>	<b>47.5</b>	<b>62.5</b>
		<sup>e</sup> LSD (0.30)	2.8					5.0	5.0	5.0	2.0	3.0	4.0	3.0	3.5	3.0	2.0
		<sup>e</sup> LSD (0.05)	5.3					9.5	9.0	9.5	4.5	6.0	7.0	5.0	7.0	5.5	4.5

<sup>a</sup>Varieties grouped according to released varieties or experimentals, and then ranked from highest to lowest yield across ten trials in 2023. Varieties not entered at all ten locations were not included to provide fair comparisons. Varieties entered in a single testing region (southeast or northeast Colorado) appear in the associated 2023 Colorado regional summary table.

<sup>b</sup>Yield adjusted to 12% moisture content. Variety yield values in the top least significant difference (LSD) yield group across the locations and within each location are in bold. Multi-location yield values for each variety are least squares means and not arithmetic averages.

<sup>c</sup>Protein adjusted to 12% moisture content and averaged across seven trials in 2023.

<sup>d</sup>Varieties with positive values headed later than the trial averages and varieties with negative values headed earlier than average. Based on three trials in 2023.

<sup>e</sup>Farmers selecting a variety based on yield should use the LSD (.30) to protect themselves from false negative conclusions (concluding varieties are the same when they are actually different). Companies or researchers may use the LSD (.05) to avoid false positive conclusions (concluding varieties are different when they are actually the same).

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## Summary of 2023 Dryland Winter Wheat Variety Performance Results - Northeast Region

Brand/Source	Market Class	Variety <sup>a</sup>	2023 Multi-Location Average					2023 Individual Trial Yield <sup>b</sup>						
			Yield <sup>b</sup>	Yield	Test Weight	Protein <sup>c</sup>	Heading <sup>d</sup>	New						
			bu/ac	percent of average	lb/bu	percent	days from average	Akron	Genoa	Julesburg	Raymer	Orchard	Roggen	Yuma
PlainsGold	<b>HWW</b>	Monarch	<b>79.8</b>	109%	57	10.4	0	<b>101.5</b>	60.5	70.5	81.0	97.5	83.5	<b>71.0</b>
Crop Research Foundation of WY	HRW	Steamboat	<b>77.0</b>	105%	59	10.5	1	95.0	63.5	<b>73.0</b>	77.5	91.5	80.0	67.5
AgriPro	HRW	AP Solid	76.1	104%	57	11.0	1	90.0	59.5	64.0	75.5	98.0	74.0	68.5
CROPLAN	HRW	CP7017AX	76.1	104%	58	10.6	0	93.0	53.0	<b>72.0</b>	81.5	96.0	77.5	65.5
PlainsGold	<b>HWW</b>	Snowmass 2.0	76.0	104%	57	10.6	-1	96.0	54.0	69.5	71.0	<b>103.0</b>	81.5	62.0
Frenchman Valley Coop	<b>HWW</b>	Valley	75.4	103%	58	10.9	0	<b>99.0</b>	44.5	<b>73.0</b>	75.0	92.0	81.0	67.0
PlainsGold	HRW	Amplify SF	75.2	103%	58	11.3	0	88.0	58.5	68.0	80.0	89.0	78.0	64.0
PlainsGold	HRW	Crescent AX	74.7	102%	58	10.9	-1	90.5	60.0	63.0	77.5	97.5	76.0	59.0
PlainsGold	HRW	Whistler	74.3	102%	56	10.0	1	76.0	62.0	68.0	<b>90.0</b>	89.0	81.0	67.0
PlainsGold	<b>HWW</b>	Sunshine	74.2	102%	57	11.0	-1	<b>97.5</b>	58.5	66.0	80.5	87.0	75.0	62.5
PlainsGold	HRW	Avery	74.1	101%	57	9.8	1	86.5	53.5	63.5	81.5	95.0	79.0	64.5
Kansas Wheat Alliance	HRW	KS Territory	74.1	101%	57	11.3	1	93.5	54.0	64.0	82.5	90.0	74.5	64.5
PlainsGold	HRW	Byrd	74.0	101%	58	10.2	0	84.5	56.0	67.5	78.0	93.5	79.0	61.5
PlainsGold	HRW	Byrd CL Plus	74.0	101%	57	10.5	0	89.0	56.5	67.0	77.0	92.5	78.0	61.5
PlainsGold	HRW	Kivari AX	73.4	101%	55	10.2	0	85.5	56.0	66.5	81.0	85.5	81.5	65.0
Meridian Seeds	HRW	MS Maverick	72.9	100%	58	11.0	0	<b>98.5</b>	55.0	68.0	76.0	89.0	73.0	60.0
AgriPro	HRW	AP Bigfoot	72.6	99%	58	10.7	-1	<b>97.5</b>	44.0	68.0	72.5	88.0	74.5	68.0
PlainsGold	HRW	Langin	72.6	99%	56	10.9	-2	77.0	62.0	60.5	71.0	94.5	83.0	61.0
PlainsGold	<b>HWW</b>	Breck	71.0	97%	59	10.5	0	82.5	53.5	61.5	74.0	91.5	73.0	63.0
PlainsGold	HRW	Canvas	70.6	97%	57	11.1	0	76.0	46.0	69.5	83.5	86.5	77.0	60.0
PlainsGold	HRW	Guardian	70.6	97%	58	10.8	0	76.5	53.0	60.0	79.5	94.0	80.0	57.5
PlainsGold	HRW	Fortify SF	70.3	96%	57	10.5	0	73.5	47.5	61.0	76.0	96.0	74.0	67.5
PlainsGold	<b>HWW</b>	Windom SF	70.1	96%	56	10.6	-1	84.0	52.5	68.5	<b>87.5</b>	72.5	68.0	61.5
PlainsGold	HRW	Brawl CL Plus	69.8	95%	58	11.6	-1	96.0	50.5	59.0	71.5	90.5	70.0	57.0
PlainsGold	HRW	Hatcher	68.8	94%	56	10.4	0	78.0	55.5	59.0	74.0	83.0	74.5	58.5
Limagrain	HRW	LCS Steel AX	67.9	93%	58	10.9	-2	84.0	56.5	59.0	65.5	88.0	74.0	58.0
Limagrain	HRW	LCS Atomic AX	66.2	91%	57	10.9	-1	80.0	48.0	65.0	57.5	84.5	75.5	56.0
PlainsGold	HRW	Ray	58.0	79%	51	11.8	6	58.5	41.5	46.0	68.0	77.5	66.0	52.5
<b>Experimentals</b>														
Colorado State University exp.	HRW	CO19410R	<b>79.9</b>	109%	58	10.9	1	<b>98.0</b>	<b>69.0</b>	66.5	85.5	95.0	78.5	<b>71.5</b>
Colorado State University exp.	HRW	CO19393R	77.7	106%	57	10.8	0	92.0	58.5	67.0	83.0	95.0	<b>87.5</b>	63.5
Colorado State University exp.	<b>HWW</b>	CO18D007W	<b>77.3</b>	106%	58	10.3	0	<b>97.0</b>	53.5	67.0	77.0	<b>102.0</b>	82.0	68.5
Colorado State University exp.	<b>HWW</b>	CO19S135W	76.2	104%	57	10.5	-1	96.5	53.5	70.5	77.0	94.0	82.0	66.5
Colorado State University exp.	HRW	CO20D108R	76.1	104%	57	10.7	1	86.5	53.0	66.5	82.0	90.5	82.0	67.0
Colorado State University exp.	HRW	CO18D297R	75.7	104%	58	11.1	0	94.5	62.0	67.5	67.0	<b>100.0</b>	78.5	64.5
Colorado State University exp.	<b>HWW</b>	CO19S129W	75.1	103%	57	10.5	0	96.5	49.5	69.5	82.5	88.0	74.5	65.0
Colorado State University exp.	<b>HWW</b>	CO19S085W	74.3	102%	57	11.5	0	90.0	55.5	65.5	78.5	95.0	79.5	61.0
Colorado State University exp.	HRW	CO19D304R	74.3	102%	56	10.5	1	84.0	54.5	68.0	<b>90.0</b>	91.5	79.5	64.5
Colorado State University exp.	HRW	CO19D087R	74.3	102%	56	10.8	-1	86.5	56.5	70.0	76.5	96.0	82.5	58.5
Colorado State University exp.	HRW	CO18035RA	73.9	101%	56	11.1	-2	91.5	56.5	63.0	79.0	88.5	80.5	63.0
University of Nebraska-Lincoln exp.	<b>HWW</b>	PSB13NEDH-14-83W	72.9	100%	58	10.3	0	<b>101.5</b>	52.5	69.5	67.0	92.0	74.5	63.0
Colorado State University exp.	HRW	CO19S053R	72.9	100%	57	10.5	0	77.5	57.0	64.0	<b>87.0</b>	92.0	77.5	63.5
Colorado State University exp.	HRW	CO18042RA	72.1	99%	57	10.3	1	88.5	61.0	62.5	74.5	84.5	78.5	59.5
Colorado State University exp.	HRW	CO200037R	69.7	95%	57	10.9	1	83.5	50.5	64.5	76.0	87.0	72.0	60.5
University of Nebraska-Lincoln exp.	HRW	NHH17450	61.8	85%	57	11.8	0	85.5	37.5	60.0	60.5	84.0	66.5	45.0
		<b>Average</b>	<b>73.1</b>	<b>100%</b>	<b>57</b>	<b>10.7</b>	<b>0</b>	<b>88.0</b>	<b>54.5</b>	<b>65.5</b>	<b>77.0</b>	<b>91.0</b>	<b>77.0</b>	<b>62.5</b>
		<sup>†</sup> LSD (0.30)	3.0					5.0	5.0	2.0	3.0	4.0	3.0	2.0
		<sup>‡</sup> LSD (0.05)	5.6					9.5	9.5	4.5	6.0	7.0	5.0	4.5

<sup>a</sup>Varieties grouped according to released varieties or experimentals, and then ranked from highest to lowest yield across seven northeast Colorado region trials in 2023.

<sup>b</sup>Yield adjusted to 12% moisture content. Variety yield values in the top least significant difference (LSD) yield group across the locations and within each location are in bold. Multi-location yield values for each variety are least squares means and not arithmetic averages.

<sup>c</sup>Protein adjusted to 12% moisture content and averaged across seven trials in 2023.

<sup>d</sup>Varieties with positive values headed later than the trial averages and varieties with negative values headed earlier than average. Based on three trials.

<sup>e</sup>Farmers selecting a variety based on yield should use the LSD (.30) to protect themselves from false negative conclusions (concluding varieties are the same when they are actually different). Companies or researchers may use the LSD (.05) to avoid false positive conclusions (concluding varieties are different when they are actually the same).

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## Summary of 2023 Dryland Winter Wheat Variety Performance Results - Southeast Region

Brand/Source	Market Class	Variety <sup>a</sup>	2023 Multi-Location Average				2023 Individual Trial Yield <sup>b</sup>		
			Yield <sup>b</sup>	Yield	Test		Burlington	Sheridan Lake	Walsh
					bu/ac	percent of average			
PlainsGold	<b>HWW</b>	Monarch	67.0	114%	57	11.1	<b>103.0</b>	43.5	54.5
Kansas Wheat Alliance	<b>HWW</b>	KS Big Bow	64.0	109%	57	11.4	99.5	40.5	52.0
PlainsGold	<b>HWW</b>	Snowmass 2.0	63.4	108%	56	11.5	101.5	35.5	53.0
CROPLAN	HRW	CP7017AX	63.1	108%	58	11.0	97.0	41.0	51.0
Frenchman Valley Coop	<b>HWW</b>	Valley	62.3	106%	57	11.2	<b>103.0</b>	38.0	46.0
Limagrain	HRW	LCS Steel AX	61.7	105%	58	11.9	<b>107.0</b>	33.0	45.0
PlainsGold	HRW	Canvas	60.9	104%	57	11.2	87.5	40.0	55.0
PlainsGold	HRW	Avery	59.1	101%	56	10.9	91.0	32.0	54.5
PlainsGold	HRW	Whistler	59.0	101%	55	11.3	75.0	<b>48.5</b>	53.5
PlainsGold	HRW	Crescent AX	58.7	100%	57	11.3	99.5	31.0	46.0
PlainsGold	<b>HWW</b>	Breck	58.6	100%	57	11.4	77.0	38.5	<b>60.5</b>
PlainsGold	HRW	Hatcher	57.9	99%	56	11.4	84.5	37.5	51.5
PlainsGold	HRW	Brawl CL Plus	57.4	98%	57	12.0	95.0	32.0	45.5
PlainsGold	HRW	Guardian	57.4	98%	57	11.8	85.5	36.0	50.5
PlainsGold	HRW	Byrd	57.1	97%	57	11.0	90.5	33.5	47.0
Meridian Seeds	HRW	MS Maverick	57.1	97%	55	12.6	81.0	36.5	53.5
PlainsGold	<b>HWW</b>	Sunshine	57.0	97%	56	11.5	91.0	31.0	49.0
PlainsGold	HRW	Amplify SF	55.5	95%	56	11.5	85.5	36.0	45.0
PlainsGold	HRW	Kivari AX	54.7	93%	55	10.1	75.0	37.5	52.0
PlainsGold	HRW	Byrd CL Plus	54.1	92%	56	11.1	91.0	34.5	37.0
PlainsGold	HRW	Langin	51.9	89%	56	10.8	88.5	31.5	36.0
PlainsGold	<b>HWW</b>	Windom SF	50.7	86%	57	11.2	64.5	40.0	47.5
PlainsGold	HRW	Fortify SF	46.9	80%	56	10.6	74.5	32.0	34.5
PlainsGold	HRW	Ray	45.2	77%	53	11.1	60.5	33.5	42.0
Limagrain	HRW	LCS Atomic AX	44.0	75%	56	11.6	100.0	21.5	10.5
<b>Experimentals</b>									
Colorado State University exp.	HRW	CO19D087R	67.1	115%	55	11.3	<b>107.0</b>	40.5	54.0
Colorado State University exp.	HRW	CO19D304R	65.2	111%	56	10.8	92.5	<b>45.5</b>	<b>58.0</b>
Colorado State University exp.	HRW	CO20D108R	65.0	111%	57	11.2	99.0	39.5	56.5
Colorado State University exp.	HRW	CO19410R	64.7	110%	57	11.2	100.0	40.0	54.0
Colorado State University exp.	HRW	CO19393R	63.1	108%	56	11.3	101.0	43.0	45.0
Colorado State University exp.	<b>HWW</b>	CO19S129W	63.0	107%	57	11.4	<b>103.0</b>	38.5	47.0
Colorado State University exp.	<b>HWW</b>	CO18D007W	62.5	107%	56	10.6	93.0	40.5	54.0
Colorado State University exp.	HRW	CO18D297R	62.4	106%	58	11.4	98.0	41.0	48.0
Colorado State University exp.	<b>HWW</b>	CO19S085W	60.3	103%	56	11.3	94.0	38.0	49.0
Colorado State University exp.	HRW	CO200037R	59.6	102%	57	11.3	90.5	36.0	52.5
Colorado State University exp.	<b>HWW</b>	CO19S135W	58.1	99%	56	11.8	<b>103.5</b>	31.5	39.5
Colorado State University exp.	HRW	CO18042RA	57.7	98%	56	11.2	96.0	35.0	42.0
Colorado State University exp.	HRW	CO19S053R	57.1	98%	57	10.9	84.5	37.0	49.5
Colorado State University exp.	HRW	CO18035RA	54.6	93%	56	11.0	85.0	35.0	43.5
<b>Average</b>			<b>58.6</b>	<b>100%</b>	<b>56</b>	<b>11.3</b>	<b>91.0</b>	<b>37.0</b>	<b>48.0</b>
<sup>d</sup> LSD (0.30)							5.0	3.5	3.0
<sup>d</sup> LSD (0.05)							9.0	7.0	5.5

<sup>a</sup>Varieties grouped according to released varieties or experimentals, and then ranked from highest to lowest yield across three southeast Colorado region trials in 2023.

<sup>b</sup>Yield adjusted to 12% moisture content. Variety yield values in the top least significant difference (LSD) yield group within each location are in bold. Multi-location yield values for each variety are arithmetic averages from across the three sites and could not be statistically analyzed due to the wide variation among locations.

<sup>c</sup>Protein adjusted to 12% moisture content and from Burlington trial in 2023.

<sup>d</sup>Farmers selecting a variety based on yield should use the LSD (.30) to protect themselves from false negative conclusions (concluding varieties are the same when they are actually different). Companies or researchers may use the LSD (.05) to avoid false positive conclusions (concluding varieties are different when they are actually the same).

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## Summary of 2-Year (2022-2023) Dryland Winter Wheat Variety Performance Results



Variety <sup>b</sup>	Brand/Source	Market Class <sup>c</sup>	2-Year Average <sup>a</sup>					
			Yield bu/ac	Yield % trial average	Test Weight lb/bu	Test Weight % trial average	Plant Height in	Protein percent
Monarch	PlainsGold	<b>HWW</b>	67.0	111%	58	101%	26	11.4
CO18D007W	Colo. State University exp.	<b>HWW</b>	63.6	106%	58	101%	27	11.4
CO18D297R	Colo. State University exp.	HRW	63.2	105%	58	102%	29	12.0
CP7017AX	CROPLAN	HRW	63.2	105%	59	102%	26	11.5
Valley	Frenchman Valley Coop	<b>HWW</b>	62.9	105%	58	101%	28	11.8
Whistler	PlainsGold	HRW	62.5	104%	56	98%	30	11.2
Snowmass 2.0	PlainsGold	<b>HWW</b>	62.4	104%	57	100%	26	11.5
Avery	PlainsGold	HRW	62.2	103%	57	99%	29	10.9
Crescent AX	PlainsGold	HRW	61.6	102%	58	102%	28	11.9
Byrd	PlainsGold	HRW	61.0	101%	58	101%	28	11.1
CO18035RA	Colo. State University exp.	HRW	61.0	101%	57	100%	26	11.6
Kivari AX	PlainsGold	HRW	60.9	101%	56	98%	27	11.1
Amplify SF	PlainsGold	HRW	60.7	101%	58	101%	29	12.1
MS Maverick	Meridian Seeds	HRW	60.3	100%	57	100%	27	12.0
CO18042RA	Colo. State University exp.	HRW	60.2	100%	57	100%	28	11.4
Canvas	PlainsGold	HRW	60.2	100%	58	100%	27	11.9
Sunshine	PlainsGold	<b>HWW</b>	60.0	100%	57	100%	26	12.1
Byrd CL Plus	PlainsGold	HRW	59.8	99%	57	99%	30	11.5
Breck	PlainsGold	<b>HWW</b>	59.4	99%	59	102%	28	11.7
Guardian	PlainsGold	HRW	59.1	98%	58	102%	27	11.8
Langin	PlainsGold	HRW	58.6	97%	57	99%	27	11.8
Brawl CL Plus	PlainsGold	HRW	57.7	96%	58	101%	27	12.4
Hatcher	PlainsGold	HRW	57.3	95%	57	99%	26	11.4
Windom SF	PlainsGold	<b>HWW</b>	56.4	94%	57	99%	26	11.8
Fortify SF	PlainsGold	HRW	55.5	92%	57	100%	28	11.5
Ray	PlainsGold	HRW	47.1	78%	52	91%	32	12.9
<b>Average</b>			<b>60.1</b>	<b>100%</b>	<b>57</b>	<b>100%</b>	<b>28</b>	<b>11.7</b>

<sup>a</sup>The 2-year average yield and test weight are based on 13 trials (ten 2023 and three 2022 trials). Plant heights and protein are based on 10 trials (seven 2023 and three 2022 trials).

<sup>b</sup>Varieties ranked from highest to lowest average 2-year yield.

<sup>c</sup>Market class: HRW=hard red winter wheat; **HWW**=hard white winter wheat.

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Contact Sally Jones-Diamond (sally.jones@colostate.edu)*

## Summary of 3-Year (2021-2023) Dryland Winter Wheat Variety Performance Results

Variety <sup>b</sup>	Brand/Source	Market Class <sup>c</sup>	3-Year Average <sup>a</sup>					
			Yield		Test Weight		Plant Height	
			bu/ac	% trial average	lb/bu	% trial average	in	percent
Monarch	PlainsGold	<b>HWW</b>	62.7	107%	57	100%	28	11.6
Snowmass 2.0	PlainsGold	<b>HWW</b>	61.2	104%	57	100%	28	12.2
CO18D007W	Colo. State University exp.	<b>HWW</b>	61.1	104%	57	100%	29	12.3
CO18D297R	Colo. State University exp.	HRW	60.6	103%	58	102%	31	12.5
CP7017AX	CROPLAN	HRW	60.0	102%	57	101%	29	12.1
Crescent AX	PlainsGold	HRW	59.4	101%	57	101%	31	12.5
Avery	PlainsGold	HRW	59.3	101%	56	99%	31	11.8
Byrd	PlainsGold	HRW	59.3	101%	57	101%	31	11.8
Langin	PlainsGold	HRW	59.1	101%	56	99%	29	12.3
Kivari AX	PlainsGold	HRW	58.7	100%	55	97%	30	11.8
Canvas	PlainsGold	HRW	58.6	100%	57	99%	30	12.4
Whistler	PlainsGold	HRW	58.5	100%	55	98%	32	11.9
Amplify SF	PlainsGold	HRW	58.2	100%	57	101%	32	12.3
Byrd CL Plus	PlainsGold	HRW	57.2	98%	56	99%	32	12.3
Breck	PlainsGold	<b>HWW</b>	57.1	98%	58	102%	31	12.5
Brawl CL Plus	PlainsGold	HRW	56.0	96%	58	101%	31	12.8
Guardian	PlainsGold	HRW	55.5	95%	57	101%	31	12.6
Fortify SF	PlainsGold	HRW	55.1	94%	57	101%	31	12.0
Hatcher	PlainsGold	HRW	54.7	93%	56	98%	30	11.9
<b>Average</b>			<b>58.5</b>	<b>100%</b>	<b>57</b>	<b>100%</b>	<b>30</b>	<b>12.2</b>

<sup>a</sup>The 3-year average yield and test weight are based on 22 trials (ten 2023, three 2022, and nine 2021). Plant heights are based on 18 trials (seven 2023, three 2022, and eight 2021). Protein based on 16 trials (seven 2023, three 2022, and six 2021).

<sup>b</sup>Varieties ranked according to average 3-year yield.

<sup>c</sup>Market class: HRW=hard red winter wheat; **HWW**=hard white winter wheat.

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## 2023 Collaborative On-Farm Test (COFT) Variety Performance Results

Sally Jones-Diamond, Ron Meyer, Kat Caswell, and Michaela Mattes

The COFT program is in its 27th 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 old inferior varieties and wider and faster adoption of improved varieties. It also brings Colorado State University wheat results to rural communities. The varieties tested in COFT this year fit different farmer needs and producers are encouraged to study the tables in the Description of Winter Wheat Varieties in Eastern Colorado and the Dryland Decision Tree for more information.

In the fall of 2022, twenty-six eastern Colorado wheat producers received seed for five varieties of wheat and planted them in side-by-side strips under the same conditions as the wheat in the rest of the field. Ten viable harvest results were obtained due to drought conditions and hail that occurred during the growing season. The objective of our on-farm testing program is to compare the performance of wheat varieties of interest for Colorado farmers under their field conditions. Each of the five varieties tested has potential advantages for farmers and should be chosen on a case-by-case basis depending on the specific farm needs.

The same five varieties were included in all tests. Amplify SF, Fortify SF, Kivari AX, and Whistler are hard red winter wheat varieties and Windom SF is a hard white winter wheat variety. Three semi-solid stemmed varieties were included in the test to help combat the wheat stem sawfly (WSS): Amplify SF, Fortify SF, and Windom SF. One CoAXium<sup>®</sup> variety was also included for grass weed control, Kivari AX. Additionally, it is important to note that all varieties tested in the COFT this year except Whistler are Certified Seed Only (CSO), which means saving back harvested seed is illegal.

Amplify SF is a CSU release (2021), marketed by PlainsGold. Amplify SF has a semi-solid stem, is medium maturity, and has good standability under severe WSS pressure with an average yield.

Fortify SF is a CSU release (2019). Fortify SF was the first Colorado-bred semi-solid wheat to combat the wheat stem sawfly. It has a medium-early maturity, carries wheat curl mite resistance, but has a below-average yield in our three-year trial average.

Windom SF is a CSU release (2022) and a non-premium variety with medium maturity. It is a hard white wheat with a semi-solid stem and a below-average yield in our two-year trial average.

Kivari AX is a CSU release (2020) marketed by PlainsGold. Higher yielding and slightly later maturing than Crescent AX, it shows intermediate reaction to stripe rust and carries wheat curl mite resistance. The CoAXium<sup>®</sup> Wheat Production System is based on the Aggressor<sup>®</sup> herbicide, a different class of compounds from Beyond<sup>®</sup>, and provides excellent control of winter annual grasses. It has an average yield in our three-year trial average.

Whistler is a CSU release (2018), marketed by PlainsGold. It is later maturing, tall, has marginal straw strength, good stripe and stem rust resistance, and carries wheat curl mite resistance from the Byrd parent. It has an average yield in the three-year trial average.



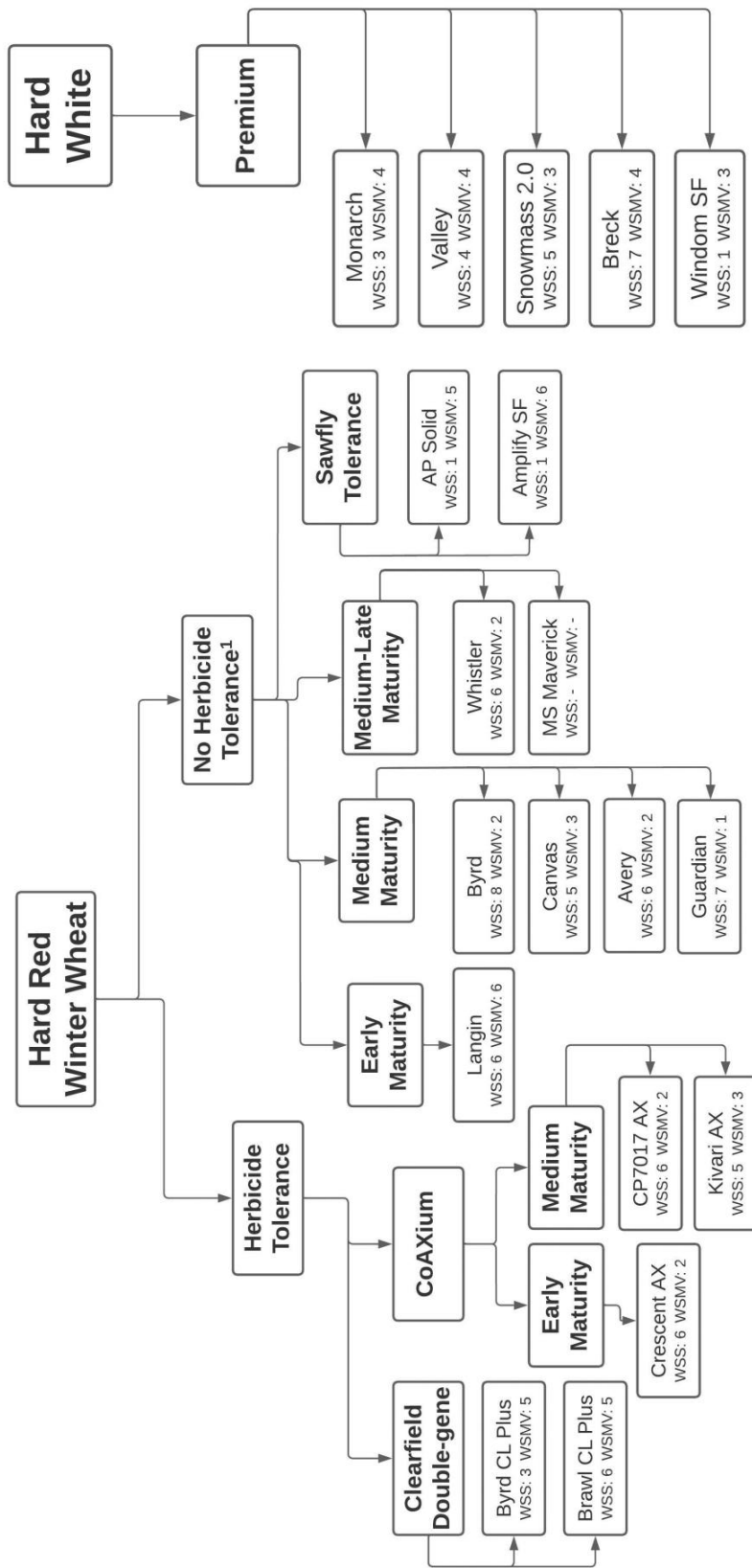
## Summary of 2023 Collaborative On-Farm Test (COFT) Winter Wheat Variety Results (10 tests included)

Variety	Yield <sup>a</sup> bu/ac	Test Weight lb/bu	Protein <sup>a</sup> percent
Amplify SF	<b>49.9</b>	58.0	11.1
Windom SF	45.6	58.5	11.0
Kivari AX	45.1	56.2	10.1
Whistler	44.5	57.1	10.7
Fortify SF	43.1	57.9	10.5
<b>Average</b>	<b>45.7</b>	<b>57.5</b>	<b>10.7</b>
	LSD <sub>(0.30)</sub>	1.9	0.6
	Coefficient of Variation (CV)	9.1%	2.1%
			3.3%

<sup>a</sup>Yield and protein corrected to 12% moisture.

# CSU Fall 2023 Dryland Winter Wheat Decision Tree

Sally Jones-Diamond



WSS=wheat stem sawfly and WSMV=wheat streak mosaic virus. Rating scale is 1=resistant and 9=susceptible. WSS ratings are based on field evaluation of tolerance to wheat stem sawfly cutting in Colorado. Values do not represent the level of stem solidness expression.  
<sup>1</sup>No tolerance to herbicides used in Clearfield or CoAXium wheat production systems.  
 Varieties in each section are listed from highest to lowest yield based on multi-year trial averages.





## Summary of 2023 Irrigated Winter Wheat Variety Performance Results

Brand/Source	Market Class	Variety <sup>a</sup>	2023 Multi-Location Average						2023 Individual Trial Yield <sup>b</sup>		
			Yield <sup>b</sup>	Yield	Test Weight	Protein <sup>c</sup>	Lodging	Heading <sup>d</sup>	Burlington	Fort Collins	Wiggins
			bu/ac	percent of average	lb/bu	percent	score (1-9) <sup>e</sup>	days from average	bu/ac		
Colorado State University exp.	HRW	CO18D297R	<b>107.4</b>	<b>111%</b>	59	12.2	3	1	<b>84.5</b>	<b>127.5</b>	<b>109.0</b>
PlainsGold	<b>HWW</b>	Monarch	<b>106.0</b>	<b>110%</b>	58	11.3	1	1	<b>84.5</b>	<b>128.5</b>	<b>105.5</b>
PlainsGold	HRW	Amplify SF	<b>103.5</b>	<b>107%</b>	58	12.4	4	2	80.0	<b>128.0</b>	103.0
PlainsGold	HRW	Guardian	<b>102.3</b>	<b>106%</b>	58	12.6	3	2	82.5	122.0	101.5
Frenchman Valley Coop	<b>HWW</b>	Valley	<b>102.2</b>	<b>106%</b>	59	11.8	3	1	80.5	<b>127.0</b>	98.5
PlainsGold	HRW	Byrd CL Plus	<b>101.1</b>	<b>104%</b>	57	11.6	5	2	82.5	118.5	103.0
CROPLAN	HRW	CP7017AX	<b>100.6</b>	<b>104%</b>	58	11.7	3	0	79.0	116.0	<b>108.0</b>
Colorado State University exp.	<b>HWW</b>	CO18D007W	<b>99.8</b>	<b>103%</b>	57	11.9	2	-1	74.0	<b>127.5</b>	96.5
Colorado State University exp.	HRW	CO19D304R	<b>99.4</b>	<b>103%</b>	57	11.9	7	2	81.5	<b>124.5</b>	93.0
PlainsGold	HRW	Crescent AX	<b>99.0</b>	<b>102%</b>	59	12.1	6	-2	<b>84.0</b>	113.5	100.5
Colorado State University exp.	HRW	CO18035RA	<b>98.3</b>	<b>102%</b>	57	11.7	6	-2	82.5	116.5	97.0
Limagrain	HRW	LCS Steel AX	<b>98.2</b>	<b>101%</b>	58	12.5	3	-3	<b>83.5</b>	110.5	98.5
PlainsGold	<b>HWW</b>	Snowmass 2.0	<b>97.6</b>	<b>101%</b>	56	12.1	4	-1	77.0	122.0	92.0
PlainsGold	HRW	Canvas	<b>97.6</b>	<b>101%</b>	57	12.2	2	0	69.0	122.5	102.0
AgriPro	HRW	SY Wolverine	<b>96.1</b>	<b>99%</b>	56	12.5	1	0	75.5	121.5	91.0
CROPLAN	HRW	CP7266AX	<b>93.3</b>	<b>96%</b>	58	12.1	7	0	<b>90.0</b>	95.0	96.5
Limagrain	HRW	LCS Atomic AX	<b>93.1</b>	<b>96%</b>	58	12.0	5	0	<b>85.0</b>	97.5	96.5
PlainsGold	<b>HWW</b>	Windom SF	<b>92.0</b>	<b>95%</b>	56	12.2	3	-1	73.0	111.0	93.5
PlainsGold	<b>HWW</b>	Breck	<b>92.0</b>	<b>95%</b>	57	12.1	1	0	62.0	122.5	91.0
Colorado State University exp.	HRW	CO18042RA	<b>91.2</b>	<b>94%</b>	58	12.0	6	0	68.0	114.5	90.5
PlainsGold	HRW	Kivari AX	<b>88.5</b>	<b>91%</b>	56	11.0	8	0	70.0	110.5	82.5
PlainsGold	HRW	Brawl CL Plus	<b>87.7</b>	<b>91%</b>	58	13.3	2	-1	70.5	103.0	89.0
PlainsGold	HRW	Ray	<b>79.3</b>	<b>82%</b>	50	12.4	3	9	46.5	111.0	81.0
<b>Average</b>			<b>96.8</b>	<b>100%</b>	57	<b>12.0</b>	<b>4</b>	<b>0</b>	<b>77.0</b>	<b>117.0</b>	<b>96.5</b>
<sup>f</sup> LSD (0.30)			6.1						7.0	4.0	5.0
<sup>f</sup> LSD (0.05)			11.7						13.0	7.5	9.5

<sup>a</sup>Varieties ranked from highest to lowest yield across three irrigated trials in 2023.

<sup>b</sup>Yield adjusted to 12% moisture content. Variety yield values in the top least significant difference (LSD) yield group across the locations and within each location are in bold. Multi-location yield values for each variety are least squares means and not arithmetic averages.

<sup>c</sup>Protein adjusted to 12% moisture content and averaged across two trials in 2023.

<sup>d</sup>Varieties with positive values headed later than the trial averages and varieties with negative values headed earlier than average. Based on one trial.

<sup>e</sup>Lodging score: 1 equals no lodging and 9 is severe lodging. Scores from three trials in 2023.

<sup>f</sup>Farmers selecting a variety based on yield should use the LSD (.30) to protect themselves from false negative conclusions (concluding varieties are the same when they are actually different). Companies or researchers may use the LSD (.05) to avoid false positive conclusions (concluding varieties are different when they are actually the same).

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## Summary of 2-Year (2022-2023) Irrigated Winter Wheat Variety Performance Results

Variety <sup>b</sup>	Brand/Source	Market Class <sup>c</sup>	2-Year Average <sup>a</sup>					
			Yield		Test Weight		Plant Height	
			bu/ac	% trial average	lb/bu	% trial average	in	percent
CO18D297R	Colorado State University exp.	HRW	96.6	110%	60	102%	28	13.2
Monarch	PlainsGold	<b>HWW</b>	93.5	107%	59	101%	28	12.5
CO18D007W	Colorado State University exp.	<b>HWW</b>	92.9	106%	59	101%	28	13.2
CP7017AX	CROPLAN	HRW	91.0	104%	60	102%	26	13.2
Valley	Frenchman Valley Coop	<b>HWW</b>	90.8	104%	59	101%	31	13.3
Crescent AX	PlainsGold	HRW	90.0	103%	60	102%	29	13.2
CO18035RA	Colorado State University exp.	HRW	89.9	103%	59	100%	28	13.1
Canvas	PlainsGold	HRW	89.7	102%	59	101%	29	13.5
Byrd CL Plus	PlainsGold	HRW	89.3	102%	59	100%	32	13.1
Guardian	PlainsGold	HRW	88.3	101%	60	102%	30	13.9
Windom SF	PlainsGold	<b>HWW</b>	86.4	99%	59	99%	27	13.3
Breck	PlainsGold	<b>HWW</b>	86.4	99%	60	101%	27	13.7
CO18042RA	Colorado State University exp.	HRW	85.5	98%	59	100%	30	13.4
Kivari AX	PlainsGold	HRW	84.1	96%	58	99%	31	12.3
CP7266AX	CROPLAN	HRW	83.0	95%	59	101%	29	13.5
Snowmass 2.0	PlainsGold	<b>HWW</b>	82.1	94%	59	99%	29	13.7
Brawl CL Plus	PlainsGold	HRW	81.1	93%	60	101%	29	14.5
Ray	PlainsGold	HRW	76.3	87%	52	88%	35	13.9
<b>Average</b>			<b>87.6</b>	<b>100%</b>	<b>59</b>	<b>100%</b>	<b>29</b>	<b>13.4</b>

<sup>a</sup>The 2-year average yield and test weight are based on six trials (three 2023 and three 2022). Plant heights and protein are based on five trials (two 2023 and three 2022).

<sup>b</sup>Varieties ranked from highest to lowest average 2-year yield.

<sup>c</sup>Market class: HRW=hard red winter wheat; **HWW**=hard white winter wheat.

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## Summary of 3-Year (2021-2023) Irrigated Winter Wheat Variety Performance Results

Variety <sup>b</sup>	Brand/Source	Market Class <sup>c</sup>	3-Year Average <sup>a</sup>					
			Yield		Test Weight		Plant Height	
			bu/ac	% trial average	lb/bu	% trial average	in	percent
CO18D007W	Colorado State University exp.	<b>HWW</b>	95.7	107%	59	100%	30	13.2
CO18D297R	Colorado State University exp.	HRW	94.8	106%	59	100%	30	13.2
Monarch	PlainsGold	<b>HWW</b>	93.8	105%	59	100%	30	12.4
CP7017AX	CROPLAN	HRW	91.1	102%	60	101%	28	13.4
Canvas	PlainsGold	HRW	90.4	101%	59	100%	30	12.9
Crescent AX	PlainsGold	HRW	90.1	101%	60	101%	32	13.1
Breck	PlainsGold	<b>HWW</b>	87.1	97%	60	101%	29	13.5
Snowmass 2.0	PlainsGold	<b>HWW</b>	87.0	97%	59	99%	31	13.0
Brawl CL Plus	PlainsGold	HRW	85.7	96%	60	101%	31	14.3
Guardian	PlainsGold	HRW	85.1	95%	60	101%	32	13.6
Kivari AX	PlainsGold	HRW	82.9	93%	58	98%	32	12.5
<b>Average</b>			<b>89.4</b>	<b>100%</b>	<b>59</b>	<b>100%</b>	<b>30</b>	<b>13.2</b>

<sup>a</sup>The 3-year average yield and test weight are based on nine trials (three each year). Plant heights and protein are based on seven trials (two 2023, three 2022, and three 2021).

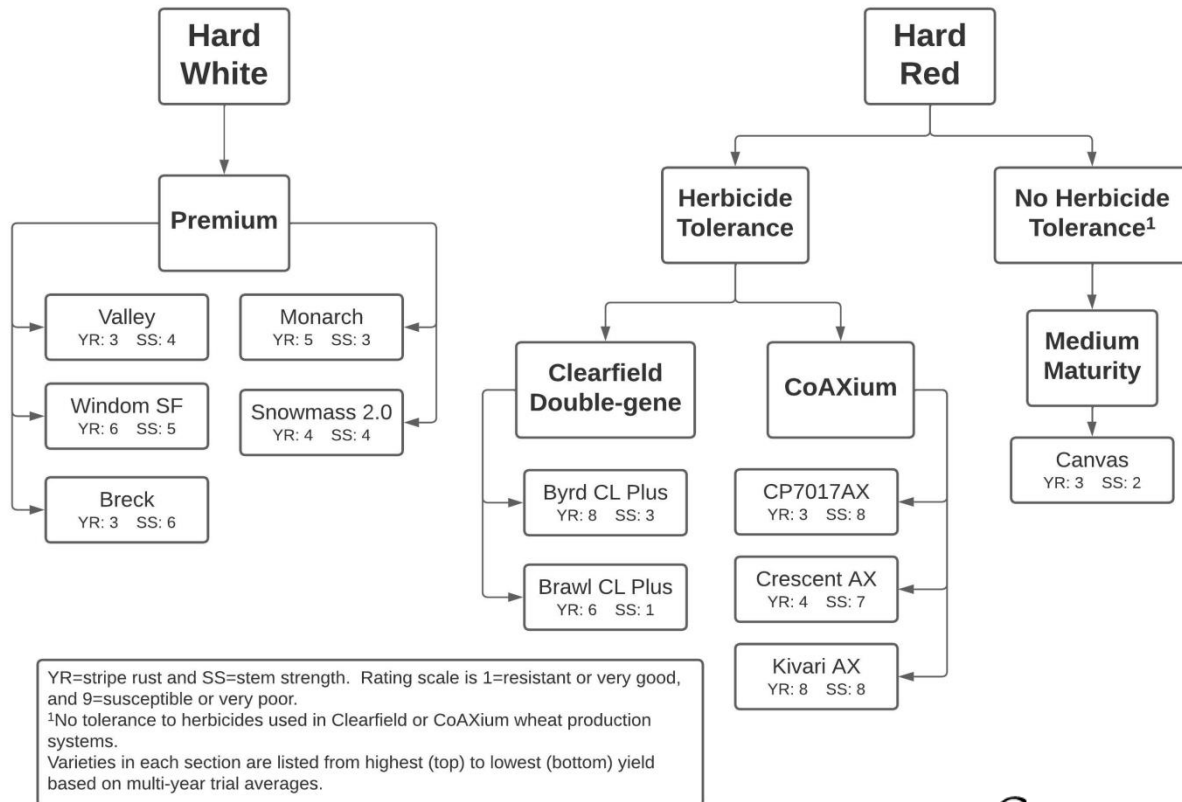
<sup>b</sup>Varieties ranked from highest to lowest average 3-year yield.

<sup>c</sup>Market class: HRW=hard red winter wheat; **HWW**=hard white winter wheat.

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# CSU 2023 Irrigated Winter Wheat Decision Tree

Sally Jones-Diamond



## Forage Wheat Trial Results

Sally Jones-Diamond and Joe Brummer

The 2022-2023 growing season was the second season of testing winter annual forages as a potential dual-purpose crop. There is little external information available on the quality and yield of forage for dual-purpose wheats as they have not been widely grown in our region. It is critical to possess local information about wheat varieties that have favorable forage characteristics with a potential for grain production and vice versa. This season we included two traditional grain wheat varieties to determine their suitability for potential forage production.

### Testing Methods:

Eight varieties were planted in small plots (6' by 30') next to the regular wheat variety trials at three dryland locations: Akron, Burlington, and Yuma. The eight varieties were Ray, Willow Creek, MTF1435, TAM 204, OK Corral, AP Baldy, Fortify SF, and Whistler. Forage sub-samples were cut from the center of the plots in May or June as each variety reached the early heading stage to determine forage yield and quality. Forage wet and dry weights were obtained and used to calculate dry matter yield along with hay quality information based on NIR analyses done at CSU. The remainder of the plots were harvested for grain (yield area adjusted to account for forage sampling), and grain test weight and protein analyses were performed.

Yield, test weight, and dry matter yield values were statistically analyzed, and least significant differences are provided under each location table to compare varieties within a location.

### Results:

We harvested forage and grain from all three sites. Forage dry matter yield, harvest moisture, and quality, along with grain yield and quality from the three locations are shown on the next page.

Wheat varieties developed for forage often produce low grain yields, as shown by Willow Creek, which produces a lot of dry matter but very low grain yield. Grain yield has been improved in the two newer varieties out of Montana, Ray and MTF-1435, to the point they would be acceptable dual-purpose wheats. OK Corral out of the Oklahoma breeding program produced acceptable forage yields and had the highest grain yield at two of the sites. At the Yuma site, the traditional wheat varieties, Whistler and Fortify SF, produced the highest grain yields.

When comparing forage quality among varieties, you want to see higher crude protein (CP), in vitro true dry matter digestibility (IVTDMD48), digestible neutral detergent fiber (dNDF48), and relative feed value (RFV) and lower acid detergent fiber (ADF), neutral detergent fiber (aNDF), and lignin. As with many forages, as dry matter yield increases, forage quality decreases which was evident with some of the varieties evaluated in this trial. The varieties developed in Montana (Willow Creek, Ray, and MTF-1435) tended to have higher forage yields but were lower in CP and higher in fiber (ADF and NDF), especially at the Yuma site. The higher yield was related to more stem production which tends to be lower in quality. A surprising variety was Fortify SF, which is a semi-solid stemmed variety. While it did not have the forage yield like some of the other varieties, it was leafy, had a soft texture, and an overall higher forage quality. If you had to pick one variety out of the ones evaluated for dual-purpose use, OK Corral would be a good choice due to its potential grain yield, intermediate forage yield, and high forage quality.

## 2023 Dryland Winter Forage Variety Performance Trials at Akron, Burlington, and Yuma

Brand/Source	Variety	Grain Harvest			Forage Harvest		Forage Quality <sup>a</sup>							
		Yield bu/ac	Test Weight lb/bu	Protein percent	Dry Matter Yield ton/ac	Moisture % at harvest	Harvest Date	CP	ADF	aNDF	dNDF48	LIGNIN	IVTDM48	RFV
<b>Akron</b>														
Montana State Univ.	MTF1435	56.0	47	12.7	4.4	79	7-Jun	7.0	37.8	66.4	36.4	5.4	73.9	83
PlainsGold	Ray	57.5	42	12.9	4.2	78	8-Jun	6.3	37.2	65.7	37.9	4.6	75.4	85
Watley Seed	TAM 204	77.0	49	12.9	4.2	78	28-May	9.3	31.4	59.8	37.3	4.1	80.6	101
Montana State Univ.	Willow Creek	31.5	48	13.8	3.8	80	13-Jun	6.3	40.4	67.1	36.2	5.9	71.9	80
Oklahoma Genetics, Inc	OK Corral	94.0	52	12.0	3.6	79	31-May	11.1	31.8	60.4	38.7	3.8	82.2	99
PlainsGold	Whistler	77.5	50	11.9	3.3	80	31-May	9.3	32.2	61.5	37.2	4.0	79.8	97
AgriPro	AP Baldy	71.0	52	12.3	3.2	80	31-May	10.7	33.1	60.2	35.6	4.0	79.6	98
PlainsGold	Fortify SF	76.5	52	11.1	3.1	75	28-May	9.9	31.8	59.4	36.5	3.9	81.2	101
	Average	67.5	49	12.5	3.7	79	2-Jun	8.7	34.4	62.6	37.0	4.5	78.1	93
	LSD (0.30) <sup>b</sup>	6.0	1		0.5									
	LSD (0.05) <sup>b</sup>	12.0	3		NS									
	Coefficient of Variation (CV)	10.1	3.1		13.7									

Brand/Source	Variety	Grain Harvest			Forage Harvest		Forage Quality <sup>a</sup>							
		Yield bu/ac	Test Weight lb/bu	Protein percent	Dry Matter Yield ton/ac	Moisture % at harvest	Harvest Date	CP	ADF	aNDF	dNDF48	LIGNIN	IVTDM48	RFV
<b>Burlington</b>														
Montana State Univ.	Willow Creek	42.5	54	13.5	4.4	77	7-Jun	5.1	41.4	69.4	34.2	6.7	66.8	76
PlainsGold	Whistler	84.5	54	11.4	4.2	86	22-May	10.7	31.3	61.6	37.2	3.8	79.6	97
Montana State Univ.	MTF1435	77.0	53	11.4	4.2	78	26-May	7.2	35.7	65.3	34.5	4.6	72.7	87
PlainsGold	Ray	73.5	44	11.7	4.1	78	26-May	10.6	31.3	59.4	36.2	3.0	81.0	101
Oklahoma Genetics, Inc	OK Corral	92.0	55	11.7	3.3	85	22-May	10.5	29.2	58.2	37.2	3.3	82.4	106
AgriPro	AP Baldy	83.0	58	11.8	3.3	77	22-May	10.9	29.5	59.0	35.8	4.1	79.8	104
PlainsGold	Fortify SF	79.0	56	10.7	2.9	78	19-May	12.3	29.3	58.8	35.8	3.3	81.4	104
Watley Seed	TAM 204	91.5	55	11.9	2.8	78	19-May	11.0	30.2	59.8	35.0	3.6	79.3	102
	Average	78.0	54	11.8	3.6	80	24-May	9.8	32.2	61.4	35.7	4.0	77.9	97
	LSD (0.30) <sup>b</sup>	4.0	1		0.3									
	LSD (0.05) <sup>b</sup>	8.0	1		0.7									
	Coefficient of Variation (CV)	5.7	1.4		10.0									

Brand/Source	Variety	Grain Harvest			Forage Harvest		Forage Quality <sup>a</sup>							
		Yield bu/ac	Test Weight lb/bu	Protein percent	Dry Matter Yield ton/ac	Moisture % at harvest	Harvest Date	CP	ADF	aNDF	dNDF48	LIGNIN	IVTDM48	RFV
<b>Yuma</b>														
Montana State Univ.	MTF1435	45.5	49	11.6	4.2	78	7-Jun	2.2	41.1	72.1	35.8	5.8	66.1	73
Montana State Univ.	Willow Creek	26.0	50	12.8	4.1	75	13-Jun	4.9	38.2	67.6	36.3	5.1	71.2	82
PlainsGold	Ray	49.5	48	11.0	3.4	78	7-Jun	3.5	38.2	66.8	37.0	4.5	73.0	83
Oklahoma Genetics, Inc	OK Corral	55.5	55	12.5	3.2	76	28-May	7.2	31.2	60.0	36.7	3.1	79.6	100
PlainsGold	Whistler	62.0	55	14.5	3.2	78	31-May	4.4	35.0	66.5	36.5	4.3	73.1	86
PlainsGold	Fortify SF	66.5	58	12.8	3.0	79	28-May	7.5	33.8	64.4	37.4	3.7	76.9	91
Watley Seed	TAM 204	54.0	52	10.9	2.8	77	28-May	7.7	31.5	61.6	36.7	3.6	77.9	98
AgriPro	AP Baldy	53.5	55	11.4	2.3	81	31-May	7.5	32.0	61.3	35.6	4.2	76.9	97
	Average	51.5	53	12.2	3.3	78	2-Jun	5.6	35.1	65.1	36.5	4.3	74.3	89
	LSD (0.30) <sup>b</sup>	4.5	1		0.4									
	LSD (0.05) <sup>b</sup>	9.0	1		0.8									
	Coefficient of Variation (CV)	9.6	1.5		12.9									

<sup>a</sup>All forage quality analyses results are dry basis values. CP=crude protein; ADF=acid detergent fiber; aNDF=neutral detergent fiber; dNDF48= digestible neutral detergent fiber at 48 hours; IVTDM48=in vitro true dry matter digestibility at 48 hours; and RFV=relative feed value.

<sup>b</sup>If the difference between two variety yields equals or exceeds the LSD value, the difference is significant. Farmers selecting a variety based on yield should use the LSD (0.30) to protect from false negative decisions. Companies or researchers may be interested in the LSD (0.05) to avoid false positive conclusions.

Trials were harvested for grain on July 13 (Burlington), July 19 (Yuma), and August 5 (Akron).

*The data included in this table may not be republished without permission.  
Contact Sally Jones-Diamond (sally.jones@colostate.edu) or Joe Brummer (joe.brummer@colostate.edu)*

## Description of Winter Wheat Varieties in Eastern Colorado Dryland and Irrigated Trials (2023-2024)

Name/Class/Pedigree	Origin	HD	HT	SS	COL	YR	LR	SR	WSMV*	TWSS*	PRO**	MILL	BAKE	Comments
Amplify SF Hard red winter Bearpaw/Antero//Antero	CSU 2021	6	7	4	7	6	3	2	6	4	1	5	4	5 CSU release (2021), marketed by PlainsGold. Medium height, medium maturity. Carries the semi-solid stem trait (17 out of 25 rating) for partial resistance to the wheat stem sawfly. Certified seed only.
AP Bigfoot Hard red winter Undisclosed	AgriPro 2022	4	5	3	3	6	2	2	4	1	7	5	4	6 AgriPro release (2021). First entered in CSU variety trials in 2022. Early to med-early variety with very good test weight and WSMV tolerance.
AP Solid Hard red winter Undisclosed	AgriPro 2021	7	3	3	5	7	6	5	5	2	1	3	2	6 AgriPro release (2021). First entered in CSU variety trials in 2020. Medium-late semi-solid stem variety for use in managing wheat stem sawfly. Very good test weight and straw strength.
Avery Hard red winter TAM 112/Byrd	CSU 2015	5	7	7	4	6	8	8	2	5	6	6	3	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. Susceptible to stripe rust.
Brawl CL Plus Hard red winter Teal 11A/Above//CO99314	CSU 2011	2	7	1	7	6	6	7	5	4	6	1	4	5 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	5	8	7	5	2	4	2	7	2	2	4 CSU release (2017), marketed by PlainsGold in CWRP-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	6	4	8	7	8	2	5	8	5	3	3 CSU release (2011), marketed by PlainsGold. Excellent drought tolerance (from TAM 112) 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	8	5	7	5	5	8	5	5	3	6	3	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. Has shown some non solid-stem based tolerance to wheat stem sawfly. Certified seed only.
Canvas Hard red winter Denali/Antero//Byrd	CSU 2018	5	4	2	5	3	6	2	3	4	5	4	2	3 CSU release (2018), marketed by PlainsGold. Hard red winter, medium maturing, medium-short, good straw strength. Good stripe and stem rust resistance and carries wheat curl mite resistance from Byrd parent. Good test weight and 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), wheat stem sawfly tolerance (WSS), 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. A priority is given to data collected in Colorado. Regional data or developer input is utilized when Colorado specific data is unavailable.

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+WSS ratings are based on field evaluation of tolerance to wheat stem sawfly cutting in Colorado. Values do not represent the level of stem solidness expression. See comments for solidness rating. ++ PRO ratings represent "grain protein deviation" (relative grain protein level accounting for differences in grain yield).

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Name/Class/Pedigree	Origin	HD	HT	SS	COL	YR	LR	SR	WSMV*	TW	WSS*	PRO**	MILL	BAKE	Comments
CO18035RA Hard red winter (AF28/Byrd//AF26/Byrd)//2*Byrd//AF10 M3/2*Byrd//AF26/Byrd//2*Byrd/ (AF28/Byrd//AF26/Byrd)//2*Byrd/Langin	CSU EXP	2	4	6	4	4	7	6	4	5	6	4	3	2	CSU experimental line. Three gene CoAXium wheat for winter annual grassy weed control. Wheat curl mite resistance from Byrd. Very good milling and baking quality. Potential release in 2024.
CO18042RA Hard red winter (AF28/Byrd//AF26/Byrd)//2*Byrd//AF10 M3/2*Byrd//AF26/Byrd//2*Byrd/ (AF28/Byrd//AF26/Byrd)//2*Byrd/Langin	CSU EXP	4	7	7	5	3	8	7	4	5	6	6	3	3	CSU experimental line. Three gene CoAXium wheat for winter annual grassy weed control. Acidic soil tolerance. Wheat curl mite resistance from Byrd. Very good milling and baking quality. Potential release in 2024.
CO18D007W Hard white winter CO12D906/CO07W722-F5	CSU EXP	4	4	2	5	7	6	1	4	5	8	2	3	3	CSU release (2023), not yet commercially available. Hard white winter wheat. Mid to early maturity and slightly short stature. Excellent straw strength and overall yield performance in irrigated and dryland environments. Excellent grain protein deviation. Very good milling and baking quality.
CO18D297R Hard red winter CO12D906/CO11D1353/Monarch	CSU EXP	5	6	5	8	2	5	1	5	3	8	3	3	4	CSU release (2023), not yet commercially available. Medium maturity and height and moderate straw strength. Good overall yield performance in irrigated and dryland environments. Good resistance to stripe rust, stem rust, and moderate for leaf rust. Excellent grain protein deviation. Good milling and baking quality.
CO19393R Hard red winter CO12D1614/KS11HW39-6	CSU EXP	6	7	5	4	1	8	2	4	4	5	4	4	4	CSU experimental line, first entered into the CSU trials in 2023. Performed at 107% of the trial mean for yield in 2023. Wsm2 for resistance to WSMV. Excellent resistance to stripe rust and stem rust. Above average milling and baking. Potential release in 2024 or 2025.
CO19410R Hard red winter Avery/CO07W722-F5//CO11D1316W	CSU EXP	5	6	6	5	4	8	2	2	5	5	5	3	3	CSU experimental line, first entered into the CSU trials in 2023. Performed at 110% of the trial mean for yield in 2023. Resistant to the wheat curl mite which vectors the mosaic virus complex. Moderate resistance to stripe rust and good resistance to stem rust. Good milling and baking quality. Potential release in 2024 or 2025.
CO19D087R Hard red winter CO12D1777/Langin	CSU EXP	3	2	4	4	2	7	2	2	4	6	4	4	3	CSU experimental line, first entered into the CSU trials in 2023. Performed at 115% of the trial mean for yield in southeastern Colorado in 2023. Resistant to the wheat curl mite which vectors the mosaic virus complex. Good resistance to stripe rust and stem rust. Good milling and baking quality. Acid soil tolerant. Potential release in 2024 or 2025.
CO19D304R Hard red winter Snowmass 2.0/CO13D1164	CSU EXP	7	8	6	5	2	8	8	6	7	7	7	3	3	CSU experimental line, first entered into the CSU trials in 2023. Performed at 111% of the trial mean for yield in southeastern Colorado in 2023. Good resistance to stripe rust. Good milling and baking quality. Potential release in 2024 or 2025.
CO19S129W Hard white winter CO13D1638/Snowmass 2.0	CSU EXP	6	5	4	4	2	9	5	4	5	2	5	5	2	CSU experimental line, first entered into the CSU trials in 2023. Hard white winter wheat. Performed at 104% of the trial mean for yield in 2023. Wsm2 for resistance to WSMV. Good resistance to stripe rust. Excellent baking quality. Potential release in 2024 or 2025.

**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), wheat stem sawfly tolerance (WSS), 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. A priority is given to data collected in Colorado. Regional data on developer input is utilized when Colorado specific data is unavailable.

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 ++ PRO ratings represent "grain protein deviation" (relative grain protein level accounting for differences in grain yield).

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Name/Class/Pedigree	Origin	HD	HT	SS	COL	YR	LR	SR	WSMV	TW	WSS	PRO	MILL	BAKE	Comments
CO200037R Hard red winter Canvas/X170868/Canvas	CSU EXP	6	4	4	6	4	5	1	2	4	6	4	3	4	CSU experimental line, first entered into the CSU trials in 2023. Similar performance as Canvas. Resistant to the wheat curl mite and contains a new gene, <i>Wsm3</i> , with broad resistance against the mosaic virus complex. Moderate resistance to stripe rust and stem rust. Good milling and baking quality. Acid soil tolerant. Potential release in 2024 or 2025.
CO20D108R Hard red winter CO13D1320/CO13D1479/Canvas	CSU EXP	7	6	4	6	4	5	1	2	6	5	6	4	2	CSU experimental line, first entered into the CSU trials in 2023. Performed at 106% of the trial mean for yield in 2023. Resistant to the wheat curl mite which vectors the mosaic virus complex. Moderate resistance to stripe rust and good resistance to stem rust. Good milling and excellent baking quality. Potential release in 2024 or 2025.
CP701TAX Hard red winter Undisclosed	Croplan 2020	4	2	7	5	3	4	1	2	4	6	6	3	7	CROPLAN by WinField United release (2020). First entered into CSU trials in 2020. CoAXium wheat for winter annual grassy weed control. Strong yield potential, strong drought tolerance, tolerates acid soils and resistant to soilborne mosaic virus. Certified seed only.
CP7220 Hard red winter Undisclosed	Croplan 2024	6	5	--	--	4	4	--	--	1	--	3	4	4	CROPLAN by WinField United release (2024). First entered into the CSU trials in 2024. Adapted to Northern Central Plains, with excellent test weight.
CP7266AX Hard red winter Undisclosed	Croplan EXP	5	5	5	6	2	1	5	--	5	5	6	2	7	CROPLAN by WinField United release (2021). First entered into CSU trials in 2022. CoAXium wheat for winter annual grassy weed control. Medium height and maturity, good resistance to stripe rust and leaf rust.
Crescent AX Hard red winter (AF28/Byrd)/(AF10/2*Byrd)	CSU 2018	3	7	8	5	4	6	--	2	4	6	7	2	2	CSU release (2018), marketed by PlainsGold. CoAXium wheat for winter annual grassy weed control. Approximately 66% Byrd and 34% Hatcher parentage. Earlier and 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.
Fortify SF Hard red winter Byrd/Bearpaw/Byrd	CSU 2019	4	6	5	6	7	7	4	2	3	2	5	2	6	CSU release (2019), marketed by PlainsGold. Medium height, medium maturity. Carries wheat curl mite resistance from Byrd parent and semi-solid stem trait (13 out of 25 rating) for partial resistance to the wheat stem sawfly. Certified seed only.
Guardian Hard red winter Antero/Snowmass/Byrd	CSU 2019	6	7	7	8	3	4	2	1	3	7	2	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 via <i>Wsm2</i> . 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/ITAM-200/3/4*Yuma/4/KS91H184/Vista	CSU 2004	5	4	6	4	4	7	3	6	6	4	7	5	5	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.

**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); wheat stem sawfly tolerance (WSS); 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. A priority is given to data collected in Colorado. Regional data or developer input is utilized when Colorado specific data is unavailable.

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## Description of Winter Wheat Varieties in Eastern Colorado Dryland and Irrigated Trials (2023-2024)

Name/Class/Pedigree	Origin	HD	HT	SS	COL	YR	LR	SR	WSMV <sup>**</sup>	TWWSS <sup>+</sup>	PRO <sup>++</sup>	MILL	BAKE	Comments
Kivari AX Hard red winter (AF28/Byrd)/(AF10/2*Byrd)	CSU 2020	5	6	8	6	6	8	5	3	6	5	8	3	3 CSU release (2020), marketed by PlainsGold. CoAXium wheat for winter annual grassy weed control. Higher yielding and slightly later maturing than Crescent AX. Intermediate reaction to stripe rust and carries wheat curl mite resistance from Byrd parent. Certified seed only.
KS Big Bow Hard white winter KS050223M-2/KS11W15	KS-Manhattan 2022	5	5	4	3	4	--	2	2	3	--	5	4	5 KSU release (2022), marketed by the Kansas Wheat Alliance. First tested in 2023. Medium maturity and medium height. Resistant to WSMV.
KS Territory Hard red winter KS11HW15/TX10A001006	KS-Hays 2022	5	4	3	5	2	4	4	2	5	--	5	5	6 KSU release (2022), marketed by the Kansas Wheat Alliance. First entered in the CSU trial in 2023. Medium maturity, excellent straw strength, and resistant to WSMV and Triticum mosaic virus (TriMV).
Langin Hard red winter CO050270/Byrd	CSU 2016	1	4	8	3	3	6	8	6	5	6	6	3	3 CSU release (2016), marketed by PlainsGold. Early maturing semidwarf. Good drought stress tolerance and winterhardness, 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 Atomic AX Hard red winter Undisclosed	Limagrain 2019	2	3	4	1	2	2	9	--	4	8	4	3	5 Limagrain release (2019), first entered in CSU Variety Trials in 2021. CoAXium wheat for winter annual grassy weed control. Excellent straw strength and resistance to stripe rust. Certified seed only.
LCS Julep Hard red winter T153/LCS Mint	Limagrain 2020	5	5	5	4	2	4	4	--	4	--	3	3	3 Limagrain release (2020). First entered in CSU variety trials in 2020. Medium maturity variety with very good stripe rust resistance and intermediate stem and leaf rust resistance. Adapted across the Central Plains. Good WSMV tolerance.
LCS Radar Hard red winter Undisclosed	Limagrain 2024	--	7	7	--	1	2	5	3	5	--	5	2	2 Limagrain release (2024). First entered into the CSU trials in 2024. Broadly adapted across the Great Plains, very good to excellent stripe and leaf rust resistance.
LCS Steel AX Hard red winter LCH13KSDH-20-87 / ACC 7-38	Limagrain 2021	1	4	2	4	8	2	8	--	3	--	3	3	6 Limagrain release (2021). First entered into the trials in 2023. CoAXium wheat for winter annual grass weed control. Broad adaptation, very good leaf rust resistance and excellent straw strength. Certified seed only.
LCS White Lightning Hard white winter Undisclosed	Limagrain 2024	--	5	9	--	1	3	9	--	6	--	7	2	4 Limagrain release (2024). First entered into the CSU trials in 2024. Hard white wheat. Adapted to western Great Plains. With excellent resistance to stripe rust. Certified seed only.

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## Description of Winter Wheat Varieties in Eastern Colorado Dryland and Irrigated Trials (2023-2024)

Name/Class/Pedigree	Origin	HD	HT	SS	COL	YR	LR	SR	WSM <sup>**</sup>	TWSS <sup>**</sup>	PRO <sup>**</sup>	MILL	BAKE	Comments	
Monarch	CSU 2018	6	3	3	6	5	5	2	4	4	3	7	3	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.
Hard white winter CO07W722-F5/Snowmass//CO07W722-F5	MT State 2018	9	9	7	3	2	--	8	--	6	--	4	4	4	Forage line available through the PlainsGold Brand with improved grain yield compared to other forage varieties.
Ray															
Hard red winter Yellowstone*2/98X168E1															
Snowmass 2.0	CSU 2018	4	4	4	4	4	5	1	3	5	5	4	3	1	CSU release (2018), marketed by PlainsGold in CWRF-Ardent Mills Ultragrain Premium Program. Hard white wheat, quality profile very similar to Showmass but low PPO and better grain protein deviation. Good stripe and stem rust resistance and wheat streak mosaic virus resistance. Good straw strength, good test weight. Certified seed only.
Hard white winter CO07W722-F5/Snowmass//Brawl CL Plus															
Steamboat	CSU 2020	6	9	7	7	3	3	3	2	3	5	6	3	4	CSU release (2020), marketed by Crop Research Foundation of Wyoming. Medium maturing, tall, marginal straw strength. Good resistance to all three rusts and carries resistance to the wheat curl mite from Byrd. Good test weight and milling and baking quality.
Hard red winter TAM 114/Antero//Byrd															
Sunshine	CSU 2014	3	6	7	5	5	6	2	7	6	6	4	4	4	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.
Hard white winter KS01HW152-6/HV9W02-267W															
SY Wolverine	Agripro 2019	4	2	2	5	4	2	2	4	5	6	2	2	5	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 mosaic virus. Good test weight. Certified seed only.
Hard red winter Everest/Platte//SY Wolf															
Valley	CSU 2022	5	7	4	3	3	6	4	4	5	4	4	4	2	CSU release (2018) marketed by PlainsGold in CWRF-Ardent Mills Ultragrain Premium Program. White-seeded with excellent quality and good pre-harvest sprouting tolerance. Moderately resistant to stripe, leaf, and stem rust. Medium height and medium maturity.
Hard white winter CO07W722-F5/Antero//Snowmass															
Whistler	CSU 2018	7	9	9	8	3	6	1	2	6	6	5	4	3	CSU release (2018), marketed by PlainsGold. Hard red winter, later maturing, tall, marginal straw strength. Good stripe and stem rust resistance and carries wheat curl mite resistance from Byrd parent. Very good milling and baking quality.
Hard red winter CO08W218/Snowmass//Byrd															
Windom SF	CSU 2022	4	2	4	7	6	8	1	3	2	1	5	3	3	CSU release (2021), marketed by PlainsGold in CWRF-Ardent Mills Ultragrain Premium Program. White-seeded with strong mixing and baking properties. Semi-solid stem (16/25) for partial resistance to the wheat stem sawfly, Wsm2 for resistance to wheat streak mosaic virus. Very good test weight, long coleoptile, tolerance to lower pH. Certified seed only.
Hard white winter Warhorse/Breck//CO12D1028															

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## **Wheat Quality Evaluations from the 2023 CSU Dryland and Irrigated Variety Trials**

John Stromberger, Esten Mason, Sally Jones-Diamond

CSU Wheat Quality Lab Manager, CSU Wheat Breeder, CSU Crops Testing Director

### **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 may not always be rewarded for improved functional quality, technological advancements promise to increase the ability of the grain trade to identify and source good quality and discount poor quality wheat.

Breeding for wheat end-use quality is relatively complex in comparison to many other 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 baking quality but may be indicative of varieties with lower yield if yield differences at a given location are not taken into account (through "grain protein deviation"). 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 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 2023, grain samples were collected from each of the dryland (UVPT) and irrigated (IVPT) variety trial locations. Preliminary small-scale quality analyses were carried out to determine suitability of each location for full-scale analyses, with the selection criteria including grain protein content not too far below or above 11.5%, sound grain free of visual defects, and good discrimination among samples at a given location for experimental dough mixing properties (using the Mixograph). In this process of sample selection, the following locations were retained for full scale testing: Dryland - Burlington, Genoa, Walsh; Irrigated - Burlington and Fort Collins.

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:

#### Milling-Related Traits

- 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 NIRST<sup>TM</sup> 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 value closer to zero 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. 100-300 kernels are analyzed to provide an average value and 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. 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. It measures the resistance of dough during the mixing process. Bakers generally prefer flours with moderate mixing time requirements (between 3-6 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) may not compare favorably with other varieties in conventional evaluations but have unique characteristics that merit handling in an identity-preserved program such as the CWRP 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 high 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**

None of the traits measured can be used alone to represent overall milling or baking quality. The development of a composite score has proven useful as a means to differentiate and characterize overall quality of different samples. The composite score also has the advantage of accounting for differences in environmental conditions from year to year and utilizing all of the data generated on the samples collected at a given trial location.

Composite scores are generated through a two-step process. First, each trait is ranked from high to low (or "very good" to "very poor") at individual locations and a score from 1=very good to 9=very 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. The 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 - 2023 IVPT Burlington**

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

Entry	Test Weight	Grain Protein	SKCS Weight	SKCS Hardness	Flour Yield	Flour Protein	Bake Absorption	Mixograph Mix Time	Mixograph Tolerance	Loaf Volume	Crumb Color	Crumb Grain	Milling Score	Baking Score
Amplify SF	53.2	12.3	<b>30.0</b>	34.7	70.8	-1.5	58.3	3.21	1	875	4	3	6	7
Brawl CL Plus	<b>55.7</b>	<b>12.6</b>	<b>32.7</b>	36.9	70.8	<b>-0.7</b>	61.4	3.16	2	1005	<b>5</b>	<b>5</b>	<b>3</b>	5
Breck	54.1	11.7	<b>25.7</b>	43.2	70.7	-1.0	61.6	4.59	3	955	<b>5</b>	<b>5</b>	<b>3</b>	<b>3</b>
Byrd CL Plus	51.7	11.4	<b>28.0</b>	<u>38.8</u>	69.6	-1.1	61.3	3.74	3	930	3	2	6	5
Canvas	54.4	<b>12.4</b>	<b>26.3</b>	41.6	71.7	-1.0	62.3	4.48	4	1045	<b>5</b>	<b>5</b>	<b>3</b>	<b>2</b>
CO18035RA	54.9	12.2	<b>29.6</b>	45.1	71.1	-1.5	62.3	<b>5.77</b>	<b>5</b>	<b>1175</b>	4	4	<b>3</b>	<b>1</b>
CO18042RA	54.1	11.5	<b>29.9</b>	39.9	71.2	-1.0	<b>63.2</b>	4.68	4	<b>1135</b>	3	4	<b>3</b>	<b>1</b>
CO18D007W	55.0	12.1	<b>31.6</b>	34.2	71.3	-1.4	62.4	4.75	3	1015	<b>5</b>	4	4	<b>3</b>
CO18D297R	55.2	11.5	<b>30.7</b>	37.1	70.5	-1.0	61.3	3.89	3	1045	<b>5</b>	<b>5</b>	<b>3</b>	<b>3</b>
CO19D304R	55.2	11.8	<b>27.9</b>	41.2	71.8	-1.3	62.3	5.21	<b>5</b>	1050	4	4	<b>3</b>	<b>1</b>
CP7017AX	54.6	11.4	<b>30.5</b>	36.0	72.0	-1.1	60.3	3.27	2	940	3	2	4	7
CP7266AX	55.0	11.8	<b>30.1</b>	45.4	71.6	-1.0	61.3	3.30	2	970	4	3	<b>2</b>	5
Crescent AX	<b>56.2</b>	11.8	<b>35.1</b>	34.4	<b>72.4</b>	-1.1	61.3	3.74	4	<b>1100</b>	<b>6</b>	<b>6</b>	<b>3</b>	<b>2</b>
Guardian	<b>55.7</b>	12.3	<b>28.8</b>	44.4	72.0	-1.1	61.4	4.68	4	1015	4	<b>5</b>	<b>2</b>	<b>3</b>
Kivari AX	54.3	10.7	<b>31.2</b>	33.2	<b>73.9</b>	-0.9	60.4	4.15	4	<b>1095</b>	4	<b>5</b>	4	<b>3</b>
LCS Atomic AX	55.1	11.5	<b>29.4</b>	41.2	72.0	-0.8	62.2	3.98	3	1055	<b>6</b>	3	<b>2</b>	<b>3</b>
LCS Steel AX	53.5	11.6	<b>29.8</b>	40.8	71.0	<b>-0.7</b>	61.2	4.02	4	<u>925</u>	2	2	<b>3</b>	5
Monarch	54.2	11.8	<b>29.3</b>	42.9	70.6	-1.8	60.4	4.18	3	1025	<b>5</b>	4	4	4
Ray	51.3	<b>12.9</b>	<b>27.8</b>	54.9	69.0	<b>-0.7</b>	<b>65.2</b>	<b>7.37</b>	<b>5</b>	1045	<b>5</b>	<b>5</b>	6	<b>1</b>
Snowmass 2.0	54.3	12.2	<b>34.1</b>	44.9	69.7	-1.9	62.3	5.41	<b>5</b>	1025	<b>5</b>	<b>5</b>	4	<b>1</b>
SY Wolverine	54.8	12.0	<b>29.7</b>	41.5	71.8	<b>-0.7</b>	60.5	3.95	2	945	<b>5</b>	<b>5</b>	<b>3</b>	4
Valley	55.2	<b>12.4</b>	<b>29.2</b>	45.1	69.6	-2.1	62.3	<b>5.67</b>	4	1025	<b>5</b>	<b>5</b>	4	<b>1</b>
Windom SF	53.7	11.7	<b>27.3</b>	48.3	68.8	-1.1	<b>63.5</b>	4.94	<b>5</b>	<b>1110</b>	<b>5</b>	4	5	<b>1</b>
Average	54.4	11.9	29.8	41.1	71.0	-1.1	61.7	4.44	3.5	1022	4.4	4.1		
Minimum	51.3	10.7	25.7	33.2	68.8	-2.1	58.3	3.16	1	875	2	2		
Maximum	56.2	12.9	35.1	54.9	73.9	-0.7	65.2	7.37	5	1175	6	6		

**Wheat Milling and Baking Quality Data - 2023 IVPT Fort Collins**

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

Entry	Test Weight	Grain Protein	SKCS Weight	SKCS Hardness	Flour Yield	Flour Protein	Bake Absorption	Mixograph Mix Time	Mixograph Tolerance	Loaf Volume	Crumb Color	Crumb Grain	Milling Score	Baking Score
Amplify SF	56.5	12.0	<b>34.6</b>	45.8	72.2	-1.1	57.3	2.43	0	845	4	3	<b>3</b>	9
Brawl CL Plus	56.6	<b>13.4</b>	<b>34.6</b>	43.5	71.4	-0.9	59.4	<u>2.83</u>	<u>1</u>	925	<b>5</b>	3	<b>1</b>	7
Breck	<b>58.0</b>	12.6	<b>35.0</b>	46.2	72.1	-1.1	<b>64.4</b>	3.86	3	1050	4	4	<b>1</b>	<b>2</b>
Byrd CL Plus	55.6	11.2	<b>35.6</b>	41.1	70.9	-1.3	59.4	2.95	2	915	3	3	<b>3</b>	7
Canvas	57.4	11.3	<b>31.1</b>	40.9	<b>74.4</b>	<b>-0.7</b>	61.4	4.24	4	<b>1090</b>	<b>5</b>	<b>5</b>	<b>1</b>	<b>2</b>
CO18035RA	56.3	12.5	<b>31.0</b>	48.8	72.8	-1.3	<b>63.4</b>	<b>5.55</b>	<b>5</b>	<b>1065</b>	4	4	<b>2</b>	<b>1</b>
CO18042RA	57.1	11.9	<b>32.9</b>	50.3	73.3	-1.0	62.4	<b>4.90</b>	4	1000	4	4	<b>1</b>	<b>3</b>
CO18D007W	57.0	11.5	<b>35.5</b>	44.2	72.8	-1.2	61.6	4.32	3	950	<b>5</b>	4	<b>1</b>	<b>4</b>
CO18D297R	<b>57.8</b>	11.9	<b>34.3</b>	46.1	71.3	-1.3	62.4	4.80	4	1005	<b>5</b>	<b>6</b>	<b>1</b>	<b>2</b>
CO19D304R	56.9	10.6	<b>33.3</b>	41.8	72.5	<b>-0.6</b>	58.5	4.07	3	960	4	4	<b>2</b>	5
CP7017AX	57.3	12.0	<b>35.3</b>	41.4	72.6	-1.1	<u>57.4</u>	<u>2.64</u>	<u>1</u>	830	<u>1</u>	<u>2</u>	<b>1</b>	<u>9</u>
CP7266AX	55.8	<b>13.1</b>	<b>32.9</b>	43.3	71.9	-1.9	59.2	3.58	<u>1</u>	845	4	3	<b>2</b>	<u>8</u>
Crescent AX	<b>57.8</b>	11.9	<b>38.7</b>	42.3	73.1	-0.9	62.4	4.26	4	<b>1175</b>	<b>5</b>	<b>6</b>	<b>1</b>	<b>1</b>
Guardian	57.3	12.2	<b>33.4</b>	52.9	71.4	-1.1	61.6	3.51	2	925	3	3	<b>2</b>	<b>6</b>
Kivari AX	56.1	11.1	<b>34.1</b>	38.3	<b>74.8</b>	-0.9	60.6	4.18	3	<b>1095</b>	<b>6</b>	<b>6</b>	<b>1</b>	<b>2</b>
LCS Atomic AX	56.3	12.2	<b>31.5</b>	49.2	72.1	-1.0	60.4	3.09	2	895	3	2	<b>3</b>	<b>7</b>
LCS Steel AX	57.5	<b>13.0</b>	<b>36.0</b>	49.1	<b>74.1</b>	-1.5	61.4	3.06	2	895	2	2	<b>1</b>	<b>7</b>
Monarch	56.6	10.9	<b>31.8</b>	48.4	71.6	-1.0	59.5	3.84	3	920	<b>5</b>	4	<b>3</b>	<b>5</b>
Ray	54.4	<b>13.0</b>	<b>32.6</b>	60.9	71.1	-0.9	<b>64.6</b>	<b>5.27</b>	<b>5</b>	970	4	4	<b>3</b>	<b>1</b>
Snowmass 2.0	57.0	12.0	<b>38.4</b>	55.9	70.4	-0.9	<b>64.5</b>	<b>5.36</b>	<b>5</b>	995	<b>5</b>	<b>5</b>	<b>3</b>	<b>1</b>
SY Wolverine	56.3	12.1	<b>32.5</b>	48.3	71.9	-1.0	58.5	3.24	0	910	3	4	<b>3</b>	<b>8</b>
Valley	56.9	11.6	<b>33.7</b>	49.7	69.2	-1.4	61.0	4.74	4	980	4	4	<b>5</b>	<b>4</b>
Windom SF	<b>58.4</b>	11.4	<b>35.9</b>	51.3	<u>70.1</u>	-1.1	<b>63.5</b>	4.19	3	<b>1080</b>	4	<b>5</b>	<b>2</b>	<b>2</b>
Average	56.8	12.0	34.1	46.9	72.1	-1.1	61.1	3.95	2.8	970	4.0	4.0		
Minimum	54.4	10.6	31.0	38.3	69.2	-1.9	57.3	2.43	0	830	1	2		
Maximum	58.4	13.4	38.7	60.9	74.8	-0.6	64.6	5.55	5	1175	6	6		

**Wheat Milling and Baking Quality Data - 2023 UVPT Burlington**

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

Entry	Test Weight	Grain Protein	SKCS Weight	SKCS Hardness	SKCS Yield	Flour Yield	Protein Recovery	Bake Absorption	Mixograph Mix Time	Mixograph Tolerance	Loaf Volume	Crumb Color	Crumb Grain	Milling Score	Baking Score
Amplify SF	56.6	10.7	<b>29.0</b>	61.2	72.6	-0.5	62.4	3.59	2	850	2	2	2	<b>2</b>	6
AP Roadrunner	56.2	10.5	<b>29.8</b>	66.2	71.6	-0.9	61.2	4.03	3	985	2	3	3	<b>3</b>	6
Avery	57.1	10.1	<b>29.5</b>	52.1	72.4	<b>-0.4</b>	61.3	4.72	<b>5</b>	975	4	<b>6</b>	<b>6</b>	<b>2</b>	<b>3</b>
Brawl CL Plus	58.1	<b>11.7</b>	<b>30.0</b>	54.3	72.4	-0.6	61.5	3.84	3	970	3	4	4	<b>2</b>	5
Breck	57.4	10.7	<b>29.0</b>	58.7	71.0	-0.9	59.4	4.28	3	920	3	2	2	<b>2</b>	6
Byrd	56.2	10.1	<b>28.6</b>	48.4	73.2	<b>-0.3</b>	61.5	4.51	<b>5</b>	1000	4	<b>5</b>	<b>2</b>	<b>2</b>	<b>3</b>
Byrd CL Plus	57.3	10.3	<b>31.4</b>	55.4	72.3	-0.8	61.3	3.38	3	925	3	3	3	<b>2</b>	6
Canvas	58.3	10.6	<b>28.3</b>	56.5	<b>73.7</b>	-0.7	62.4	4.72	4	985	<b>5</b>	<b>5</b>	<b>5</b>	<b>1</b>	<b>3</b>
CO18035RA	55.4	10.4	<b>27.0</b>	52.1	72.2	-0.6	63.4	<b>5.53</b>	<b>5</b>	<b>1020</b>	3	<b>5</b>	<b>5</b>	<b>3</b>	<b>2</b>
CO18042RA	58.1	10.9	<b>29.7</b>	55.0	<b>73.9</b>	-0.8	61.3	4.26	4	980	<b>6</b>	<b>5</b>	<b>5</b>	<b>1</b>	<b>3</b>
CO18D007W	58.4	9.6	<b>31.2</b>	50.9	72.4	-0.5	62.5	4.19	4	950	4	<b>5</b>	<b>5</b>	<b>2</b>	<b>3</b>
CO18D297R	<b>59.2</b>	10.6	<b>28.1</b>	66.6	72.2	-0.9	62.4	3.90	4	940	4	4	4	<b>2</b>	4
CO19393R	57.4	10.7	<b>28.9</b>	59.9	72.3	-0.8	61.2	4.37	3	975	4	4	4	<b>2</b>	4
CO19410R	<b>59.2</b>	10.2	<b>27.4</b>	61.3	73.1	<b>-0.5</b>	<b>64.4</b>	4.12	4	970	<b>5</b>	<b>5</b>	<b>5</b>	<b>1</b>	<b>3</b>
CO19D087R	56.5	10.8	<b>28.1</b>	52.7	73.0	-1.1	61.1	4.76	4	995	3	3	3	<b>2</b>	4
CO19D304R	58.2	10.1	<b>27.6</b>	58.5	73.0	-0.5	61.4	4.82	4	985	2	4	4	<b>1</b>	4
CO19S129W	58.1	10.5	<b>29.5</b>	66.3	70.6	-0.5	<b>65.3</b>	<b>5.72</b>	<b>5</b>	<b>1020</b>	4	2	2	<b>3</b>	<b>2</b>
CO200037R	58.1	11.1	<b>29.4</b>	55.1	<b>73.7</b>	-1.1	61.4	4.58	4	970	3	4	4	<b>2</b>	4
CO20D108R	58.6	10.3	<b>28.5</b>	62.2	72.8	-0.6	61.4	<b>7.86</b>	<b>5</b>	995	4	4	4	<b>1</b>	<b>2</b>
CP7017AX	58.4	10.4	<b>30.5</b>	50.8	<b>74.2</b>	-0.5	60.4	3.34	3	820	2	2	2	<b>1</b>	7
Crescent AX	58.7	10.5	<b>33.6</b>	48.4	<b>74.0</b>	<b>-0.3</b>	60.4	4.50	4	<b>1075</b>	4	4	<b>5</b>	<b>1</b>	<b>3</b>
Fortify SF	56.8	9.7	<b>27.6</b>	43.4	<b>74.1</b>	<b>-0.4</b>	58.3	4.34	3	970	4	4	4	<b>2</b>	6
Guardian	57.5	<b>11.6</b>	<b>28.2</b>	62.1	71.4	-1.3	62.2	4.40	4	975	4	3	3	<b>3</b>	4
Hatcher	58.2	10.5	<b>29.9</b>	55.6	71.3	-0.7	62.2	4.43	3	890	4	3	3	<b>2</b>	5
Kivari AX	55.7	9.8	<b>27.4</b>	47.1	<b>74.3</b>	-1.1	58.1	3.75	4	955	4	4	4	<b>3</b>	5
KS Big Bow	57.7	10.9	<b>32.6</b>	52.0	71.0	-1.0	61.2	3.60	3	885	<b>5</b>	<b>5</b>	<b>3</b>	<b>3</b>	5
Langin	54.7	10.1	<b>27.6</b>	48.0	71.9	-0.5	62.5	<b>5.37</b>	<b>5</b>	950	4	<b>5</b>	<b>4</b>	<b>4</b>	<b>3</b>
LCS Atomic AX	57.5	<b>11.3</b>	<b>30.5</b>	53.3	<b>73.8</b>	-0.9	59.0	3.97	3	950	<b>6</b>	<b>5</b>	<b>5</b>	<b>1</b>	5
LCS Steel AX	<b>59.2</b>	<b>11.6</b>	<b>38.7</b>	43.0	<b>75.0</b>	-1.4	60.3	4.07	4	940	3	3	3	<b>2</b>	5
Monarch	57.5	10.3	<b>30.4</b>	62.5	71.2	-0.7	62.4	4.89	4	850	4	3	3	<b>3</b>	5
MS Maverick	57.9	<b>12.5</b>	<b>34.3</b>	59.2	70.4	-1.2	63.1	3.65	3	950	3	2	2	<b>2</b>	5
Ray	53.0	10.6	<b>26.7</b>	71.0	68.2	-0.5	61.3	<b>6.37</b>	<b>5</b>	915	4	3	3	<b>6</b>	<b>3</b>
Snowmass 2.0	58.5	10.9	<b>34.2</b>	60.4	71.5	-0.9	<b>65.6</b>	4.48	<b>5</b>	<b>1025</b>	<b>6</b>	<b>5</b>	<b>4</b>	<b>2</b>	<b>1</b>
Sunshine	58.6	10.8	<b>35.2</b>	46.5	71.6	-0.9	62.2	4.18	4	970	<b>5</b>	<b>5</b>	<b>4</b>	<b>3</b>	<b>3</b>
Valley	57.7	10.6	<b>31.4</b>	62.0	69.5	-1.1	<b>65.3</b>	4.83	4	945	4	3	3	<b>3</b>	<b>3</b>
Whistler	55.8	10.4	<b>28.9</b>	64.5	71.4	-0.7	63.4	4.27	4	<b>1020</b>	2	3	3	<b>3</b>	4
Windom SF	<b>59.6</b>	10.5	<b>34.6</b>	60.6	<b>70.8</b>	-0.7	63.3	4.28	4	1005	4	4	3	<b>1</b>	4
Average	57.5	10.6	30.1	56.3	72.3	-0.7	61.8	4.48	3.9	959	3.8	3.7			
Minimum	53.0	9.6	26.7	43.0	68.2	-1.4	58.1	3.34	2	820	2	2			
Maximum	59.6	12.5	38.7	71.0	75.0	-0.3	65.6	7.86	5	1075	6	6			

**Wheat Milling and Baking Quality Data - 2023 UVPT Genoa**

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

Entry	Test Weight	Grain Protein	SKCS Weight	SKCS Hardness	Flour Yield	Flour Protein	Recovery	Bake Absorption	Mixograph Mix Time	Mixograph Tolerance	Loaf Volume	Crumb Color	Crumb Grain	Milling Score	Baking Score
Amplify SF	54.8	<b>13.0</b>	<b>26.8</b>	52.4	70.7	-1.1	61.3	3.43	1	875	3	3	5	6	
AP Bigfoot	<b>57.8</b>	9.9	<b>29.3</b>	47.6	71.5	-1.1	56.3	5.68	3	825	4	4	4	6	
AP Roadrunner	56.0	11.0	<b>27.8</b>	63.4	70.7	-0.7	60.4	3.41	3	915	3	3	3	6	
AP Solid	<b>58.7</b>	9.8	<b>30.1</b>	55.9	70.5	-0.6	58.4	4.11	2	845	4	3	2	7	
Avery	55.9	8.8	<b>32.0</b>	45.7	70.1	-0.5	57.4	4.22	4	840	4	4	4	6	
Brawl CL Plus	<b>57.5</b>	10.7	<b>31.5</b>	47.9	<b>71.6</b>	-0.9	59.6	3.72	3	910	4	4	3	6	
Breck	<b>57.9</b>	9.1	<b>31.2</b>	52.8	70.7	-0.9	57.5	3.77	3	845	5	4	3	6	
Byrd	56.1	9.0	<b>31.3</b>	44.0	<b>72.0</b>	-0.9	57.6	5.34	5	840	4	4	4	5	
Byrd CL Plus	55.2	9.5	<b>31.7</b>	46.0	69.6	-0.8	58.1	4.74	4	790	2	3	5	7	
Canvas	56.4	10.9	<b>24.3</b>	58.5	<b>71.8</b>	-1.2	60.4	5.19	4	950	4	4	2	4	
CO18035RA	50.4	<b>12.9</b>	<b>24.5</b>	52.8	67.8	<b>-0.2</b>	<b>66.2</b>	<b>8.13</b>	6	<b>1140</b>	2	3	5	1	
CO18042RA	55.0	9.0	<b>28.8</b>	44.4	69.9	-0.7	58.4	5.93	5	875	3	4	5	5	
CO18D007W	56.7	8.9	<b>31.0</b>	45.6	70.8	-0.7	61.5	5.34	5	875	4	4	4	4	
CO18D297R	55.4	11.6	<b>26.4</b>	52.8	70.0	-1.4	<b>63.5</b>	3.84	4	925	4	3	4	4	
CO19393R	53.5	<b>12.7</b>	<b>23.0</b>	62.0	69.2	-1.2	<b>64.3</b>	4.38	4	<b>1055</b>	3	3	4	3	
CO19410R	55.8	10.3	<b>26.7</b>	53.4	70.2	-0.5	62.2	4.83	4	910	4	3	3	4	
CO19D087R	53.0	<b>12.1</b>	<b>25.5</b>	49.9	69.6	-1.0	<b>63.4</b>	5.62	5	<b>1035</b>	4	5	5	2	
CO19D304R	52.8	10.4	<b>25.2</b>	58.3	68.9	<b>-0.0</b>	<b>63.2</b>	5.94	5	<b>1020</b>	3	3	3	3	
CO19S129W	56.6	8.8	<b>32.5</b>	52.2	68.2	-1.0	60.5	6.12	5	810	4	4	4	4	
CO200037R	<b>57.7</b>	9.9	<b>27.3</b>	54.9	<b>72.3</b>	<b>-0.1</b>	60.5	4.46	4	950	3	3	2	5	
CO20D108R	56.2	9.3	<b>27.7</b>	46.5	71.3	-1.2	59.7	<b>8.64</b>	5	855	4	4	4	3	
CP7017AX	56.9	9.8	<b>30.1</b>	48.1	<b>72.0</b>	-0.6	59.2	3.10	3	830	2	1	3	8	
Crescent AX	54.1	11.4	<b>29.7</b>	50.8	70.1	<b>-0.4</b>	62.3	5.85	5	<b>1025</b>	3	3	4	3	
Fortify SF	56.2	9.6	<b>27.6</b>	39.8	<b>72.6</b>	-1.2	54.3	4.92	2	855	3	2	4	8	
Guardian	56.2	10.7	<b>28.3</b>	57.1	69.9	-0.7	62.3	4.36	4	975	5	5	3	3	
Hatcher	57.1	8.4	<b>32.8</b>	41.5	68.3	-0.4	54.4	5.03	2	735	5	3	4	8	
Kivari AX	53.6	10.4	<b>27.3</b>	52.6	<b>71.8</b>	<b>-0.1</b>	61.3	4.55	5	<b>1060</b>	5	5	3	2	
KS Territory	56.4	10.4	<b>30.8</b>	59.9	69.5	-0.8	59.5	4.00	3	825	2	3	3	7	
Langin	51.8	<b>12.3</b>	<b>24.7</b>	53.4	68.4	-0.8	62.4	<b>7.15</b>	5	<b>1100</b>	4	3	5	1	
LCS Atomic AX	54.6	11.0	<b>26.2</b>	55.3	70.4	-0.4	60.4	5.39	4	<b>1020</b>	4	3	3	4	
LCS Steel AX	<b>57.6</b>	9.9	<b>31.8</b>	45.7	<b>73.2</b>	-0.5	59.4	4.95	3	850	4	3	3	6	
Monarch	55.3	10.0	<b>27.2</b>	57.6	69.9	<b>-0.3</b>	59.4	6.47	4	895	4	3	3	5	
MS Maverick	<b>58.3</b>	10.1	<b>33.8</b>	51.7	68.8	-0.4	60.5	3.82	4	880	3	3	2	6	
Ray	53.0	<b>12.0</b>	<b>26.1</b>	70.5	69.7	<b>-0.3</b>	62.4	5.73	5	845	5	4	3	4	
Snowmass 2.0	56.7	9.3	<b>33.2</b>	59.8	69.9	-0.5	<b>65.3</b>	<b>7.14</b>	4	885	5	4	3	1	
Steamboat	56.0	10.5	<b>28.7</b>	52.0	71.0	-1.0	58.4	5.15	5	925	3	3	3	6	
Sunshine	54.7	<b>11.8</b>	<b>30.6</b>	46.0	70.1	-1.3	<b>63.5</b>	5.46	5	925	4	4	5	3	
Valley	53.9	<b>12.7</b>	<b>22.7</b>	67.7	67.7	-1.1	<b>64.4</b>	5.71	5	<b>1070</b>	5	4	5	1	
Whistler	55.8	8.6	<b>31.7</b>	49.6	69.5	-0.5	59.5	<b>7.17</b>	5	840	3	4	4	4	
Windom SF	<b>58.2</b>	8.7	<b>35.0</b>	50.8	68.7	-0.8	58.3	6.10	5	835	5	4	3	4	
Average	55.6	10.4	28.8	52.4	70.2	-0.7	60.5	5.22	4.1	912	3.7	3.5			
Minimum	50.4	8.4	22.7	39.8	67.7	-1.4	54.3	3.10	1	735	2	1			
Maximum	58.7	13.0	35.0	70.5	73.2	-0.0	66.2	8.64	6	1140	5	5			

**Wheat Milling and Baking Quality Data - 2023 UVPT Walsh**

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

Entry	Test Weight	Grain Protein	SKCS Weight	SKCS Hardness	Flour Yield	Flour Protein	Recovery	Absorption	Bake	Mixograph Mix Time	Mixograph Tolerance	Loaf Volume	Crumb Color	Crumb Grain	Milling Score	Baking Score
Amplify SF	55.9	11.9	<b>31.1</b>	34.3	71.7	-1.1	61.3	61.3	2	3.38	2	970	4	3	4	4
AP Roadrunner	56.1	<b>13.1</b>	<b>27.8</b>	54.0	71.5	-1.1	62.5	62.5	4	3.92	4	965	4	5	2	4
Avery	56.3	13.0	<b>31.6</b>	33.7	71.6	-1.3	62.0	62.0	5	5.63	5	<b>1225</b>	5	3	3	1
Brawl CL Plus	56.9	<b>13.9</b>	<b>31.1</b>	40.4	71.4	-1.1	64.1	64.1	3	3.22	3	<b>1155</b>	4	2	3	3
Breck	<b>57.6</b>	12.4	<b>27.2</b>	43.7	71.5	-1.5	<b>64.6</b>	<b>64.6</b>	3	4.14	3	1075	5	4	4	3
Byrd	56.6	11.4	<b>30.6</b>	28.1	<b>73.3</b>	-1.9	59.4	59.4	5	5.32	5	1025	4	5	3	3
Byrd CL Plus	56.1	12.4	<b>31.5</b>	33.8	71.1	-1.6	61.2	61.2	4	4.08	4	1025	3	3	4	4
Canvas	<b>57.9</b>	12.2	<b>27.1</b>	40.2	<b>73.9</b>	-1.0	62.4	62.4	4	4.85	4	1050	4	4	2	3
CO18035RA	56.5	11.8	<b>26.1</b>	40.7	72.5	-0.9	62.4	62.4	5	<b>7.02</b>	5	1075	4	4	3	1
CO18042RA	56.5	11.1	<b>27.2</b>	37.6	72.6	-1.5	59.4	59.4	5	6.14	5	975	4	4	4	3
CO18D007W	56.5	<u>10.7</u>	<b>30.5</b>	40.5	71.1	-1.3	60.4	60.4	5	5.37	5	985	3	3	4	4
CO18D297R	56.2	11.2	<b>25.4</b>	41.4	69.7	-1.5	62.4	62.4	5	5.13	5	990	5	5	4	2
CO19393R	57.3	11.8	<b>29.3</b>	38.9	72.1	-2.0	61.6	61.6	4	5.52	4	1020	3	3	4	4
CO19410R	57.1	12.6	<b>29.6</b>	40.0	71.8	-1.3	<b>66.2</b>	<b>66.2</b>	5	4.92	5	1100	5	3	3	1
CO19D087R	55.8	12.4	<b>25.1</b>	43.1	72.0	-1.7	61.3	61.3	5	6.02	5	970	4	4	4	3
CO19D304R	57.0	12.4	<b>28.6</b>	41.5	72.7	-1.3	62.3	62.3	5	<b>6.50</b>	5	1080	4	4	3	1
CO19S129W	55.7	12.5	<b>31.1</b>	43.0	69.6	-1.7	<b>65.3</b>	<b>65.3</b>	5	<b>7.15</b>	5	1030	5	3	5	1
CO200037R	<b>57.7</b>	11.7	<b>28.9</b>	38.1	<b>73.6</b>	-0.7	63.3	63.3	4	4.39	4	1085	4	4	2	3
CO20D108R	56.5	<u>11.1</u>	<b>27.3</b>	39.0	71.9	-1.3	61.9	61.9	4	<b>6.87</b>	4	940	4	4	3	2
CP7017AX	56.9	12.1	<b>30.2</b>	34.3	72.9	-1.4	59.3	59.3	2	4.02	2	880	2	3	3	7
Crescent AX	56.6	12.6	<b>33.3</b>	32.6	72.8	-1.1	61.2	61.2	4	4.84	4	<b>1155</b>	6	4	3	2
Fortify SF	55.8	12.2	<b>27.0</b>	31.8	<b>73.5</b>	-1.3	59.3	59.3	1	3.38	1	1090	6	5	3	5
Guardian	<b>57.7</b>	12.0	<b>31.7</b>	38.9	72.0	-1.5	61.2	61.2	5	5.36	5	990	4	4	3	3
Hatcher	56.2	11.9	<b>30.9</b>	37.7	70.2	-1.5	63.5	63.5	4	4.44	4	910	5	5	4	3
Kivari AX	55.4	12.3	<b>29.3</b>	31.0	<b>74.4</b>	-1.5	61.4	61.4	5	4.98	5	<b>1160</b>	4	4	3	2
KS Big Bow	57.0	<b>13.4</b>	<b>36.0</b>	32.9	70.8	-1.7	62.4	62.4	2	4.23	2	975	5	5	4	4
Langin	56.5	<b>13.6</b>	<b>26.9</b>	46.6	72.2	-1.9	64.2	64.2	5	<b>6.43</b>	5	<b>1140</b>	4	3	3	1
LCS Atomic AX	55.6	<b>13.7</b>	<b>25.8</b>	51.0	70.7	-1.2	63.1	63.1	3	4.08	3	<b>1115</b>	4	3	3	3
LCS Steel AX	<b>58.3</b>	<b>13.4</b>	<b>34.0</b>	37.8	<b>73.3</b>	-1.7	62.2	62.2	4	4.06	4	1000	4	3	2	5
Monarch	55.4	<u>10.9</u>	<b>29.7</b>	40.0	70.1	-1.3	62.4	62.4	4	5.91	4	<u>955</u>	5	4	5	3
MS Maverick	<b>57.4</b>	<b>13.5</b>	<b>34.3</b>	33.3	70.2	-1.1	63.4	63.4	3	3.50	3	1015	5	4	4	4
Ray	56.2	12.5	<b>29.2</b>	67.3	71.7	-0.6	<b>65.3</b>	<b>65.3</b>	5	6.31	5	960	5	4	2	1
Snowmass 2.0	57.0	12.2	<b>32.5</b>	48.2	69.9	-1.1	<b>65.6</b>	<b>65.6</b>	5	<b>7.96</b>	5	1000	5	4	4	1
Sunshine	56.9	12.1	<b>32.9</b>	31.6	71.4	-1.6	62.4	62.4	5	5.36	5	1075	4	4	4	2
Valley	56.2	12.5	<b>27.4</b>	46.6	70.2	-1.3	<b>65.2</b>	<b>65.2</b>	5	<b>6.46</b>	5	1100	4	2	4	1
Whistler	56.6	11.8	<b>30.9</b>	33.5	70.9	-1.6	<b>64.6</b>	<b>64.6</b>	5	5.83	5	1030	4	4	4	2
Windom SF	<b>58.3</b>	<b>13.3</b>	<b>31.1</b>	46.5	70.1	-1.3	63.2	63.2	4	4.91	4	1090	5	2	3	3
Average	56.7	12.3	29.7	39.8	71.7	-1.4	62.5	62.5	4.1	5.18	4.1	1037	4.3	3.7		
Minimum	55.4	10.7	25.1	28.1	69.6	-2.0	59.3	59.3	1	3.22	1	880	2	2		
Maximum	58.3	13.9	36.0	67.3	74.4	-0.6	66.2	66.2	5	7.96	5	1225	6	5		

# Water Absorption Capacity in Wheat Flour: Enhancing Baking Quality

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## Introduction

Water absorption capacity is a key quality trait in wheat that significantly impacts the baking and processing characteristics of wheat-based products. It refers to the amount of water that wheat flour can absorb and retain during the dough-making process, which affects the dough's consistency, dough strength, volume, texture, bread yield and shelf life of the final baked goods.

## Key Factors Affecting Water Absorption

1. **Gluten Concentration:** Essential for dough elasticity and strength, higher gluten levels generally enhance water absorption.
2. **Pentosan Concentration:** Pentosans, known as arabinoxylans, are water-soluble polysaccharides that significantly impact water retention. Water absorption capacity increases when there is a higher concentration of pentosans in the flour.
3. **Damaged Starch:** The presence of damaged starch increases the flour's capacity to absorb water, which is crucial during the mixing process.

## The Solvent Retention Capacity Test

This test is a widely recognized method for assessing the water absorption capacity of wheat flour. It uses various solvents that are associated with the concentrations of different flour components that influence water absorption. Solvents include:

- **Water:** Measures overall water absorption capacity.
- **Sucrose:** Estimates pentosan concentration.
- **Lactic Acid:** Associated with gluten concentration.
- **Sodium Carbonate:** Indicates the amount of damaged starch.

Optimal water absorption capacity, which is  $\geq 62\%$ , ensures higher dough yield and superior quality in finished products, making this trait a key consideration in wheat variety selection.

Colorado State University's wheat breeding program has been selecting for improving water absorption capacity in hard winter wheat. This has led to the development of varieties with optimized water absorption properties, benefiting both baking quality and product consistency.

## Summary of Samples and Data Analysis

- **Sample Size:** 497 hard winter wheat genotypes.
- **Evaluation Period:** 2014-2021.
- **Location:** Various Colorado State University (CSU) wheat breeding sites.
- **Data Collection:** The Solvent Retention Capacity (SRC) test was done using water, sucrose, lactic acid, and sodium carbonate solvents to assess the contributions of various flour components to water absorption capacity.
- **Data Analysis:** Best Linear Unbiased Estimates (BLUEs) were used to analyze the data.

**Table 1.** Water absorption capacity of CSU-developed wheat cultivars evaluated using the solvent retention capacity test. A higher SRC value is more favorable for baking quality.

Variety	SRC-water (%)	SRC-sucrose (%)	SRC-lactic acid (%)	SRC-carbonate (%)
Avery	62.28	88.48	114.86	73.58
Battle AX	60.64	85.03	108.47	71.23
Brawl CL Plus	61.53	87.72	116.60	71.66
Breck	62.71	91.68	118.80	75.36
Byrd	60.51	87.22	116.83	71.14
Byrd CL Plus	60.44	86.95	110.53	71.08
Canvas	59.23	86.27	114.09	70.41
Crescent AX	59.93	86.06	117.29	69.51
Denali	60.86	86.22	105.87	74.00
Fortify SF	58.35	84.46	102.27	69.72
Guardian	63.78	91.96	119.54	76.11
Incline AX	61.64	87.78	112.26	73.33
Kivari AX	59.99	88.06	113.81	71.85
Langin	59.95	86.07	114.82	71.84
LCS Fusion AX	62.04	88.36	108.39	72.37
Monarch	62.87	91.23	106.55	76.65
Snowmass	69.78	99.52	118.05	83.84
Snowmass 2.0	66.55	96.14	118.96	79.96
Steamboat	60.78	89.62	114.95	73.52
Sunshine	63.57	93.69	123.26	71.23
Whistler	64.92	95.17	124.24	76.86
Mean	62.21	89.41	114.31	73.58
Minimum	58.35	84.46	102.27	69.51
Maximum	69.78	99.52	124.24	83.84

## Colorado Wheat Update

Brad Erker – Executive Director

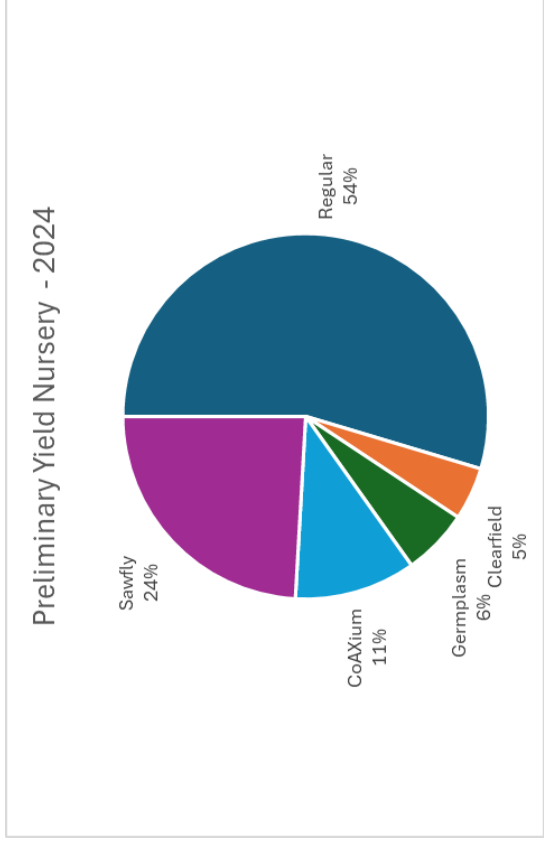
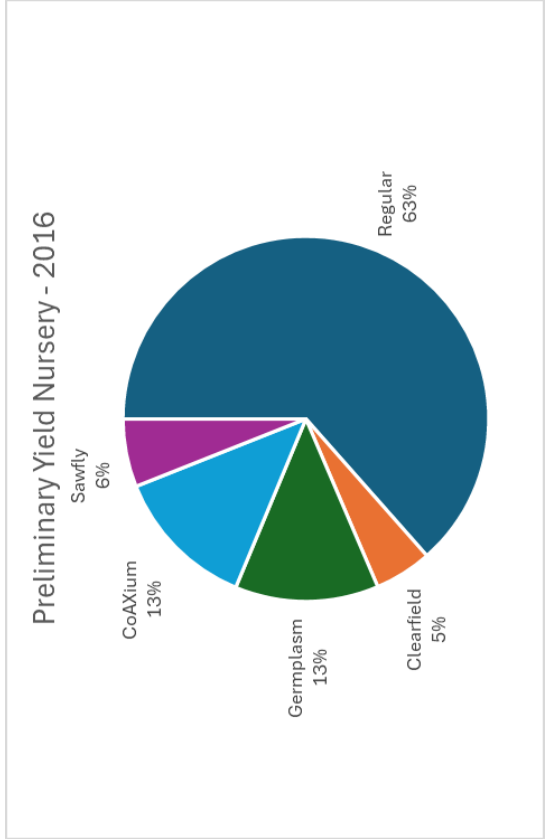
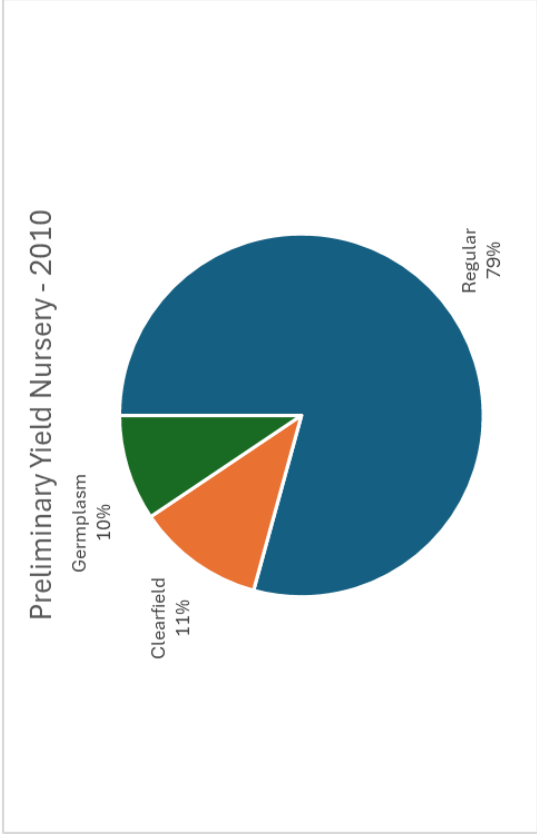
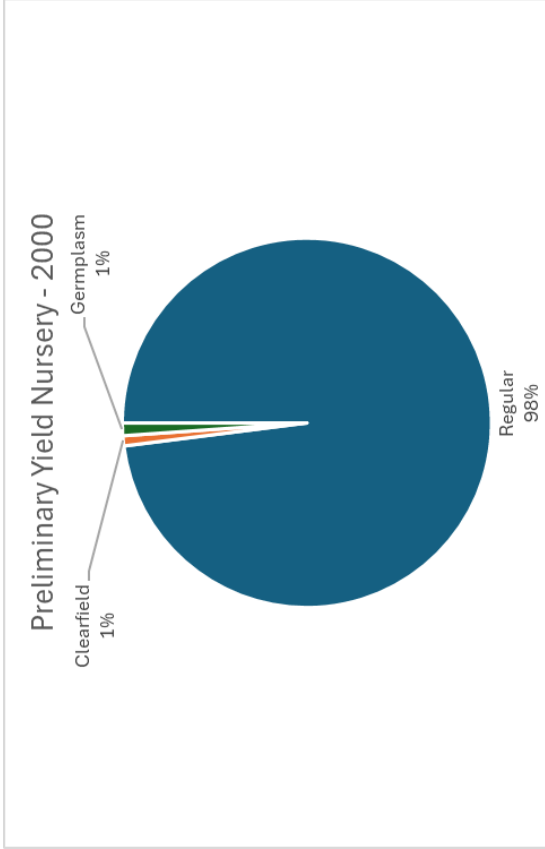
Colorado Wheat is a strategic alliance that houses three distinct but cooperating organizations working together to serve the state’s wheat growers. The **Colorado Wheat Administrative Committee (CWAC)** collects an assessment of two cents per bushel at first point of sale, and invests those funds in research, education, and promotional activities. Board members serve on the Boards of US Wheat Associates, Wheat Marketing Center, and Plains Grains Inc. The **Colorado Association of Wheat Growers (CAWG)** is funded by voluntary membership fees and sponsorships. CAWG lobbies at the State and National level on policies that affect wheat, and Board members serve on the Board of the National Association of Wheat Growers. CAWG does not utilize assessment funds for lobbying. The **Colorado Wheat Research Foundation** takes ownership of wheat varieties and traits developed at CSU and markets them in Colorado and regionally in the PlainsGold brand.

Colorado is the only wheat state that runs these three types of organizations in tandem as much as we do. CWAC and CAWG meetings are held jointly four times per year. The CWRFB Board is composed of four members from CWAC, three members from CAWG, and two members from the Colorado Seed Growers Association. This cohesiveness is reflected in the new Colorado Wheat logos which all have a similar style, and in the new website, still at [www.coloradowheat.org](http://www.coloradowheat.org).



Colorado wheat producers planted 2.10 million acres for harvest in 2024, down 200,000 acres from the previous year. **Amplify SF**, a hard red winter variety released by CSU in 2021, was the top planted variety for the first time with 13.6% of the acreage (NASS Winter Wheat Seedings by Variety Survey, 2024 Crop). This is the first time a semi-solid stemmed variety has taken the top spot in the survey, which is reflective of the severity of the wheat stem sawfly problem in the state. **Langin** slipped to second place at 11.6%, followed by **Byrd** at 9.1%, **Avery** at 6%, and **Byrd CL Plus** at 5.1%. Of varieties reported by name, 86% of the acreage was planted to varieties supported by the 2-cent/bushel wheat assessment (those released by CSU and marketed by PlainsGold). Colorado producers also reported that 67% percent of their seed planted was Certified wheat seed, and that 22% of their seed planted was treated.

**The CSU Wheat Breeding and Genetics Program** is constantly changing and evolving. The following graphs from Dr. Esten Mason look at percentage of plots in the Preliminary Yield Nursery, the first time a potential new wheat variety is put into a yield plot, going back to 2000. You can see that breeding for Wheat Stem Sawfly tolerance has taken on increasing prominence in the program. At the same time, breeding for ‘regular’ wheat varieties (hard red winter and hard white winter varieties with good yield, quality, and disease resistance) is becoming a smaller part, but is still the largest. Breeding for CoAXium® and Clearfield® varieties is an important piece that isn’t going away. Germplasm development fluctuates over time as specialty projects or introgression of novel genes come into the program and get completed. Your input as a farmer is always valued to help us continually shape the program to meet your needs.



**CWRF/Ardent Mills Ultragrain® Premium Program:** CWRF continues to partner with Ardent Mills to provide hard white winter wheat varieties with sound agronomics and superior quality to farmers throughout the region, along with variety and protein premiums.

For the 2024 crop year, five varieties are included in the program (Snowmass 2.0, Breck, Windom SF, Monarch, and Thunder CL). CSU continues to put significant breeding effort into hard white wheat. Certified seed is required on all Ardent Mills contracts, and the use of glyphosate for pre-harvest crop desiccation is prohibited.

Ardent Mills is currently paying premiums as follows for the 2024 crop. Future year contracts are subject to market conditions and may change. For 2024, all varieties are paid at the same premium levels:

\$0.40/bushel base grower premium, regardless of protein level  
\$0.60/bushel @ 12.0% protein  
+\$0.02 per 1/5 from 12.2% to 13.0% protein



For further details on delivery points and seed availability from your local seed grower, visit [coloradowheat.org](http://coloradowheat.org) or [plainsgold.com](http://plainsgold.com), or call the Colorado Wheat office at (970) 449-6994.

For more information on any of the work being done by Colorado Wheat, stay in touch with us:

Phone: (970) 449-6994

Email: [info@coloradowheat.org](mailto:info@coloradowheat.org)

Websites: [www.coloradowheat.org](http://www.coloradowheat.org) | [www.plainsgold.com](http://www.plainsgold.com) | [www.coaxium.com](http://www.coaxium.com)

Social media:



@coloradowheat  
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Facebook.com/coloradowheat  
Facebook.com/PlainsGold

## Not All Wheat Seed is Equal, Advantages of Certified Seed

Laura Pottorff

The quality of the seed one chooses to plant has been shown to influence yield. The use of certified seed, considered some of the highest quality seed on the market, has been suggested to increase yield 1.2 to 1.5 bushels per acre compared to bin run or saved seed<sup>1</sup>.

High quality seed is the oldest of technologies available to the grower, and yet continued advancement in varietal development means seed is also the newest of technologies available. New varieties will continue to be needed to tolerate changing environmental and pest conditions<sup>2</sup>. With new technology and superior varieties often come higher seed costs.

The initial investment in seed made by a grower is an individual and often complex decision. The profitability of crops harvested from Certified or saved seed sources can vary widely depending on the variety chosen, environment, market conditions, specific pest pressures, and farming practices.

Advantages of choosing Certified seed varieties will be noticeably apparent to growers who experience increased levels of:

- Insects and mites that cannot be adequately controlled with insecticides
  - wheat stem sawfly
  - wheat curl mite and other virus vectors
- Disease pressures with no available chemical control or seed treatment solutions
  - plant pathogenic viruses
- Grassy weeds or other inseparable seed crop contaminants in wheat fields without herbicide selectivity
  - Volunteer rye in wheat
  - Jointed goatgrass in wheat

Solutions to these yield-reducing issues are available with new trait development in Certified seed varieties. Varieties that facilitate the latest pest and weed reduction strategies are on the market and available.

Certified seed is true to type (genetic purity), retaining all the traits and benefits developed in the plant breeding process as the seed is multiplied from Foundation to Registered to Certified class seeds. Seed certification agencies like the Colorado Seed Growers Association (CSGA) will conduct official field inspections to validate genetic purity by ensuring the varietal description from the plant breeder corresponds to the crop growing in the field. During official field inspections, other crops and weeds producing seed the same size as the crop seed, noxious weeds and seedborne diseases are also identified and noted. The presence of certain diseases, other crops, weeds, or noxious weeds may be cause for denial of certification if not reduced or brought below minimum standards.

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<sup>1</sup> [FARMERS YIELD INITIATIVE](#)

<sup>2</sup> [Seed Innovation — Spotlight On: Produced by Trivue Entertainment](#)

Seed Conditioning – The seed certification system was developed to verify both varietal and mechanical purity of seed from breeder to farmer. Seed conditioners play an important role in upgrading and safeguarding the quality of the seed lot they receive. As a result, a system for approved seed conditioners was established to verify the use of minimum conditioning standards, screening methodology, cleaning and recordkeeping ensuring integrity and quality. Seed conditioners must keep records of each lot conditioned and a two-pound sample of each raw and cleaned seed lot for two years.

Lab Analysis – Submission of a conditioned seed sample to an AOSA certified seed lab is another critical step in the value provided by certification. Germination and purity minimum standards are stricter for Certified seed when compared to saved or bin run seed. Standardization and minimum requirements help mitigate liability, risk and protect both the seed grower, conditioner and end user.

Labeling – Seed that is certified in the United States and Canada will have uniform labeling. Therefore, a purchaser will know the difference between Certified and other classes or sources of seed.

Determining when the investment in Certified seed pays for itself, can be complicated. It is our job at CSU and CSGA to continue to develop and deliver wheat seed varieties that are true to type and of higher quality, allowing producers sustainability as we move toward a future of changing pest, weed, water availability and warming pressures. Certification programs are sure to expand and prove beneficial to seed sellers and users alike.

**FOUNDATION SEED**

	Grower	Kind	Date Tested
	County	Variety	% Pure Seed
	Lot No.	Net Weight	% Weed Seed
			% Other Crop
			% Inert
			% Germination
			% Dormant Seed or Hard Seed
			% Total Viable

COLORADO SEED GROWERS ASSN.  
 COLORADO STATE UNIVERSITY  
 FT. COLLINS, COLORADO 80523

This certification is made by the Seed Certification Service of the Cooperative Extension as authorized by the State Board of Agriculture of the State of Colorado pursuant to 35-27-101 et seq., C.R.S. 1984 Replenishment Vol. 14 as amended. THE COOPERATIVE EXTENSION AND COLORADO SEED GROWERS ASSOCIATION ARE NOT SELLERS AND MAKE NO WARRANTIES EXPRESS OR IMPLIED, OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR OTHERWISE. The seller warrants that the seed to which this certification is attached is from the lot shown on this certification, and that every portion or bag of which is uniform within recognized tolerances for the analysis shown. THE SELLER MAKES NO OTHER WARRANTIES, EXPRESS OR IMPLIED, OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR OTHERWISE. LIABILITY LIMITED TO PURCHASE PRICE OF SAID SEEDS.

UNDER THE "COLORADO SEED ACT," ARBITRATION IS REQUIRED AS A PREREQUISITE TO CERTAIN LEGAL ACTIONS, COUNTERCLAIMS, OR DEFENSES AGAINST A SELLER OF SEED. INFORMATION ABOUT THIS REQUIREMENT MAY BE OBTAINED FROM THE COLORADO COMMISSIONER OF AGRICULTURE.

MEMBER OF THE ASSOCIATION OF OFFICIAL SEED CERTIFYING AGENCIES

**REGISTERED SEED**

	Grower	Kind	Date Tested
	County	Variety	% Pure Seed
	Lot No.	Net Weight	% Weed Seed
			% Other Crop
			% Inert
			% Germination
			% Dormant Seed or Hard Seed
			% Total Viable

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MEMBER OF THE ASSOCIATION OF OFFICIAL SEED CERTIFYING AGENCIES

**CERTIFIED SEED**

	Grower	Kind	Date Tested
	County	Variety	% Pure Seed
	Lot No.	Net Weight	% Weed Seed
			% Other Crop
			% Inert
			% Germination
			% Dormant Seed or Hard Seed
			% Total Viable

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MEMBER OF THE ASSOCIATION OF OFFICIAL SEED CERTIFYING AGENCIES

## Wheat Stem Sawfly in Colorado – Frequently Asked Questions

Dr. Punya Nachappa and Adam Osterholzer

### Q: What type of insect is the wheat stem sawfly?

A: Wheat stem sawflies (WSS) aren't flies but wasps! They belong to a group of insects called Hymenoptera, alongside ants, bees, and other wasps. Wheat stem sawflies cannot sting. The name "sawflies" comes from the saw-like appearance of their ovipositors, which the females use to cut into plants and lay their eggs. Males lack this trait.

### Q: How do I know if I have wheat stem sawfly in my field? What do they look like?

A: Starting in early to mid-May, look for small yellow and black wasps (7-12mm) on wheat plants along the edges of your field. Resting sawflies will sit on the stem facing the ground. There are other insects that are similar in appearance, but they typically won't exhibit this resting posture or be abundant in field edges. In mid to late-June, stems can be cut open to look for their white, S-shaped larvae. Compacted sawdust-like material resulting in stems from their feeding, called "frass", is also an indication of sawfly infestation.



Adult female wheat stem sawfly sitting facing the ground (left). Wheat stem sawfly larvae in stub (right).

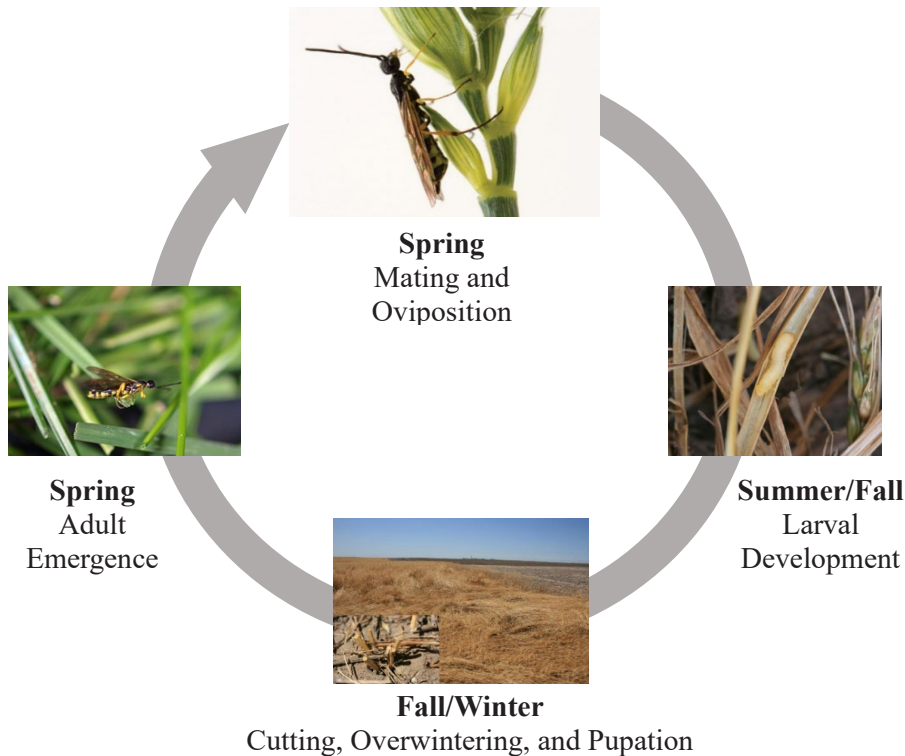
### Q: What does wheat stem sawfly damage look like?

A: Before your wheat crop dries, you can cut open stems and find larvae, as well as sawdust-like frass from their feeding. Nutrients and tissue are being stolen from the plant by the larvae, decreasing crop yield. When the larvae finish feeding, they cut the insides of the stems horizontally near the soil, making them prone to lodging. Lodging is common during strong winds and precipitation events. Unlike stems lodged from other causes, sawfly-cut stems are no longer connected to the plant.

### Q: What is the life cycle of the wheat stem sawfly?

A: Wheat stem sawflies have a single generation per year. Adult WSS emerge from the previous year's stubble from May to June. Females lay their eggs inside wheat stems. Although several eggs may be laid within a stem, only a single larva survives to maturity. As the plant matures, the larva moves down to the base of the stem and chews a notch around the inside of the stem. The notch usually causes the stem to break, producing a small stub that remains anchored in the

ground. This stub is then filled with frass, which creates a protective chamber where the larva overwinters and undergoes pupation. The new adult either chews through the frass plug or through the side of the wheat stub in the spring to start the cycle again.



Life cycle of wheat stem sawfly. Photo credits: Bugwood.wiki, Kelsey Dawson

**Q: How do weather patterns impact sawfly movement and would severe cold temperatures kill larvae?**

A: Dry weather favors WSS. Excessively wet conditions tend to be detrimental to both sawfly and parasitic wasp populations. Severe cold as seen during the winter storm of 2020 typically do not affect WSS populations, as they are known to tolerate much colder temperatures in Canada. We are currently studying how weather trends impact the emergence timelines of adult sawflies.

**Q: Do we find wheat stem sawflies in all wheat-producing counties?**

A: Yes, as of 2020 WSS has been found in wheat in all wheat-producing counties in Eastern Colorado. Most damaging infestations have been found in north-central Colorado, with a few lighter infestations occurring as far south as Baca County. Of note in 2023, WSS infestation was discovered in Boulder County, suggesting further spread westward.

**Q: Where are the wheat stem sawflies coming from?**

A: The WSS is native to Colorado and was first discovered in 1872 on non-cultivated grasses. Many believe that the insect adapted to wheat as European settlers began large-scale cultivation of cereal crops. It has long been a threat to spring wheat production in the northern plains and has become a significant pest of winter wheat as well.

**Q: Why are we starting to have wheat stem sawfly problems now?**

A: There is no good answer to this, but it likely is due to a combination of changes in the wheat stem sawfly's preference for wheat, production practices (e.g., reduced tillage), and climate.

**Q: What is the estimated crop loss due to wheat stem sawfly in Colorado?**

A: The annual economic loss in Colorado is conservatively estimated at \$41 million.

**Q: How fast can wheat stem sawflies spread?**

A: According to CSU surveys, damage in wheat was mostly limited to the New Raymer area in 2012. By 2020, WSS was in all Eastern Colorado wheat-producing counties. Heavily damaging populations can be as far south as I-70, with most hotspots in the northern part of the state.

**Q: Can we predict/react to wheat stem sawfly infestations ahead of time?**

A: According to Canadian guidelines, observing greater than 10 to 15% sawfly cutting in wheat stems from the previous year indicates that adjacent fields should be planted with something other than wheat. If wheat is planted, resistant commercial varieties should be utilized.

**Q: What are the hosts of wheat stem sawfly?**

A: The cultivated hosts of WSS are limited to cereal grains with similar life cycles to wheat (winter/spring wheat, triticale, barley, rye). Wheat stem sawfly is not known to survive on oats or flax. The list of grass hosts of the WSS is extensive and includes brome grasses, wheat grasses, wild ryes, and many other species commonly found in the state.

**Q: What rotation crops can reduce the level of wheat stem sawfly infestation?**

A: None of the common rotational crops (corn, proso millet, sorghum, sunflower) are affected by WSS. It is very important to avoid planting new wheat immediately adjacent to infested stubble.

**Q: How long do I have to stay out of wheat to reduce the problem?**

A: Wheat stem sawflies infest a wheat crop in May and June and will remain in the stubble from that crop until adults emerge the following spring. At that time, adult sawflies disperse from the field looking for new wheat to infest, so the field could be planted with wheat that fall without risk of infestation by the sawflies of the previous year. However, sawflies from adjacent fields or greater distances may infest the new crop, and sawflies can still live in nearby native grasses.

**Q: How effective is tillage in controlling the wheat stem sawfly?**

A: Both fall and spring tillage have been used to expose crowns containing overwintering larvae to moisture and temperature extremes, but it has not been very effective. Tillage will negatively impact the natural enemies that also overwinter in the stubs. If tillage is utilized, it is a tool best reserved for use in fields with low-to-moderate infestation.

**Q: Are there wheat varieties that are resistant to wheat stem sawfly?**

A: Yes, sawfly-resistant varieties have a trait called 'solid stem'. In these plants, the center of the stem is filled entirely with tissue, making it difficult for eggs to be laid inside. Solid stem varieties are also effective in impeding larval development and movement, thus reducing larval survival. CSU has released several semi-solid lines that are optimized for WSS resistance while reducing yield penalties. Breeding for WSS resistance remains a high priority for CSU.

**Q: What is known about the consistency of expression of stem solidness, and the degree of resistance conferred by the new semi-solid varieties?**

A: Reports from Montana and Canada suggest that certain environmental conditions, such as lower light intensity from increased cloud cover or lower elevation, may result in reduced expression of solidness. The level of expression of semi-solidness observed has provided significant reductions in stem cutting during field trials.

**Q: Is there a yield drag associated with the new semi-solid varieties?**

A: There is a yield drag based on the CSU Elite trials. When comparing the semi-solid to non-resistant varieties, we estimated the yield drag to be 4.5% in the absence of WSS. Semi-solid varieties should outyield susceptible varieties if both are infested with sawflies.

**Q: Does the wheat stem sawfly have any natural enemies?**

A: A few insects feed on the WSS. The most important are two parasitic wasps, *Bracon cephi* and *Bracon lissogaster*, whose larvae can be found feeding on WSS larva inside wheat stems.



**Q: How important are these parasitic wasps in Colorado?**

A: To date, in Colorado few specimens of either wasp species have been found feeding on WSS in wheat. They are more easily found on WSS larvae infesting non-cultivated grasses. The parasitic wasps are considered important management tools in the Northern Plains, which have a longer history of WSS infestations in wheat.

**Q: Are there practices that will encourage the parasitic wasps to attack wheat stem sawfly?**

A: The parasitic wasps are expected to become more important as they adapt to WSS infestations in wheat. Tillage and swathing fields are known to affect them negatively. However, if provided with sugar resources such as flowers, adult parasitoid wasps can live longer and produce more offspring. Research has shown incorporating buckwheat into cover crop mixes could enhance parasitoid performance. Parasitoid introduction efforts via transport in hay bales are ongoing.

**Q: How can I control existing wheat stem sawfly infestations in my wheat?**

A: Little can be done to eradicate the sawflies once your wheat is infested. No effective chemical controls are available at this time. Stem cutting can be reduced by swathing, and stripper headers are better at picking up cut stems than traditional headers. Planting resistant varieties of wheat and using proper crop rotations can further mitigate losses.

**Q: Can wheat stem sawflies be controlled with insecticides?**

A: The egg, larval, and pupal stages are found within the stem, making them inaccessible to most insecticides. No insecticides have been found to be cost-effective at controlling WSS. More research is underway. It is suspected that the exact timing of pesticide applications will impact their effectiveness. We are using growing degree-day modeling to increase the timing accuracy.

**Q: Will swathing my wheat reduce losses to wheat stem sawflies?**

A: Wheat can be swathed before stem cutting. Disadvantages include the cost of an extra field operation and negative effects on the parasitic wasps that are feeding on sawfly larvae. Costs can be reduced by only swathing the field margins, where infestations are usually more severe. Effects on natural enemies to WSS can be reduced by leaving the lower third of the stem intact.

**Q: What is the best way to recover cut stems during harvest?**

A: Combines equipped with stripper headers are the most efficient means of retrieving cut stems.

**Q: Can the wheat stem sawfly be eradicated?**

A: No. We have no appropriate management methods that can eliminate this insect from fields. WSS is native to Colorado and is well-adapted to our environment. You would need to eradicate them from all non-cultivated grasses and wheat, since they can reside in both types of hosts.

**Q: How do I prevent wheat stem sawfly infestations in my wheat?**

A: Preventive measures include planting semi-solid varieties, reducing the amount of wheat in your rotation, avoiding planting new wheat crops next to wheat stubble, and planting larger fields of wheat to minimize field edges. The most severe infestations are found in field edges.

**Q: What research is being done at CSU in response to the wheat stem sawfly outbreak?**

A: CSU is emphasizing the development of high quality, productive wheat varieties resistant to WSS. Other research projects include developing a degree-day model for WSS emergence and population peak, screening for novel sources of resistance, improving biological controls, testing the use of trap crops, and trying new approaches to chemical control. We also conduct surveys to track the spread of this pest, to help growers see if their regions are hotspots for infestation.

**Acknowledgements:**

Frank Peairs wrote the original document, which was updated by Punya Nachappa and Adam Osterholzer. Thanks to Frank Peairs, Scott Haley, Esten Mason, Tyler Benninghoven, Brad Erker, Assefa Gebre-Amlak, Jerry Johnson, and Sally Jones-Diamond for providing questions and reviewing earlier versions of this work.

**Additional Resources:** [BugwoodWiki](#)      [CSU Extension Factsheet on WSS](#)

**Further information:** [www.csuwheatentomology.com](http://www.csuwheatentomology.com)

## Colorado Wheat Stem Sawfly Survey

Adam Osterholzer and Dr. Punya Nachappa

The wheat stem sawfly (WSS) has been a pest of growing concern in Eastern Colorado since it was found in wheat fields in 2010 near New Raymer. Adult sawflies emerge from wheat stubble in spring while the crop is jointing and lay eggs over their flight period. This flight lasts 4 to 6 weeks. The eggs hatch and develop into larvae that chew the interior pith of the growing wheat stems. As the crop dries, the larvae create a chamber near the root crown and cut the stems, causing lodging before the crop is harvested.

A statewide survey of WSS infestation has been conducted since 2013 to determine the scope of infestations across the state. Changes to the pest’s range are also monitored. Approximately 100 sites are surveyed each year after the WSS flight has completed, with the number of sites collected from each county being proportional to the amount of wheat grown in the county. Collection sites are wheat fields directly adjacent to the previous year’s wheat stubble, and each site is a minimum of 10 miles apart. For each site surveyed, 100 tillers are collected and dissected to check for the presence of WSS larvae. The percentage of infested tillers is reported for each sample location, with low infestation being less than 10% of total tillers having WSS infestation, medium having between 10% and 50% infestation, and high infestation being any site with more than 50% of tillers infested.

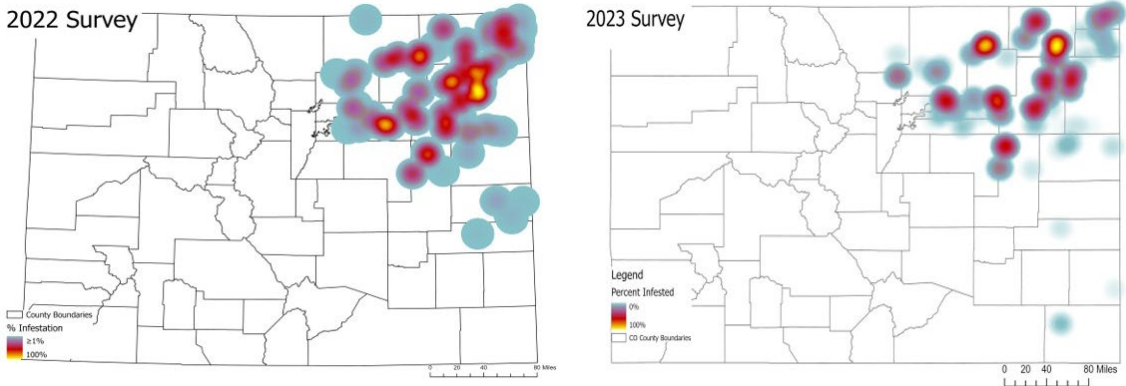
Throughout the study the proportion of infested sites has increased over the years (Table 1). The ratio of sites with medium (10%-50%) and high infestation (>50%) levels has also grown over this period.

For the 2023 survey, we observed a departure from this trend. There was a significant decrease in the proportion of sites with high infestation. We saw percentage increases for sites that had no infestation and low/moderate infestation. The high levels of precipitation in Colorado last year are the suspected cause of this reduced infestation.

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
<b>Not Infested</b>	56	50	32	81	42	46	41	33	44	34	17
<b>&lt;10%</b>	20	30	48	11	36	26	29	41	33	15	25
<b>10-50%</b>	13	15	16	4	13	12	22	20	20	24	19
<b>&gt;50%</b>	5	5	3	3	5	12	14	11	3	21	4
<b>Total Sites</b>	94	100	99	99	96	96	106	105	100	94	65

**Table 1: Number of Colorado wheat fields in each infestation category using WSS larval infestations from 2013 to 2023.**

The range of WSS increased in 2023, despite the decrease in overall infestation. For example, we found sawfly larvae in both Baca and Boulder counties, neither of which had WSS present in 2022. Additional results for 2021-2022 can be found at: [www.csuwheatentomology.com](http://www.csuwheatentomology.com).



**Figure 1: Percentage infestation of wheat fields sampled in 2022 and 2023 by WSS larvae.**

**Acknowledgements**

We would like to acknowledge the work of Dr. Frank Peairs, Terri Randolph, Erika Peirce and Darren Cockrell for their methodology development and authorship of the complete results. We would also like to thank Jeff Rudolph and Laura Newhard for their technical support. Numerous lab technicians have collected and processed these samples. We would like to acknowledge the wheat growers of Colorado and the Colorado Wheat Administrative Committee that provided their support for this project.

## The Economic Impact of Wheat Stem Sawfly on Colorado Wheat

Rebecca Wasserman-Olin, Dr. Rebecca Hill, Adam Osterholzer, and Dr. Punya Nachappa

Wheat stem sawfly, a pest of growing concern in Colorado, caused large yield losses to wheat production over the past few years. The insects lay eggs in the stems of wheat plants, often causing them to fall over and not be harvestable using typical methods. Farmers are trying different prevention and mitigation efforts to combat the pest and lessen the infestations. Based on the annual wheat stem sawfly survey conducted by the CSU Wheat Entomology Lab, a preliminary estimate of the economic impact was calculated, but more precise information was needed to understand the full economic impact of the pest. We updated that analysis using responses from a survey conducted in 2023. This survey asked farmers about their experience with wheat stem sawfly, different mitigation and prevention practices they employed, and what the impact of the pest was on their production.

During the summer of 2023, we collected 51 responses to the wheat stem sawfly survey used for analysis. The responses represented about 123,000 acres or 10% of Colorado's annual wheat production. Of the 51 individuals surveyed, 31 stated that they had at least one wheat stem sawfly infestation in the past 4 years. For the rest of the summary, we will focus on the responses of those with current sawfly infestations.

One of the goals of this survey was to understand what practices are currently being used to prevent and mitigate damage from sawflies. We asked what practices were currently being used and what practices they are not currently doing but are considering using in the future. The results do not comment on the effectiveness of the practices but are instead trying to understand the current methods and their economic implications.

<b>Practice</b>	<b>Currently Using</b>	<b>Considering Using</b>
Use Solid/Semi-Solid Varieties	71%	13%
Increase Diversification	58%	10%
Plant Larger Blocks of Wheat	42%	3%
Plant Less Wheat	-	42%
Increasing Swathing	42%	0%
Less No-Till	29%	0%
Avoiding Past Infested Areas	23%	3%
Edge Trap Crops	13%	0%
Increase Insecticide Use for Adult Sawflies	13%	0%

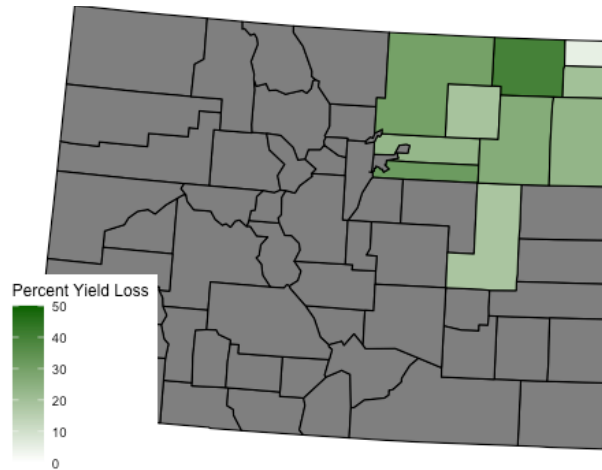
Table 1 shows that in regions with wheat stem sawflies, it is common to change agricultural practices to attempt to lessen the infestation. The most common practice is using semi-solid or solid-stem wheat varieties. This is followed by increasing diversification of planting rotations and planting larger wheat blocks. When asked what they would consider changing in the future, the most common answer was to plant less wheat.

In addition to the current practices, we also asked about other non-wheat impacts on agricultural systems. Specifically, we asked if they believed the wheat stem sawfly infestations were impacting other aspects of agriculture, including negatively impacting the next season's crop, increasing winter soil loss, and decreasing the soil's ability to hold moisture. As seen in Table 2, respondents confirmed that all three possible impacts are of concern, and about 30% do not believe they saw any of them.

Next Season's Crop	58%
Negatively Impact Soil Moisture	48%
Increase Winter Soil Loss	39%
None	32%

Using the information collected last summer and the Wheat Stem Sawfly Survey conducted by the CSU Wheat Entomology Lab, we estimated the lost wheat yield in Colorado due to wheat stem sawflies and its economic impact. The map to the right shows the estimated average yield loss by county in 2022. In total, the estimated value of the yield loss in 2022 was \$41 million. Using the same procedure, the value of the yield loss was estimated for 2019-22. The estimates presented in Table 3 are the direct losses from yield losses due to wheat stem sawfly infestations in Colorado.

**Figure 1: 2022 Estimated Yield Loss by County**



Year	Estimated Losses (rounded USD)
2019	\$23,900,000
2020	\$21,100,000
2021	\$37,800,000
2022	\$41,500,000

In addition to the direct losses from lower yields, there are ripple effects throughout the economy. The lower yields impact milling or other value-added businesses. It also impacts farmers' incomes in sawfly regions and how much income is spent in daily life. All these impacts are called indirect and induced effects and result from lower wheat

yields. When adding the yield loss (the direct effect) and the ripples through the state's economy (the indirect and induced effects) together, we estimate the total economic impact of wheat stem sawfly yield losses on the economy of the state of Colorado. We estimated that, on average, over the past four years, the total economic impact of yield losses due to wheat stem sawfly is \$70,050,650 on average per year.

These results are the preliminary stage of this research. Keep an eye out for reports and newsletters detailing the final results of this work over the next few months!

**Acknowledgments:**

We would like to thank all the farmers who took the survey last summer; this work would not be possible without you! We also thank the Colorado Wheat Research Foundation for funding this work.

# Risks, Management, and Effects of the *Fusarium* Pathogen on Winter Wheat

Robyn Roberts

## The *Fusarium* pathogen

Last year, an uncommon disease called Fusarium head blight (FHB, also known as head scab) appeared in Colorado wheat growing areas. This disease is caused by several species of fungi, but primarily *Fusarium graminearum* in cereals. The pathogen requires wet conditions to cause disease, so FHB is more common after significant, prolonged rainfall, much like what we encountered in late May-early June last year. *Fusarium* prefers warm temperatures (~75-85°F), but under extended wet conditions the fungus can be active at cooler temperatures. The fungus infects flowers, so the timing of the wet, warm weather with flowering last year provided optimal conditions for disease development.



**Figure 1.** Fusarium head blight (scab) symptoms on wheat. Note light brown spikelets contrasted against green heads.

## Fusarium head blight

Symptoms of FHB include individual bleached spikelets on green heads (**Figure 1**). Pinkish-orange fungal spores may also be visible. Importantly, not only does FHB cause yield and quality losses, but the pathogen also produces a mycotoxin called deoxynivalenol (DON) which is toxic to people and livestock. Elevated levels of mycotoxin can accumulate even under minor disease conditions, and high numbers of damaged, wrinkled, or ‘tombstone’ grains may indicate high levels of mycotoxin. The spores produced from the initial infection can produce additional spores that infect other heads. Significant disease problems can therefore occur if wheat stands are uneven with late flowering tillers.

Infected corn or wheat residue can be a significant source of inoculum, and due to the high levels of FHB last year there is likely significant inoculum present in the environment to start disease this year. Managing residue and applying a fungicide that is labeled for FHB at early flowering are the best control methods, in addition to genetic resistance. Fungicide efficacy tables may be found at the Crop Protection Network Site:

<https://cropprotectionnetwork.org/publications/fungicide-efficacy-for-control-of-wheat-diseases>.

Additionally, colleagues at the Fusarium Scab Initiative have developed a risk assessment tool to predict the likelihood of FHB to aid in decision making, available at <https://tinyurl.com/2jcvcze9>.

### **Fusarium root and crown rot**

Planting FHB-infected seed from 2023 can also lead to root rot disease. Seeds can be infected with FHB with or without showing any symptoms, which also emphasizes the importance of planting clean seed. If infested seed is planted, root rot and crown rot may develop, as the fungus emerges and infects wheat plants directly from the seed (**Figure 2**). Prolonged drought stress coupled with high soil temperature in the fall promotes early disease development, so conditions last fall were favorable for disease development this spring. Once root and crown rot appears, there is no effective treatment since fungicides won't work once there are disease symptoms. Therefore, prevention is the best method for disease control, including using certified, clean, high-quality seed treated with fungicide. Since corn and other cereals are hosts of *Fusarium*, it is also important to implement crop rotation so that the inoculum does not build up in residue.



**Figure 2.** Fusarium root and crown rot symptoms. Note the pink stem, poor root development, and the brown, rotted roots and crown. *Left Photo: Tyler Benninghoven.*

## Increasing Incidence and Severity of *Triticum mosaic virus* Disease

Lukas Migliano, Matt West, and Robyn Roberts

Viruses cause major economic losses to winter wheat. In Colorado, the two most common and agronomically significant viruses are *Triticum mosaic virus* (TriMV) and *wheat streak mosaic virus* (WSMV). Symptoms of plants infected with either of these two viruses include chlorotic streaks, mosaics, speckles, stunting, and early maturation (**Figure 1**). A co-infection of these two viruses leads to more severe symptoms and overall losses.

### Virus Incidence

Historically, WSMV has been the predominant virus in Colorado wheat crops. When TriMV was first reported, it was seen mostly in co-infections with WSMV. However, since 2021, the Roberts lab at Colorado State University has observed an increasing number of samples infected with TriMV only, and a decreasing number of samples with WSMV (**Table 1**).

### Virus Transmission

The wheat curl mite (WCM, *Aceria tosichella*) vectors both TriMV and WSMV. It can pick up the viruses from infected plants during feeding and transfer them to healthy ones. Weather impacts mite activity which therefore impacts disease transmission. During periods of hot, dry weather, the wheat curl mite actively seeks out water and moves more frequently between plants. Additionally, strong winds can blow the mites further distances and spread diseases. Conversely, cooler temperatures and rainfall tend to decrease the WCM activity and suppress disease spread.



**Figure 1.** Wheat plants co-infected with WSMV and TriMV.

### Virus Management and Prevention

In addition to planting varieties resistant to WSMV and the WCM, volunteer wheat management is essential. The WCM overwinters inside volunteers or weeds left in fields between harvest and planting. The continuation of the ‘green bridge’ allows mites to survive from one field season to the next, feeding on the next season’s plants and transmitting viruses they acquired.

**Table 1.** TriMV incidence is increasing in field-collected, virus symptomatic samples sent to the Roberts lab for diagnostics.

Year	Total # of Samples	WSMV	TriMV	WSMV+TriMV	% of Samples with TriMV Only
2021	32	4	1	3	3%
2022	6	0	0	5	0%
2023	17	0	16	1	94%
2024 (as of 5/21)	8	1	6	1	75%

## Soil Carbon in Diversified Dryland Cropping Systems

Carolita Landers, Meagan Schipanski, Catherine Stewart, Grace Miner, Steven Fonte

Soil organic matter (SOM) is a critical component of soil health and is proven to support a range of soil functions including productivity and yield stability. Diversifying dryland cropping systems and reducing time of summer fallow have been shown to improve soil organic matter in the top 20 cm of the soil profile relative to traditional wheat-fallow cropping systems, due to different amounts of crop residue returned to the soil (Rosenzweig et al., 2018). However, the effects on carbon and nitrogen in deeper layers of the soil profile remain unclear. Deep soil organic carbon (SOC) is gaining more attention from policy makers and those involved with emerging carbon markets for its potential role in climate change mitigation, especially given that SOC is thought to be more stable at depth.

In 2021 we sampled the Dryland Agroecosystems Project for its 36<sup>th</sup> year and final timepoint. This project was established in 1985, spanning across a climate gradient from Sterling to Stratton to Walsh, Colorado, to examine the effects of varying climate, topography, and cropping system on production, water-use efficiency, and a range of soil chemical and physical properties (Peterson et al., 1993). We sampled to a depth of 80 cm to understand how soil carbon deposition varies at depth across cropping systems varying in diversity and intensity. The cropping systems sampled were wheat-fallow (WF), wheat-corn-fallow (WCF), forage sorghum-hay millet (Fs-HM), wheat-forage sorghum-hay millet (W-Fs-HM), OPP (opportunity or continuous cropping with no set rotation), and perennial grass representing a Conservation Reserve program (CRP) mixture.

Our results indicate that crop rotation does not significantly affect SOC beyond 20 cm depth. At



the same time, significant interaction between slope position and depth ( $p < 0.001$ ) suggests that SOC is higher at shallower depths in the toe slope, but tends to be distributed more deeply in the summit and side slope positions. There was also a site by depth interaction ( $p < 0.002$ ),

indicating variability in SOC with depth based on soil type and PET, with Stratton showing the highest SOC levels throughout the soil profile and Walsh, Colorado, exhibiting the lowest SOC accumulation down to 80 cm. On March 28<sup>th</sup>, 2024 we hosted a symposium to commemorate 36 years of the Dryland Agroecosystems Project. We reviewed some of the key research it has produced, honored the several people involved, and discussed the future of research and outreach serving dryland producers in Colorado. More information and a list of publications for the DAP project can be found here: [drylandag.org](http://drylandag.org).

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