Technical Report **TR24-2 January 2024**

Colorado State University

Agricultural Experiment Station

College of Agricultural Sciences | Department of Soil and Crop Sciences | Plainsman Research Center | Extension

Plainsman Research Center 2023 Research Reports

For a full list of authors for this research report refer to the personnel with projects page

Kevin Larson, Superintendent and Research Scientist II

Plainsman Research Center
Box 477
42790 Hwy 160
Walsh, CO 81090

(719) 324-5643

Kevin.Larson@colostate.edu

This current and past research reports of the Plainsman Research Center can be downloaded from the publication list at the Colorado Agricultural Experiment Station:

http://aes.agsci.colostate.edu/publications/caes-publications-list/caes_pub_list/

Funded by the Colorado Agricultural Experiment Station,

Crop Management and Sorghum Improvement, USDA, NIFA Project No. COL00654

in cooperation with the Plainsman Agri-Search Foundation

This 50th Anniversary of the Plainsman Research Center booklet is dedicated to:

All the Former and Current Plainsman Agri-Search Foundation Board Members, Especially the Original Founding Board Members in 1974:

Bill Wright (President), Bernard Neill (Vice President), Dean Nichols, Dick Patterson (Secretary/Treasurer), John Clark, Larry Forgey, Terry Cournkamp, Greg Lohrey, Greg Thompson, Lynn Bitner, Jr., Lawrence Bitner, Andy Harper, Howard Schmidt, Herbert Mann, and Edward Langin

We honor these Founding Fathers and all former and current Plainsman Board Members that created and developed the Plainsman Agri-Search Foundation.

From the Beginning, to the Present, Through the Future

The Research and Grower Association Model

The Neill Foundation Board:

James Hume, Corwin Brown, Randy Hutches, Pat Cooper, Dawn Rodarmel, and Todd Rose

The grant from the Neill Foundation will provide efficient transport of Plainsman's grain crops from both our research and bulk fields. In addition, this grant will allow us to precisely and uniformly plant row crops, including both small research plots and larger strip plots. This funding helps support agronomic research studies that are the first step to create cost effective change, helping growers become economically viable and sustainable stewards of the land. Thank you.

The spirit of Bernard lives on through your generous funding decisions. We truly appreciate your continued support.

Plainsman Research Center, 2023 Research Reports

Content | Page

2023 Plainsman Research Center Staff and Personnel with Projects

Kevin Larson (719) 324-5643	Superintendent and Research Scientist II, Plainsman Research Center, Agricultural Experiment Station, Colorado State University.
Brett Pettinger (719) 324-5643	Research Associate III, Plainsman Research Center, Agricultural Experiment Station, Colorado State University.
Perry Jones (719) 324-5643	Technician III, Plainsman Research Center, Agricultural Experiment Station, Colorado State University.
Zane Jenkins (719) 324-5643	Manage and Research Associate IV, Plainsman Research Center, Agricultural Experiment Station, Colorado State University.
Sally Jones-Diamond (970) 491-1914	Crop Testing Program Director and Extension Specialist, Dept. of Soil and Crop Sciences, Colorado State University.

2023 Climatological Summary
Plainsman Research Center

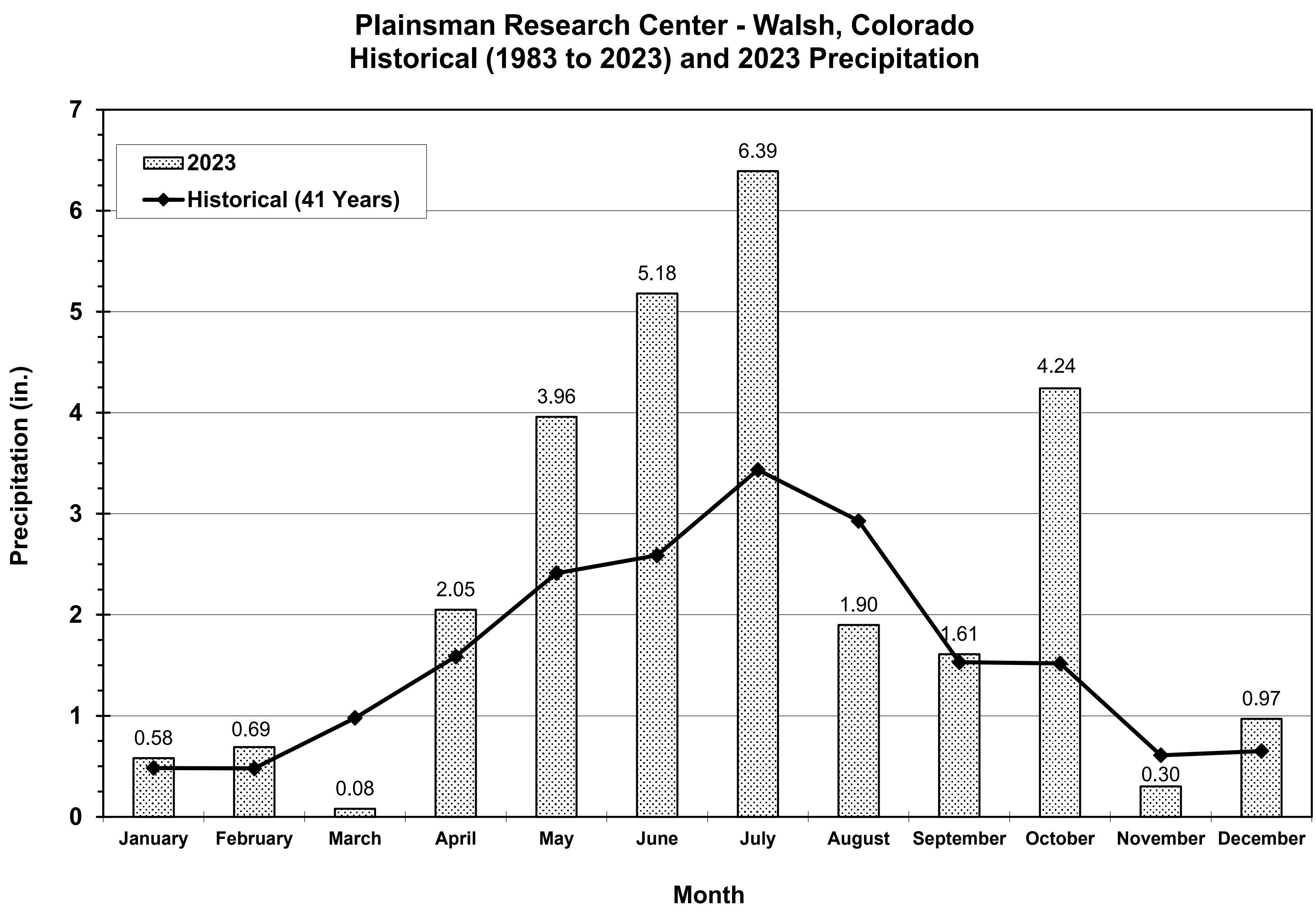
Month	Temperature Max F	Min F	Max. Mean F	Min. Mean F	Precip. In.	Greatest Day of Precip-atation	Snow-Fall In.	Greatest Snow Depth In.	Average Soil Temp.	Evapor-ation In.
Jan.	68	-4	45.6	18.9	0.58	0.38	5.60	4.00	33.61	
Feb.	75	2	51.0	18.9	0.69	0.25	3.30	2.30	34.11	
Mar.	80	11	56.7	26.2	0.08	0.06	0.80	0.80	42.39	
Apr.	93	16	69.5	35.8	2.05	0.77	T	T	56.07	4.24
May	93	44	77.8	51.4	3.96	1.07	0.00	0.00	63.29	8.05
Jun.	98	49	82.4	56.3	5.18	1.10	0.00	0.00	68.80	7.12
Jul.	103	53	90.8	62.5	6.39	3.36	0.00	0.00	76.26	9.45
Aug.	101	54	91.9	61.7	1.90	1.12	0.00	0.00	78.10	12.14
Sept.	101	47	87.0	54.8	1.61	0.98	0.00	0.00	71.27	10.52
Oct.	90	13	71.9	40.2	4.24	3.87	T	T	58.03	3.50
Nov.	86	12	60.6	29.4	0.30	0.22	2.50	2.50	46.63	
Dec.	74	14	51.4	25.1	0.97	0.77	2.70	2.50	37.29	
Total			**69.7**	**40.09**	**27.95**		**14.90**			**55.02**

*** NOTE: Evaporation read April 15 through October 15th.
Wind velocity is recorded at two feet above ground level.
Total evaporation from a four foot diameter pan for the period indicated.

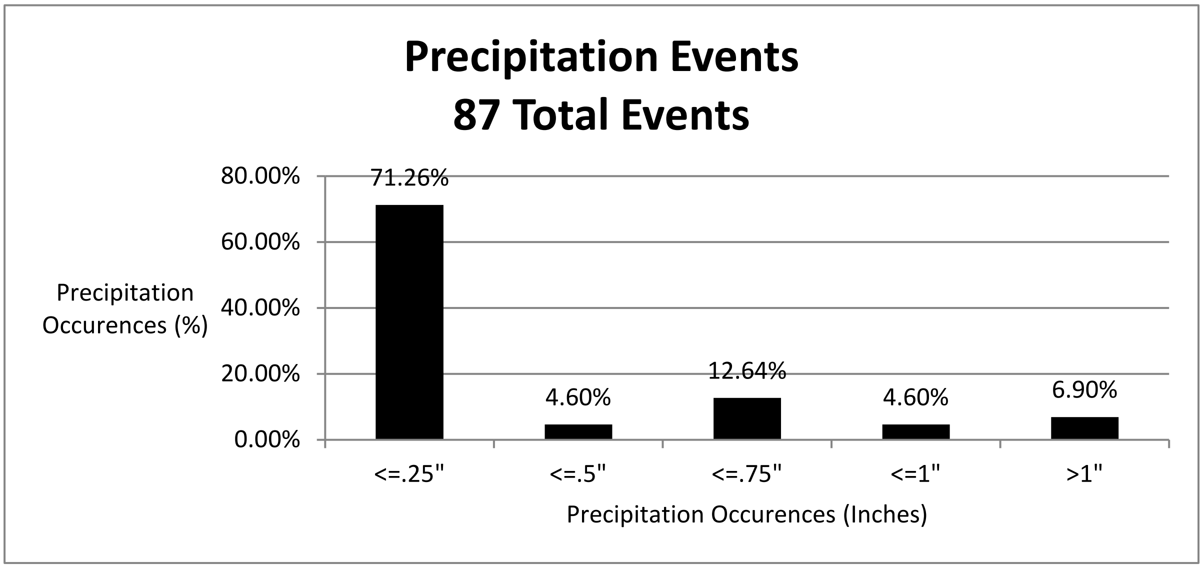
	2023	2022
Highest Temperature:	103 on July 18th	109 on July 17th
Lowest Temperature:	-4 F Jan 31st	-9 F Feb. 4, Dec. 22, 23
Last freeze in spring:	27 F on April 22nd	32 F on May 1st
First freeze in fall:	31 F on Oct. 14th	30 F on Oct. 17th
Frost free season:	175 frost free days	169 frost free days
Avg. Precip for 41 yrs:	19.2	

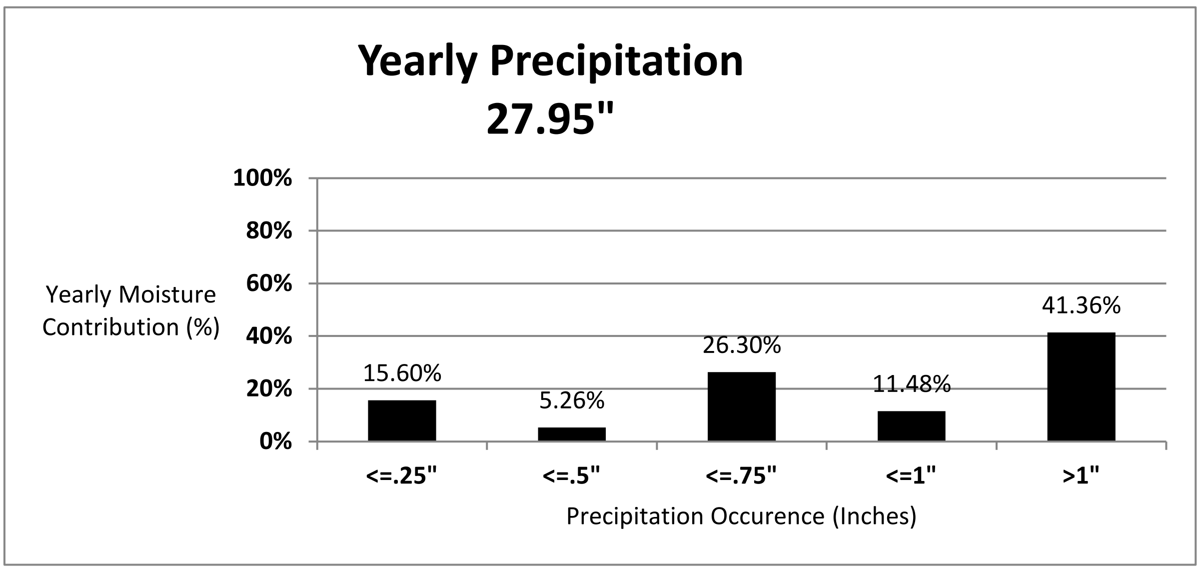
Maximum Wind:

Jan.	44 mph on 12th	July.	50 mph on 11th
Feb.	47 mph on 16th	Aug.	37 mph on 26th
Mar.	43 mph on 31st	Sept.	31 mph on 30th
Apr.	49 mph on 20th	Oct.	44 mph on 3rd
May	44 mph on 11th	Nov.	38 mph on 21st
Jun.	51 mph on 27th	Dec.	44 mph on 25th



Plainsman Research Center - Walsh, Colorado
Historical (1983 to 2023) and 2023 Precipitation
2023
Historical (41 Years)
Precipitation (in.)
0
1
2
3
4
5
6
7
0.58
0.69
0.08
2.05
3.96
5.18
6.39
1.90
1.61
4.24
0.30
0.97
January
February
March
April
May
June
July
August
September
October
November
December
Month


Precipitation Events
87 Total Events
80.00%
60.00%
40.00%
20.00%
0.00%
Precipitation
Occurences (%)
71.26%
4.60%
12.64%
4.60%
6.90%
<=.25"
<=.5"
<=.75"
<=1"
>1"
Precipitation Occurences (Inches)


Yearly Precipitation
27.95"
100%
80%
60%
40%
20%
0%
Yearly Moisture
Contribution (%)
15.60%
5.26%
26.30%
11.48%
41.36%
<=.25"
<=.5"
<=.75"
<=1"
>1"
Precipitation Occurence (Inches)

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 ft2 (except the Fort Collins irrigated trial, which was 80 ft2). 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 5

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 was not an issue until 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.

COLORADO STATE UNIVERSITY EXTENSION

Crops Testing www.csucrops.com

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

Brand/Source	Market Class	Variety[a]	2023 Multi-Location Average: Yield[b]	Yield	Test Weight	Protein[c]	2023 Individual Trial Yield[b]: Burlington	Sheridan Lake	Walsh
			bu/ac	percent of average	lb/bu	percent	bu/ac	bu/ac	bu/ac
PlainsGold	**HWW**	Monarch	*67.0*	*114%*	*57*	*11.1*	**103.0**	43.5	54.5
Kansas Wheat Alliance	**HWW**	KS Big Bow	*64.0*	*109%*	*57*	*11.4*	99.5	40.5	52.0
PlainsGold	**HWW**	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	**HWW**	Valley	*62.3*	*106%*	*57*	*11.2*	**103.0**	38.0	46.0
Limagrain	HRW	LCS Steel AX	*61.7*	*105%*	*58*	*11.9*	**107.0**	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	**48.5**	53.5
PlainsGold	HRW	Crescent AX	*58.7*	*100%*	*57*	*11.3*	99.5	31.0	46.0
PlainsGold	**HWW**	Breck	*58.6*	*100%*	*57*	*11.4*	77.0	38.5	**60.5**
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	**HWW**	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	**HWW**	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
Experimentals									
Colorado State University exp.	HRW	CO19D087R	*67.1*	*115%*	*55*	*11.3*	**107.0**	40.5	54.0
Colorado State University exp.	HRW	CO19D304R	*65.2*	*111%*	*56*	*10.8*	92.5	**45.5**	**58.0**
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.	**HWW**	CO19S129W	*63.0*	*107%*	*57*	*11.4*	**103.0**	38.5	47.0
Colorado State University exp.	**HWW**	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.	**HWW**	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.	**HWW**	CO19S135W	*58.1*	*99%*	*56*	*11.8*	**103.5**	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
		Average	***58.6***	***100%***	***56***	***11.3***	**91.0**	**37.0**	**48.0**
		[d]LSD (0.30)					5.0	3.5	3.0
		[d]LSD (0.05)					9.0	7.0	5.5

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

[b]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.

[c]Protein adjusted to 12% moisture content and from Burlington trial in 2023.

[d]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).

COLORADO STATE UNIVERSITY
EXTENSION

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

Crops Testing
www.csucrops.com

			2-Year Average[a]					
Variety[b]	Brand/Source	Market Class[c]	Yield	Yield	Test Weight	Test Weight	Plant Height	Protein
			bu/ac	% trial average	lb/bu	% trial average	in	percent
Monarch	PlainsGold	**HWW**	67.0	111%	58	101%	26	11.4
CO18D007W	Colo. State University exp.	**HWW**	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	**HWW**	62.9	105%	58	101%	28	11.8
Whistler	PlainsGold	HRW	62.5	104%	56	98%	30	11.2
Snowmass 2.0	PlainsGold	**HWW**	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	**HWW**	60.0	100%	57	100%	26	12.1
Byrd CL Plus	PlainsGold	HRW	59.8	99%	57	99%	30	11.5
Breck	PlainsGold	**HWW**	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	**HWW**	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
		Average	**60.1**	**100%**	**57**	**100%**	**28**	**11.7**

[a]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).

[b]Varieties ranked from highest to lowest average 2-year yield.

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

COLORADO STATE UNIVERSITY EXTENSION

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

Crops Testing www.csucrops.com

Variety[b]	Brand/Source	Market Class[c]	3-Year Average[a] Yield	Yield	Test Weight	Test Weight	Plant Height	Protein
			bu/ac	% trial average	lb/bu	% trial average	in	percent
Monarch	PlainsGold	**HWW**	62.7	107%	57	100%	28	11.6
Snowmass 2.0	PlainsGold	**HWW**	61.2	104%	57	100%	28	12.2
CO18D007W	Colo. State University exp.	**HWW**	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	**HWW**	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
		Average	**58.5**	**100%**	**57**	**100%**	**30**	**12.2**

[a]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).

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

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

2023 Dryland Winter Wheat
Variety Performance Trial at Walsh

Variety	Brand/Source	Market Class	Grain Yield[a]	Test Weight
			bu/ac	lb/bu
Breck	PlainsGold	**HWW**	**60.5**	**58**
CO19D304R	Colorado State University exp.	HRW	**58.0**	**58**
CO20D108R	Colorado State University exp.	HRW	56.5	**58**
Canvas	PlainsGold	HRW	55.0	**58**
Monarch	PlainsGold	**HWW**	54.5	57
Avery	PlainsGold	HRW	54.5	57
CO19D087R	Colorado State University exp.	HRW	54.0	57
CO18D007W	Colorado State University exp.	**HWW**	54.0	57
CO19410R	Colorado State University exp.	HRW	54.0	**58**
MS Maverick	Meridian Seeds	HRW	53.5	**58**
Whistler	PlainsGold	HRW	53.5	57
Snowmass 2.0	PlainsGold	**HWW**	53.0	**58**
CO200037R	Colorado State University exp.	HRW	52.5	**59**
Kivari AX	PlainsGold	HRW	52.0	56
KS Big Bow	Kansas Wheat Alliance	**HWW**	52.0	**58**
Hatcher	PlainsGold	HRW	51.5	57
CP7017AX	CROPLAN	HRW	51.0	**58**
Guardian	PlainsGold	HRW	50.5	**58**
CO19S053R	Colorado State University exp.	HRW	49.5	**58**
CO19S085W	Colorado State University exp.	**HWW**	49.0	57
Sunshine	PlainsGold	**HWW**	49.0	57
CO18D297R	Colorado State University exp.	HRW	48.0	57
Windom SF	PlainsGold	**HWW**	47.5	**58**
Byrd	PlainsGold	HRW	47.0	**58**
CO19S129W	Colorado State University exp.	**HWW**	47.0	57
Valley	Frenchman Valley Coop	**HWW**	46.0	57
Crescent AX	PlainsGold	HRW	46.0	57
Brawl CL Plus	PlainsGold	HRW	45.5	57
Amplify SF	PlainsGold	HRW	45.0	57
LCS Steel AX	Limagrain	HRW	45.0	**59**
CO19393R	Colorado State University exp.	HRW	45.0	**58**
AP Roadrunner	AgriPro	HRW	44.5	57
CO18035RA	Colorado State University exp.	HRW	43.5	57
CO18042RA	Colorado State University exp.	HRW	42.0	57
Ray	PlainsGold	HRW	42.0	56
CO19S135W	Colorado State University exp.	**HWW**	39.5	57
Byrd CL Plus	PlainsGold	HRW	37.0	57
Langin	PlainsGold	HRW	36.0	57
Fortify SF	PlainsGold	HRW	34.5	57
LCS Atomic AX	Limagrain	HRW	10.5	-
		Average	**47.5**	**57**
		[b]LSD (0.30)	3.0	1
		[b]LSD (0.05)	5.5	1
		Coeffecient of Variation (CV)	9.4	

[a]Yield adjusted to 12% moisture and varieties ranked by yield (highest to lowest). Variety yields in bold are in the top LSD group (0.30).

[b]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).

Site Information

Collaborator:	Plainsman Research Center (Kevin Larson, Brett Pettinger, and Perry Jones)
Harvest date:	July 17, 2023
Planting date:	September 21, 2022
Soil Type:	Wiley loam
GPS Coordinates:	37.43116, -102.31043
Trial Comments:	Planted 2" deep into moisture. Fall emergence was acceptable and there was 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 severe stripe rust pressure in late June, trial was not sprayed. LCS Atomic AX had severe shattering and lodging from high winds. Radar estimates showed the trial received 11.1" of precipitation and 4,274 growing degree-days (GDD) (base 32°F) from January 1st through July 16th.

2023 Dryland Winter Wheat
Variety Performance Trial at Sheridan Lake

Variety	Brand/Source	Market Class	Grain Yield[a]	Test Weight	Plant Height
			bu/ac	lb/bu	in
Whistler	PlainsGold	HRW	**48.5**	54	31
CO19D304R	Colorado State University exp.	HRW	**45.5**	52	30
Monarch	PlainsGold	**HWW**	43.5	**56**	23
CO19393R	Colorado State University exp.	HRW	43.0	52	27
CO18D297R	Colorado State University exp.	HRW	41.0	**55**	27
CP7017AX	CROPLAN	HRW	41.0	**56**	22
CO18D007W	Colorado State University exp.	**HWW**	40.5	**55**	25
CO19D087R	Colorado State University exp.	HRW	40.5	53	26
KS Big Bow	Kansas Wheat Alliance	**HWW**	40.5	54	23
Canvas	PlainsGold	HRW	40.0	54	29
CO19410R	Colorado State University exp.	HRW	40.0	54	28
Windom SF	PlainsGold	**HWW**	40.0	53	22
CO20D108R	Colorado State University exp.	HRW	39.5	54	29
Breck	PlainsGold	**HWW**	38.5	**56**	23
CO19S129W	Colorado State University exp.	**HWW**	38.5	**56**	26
CO19S085W	Colorado State University exp.	**HWW**	38.0	**55**	28
Valley	Frenchman Valley Coop	**HWW**	38.0	**56**	30
Hatcher	PlainsGold	HRW	37.5	53	24
Kivari AX	PlainsGold	HRW	37.5	53	26
CO19S053R	Colorado State University exp.	HRW	37.0	**55**	25
MS Maverick	Meridian Seeds	HRW	36.5	52	29
Amplify SF	PlainsGold	HRW	36.0	53	31
CO200037R	Colorado State University exp.	HRW	36.0	54	24
Guardian	PlainsGold	HRW	36.0	**55**	26
Snowmass 2.0	PlainsGold	**HWW**	35.5	54	23
CO18035RA	Colorado State University exp.	HRW	35.0	54	24
CO18042RA	Colorado State University exp.	HRW	35.0	54	22
Byrd CL Plus	PlainsGold	HRW	34.5	53	30
Byrd	PlainsGold	HRW	33.5	**55**	28
Ray	PlainsGold	HRW	33.5	48	28
LCS Steel AX	Limagrain	HRW	33.0	54	26
Avery	PlainsGold	HRW	32.0	53	27
Brawl CL Plus	PlainsGold	HRW	32.0	54	25
Fortify SF	PlainsGold	HRW	32.0	53	26
CO19S135W	Colorado State University exp.	**HWW**	31.5	53	28
Langin	PlainsGold	HRW	31.5	54	26
Crescent AX	PlainsGold	HRW	31.0	**55**	25
Sunshine	PlainsGold	**HWW**	31.0	54	22
AP Roadrunner	AgriPro	HRW	22.5	52	24
LCS Atomic AX	Limagrain	HRW	21.5	53	24
		Average	**36.5**	**54**	**26**
		[b]LSD (0.30)	3.5	1	
		[b]LSD (0.05)	7.0	2	
		Coeffecient of Variation (CV)	13.1		

[a]Yield adjusted to 12% moisture and varieties ranked by yield (highest to lowest). Variety yields in bold are in the top LSD group (0.30).

[b]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).

Site Information

Collaborator:	Scherler Farms
Harvest date:	July 14, 2023
Planting date:	September 5, 2022
Soil Type:	Wiley loam
GPS Coordinates:	38.53187, -102.43544
Trial Comments:	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. Radar estimates showed the trial received 14.5" of precipitation and 3,719 growing degree-days (GDD) (base 32°F) from January 1st through July 14th.

Dryland Wheat Strips for Forage and Grain Yield at Walsh, 2023

Kevin Larson, Brett Pettinger, and Perry Jones

Purpose: To determine which wheat varieties are best suited for dual-purpose forage and grain production in Southeastern Colorado.

Materials and Methods: Thirteen wheat varieties were planted on September 28, 2022 at 50 lb seed/a in 20 ft. by 800 ft. strips with two replications. We stream applied 50 lb N/a and seedrow applied 5 gal/a of 10-34-0 (20 lb P_2O_5, 6 lb N/a). Express 0.4 oz/a, dicamba 2oz/a, and 2,4-D ester 0.38 lb/a was sprayed for weed control. Two 2 ft. by 2.5 ft. forage samples were taken at jointing (April 12) and at boot (May 5). We measure the forage for fresh weight, oven-dried the samples, and recorded dry weight at 15% moisture content. We harvested the plots on July 19, 2023 with a self-propelled combine equipped with a HarvestMaster H2 automated weighing system. Grain yields were adjusted to 12% seed moisture content.

Results: Grain yields were above average, despite the dry conditions throughout the fall and winter, and because of the wet May. The average grain yield for the 13 varieties of this study was only 36.2 bu/a. The yield separation between the highest yielding variety, WB4792, and the lowest yielding variety, Langin, was 29.2 bu/a. The low yield of Langin was due to shattering from a high wind event after seed maturation. Windom SF had the highest forage yield at jointing and Avery had the highest yield at boot. Four varieties: Avery, Canvas, Guardian, and WB4792 had above average two-year grain yield averages compared to the other wheat tested. Canvas was the only variety that produced above average three-year average grain yields.

Discussion: This year we chose Avery as the best overall dual-purpose wheat variety of the 13 wheat varieties tested. Avery produced the sixth highest grain yield, the third highest forage yield at jointing, and the highest forage yield at boot. Canvas would be a good dual-purpose wheat choice if forage at jointing is not a priority. Canvas produced the highest forage yield at boot, below average forage yield at jointing, and the second highest grain yield.

Grain yield averages for this trial during the last three harvest years have been above our long-term average this year (36 bu/a), slightly below our long-term average in 2021 (25 bu/a) and below our long-term average in 2020 (12 bu/a). Canvas is the only wheat variety tested that had above average grain yields each of the last three production seasons. Producing above average yields in response to our wide-ranging seasonal conditions suggests that Canvas can handle our weather extremes. We recommend including Canvas as part of your wheat variety selections to produce above average grain yields to counter our diverse weather conditions.

Table .Dryland Wheat Strips, Forage and Grain Yield at Walsh, 2023.

Variety	Jointing		Boot		Plant	Test	Grain	Grain
	Fresh Wt.	Dry Wt.	Fresh Wt.	Dry Wt.	Height	Weight	Protein	Yield
	------------------------lb/a------------------------				in	lb/bu	%	bu/a
WB4792	2950	1126	10814	2745	26	63.8		51.5
Canvas	2678	1075	11206	3189	24	62.0		45.3
Guardian	3603	1406	9266	2486	26	62.8	13.6	40.9
T158	3541	1348	10309	2975	23	60.9		39.2
KS Dallas	1976	795	7599	2078	24	61.5		38.8
Avery	3825	1495	12363	3574	25	59.8		38.1
Windom SF	3798	1571	10782	2953	23	61.0	12.8	34.6
Whistler	3075	1139	8121	2458	27	58.9	12.9	34.5
Joe	3970	1549	10728	2915	25	60.8		34.4
Kivari AX	2354	953	9133	2633	23	58.2	12.7	31.9
Fortify SF	2410	974	9392	2628	27	59.7	13.0	29.8
Amplify SF	1575	633	7051	1956	26	59.1	13.3	29.7
Langin	3655	1359	11227	3140	23	59.6		22.3
Average	3032	1186	9845	2749	25	60.6		36.2
LSD 0.20	605.0	388.2	1851.4	554.1				4.75

Planted: September 28, 2022; 50 lb seed/a; 5 gal/a 10-34-0.
Harvested: July 19, 2023; harvest area: 15 ft. by 1114 ft.
Jointing sample taken April 12, 2023.
Boot sample taken May 5, 2023.
Wet Weight is reported at field moisture.
Dry Weight is adjusted to 15% moisture content.
Grain yields adjusted to 12% grain moisture content.
The low yield of Langin was due to shattering from a high wind event after seed maturation.

Table .--Summary: Dryland Wheat Strips Variety Performance Tests at Walsh, 2020, 2021, and 2023.

		Grain Yield					Yield as % of Trial Average				
Firm	Variety	2020	2021	2023	2-Year Avg	3-Year Avg	2020	2022	2023	2-Year Avg	3-Year Avg
		----------------bu/a----------------					------------------%------------------				
CSU PlainsGold	Avery	11	26	38	32	25	89	104	105	103	100
CSU PlainsGold	Canvas	14	30	45	38	30	113	120	124	121	119
CSU PlainsGold	Fortify SF	--	28	30	29	--	--	112	83	94	--
CSU PlainsGold	Guardian	--	25	41	33	--	--	100	113	106	--
CSU PlainsGold	Langin	9	30	22	26	20	73	120	61	84	81
CSU PlainsGold	Whistler	16	24	35	30	25	129	96	97	95	100
KSU Wheat Alliance	Joe	13	28	34	31	25	105	112	94	100	100
Westbred	WB4792	--	25	52	39	--	--	100	144	124	--
Average		12	25	36	31	25					

Grain Yields were adjusted to 12.0 % seed moisture content.

No wheat yields recorded for 2020 due to drought.

Single Disc Drill and Hoe Drill Comparison for Wheat Production

Brett Pettinger, Perry Jones, and Kevin Larson

There are two commonly used, deep-placement, wheat seeding systems in our area: air seeder/single disc drill with 10 in. spacings and hoe drill with 12 in. spacings. There are advantages for both systems. The advantage for the air seeder/single disc drill is that it does not disturb the soil and leaves the residue intact for less evaporation and greater precipitation interception. The advantage for the hoe drill is that it creates seed furrows for some soil protection and some snow catch. We conducted this study because growers inquired if there might be a yield advantage between the planting systems.

Materials and Methods

We used a no-till, wheat-fallow site for this study. We compared a 24-row, John Deere 1590 drill with 10 in. row spacings and an eleven-shank (cut down from a 40 ft. drill), Crustbuster 3400 with 12 in. row spacings. For both treatments, we surface applied liquid 32-0-0 in streams 20 in. apart at 50 lb N/a. We applied 20 lb/a of P_2O_5 as a dry fertilizer/wheat seed mix for the hoe drill and as a liquid seedrow applied fertilizer for the single disc drill. We planted Avery at 50 lb/a on September 28, 2022 for the single disc drill and October 5, 2022 for the hoe drill. Grain yields were average to above average, despite the dry conditions throughout the fall and winter, and because of the wet May.. For weed control, we applied Express 0.4 oz/a, dicamba 2oz/a, and 2,4-D ester 0.38 lb/a. We harvested the 15 ft. centers of the 800 ft. long wheat plots on July 19, 2023 with a self-propelled combine equipped with an automated weighing system. Grain yields were adjusted to 12% seed moisture content.

Results and Discussion

There was a significant grain yield difference between the single disc drill and the hoe drill. The dryland wheat planted with the single disc drill on 10 in. row spacing produced 11 bu/a more than the hoe drill on the 12 in. The grain from the single disc drill was 0.3% drier and had 0.7 lb/bu better test weight than the hoe drill. In late spring, we noted that plant stands were more consistent with the single disc drill than the hoe drill, which, no doubt, contributed to higher yield with the single disc drill. This is the first harvest year since we began this study in 2020 that there was a significant yield difference between the single disc drill and the hoe drill. In 2020, the single disc drill yielded 2.2 bu/a more than the hoe drill, but it was not significantly different. In 2021, the drill treatments again produced non-significant yield difference with just 0.2 bu/a separating them. There was no wheat harvested in this study in 2022. This year the single disc drill produced 11 bu/a more than the hoe drill.

Narrow Row Single Disc and Hoe Drill Comparison for Wheat Production, Walsh, 2023.

Planter Type	Row Spacing Arragement	Wheat Yield	Test Weight	Moisture Content	Plant Height
		bu/ac	lb/bu	%	in
Single Disc	10 in. single disc	39.4	59.5	10.3	25
Hoe Drill	12 in. hoe openers	28.4	58.8	10.6	25
Average		33.9	59.2	10.5	25
LSD (0.20)		6.0			

Planted: single disc on September 28, 2022 and hoe drill October 5, 2022.
Avery at 50 lb/acre for both drills.
Harvested: July 19, 2021.
Drills: John Deere 1590 single disc drill; Crustbuster 3400 hoe drill.

2023 Dryland Grain Sorghum Hybrid Performance Trial at Walsh

Brand	Hybrid	Grain Yield[a]	Yield	2-Year Average Yield	Test Weight	Plant Lodging	Emerged Plant Population	Plant Height	50% Bloom	GDD[b]	50% Mature	Maturity Group[c]	Grain Color
		bu/ac	% of test average	bu/ac	lb/bu	percent	plants/ac	in	days after planting		days after planting		
Dekalb	DKS29-28	**51.6**	124	63	58	10	31,400	40	63	1491	107	E	Bronze
Dekalb	DKS38-16	**49.9**	120	67	60	15	32,500	46	72	1728	117	M/ME	Bronze
Sorghum Partners	SP 30A30 DT	**48.2**	116	--	58	15	37,200	41	65	1542	109	E	Bronze
Alta Seeds	ADV G2106	**46.0**	111	--	60	12	36,000	44	66	1563	110	ME/M	Red
Dekalb	DKS29-95	**45.2**	109	62	58	5	34,500	41	64	1517	107	E	Dark Red
Sorghum Partners	SP 31A15	**45.0**	108	--	58	7	38,300	41	65	1542	109	E	Bronze
Sorghum Partners	SP 65M60	**44.8**	108	--	60	4	32,500	39	69	1637	114	ME/M	Bronze
Sorghum Partners	SP 45A45 DT	**44.7**	107	--	58	6	35,200	43	71	1701	115	M/ME	Bronze
Dekalb	DKS36-07	**43.8**	105	69	58	8	35,200	48	71	1701	116	M/ME	Bronze
DynaGro	M60GB31	**43.8**	105	61	59	10	31,000	44	70	1669	114	ME	Bronze
Sorghum Partners	SPSD353	43.1	104	55	61	0	29,000	42	73	1748	118	M	Bronze
Sorghum Partners	SP 66M16	43.1	104	--	60	1	36,800	39	69	1637	113	ME/M	Bronze
DynaGro	M59GB94	41.7	100	61	60	4	38,700	42	66	1563	110	ME	Bronze
DynaGro	GX22923	40.7	98	64	58	31	38,700	46	66	1563	110	ME	Cream
DynaGro	M59GB57	40.2	97	54	59	20	31,400	40	65	1542	109	E	Bronze
Dekalb	DKS28-05	39.8	96	--	59	36	36,800	49	62	1464	106	E	Bronze
Alta Seeds	ADV G2193IG	39.6	95	--	59	5	35,200	40	67	1588	110	ME/M	Red
Sorghum Partners	SP 43M80	38.0	91	59	59	8	35,600	45	68	1614	114	ME	Bronze
DynaGro	M63GB78	37.9	91	63	59	15	32,100	44	71	1701	115	M	Bronze
Dekalb	DKS28-07	37.9	91	59	59	26	37,200	42	63	1491	107	E	Bronze
Alta Seeds	ADV G2168IG	37.4	90	--	59	7	31,800	43	71	1701	115	M	Red
DynaGro	M60GB88	37.2	89	58	57	34	33,300	45	65	1542	107	E	Bronze
DynaGro	M54GR24	34.5	83	57	59	39	40,300	43	61	1434	104	E	Red
Alta Seeds	ADV G1329	23.1	56	--	59	6	31,800	29	65	1542	109	E	Cream
Average		**41.6**		**61**	**59**	**14**	**34,700**	**42**	**67**	**1593**	**111**	**ME**	
[d]LSD (P<0.20)		8.2				22							
[d]LSD (P<0.05)		12.5				14							

[a]Yields adjusted to 14% moisture and hybrids ranked by yield. Yields in bold are in the top LSD (.20) group and are not significantly different from one another.

[b]GDD: Sorghum growing degree days to 50% bloom date.

[c]Maturity Group: E=early; ME=medium-early; M=medium; ML=medium late; L=late. Maturity groupings with two classes are trial observation/seed company description.

[d]Farmers selecting a hybrid based on yield should use the LSD (.20) to protect themselves from false negative conclusions (concluding hybrids are the same when they are actually different). Companies or researchers may be interested in the LSD (.05) to avoid false positive conclusions (concluding hybrids are different when they are actually the same). Yield differences less than the LSD value are considered the same.

Site Information

Collaborator:	Plainsman Research Center (Kevin Larson, Brett Pettinger, Perry Jones, and Zane Jenkins)
Planting Date:	June 2, 2023 at 43,500 seeds/ac, planting depth 1.5 in.
Harvest Date:	November 2, 2023 with a harvest area of 10 ft. by 44 ft. per plot.
Previous Crop:	Wheat
Herbicide:	Preemergence: Flumioxazin at 3.0 oz/ac, Atrazine at 1.0 lb/ac, Mesotrione at 6.4 oz/ac, and Outlook at 16 oz/ac; Post emergence: Huskie at 15 oz/ac, Atrazine at 0.5 lb/ac, and AMS at 1.0 lb/ac.
Fertilizer:	Anhydrous N at 60 lb/ac and 10-34-0 at 5 gal/ac (20 lb P_2O_5/ac, 6 lb N/ac) was strip till applied.
Soil Type:	Richfield silt loam
Comments:	Planted into strip tilled wheat stubble. Rapid emergence and good stands. Total rainfall for the growing season was well above average with 19.13 in. June (5.18 in.) and July (6.39 in.) were wet. August was dry with 1.90 in. September was hot with three days over 100F. Weed control was good. Three hybrids had more than 30% lodging at harvest.

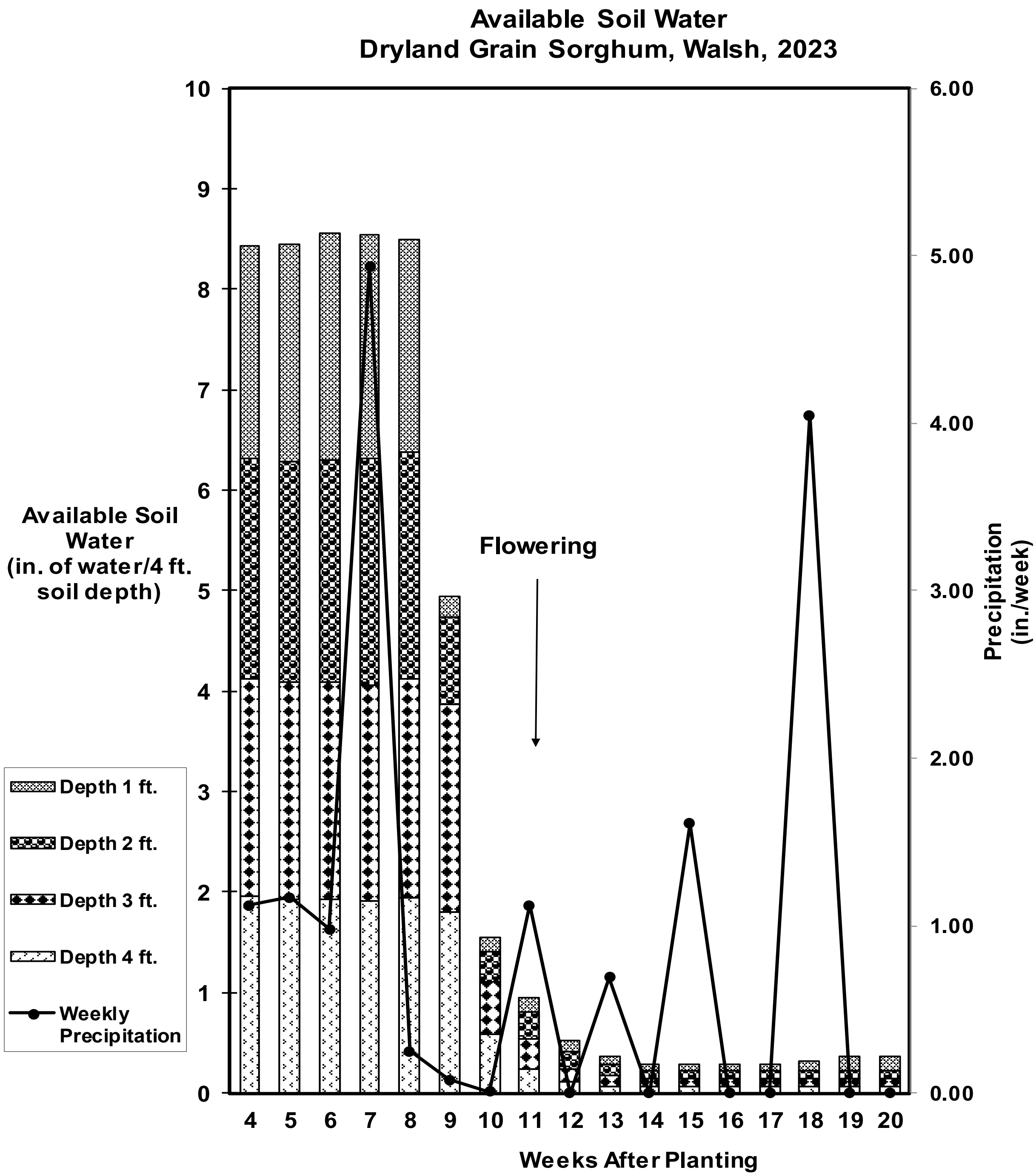


Fig. . Available soil water in dryland grain sorghum at Walsh. Gypsum block measurements taken to 4 ft. with 1 ft. increments. Total rainfall at Walsh from planting (June 2) to first freeze (October 15) was 19.13 in. Any increase in available soil water between weeks is from rain.

2023 Sprinkler Irrigated Grain Sorghum Hybrid Performance Trial at Walsh

Brand	Hybrid	Grain Yield[a]	Yield	2-Year Average Yield	Test Weight	Emerged Plant Population[b]	Plant Height	50% Bloom	GDD[c]	50% Mature	Maturity Group[d]	Grain Color
		bu/ac	% of test average	bu/ac	lb/bu	plants/ac	in	days after planting		days after planting[e]		
Dyna-Gro Seed	M60GB31	**112.4**	111	112	63.8	39,500	58	73	1785	119	M/ME	Bronze
Sorghum Partners	SP 65M60	**112.0**	111	--	60.6	40,900	55	75	1823	122	M	Bronze
Sorghum Partners	SPSD353	**111.9**	111	109	62.0	34,100	58	74	1805	121	M	Bronze
Dyna-Gro Seed	M59GB94	**111.4**	110	103	62.4	35,100	59	69	1671	115	ME	Bronze
Dyna-Gro Seed	M63GB78	**107.7**	106	106	61.2	37,100	53	73	1785	120	M	Bronze
Sorghum Partners	SP 43M80	100.5	99	91	63.2	44,100	56	69	1671	115	ME	Bronze
Sorghum Partners	SP 66M16	100.5	99	--	63.1	38,500	55	72	1758	118	M	Bronze
Sorghum Partners	SP 65B21 DT	99.0	98	--	61.4	35,500	45	71	1726	118	M	Bronze
Sorghum Partners	SP 58M85 DT	97.9	97	--	62.8	36,500	53	69	1671	115	M	Bronze
Sorghum Partners	SP 45A45 DT	97.3	96	--	62.2	43,100	53	69	1671	114	ME	Bronze
Dyna-Gro Seed	M60GB88	96.9	96	98	60.8	43,500	56	68	1645	111	E	Bronze
Sorghum Partners	SP 30A30 DT	92.9	92	--	62.5	41,900	54	68	1645	112	E	Bronze
Dyna-Gro Seed	M59GB57	89.0	88	89	61.3	38,900	45	63	1521	107	E	Bronze
Dyna-Gro Seed	M54GR24	87.0	86	89	61.1	44,500	51	62	1491	106	E	Red
Average		**101.2**		**100**	**62.0**	**39,500**	**54**	**70**	**1691**	**115**	**M**	
[f]LSD (P<0.20)		5.3										
[f]LSD (P<0.05)		8.5										

[a]Yields adjusted to 14% moisture and hybrids ranked by yield. Yields in bold are in the top LSD (.20) group and are not significantly different from one another.

[b]Plant population taken after final stand. Main plants only, does not include tillers.

[c]GDD: Sorghum growing degree days to 50% bloom date.

[d]Maturity Group: E=early; ME=medium-early; M=medium; ML=medium late. Maturity groupings with two classes are trial observation/seed company description.

[e]Days after planting or seed maturation.

[d]Farmers selecting a hybrid based on yield should use the LSD (.20) to protect themselves from false negative conclusions (concluding hybrids are the same when they are actually different). Companies or researchers may be interested in the LSD (.05) to avoid false positive conclusions (concluding hybrids are different when they are actually the same). Yield differences less than the LSD value are considered the same.

Site Information

Collaborator:	Plainsman Research Center (Kevin Larson, Brett Pettinger, Perry Jones, and Zane Jenkins)
Planting Date:	May 31, 2023 at 50,000 seeds/ac.
Harvest Date:	October 27, 2023, harvest area was 10 ft. by 800 ft. (average).
Previous Crop:	Corn
Herbicide:	Preemergence: Flumioxazin at 3.0 oz/ac; Atrazine at 1.0 lb/ac, Mesotrione at 6.4 oz/ac; and Outlook at 16 oz/ac; Post emergence: Huskie at 15 oz/ac, Atrazine 0.5 lb/ac, AMS at 1 lb/ac.
Fertilizer:	Anhydrous N at 150 lb/ac and 10-34-0 at 7.5 gal/ac was strip till applied and 10-34-0 at 5 gal/ac at planting.
Irrigation:	Sprinkler irrigated with 10.0 in./ac of total applied irrigation.
Soil Type:	Wiley loam
Comments:	Planted into strip tilled corn stalks. Rapid emergence and good stands. Total rainfall for the growing season was well above average with 19.13 in. June (5.18 in.) and July (6.39 in.) were wet. August was dry with 1.90 in. September was hot with three days over 100F. Weed control was only fair due to considerable volunteer corn. Little or no lodging noted at harvest. Total sprinkler applied irrigation was 10 in/ac.

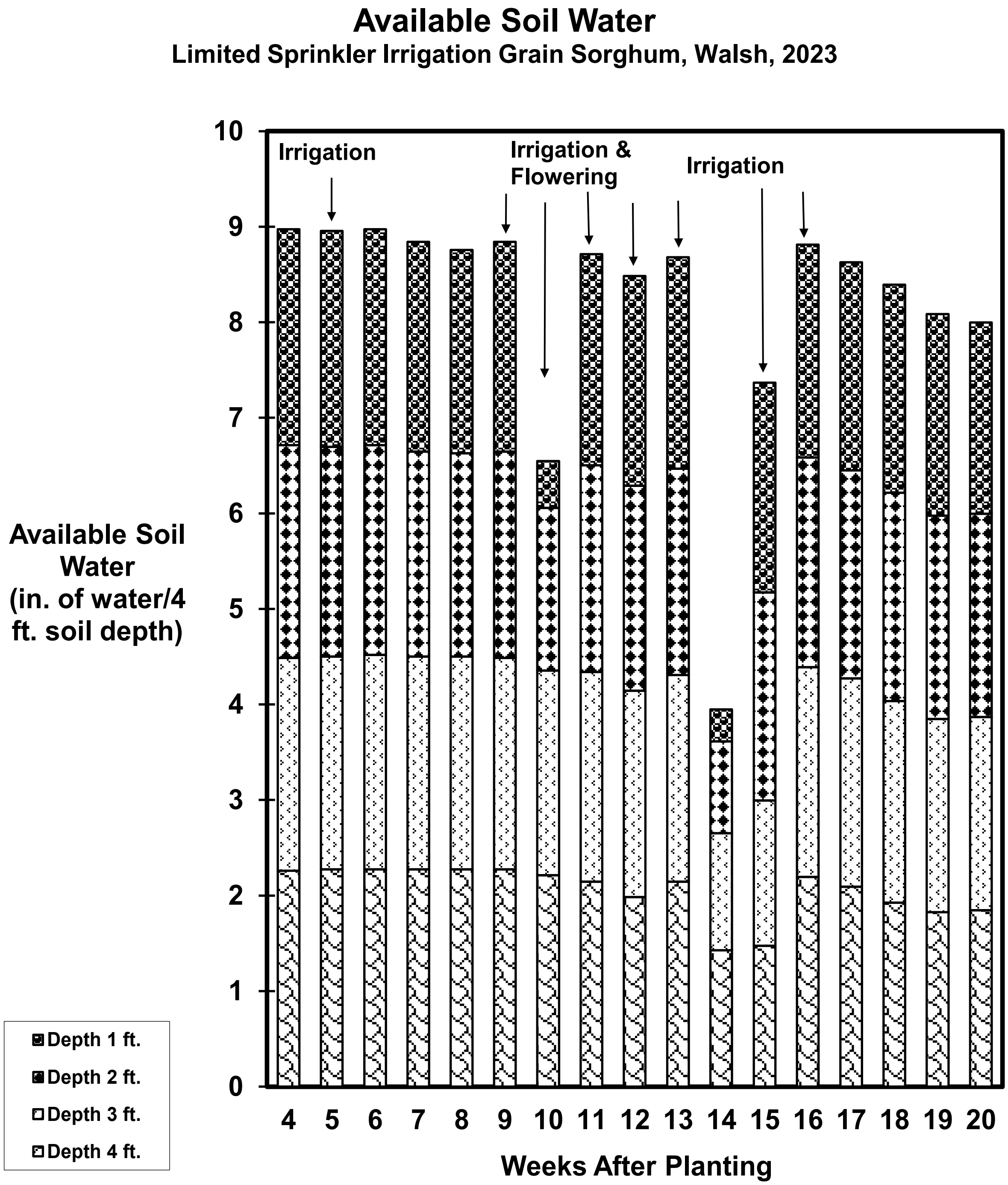


Fig. . Available soil water in irrigated grain sorghum at Walsh. Gypsum block measurements taken to 4 ft. with 1 ft. increments. Total rainfall at Walsh from planting (May 31) to first freeze (October 15) was 19.13 in. Total applied sprinkler irrigation was 10.0 in. Any increase in available soil water between weeks not attributed to applied irrigation is from rain.

2023 Dryland Hybrid Forage Sorghum Performance Trial at Walsh

Brand	Hybrid	Forage Yield[a]	Yield	Brix	Harvest Density	Plant Height	Lodging	Days to Flowering	Relative Maturity[b]	Forage Type[c]	Traits[d]
		tons/ac	% of test average	%	plants/ac (1000x)	in	%	days after planting			
Dyna-Gro Seed	Super Sile 30	**13.4**	144	11.2	51.9	79	1	95	M/ME	FS	-
Dyna-Gro Seed	F72FS05	11.0	118	9.6	49.2	55	0	96	M/ME	FS	-
Dyna-Gro Seed	Fullgraze II	10.7	115	16.8	55.4	104	0	103	ML	SS	-
Sorghum Partners	SS405	10.7	114	14.1	44.5	87	3	112	ML	FS	-
Dyna-Gro Seed	Super Sile 20	10.5	112	16.2	57.3	81	0	106	ML	FS	-
Sorghum Partners	SP2707 DT	10.5	112	14.5	41.4	44	0	87	M/ME	FS	DT
Sorghum Partners	SP2606 BMR	10.3	110	12.3	48.8	56	5	87	M/ME	FS	BMR
Dyna-Gro Seed	F74FS23 BMR	10.1	108	8.5	48.8	71	1	95	M	FS	BMR
Dyna-Gro Seed	Danny Boy II BMR	10.0	107	13.3	52.3	81	0	Veg	PPS	SS	PPS BMR
Dyna-Gro Seed	F74FS72 BMR	9.5	102	15.3	54.6	49	0	107	ML/M	FS	BMR
Dyna-Gro Seed	Fullgraze II BMR	9.4	101	12.8	53.8	82	0	129	L/ML	SS	BMR
Dyna-Gro Seed	Sweet Ton MS	9.3	100	13.3	51.9	92	6	79	M/ML	FS	MS
Sorghum Partners	NK300	8.7	93	8.0	50.3	55	1	85	M/ME	FS	-
Dyna-Gro Seed	F72FS25 BMR	8.5	90	12.8	41.8	55	0	98	M	FS	BMR
Dyna-Gro Seed	F75FS13	8.3	89	8.2	46.5	84	32	74	ME/M	FS	-
Dyna-Gro Seed	F71FS72 BMR	8.2	88	12.1	49.2	67	13	73	ME/E	FS	BMR
Sorghum Partners	SP1727 MS BMR	8.1	87	8.6	51.1	75	3	81	M	FS	MS BMR
Dyna-Gro Seed	Dynagraze II BMR	7.8	83	16.5	51.5	86	0	80	M/ME	SS	BMR
Dyna-Gro Seed	Super Sweet 10	6.0	64	12.5	48.4	74	6	71	ME/M	SS	-
Dyna-Gro Seed	Dynagraze II	5.9	63	11.7	45.7	85	3	73	ME	SS	-
Average		**9.3**		**12.4**	**49.7**	**73**	**4**	**91**			
[e]LSD (P<0.20)		1.01					3.1				
[e]LSD (P<0.05)		1.56					4.8				

[a]Yields are adjusted to 65% moisture content based on oven-dried samples.

[b]Relative Maturity: E=early; ME=medium-early; M=medium; ML=medium-late; L=late; PPS=photoperiod sensitive. Maturity groups with two classes are trial observation/seed company description.

[c]Forage Type: FS=forage sorghum; S=sudangrass; SS=sorghum sudangrass.

[d]Traits: BD=brachytic dwarf; BMR=brown mid-rib; DT=Double Team; SCA=Sugar Cane Aphid.

[e]Farmers selecting a hybrid based on yield should use the LSD (.20) to protect themselves from false negative conclusions (concluding hybrids are the same when they are actually different). Companies or researchers may be interested in the LSD (.05) to avoid false positive conclusions (concluding hybrids are different when they are actually the same). Yield differences less than the LSD value are considered the same.

Site Information

Collaborator:	Plainsman Research Center (Kevin Larson, Brett Pettinger, Perry Jones, and Zane Jenkins)
Planting Date:	6/2/2023
Harvest Date:	10/17/2023
Previous Crop:	Wheat
Herbicide:	Preemergence: Flumioxazin at 3.0 oz/ac; Atrazine at 1.0 lb/ac; Mesotrione at 6.0 oz/a; Metolachlor at 1.33 pts/ac; Gylphosate Post emergence: Huskie at 15 oz/ac; Atrazine at 0.5 lb/ac; NIS at 8 oz/ac; AMS at 1.0 lb/ac.
Fertilizer:	Anhydrous N at 60 lb/ac and 10-34-0 at 5 gal/ac (20 lb P_2O_5/ac, 6 lb N/ac) was strip till applied.
Soil Type:	Richfield silt loam
Comments:	Planted into strip tilled wheat stubble. Rapid emergence and good stands. Precipitation for the growing season was well above average. June and July were wet (5.18 in. for June and 6.33 in for July). August was dry (1.90 in). Weed control was good. Two hybrids had greater than 10% lodging at harvest.

2023 Dryland Forage Sorghum Hybrid Performance Trial Feed Quality at Walsh

Brand	Hybrid	Forage Yield[b]	Forage Quality[a] RFQ	CP	aNDFom	Lignin	WSC Sugar	Starch	Fat	Ash	NDFD 30hr	NDFD 240hr	TDN Milk	NEL	Milk/Ton	Beef/Ton
		tons/ac		percent										Mcal/cwt	lb/ton	lb/ton
Dyna-Gro Seed	Super Sile 30	13.4	120	7.2	52	4	12	10	2	6	52	67	61	66	3012	148
Dyna-Gro Seed	F72FS05	11.0	135	7.6	50	3	10	17	2	9	58	72	62	66	3015	166
Dyna-Gro Seed	Fullgraze II	10.7	110	8.1	59	4	9	5	2	4	55	71	60	65	2974	150
Sorghum Partners	SS405	10.7	126	8.0	53	4	13	7	2	4	55	72	63	69	3198	189
Dyna-Gro Seed	Super Sile 20	10.5	123	8.6	52	4	11	6	2	8	55	74	60	65	2954	162
Sorghum Partners	SP2707 DT	10.5	140	9.6	47	4	10	18	3	3	52	68	66	73	3447	216
Sorghum Partners	SP2606 BMR	10.3	125	8.2	51	5	10	13	2	7	54	72	61	66	3029	164
Dyna-Gro Seed	F74FS23 BMR	10.1	161	9.0	46	3	12	12	3	5	61	74	68	72	3461	241
Dyna-Gro Seed	Danny Boy II BMR	10.0	135	11.4	55	5	7	2	2	7	63	77	64	66	3087	203
Dyna-Gro Seed	F74FS72 BMR	9.5	136	9.6	43	4	11	8	3	6	57	73	66	72	3413	227
Dyna-Gro Seed	Fullgraze II BMR	9.4	128	8.8	57	5	9	4	2	5	62	75	64	67	3121	195
Dyna-Gro Seed	Sweet Ton MS	9.3	137	7.2	46	4	14	18	3	2	47	65	66	75	3517	212
Sorghum Partners	NK300	8.7	143	10.1	48	4	11	18	2	5	55	69	65	72	3375	209
Dyna-Gro Seed	F72FS25 BMR	8.5	141	7.9	50	3	13	8	3	8	60	74	63	67	3090	189
Dyna-Gro Seed	F75FS13	8.3	147	7.8	46	3	12	21	2	4	53	69	66	73	3447	213
Dyna-Gro Seed	F71FS72 BMR	8.2	204	8.8	36	4	12	38	3	4	54	65	72	80	3908	251
Sorghum Partners	SP1727 MS BMR	8.1	157	9.5	45	4	14	12	3	8	59	72	65	70	3290	213
Dyna-Gro Seed	Dynagraze II BMR	7.8	141	8.5	52	4	11	9	2	7	62	75	64	67	3116	195
Dyna-Gro Seed	Super Sweet 10	6.0	120	8.3	52	4	11	16	2	7	54	69	61	66	3020	151
Dyna-Gro Seed	Dynagraze II	5.9	135	8.7	47	4	11	19	2	5	51	66	64	71	3284	184
	Average	**9.3**	**138**	**8.6**	**49**	**4.0**	**11.2**	**13**	**2**	**6**	**56**	**71**	**64**	**69**	**3,238**	**194**
	[c]LSD (0.20)	1.01														
	[c]LSD (0.05)	1.56														

[a]All forage quality analyses results are dry basis values. CP=crude protein; aNDFom=ash free neutral detergent fiber; NDFD=neutral detergent fiber digestibility; TDN=total digestable nutrients; NEL=net energy for lactation; Milk/ton= predicted amount of milk produced per ton of silage dry matter calculated using MILK2013.

[b]Yields are adjusted to 65% moisture content based on oven-dried samples. Yields in bold are in the top LSD (.20) group and are not significantly different from one another.

[c]Farmers selecting a hybrid based on yield should use the LSD (.20) to protect themselves from false negative conclusions (concluding hybrids are the same when they are actually different). Companies or researchers may be interested in the LSD (.05) to avoid false positive conclusions (concluding hybrids are different when they are actually the same). Yield differences less than the LSD value are considered the same.

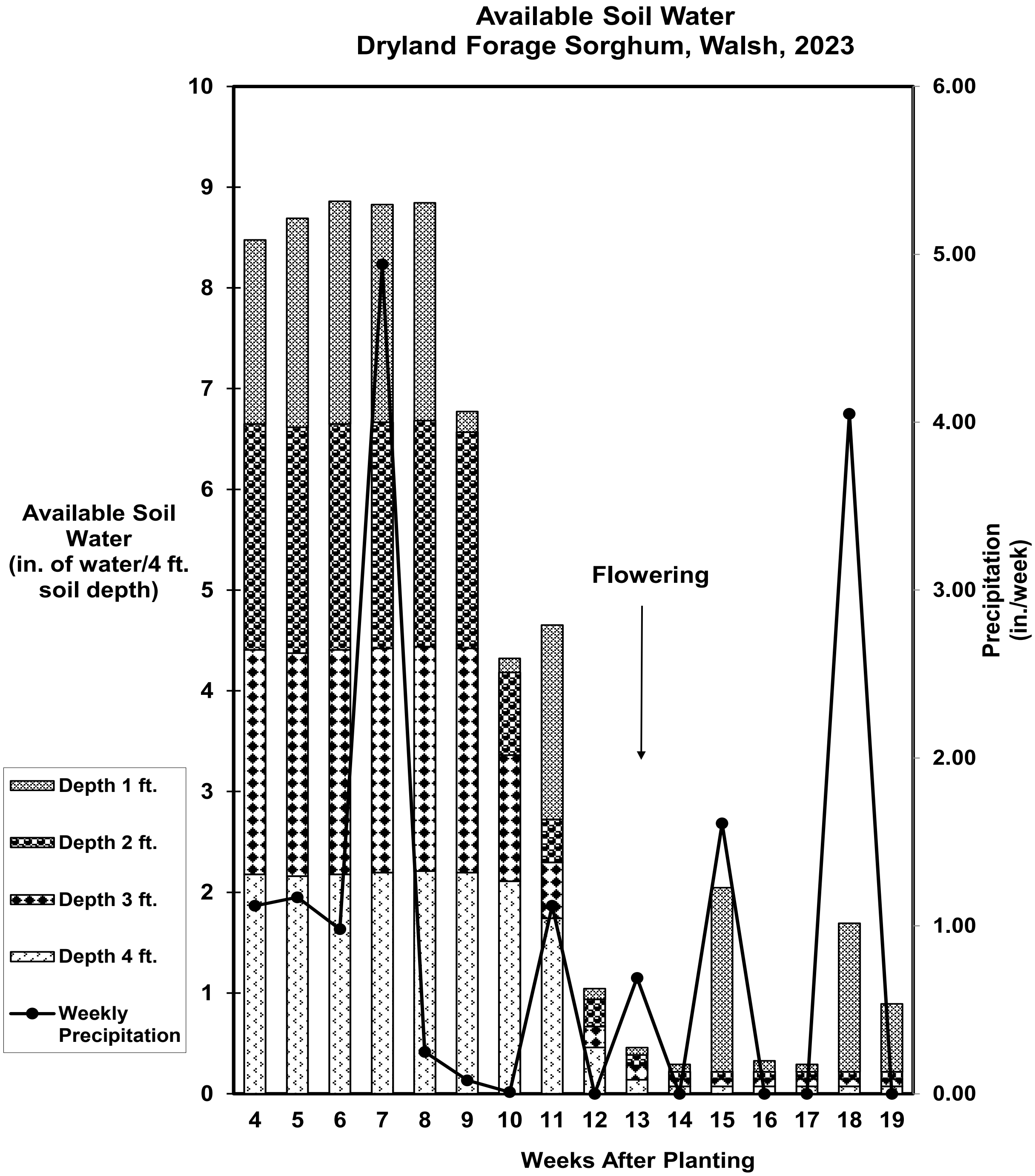


Fig. . Available soil water in dryland grain sorghum at Walsh. Gypsum block measurements taken to 4 ft. with 1 ft. increments. Total rainfall at Walsh from planting (June 2) to harvest (October 17) was 19.13 in. Any increase in available soil water between weeks is from rain.

Sprinkler Irrigation Corn Hybrid Study at Walsh, 2023

COOPERATORS: Plainsman Agri-Search Foundation; Kevin Larson, Brett Pettinger, Perry Jones, Plainsman Research Center, Walsh, Colorado.

PURPOSE: To identify corn hybrids that produce highest yields given sprinkler irrigation.

RESULTS: The average yield for all seven hybrids tested was 183 bu/a. Grain yield ranged from 167 bu/a for Rob Seed Co RC6541-V to 196 bu/a for NC+ EX1437PCE.

PLOT: Eight rows with 30” row spacing, at least 800’ long. SEEDING DENSITY: 28,000 seeds/a. PLANTED: May 3. HARVESTED: October 25.

PEST CONTROL: Preemergence Herbicides: Flumioxazin 3.0 oz/a, Atrazine 1lb/a, S-Metolachlor 24 oz/a, Mesotrione 6.4 oz/a; Post Herbicides: Glyphosate 32 oz/a, Status 5 oz/a. CULTIVATION: None. INSECTICIDE: Capture LFR 16 oz/a with seedrow 10-34-0 fertilizer.

Summary: Growing Season Precipitation and Temperature \1
Walsh, Baca County.

Month	Rainfall	Irrigation \2	GDD \3	>90 F	>100 F	DAP \4
	in	in	--------no. of days--------			
May	3.96	1.25	412	1	0	28
June	5.18	3.75	582	7	0	58
July	6.39	3.75	826	20	2	89
August	1.90	3.75	832	21	3	120
September	1.61	2.50	631	14	3	150
October	4.05	0.00	196	1	0	165
Total	23.09	15.00	3479	64	8	165

\1 Growing season from May 3 (planting) to October 15 (freeze, 27F).
\2 Total in-season water from irrigation and precipitation was 38.09 in/a.
\3 GDD: Growing Degree Days for sorghum.
\4 DAP: Days After Planting.

FIELD HISTORY: Previous Crop: Grain sorghum. FIELD PREPARATION: Strip-tilled.

COMMENTS: Planted into strip-tilled grain sorghum stalks. Good planting soil moisture and good stand establishment. Weed control was good. The growing season precipitation was well above average with wet months of May, June, July, and October and dry for the months of August and September. Grain yields and test weights were very good. We applied 15 in/a of irrigation.

SOIL: Wiley loam for 0-8” and loam 8”-24” depths from soil analysis.

Summary: Soil Analysis.

Depth	pH	EC	OM	N	P	K	Zn	S
		mmhos/cm	%	----------------ppm----------------				
0-8” 8”-24”	8.1	0.3	2.6	12 6	4.4	605	0.7	49.3
Comment	Alka	VLo	Hi	Mod	Lo	VHi	Lo	Adeq

Iron was adequate.

Summary: Fertilization.

Fertilizer	N	P_2O_5	Zn	S
	--------------------lb/a------------------			
Recommended	190	60	5	0
Applied	175	50	0.3	0

Yield Goal: 160 bu/a.
Actual Yield: 183 bu/a.

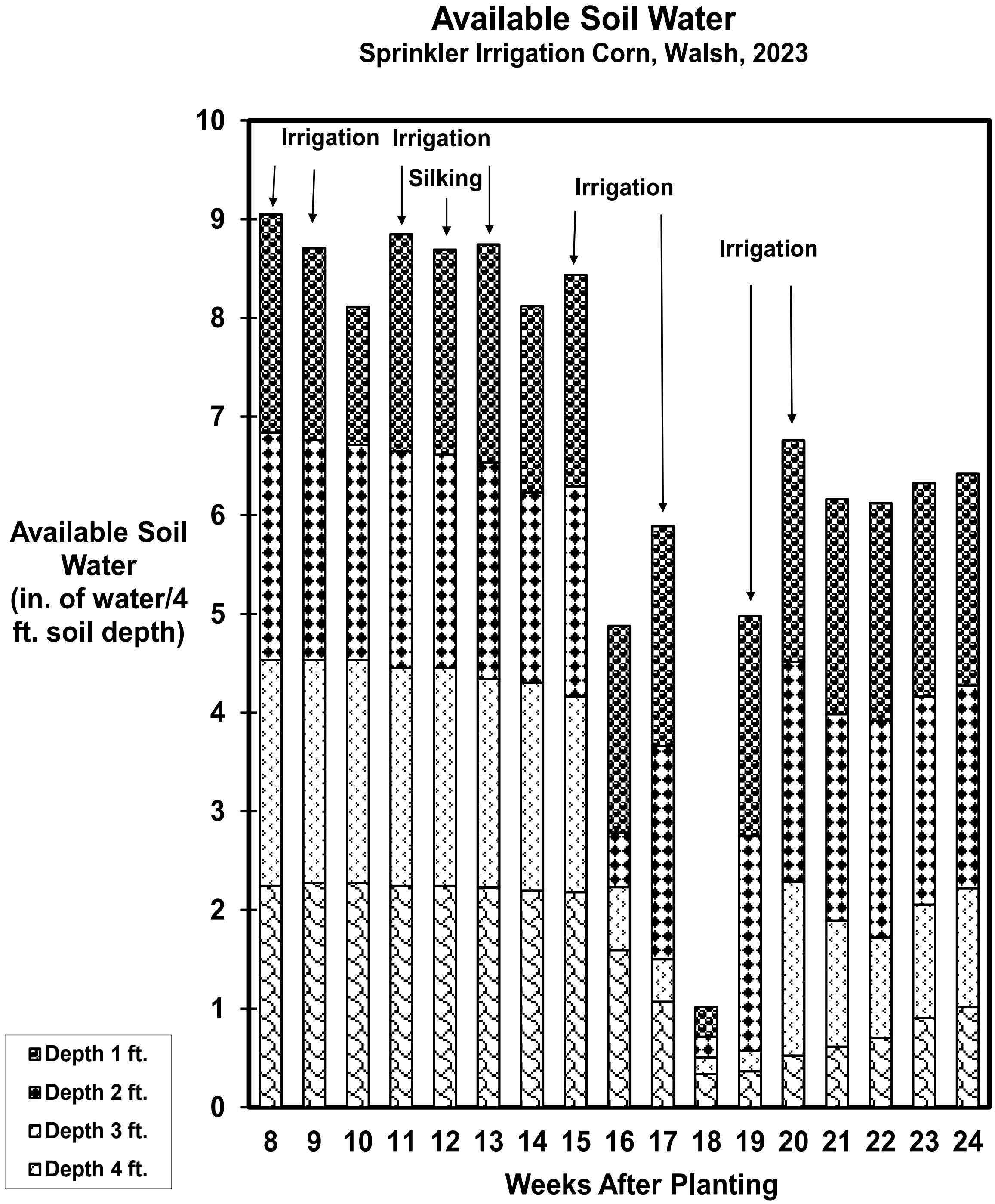


Fig. . Available soil water in limited sprinkler irrigation corn at Walsh. Gypsum block measurements taken to 4 ft. with 1 ft. increments. Total rainfall at Walsh from planting (May 3) to first freeze (October 15) was 23.09 in. Total applied sprinkler irrigation was 15.0 in. Any increase in available soil water between weeks not attributed to applied irrigation is from rain.

Sprinkler Irrigated Corn, Plainsman Research Center, Walsh, 2023.

Brand	Hybrid	Grain Yield	Seed Moisture	Test Weight	Plant Density	50% Silking Date
		bu/a	%	lb/bu	plants/a (X 1000)	
NC+	EX1437PCE	195.5	16.8	60.7	27,200	26-Jul
Golden Harvest	G13N18-3111	189.2	17.2	56.6	26,800	23-Jul
Rob Seed Co	RC6411-VT2PRIB	188.6	17.3	61.4	28,000	23-Jul
NC+	14-36PCE	187.4	15.3	60.9	28,000	26-Jul
Golden Harvest	G10L16-DV	182.5	13.1	59.3	27,600	23-Jul
Rob Seed Co	RC6170-D	172.7	15.0	60.8	27,000	24-Jul
Rob Seed Co	RC6541-V	166.8	16.2	58.5	26,400	22-Jul
Average		183.2	15.8	59.7	27,286	24-Jul
LSD 0.20		13.2				

Planted: May 3; Harvested: October 25, 2023.
Grain Yield adjusted to 15.5% moisture content.
This corn trial received a total of 15.0 acre-in./acre of irrigation.

Dryland Corn Hybrid Trial, Plainsman Research Center at Walsh, 2023

COOPERATORS: Plainsman Agri-Search Foundation, Kevin Larson, Perry Jones, Brett Pettinger, and Zane Jenkins.

PURPOSE: To identify dryland corn hybrids that produce highest yields under dryland conditions.

RESULTS: The average yield for the four corn hybrids tested was 23 bu/a. NC+ EX 0337PCE produced the highest yield of 34 bu/a and Golden Harvest G10L16-DV produced the lowest yield, 12 bu/a, of the four hybrids tested. This dryland corn trial was mistakenly planted at the irrigated seeding rate of 28,000 seeds/a.

PLOT: Four rows with 30 in. row spacing, 1230 ft. long. SEEDING DENSITY: 28,000 seeds/a. PLANTED: May 4. HARVESTED: October 12.

PEST CONTROL: Preemergence Herbicides: Flumioxazin 3.0 oz/a, Metolachlor 24 oz/a, Atrazine 1.0 lb/a, Mesotrione 6.4 oz. Post Herbicides: Glyphosate 32 oz/a. CULTIVATION: None. INSECTICIDE: None.

FIELD HISTORY: Previous Crop: Failed wheat. FIELD PREPARATION: Strip till.

Summary: Growing Season Precipitation and Temperature \1
Walsh, Baca County.

Month	Rainfall	GDD \2	>90 F	>100 F	DAP \3
	in		-------no. of days--------		
May	3.96	412	1	0	27
June	5.18	582	7	0	57
July	6.39	826	20	2	88
August	1.90	832	21	3	119
September	1.61	631	14	3	149
October	4.05	177	1	0	161
Total	23.09	3460	64	8	161

\1 Growing season from May 4 (planting) to October 12 (harvest).
\3 GDD: Growing Degree Days for sorghum.
\4 DAP: Days After Planting.

SOIL: Richfield silt loam.

FERTILIZATION: N at 60 lb/a, P_2O_5 at 40 lb/a, Zn (chelate) at 0.38 lb/a.

COMMENTS: Planted in good soil moisture, which resulted in good seed germination and stand establishment; however, this dryland corn trial was mistakenly planted at the irrigated seeding rate of 28,000 seeds/a instead of the planned 12,500 seeds/a. Weed control was good. The growing season precipitation was well above average. May, June, July, and October were wet; August and September were dry. Grain yields were low due to the irrigated seeding rate used and dry conditions during the grain-filling period (August and September).

Dryland Corn Hybrid Trial, Plainsman Research Center, Walsh, 2023.

Brand	Hybrid	Grain Yield	Seed Moisture	Test Wt.	Plant Density	50% Silking Date
		bu/ac	%	lb/bu	plants/ac	
NC +	EX 0337PCE	33.6	9.5	57.9	27,800	22-Jul
NC +	01-01VT2PRIB	32.4	9.1	57.3	27,200	23-Jul
Rob-Seed Co	RC 6170-D	15.5	12.2	58.8	27,800	27-Jul
Golden Harvest	G10L16-DV	11.6	10.7	58.3	28,000	26-Jul
Average		23.3	10.4	58.1	27,700	24-Jul
LSD 0.20		10.0				

Planted: May 4 at 28,000 seeds/acre; Harvested: October 12, 2023.
Grain Yield adjusted to 15.5% moisture content.

Dryland Corn Hybrid Trial, Thunderbird Farms at Towner, 2023

COOPERATORS: Chris Stum, Lane Stum, Linly Stum, Thunderbird Farms; Kevin Larson, Plainsman Research Center.

PURPOSE: To identify dryland corn hybrids that produce highest yields under dryland conditions.

RESULTS: The average yield for the fourteen corn hybrids tested was 68 bu/a. NC+ EX0337PCE produced the highest yield of 89 bu/a and Axis A49 produced the lowest yield, 40 bu/a, of the 14 hybrids tested.

PLOT: Twelve rows with 30 in. row spacing, 2440 ft. long. SEEDING DENSITY: 12,500 seeds/a. PLANTED: May 30. HARVESTED: October 9.

PEST CONTROL: Preemergence Herbicides: Flumioxazin 3.0 oz/a, Acetochlor 1.3 lb/a, Atrazine 1 lb/a, Mesotrione 6 oz/a, Dicamba 5 oz/a, Post Herbicides: Glyphosate 1.0 lb/a. CULTIVATION: None. INSECTICIDE: None.

FIELD HISTORY: Previous Crop: Wheat. FIELD PREPARATION: No-till.

Summary: Growing Season Precipitation and Temperature \1
Chivington, Kiowa County.

Month	Rainfall	GDD \2	>90 F	>100 F	DAP \3
	in		--------no. of days--------		
May	0.14	38	0	0	2
June	4.43	532	4	0	32
July	2.00	757	20	6	63
August	2.19	751	18	7	94
September	0.67	594	14	4	124
October	0.18	87	0	0	130
Total	9.61	2759	56	17	130

\1 Growing season from May 30 (planting) to October 6 (first freeze).
\3 GDD: Growing Degree Days for sorghum.
\4 DAP: Days After Planting.

SOIL: Richfield silt loam.

FERTILIZATION: N at 70 lb/a, P_2O_5 at 28 lb/a, S at 5 lb/a, Zn at 0.7 lb/a (applied dry). XRN at 1.5 gal/a.

COMMENTS: Planted in good soil moisture, which resulted in good seed germination and stand establishment. Weed control was very good. The growing season precipitation was above average. June was very wet; September was dry. Grain yields and test weights were good.

Dryland Corn Hybrid Trial, Thunderbird Farms, Towner, 2023.

Brand	Hybrid	Grain Yield	Seed Moist.	Test Wt.	Plant Density	Ear Position/ Set	50% Silking Date
		bu/ac	%	lb/bu	plants/ac		
NC+	EX0337PCE	89.3	15.0	58.2	12,200	High/2Good	2-Aug
NC+	NC+0101	81.9	15.1	57.3	12,800	High/2Good	2-Aug
FBN	MB2P920V	77.6	12.2	58.1	12,400	High/2Good	1-Aug
FBN	MB21C9391	77.3	12.9	57.4	12,400	High/2Tillering	1-Aug
PGS	PGS5898	73.7	14.7	57.4	13,000	Mid/2Good	3-Aug
FBN	F2F1G1011	72.9	13.7	58.3	12,400	Low/2Good	2-Aug
Axis	A57K19-3111	71.9	17.7	54.3	12,800	High/2Good	4-Aug
PGS	PGS7410	71.3	19.0	55.8	11,600	High/2Good	3-Aug
Channel	C200148	65.9	12.9	57.4	11,800	Mid/2Good	2-Aug
Axis	A61M37	60.5	17.2	54.8	11,400	High/2Good	3-Aug
Golden Harvest	G10L161DV	57.7	17.6	55.0	12,600	Mid/2Tillering	4-Aug
PGS	PGS4294	56.7	13.8	59.8	9,200	Mid/2Good	30-Jul
Axis	A52F32	54.5	11.6	59.2	12,000	Mid/2Good	1-Aug
Axis	A49	39.5	11.5	59.2	12,400	Mid/2Small	30-Jul
Average		67.9	14.6	57.3	12,100		1-Aug

Planted: May 30 at 12,500 seeds/acre; Harvested: October 9, 2023.
Grain Yield adjusted to 15.5% moisture content.

Twin Row and Conventional Row Spacing Comparison for W-S-F Production

Brett Pettinger, Perry Jones, Kevin Larson, and Zane Jenkins

This twin row and conventional row spacing comparison for W-S-F production study had its origin in a dryland wheat row spacing study. For the dryland wheat row spacing study, we tested five row spacing arrangements: 6 in., 7.5 in., 12 in., 15 in., and twin 7.5 in. (two rows 7.5 in. apart, centered on 30 in., with a 22.5 in. space between the outside rows). We included the twin 7.5 in. treatment because we thought growers would find it humorous, and because it was easy to identify even without a plot map. At our wheat field days, we were surprised by the positive reaction to the twin 7.5 in. treatment. Several growers recalled experiences where the wheat stands winterkilled on top of the beds, leaving only the bottom of the furrows with wheat stands to harvest. They furthermore recounted that wheat harvested from only the remaining furrows produced nearly as much as their adjacent crops with solid stands. The results from our dryland wheat row spacing study aligned with grower experiences about achieving relatively high yields from partial plant stand failures that resembled twin row planted wheat. There were no significant grain yield differences in the wheat row spacing study between the twin row wheat spacing and any of the other wheat row spacings, except for the 12 in. row spacing which produced significantly higher grain yield than any of the other row spacings. Many growers felt that, even if the 7.5 in. twin did not produce the highest wheat yield, if next season, we planted grain sorghum in 7.5 in. twin rows in the 22.5 in. gap between the twin row wheat stubble that the additional grain sorghum yield would more than compensate for the lower wheat yield. Because of growers' research suggestions for this twin row system, we developed this twin row study for Wheat-Sorghum-Fallow rotation production to compare twin row and conventional single row spacing arrangements.

Materials and Methods

For our row spacing and crop sequencing treatments in Wheat-Sorghum-Fallow (W-S-F) rotation, we tested three row spacing arrangements: 1) twin 7.5 in. rows of wheat followed by twin 7.5 in. rows of grain sorghum planted in the unplanted areas (22.5 in. gaps) between the twin row wheat stubble, (Twin W:Twin GS); 2) twin 7.5 in. rows of wheat followed by single uniformly spaced 30 in. rows of grain sorghum planted between the twin rows and in the unplanted areas (22.5 in. gaps) between the wheat stubble, (Twin W:Single GS); and 3) single uniformly spaced 10 in. rows of wheat followed by single uniformly spaced 30 in. rows of grain sorghum planted in the single uniformly spaced 10 in. rows of wheat stubble, (Single W:Single GS). For the twin row planting, we used our newly fabricated 20 ft., double disc, twin row planter with 8 sets of 7.5 in. twin rows, which the fabrication team (Brett and Perry) call, the "Great Plains Buffalo Tye Deere Twin Row Planter" for obvious reasons. For the uniform 10 in. spacing single row wheat planting, we used a 20 ft. John Deere 1590 single disc drill with 10 in. spacing. For the uniform 30 in. spacing single row grain sorghum planting, we used a 20 ft. John Deere 7300 vacuum planter with eight rows spaced 30 in. apart. This is the fitth year that we harvested grain crops from established rotations for complete row-spacing interactions. We planted wheat, Avery, at 50 lb/a on October 1, 2022 for the single, 10 in. treatment and October 7, 2022 for the twin, 7.5 in. treatment.

The wheat for all three treatments was planted in dry soil and did not emerge until April when there was sufficient precipitation for germination. We planted grain sorghum, Sorghum Partners 45A45 DT, at 34,000 seeds/a on June 1 for single, 30 in. and Jun 2 for twin, 7.5 in. treatments. We applied 60 lb/a of N to the study site. To control glyphosate-resistant kochia, we applied flumioxazin 3.0 oz/a in the spring. Before planting we sprayed one application of glyphosate at 32 oz/a, LoVol at 0.5 lb/a, and dicamba 6 oz/a. For in-season weed control for the grain sorghum, we applied pre-emergence: S-metolachlor 24 oz/a, mesotrione 6.4 oz/a, atrazine 1.0 lb/a, and post emergence: Brox 2EC 24 oz/a and Stare Down 6.4 oz/a. To control sandburs with the Double Team grain sorghum, we applied FirstAct 10 oz/a, AMS 2.5 lb/a, COC 1% v/v. For in-season weed control in the wheat, we applied Express 0.4 oz/a, LoVol 8 oz/a, dicamba 2 oz/a. For fallow, we applied glyphosate 32 oz/a, dicamba 6 oz/a, LoVol 0.5 lb/a two times, and one of these applications we included Stare Down 6.4 oz/a to all the fallow plots to control glyphosate-resistant kochia. We harvested the wheat crop on July 29 and the grain sorghum crop on October 31 with a self-propelled combine equipped with a HarvestMaster H2 automated grain weighing system. We used 12% for wheat and 14% for grain sorghum for moisture-adjusted grain yield comparisons. We recorded cost of production and yields to determine treatment revenues.

Results and Discussion

Wheat grain yields were poor, averaging 2.4 bu/a. The below average wheat yields were due to dry soil conditions at planting, which delayed seedling emergence until spring. Dry conditions prevailed through April. May was wet and the rains in May were primarily responsible for the grain yield. Grain sorghum yields were good, averaging 41 bu/a for all row arrangements. The grain sorghum was planted in good soil moisture, and emergence was good, but hot and dry conditions during grain-filling reduced grain yields. Growing season precipitation was well above average, June (5.18 in.), July (6.39 in.), and October (4.05 in.) were wet and August and September were dry. Total precipitation from June 1 (planting) to October 15 (the first freeze) was 19.13 in. This year, combining both wheat and grain sorghum crop production, the annual rotation row spacing productions of the W-S-F rotation had a 249 lb/a range, 706 lb/a for Single W:Single GS to 955 lb/a for Twin W:Twin GS. Because of the dry wheat growing conditions, the wheat yields were poor and only 0.9 bu/a separated the treatment yields with single, 10 in. treatment producing more than twin, 7.5 in. treatments. For grain sorghum, the yields were much higher than the wheat and some of the yield separations were higher as well. The Twin W:Twin GS treatment produced 8.8 bu/a more than the Twin W:Single GS treatment and 14.3 bu/a more grain sorghum than the Single W:Single GS treatment. This year, since the twin row spacing treatment produced significantly more grain sorghum yield than the conventional row spacing treatment, and wheat yields were low for all treatments, there was a yield advantage for the twin row grain sorghum treatment.

When comparing the income of the conventional Single W:Single GS to the other two row arrangements, the Twin W:Twin GS was $60/a more and the Twin W:Single GS was $19/a more than the Single W:Single GS treatment. Because we have all phases of each crop rotation present each year, we can compare annual rotation production and income even without a full crop rotational cycle. This year, we harvested both wheat and grain sorghum crops. Most of the grain yield came from the grain sorghum crop and very little from the wheat crop. The total rotation production difference was 747 lb/a between the highest and lowest yielding row arrangement treatments. The 2023 total production for the Twin W:Twin GS in the W-S-F rotation was 2865 lb/a. The yields from the crop rotational phases were: wheat, 132 lb/a; grain sorghum, 2733 lb/a; and, of course, no production for fallow. The annual rotation production was 955 lb/a, which is one-third the total production because the W-S-F rotation takes three years to complete one rotation cycle.

This year is the fifth year of complete rotational cycles; however, there was no wheat production in 2002. This is the secon year that the Twin W:Twin GS produce higher yield and income than the conventional row spacing treatment.

In 2019, the first year of complete rotational cycles, the conventional solid planted wheat produced 14.4 bu/a more than the average of the twin row planted wheat. The Twin W:Single GS treatment did produce 5.2 bu/a more grain sorghum than the Single W:Single GS treatment, but the sorghum yield increase was not enough to compensate for the much higher wheat yield of the conventional row wheat. The income difference between the conventional row spacing arrangement, Single W:Single GS, and the twin row wheat arrangements, Twin W:Single GS and Twin W:Twin GS, ranged from $65/a to $79/a, respectively.

In 2020, the income difference between the Single W:Single GS was $49.98 more than the Twin W:Twin GS and $32.55 more than the Twin W:Single GS treatments. We harvested both wheat and grain sorghum crops and the total rotation production difference was 544 lb/a between the highest and lowest yielding row arrangement treatments.

Because of the dry wheat growing conditions in 2021, the wheat yields were poor and only 3.3 bu/a separated the treatment yields with single, 10 in. treatment producing more than twin, 7.5 in. treatment. For grain sorghum, the yields were much higher than the wheat and some of the yield separations were higher as well. The Single W:Single GS treatment produced 2.7 bu/a more than the Twin W:Single GS treatment and 8.8 bu/a more grain sorghum than the Twin W:Twin GS treatment. When comparing the income of the conventional Single W:Single GS to the other two row arrangements, the Twin W:Twin GS was $30.62 less and the Twin W:Single GS was $14.93 less than the Single W:Single GS treatment.

In 2022, comparing the income of the conventional Single W:Single GS to the other two row arrangements, the Twin W:Twin GS was $45/a more and the Twin W:Single GS was $3/a less than the Single W:Single GS treatment. Since the wheat crop failed, we harvested only the grain sorghum crops and the total rotation production difference was 375 lb/a between the highest and lowest yielding row arrangement treatments. The 2022 total production for the Twin W:Twin GS in the W-S-F rotation was 3819 lb/a. This is the first year that the Twin W:Twin GS produce higher yield and income than the conventional row spacing treatment.

For the past five years with complete rotational cycles, the conventional row spacing treatment produced higher total income than the twin row treatments. In total gross income, the conventional Single W:Single GS treatment provided $40/a more than Twin W:Twin GS treatment and $111/a more than the Twin W:Single GS treatment after five years of complete rotational cycles. However, this is still a relatively new row spacing arrangement comparison study, and we are still establishing the rotational treatments effects, therefore only limited long-term rotational outcomes can be evaluated at present.

Twin Row and Convention Row Spacing for W-S-F, Crop Production, 2023.

Crop	Row Arrangement & Spacing	-------2023 Crop------- Wheat	Grain Sorghum	Fallow	2023 Total Rotation Production	Annual Rotation Production
		lb/ac (bu/ac)	lb/ac (bu/ac)	-------------lb/ac------------		
1 Wheat:	Twin, 7.5 in.	132 (2.2)		--	2865	955
1 Grain Sorghum	Twin, 7.5 in.		2733 (48.8)			
2 Wheat:	Twin, 7.5 in	120 (2.0)		--	2360	787
2 Grain Sorghum	Single, 30 in.		2240 (40.0)			
3 Wheat:	Single, 10 in.	186 (3.1)		--	2118	706
3 Grain Sorghum	Single, 30 in.		1932 (34.5)			
Average		146 (2.4)	2302 (41.1)	--	2448	816
LSD 0.20		138 (2.3)	246 (4.4)			

Annual Rotation Production is Total Rotation Production divided by the number of years to complete one rotation cycle.
This is the fifth year that crops are planted in the correct row arrangements.
Wheat planted October 1, 2022 for single, 10 in.drill treatment.
Wheat planted October 7, 2022 for twin, 7.5 in. drill treatment.
Grain sorghum planted June 1, 2023 for single, 30 in. planter treatment.
Grain sorghum planted June 2, 2023 for twin, 7.5 in. planter treatment.
Wheat harvested July 29, 2023
Grain Sorghum harvested October 31, 2023

Twin Row and Conventional Row Spacing in W-S-F Rotation, Income Comparison, Walsh, 2023.

Crop	Row Spacing Arrangement	Test Weight	Grain Yield	Gross Income	Comparison to Conventional Spacing
		lb/bu	bu/ac	$/ac	$/ac
Wheat	Twin Row 7.5 in.		2.2	12.67	
Grain Sorghum	Twin Row 7.5 in.	61.4	48.7	227.92	
Treatment Total				240.59	60.34
Wheat	Twin Row 7.5 in.		2.0	11.52	
Grain Sorghum	Single Row 30 in.	60.7	40.0	187.20	
Treatment Total				198.72	18.47
Wheat	Single Row 10 in.		3.1	17.86	
Grain Sorghum	Single Row 30 in.	60.8	34.7	162.40	
Treatment Total				180.25	--
Average Wheat			2.4	14.02	
Average Grain Sorghum		61.0	41.1	192.50	
Wheat LSD 0.20			2.48		
Grain Sorghum LSD 0.20			8.65		

Wheat planted: October 1 for Single Row, October 7, 2022 for Twin Row.
Wheat harvested July 29, 2023
Grain sorghum planted June 1, 2023 for single, 30 in. planter treatment.
Grain sorghum planted June 2, 2023 for twin, 7.5 in. planter treatment.
Grain Sorghum harvested October 31, 2023
Both wheat and grain sorghum planted in correct row arragement stubble.
Wheat crop price: $5.76/bu
Grain Sorghum price: $4.68/bu.

Twin Row and Standard Row Spacing in W-S-F Rotation, Income Comparison, Walsh, 2019-2023.

Crop	Row Spacing Treatment	2019 Gross Income	2019 Gross Income Diff.	2020 Gross Income	2020 Gross Income Diff.	2021 Gross Income	2021 Gross Income Diff.	2022 Gross Income	2022 Gross Income Diff.	2023 Gross Income	2023 Gross Income Diff.	Total Income Standard Spacing Comp.
		$/ac	$/ac	$/ac	$/ac	$/ac	$/ac	$/ac	$/ac		$/ac	$/ac
Wheat	Twin 7.5 in.	267.50		10.32		88.85		0.00		12.672		
Grain Sorghum	Twin 7.5 in.	191.40		191.48		341.01		486.27		227.92		
Treatment Total		458.90		201.80		429.86		486.27		240.59		
Standard Spacing Comparison			**-65.01**		**-49.98**		**-30.62**		**44.92**		**60.34**	**-40.35**
Wheat	Twin 7.5 in.	256.00		0.00		101.66		0.00		11.52		
Grain Sorghum	Single 30 in.	188.76		219.23		343.89		438.50		187.20		
Treatment Total		444.76		219.23		445.55		438.50		198.72		
Standard Spacing Comparison			**-79.15**		**-32.55**		**-14.93**		**-2.85**		**18.47**	**-111.01**
Wheat	Single 10 in.	333.50		19.78		113.70		0.00		17.86		
Grain Sorghum	Single 30 in.	190.41		231.99		346.78		441.35		162.40		
Treatment Total		523.91		251.77		460.48		441.35		180.25		
Standard Spacing Comparison			**--**		**--**		**--**		**--**		**--**	**--**
Average Wheat		285.67		10.03		101.40		0.00		14.02		
Average Grain Sorghum		190.19		214.23		343.89		455.37		192.50		

Since 2019 both wheat and grain sorghum planted in correct row arragement stubble.
No wheat emerged for the Twin W/Single GS treatment in 2020.
Wheat failed in all treatments in 2022 because of drought in the fall through spring of 2021-2022.

Narrow Row Drill and Conventional Row Vacuum Planter Comparison for Grain Sorghum Production

Perry Jones, Brett Pettinger, Kevin Larson, and Zane Jenkins

Currently there are two major planting systems for seeding grain sorghum in our area: air drill with narrow rows (10 in. spacings) and vacuum planter with conventional rows (30 in. spacings). There are advantages for both systems. The advantages of the air seeder are that planting acreage is more rapidly covered and the narrow rows suppress weeds. The advantages of the vacuum planter are precision placement of seeds and the ability to cultivate between rows and harvest of lodged plants. We conducted this study because growers were curious if there might be a yield advantage between the planting systems.

Materials and Methods

We used a wheat stubble site for this dryland grain sorghum planting study. We compared a 24-row, John Deere 1590 drill with 10 in. row spacings and an eight-row, John Deere 7300 vacuum planter with 30 in. row spacings. For both treatments, we surface applied liquid 28-0-0 in streams 20 in. apart at 60 lb N/a on September 24, 2022. For phosphate fertilization, we seedrow applied 10-34-0 at 5 gal/a at planting for both the vacuum planter and the drill. We planted Pioneer 86P20 on June 9 at 34,000 seeds/a for the vacuum planter and we planted 84,000 seeds/a for the drill on June 9. For pre-emergence weed control, we applied flumioxazin at 3.0 oz/a, S-metolachlor at 24 oz/a, mesotrione at 6.4 oz/a and atrazine at 1.0 lb/a, and for post emergence weed control, we applied: quinclorac at 12 oz/a, 2,4-D ester at 3 oz/a, NIS at 3 oz/a, and AMS at 2 lb/a. We harvested the 60 ft. wide by 1200 ft. long grain sorghum plots on November 10 for the vacuum planter treatment using a modified corn head with ARRO conversions, and on November 10 for the drill treatment using a 20 ft. Case 1020 flex platform with a Case-IH 2388 combine and weighed them in a digital scale cart. Grain samples were collected for seed moistures and test weights. Grain yields were adjusted to 14% seed moisture content.

Results and Discussion

This year, there was a significant yield difference between the conventional row spacing planter and the narrow row spacing drill with 11.8 bu/a separating the dryland grain sorghum planted with the vacuum planter on 30 in. row spacing and the drill with 10 in. row spacing. The significant yield difference between the conventional 30 in. row spacing and the 10 in. drill treatments also translated to 3.9 lb/bu higher test weight of the of the conventional planter treatment compared to the drilled treatment. The reason for the significant yield and test weight differences between the wide (30 in. rows) vacuum planter treatment and the narrow (10 in. rows) drill treatment is undoubtedly related to the seeding rates of the two treatments, 34,000 seeds/a for the vacuum planter and 84,000 seeds/a for the drill. The high plant population of the drilled grain sorghum, which resulted in 128,600 tillers/a compared to 44,400 tillers/a for the conventional planter, could not be sustained during the hot and dry grain-filling period of

August and September that caused a reduction in yield and test weight of the drill treatment compared to the conventional planter treatment.

In 2022, only 0.3 bu/a separated the dryland grain sorghum planted with the vacuum planter on 30 in. row spacing and the drill with 10 in. row spacing. Even though there was no significant yield difference between the conventional 30 in. row spacing and the 10 in. drill treatments, the test weight of the drilled treatment was 2.0 lb/bu higher than the conventional planter treatment. The reason for the similar yields of the wide (30 in. rows) vacuum planter treatment and the narrow (10 in. rows) drill treatment is unclear; however, it undoubtedly relates to the 4.36 in. rainfall event in the middle of August, which provided abundant water for plant and grain development despite the wide difference in plant populations between the two treatments (19,800 plants/a for 30 in. row planter and 56,100 plants/a for 10 in. row drill).

In 2021, the dryland grain sorghum planted with the vacuum planter on 30 in. row spacing produced 21 bu/a more than the drill with 10 in. row spacing. The 30 in. row vacuum planter also had 6 lb/bu higher test weight than the 10 in. row drill. This year, the reason the 30 in. row vacuum planter produced significantly higher yield than the 10 in. drill was because of water runoff from an adjacent field that covered the vacuum planter replications more than the drill replications.

For this narrow row (10 in.) drill and conventional row (30 in.) planter study, there was no dryland grain sorghum harvested for 2020 because of dry conditions.

In 2019, we suggested two plausible reasons that contributed to the vacuum planter yielded more than the air drill. First, we noticed that the stand of the air drill had some gaps down planted rows; whereas, the vacuum planter had more uniform stands. The reason there were planting gaps in the air seeder treatment was because it required a rather long planting distance to properly distribute the seed, particularly for low seeding rates. Even though these are large field size plots, uniform seed distribution was difficult to achieve, particularly at the beginning of the plots. This was not an issue for the vacuum planter with its seed plates.

The second reason the vacuum planter produced higher yields than the air seeder was because of weeds. The gaps from nonuniform seed distribution allowed weeds (mostly sandbur) to flourish. Cultivation was not an option for the air seeder with its narrow seed rows.

In 2017 with uniform stands from a higher seeding rate, the air drill produced significantly more yield than the vacuum planter, and the narrow row air drill also suppressed weeds. In fact, the air drill suppressed sandburs so well that last year we used the air drill to plant grain sorghum seed in some of Plainsman's sandbur infested fields, and it worked well.

For three of the five harvest years that we have conducted this dryland study, the vacuum planter produced higher grain sorghum yields than the drill treatment. Only in 2017 did the drill treatment produce higher yields and variable net incomes than the vacuum planter. In 2022, there was no yield difference between the vacuum planter and drill treatments. In 2021, the vacuum planter had an unfair advantage with the water runoff targeting its replications, therefore, there are only four harvest years of equitable comparison: two years where the 30 in. row vacuum planter had the highest yield, one year where the 10 in. row drill had the highest yield, and last year where there was no yield difference between the 30 in. row planter and 10 in. row drill treatments.

Narrow Row Drill and Conventional Row Vacuum Planter Comparison
for Grain Sorghum Production, Walsh, 2023.

Planter Type	Row Spacing Arragement	Grain Sorghum Yield	Test Weight	Moisture Content	Flowering Date
		bu/ac	lb/bu	%	
Vacuum Planter	30 in. double disc	37.4	55.9	9.9	10-Aug
Drill	10 in. single disc	25.6	52.0	10.5	11-Aug
Average		37.4	55.9	9.9	11-Aug
LSD (0.20)		4.77			

Planted: June 9 for both treatments.
Pioneer 86P20, at 34,000 seeds/acre for no-till and strip till, and at 84,000 seeds/ac for drill.
Both treatments harvested on November 10, 2023.
Planters: John Deere 1590 drill; John Deere 7300 Vacuum Planter.

Strip Till Zone Planting Proximity, Planting On and Off Strip Till Zone

Kevin Larson, Brett Pettinger, Perry Jones, and Zane Jenkins

Higher N fertilizer costs have growers searching for ways to lower fertilizer expense. Anhydrous ammonia is the least expensive form of N fertilizer. Strip till is a zone tillage and fertilizer placement method which allows the use of anhydrous N. Strip till employs chisel shanks to till zones and inject anhydrous N into the soil. Strip tilling subjects the soil in the tillage zones to drying. Under dry planting conditions, planting on the strip till zone may be too dry for adequate seed germination, whereas there may be enough planting moisture for seed germination by planting beside the strip till zone. We conducted this study to compare planting sorghum on and off the strip till zone for their effect on plant densities and grain yields.

Materials and Methods

We performed this dryland grain sorghum study at the Plainsman Research Center on a site in which the previous crop was wheat. For the strip till treatment, we applied anhydrous N at 60 lb N/a and 10-34-0 at 5 gal/a in eight, 30 in. rows to a depth of 8 in. on September 23, 2022. We planted Pioneer 86P20 at 34,000 seeds/a on June 9, 2023 with a John Deere vacuum planter with eight, 30 in. rows on the strip till zone (On Zone treatment) and 8 in. beside the strip till zone (Off Zone treatment). For pre-emergence weed control we applied Flumioxazin 3.0 oz/a, S-metolachlor at 24 oz/a, Mesotrione 6.4 oz/a and Atrazine at 1.0 lb/a, and for post emergence weed control, we applied quinclorac at 12 oz/a, 2,4-D ester at 3 oz/a, NIS at 3 oz/a, and AMS at 2 lb/a. We harvested the 20 ft. wide by 1200 ft. long grain sorghum plots on November 3 with a Gleaner F3 combine equipped with a HarvestMaster H2 automated weighing and seed moisture system. Grain yields were adjusted to 14% seed moisture content.

Results and Discussion

The Off Zone planting yielded 2.7 bu/a more than the On Zone planting, and even though the yield difference was relatively small, the yield increase was significantly different at the 0.20 alpha level. This is the second year that the Off Zone planting produced significantly higher yield than the On Zone planting. Unlike last year where there was a large difference in emerged plant population that helped explained the significant yield difference, this year only 200 plants/a separated their emerged plant populations. Therefore, unlike last year, this year’s emerged plant population does not fully explain the significant yield increase of the Off Zone planting compared to the On Zone planting. After planting, the wet months of June and July followed by the hot and dry grain-filling period during August and September, may help explain the yield difference better than the emerged plant population.

In 2022, the Off Zone planting produced 16.8 bu/a more grain yield than the On Zone planting. The yield increase undoubtedly was the result of the higher emerged plant population of 11,300 plants/a achieved by Off Zone planting compared to On Zone planting. Because of the dry winter and spring, there was only marginal soil moisture at planting. Soil water was lost by strip tilling and only partially replaced by winter and spring precipitation. Therefore, planting on the strip till zone, where planting moisture was lacking, reduced seedling stands compared to planting 8 in. off the strip till zone, where soil moisture remained and was not lost to strip tilling.

We will continue this strip till zone planting proximity study in both dry and wet years to discover if off zone planting is an important strategy not only for dry years, but wet years as well.

Planting Proximity On and Off Strip Till Zone Comparison for Grain Sorghum Production, Walsh, 2023.

Planted Strip Till Zone Proximity	Distance From Strip Till Zone	Grain Sorghum Yield	Test Weight	Moisture Content	Plant Population	Flowering Date
		bu/ac	lb/bu	%	plants/ac	
Off	8 in. Off Zone	41.1	59.3	10.3	28,900	10-Aug
On	On Zone	38.4	59.5	10.2	28,700	12-Aug
Average		39.8	59.4	10.3	28,800	11-Aug
LSD (0.20)		1.1				

Planted: June 9, 2023 at 34,000 seeds/ac on or 8 in. beside strip till zone.
Strip tilled: September 23, 2022 at 60 lb N/ac and 10-34-0 at 5 gal/ac to 8 in. depth.
Harvested: November 3, 2023.

Proximity Planting: On and Off Strip Till Zone Comparison for Grain Sorghum Production, Walsh, 2022-2023.

Planted Strip Till Zone Placement	Distance From Strip Till Zone	Grain Sorghum Yield	Test Weight	Moisture Content	Plant Population	Flowering Date
		bu/ac	lb/bu	%	plants/ac	
Year 2022						
Off	8 in. Off Zone	81.9	59.5	10.5	30,200	12-Aug
On	On Zone	65.1	58.7	11.0	18,900	14-Aug
Average		73.5	59.1	10.8	24,550	13-Aug
LSD (0.20)		12.2				
Year 2023						
Off	8 in. Off Zone	41.1	59.3	10.3	28,900	10-Aug
On	On Zone	38.4	59.5	10.2	28,700	12-Aug
Average		39.8	59.4	10.3	28,800	11-Aug
LSD (0.20)		1.1				

Planted at 34,000 seeds/ac on or 8 in. beside strip till zone on June 6 for 2022 season and on June 9 for 2023 season.
Strip tilled at 60 lb N/ac and 10-34-0 at 5 gal/ac to 8 in. depth on November 4, 2021 for 2022 planting and September 23, 2022 for 2023 planting.
2022 Harvested on November 7, 2022 and 2023 Harvested on November 3, 2023.

Strip Till N Rates for Dryland Grain Sorghum Production

Perry Jones, Kevin Larson, and Zane Jenkins

Nitrogen is the primary nutrient needed and used for fertilizing crops. Nitrogen is the first plant nutrient listed in a “complete fertilizer” of N-P-K. Nitrogen rates on dryland grain sorghum have not been fully studied for decades at the Plainsman Research Center. Instead, we have focused on the timing and placement of P rates, both strip till (chisel) applied, and planter (seedrow) applied. After decades of overlooking it, growers and staff thought it was time to revisit N rates for dryland grain sorghum production.

Materials and Methods

We conducted this dryland grain sorghum study at the Plainsman Research Center on a site in which the previous crop was wheat. For the N rates, we strip tilled applied anhydrous N at 30, 60, 90, and 120 lb N/ac and 10-34-0 at 5 gal/a in eight, 30 in. rows to a depth of 8 in. on September 23, 2022. We planted Pioneer 86P20 at 34,000 seeds/a on June 9, 2023 with a John Deere vacuum planter with eight, 30 in. rows. For pre-emergence weed control we applied Flumioxazin 3.0 oz/a, S-metolachlor at 24 oz/a, mesotrione 6.4 oz/a and atrazine at 1.0 lb/a, and for post emergence weed control, we applied quinclorac at 12 oz/a, 2,4-D ester at 3 oz/a, NIS at 3 oz/a, and AMS at 2 lb/a. We harvested the 20 ft. wide by 1200 ft. long grain sorghum plots on November 11 with a Gleaner F3 combine equipped with a HarvestMaster H2 automated weighing and seed moisture system. Grain yields were adjusted to 14% seed moisture content.

Results and Discussion

The grain yield of the strip tilled N rates was the same for the 30 lb N/ac and 60 lb N/ac treatments, 35 bu/ac, but declined for the 90 lb N/ac, 33 bu/ac, and the 120 lb N/ac, 31 bu/ac, treatments. The increasing N rate had a declining polynomial grain yield curve with an R^2 of 0.937. The variable net income of the N rates is the gross income of the grain yield minus the cost of N fertilizer. The 30 lb N/ac treatment had the highest variable net income of $143/ac, and the variable net income continued to decline to the lowest level with the 120 lb N/a treatment at $70/ac. Since the grain yields of the N rates were the same or decreased with increasing N rates, the variable net income was a straight-line income loss with increasing N rates (R^2 of 0.9995). The income loss from increasing N fertilization was $0.81 per lb of additional N. Most of this variable net income loss was due to the cost of anhydrous N at $1047/ton or $0.64/lb.

Strip Till N Rates on Dryland Grain Sorghum at Walsh, 2023.

Treatment	Strip Till Fertilizer N Rate	Grain Yield	Seed Moisture	Test Weight	Plant Height
	lb/ac	bu/ac	%	lb/bu	in
30N	30	34.6	8.0	58.2	41.5
60N	60	34.7	8.1	57.9	41.0
90N	90	32.6	8.2	58.5	40.5
120N	120	31.4	8.2	58.4	40.0
Average		33.3	8.1	58.3	40.8

Planted: June 8, 2023 Pioneer 86P20 at 34,000 seeds.ac.
Harvested: November 7, 2023
Strip tilled applied anhydrous N on September 23, 2022 with 5gal/ac of 10-34-0 to all treatments.

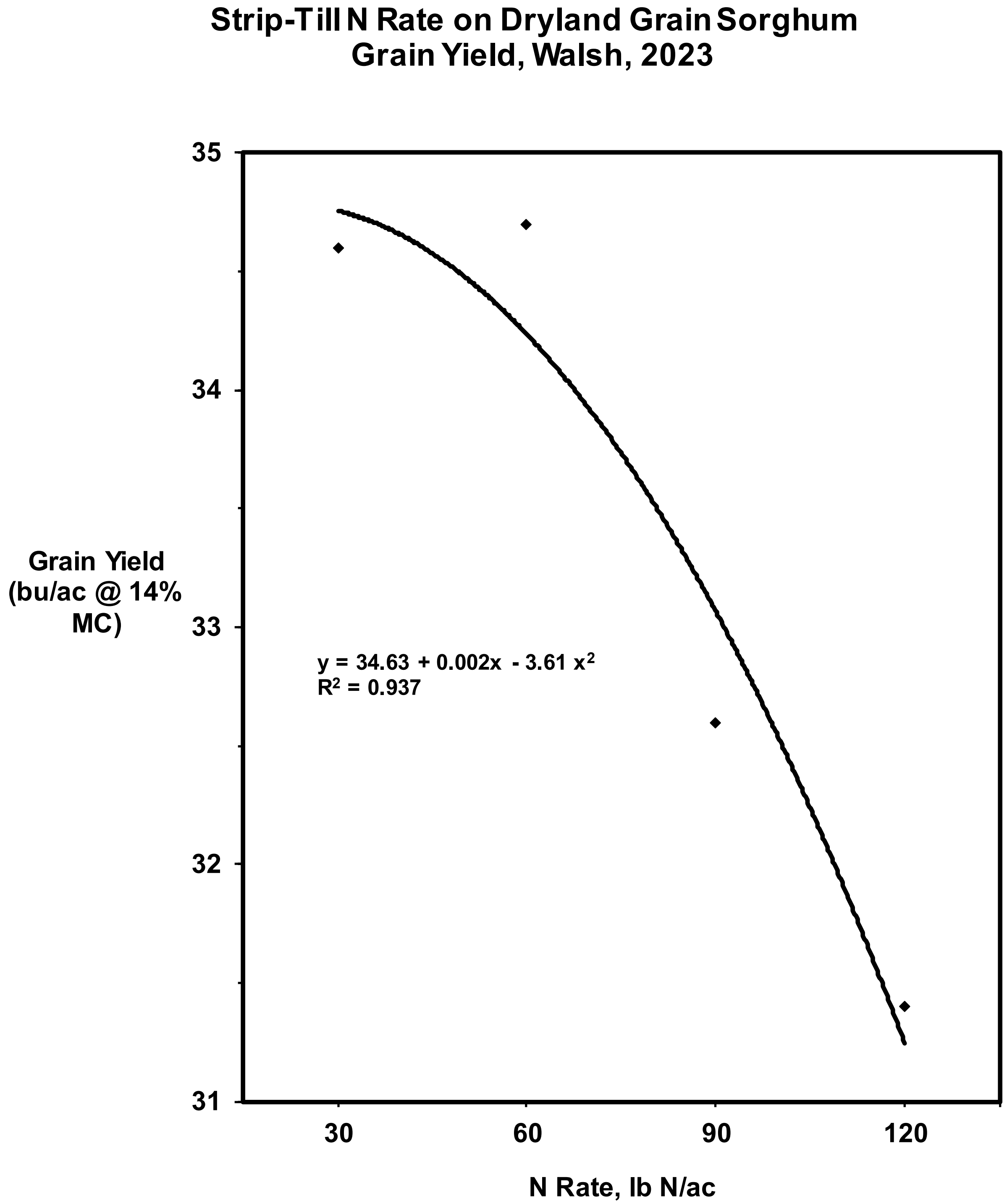


Fig.   . Grain yield of strip till N rates on dryland grain sorghum at Walsh. Strip tilled (as anhydrous N 82-0-0) N rates were 30, 60, 90, and 120 lb N/ac. All N treatments also received 5 gal/ac of 10-34-0 at strip-tilling. The soil test recommendation for 50 bu/ac yield goal on grain sorghum was 25 lb N/ac.

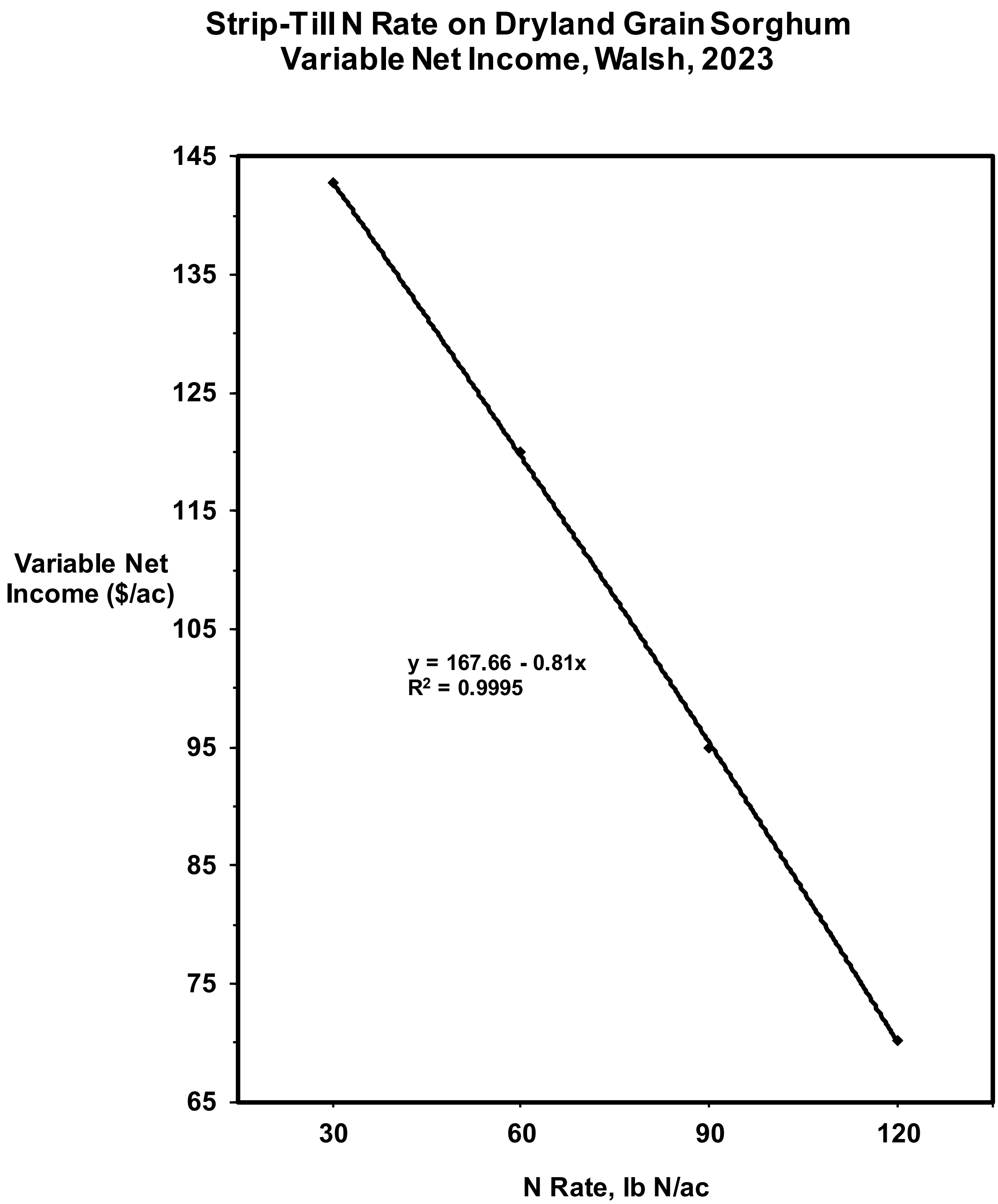


Fig. . Variable net incomes of strip till N rates on dryland grain sorghum at Walsh. Strip tilled (as anhydrous N 82-0-0) N rates were 30, 60, 90, and 120 lb N/ac. Anhydrous N cost was $1047/ton.

Strip Till and No Till N Fertilization Comparison for Dryland Grain Sorghum Production

Kevin Larson, Perry Jones, Brett Pettinger, and Zane Jenkins

Grower inquiries on the production of strip till compared to no till for dryland grain sorghum were the impetus for this study. In the Southern High Plains, the predominant planting system for irrigated production of row crops is strip till. For dryland row crop production, no till is a far more common practice than strip till. The main advantage of no till is that it causes the least disruption of residue cover, and thereby, conserves more soil and water than strip till or conventional tillage. However, no-till requires liquid fertilizer, the most expensive nitrogen fertilizer, whereas strip till allows the use of anhydrous N, the least expense nitrogen fertilizer. Another benefit of strip till is the deeper placement of phosphate fertilizer, which makes the immobile phosphate fertilizer more available for root interception throughout the season compared to no till, where phosphate fertilizer is applied with the seed at planting.

Materials and Methods

We conducted this dryland grain sorghum study at the Plainsman Research Center on a site in which the previous crop was wheat. For the strip till treatment, we applied anhydrous N at 60 lb N/a and 10-34-0 at 5 gal/a in eight, 30 in. rows to a depth of 8 in. on September 23, 2022. For the no till treatment, we surface applied liquid 32-0-0 in streams 20 in. apart at 60 lb N/a on September 24, 2022 and seedrow applied 10-34-0 at 5 gal/a at planting. We planted Pioneer 86P20 at 34,000 seeds/a on June 9, 2023 with a John Deere vacuum planter with eight, 30 in. rows. For pre-emergence weed control we applied Flumioxazin 3.0 oz/a, S-metolachlor at 24 oz/a, mesotrione 6.4 oz/a and atrazine at 1.0 lb/a, and for post emergence weed control, we applied quinclorac at 12 oz/a, 2,4-D ester at 3 oz/a, NIS at 3 oz/a, and AMS at 2 lb/a. We harvested the 60 ft. wide by 1200 ft. long grain sorghum plots on November 10 with a Case-IH 2388 combine using a modified corn head with ARRO conversions and weighed them in a digital scale cart. Grain samples were collected for seed moistures and test weights. Grain yields were adjusted to 14% seed moisture content.

Results and Discussion

The no till treatment produced 8.8 bu/a more than the strip till treatment and this yield difference was significant at the 0.20 alpha level. The cost of 60 lb/a of N fertilizer was $1.44/a less expensive for strip till using anhydrous N than for no till using liquid N (anhydrous cost was $1047/ton and liquid 32-0-0 cost was $425/ton). Custom application cost of strip till was $8.50/a more than boom application for no till ($15/a for strip till and $6.50/a for no till). The cost of 10-34-0 increased $135/ton from the strip till fall application to the planter applied spring application ($525/ton in September 2022 to $660/ton in June 2023). No application cost was charged for the phosphate fertilizer because applications were performed either with the anhydrous N during the strip till operation, or with the seed at planting for no till. Total N and P variable treatment cost was $3.06 more for the strip till treatment compared to the no till treatment. The variable net income of no till was $44/a more than strip till, due to the higher grain yield of no till (8.8 bu/a @ $4.68/bu). This year there was little N and P fertilizer production cost difference between the Off Zone and On Zone treatments. This is the seven year of this study and for five of the seven years of this study, production costs with typical N fertilizer rates were the same or nearly equivalent for strip till and no till. For two years of this study, the production cost of dryland grain sorghum using typical N fertilizer rates was more expensive for no till compared to strip till. This year, the yield advantage of no till compared to strip till under our dryland conditions made no till dryland grain sorghum production more profitable than strip till. For six of the seven harvest years that we have conducted this dryland study, no till has produced higher grain sorghum yields and net incomes than strip till. Only in 2017 did strip till produce higher yields and variable net incomes than no till. In 2022, no till produced higher yield and income than strip till because the plant population of strip till was low and non-uniform compared to no till. The low plant population of strip till was due to marginal planting moisture, particularly in the strip till zone. This year, the emerged plant population was similar between the no till and strip till treatments; therefore, plant population does not explain the significantly higher yield of the no till treatment. In 2020, no till produced significantly higher yields than strip till because of water runoff from an adjacent field that covered the no till replications more than the strip till replications. Therefore, only six years of this study had equitable comparisons: five years no till had higher yields and income, and one year strip till had higher yield and income.

No Till and Strip Till N Fertilizer Comparison on Dryland Grain Sorghum at Walsh, 2023.

Tillage Treatment	Grain Yield	Test Wt.	Plant Population	N Fertilizer	N Fertilizer Cost	N Application Cost	Total N & P Variable Treatment Cost	Variable Net Income
	bu/ac	lb/bu		type	$/60 lb N	$/ac	$/ac	$/ac
No Till	37.4	55.9	28,600	Liquid (28-0-0)	39.84	6.50	65.79	109.24
Strip Till	28.6	56.2	27,600	Anhydrous (82-0-0)	38.40	15.00	68.85	65.00
Average	33.0	56.1	28,100		39.12	10.75	67.32	87.12
LSD (0.20)	1.39							

Strip till: anhydrous N applied September 23, 2022 on 30 in. row spacing at a depth of 8 in.
No till: surface applied liquid 32-0-0 on September 24, 2022 in streams 20 in. apart.
Liquid 10-34-0 at 5 gal/ac was applied with the anhydrous N for the strip till treatment and with the seed at planting for the no till treatment.
Anhydrous cost: $1047/ton; 32-0-0 cost $425/ton.
P as 10-34-0 cost: $525/ton in September and $660/ton in May.
Grain sorghum price: $4.68/bu.
Planted: Pioneer 86P20 at 34,000 seeds/ac on June 9, 2023.
Harvested: November 10, 2023

Strip Till and Planter Applied P Comparison for Grain Sorghum Production

Perry Jones and Brett Pettinger

Two common methods and timings for application of liquid phosphate are deep placement with a strip still implement and seedrow placement with a planter. There are advantages for both systems. The advantage for strip till chisel applied P is that the deep placement of P allows roots to intercept P (P has low mobility) season long because roots only grow where there is soil water. The advantage for seedrow planter applied P is that P placement with the seed allows the seedlings direct contact and uptake of P for early plant growth. We conducted this study to determine which P placement method produces the highest yields and income.

Materials and Methods

We strip tilled anhydrous N at 60 lb N/ac at 8 in. deep around September 23, 2022 into standing wheat stubble for all treatments for this dryland grain sorghum P placement and rate study. We compared: 1) No P, no applied P; 2) Planter P, seedrow P placement with a vacuum planter with 30 in. spacing at 5 gal/ac of 10-34-0; 3) Strip Till P, deep P placement with a strip tiller at 5 gal/ac of 10-34-0; and 3) Strip Till P/Planter P, both strip till P and planter P at 5 gal/ac of 10-34-0 for each operation. For strip till P placement, we used a 20 ft. tool bar with 8 rows of Yetter strip till chisel units on 30 in. spacing. For planter P placement, we used a 20 ft. John Deere 7300 vacuum planter with eight 30 in. rows. We planted Pioneer 86P20 on May 24, 2023 at 34,000 seeds/ac. For pre-emergence weed control, we applied flumioxazin at 3.0 oz/ac, S-metolachlor at 24 oz/ac, mesotrione at 6.4 oz/ac and atrazine at 1.0 lb/ac. Post emergence herbicides of 5oz of 2, 4-D LV6 was applied on July 3, 2023. We harvested the 20 ft. wide by 1255 ft. long grain sorghum plots on October 26, 2023 with a Case-IH 2388 combine using a modified corn head with ARRO conversions and weighed them in a digital scale cart. Grain samples were collected for seed moistures and test weights. Grain yields were adjusted to 14% seed moisture content.

Results and Discussion

In 2023, the different P placement and timing treatments resulted in differences in grain sorghum yields compared to the No P treatment, DLSD 0.10 (5.0 bu/ac). Two P treatments produce significantly more yield than the No P treatment, the 5 gal of 10-34-0 at strip till plus 5 gal/ac with the planter (Total 40 lb P_2O_5/ac, 12 lb N/ac) treatment with 10.5 bu/ac more than No P treatment, and the 2.5 gal/ac strip till plus 2.5 gal/ac planter (Total 20 lb P_2O_5/ac, 6 lb N/ac) treatment with 7.2 bu/ac more than the No P treatment. The highest yield of 93.1 bu/ac was achieved by the 5 gal of 10-34-0 at strip till plus 5 gal/ac with the planter (Total 40 lb P_2O_5/ac, 12 lb N/ac) treatment, and the lowest yielding treatment was 81.4 bu/ac achieved by the 5 gal/ac strip till (Total 20 lb P_2O_5/ac, 6 lb N/ac) treatment. However when we look at the net income in 2023 the 2.5 gal/ac strip till plus 2.5 gal/ac planter (Total 20 lb P_2O_5/ac, 6 lb N/ac) performed the best among all treatments with $400.31 per acre ($13.74/ac more than the No P treatment) with the 5 gal/ac strip plus 5 gal/ac planter treatment coming in second overall with $395.81 per acre ($9.24/ac more than the No P treatment). For comparison the No P check had a net income of $386.57 per acre.

This is the first year that we included the 2.5 gal/ac strip till plus 2.5 gal/ac planter (Total 20 lb P_2O_5/ac, 6 lb N/ac) treatment in this P study, and it produced $13.74/ac more variable net income than the No P treatment. However, after four years of testing the other three P treatments compared to the No P treatment, all the other P treatments produced negative variable net incomes compared to the No P treatment, ranging from -$23.51/ac for the 5 gal strip till P treatment to -$89.05/ac for the 5 gal strip till P plus 5 gal planter P treatment.

Strip Till and Planter Applied P Comparison for Grain Sorghum Production, Walsh, 2023.

Application Method	10-34-0 Rate	Grain Sorghum Yield	Grain Yield Comparison to No P	Test Weight	Moisture Content	10-34-0 Cost	Variable Net Income
		bu/ac	bu/ac	lb/bu	%	$/ac	$/ac
5 Strip Till 2.5P/ 5 Planter 2.5P	2.5 gal/a 2.5 gal/a	89.8	7.2	59.1	10.5	19.95	400.31
4 Strip Till 5P/ 4 Planter 5P	5 gal/a 5 gal/a	93.1	10.5	58.5	10.8	39.90	395.81
3 Planter P	5 gal/a	86.8	4.2	59.1	10.8	19.45	386.77
1 No P	0	82.6	0.0	59.0	10.8	0.00	386.57
2 Strip Till P	5 gal/a	81.4	-1.2	58.1	11.1	20.45	360.50
Average		83.6	1.0	58.7	10.9		385.99
Dunnett's LSD (0.10)		5.0	5.0				
(DLSD Comparison to No P)							

Planted: Pioneer 86P20 on May 24, 2023 at 34,000 seeds/a with John Deere 7300 vacuum planter on 30 in. spacing.
All plots strip tilled on September 23, 2022 applied 60 lb N/a.
Strip till P: 10-34-0 at 2.5 or 5 gal/a applied with strip tiller on September 23, 2022.
Planter P: 10-34-0 at 2.5 or 5 gal/a applied seedrow with planter on May 24, 2023.
Strip till P/Planter P: 10-34-0 at 5 gal/a with strip tiller and 10-34-0 at 5 gal/a with planter, total applied 10-34-0 for Strip till P/Plant P was 10 gal/a.
P as 10-34-0 cost: $695/ton for September 2023 and $660/ton for May 2023.
Grain sorghum price: $4.68/bu
Variable Net Income is Yield X $4.68/bu -P cost.

Strip Till and Planter Applied P Four Years Comparison for Grain Sorghum Production, Walsh, 2020 to 2023.

Application Method	10-34-0 Rate	2020 Variable Net Income	2021 Variable Net Income	2022 Variable Net Income	2023 Variable Net Income	2020-2023 Total Variable Net Income	2020-2023 Comparison to No P Net Income
		$/ac	$/ac	$/ac	$/ac	$/ac	$/ac
1 No P	0	170.39	349.66	592.50	386.57	1499.12	0.00
2 Strip Till P	5 gal/a	150.42	351.46	613.24	360.50	1475.61	-23.51
3 Planter P	5 gal/a	151.53	366.46	547.39	386.77	1452.14	-46.98
4 Strip Till 5P/ 4 Planter 5P	5 gal/a 5 gal/a	126.56	350.95	536.75	395.81	1410.07	-89.05
5 Strip Till 2.5P/ 5 Planter 2.5P	2.5 gal/a 2.5 gal/a				400.31	400.31*	13.74* (*2023 only)
Average		149.72	354.63	572.47	385.99	1462.82	-39.88

Planted: Late May to early June at 34,000 seeds/a with John Deere 7300 vacuum planter on 30 in. spacing.
All plots strip tilled on September to November applied 60 lb N/a.
P as 10-34-0 cost: $415/ton, 2020; $605/ton, 2021; $700/ton, November 2021 and $830/ton, May 2002; $695/ton, September 2023 and $660/ton, May 2023.
Grain sorghum price: $5.55/bu, 2020; $5.77/bu, 2021; $7.13/bu, 2022; $4.68/bu, 2023.
Variable Net Income is Yield X grain price/bu -P cost.

Herbicide and Single Tillage Control of Kochia in Wheat-Sorghum-Fallow Rotation

Kevin Larson, Brett Pettinger, Perry Jones, and Zane Jenkins

Kochia (*Kochia scoparia*) is an introduced plant that was originally grown as an ornamental but has become a pervasive weed in many cultivated fields. Soon after ALSs were first registered for long term broadleaf control in cereals, kochia developed resistant to these sulfonureals. In recent years, some kochia populations have become resistant to glyphosate. Continual dependence on glyphosate for broad spectrum weed control has led to kochia becoming resistant. Since kochia has become difficult to control with glyphosate, we conducted this study to investigate alternative kochia controlling herbicides and practices.

Materials and Methods

We conducted this dryland Wheat-Sorghum-Fallow rotation study at the Plainsman Research Center in which the previous crop rotation was Wheat-Sunflower-Fallow rotation. The kochia population on this site became glyphosate resistant after extensive reliance on glyphosate for weed control for the 10-year duration of the no till Wheat-Sunflower-Fallow rotation study. The kochia-controlling treatments prior to grain sorghum in 2023 were: 1) flumioxazin 3.0 oz/a; 2) mesotrione 6 oz/a and atrazine 0.75 lb/a; 3) dicamba 16 oz/a and atrazine 0.75 lb/a; and 4) dicamba 16 oz/a and atrazine 0.75 lb/a plus a single sweep plow tillage operation. The application date for the herbicide treatments prior to grain sorghum in 2023 was March 14, 2023, and the sweep plow tillage portion of treatment was performed May 26, 2023. The kochia-controlling treatments prior to wheat in 2023 were: 1) flumioxazin 3.0 oz/a; 2) mesotrione 6 oz/a and atrazine 0.75 lb/a; 3) dicamba 16 oz/a and atrazine 0.75 lb/a; and 4) dicamba 16 oz/a and atrazine 0.75 lb/a plus a single sweep plow tillage operation. The application date for the treatments before wheat in 2023 was March 25, 2022 for the herbicide treatments, and May 30, 2022 for the sweep plow treatment. We applied a pre-plant application to the grain sorghum of metolachlor 24 oz/a, atrazine 1.0 lb/a and glyphosate 32 oz/a. We planted wheat, Avery, at 50 lb seed/a on September 30, 2022. We planted grain sorghum, Sorghum Partners 45A45 DT, at 40,000 seeds/a on June 1, 2023. To control sandburs with the Double Team grain sorghum, we applied FirstAct 10 oz/a, AMS 2.5 lb/a, COC 1% v/v on June 28. A post emergence application of Stare Down 6.4 oz/a and Brox 2EC 24 oz/a was applied to all grain sorghum treatments on July 7. Since no wheat emerged because of drought conditions, we did not apply any post emergence herbicides to the wheat. For fertilization, we surface streamed 60 lb N/a to the entire site and we seedrow applied at planting 10-34-0 at 5 gal/a to both the grain sorghum and wheat crops. No wheat was harvested. We harvested the 20 ft. wide by 1000 ft. long grain plots of grain sorghum on November 6, 2023 with a modified Gleaner F3 combine equipped with a HarvestMaster H2 weighing and seed moisture system. Grain yields were adjusted to 14.0% seed moisture content for grain sorghum.

Results and Discussion

We did not harvest any wheat due to drought conditions from October 2022 (wheat planting) through late April 2023. The wheat growing season was dry and no wheat was harvested, but the grain sorghum growing season precipitation was well above average. May, June, and July were wet with total rainfall of 15.53 in., but August and September were dry.

Since no wheat was harvested, the wheat phase of the W-S-F rotation was just expenses of herbicide and application costs. The flumioxazin at 3.0 oz/a treatment and the tillage plus dicamba 16 oz/atrazine 0.75 lb treatment had the highest grain sorghum yield averages of 47 bu/a. The dicamba 16 oz/atrazine 0.75 lb treatment had the lowest grain yield of 40 bu/a. There was no significant yield difference between any of the treatments at the alpha 0.20 level. With the highest grain sorghum yield and the lowest treatment cost, the flumioxazin treatment had the highest total rotational variable net income of $194/a. The total rotational variable net income of the flumioxazin treatment was $26/a higher than the second highest treatment, mesotrione 6 oz/atrazine 0.75 lb. All treatments had negative variable net incomes for wheat and positive variable net incomes for grain sorghum. Even with the negative variable net incomes of the wheat phase, all the W-S-F rotational variable net incomes for all the treatments were positive. The flumioxazin treatment had the highest rotational variable net income and provided $43/a more return than the lowest treatment, the dicamba/atrazine treatment.

Herbicide and Single Tillage Control of Kochia in W-S-F Rotation, Wheat Crop, Walsh, 2023.

Treatment	Product Dosage	Dosage Unit	Application Date	Seed Moisture %	Test Weight lb/bu	Grain Yield bu/a	Treatment Cost $/a	Variable Net Income $/a
1 Flumioxazin	3	oz/a	3/25/2022	0.0	0.0	0.0	12.68	-12.68
2 Mesotrione	6	oz/a	3/25/2022	0.0	0.0	0.0	15.58	-15.58
2 Atrazine	0.75	lb/a	"					
3 Dicamba	16	oz/a	3/25/2022	0.0	0.0	0.0	17.20	-17.20
3 Atrazine	0.75	lb/a	"					
4 Tillage (sweep plow)			5/30/2022	0.0	0.0	0.0	28.20	-28.20
4 Dicamba	16	oz/a	3/25/2022					
4 Atrazine	0.75	lb/z	"					
Average				0.0	0.0	0.0	18.42	-18.42
LSD 0.20								

Planted: September 30, 2022, wheat variety: Avery at 50 lb seed/a.
Herbicide treatments applied: 3/25/22 to 20 ft. by 1000 ft. with 2 replications, prior to kochia emergence.
Treatment cost is herbicide cost plus application cost at $6.50/a. Sweep plow cost is $11/a.
No in-season weed control.
There was no wheat harvested because of the drought in the fall and early spring.
Variable Net Income: gross income (grain yield x $5.76/bu) minus treatment cost.
Wheat price: $5.76/bu.

Herbicide and Single Tillage Control of Kochia in W-S-F Rotation, Grain Sorghum Crop, Walsh, 2023.

Treatment	Product Dosage	Dosage Unit	Application Date	Seed Moisture %	Test Weight lb/bu	Grain Yield bu/a	Treatment Cost $/a	Variable Net Income $/a
1 Flumioxazin	3	oz/a	3/14/2023	10.2	60.9	46.9	12.52	206.97
2 Mesotrione	6	oz/a	3/14/2023	10.3	60.6	42.8	16.30	184.00
2 Atrazine	0.75	lb/a	"					
3 Dicamba	16	oz/a	3/14/2023	10.2	60.5	39.7	17.24	168.56
3 Atrazine	0.75	lb/a	"					
4 Tillage (sweep plow)			5/26/2023	10.4	60.7	47.0	29.24	190.72
4 Dicamba	16	oz/a	3/14/2023					
4 Atrazine	0.75	lb/a	"					
Average				10.3	60.7	44.1	18.83	187.56
LSD 0.20						9.33		

Planted: June 1, 2023, grain sorghum hybrid: Sorghum Partners 45A45 DT at 40,000 seeds/a.

Herbicide treatments applied: March 14, 2023, 20' by 1000', 2 replications, prior to kochia emergence.

Pre-planted application: atrazine 1.0 lb/a, metolachlor 24 oz/a, glyphasate 32 oz/a.

In-season sandbur control applied to all treatments June 28, 2023: FirstAct 10.7 oz/a, COC 32 oz/a, AMS 2.5 lb/a.

In-season weed control applied to all treatments July 7, 2023: Staredown 6.4 oz/a, Brox 2EC 24 oz/a.

Treatment cost is herbicide cost plus application cost at $7/a. Sweep plow cost is $12/a.

Variable Net Income: gross income (grain yield x $4.68/bu) minus treatment cost.

Grain sorghum price: $4.68/bu.

Table .--Herbicide and Single Tillage Control of Kochia for W-S-F Rotation, Walsh, 2023.

Treatment	Product Dosage	Dosage Unit	Application Date	Test Weight lb/bu	Grain Yield bu/a	Treatment Cost $/a	Variable Net Income $/a	Total Rotational Variable Net Income $/a
1 Flumioxazin (Wheat)	3	oz/a	3/25/2022	0.0	0.0	12.68	-12.68	194.29
1 Flumioxazin (Milo)	3	oz/a	3/14/2023	60.9	46.9	12.52	206.97	
2 Mesotrione (Wheat)	6	oz/a	3/25/2022	0.0	0.0	15.58	-15.58	168.42
2 Atrazine (Wheat)	0.75	lb/a	"					
2 Mesotrione (Milo)	6	oz/a	3/14/2023	60.6	42.8	16.30	184.00	
2 Atrazine (Milo)	0.75	lb/a	"					
3 Dicamba (Wheat)	16	oz/a	3/25/2022	0.0	0.0	17.20	-17.20	151.36
3 Atrazine (Wheat)	0.75	lb/a	"					
3 Dicamba (Milo)	16	oz/a	3/14/2023	60.5	39.7	17.24	168.56	
3 Atrazine (Milo)	0.75	lb/a	"					
4 Tillage (Wheat)			5/30/2022	0.0	0.0	28.20	-28.20	162.52
4 Dicamba (Wheat)	16	oz/a	3/25/2022					
4 Atrazine (Wheat)	0.75	lb/a	"					
4 Tillage (Milo)			5/26/2023	60.7	47.0	29.24	190.72	
4 Dicamba (Milo)	16	oz/a	3/14/2023					
4 Atrazine (Milo)	0.75	lb/a	"					
Wheat Average				0.0	0.0	18.42	-18.42	
LSD 0.20 (Wheat)								
Milo Average				60.7	44.1	18.83	187.56	
LSD 0.20 (Milo)					9.33			

Wheat planted: 9-30-22, Avery at 50 lb seed/a. Milo planted: 6-1-23, Sorghum Partners 45A45 DT at 40,000 seeds/a.
Herbicide treatments applied to 20 ft. by 1000 ft. with 2 replications, prior to kochia emergence.
Treatment cost for 3/25/2022 is herbicide cost plus application cost at $6.50/a. Sweep plow cost is $11/a.
Treatment cost for 3/14/2023 is herbicide cost plus application cost at $7/a. Sweep plow cost is $12/a.
Variable Net Income: gross income (grain yield x $5.76/bu for wheat; $4.68/bu for milo) minus treatment cost.

Dryland Millet and Wheat Rotation Study

Kevin Larson, Brett Pettinger and Perry Jones

This was the seventeenth cropping year for our dryland millet and wheat rotation study. We established these rotations to identify which millet and wheat and fallow rotation sequences produce the highest net incomes. Each rotation represents a different fallow length. We began this dryland rotation study with these six rotations in 2006: 1) Wheat-Fallow (15-month fallow period), 2) Wheat-Wheat (3-month fallow period), 3) Millet-Millet (8-month fallow period), 4) Wheat-Millet-Fallow (23-month fallow period, 11 months between wheat harvest and millet planting, and 12 months between millet harvest and wheat planting), 5) Millet/Wheat-Fallow, (no fallow between millet harvest and wheat planting and 11 months between wheat harvest and millet planting), and 6) Wheat/Millet-Fallow (no fallow between wheat harvest and millet planting and 11 months between millet harvest and wheat planting).

Materials and Methods

This was our sixteenth crop harvest for the following rotations: Wheat-Fallow (W-F), Wheat-Wheat (W-W), Millet-Millet (M-M), Wheat-Millet-Fallow (W-M-F), Millet/Wheat-Fallow (M/W-F), and Wheat/Millet-Fallow (W/M-F). We planted winter wheat, Avery, at 50 lb/a on October 1, 2022 (no wheat planted in M/W-F) and Proso millet, Dryland Genetics 240, at 10 lb/a on June 15, 2023 (no millet planted in W/M-F). We applied 50 lb N/a to the study site. Before planting, we sprayed two applications of glyphosate at 40 oz/a, dicamba 8 oz/a, Low Vol 0.5 lb/a, AMS 1 lb/a and we applied Stare Down 6.4 oz/a once to the fallow plots to control glyphosate resistant kochia. For in-season weed control, we chose short-residual herbicides that should not interfere with crop rotations: wheat, Express 0.4 oz/a, Low Vol 0.38 lb/a, dicamba 1.5 oz/a and NIS 90:10 8 oz/a; millet, Stare Down 6.4 oz/a and 2,4-D ester 8 oz/a; and fallow, glyphosate 40 oz/a, dicamba 8 oz/a, Low Vol 0.5 lb/a, AMS 1 lb/a two times. It was too dry after wheat harvest to plant millet in the W/M-F rotation, and it was too dry after millet harvest to plant wheat in the M/W-F rotation. In the W/M-F and M/W-F rotations, we applied glyphosate 40 oz/a, Staredown 6.4 oz/a, Low Vol 0.5 lb/a, and AMS 1 lb/a as a cleanup. Most rotations with a wheat phase failed due to drought and only the wheat in the W/M-F rotation was harvested on July 20, 2023. We harvested the millet on October 2, 2023 using a modified Gleaner F3 combine equipped with HarvestMaster H2 grain weighing and seed moisture system. Grain yields were adjusted to 14% moisture content for millet and 12% moisture content for the wheat. We recorded costs of production and yields to determine rotation revenues. There were no crops harvested in 2008 because of drought. Only wheat was harvested in 2011: millet was not planted because of drought. There was no wheat harvested in 2017, because it was too dry to emerge. No millet was harvested in 2018 due to poor stands from dry planting conditions. In 2019, the millet in the W/M-F rotation was not planted because it was too dry and the millet in the M-M rotation was terminated because of poor stand and sandburs. In 2020, no millet was harvested in any of the rotations because of poor stand and sandbur infestations. In 2021, it was too dry after wheat harvest to plant millet in the W/M-F rotation. No wheat was harvested in 2022 because it failed to emerge due to drought, and the millet was sprayed out in M-M rotation because it was severely infested with sandburs.

Results and Discussion

This year, wheat emergence was poor due to fall and late-spring drought and only the W/M-F rotation was harvested. Because the W/M-F rotation was the only rotation with a wheat phase to have a wheat harvest, the W/M-F rotation was the only wheat rotation to have a positive wheat variable net income. The millet also struggled to establish a uniform stand due to the late-spring drought. When the rains did come in late-June, it was too late for the millet, which was reflected in the average yield of only 68 lb/a. The meager millet harvest was not enough to offset the cost of millet production, therefore, all rotations with a millet phase had negative millet variable net incomes. After millet harvest, it was too dry to plant wheat in the M/W-F rotation, and after wheat harvest it was too dry to plant millet in the W/M-F rotation. Since the wheat in the M/W-F rotation and millet in the W/M-F rotation were not planted, there was no production for the unplanted phases of these rotations and their variable net incomes were negative. Because only the W/M-F rotation had wheat harvested, and the millet yields were poor, all rotations produced negative variable net incomes. The M-M rotation had the highest variable net income, but it still had a negative return of -$13/a.

We have conducted this study for seventeen years. We have had multiple crop failures and missed plantings, therefore rotational effects are, at best, difficult to generalize and quantify. This year because of drought, only the W/M-F rotation had wheat harvested, and the millet crop was poor. Over the past seven harvest years, the continuous wheat (W-W) rotation provided the highest average annual rotational variable net return of $48/a. For the past seven harvest years, and acknowledging crop failures and missed plantings, W-W produced $10/a more than M/W-F, the second highest rotation.

In 2022, the wheat did not emerge due to fall and spring drought and was not harvested. The millet also struggled to establish a uniform stand due to spring drought. When the rains did come in August, it was too late for the millet, which was reflected in the average yield of only 133 lb/a. The M-M rotation was sprayed out because it was infested with sandburs. Because there was no wheat harvested and poor millet yields, all rotations produced negative variable net incomes. The W/M-F rotation had the highest millet yield, but it still had a negative variable net income of -$10/a. In 2021, wheat yields were low due to the dry wheat growing season, but millet yields were good due to timely summer rains, and perhaps, from the elimination of flumioxazin from the spray mix that may have caused injury to millet in past years. In 2020, the wheat crop was very poor because it was dry from planting to harvest. Millet crops were not harvested because of poor stands and heavy infestation of sandburs. In 2019, the wheat crop was very good because there was abundant precipitation during the fall and spring for uniform stands and grain filling. Millet yields were poor because of nonuniform stands. Because of a poor stand and heavy infestation of sandburs, the M-M rotation was sprayed out. No millet was planted in the W/M-F rotation due to dry conditions after wheat harvest. In 2018, millet yields were very good, but the wheat crop failed due to dry conditions that caused a lack of emergence. In 2016, wheat yields were very good, but millet yields were reduced by a late planting date. In 2015, both wheat and millet yields were low. The wheat yields were low because a hailstorm caused considerable lodging and seed shattering. The millet yields were low because of a late planting date. In 2014, late planting dates for both wheat and millet reduced yields (and the M-M rotation failed to establish a stand). In 2013, dry conditions reduced yields of both wheat and millet crops, and we failed to plant millet in the W/M-F rotation. In 2012, millet was the only crop harvested because the wheat crop was completely lost to hail, and we failed to plant millet in the M/W-F and W/M-F rotations. In 2011, we had wheat production, but no millet production. We were able to plant and harvest only the wheat for in all phases of the rotations containing wheat. In 2010, there was enough precipitation to plant and harvest all wheat and millet crops in all rotations. The W-W rotation had the highest annual rotation variable net income in 2010. In 2009, adequate spring and summer moisture produced good yields for most crops with the wheat and millet producing similar yields. In 2009, we did not plant millet in the W/M-F rotation because of delayed volunteer wheat control. No crops were harvested in 2008 because of drought. Winter wheat performed better than millet in both yield and income in 2007. In 2007, it was too dry for the millet planted immediately after wheat harvest (millet in the W/M-F rotation) to establish a stand.

All rotations for three of the last seven cropping years have had negative net returns because of low or no crop production due to dry conditions. Those rotations with the least crop productions costs, especially fallow costs, tended to have the highest annual variable net incomes, W-W, M/W-F, and M-M rotations. With higher crop yields in past years, there appeared to be little relationship between fallow length and yields and incomes of the wheat and millet rotations in this study. The rotation with the highest annual rotation variable net income from past years was W-W, which has the shortest fallow period of 3 months. The W-M-F rotation had an average annual rotation variable net incomes from past years and it has the longest fallow length of 23 months (when totaling both fallow periods between the wheat and millet). In past years, when correlating production performance against precipitation, the W-W rotation tended to perform better in wetter years (except 2007, which was a dry year but had good winter moisture), while the W-M-F rotation tended to perform better in drier years.

Dryland Millet-Wheat Rotation, Crop Production, 2023.

Rotation	-----------2023 Crop----------- Wheat	Millet	Fallow	2023 Total Rotation Production	Annual Rotation Production
	-----------------------------lb/a (bu/a)-----------------------------				
W/M-F	377 (6.3)	0 (0.0)	0	377	189
M-M		79 (1.4)		79	79
M/W-F	0 (0.0)	130 (2.3)	0	130	65
W-M-F	0 (0.0)	61 (1.1)	0	61	20
W-F	0 (0.0)		0	0	0
W-W	0 (0.0)			0	0
Average	75 (1.3)	68 (1.2)		108	59

Annual Rotation Production is Total Rotation Production divided by the number of years to complete one rotation cycle.
It was too dry after wheat harvest to plant millet in W/M-F.
It was too dry after millet harvest to plant wheat in M/W-F.

Dryland Millet and Wheat Rotation Study, Walsh, 2023.

Crop Rotation	Seeding Density	Seed Cost	Weed Control Cost	Yield	Crop Price	Gross Income	Variable Net Income
	lb/a	$/a	$/a	bu/a	$/bu	$/a	$/a
Wheat							
W/M-F	50	12.50	15.75	6.3	5.76	36.29	8.04
M/W-F	--	--	21.46	0.0	5.76	0.00	-21.46
W-W	50	12.50	15.75	0.0	5.76	0.00	-28.25
W-M-F	50	12.50	15.75	0.0	5.76	0.00	-28.25
W-F	50	12.50	15.75	0.0	5.76	0.00	-28.25
Wheat Average	**50**	**12.50**	**16.89**	**1.3**	**5.76**	**7.26**	**-19.63**
Millet							
M/W-F	10	5.50	13.40	2.3	3.92	9.02	-9.88
M-M	10	5.50	13.40	1.4	3.92	5.49	-13.41
W-M-F	10	5.50	13.40	1.1	3.92	4.31	-14.59
W/M-F	--	--	21.46	0.0	3.92	0.00	-21.46
Millet Average	**10**	**5.50**	**15.42**	**1.2**	**3.92**	**4.70**	**-14.84**
Fallow	---	---	45.48	---	---	-45.48	-45.48
Average		9.39	19.16			0.96	-20.30

Planted: Millet, Dryland Genetics 240 at 10 lb/a on June 15, 2022 (not W/M-F); Wheat, Avery at 50 lb/a c
October 1, 2022 (not M/W-F).
Harvested: Millet on October 2, 2023; Wheat on July 20, 2023 (only W/M-F harvested).
Wheat herbicides: Express 0.4 oz/a, 2,4-D 0.38 lb/a, dicamba 1.5 oz/a, NIS 90:10 4 oz/a;
Wheat herbicide cost: $8.75/a
Millet herbicides: Staredown 6.4 oz/a, 2,4-D ester 8 oz/a; Glyphosate 40 oz/a for W/M-F and M/W-F clea
Millet herbicide cost: $8.06/a; Glyphosate cost: $6.40/a
Fallow herbicides: glyphosate 40 oz/a, 2,4-D 0.5 lb/a, dicamba 8 oz/a, AMS 1 lb/a.
Fallow herbicide cost: $12.99/a per application (two applications, $7/a per application)
Applied Stare Down 6.4 oz/a to control kochia. Kochia control cost: $5.50/a.
Weed control cost is herbicide cost and $7/a application cost for each application.

Dryland Millet-Wheat Rotation, Variable Net Income, 2023.

Rotation	Wheat	Millet	Fallow	2023 Total Crop Net Income	Annual Rotation Variable Net Income
	-----------2023 Crop----------				
	-------------------------$/a----------------------------				
M-M		-13.41		-13.41	-13.41
W-W	-28.25			-28.25	-28.25
W-M-F	-28.25	-14.59	-45.48	-88.32	-29.44
W/M-F	8.04	-21.46	-45.48	-58.90	-29.45
W-F	-28.25		-45.48	-73.73	-36.87
M/W-F	-21.46	-9.88	-45.48	-76.82	-38.41
Average	-15.34	-14.84	-45.48	-56.57	-29.30

Variable Net Income is gross income minus seed cost and weed control cost.
Annual Rotation Variable Net Income is Total Crop Net Income divided by the number of years to complete one rotation cycle.
Millet in W/M-F was too dry to plant after wheat harvest.
Wheat in M/W-F was too dry to plant after millet harvest.

Millet-Wheat Rotation, Annual Rotation Income, 2017 to 2023.

Rotation	Annual Rotation Variable Net Income 2017	2018	2019	2020	2021	2022	2023	Total Annual Rotation Variable Net Income	Average Annual Rotation Variable Net Income
	$/a								
W-W	-16.46	126.11	234.19	-16.97	46.13	-12.50	-28.25	332.25	47.46
M/W-F	45.74	9.88	134.99	-31.11	166.44	-27.85	-38.41	259.68	37.10
M-M	102.90	-28.68	-12.08	-13.30	201.91	-18.89	-13.41	218.45	31.21
W-M-F	31.50	29.15	97.84	-19.16	90.52	-24.28	-29.44	176.14	25.16
W/M-F	54.96	25.14	122.05	-27.88	33.91	-10.23	-29.45	168.48	24.07
W-F	-20.95	54.84	116.39	-22.31	49.94	-32.27	-36.87	108.77	15.54
Average	32.95	36.07	115.56	-21.79	98.14	-21.00	-29.30	210.63	30.09

No millet was harvested in 2018 and 2020 (poor stands).
No wheat was harvested in 2017 and 2022 (too dry to emerge).
Variable Net Income is gross income minus seed cost and weed control cost.
Annual Rotation Variable Net Income is Total Crop Variable Net Income divided by years to complete one rotational cycle.

Dryland Crop Rotation Study

Kevin Larson, Brett Pettinger, Perry Jones, and Zane Jenkins

This is the nineteenth cropping year for our dryland rotation study. We established these rotations because of results from our dryland rotation sequencing study and growers' desire to include winter wheat in the rotations. The dryland rotation sequencing study was designed for spring crops, and the inclusion of winter wheat with its fall planting and early summer harvesting times would not fit into the design pattern of the sequencing study. To include winter wheat into a dryland rotation study, we began a new dryland rotation study with these three rotations in 2005: 1) Wheat-Sorghum-Fallow, 2) Wheat-Sunflower-Fallow, and 3) Sorghum-Millet. In 2006, we added a fourth rotation, Millet/Wheat-Fallow, to this rotation study. In 2015, we changed the Wheat-Sunflower-Fallow to Wheat-Corn-Fallow because the sunflower crops failed too often.

Materials and Methods

This is our seventeenth harvest year in testing the following rotations: Wheat-Grain Sorghum-Fallow (W-S-F) and Sorghum-Millet (S-M). We added a fourth rotation of Millet/Wheat-Fallow (M/W-F) in 2006. In 2015, we changed the Wheat-Sunflower-Fallow rotation to Wheat-Corn-Fallow. In 2008 and 2011, no crops were harvested because of drought. We planted wheat, Avery, at 50 lb/a on October 1, 2022; proso millet, Dryland Genetics, at 10 lb/a on June 15; grain sorghum, Sorghum Partners 45A45 DT, at 40,000 seeds/a on June 1; and corn, Golden Harvest G10L16-DV, at 12,500 seeds/a on May 5, 2023. We applied 60 lb/a of N to the study site. Before planting we sprayed two applications of glyphosate at 40 oz/a, Low Vol at 0.5 lb/a, and dicamba 8 oz/a. For in-season weed control, we chose short-residual herbicides that should not interfere with crop rotations: wheat, Express 0.4 oz/a, Low Vol 8 oz/a, dicamba 1.5 oz/a, Activator 90 4 oz/a; millet, Stare Down 6.4 oz/a, Low Vol 8 oz/a; grain sorghum, pre-plant: atrazine 1.0 lb/a, mesotrione 6.4 oz/a, Metal 24 oz/a; post sandbur control: FirstAct 10.7 oz/a, COC 32 oz/a, AMS 2.5 lb/a; post broadleaf weed control: Low Vol 5 oz/a; corn, pre-plant: atrazine 1.0 lb/a, mesotrione 6.4 oz/a, Medal 24 oz/a; post weed control: glyphosate 40 oz/a two times, one with Status 5 oz/a, AMS 4 lb/a, Activator 90 12.8 oz/a. For fallow, we applied glyphosate 40 oz/a, dicamba 8 oz/a, Low Vol 10.7 oz/a, AMS 1 lb/a two times, and to one of these applications we included Stare Down 6.4 oz/a to all the fallow plots to control glyphosate-resistant kochia. There was poor emergence of wheat in the M/W-F rotation, so we cleaned it up with glyphosate 40 oz/a, Staredown 6.4 oz/, Low Vol 10.7 oz/a, AMS 1 lb/a. We harvested the crops with a modified Gleaner F3 combine equipped with a HarvestMaster H2 weighing and seed moisture system: wheat, July 20; millet October 2; grain sorghum, November 1; and corn, October 13. No wheat was harvested in the M/W-F rotation because of poor emergence. The seed moisture contents were adjusted to 12.0% for wheat; 14% for grain sorghum; 15.5% for corn, and 14% for millet. We recorded costs of production and yields to determine rotation revenues.

Results and Discussion

This year all crops in the rotations were harvested, except for the wheat phase of the M/W-F rotation, where the wheat had poor emergence due to dry conditions and was not harvested. The W-S-F rotation produced the highest total rotation production of 3901 lb/a. The W-S-F rotation made 300 lb/a more total rotation production than the W-C-F rotation, the second highest rotation. Wheat and millet yields were low, averaging 662 lb/a (11.0 bu/a) and 370 lb/a (6.6 bu/a), respectively. Wheat and millet did not contribute nearly as much as grain sorghum and corn to total rotation productions. The corn in the W-C-F rotation averaged 2845 lb/a (50.8 bu/a) and the grain sorghum averaged 2800 lb/a (50.0 bu/a). Because we have all phases of each crop rotation present each year, we can compare annual rotation production and income even without a full crop rotational cycle. For example, the 2023 total production for the W-S-F rotation was 3901 lb/a. The crop rotational phases were wheat, 1230 lb/a; grain sorghum, 2671 lb/a; and, of course, no production for fallow. The annual rotation production was 1300 lb/a, which is one-third the total production because the W-S-F rotation takes three years to complete one rotation cycle. Even though the W-S-F had the highest total rotation production, the S-M rotation had the highest annual rotation production of 1635 lb/a because the S-M rotation takes two years to complete its rotation cycle and the W-S-F rotation takes three years to complete its rotation cycle.

The two-year rotation cycle of S-M and the three-year rotation cycle of W-S-F also dictated the highest total rotation variable net income of $181/a for the W-S-F rotation and the highest annual rotation variable net income of $81/a for the S-M rotation. This year, the M/W-F rotation had the lowest annual rotation variable net income of -$36/a due to it failed wheat phase and low millet yield.

After the last seven harvest years, the W-S-F rotation had the highest long-term annual rotation income of $79/a; however, the income of the W-S-F rotation was only $5/a more than the income of the W-C-F rotation. The W-S-F and W-C-F rotations have extended fallow periods with a summer fallow preceding the wheat and a long winter fallow before sorghum or corn. During the dry years, the extended fallow periods of the W-S-F and W-C-F rotations have contributed to their higher production and income. The S-M rotation had the third highest annual rotation income average for the last seven harvest years. The S-M rotation has typical winter fallow periods between the summer crops, which are sufficient fallow periods under average winter moisture conditions. The rotation with the lowest annual net income average after the last seven years was M/W-F due in part to its back-to-back wheat failures.

In past years, winter wheat performed better than the spring crops in both yield and income. However recently, the wheat crops failed in six of the last ten years: one year it was lost because of drought, two years it was lost to hail, one year it winterkilled, and two years it was too dry and failed to emerge. Corn replaced sunflower in the W-Sunflower-F rotation because the sunflower crops failed six out of seven cropping years. This year with good corn and good grain sorghum crops, and low wheat and millet crops, rotations containing grain sorghum and corn had higher incomes. This suggests with the frequent failure of wheat, particularly during fall and early spring droughts, that rotations should concentrate on adapted spring crops that may take advantage of the higher rainfall patterns during the summer months.

Dryland Crop Rotation Study, Crop Production, 2023.

	Crop Production						
	--------------2023 Crop--------------					2023 Total Rotation Production	Annual Rotation Production
Rotation	Wheat	Grain Sorghum	Millet	Corn	Fallow		
	------------------lb/a (bu)------------------						
S-M		2929 (52.3)	341 (6.1)			3270	1635
W-S-F	1230 (20.5)	2671 (47.7)			0	3901	1300
W-C-F	756 (12.6)			2845 (50.8)	0	3601	1200
M/W-F	0		398 (7.1)		0	398	199
Average	662 (11.0)	2800 (50.0)	370 (6.6)	2845 (50.8)	0	2793	1084
LSD0.20	138 (2.3)	364 (6.5)	103 (1.8)				

Annual Rotation Production is Total Rotation Production divided by the number of years to complete one rotation cycle.
Wheat was not harvested in the M/W-F rotation because it was too dry and failed to emerge.

Dryland Crop Rotation Study, Variable Net Income, 2023.

	--------------2023 Crop--------------					2023 Total Rotation	Annual Rotation Variable
Rotation	Wheat	Grain Sorghum	Millet	Corn	Fallow	Net Income	Net Income
	------------------$/a------------------						
S-M		158.59	3.35			161.94	80.97
W-S-F	89.83	137.07			-45.48	181.42	60.47
W-C-F	44.33			121.39	-45.48	120.24	40.08
M/W-F	-34.65		7.27		-45.48	-72.86	-36.43
Average	33.17	147.83	5.31	121.39	-45.48	97.69	36.27

Variable Net Income is gross income minus seed cost and weed control cost.
Annual Rotation Variable Net Income is Total Crop Net Income divided by the number of years to complete one rotation cycle.
The wheat in M/W-F failed to emerge because it was too dry and was not harvested.

Dryland Crop Rotation Study at Walsh, 2023.

Crop Rotation	Seeding Density	Seed Cost	Weed Control Cost	Yield	Crop Price	Gross Income	Variable Net Income
		------------------------------------$/a--					
<u>Wheat</u>	50 lb	12.50	17.88	11.0 bu	5.76/bu	63.55	33.17
M/W-F			22.15	0.0	5.76	0.00	-34.65
W-C-F			15.75	12.6	5.76	72.58	44.33
W-S-F			15.75	20.5	5.76	118.08	89.83
<u>Millet</u>	10 lb	5.50	15.06	6.6 bu	3.92/bu	25.87	5.31
S-M			15.06	6.1	3.92	23.91	3.35
M/W-F			15.06	7.1	3.92	27.83	7.27
<u>Grain Sorghum</u>	40,000 seeds	19.78	66.39	50.0 bu	4.68/bu	234.00	147.83
S-M			66.39	52.3	4.68	244.76	158.59
W-S-F			66.39	47.7	4.68	223.24	137.07
<u>Corn</u>	12,500 seeds	47.50	87.65	50.8 bu	5.05/bu	256.54	121.39
W-C-F			87.65	50.8	5.05	256.54	121.39
Fallow	---	---	45.48	---	---	-45.48	-45.48
Average			107.33			106.90	52.44

Planted: Grain Sorghum, Sorghum Partners 45A45 DT at 40,000 seeds/a on June 1; Millet, Dryland Genetics 240 at 10 lb/a on June 15; Corn, Golden Harvest G10L16-DV at 12,500 seeds/a on May 5; and Wheat, Avery at 50 lb/a on October 1, 2022 .
Wheat herbicides: Express 0.4 oz/a, 2,4-D 0.38 lb/a, dicamba 1.5 oz/a, NIS 90:10 4 oz/a;
Wheat herbicide cost: $8.75/a
Millet herbicides: Staredown 6.4 oz/a, 2,4-D ester 8 oz/a; Added Glyphosate 40 oz/a for M/W-F cleanup.
Millet herbicide cost: $8.06/a; Glyphosate cost: $6.40/a
Grain Sorghum herbicides: preemergence: flumioxazin at 3.0 oz/ac, S-metolachlor at 24 oz/ac, mesotrione at 6.4 oz/a and atrazine at 1.0 lb/a; In-season sandbur control on June 28: FirstAct 10.7 oa/a, COC 32 oz/a, AMS 2.5 lb/a; In-season weed control: Low Vol 5 oz/a.
Grain Sorghum herbicide cost: pre-plant, $27.69/a; sandbur control, $16.10/a; Low Vol, $1.60/a.
Corn herbicides: preemergence: flumioxazin at 3.0 oz/ac, S-metolachlor at 24 oz/ac, mesotrione at 6.4 oz/a and atrazine at 1.0 lb/a; Post: glyphosate 40 oz/a (twice), Status 5 oz/, AMS 4 lb/a, Act 90 12.8 oz/a.
Corn herbicide cost: pre-plant, $27.69; post, $32.56/a + $6.40/a.
Poor emergence of wheat in M/W-F so was sprayed out; herbicide cost: $14.46/a.
Fallow herbicides: Glyphosate 40 oz/a, Low Vol 10.7 oz/a, dicamba 8 oz/a, AMS 1 lb/a (twice), plus Staredown 6.4 oz/a added one time for kochia control.
Fallow herbicide cost: $12.99/a twice + $5.50/a added once.
Harvested: Wheat, July 20; Millet, October 2; Grain Sorghum, November 1; Corn, October 13.
Crop price: Wheat, $5.76/bu; Millet, $3.92/bu; Grain Sorghum, $4.68/bu; Corn, $5.05/bu.
Weed control cost is herbicide cost and $7/a application cost for each application.

Table .-Dryland Crop Rotation Study, Annual Rotation Income, 2017 to 2023.

Rotation	Annual Rotation Variable Net Income 2017	2018	2019	2020	2021	2022	2023	Total Annual Rotation Variable Net Income	Average Annual Rotation Variable Net Income
	$/a								
W-S-F	91.11	49.89	142.92	22.89	108.55	80.53	60.47	556.36	79.48
W-C-F	44.73	54.33	127.09	-24.00	155.60	123.37	40.08	521.19	74.46
S-M	93.93	64.19	58.34	-26.42	160.87	-36.49	80.97	395.39	56.48
M/W-F	30.61	19.24	103.87	107.31	73.13	-15.27	-36.43	282.45	40.35
Average	65.09	46.91	108.06	19.94	124.54	38.04	36.27	438.85	62.69

No crops were harvested in 2008 and 2011 because of drought.
The 2012 (hail), 2014 (winterkill), 2015 (hail), 2017 (too dry, no emergence), and 2022 (too dry, no emergence) wheat crops were not harvested.
The 2016, 2017, 2018, 2019 millet crops were not harvested because of poor stands.
In 2015 corn replaced sunflower in the W-Sun-F rotation.
Variable Net Income is gross income minus seed cost and weed control cost.
Annual Rotation Variable Net Income is Total Crop Variable Net Income divided by years to complete one rotational cycle.

Four-Year (W-C-M-F) and Three-Year (W-S-F) Rotation Comparison

Kevin Larson, Brett Pettinger, Perry Jones, and Zane Jenkins

Wheat-Fallow (W-F), with tillage to control weeds in the fallow period, was the standard crop rotation in Eastern Colorado until the 1990's, when the adoption of no-till farming practices began to predominate. These no-till practices retain crop residues that reduced soil erosion and conserved water. With more water available for crop use, no-till practices allowed more extensive and successful crop rotations than W-F (Anderson, Bowman, Nielson, Vigil, Aiken, and Benjamin, 1999). Three-year and four-year crop rotations, such as, Wheat-Sorghum-Fallow (W-S-F), Wheat-Corn-Fallow (W-C-F), Wheat-Millet-Fallow (W-M-F), Wheat-Corn-Millet-Fallow (W-C-M-F), and Wheat-Corn-Sunflower-Fallow (W-C-Sun-F) began to emerge. Randy Anderson reported that some of these three-year and four-year rotations were much more effective in controlling weeds than others (Anderson, 2005). In rotations where one cool-season crop was followed by one warm-season crop (1 cool crop: 1 warm crop), such as winter wheat-millet, were compared to four-year rotations of two cool-season crops followed by two warm season crops (2 cool crops: 2 warms crops), he found over multiple rotation cycles that weeds increased in the 1 cool crop: 1 warm crop rotations and declined in the rotations of 2 cool crops: 2 warm crops. Because of the reduction in weeds and associated weed control savings, Anderson recommended using rotations of two cool-season crops followed by two warm season crops, such as W-C-M-F (Anderson considers fallow as a cool-season or warm-season crop alternative). After growers read of the potential production and weed control savings by switching to rotations of 2 cool crops: 2 warm crops, they suggested that we conduct a study to investigate if the W-C-M-F rotation would provide more income than our well adapted W-S-F rotation. In 2023, we switched the sequence order of the W-C-M-F rotation to W-M-C-F.

This is the seventh cropping year for our dryland W-C-M-F and W-S-F rotation comparison study. In fact, this rotation study is so new that 2018 was the first year of winter wheat harvest for the rotations. To make rotation comparisons on a yearly basis, we planted all phases of the rotations. For example, each crop (including fallow) of the W-C-M-F rotation is present every year. Each year, there are four study plots for the W-C-M-F rotation: one plot of wheat, one plot of corn, one plot of millet, and one plot of fallow. By having all rotation phases each year, we can annually compare multi-year rotations.

Materials and Methods

This is our seventh crop harvest year in comparing the following rotations: Wheat-Corn-Millet-Fallow (W-C-M-F) and Wheat-Grain Sorghum-Fallow (W-S-F). In 2023, we switched the order of W-C-M-F rotation to W-M-C-F. We planted: proso millet, Dryland Genetics 240, at 10 lb/a on June 15; grain sorghum, Sorghum Partners 45A45 DT, at 40,000 seeds/a on June 1; and corn, Golden Harvest G10L16-DV, at 12,500 seeds/a on May 5, 2023. We planted wheat, Avery, at 50 lb/a on October 1, 2022. We applied 60 lb/a of N to the study site. We applied flumioxazin 3 oz/a to the strips going into wheat in March 2022, and the strips going into corn and sorghum in March 2023 (no flumioxazin was applied to the strips going into millet). Before planting we sprayed two applications of glyphosate at 40 oz/a, LoVol at 0.5 lb/a, and dicamba 8 oz/a. For in-season weed control, we chose short-residual herbicides that should not interfere with crop rotations: wheat, Express 0.4 oz/a, Low Vol 8 oz/a, dicamba 1.5 oz/a, Activator 90 4 oz/a; millet, Stare Down 6.4 oz/a, Low Vol 8 oz/a; grain sorghum, pre-plant: atrazine 1.0 lb/a, mesotrione 6.4 oz/a, Metal 24 oz/a; post sandbur control: FirstAct 10.7 oz/a, COC 32 oz/a, AMS 2.5 lb/a; post broadleaf weed control: Low Vol 5 oz/a; corn, pre-plant: atrazine 1.0 lb/a, mesotrione 6.4 oz/a, Medal 24 oz/a; post weed control: glyphosate 40 oz/a and Status 5 oz/a, AMS 4 lb/a, Activator 90 12.8 oz/a. For fallow, we applied glyphosate 40 oz/a, dicamba 8 oz/a, Low Vol 10.7 oz/a, AMS 1 lb/a two times, and to one of these applications we included Stare Down 6.4 oz/a to all the fallow plots to control glyphosate-resistant kochia. We harvested the crops with a modified Gleaner F3 combine equipped with a HarvestMaster H2 weighing and seed moisture system: wheat, July 20; millet, October 2; grain sorghum, November 1; and corn, October 13. We used moisture-adjusted grain yields for comparisons: wheat, 12%; millet, 14%; grain sorghum, 14%; and corn, 15.5%. We recorded costs of production and yields to determine rotation revenues.

Results and Discussion

The W-S-F rotation produced higher total rotation production, 439 lb/a more than the W-M-C-F rotation because grain sorghum production in the W-S-F rotation was much higher than corn and millet production combined in the W-M-C-F. The W-S-F rotation produced higher annual rotation production and higher annual rotation variable net income than the W-M-C-F rotation. This income difference was $37/a. The higher income of the W-S-F rotation, $39/a, compared to the W-M-C-F rotation, $2/a, was due to the high yielding grain sorghum crop. Because we have all phases of each crop rotation present each year, we can compare annual rotation production and income even without a full crop rotational cycle. For example, the 2023 total production for the W-M-C-F rotation was 2561 lb/a. The crop rotational phases were: wheat, 1134 lb/a; millet, 637 lb/a; corn, 970 lb/a; and, of course, no production for fallow. The annual rotation production was 640 lb/a, which is one-fourth the total production because the W-M-C-F rotation takes four years to complete one rotation cycle.

This is the seventh cropping year and only the fifth year that the crops followed the correct cropping sequence. After five years of following the correct cropping sequence, the W-S-F rotation generated $40/a more in annual rotation variable net income than the W-C-M-F rotation (W-M-C-F starting in 2023). However, since this is only the seventh cropping year for this rotation study, no long-term rotational effects can be fully evaluated.

Literature Cited

Anderson, R.L., R.A. Bowman, D.C. Nielsen, M.F. Vigil, R.M. Aiken, and J.G. Benjamin. 1999. Alternative crop rotations for the central Great Plains. J. Prod. Agric. 12:95-99.

Anderson, R.L. 2005. A multi-tactic approach to manage weed population dynamics in crop rotations. Agron. J. 97:1579-1583.

WMCF and WSF Rotation Comparison Study, Walsh, 2023.

Crop Rotation	Seeding Density	Seed Cost	Weed Control Cost	Yield	Crop Price	Gross Income	Variable Net Income
		--------------------	--------------------	$/a	--------------------	--------------------	--------------------
Wheat	50 lb	12.50	15.75	14.4 bu	5.76/bu	82.66	54.41
W-M-C-F				18.9	5.76	108.86	80.61
W-S-F				9.8	5.76	56.45	28.20
Corn	12,500 seeds	47.50	74.25	14.1 bu	5.05/bu	71.21	-50.55
W-M-C-F				14.1	5.05	71.21	-50.55
Millet	10 lb	5.50	15.06	11.4 bu	3.92/bu	44.69	24.13
W-M-C-F				11.4	3.92	44.69	24.13
Grain Sorghum	40,000 seeds	19.78	66.89	47.3 bu	4.68/bu	221.36	134.69
W-S-F				47.3	4.68	221.36	134.69
Fallow	---	---	45.48	---	---	-45.48	-45.48
Average			43.49			74.89	23.44

Planted: Grain Sorghum, Sorghum Partners 45A45 DT at 40,000 seeds/a on June 1; Millet, Dryland Genetics 240 at 10 lb/a on June 15; and Corn, Golden Harvest G10L16-DV at 12,500 seeds/a on May 5; Wheat, Avery at 50 lb/a on October 1, 2022.
Harvested: Wheat, July 20; Grain Sorghum, October 31; Corn, October 13; Millet, October 7.
Weed control cost is herbicide cost and $7/a application cost for each application.

Dryland WMCF and WSF Rotation Comparison Study, Crop Production, 2023.

Crop Production							
	--------------------------2023 Crop--------------------------					2023 Total	Annual
Rotation	Wheat	Grain Sorghum	Millet	Corn	Fallow	Rotation Production	Rotation Production
	------------------------------------lb/a------------------------------------						
W-S-F	588 (9.8)	2649 (47.3)			0	3237	1079
W-M-C-F	1134 (18.9)		637 (11.4)	790 (14.1)	0	2561	640
Average	861 (14.4)	2649 (47.3)	637 (11.4)	790 (14.1)	0	2899	860

Annual Rotation Production is Total Rotation Production divided by the number of years to complete one rotation cycle.
This is the seventh cropping year of this rotational study.

Dryland WMCF and WSF Rotation Comparison Study, Variable Net Income, 2023.

	--------------------------2023 Crop--------------------------					2023 Total	Annual Rotation
Rotation	Wheat	Grain Sorghum	Millet	Corn	Fallow	Rotation Net Income	Variable Net Income
	------------------------------------$/a------------------------------------						
W-S-F	28.20	134.69			-45.48	117.41	39.14
W-M-C-F	80.61		24.13	-50.55	-45.48	8.71	2.18
Average	54.41	134.69	24.13	-50.55	-45.48	63.06	20.66

Variable Net Income is gross income minus seed cost and weed control cost.
Annual Rotation Variable Net Income is Total Crop Variable Net Income divided by the number of years to complete one rotation cycle.

WCMF and WSF Rotation, Annual Rotation Income, 2019 to 2023.

Rotation	2019	2020	2021	2022	2023	Total Annual Rotation Variable Net Income	Average Annual Rotation Variable Net Income
	Annual Rotation Variable Net Income						
	---$/a---						
WSF	59.72	136.98	90.89	98.60	39.14	425.32	106.33
WCMF/ WMCF	23.83	97.64	110.58	31.39	2.18	265.62	66.40
Average	41.77	117.31	100.74	65.00	20.66	345.47	86.37

Variable Net Income is gross income minus seed cost and weed control cost.
Annual Rotation Variable Net Income is Total Crop Variable Net Income divided by years to complete one rotational cycle.
In 2023 the WCMF rotation order was switched to WMCF rotation.

Dryland Corn Production, With and Without Fallow, and Cover Crops in Fallow

Kevin Larson, Perry Jones, Brett Pettinger, and Zane Jenkins

At the 2020 Plainsman Agri-Search Foundation research advisory meeting, a couple of board members proposed a new research study for Plainsman. They had read an online AgWeb article about wide row spacings in corn seeded to cover crops (Bennet, 2019). They were excited about the prospect of raising corn on 60-inch row spacings with cover crops in between the rows that had, according to the article, little or no yield drag compared to conventional 30-inch row corn. Since we lacked the necessary equipment for the row arrangement logistics for 60-inch rows, and still maintain comparative treatments of corn, fallow, and cover crops, we used the width of our 8-row planter (20 ft.) as the width of our treatment strips. These 20 ft. wide corn, fallow, and cover crops strips would allow us to plant, spray, and harvest them without damaging adjacent strip treatments.

Materials and Methods

We tested three dryland corn, fallow, and cover crop rotational strips: 1) Corn-Fallow, 2) Corn-Cover Crops (in fallow), and 3) Corn-Corn (continuous corn). We planted a mix of spring cover crops from Green Cover Seed in Bladen, Nebraska at 43 lb/a on March 24, 2022. The Spring N Mix consisted of spring oats at 15 lb/a, spring barley at 15 lb/a, spring forage pea at 10 lb/a, and rapeseed at 3 lb/a. Before emergence of cover crops, we sprayed Sharpen at 0.75 oz/a, glyphosate at 32 oz/a, MSO at 16 oz/a, and AMS at 2.5 lb/a. Cover crop planting conditions were dry, but adequate for seed germination and stand establishment. On June 11, 2022, we terminated the spring cover crops and controlled weeds in the fallow plots with an application of glyphosate 32 oz/a, 2,4-D ester 16 oz/a, StareDown 6.4 oz/a, AMS 2.5 lb/a, and flumioxazin 3 oz/a. For the fallow and cover crops in fallow treatments, we applied an additional application of glyphosate 32 oz/a, 2,4-D ester 16 oz/a, StareDown 6.4 oz/a, and AMS 2.5 lb/a during the fallow period. We applied N at 60 lb/a to all treatments. For weed control prior to corn planting, we applied a mix of atrazine 1.0 lb/a, mesotrione 6.4 oz/a, metolachlor 24 oz/a; and glyphosate 32 oz/a. We planted the corn strips on May 5, 2023, to Golden Harvest G10L16 at 12,500 seeds/a and seedrow applied 10-34-0 at 5 gal/a and Zn chelate at 0.38 lb/a. For in-season weed control in the corn crop, we applied a tank mix of glyphosate 40 oz/a, Status 5 oz/a, AMS 4 lb/a, Activator 90 12.8 oz/a. After establishing the rotations, all phases of each rotation were present each year. We harvested the corn on October 13, 2023 with a modified Gleaner F3 combine equipped with a HarvestMaster H2 weighing and seed moisture system. Corn yields were adjusted to 15.5% seed moisture content.

Results and Discussion

This is the third year that all phases of the Corn-Fallow (C-F), Corn-Cover Crops in fallow (C-CC), and Corn-Corn (C-C) rotations followed their correct sequences. Unlike the 2020 spring cover crops which failed to emerge, the 2021 and 2022 spring cover crops made a fair amount of forage. The C-C rotation produced the highest yield of 29 bu/a, but it was not significantly higher than the C-CC, which averaged 22 bu/a, nor the C-C, which averaged 17 bu/a ($p<0,20$). This year, the corn yields were low for all corn rotation treatments, but the C-C rotation had the lowest yield. However, the C-C rotation, despite having the lowest yield, had the highest total variable net income of $84/a per corn crop, $35/a more than the C-F and $55/a more than the C-CC rotations. The C-C rotation had higher total variable net income than the C-F and C-CC rotations, because of the high cost of fallow for the C-F rotation and even higher cost of the cover crops in fallow for the C-CC rotation. The C-F and C-CC rotations produce a corn crop (income) once every two years, while the C-C rotation produces a corn crop (income) every year. With a crop every year, the C-C rotation provided the highest annual rotation variable net income of $84/a. In contrast, the C-F and C-CC rotations have a corn crop (income) once in two years, therefore their variable net incomes are halved because it takes two years to complete their rotation cycles. The C-C rotation produced $70/a more annual rotation variable net income than the C-CC rotation because of the high cost of cover crop production in fallow and its variable net income is halved because it takes two years to complete its rotation cycle.

This is the fourth cropping year and only the third year that the crops followed the correct cropping sequence. Moreover, in 2020 the cover crops in the C-CC rotation failed, so there were only cover crop expenses and no benefits from their inclusion. The cover crops planted in 2021 and 2022 produced some forage, therefore the C-CC rotation effects were more fully realized. However, this was only the third year of following the correct cropping sequence, and only two years in which cover crop rotational effects were established, thus long-term rotational effects cannot be fully evaluated.

Reference Cited

Bennet, C. 2019. Corn Maverick: Cracking the Mystery of 60-Inch Rows. AgWeb (Online). Farm Journal, Lenexa, KS. Available at https://www.agweb.com/news/crops/corn/corn-maverick-cracking-mystery-60-inch-rows (Posted 28 Oct. 2019).

Corn Production, With & Without Fallow, and Cover Crops in Fallow, Walsh, 2023.

Treatment	Corn Yield	Test Wt.	Cover Dry Matter	Cover N	Fixed N	Variable Treatment Cost	Fixed N Income	Variable Net Income
	bu/a	lb/bu	lb/a	lb/a	lb/a	$/a (per corn crop)	$/a	$/a
Corn-Corn	17	57.3						84.34
Corn-Fallow	22	57.6				62.80		49.82
Corn-Cover Crops	29	57.7	2811	101.7	0.0	118.55	0.00	28.91
Average	23	57.5				60.45		54.35
LSD 0.20	25.9							

Cover crops planted: March 24, 2022 on 12-in. row spacings.
Cover crops pre-emergence weed control: Sharpen 0.75 oz/a, glyphosate 32 oz/a, MSO 16 oz/a, AMS 2.5 lb/a. Herbicide cost: $14.70/a.
Sampled and terminated spring cover crops: June 11, 2022.
Cover crops termination and fallow weed control with two applications of glyphosate 32 oz/a, Staredown 6.4 oz/a, Low Vol 16 oz/a, dicamba 8 oz/a, AMS 2.5 lb/a, Activator 90 12.8 oz/a. Hericide cost: $22.14/a per application, plus flumioxazin 3 oz/a was added to the first application, cost: $5.52/a.
Corn strips planted: May 5, 2023, to Golden Harvest G10L16 at 12,500 seeds/a.
Corn harvested: October 13, 2023. Grain yields were adjusted to 15.5% moisture.
Spring cover crop seeding rate: spring oats 15 lb/a, spring barley 15 lb/a, spring pea 10 lb/a, rapeseed 3 lb/a. Spring cover seed cost: $19.55/a.
Treatment application cost: cover crop planting, $15/a: sprayer application,$6.50/a.
We used oats from an adjacent study as a non N fixing comparative cover crop. Oats in the adjacent cover crop study had 117.5 lb of N/a. The Spring N mix used for the cover crop in Corn-CC had 101.7 lb of N/a, so no fixed N amount.
Corn price: $5.05/bu.

Corn Production, With and Without Fallow, and Cover Crops in Fallow, Variable Net Income, Walsh, 2023.

Rotation	Corn Yield	Corn Gross Income	Fallow Cost	Cover Crop Fallow Cost	Total Crop Variable Net Income	Annual Rotation Variable Net Income
	bu/a	-------------	-------------	-$/a-	-------------	-------------
Corn-Corn	17	84.34			84.34	84.34
Corn-Fallow	22	112.62	62.80		49.82	24.91
Corn-Cover	29	147.46		118.55	28.91	14.46
Average	23	114.80	62.80	118.55	54.35	41.23

Variable Net Income is gross income minus fallow and cover crop costs.
Annual Rotation Variable Net Income is Total Crop Net Income divided by the number of years to complete one rotation cycle.
Cover crops planted: March 24, 2022 on 12-in. row spacings.
Sampled and terminated spring cover crops: June 11, 2022.
The cover crops made 2811 lb/a.
Corn price: $5.05/bu.

Corn Production, With & Without Fallow, and Cover Crops in Fallow, Annual Rotation Variable Net Income, 2021-2023.

Rotation	Annual Rotation Variable Net Income 2021	2022	2023	Total Annual Rotation Varible Net Income	Average Annual Rotation Variable Net Income
	------------------------------$/a			------------------------------	
Corn-Corn	546.27	139.54	84.34	770.15	256.72
Corn-Fallow	315.20	211.64	24.91	551.75	183.92
Corn-Cover	273.95	125.63	14.46	414.04	138.01
Average	378.47	158.94	41.24	578.64	192.88

Variable Net Income is gross income minus fallow and cover crop costs.
Annual Rotation Variable Net Income is Total Crop Variable Net Income divided by years to complete one rotational cycle.

The Effects of Spring and Winter Cover Crops on Dryland Crop Production

Kevin Larson, Brett Pettinger, Perry Jones, and Zane Jenkins

One of the Natural Resource Conservation Service (NRCS) current focuses is on cover crops and their effects on soil health. Much of this recent work with cover crops is from much higher precipitation and much lower evaporation locations, such as the Upper Midwest (Conservation Tillage & Technology Conference, 2011), than we have in Southeastern Colorado. Few cover crop studies have been conducted on dryland rotations in low moisture, high evaporation climates such as we experience in our region and the reports from these dryland cover crop studies have been less than favorable (Larson, 1995; Schlegel and Havlin, 1997; Vigil and Nielsen, 1998). We began this study to measure the effects of cover crops on yields of common dryland crop rotations in our semi-arid climate where water conservation is the key to successful dryland crop production.

Materials and Methods

We tested cover crops and N rates in two common crop rotations: Wheat-Fallow (W-F) and Wheat-Sorghum-Fallow (W-S-F). Our treatments for this cover crop study were: four spring and four winter cover crops, three N rates, and two crop rotations. We planted spring cover crops: oats at 60 lb/a, rapeseed or canola at 5 lb/a, hairy vetch at 30 lb/a, and Spring N Mix at 65 lb/a (spring barley, 15 lb/a; oats, 15 lb/a; spring pea, 15 lb/a, common vetch, 10 lb/a; rapeseed, 2 lb/a; Nitro radish, 2 lb/a; crimson clover, 3 lb/a; flax, 3 lb/a). We planted winter cover crops for W-F in 2021: triticale at 60 lb/a or wheat at 50 lb/a, rapeseed or canola at 5 lb/a, hairy vetch at 30 lb/a, Winter N Mix at 43 lb/a (hairy vetch, 8 lb/a; winter pea, 8 lb/a; sweet clover, 2 lb/a; triticale, 20 lb/a; rapeseed, 2 lb/a; sorghum sudan grass, 3 lb/a). We planted winter cover crops for W-S-F in 2022: triticale at 60 lb/a or wheat at 50 lb/a, rapeseed or canola at 5 lb/a, hairy vetch at 30 lb/a, Winter N Mix at 60 lb/a (rye, 26 lb/a; winter barley, 20 lb/a; hairy vetch, 17 lb/a; winter pea, 5 lb/a; rapeseed, 2 lb/a; sweet clover, 2 lb/a). All cover crop seeds were from Green Cover Seed in Bladen, Nebraska. Our three N rates were 0, 25, and 50 lb/a stream applied as 28-0-0 or 32-0-0. No N was applied to the cover crop plots. After establishing the rotations, all phases of each rotation were present each year. We inserted gypsum blocks at 6 in., 18 in., and 30 in. depths to measure soil water use by the cover crops.

We planted the W-F winter cover crops on September 27, 2021 after wheat harvest. We planted the cover crops in inadequate soil moisture for germination, and the cover crops failed due to dry conditions throughout the growing season. For the wheat phase of the W-S-F rotation, we planted the spring cover crops in the W-S-F rotation on March 24, 2022 during the fallow period after sorghum harvest. There was marginal moisture at planting, which delayed cover crop emergence until May, combined with the low precipitation throughout the season resulted in low cover crop forage yields. We terminated the spring cover crops on July 22, 2022 and controlled weeds in the N plots with an application of glyphosate 32 oz/a, 2,4-D ester 12 oz/a, flumioxazin 2.5 oz/a, StareDown 6.4 oz/a, NIS 8 oz/a, and AMS 1.0 lb/a. We planted both the W-S-F and the W-F wheat on October 1, 2022 with Avery at 50 lb/a and seedrow applied 10-34-0 at 5 gal/a at planting. It was too dry at wheat planting for seedling emergence; therefore, the wheat crop did not emerge until spring, which caused the wheat yields to be poor. For in-season weed control in the wheat we applied: Express 0.4 oz/a, Low Vol 8 oz/a, dicamba 1.5 oz/a, Activator 90 4 oz/a. We harvested the wheat in the W-F and W-S-F rotations on July 28, 2023.

We planted the winter cover crops prior to sorghum planting in the W-S-F rotation on August 15, 2022, into wheat stubble in adequate soil moisture for seed emergence, and we sprayed a tank mix of glyphosate 32 oz/a, Sharpen 0.75 oz/a, NIS 12 oz/a, and AMS 2.0 lb/a prior to planting cover crops and to control weeds in the N plots. The cover crop growing season precipitation was good, especially late in the season for average forage yields of the cover crops. Prior to grain sorghum planting, we sprayed a mix of glyphosate 40 oz/a, StareDown 6.4 oz/a, flumioxazin 2.5 oz/a, MSO 16 oz/a, and AMS 2 lb/a. We planted Sorghum Partners 45A45 DT at 40,000 seeds/a on June 1, 2023 and seedrow applied 5 gal 10-34-0/a at planting. For weed control in the grain sorghum, we applied pre-plant: atrazine 1.0 lb/a, mesotrione 6.4 oz/a, Metal 24 oz/a; and for post emergence sandbur control, we applied: FirstAct 10.7 oz/a, COC 32 oz/a, AMS 2.5 lb/a; and for post emergence broadleaf weed control, we applied: Low Vol 5 oz/a.

Wheat was harvested in the W-F and W-S-F rotations on July 28, 2023. We harvested the W-S-F grain sorghum on November 11, 2023, with a modified Gleaner F3 combine equipped with a HarvestMaster H2 weighing and seed moisture system. Grain yields were adjusted to 12% seed moisture content for wheat and 14.0% seed moisture content for grain sorghum.

Results and Discussion

This year, we were able to harvest the wheat crops in the W-F and W-S-F rotations, as well as the grain sorghum crop in the W-S-F rotation. Wheat yields were low in the W-F rotation and lower still in the W-S-F rotation. Grain sorghum yields were good for all the cover crops and N treatments. The winter cover crops, planted in 2021, preceding wheat planting for the W-F rotation failed to emerge and grow due to dry conditions at cover crop planting and throughout the cover crop growing season. The winter cover crops, planted in 2022, preceding grain sorghum planting produced good forage yields. The spring cover crops, planted in 2023, preceding wheat planting for the W-S-F rotation survived, but the late emergence of the spring cover crops reduced their forage yields. Thus far, 2020, 2019 and 2016 were the only years that the winter and spring cover crops survived, and we were able to harvest both grain sorghum and wheat crops. In all other years, including this year, either the cover crops did not survive, or the wheat crops were lost to hail, drought, or winterkilled.

Grain Sorghum Phase, W-S-F Rotation

Precipitation from planting to termination of the winter cover crops (eight months, mid-August 2022 through early May 2023) for the grain sorghum phase of the W-S-F rotation was 12.85 in. The eight months of the cover crop growing season had good precipitation at planting, dry during the winter and early spring months, and wet during the late spring months, which produced average forage yields for the cover crops prior to sorghum planting. The dry matter yields of the cover crops averaged 3157 lb/a. The rapeseed cover produced the highest dry matter of 3908 lb/a and it was significantly higher (at 0.20 alpha level) than the two lowest cover crop treatments, hairy vetch with 2286 lb/a and Winter N Mix with 2726 lb/a.

When terminated after eight months of growth, the cover crops preceding the grain sorghum had these changes in available soil water (at termination minus at planting): -3.13 in. for wheat, -4.15 in. for rapeseed, -3.50 in. for hairy vetch, and -2.79 in. for Winter N Mix of soil water to a depth of three feet. The fallow 0N check (at termination minus at planting) lost -1.79 in. of soil water to a depth of three feet during the same eight-month period. Therefore, subtracting soil water used by cover crops from soil water gained during no-till fallow equals the water use cost of cover crops. The water use cost to a soil water depth of three feet was: 1.34 in. for wheat, 2.36 in. for rapeseed, 1.71 in. for hairy vetch, and 1.00 in. for Winter N Mix. Water use by the cover crops averaged 1.60 in. for the four cover crops tested.

The treatment with the highest grain sorghum yield was the 0N treatment with 39.8 bu/a, which was significantly higher (at 0.20 alpha level) than the two lowest yielding treatments, hairy vetch with 20.9 bu/a and Winter N Mix with 17.8 bu/a. All N fertilizer treatments produced significantly more yield than the hairy vetch and Winter N Mix treatments. The wheat cover crop with 32.2 bu/a was the only cover crop treatment to yield significantly more than the Winter N Mix cover crop.

The 0N treatment produced the highest variable net income, $186/a, because it had the highest grain yield and no variable treatment cost. The 0N and 25N treatments produced higher variable net incomes than the four cover crop treatments. The 25N treatment was second in variable net income, $135/a, because it had the third highest grain sorghum yield, which more than compensated for its third lowest treatment cost. The lowest variable net income of $23/a was from Winter N Mix, which had the lowest yield and the second highest treatment cost.

After six cropping years of grain sorghum harvest, the highest average annual variable net income was the 0N treatment with $98/a, which was only $7/a higher than the 25N treatment, the second highest treatment. All the N treatments had higher average annual variable net incomes than all the cover crop treatments. The cover crop treatment with the highest average annual variable net income was rapeseed with $64/a. The average annual income of the rapeseed cover crop was $6/a better than any of the other cover crops.

<u>Wheat, W-F Rotation</u>

Precipitation from planting to termination of the winter cover crops (eight months, September 2021 through April 2022) for the W-F rotation was 3.30 in. The very dry conditions at planting and throughout the typical cover crop growing season resulted in the cover crops failing with no cover crop emergence and no growth. No soil water was used by the cover crops since they did not grow; therefore, the cost of planting the cover crops (seed and drilling) was expenses without benefits.

The wheat harvested in the W-F rotation was quite low, averaging 9.3 bu/a. The 50N treatment had the highest yield of 15.2 bu/a, which was significantly higher (LSD 0.20) than any of the N treatments and any of the cover crop treatments. The cover crop treatments of wheat and hairy vetch and all the N treatments yielded significantly more than the rapeseed cover treatment.

The treatment with the highest variable net income was 0N with $57/a because it had one of the highest wheat yields and no variable treatment cost. All three N treatments had higher variable net incomes than any of the cover crop treatments. This was due to the comparable or higher yields of the N treatments and relatively lower treatment costs compared to the cover crops. Two treatments had negative net returns, Winter N Mix, -$6/a, and hairy vetch, -$12/a, due mostly to their high treatment costs. The 0N and 25N treatments produced higher variable net incomes than the four cover crop treatments.

After six cropping years, encompassing one year of wheat crop failure and one year of very low wheat yields, the 0N treatment of the W-F rotation had the highest average annual variable net income of $94/a, which was $10/a better than the second highest treatment, the rapeseed treatment. The average annual income of the rapeseed cover crop was $14/a better than any of the other cover crops, and only $1/a better than the 25N treatment.

<u>Wheat Phase, W-S-F Rotation</u>

Precipitation from planting to termination of the spring cover crops (4 months, late March 2022 through mid-July 2022) for the wheat phase of the W-S-F rotation was 4.56 in. Conditions were dry at cover crop planting and during much of the cover crop growth. Because of the dry planting conditions, the cover crops did not emerge until late May. Four months after planting, the average dry matter production of the spring cover crops was only 496 lb/a. Cover crop forage yields ranged from 58 lb/a for hairy vetch cover to 1110 lb/a for rapeseed. Rapeseed cover had significantly higher forage yield than any of the other cover crops at the 0.20 alpha level. The second highest forage production was oats with 495 lb/a, which was significantly higher than the dry matter production of hairy vetch.

All the cover crops had no available soil water at planting because of the dry conditions. When terminated four months after planting, the cover crops preceding wheat had used up all the available soil water from in-season rainfall; therefore, there were no changes in available soil water (at termination minus at planting) for any of the cover crops. The fallow 0N check (at termination minus at planting) gained +0.34 in. of soil water to a depth of three feet during the same four-month period. Therefore, subtracting 0 inches of soil water used by the cover crops from the soil water gained during no-till fallow (+0.34 in.) equals the water use cost of cover crops. Water use cost to the soil water depth of three feet by the cover crops was the same 0.34 in. for the forage production of all four cover crops.

Wheat yields were very low because of dry growing conditions for all the treatments of the W-S-F rotation, averaging just 5.6 bu/a. The 0N treatment had the highest yield of 8.6 bu/a, which was significantly higher (LSD 0.20) than rapeseed, oats, and Spring N Mix cover crops. The Spring N Mix had the lowest wheat yield of 2.4 bu/a, which was significantly lower yielding than any of the N treatments.

The 0N treatment had the highest variable net income of $49/a compared to all the other treatments because it had the highest wheat yield and no production cost. The 25N treatment had the second highest variable net income, but its variable net income was $39/a less the 0N treatment. The treatments with the highest production costs, hairy vetch, Spring N Mix, and 50N, all had negative net returns.

After six cropping years that spanned one year of complete wheat failure and one year of extremely low wheat yields, the wheat phase of the 0N treatment in the W-S-F rotation had the highest average annual variable net income of $79/a, which was only $7/a higher than 25 N, the second highest treatment. The cover crop treatment with the highest average annual variable net income was rapeseed with $61/a. The average annual income of the rapeseed cover crop was only $2/a better than the oats cover crop, and $4/a better than the 50 N treatment.

Conclusion

The 0N treatment had the highest average annual variable net income after six cropping years for both the wheat and grain sorghum crops of both the W-F and W-S-F crop rotations compared to all the winter and spring cover crops and N treatments tested. The 25 N treatment had the second highest average annual variable net income for both wheat and grain sorghum crops in the W-S-F rotation, and the 25N treatment was only $1/a less than the rapeseed cover, the second highest average annual variable net income treatment for the W-F rotation. The cover crop with the highest average annual variable net income was rapeseed, and the rapeseed treatment income was the second highest in the W-F rotation, the third highest for the wheat phase of the W-S-F rotation, and the fourth highest for the grain sorghum phase of the W-S-F rotation. The overall trend of increasing average annual variable net income after six cropping years is that the lowest cost treatments have the highest incomes. This increasing income trend with low-cost treatments is especially evident for crop failure and low crop production years.

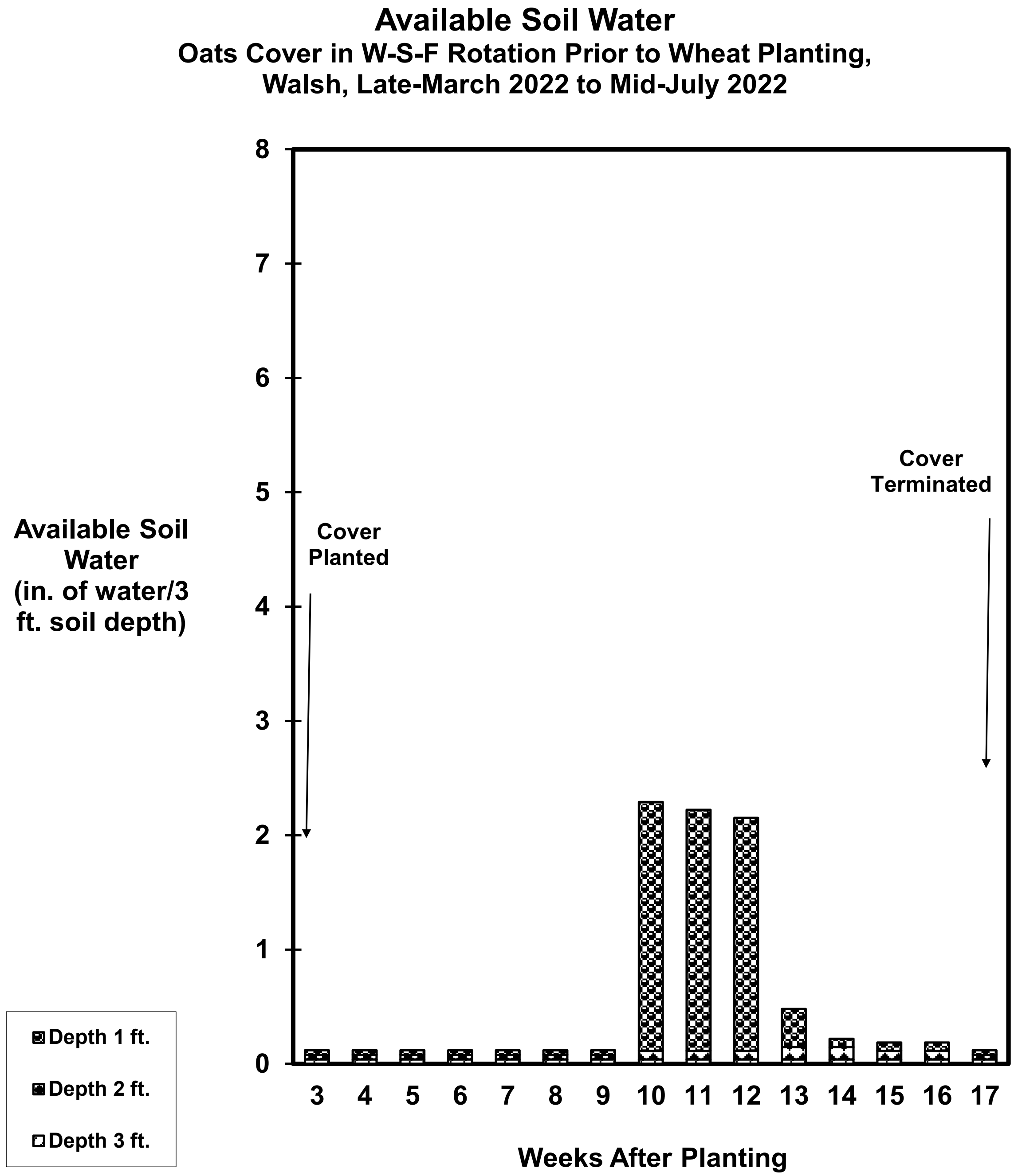
Reference Cited

Conservation Tillage & Technology Conference. February 23-24, 2011. 2011 proceedings of the Midwest Cover Crop Council. Ohio Northern University, Ada, Ohio. http://www.mccc.msu.edu/meetings/2011/2011_MCCC_Proceedings_web2.pdf Accessed: January 15, 2013.

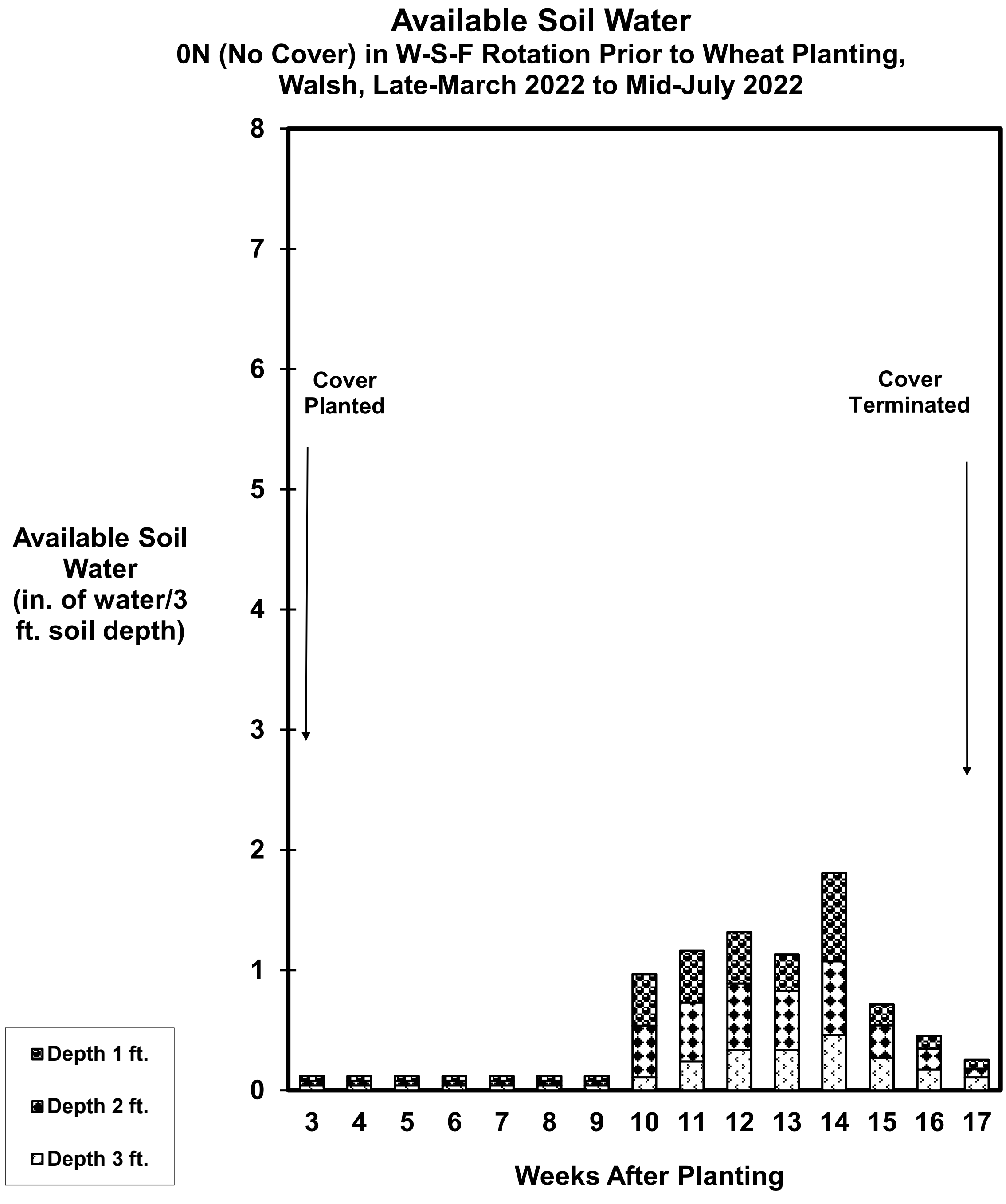
Larson, K. J., 1995. Legumes for cover and N in Wheat-Fallow and continuous grain sorghum at Walsh, 1993-94. *In*: Plainsman Research Center, 1994 Research Results, Larson, et al. CAES, CE, CSU, Fort Collins, Colorado.

Schlegel, Alan J. and John L. Havlin. 1997. Green fallow for the Central Great Plains. Agron. J. 89:762-767 (1997).

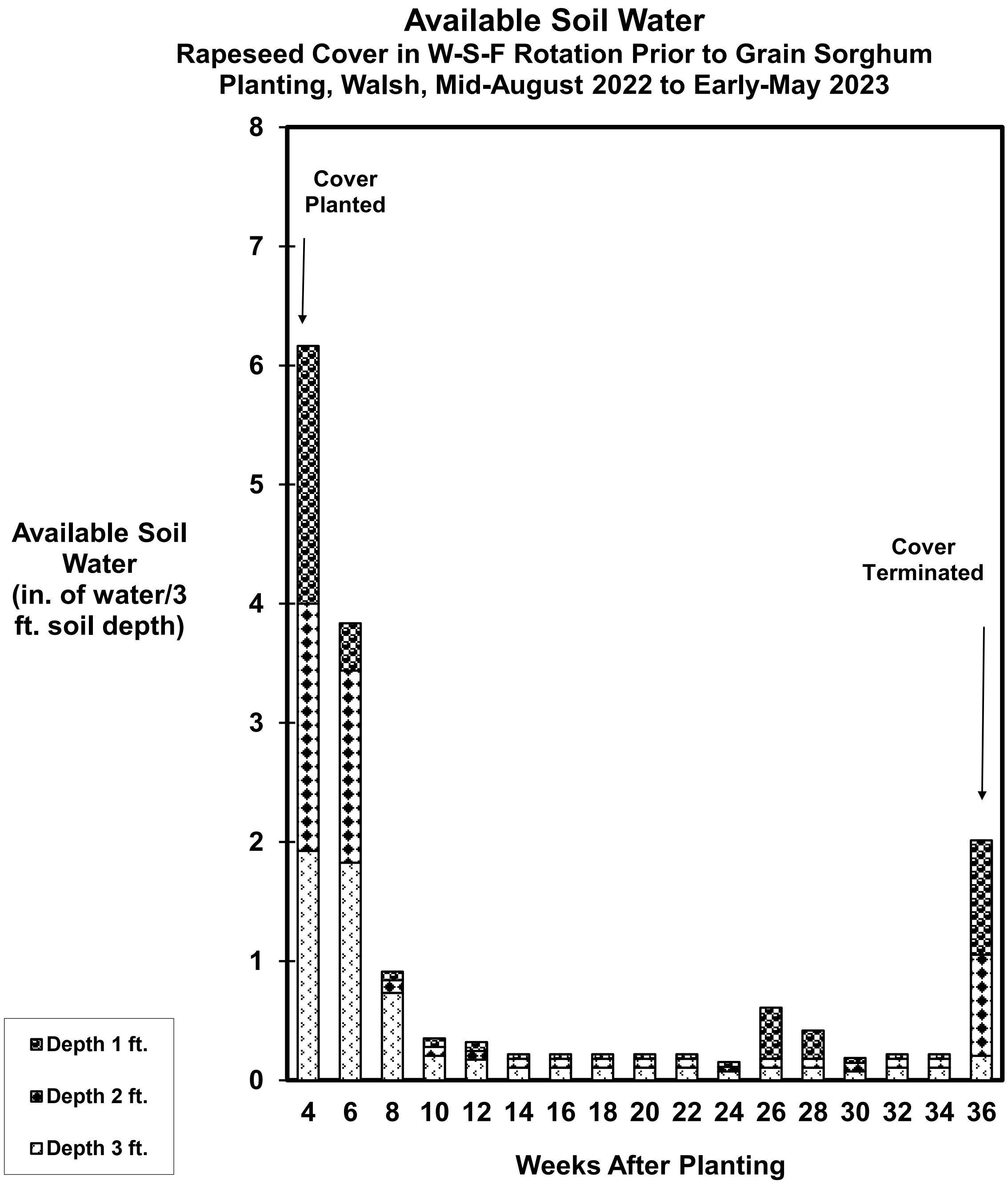
Vigil, Merle F. and David C. Nielsen. 1998. Winter wheat depression from legume green fallow. Agron. J. 90:727-734 (1998).



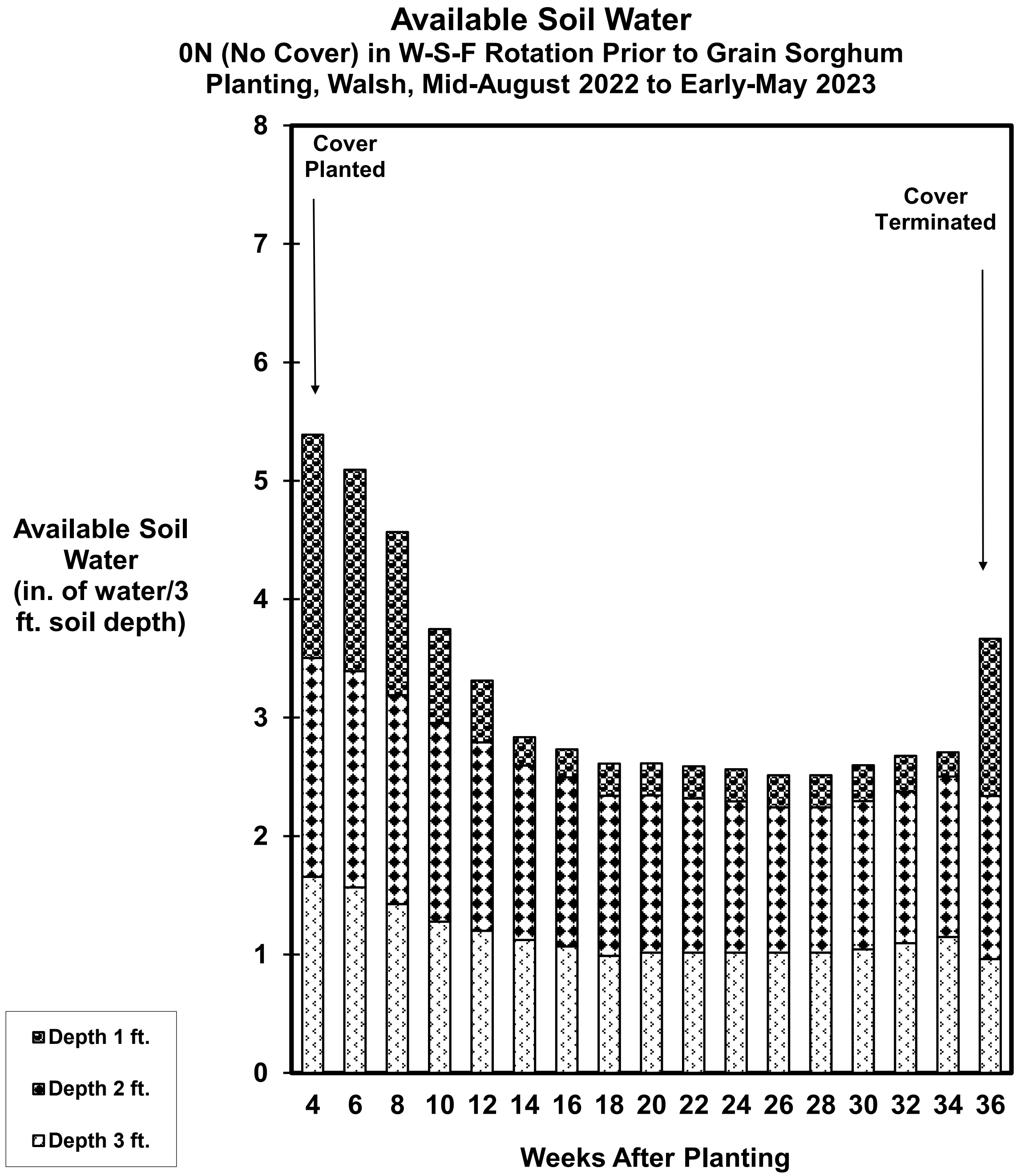
Available soil water of oats cover in W-S-F Rotation prior to wheat planting at Walsh. Gypsum block measurements taken to 3 ft. with 1 ft. increments. Total rainfall at Walsh from cover crop planting to cover crop termination was 4.56 in. Any increase in available soil water between weeks is from rain.



Available soil water of 0N (no cover) in W-S-F Rotation prior to wheat planting at Walsh. Gypsum block measurements taken to 3 ft. with 1 ft. increments. Total rainfall at Walsh from cover crop planting to cover crop termination was 4.56 in. Any increase in available soil water between weeks is from rain.



Available soil water of rapeseed cover in W-S-F Rotation prior to grain sorghum planting at Walsh. Gypsum block measurements taken to 3 ft. with 1 ft. increments. Total rainfall at Walsh from cover crop planting to cover crop termination was 12.85 in. Any increase in available soil water between weeks is from rain.



Available soil water of 0N (no cover) in W-S-F Rotation prior to grain sorghum planting at Walsh. Gypsum block measurements taken to 3 ft. with 1 ft. increments. Total rainfall at Walsh from cover crop planting to cover crop termination was 12.85 in. Any increase in available soil water between weeks is from rain.

Cover Crop Study, Grain Sorghum (W-S-F) after Winter Cover Crop, Walsh, 2023.

Treatment	Grain Sorghum Yield	Test Wt.	Cover Dry Matter	Cover N	Fixed N	Treatment Cost	Fixed N Income	Variable Net Income
	bu/a	lb/bu	lb/a	lb/a	lb/a	$/a	$/a	$/a
Wheat	32.2	61.1	3710	131.1		27.50		123.20
Rapeseed	30.5	60.9	3908	103.7		19.75		122.99
Hairy Vetch	20.9	60.5	2286	79.7	0.0	72.00	0.00	25.81
Winter N Mix	17.8	60.6	2726	95.4	0.0	60.70	0.00	22.60
0 N	39.8	60.8				0.00		186.26
25 N	33.8	61.0				23.10		135.08
50 N	34.3	60.8				39.70		120.82
Average	29.9	60.8	3157	102.5		34.68		105.25
LSD 0.20	12.58		1011					

Cover crops planted: August 15, 2022.
Cover crops terminated: May 6, 2023.
Grain sorghum planted: June 1, 2023; Harvested: November 11, 2023.
Cover crop seeding rate: Winter N Mix, 60 lb/a; hairy vetch, 30 lb/a; canola, 5 lb/a; wheat, 50 lb/a.
Winter N Mix: winter rye 26lbs, winter barley 20lbs, winter peas 5lbs, hairy vetch 17 lbs, rapeseed 2lbs, sweet clover 2lbs.
Cover seed cost: Winter N Mix, $45.70/a; hairy vetch, $57/a; rapeseed, $4.75/a; wheat, $12.50/a.
N fertilizer cost: 32-0-0, $0.664 N/lb ($425 per ton)
Treatment application cost: cover crop planting, $15/a; N application, $6.50/a.
Grain sorghum price: $4.68/bu.

Cover Crop Study, Wheat (W-S-F) after Spring Cover Crop, Walsh, 2023.

Treatment	Wheat Yield	Test Wt.	Cover Dry Matter	Cover N	Fixed N	Treatment Cost	Fixed N Income	Variable Net Income
	bu/a	lb/bu	lb/a	lb/a	lb/a	$/a	$/a	$/a
Rapeseed	4.4	52	1110	29.0		16.75		8.59
Oats	4.6	51	495	18.7		24.60		2.13
Hairy Vetch	5.5	54	58	2.1	0.0	69.00	0.00	-37.61
Spring N Mix	2.4		321	11.6	0.0	57.50	0.00	-43.73
0 N	8.6	53				0.00		49.42
25 N	6.6	54				27.93		9.97
50 N	7.2	52				49.35		-7.94
Average	5.6	45	496	15.3		35.02		-2.74
LSD 0.20	3.80		290.5					

Planted cover crop March 24, 2022.
Cover crops hand-sampled and terminated: July 22. 2022.
Wheat planted: October 1, 2022, Avery at 50 lb seed/a, 5 gal/a of 10-34-0.
Wheat harvested: July 28, 2023.
Spring cover crop seeding rate: Spring N Mix, 65 lb/a; hairy vetch, 30 lb/a; canola, 5 lb/a; oats, 60 lb/a. Spring N Mix: spring barley, 15 lb/a; common vetch, 10 lb/a; spring forage pea, 15 lb/a; oats, 15 lb/a; rapeseed, 2 lb/a; Nitro radish, 2 lb/a; crimson clover, 3 lb/a; flax, 3 lb/a.
Cover seed cost: Spring N Mix, $45.50/a; hairy vetch, $57/a; canola, $4.75/a; oats, $12.60/a.
N fertilizer cost: 28-0-0, $0.857 N/lb ($480 per ton).
Treatment application cost: cover crop planting, $12/a; N application, $6.50/a.
Wheat price: $5.76/bu.

Cover Crop Study, Wheat (W-F) after Winter Cover Crop, Walsh, 2023.

Treatment	Wheat Yield	Test Wt.	Cover Dry Matter	Cover N	Fixed N	Treatment Cost	Fixed N Income	Variable Net Income
	bu/a	lb/bu	lb/a	lb/a	lb/a	$/a	$/a	$/a
Wheat	9.1	54	0	0.0		22.42		29.71
Rapeseed	4.4	55	0	0.0		16.75		8.59
Winter N Mix	7.0	55	0	0.0	0.0	46.25	0.00	-5.76
Hairy Vetch	9.9	55	0	0.0	0.0	69.00	0.00	-11.75
0 N	9.8	55	0			0.00		56.51
25 N	9.9	53	0			22.50		34.70
50 N	15.2	55	0			38.50		49.17
Average	9.3	55	0	0.0		30.77		23.02
LSD 0.20	3.29							

Cover crops planted: September 27, 2021.
Cover crops did not germinate and emerge.
Wheat planted: October 1, 2022, Avery 50 lb/a and 5 gal/a of 10-34-0.
Wheat harvested: July, 28, 2023.
Cover crop seeding rate: Winter N Mix, 43 lb/a; hairy vetch, 30 lb/a; canola, 5 lb/a; wheat, 50 lb/a.
Winter N Mix: hairy vetch, 8 lb/a; sweet clover, 2 lb/a; winter forage pea, 8 lb/a; triticale, 20 lb/a; rapeseed, 2 lb/a; sorghum sudangrass BMR, 3 lb/a.
Cover seed cost: Winter N Mix, $34.25/a; hairy vetch, $57/a; rapeseed, $4.75/a; wheat, $10.42/a.
N fertilizer cost: 28-0-0, $0.64 N/lb ($358 per ton).
Treatment application cost: cover crop planting, $12/a; N application, $6.50/a.
Wheat price: $5.76/bu.

Cover Crop Study, Grain Sorghum (W-S-F) after Winter Cover Crop, Annual Variable Net Income, Walsh, 2018 to 2023.

Treatment	Annual Variable Net Income						Total Annual Variable Net Income	Average Annual Variable Net Income
	2018	2019	2020	2021	2022	2023		
	$/a							
Rapeseed	97.98	117.56	4.34	166.74	233.51	122.99	386.61	64.44
Wheat	45.07	73.72	13.80	219.96	203.60	123.20	352.54	58.76
Hairy Vetch	93.10	77.30	-35.50	170.46	277.52	25.81	305.35	50.89
Winter N Mix	50.19	108.83	-24.55	150.51	204.73	22.60	284.97	47.50
0 N	109.53	123.09	26.64	325.43	260.96	186.26	584.68	97.45
25 N	115.10	126.05	13.25	286.77	300.49	135.08	541.17	90.20
50 N	92.73	102.51	4.70	263.85	249.55	120.82	463.78	77.30
Average	86.24	104.15	0.38	226.24	247.19	105.25	417.02	69.50

Rapeseed cover crop was canola or rapeseed.
Wheat cover crop was wheat or triticale.
Variable Net Income is gross income minus cover crop and N treatment costs.
Annual Variable Net Income is Total Crop Variable Net Income divided by years in study.

Cover Crop Study, Wheat (W-S-F) after Spring Cover Crop, Annual Variable Net Income, Walsh, 2018 to 2023.

Treatment	Annual Variable Net Income 2018	2019	2020	2021	2022	2023	Total Annual Variable Net Income	Average Annual Variable Net Income
	---$/a---							
Rapeseed	51.16	280.75	-13.31	63.82	-16.75	8.59	365.68	60.95
Oats	44.89	298.17	-16.03	48.19	-20.33	2.13	354.89	59.15
Spring N Mix	40.85	269.75	-32.70	23.78	-40.36	-43.73	261.32	43.55
Hairy Vetch	3.77	236.50	-64.70	21.36	-69.00	-37.61	127.93	21.32
0 N	67.91	308.50	12.47	83.58	0.00	49.42	472.47	78.74
25 N	64.43	321.50	-1.17	66.82	-22.50	9.97	429.08	71.51
50 N	36.72	312.00	-8.31	37.74	-38.50	-7.94	339.65	56.61
Average	44.25	289.60	-17.68	49.33	-29.63	-2.74	335.86	55.98

Rapeseed cover crop was canola or rapeseed.
Variable Net Income is gross income minus cover crop and N treatment costs.
Annual Variable Net Income is Total Crop Variable Net Income divided by years in study.

Cover Crop Study, Wheat (W-F) after Winter Cover Crop, Annual Variable Net Income, Walsh, 2018 to 2023.

Treatment	Annual Variable Net Income 2018	2019	2020	2021	2022	2023	Total Annual Variable Net Income	Average Annual Variable Net Income
	$/a							
Rapeseed	52.78	321.25	6.04	131.59	-16.75	8.59	503.50	83.92
Wheat	55.67	273.50	-11.33	92.49	-22.42	29.71	417.62	69.60
Hairy Vetch	22.09	353.67	-46.06	140.89	-69.00	-11.75	389.84	64.97
Winter N Mix	44.30	295.75	-14.00	105.86	-46.25	-5.76	379.90	63.32
0 N	62.52	331.50	13.76	153.61	0.00	56.51	561.40	93.57
25 N	39.63	316.50	1.41	160.95	-22.50	34.70	495.99	82.67
50 N	39.95	319.50	-1.86	124.34	-38.50	49.17	443.43	73.90
Average	45.28	315.95	-7.43	129.96	-30.77	23.02	455.95	75.99

Rapeseed cover crop was canola or rapeseed.
Wheat cover crop was wheat or triticale.
Variable Net Income is gross income minus cover crop and N treatment costs.
Annual Variable Net Income is Total Crop Variable Net Income
divided by years in study.

Long Term Evaluation of CRP Conversion Back into Crop Production

Kevin Larson, Brett Pettinger, and Zane Jenkins

The Conservation Reserve Program has been one of the most important USDA programs for Colorado. It has added millions of dollars to Colorado farm income, regardless of weather and commodity fluctuations. In 2011, Colorado had 1.87 million acres in CRP, and of that total, 571,000 acres expired October 2012 (USDA, FSA, 2011). Because of high commodity prices and funding uncertainty for CRP extensions, many CRP acres were converted back into crop production. CRP has provided soil erosion protection by growing perennial grass cover. We developed this study to identify which CRP grass conversion method, chemical (no-till) or tillage, provides the highest variable net return over multiple years for two common crop rotations, Wheat-Fallow (W-F) and Wheat-Sorghum-Fallow (W-S-F).

Materials and Methods

We are testing our long-term CRP conversion in two common crop rotations: Wheat-Fallow (W-F) and Wheat-Sorghum-Fallow (W-S-F). After establishing the rotations, all phases of each rotation were present each year. We began our long-term CRP conversion study on March 29, 2012 using chemical or tillage. Because we were still establishing the crop rotations, grain sorghum was the only crop studied for the 2012 cropping season. For the 2013 cropping season, we were able to harvest the first wheat crops and the extended-fallow grain sorghum crop. For chemical CRP conversion prior to wheat and extended-fallow grain sorghum crops, we applied glyphosate at 128 oz/a and ammonium sulfate (AMS) at 2 lb/a on six application dates: March 29, April 25, May 18 and June 21, July 27, and October 3, 2012. For tillage CRP conversion prior to wheat and extended-fallow grain sorghum crops, we disked four times with an offset disk on four dates: March 29, April 23, May 18 and June 21, 2012, and swept two times on July 27 and October 9, 2012.

For this twelfth cropping season, we treated both the chemical and tillage treatments the same starting in March 2015. The chemical treatment for the fallow periods, we sprayed glyphosate 40 oz/a, dicamba 8 oz/a, 2,4-D 12 oz/a, AMS 2 lb/a two times prior to the wheat and grain sorghum crops for the W-S-F rotation and three times for the W-F rotation. We applied flumioxazin 3.0 oz/a in March 2022 for wheat and March 2023 for grain sorghum. No wheat emerged because of drought, so no in-season weed control was applied to the wheat. For pre-emergence weed control, we applied atrazine 1 lb/a, mesotrione 6.4 oz/a, and Medal 24 oz/a for the grain sorghum. For N fertilization, we streamed 28-0-0 at 60 lb N/a on 20 in. spacing. We planted wheat, Avery at 50 lb/a and seedrow applied 5 gal 10-34-0/a, on October 1, 2022. For the sorghum crop, we planted Pioneer 86P20 at 34,000 seeds/a on June 1, 2023 and seedrow applied 5 gal 10-34-0/a at planting. No wheat was harvested because of droughty conditions from fall planting through the spring. We harvested the grain sorghum on November 6, 2023, using a modified Gleaner F3 combine equipped with a HarvestMaster H2 weighing and seed moisture system. Seed moisture content for the yields were adjusted to 12% for wheat and 14% for grain sorghum. We recorded costs of production and yields to determine conversion and rotation revenues.

Results and Discussion

On August 3, 1990, Ken Lair, Soil Conservation Service, planted these 11 perennial grass strips: Hycrest, crested wheat grass; Bozorsky, Russian wildrye; Oahe, intermediate wheatgrass; Luna, pubescent wheatgrass; 9053823, smooth brome; Paiute, orchard grass; Granada, yellow bluestem; WWSpar, old world bluestem; Caucasian, bluestem; Ironmaster, bluestem; Morpa, weeping lovegrass. Each of our CRP conversion treatments transects all 11 perennial grass strips.

For this CRP conversion study, we are investigating the effects of maintaining the grass cover on subsequent crop yields over multiple years. So far, only five wheat crops have been harvested, but this is our eleventh harvested grain sorghum crop. The first wheat crop, following our initial burn down or tillage to control the perennial grasses, and the 2016, 2018, 2019, and 2021 wheat crops have been our only harvested wheat crops.

For our initial wheat crop, dry conditions and multiple late freezes damaged tillers and resulted in very poor wheat yields for both chemical and tillage CRP conversion treatments. Wheat yields ranged from 0.3 bu/a to 2.1 bu/a. Both CRP conversion methods had significant cash losses in variable net incomes, averaging -$80/a for tillage and -$100/a for chemical. Wheat production was too low to offset the high cost of CRP conversion, regardless of conversion method. Nonetheless, chemical conversion was costlier than tillage conversion for this first wheat crop, and thus lost as much as -$24/a more than tillage conversion.

Early in the process of establishing the crop rotations, we were able, in 2013, to create our first summer fallow period before the sorghum crop. In 2013, the extended fallow period produced good grain sorghum yields for both CRP conversion methods, 35.3 bu/a for chemical and 24.6 bu/a for tillage. The higher cost of chemical conversion compared to tillage conversion was more than offset by the higher grain sorghum production obtained with chemical conversion compared to tillage conversion. Chemical CRP conversion provided $16/a more variable net income than tillage conversion with the summer fallow grain sorghum crop.

In 2014, the grain sorghum crop produced high yields, 70.6 bu/a for the chemical treatment and 52.7 bu/a for the tillage treatment. Since we have already controlled the perennial grasses, we no longer needed the additional tillage operations and extra chemical rates to maintain the tillage and no-till plots. With fewer tillage and chemical operations in 2014, the cost of both treatments was lower and the difference between chemical and tillage treatments was less. However, the chemical treatment still costs $16.64/a more than the tillage treatment, but because of its higher yield, the chemical treatment provided $50.48/a more than the tillage treatment.

In 2015, grain sorghum was the only crop harvested because the wheat crop was severely damaged by hail. The chemical treatment produced 10.1 bu/a more grain sorghum yield than the tillage treatment. There were fewer chemical and tillage operations, resulting in $4.52/a higher chemical treatment cost. However, the higher grain yield of the chemical treatment more than compensated for its higher treatment cost by producing $28.31/a more income than the tillage treatment.

In 2016, we were able to harvest both the wheat and the grain sorghum crops. This is only the second time that we harvested wheat for this study. We suspended the tillage operations for the tillage treatment and treated both chemical and tillage treatments using the same no-till methods. We suspended tillage operations to determine the length of the recovery period required for the tillage treatment to produce yields equivalent to the chemical treatment. The tillage treatment produced higher grain sorghum yield than the chemical treatment, although the 2.7 bu/a yield difference was not significant. Likewise, the W-F tillage treatment produced significantly higher wheat yield, 7.4 bu/a more than the chemical treatment. The greater production for the tillage treatment did not hold true for the wheat yield in the W-S-F rotation, where the chemical treatment produced 3.5 bu/a more yield than the tillage treatment. It appears that the length of recovery period for the tillage treatment to produce at a similar yield level as the chemical treatment was only one season without tillage.

In 2017, we harvested only the grain sorghum crop. The chemical and tillage treatments were treated the same since we suspended the tillage operations in March of 2015. Grain sorghum yields were very high averaging 111.7 bu/a and only 1.2 bu/a separated the chemical and old tillage treatments. With similar yields and the same treatment cost, there was only $3.60 difference between the treatments in variable net income. These minor yield and income differences verify that suspending tillage operations requires only one or two years for full yield recovery.

In 2018, we harvested both the wheat and grain sorghum crops. This is only the third time that we have harvested a wheat crop in the seven years of this study. The chemical and tillage yields for both the wheat and the sorghum produce very similar yields. This is not surprising because the chemical and tillage treatments have been treated the same since March 2015. Only 1.3 bu/a separated the wheat yields between the chemical and old tillage treatments, and there was only 0.3 bu/a difference in grain sorghum yields between the chemical and old tillage treatments. The grain yields were fair for the wheat, averaging 21.7 bu/a, and very good for the grain sorghum, averaging 70.9 bu/a. With similar yields and the same treatment costs, the maximum variable net income difference between the wheat treatments was $7/a, and $1/a for the grain sorghum treatments.

In 2019, we harvested both the wheat and grain sorghum crops. This was only the fourth time that we have harvested a wheat crop in the seven years of this study. Only 1 to 2 bu/a separated the wheat yields of the chemical and tillage treatments for both the W-F and W-S-F rotations. However, the chemical treatment produced 5.2 bu/a more grain sorghum than the tillage treatment. The greater grain sorghum yield of the chemical treatment compared to the tillage treatment is surprising because we suspended tillage in March 2015, so both chemical and tillage treatments were treated the same. For the last three years since we stopped tillage, the chemical and tillage treatments produced similar yields. We do not have an explanation for the higher grain sorghum yield of the chemical treatment this year. The grain yields were exceptional for the wheat, averaging 79 bu/a, and very good for the grain sorghum, averaging 61 bu/a. With similar yields and the same treatment costs, the maximum variable net income difference between the wheat treatments was $9/a. The significantly higher grain sorghum yield of the chemical treatment produced $17/a more than the tillage treatment.

In 2020, we harvested only the grain sorghum crop. The wheat crop failed because conditions were too dry throughout the wheat growing season. The chemical and tillage treatments were treated the same since we suspended the tillage operations in March of 2015. Grain sorghum yields were low averaging 10.2 bu/a and only 0.7 bu/a separated the chemical and old tillage treatments. With similar yields and the same treatment cost, there was only $3.88 difference between the treatments in variable net income. These minor yield and income differences is not surprising since we treated the chemical and tillage treatments the same.

In 2021, we harvested both the grain sorghum and wheat crops. However, the wheat crop was poor, averaging less than 2 bu/a, because conditions were very dry throughout the wheat growing season. This was only the fifth time that we have harvested a wheat crop in the ten years of this study. The chemical and tillage treatments were treated the same since we suspended the tillage operations in March of 2015. Grain sorghum yields were exceptionally high, averaging 94.5 bu/a, and only 0.1 bu/a separated the chemical and old tillage treatments. With similar yields and the same treatment cost (both tillage and chemical were treated the same), there was only $0.58 difference between the treatments in variable net income.

In 2022, the wheat did not emerge because of drought conditions at planting and throughout the wheat growing season. The no wheat harvest has been a common theme throughout this CRP conversion study. The tillage treatment grain sorghum yield was 6.3 bu/a higher than the chemical treatment. This significant yield difference between tillage and chemical treatments is surprising because the tillage and chemical treatments have been treated the same since March 2015. We have no explanation for the significant yield difference between tillage and chemical treatments. In 2019, a similar occurrence happened where the grain sorghum yield of the tillage treatment was significantly higher than the chemical treatment. In 2019, like this year, we had no explanation for the yield difference, especially considering that tillage and chemical treatments were treated the same.

This year, the wheat did not emerge due to continued drought conditions at planting time. The result was a fourth year since 2017 without a wheat harvest due to dry conditions during the fall and early spring period of the year. Grain sorghum was harvested in early November with the chemical treatment yielding 6.6 bu/ac higher than the tillage treatment.

Average annual variable income for the past six years of the study (2018-2023) have resulted in small positive incomes for both W-F treatments and large positive incomes for both W-S-F treatments. The W-F tillage treatment resulted in a $4.95 per acre while the chemical treatment produced just $2.65 per acre. This is the result of three of six years (2020, 2022, and 2023) having complete failure of the wheat crop due to drought. In 2019 high yields lead to a surplus of profitability for the W-F rotation that has since been slowly reduced due to the years of failed wheat crops. The W-S-F treatments continue to maintain profitability as a whole and there is virtual no difference in profitability between the two treatments of W-S-F rotations with average annual profitability for the chemical treatment being $223.42 per acre and the tillage treatment being 223.46 since 2018.

Reference Cited

USDA, FSA. December 30, 2011. Conservation Reserve Program - Monthly CRP Acreage Report, Summary of Active and Expiring CRP Acres by State. Accessed: January 12, 2012. ftp://ftp.fsa.usda.gov/crpstorpt/RMEPEGG/MEPEGGR1.HTM

Long Term CRP Conversion Using Tillage or Chemical, Twelfth Season, Wheat-Sorghum-Fallow and Wheat-Fallow, Wheat Crop, Walsh, 2023.

CRP Conversion	Rotation	Wheat Yield	Test Weight	Gross Income	Treatment Cost	Variable Net Income
		bu/a	lb/bu	$/a	$/a	$/a
Tillage	W-F	0	0	0.00	72.49	-72.49
Chemical	W-F	0	0	0.00	72.49	-72.49
Tillage	W-S-F	0	0	0.00	72.49	-72.49
Chemical	W-S-F	0	0.0	0.00	72.49	-72.49
Average		0.0	0.0	0.00	72.49	-72.49
LSD 0.20						

Chemical: glyphosate 40 oz/a, dicamba 8 oz/a, 2,4-D 12 oz/a, AMS 2 lb/a applied three times. Flumioxazin 3 oz/a applied in March 2022.
Chemical cost: $12.99/a (3X), $5.52/a (1X) and $7.00/a (4X) application cost.
No wheat emergence due to drought, so no post chemical application cost.
Tillage and no till treated the same.
N fertilizer applied at 60 lb/a as 28-0-0.
Wheat , Avery, 50 lb seeds/a, 5 gal 10-34-0/a seedrow applied at planting.
Wheat planted on October 1, 2022; Harvested:.
wheat price: $5.76/bu.
Variable Net Income is Gross Income minus Treatment Cost.

Long Term CRP Conversion After Using Tillage or Chemical, Twelth Season Wheat-Sorghum-Fallow, Grain Sorghum Crop, Walsh, 2023.

CRP Conversion	Rotation	Grain Sorghum Yield	Test Weight	Gross Income	Treatment Cost	Variable Net Income
		bu/a	lb/bu	$/a	$/a	$/a
Tillage	W-S-F	65.0	60.7	304.20	52.50	251.70
Chemical	W-S-F	71.6	61.1	335.09	52.50	282.59
Average		68.3	60.9	319.64	52.50	267.14
LSD 0.20		37.86				

Fallow chemical: 5.4 Glyphosate 40 oz/a, dicamba 8 oz/a, 2,4-D 12 oz/a, AMS 2 lb/a applied two times. Flumioxazin 3.0 oz/a applied March 2023.
Chemical cost: $12.99/ac(2X), $5.52 (1X) and $7.00/a (3X) application cost.
Pre-emergence chemical: Atrazine 1 lb/a, Mesotrione 6.4 oz/a, Medal 24 oz/a.
Pre-emergence chemical cost: $22.47/a and $7.00/a for application.
Tillage and no till treated the same.
N fertilizer applied at 60 lb/a as 28-0-0.
Grain sorghum, Pioneer 86P20, planted at 34,000 seeds/a and seedrow applied 5 gal 10-34-0/a at planting.
Grain sorghum planted on June 1 2023; harvested on November 6, 2023.
Grain sorghum price: $4.68/bu.
Variable Net Income is Gross Income minus Treatment Cost.

CRP Conversion, Chemical and Tillage Comparison, Annual Rotational income, 2018 to 2023.

Rotation and Conversion Treatment	Annual Rotation Variable Net Income 2018	2019	2020	2021	2022	2023	Total Annual Rotation Variable Net Income	Average Annual Rotation Variable Net Income
	$/a							
<u>Chem</u>								
W-S-F	200.90	424.40	-77.66	426.89	155.88	210.10	1340.51	223.42
W-F	36.13	247.98	-69.03	-47.36	-79.35	-72.49	15.88	2.65
<u>Tillage</u>								
W-S-F	202.41	402.84	-73.51	428.98	200.80	179.21	1340.73	223.46
W-F	37.21	257.22	-69.03	-43.89	-79.35	-72.49	29.67	4.95
Average	119.16	333.11	-72.31	191.16	49.50	61.08	681.70	113.62

The first wheat crop was 2013. There was no wheat harvested in 2014 (winterkill); 2015 (hail); 2017, 2020, 2022, and 2023 (too dry, poor emergence).
Variable Net Income is gross income minus treatment cost.
Annual Rotation Variable Net Income is Total Rotation Variable Net Income divided by years.
Chemical and Tillage treatment have been treated the same since March 2015.

Dryland Cowpea: Row Spacing and Variety Study at Walsh, 2023

COOPERATORS: Plainsman Agri-Search Foundation, Kevin Larson and Brett Pettinger, Walsh.

PURPOSE: To identify dryland cowpea varieties that produce highest yields when grown with narrow or wide row spacings.

RESULTS: There were no significant seed yield differences between cowpea varieties, or between narrow and wide row spacings. The average yield for the two cowpea varieties tested was 232 lb/a. CB5 yielded only 7 lb/a more than CB46 when combining both row spacing treatments. The 30 in. row spacing produced 33 lb/a more yield than the 12 in. row spacing when combining both varieties.

PLOT: Four rows with 30 in. row spacing and 10 rows with 12 in. spacing, 200 ft. long. SEEDING DENSITY: 60,000 seeds/a for 30 in. spacing and 80,000 seeds/a for 12 in. spacing. PLANTED: June 15. HARVESTED: October 11.

PEST CONTROL: Preemergence Herbicides: Prowl H2O 32 oz/a and Glyphosate 32 oz/a. CULTIVATION: None. INSECTICIDE: None.

FIELD HISTORY: Previous Crop: Failed wheat. FIELD PREPARATION: No till.

SOIL: Richfield silt loam.

FERTILIZATION: N at 60 lb/a.

Summary: Growing Season Precipitation and Temperature \1
Walsh, Baca County.

Month	Rainfall	GDD \2	>90 F	>100 F	DAP \3
	in		-------no. of days--------		
June	3.33	344	7	0	15
July	6.39	826	20	2	46
August	1.90	832	21	3	77
September	1.61	631	14	3	107
October	4.05	159	1	0	118
Total	17.28	2792	63	8	118

\1 Growing season from June 15 (planting) to October 11 (harvest).
\3 GDD: Growing Degree Days for sorghum.
\4 DAP: Days After Planting.

COMMENTS: Planted in good soil moisture, which resulted in good seed germination and stand establishment. The growing season precipitation was well above average. June, July, and October were wet; August and September were dry. Flowering and pod development for the cowpea varieties occurred during the hot and dry period of mid-August and early September, which resulted in flower and pod abortion and low seed yields.

Dryland Cowpea: Row Spacing and Variety Study at Walsh, 2023.

Row Spacing	Variety	Grain Yield
		lb/a
30 in.	CB5	274
30 in.	CB46	225
12 in.	CB5	201
12 in.	CB46	231
Average		232
LSD 0.20		159.8
Row Spacing		
30 in.		249
12 in.		216
Row Spacing Average		232
LSD 0.20		155.4
Variety		
CB5		237
CB46		228
Variety Average		232
LSD 0.20		80.8

No Row Spacing X Variety Interaction

Planted: June 15, 2023, 30 in. rows, 60,000 seeds/a; 12 in. rows, 80,000 seeds/a; Harvested: October 11, 2023.

Dryland Pearl and Foxtail Millet Comparison at Walsh, 2023

COOPERATORS: Plainsman Agri-Search Foundation, Kevin Larson, Brett Pettinger, Zane Jenkins, Walsh.

PURPOSE: To compare dryland pearl millet and foxtail millet production for adaptation to Southeastern Colorado.

RESULTS: The foxtail millet produced significantly more grain yield than the pearl millet. The average grain yield for the foxtail millet planted in 12 in. rows was 974 lb/a, and the average grain yield for the pearl millet planted in 30 in. rows was 435 lb/a.

PLOT: Four rows with 30 in. row spacing for pearl millet and 10 rows with 12 in. spacing for foxtail millet, 200 ft. long. SEEDING DENSITY: 2.5 lb seed/a for 30 in. spacing (pearl millet) and 5 lb seed/a for 12 in. spacing (foxtail millet). PLANTED: June 15 for both pearl and foxtail millets. HARVESTED: October 7 for foxtail millet and October 20 for pearl millet.

PEST CONTROL: Preemergence Herbicides: Atrazine 0.75 lb/a, Staredown 6.4 oz/a, and Glyphosate 32 oz/a. CULTIVATION: None. INSECTICIDE: None.

Summary: Growing Season Precipitation and Temperature \1
Walsh, Baca County.

Month	Rainfall	GDD \2	>90 F	>100 F	DAP \3
	in		--------no. of days--------		
June	3.33	344	7	0	15
July	6.39	826	20	2	46
August	1.90	832	21	3	77
September	1.61	631	14	3	107
October	4.05	196	1	0	122
Total	17.28	2829	63	8	122

\1 Growing season from June 15 (planting) to October 15 (first freeze, 27F).
\3 GDD: Growing Degree Days for sorghum.
\4 DAP: Days After Planting.

FIELD HISTORY: Previous Crop: Failed wheat. FIELD PREPARATION: No till.

SOIL: Richfield silt loam.

FERTILIZATION: N at 60 lb/a.

COMMENTS: Planted in good soil moisture, which resulted in good seed germination and stand establishment. The growing season precipitation was well above average. June, July, and October were wet; August and September were dry. The German Foxtail Millet with its higher grain production was better adapted to our environmental conditions than the Bharat Common Pearl Millet. The Bharat Common Pearl Millet was a variety from India which appeared to be more of a forage-type pearl millet than a grain-type pearl millet.

Dryland Foxtail Millet and Pearl Millet Production Comparison at Walsh, 2023.

Millet Type	Row Spacing	Variety	Dry Matter	Test Weight	Grain Yield
			lb/a	lb/bu	lb/a
Foxtail	12 in.	German Foxtail		47	974
Pearl	30 in.	Bharat Common	585	61	435
Average				54	704
LSD 0.20					150.8

Planted: Pearl Millet on June 15, 30 in. rows at 2.5 lb seed/a; Foxtail Millet on June 15, 2023, 12 in. rows at 5 lb seed/a.
Harvested: Foxtail Millet on October 7, with small grain header; Pearl Millet on October 20, 2023 with row crop header.