



SOUTHWEST RESEARCH-EXTENSION CENTER

FIELD DAY

2021

K·STATE
Research and Extension

KANSAS STATE UNIVERSITY AGRICULTURAL EXPERIMENT STATION AND COOPERATIVE EXTENSION SERVICE



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FIELD DAY

2021

Contents

- 3 2020 Southwest Research-Extension Center Staff*

Weather

- 5 Weather Information for Garden City, 2020
7 Weather Information for Tribune, 2020

Cropping and Tillage

- 9 Occasional Tillage in a Wheat-Sorghum-Fallow Rotation
13 Wheat Stubble Height on Subsequent Corn and Grain Sorghum Crops
17 Wheat and Grain Sorghum in Four-Year Rotations
22 Large-Scale Dryland Cropping Systems
28 Tillage Intensity in a Long-Term Wheat-Sorghum-Fallow Rotation

Soil Fertility

- 33 Irrigated Grain Sorghum Response to Long-Term Nitrogen, Phosphorus,
and Potassium Fertilization

Weed Science

- 41 Zest Application Timings for Efficacy in Grain Sorghum
44 Weed Control with Imazamox Rates and Timings in Herbicide-Tolerant
Grain Sorghum
49 Weed Control with Single and Split Herbicide Applications in Corn
52 Impact and Liberty Rates and Mixtures for Efficacy in Corn
57 Fallow Weed Control with Vida Tank Mixtures
60 Novel Sorghum Herbicides for Grass Control in Fallow

- 63 Outlook Alone and in Mixtures for Efficacy in Corn
- 66 Fallow Weed Control with Liberty and Enlist One Tank Mixtures and Application Timings
- 71 Pixxaro Alone and in Combination for Weed Control in Fallow

Irrigation

- 74 Testing Irrigated Cotton Production
- 79 Working with Less Water for Corn Production
- 85 Alternative Cropping Systems with Limited Irrigation
- 89 Irrigated Corn Response to Long-Term Nitrogen and Phosphorus Fertilization

Forage Report

- 97 2020 Kansas Summer Annual Forage Hay and Silage Variety Trial

- 132 Acknowledgments

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Weather Information for Garden City, 2020

J. Elliott

Precipitation in Garden City, KS, for 2020 totaled 15.07 inches. This was 4.46 inches below the 30-year average of 19.53 inches. From January through the end of June, we received 5.26 inches, which was 4.90 inches below normal for that point of the year, resulting in challenging spring planting conditions. Although good rains in July reduced the precipitation deficit, relatively normal moisture the rest of the year resulted in a below average annual total. No significant hail was noted in 2020. The largest precipitation events were 1.25 inches recorded on July 15, 1.82 inches on July 27, and 1.25 inches on August 3 through August 7.

Measurable snowfall occurred in January, February, April, October, and December. Annual snowfall totaled 12.6 inches compared to an average of 16.99 inches. Seasonal snowfall (2019–2020) was 9.9 inches and was 7.12 inches below the average of 17.02 inches.

Average daily wind speed was 5.1 mph compared to the 30-year average of 4.96 mph. Open pan evaporation was measured daily from April through October, and totaled 77.99 inches. This was 3.98 inches above the 30-year mean of 74.01 inches.

Our mean annual temperature was 55.5°F compared to the 30-year average of 54.3°F. Triple-digit temperatures were observed on 12 days in 2020, with the highest being 104°F on June 9. Record high temperatures were set on February 3 at 78°F; September 25 and 26 with 96°F and 100°F, respectively. In addition, record highs were observed on October 8 and October 9 of 93°F and 94°F.

No sub-zero temperatures occurred in 2020. The lowest temperature was 5°F noted on January 11 and 12, February 13, and December 16 and 17. Three record low temperatures were equaled or exceeded: 35°F on September 9 and 10 as well as 16°F on October 26.

The last spring freeze was 32°F on April 25, which was four days earlier than the 30-year average. The first fall freeze was 30°F on October 23, which was ten days later than normal. This resulted in a 181 day frost-free period, which is 13 days longer than the 30-year average.

The 2020 climate information for Garden City is summarized in Table 1.

WEATHER

Table 1. 30-year averages are for the period 1991-2020

Month	Temperatures											
	2020	Precip	Average						Wind		Evaporation	
		91-20	2020			91-20	2020 extremes		91-20		91-20	
		Average	Max	Min	Mean	Average	Max	Min	2020	Average	2020	Average
										mph	inches	
January	0.83	0.47	50.1	19.7	34.9	31.0	61	5	3.39	4.19	n/a	n/a
February	0.82	0.59	48.1	20.4	34.3	34.1	78	5	4.84	5.00	n/a	n/a
March	0.48	1.14	62.0	32.0	47.0	43.6	85	22	5.59	5.84	n/a	n/a
April	0.15	1.64	69.1	34.6	51.8	52.3	87	19	5.44	6.24	8.45	8.19
May	0.80	2.79	78.3	49.2	63.7	63.1	97	36	6.16	5.50	11.65	10.55
June	2.18	3.09	94.9	63.2	79.1	74.1	104	47	8.31	5.46	18.38	13.28
July	5.09	3.16	92.9	65.6	79.2	78.8	103	58	5.04	4.58	12.44	13.86
August	2.20	2.80	91.2	62.1	76.6	76.6	101	57	4.28	4.18	11.35	11.67
September	1.54	1.33	81.8	48.6	65.2	68.6	100	35	4.01	4.81	8.49	9.78
October	0.13	1.32	68.3	35.7	52.0	55.2	94	15	4.50	4.82	7.23	6.68
November	0.52	0.49	64.2	30.9	47.6	42.0	84	7	5.40	4.67	n/a	n/a
December	0.33	0.71	50.0	18.9	34.5	32.3	71	5	4.26	4.20	n/a	n/a
Annual	15.07	19.53	70.9	40.1	55.5	54.3	104	5	5.10	4.96	77.99	74.01
			Average			2020						
Latest spring freeze			April 29			April 25						
Earliest fall freeze			October 13			October 23						
Frost free period			168 days			181 days						

Weather Information for Tribune, 2020

D. Bond and J. Slattery

In 2020, annual precipitation of 14.62 in. was recorded, which is 3.28 in. below normal for Tribune, KS. Only four months had above-normal precipitation. July (4.29 in.) was the wettest month. The largest single amount of precipitation was 2.65 in. on July 27. November, the driest month, only recorded 0.05 in. of precipitation. In addition, April and October only recorded 0.06 in. and 0.08 in. of precipitation, respectively.

Snowfall for the year totaled 16.0 in. (6.2 in. below normal); January, February, March, October, and December had 3.7, 3.9, 2.0, 1.9, and 4.5 in., respectively. There was a total of 17 days of snow cover, which is eight days below normal. The longest consecutive period of snow cover, 7 days, occurred December 11 through December 17.

Record-high temperatures were recorded on 2 days: February 3 (77°F) and November 4 (84°F). A historical record-high temperature was tied on October 10 (91°F). Record-low temperatures were recorded on 7 days: September 8 (39°F), 9 (30°F), and 10 (31°F); and October 24 (14°F), 26 (9°F), 27 (4°F), and 28 (7°F). Historical record-low temperatures were tied on 2 days: April 14 (12°F) and September 11 (38°F). July was the warmest month with a mean temperature of 75.8°F. The hottest day of the year (102°F) occurred on July 19. The coldest days of the year (-2°F) occurred on January 11 and December 14. February was the coldest month with a mean temperature of 30.5°F.

Mean air temperature was below normal for 7 months. November had the greatest departure above normal (4.1°F), and October had the greatest departure below normal (-4.5°F). Temperatures were 100°F or higher on 6 days, which is 5 days below normal. Temperatures were 90°F or higher on 66 days, which is 3 days above normal. The latest spring freeze was April 18, which is 18 days earlier than normal; the earliest fall freeze fell on September 9, which is 28 days earlier than normal. This produced a frost-free period of 144 days, which is 10 days less than the normal of 154 days.

Open-pan evaporation from April through September totaled 74.19 in., which is 2.79 in. above normal. Wind speed for this period averaged 4.4 mph, which is 0.9 mph less than normal.

The 2020 weather information for Tribune is summarized in Table 1.

WEATHER

Table 1. Climatic data, Southwest Research-Extension Center, Tribune, KS

Month	Precipitation (in.)		Monthly average temperatures (°F)						Wind (MPH)		Evaporation (in.)	
	2020	Normal	2020		Normal		2020 extreme		2020	Normal	2020	Normal
			Max	Min	Max	Min	Max	Min				
January	0.41	0.49	48.9	17.6	44.0	16.2	60	-2	---	---	---	---
February	1.36	0.52	44.5	16.5	47.5	19.4	77	-1	---	---	---	---
March	1.58	1.22	58.6	29.2	56.3	26.8	78	17	---	---	---	---
April	0.06	1.45	66.4	31.0	65.7	34.9	82	12	3.7	6.0	8.70	8.27
May	1.02	2.38	75.1	45.0	75.1	46.4	94	33	4.6	5.6	12.53	11.75
June	2.06	2.94	92.0	57.1	85.7	56.6	101	41	6.4	5.2	18.15	14.04
July	4.29	2.85	90.5	61.0	91.8	61.7	102	54	4.4	5.2	13.64	15.58
August	2.66	2.33	89.7	58.5	89.4	60.4	97	51	3.7	4.7	12.23	12.16
September	0.66	1.18	80.3	46.2	81.5	50.6	100	30	3.5	5.0	8.94	9.60
October	0.08	1.49	66.4	30.7	68.9	37.1	91	4	3.3*	4.5*	5.89*	6.09*
November	0.05	0.55	61.8	27.0	54.9	25.7	84	8	---	---	---	---
December	0.39	0.50	46.2	17.4	44.7	17.0	70	-2	---	---	---	---
Annual	14.62	17.90	68.4	36.5	67.1	37.7	102	-2	4.4	5.3	74.19	71.40

Normal latest freeze (32°F) in spring: May 6. In 2020: April 18.

Normal earliest freeze (32°F) in fall: October 7. In 2020: September 9.

Normal frost-free (>32°F) period: 154 days. In 2020: 144 days.

Normal for precipitation and temperature is 30-year average (1981–2010) from National Weather Service.

Normal for latest freeze, earliest freeze, wind, and evaporation is 30-year average (1981–2010) from Tribune weather data.

* Normal for October wind and evaporation is the 10-year average (2001–2010) from Tribune weather data; October not included in annual totals.

Occasional Tillage in a Wheat-Sorghum-Fallow Rotation

A. Schlegel and J. Holman

Summary

Beginning in 2012, research was conducted in Garden City and Tribune, KS, to determine the effect of a single tillage operation every 3 years on grain yields in a wheat-sorghum-fallow (WSF) rotation. Grain yields of wheat and grain sorghum were generally not affected by a single tillage operation every 3 years in a WSF rotation. Grain yield varied greatly by year from 2014 to 2020. Wheat yields ranged across years from mid-20s to 90 bu/a at Tribune and less than 10 to 100 bu/a at Garden City. Grain sorghum yields ranged from 40 to greater than 140 bu/a, depending upon year and location. In 2019 wheat yields at Garden City were less when tillage was implemented post-wheat harvest in 2016. There were no other years or locations where grain yields were significantly affected by a single tillage operation. However, at Tribune, when averaged across the 7-year period, a single tillage after wheat harvest reduced grain sorghum yields compared to a complete no-till (NT) system. At Garden City, averaged across the 7-year period, wheat yields were not different, but tended to be greater following a single one-time tillage prior to wheat. This indicates that if a single tillage operation is needed to control troublesome weeds, that tillage during fallow prior to wheat planting may be better than tillage after wheat harvest. This study supports the hypothesis that if herbicide-resistant weed populations are high enough to cause yield reductions, then tillage might improve yields.

Introduction

Previous research has shown lower dryland wheat and grain sorghum yields with reduced tillage compared with no-tillage in a wheat-sorghum-fallow (WSF) rotation (Schlegel et al., 2018). The reduced tillage systems generally used four or more tillage operations in the 3-yr rotation. With increased incidence of herbicide-resistant weeds, the use of a complete NT system may not be economical and tillage may be needed for effective control. The objective of the research project is to determine the effect of a single tillage operation every 3 years on grain yields in a WSF rotation.

Procedures

Research on occasional tillage intensities in a predominantly no-tillage WSF rotation at the Kansas State University Southwest Research-Extension Center research stations at Garden City and Tribune, KS, was initiated in 2012. The three tillage treatment intensities in this study are a single tillage in May or June during fallow, a single tillage after wheat harvest, and a complete no-tillage system. A sweep plow (Minimizer by Premier Tillage) was used for all tillage operations. When needed, herbicides were used to control weeds during fallow for all treatments. All treatments used herbicides for in-crop weed control. All other cultural practices (variety/hybrid, seeding rate, fertilization, etc.) were the same for all treatments.

Results and Discussion

Weeds were effectively controlled in all treatments, although herbicide-resistant kochia and Johnsongrass at Garden City were difficult to control.

At Tribune, wheat yields were slightly less in 2020 (40 to 45 bu/a) compared with 48 to 50 bu/a for the 7-yr average (Table 1). There were no significant yield differences among tillage treatments in any year or across years. Grain sorghum yields in 2020 (ranging from 94 to 102 bu/a) were about 20 bu/a less compared with the 7-yr average (Table 2). Similar to wheat, there were no significant yield differences among tillage treatments in any year. However, averaged across years, NT produced greater yields than tillage post-wheat harvest.

Precipitation pattern at Garden City tended to mostly occur during the summer period which favored grain sorghum yield and reduced wheat yields. Wheat yields at Garden City were highly variable depending on growing season, ranging from less than 10 bu/a in 2018 to 100 bu/a in 2019. The average wheat yield across years was about 35 bu/a, which would be similar to the long-term county average. Treatment differences varied across years, but there was a tendency for increased yield with a single tillage in fallow compared to no-tillage. There was no treatment difference in grain sorghum yield. Grain sorghum yield ranged from 40 bu/a in 2019 to 121 bu/a in 2016. Over the course of this study, grain sorghum yield averaged about 67 bu/a.

In other research (Schlegel et al. 2018), reduced tillage systems (with four tillage operations) produced lower yields than a complete NT system in a WSF rotation. In this research, there was a tendency for wheat yields at Garden City and grain sorghum yields at Tribune to be less following a single tillage post-wheat compared to no-till or a single tillage prior to wheat. These results suggest that if a single tillage is needed for weed control the best timing may be prior to wheat during the fallow year.

Acknowledgment

This research was supported in part by the Ogallala Aquifer Program, a consortium between U.S. Department of Agriculture Agricultural Research Service, Kansas State University, Texas AgriLife Research, Texas AgriLife Extension Service, Texas Tech University, and West Texas A&M University.

References

Schlegel, A.J., Y. Assefa, L.A. Haag, C.R. Thompson, and L.R. Stone. 2018. Long-term tillage on yield and water use of grain sorghum and winter wheat. *Agron. J.* 110:269-280.

CROPPING AND TILLAGE

Table 1. Grain yield response of dryland wheat to a single tillage operation (sweep plow) in a 3-year wheat-sorghum-fallow rotation grown from 2014 to 2020 near Tribune, KS

Tillage	Year							Average
	2014	2015	2016	2017	2018	2019	2020	
	----- bu/a -----							
No-tillage	28	24	75	30	57	93	45	50
June in fallow	22	22	81	25	58	89	40	48
July post-harvest	23	21	77	27	57	89	42	48
ANOVA (P > F)								
Treatment	0.427	0.599	0.174	0.477	0.857	0.202	0.130	0.097
Year	---	---	---	---	---	---	---	0.001
Year × treatment	---	---	---	---	---	---	---	0.461

ANOVA = analysis of variance.

Table 2. Grain yield response of dryland grain sorghum to a single tillage operation (sweep plow) in a 3-year wheat-sorghum-fallow rotation grown from 2014 to 2020 near Tribune, KS

Tillage	Year							Average
	2014	2015	2016	2017	2018	2019	2020	
	----- bu/a -----							
No-tillage	77	133	129	147	130	132	99	121a*
June in fallow	84	114	129	145	123	129	102	118ab
July post-harvest	86	108	126	141	115	131	94	114b
ANOVA (P > F)								
Treatment	0.573	0.104	0.280	0.567	0.065	0.779	0.259	0.034
Year	---	---	---	---	---	---	---	0.001
Year × treatment	---	---	---	---	---	---	---	0.120

ANOVA = analysis of variance.

* Means within a column with the same letter are not statistically different at $P = 0.05$.

CROPPING AND TILLAGE

Table 3. Grain yield response of dryland wheat to a single tillage operation (sweep plow) in a 3-year wheat-sorghum-fallow rotation grown from 2014 to 2020 near Garden City, KS

Tillage	Year							Average
	2014	2015	2016	2017	2018	2019	2020	
	----- bu/a -----							
No-tillage	8	34	55	20	4	90ab*	27	34
June in fallow	6	35	60	19	3	100a	29	36
July post-harvest	9	30	56	23	7	83b	24	33
ANOVA (P > F)								
Treatment	0.601	0.363	0.369	0.420	0.199	0.029	0.1582	0.1124
Year	---	---	---	---	---	---	---	<0.0001
Year × treatment	---	---	---	---	---	---	---	0.0584

ANOVA = analysis of variance.

* Means within a column with the same letter are not statistically different at $P = 0.05$.

Table 4. Grain yield response of dryland grain sorghum to a single tillage operation (sweep plow) in a 3-year wheat-sorghum-fallow rotation grown from 2014 to 2020 near Garden City, KS

Tillage	Year							Average
	2014	2015	2016	2017	2018	2019	2020	
	----- bu/a -----							
No-tillage	58	63	116	51	98	41	47	68
June in fallow	57	62	121	46	88	41	46	66
July post-harvest	47	73	118	44	93	40	47	66
ANOVA (P>F)								
Treatment	0.110	0.464	0.642	0.579	0.572	0.946	0.9942	0.918
Year	---	---	---	---	---	---	---	<0.0001
Year × treatment	---	---	---	---	---	---	---	0.9946

ANOVA = analysis of variance.

Wheat Stubble Height on Subsequent Corn and Grain Sorghum Crops

A. Schlegel, A. Burnett, and L. Haag

Summary

A field study initiated in 2006 at the Southwest Research-Extension Center near Tribune, KS, was designed to evaluate the effects of three wheat stubble heights on subsequent grain yields of corn and grain sorghum. Corn and sorghum yields in 2020 were near the long-term average despite lower than normal precipitation. When averaged across years from 2007 through 2020, corn grain yields were 8 bu/a greater when planted into either high or strip-cut wheat stubble than into low-cut stubble. Average grain sorghum yields were 5 bu/a greater in high-cut stubble than low-cut stubble. Similarly, water use efficiency was greater for high or strip-cut stubble for corn, and greater for high-cut stubble for grain sorghum than for low-cut stubble. Harvesting wheat stubble shorter than necessary causes a yield penalty for the subsequent corn and grain sorghum crops.

Introduction

Seeding of summer row crops throughout the west-central Great Plains often occurs following wheat in a 3-year rotation (wheat-summer crop-fallow). Wheat residue provides numerous benefits, including evaporation suppression, delayed weed growth, improved capture of winter snowfall, and soil erosion reductions. Stubble height affects wind velocity profile, surface radiation interception, and surface temperatures, all of which affect evaporation suppression and winter snow catch. Taller wheat stubble is also beneficial to pheasants in postharvest and overwinter fallow periods. Using stripper headers increases harvest capacity and provides taller wheat stubble than previously attainable with conventional small-grain platforms. Increasing wheat cutting heights or using a stripper header should further improve the effectiveness of standing wheat stubble. The purpose of this study is to evaluate the effect of wheat stubble height on subsequent summer row crop yields.

Experimental Procedures

This study was conducted at the Southwest Research-Extension Center dryland station near Tribune, KS. From 2007 through 2020, corn and grain sorghum were planted into standing wheat stubble of three heights. Optimal (high) cutter-bar height is the height necessary to maximize both grain harvested and standing stubble remaining (typically around two-thirds of total plant height), the short cut treatment was half of optimal cutter-bar height, and the third treatment was stubble remaining after stripper header harvest. For 2020, these heights were 20, 12, and 29 in. (cut after 2018 wheat harvest) for high, low, and strip-cut stubble, respectively. In 2020, corn and grain sorghum were seeded at rates of 15,000 seeds/a and 45,000 seeds/a, respectively. Nitrogen was applied to all plots at a rate of 100 lb/a. Starter fertilizer (10-34-0 nitrogen-phosphorus-potassium (N-P-K)) was surface-dribbled off-row at a rate of 7 gal/a. Plots were 40 × 60 ft, with treatments arranged in a randomized complete block design with six replications. Two rows from the center of each plot were harvested with a plot combine for yield and

yield component analysis. Soil water measurements were obtained with neutron attenuation to a depth of 6 ft in 1-ft increments at seeding and harvest to determine water use and water use efficiency.

Results and Discussion

The 2020 growing season was below normal in precipitation (14.62 inch in 2020 vs. normal of 17.90 inch) and above normal in open pan evaporation (74.19 in. vs. normal of 71.40 in.). Despite these conditions, near average yields were produced for both corn and sorghum (Tables 1–4). Wheat stubble height had little effect on corn yield or other parameters (Table 1). When averaged across 2007 to 2020, corn yields were 8 bu/a greater in high or strip-cut than low-cut wheat stubble (Table 2). Biomass production and water use efficiency were also greater with the taller stubble.

Grain sorghum yields in 2020 were also not affected by stubble height (Table 3). When averaged across years from 2007 through 2020, sorghum yields were 5 bu/a greater with high-cut stubble compared with low-cut stubble (Table 4). Water use efficiency was also greater for high-cut stubble compared with low-cut stubble. None of the other measured parameters for grain sorghum were affected by wheat stubble height.

CROPPING AND TILLAGE

Table 1. Corn yield, biomass, and yield components as affected by stubble height, Tribune, KS, 2020

Stubble height	Yield	Plant	Ear	Biomass	Residue	1,000-	Kernels	WUE ¹	
		population	population			seed			weight
	bu/a	-----	1000/a	-----	lb/a	-----	oz	no./ear	lb/in.
Low	88	14.7	15.3	10939	6783	8.95	576	357	
High	92	14.5	14.5	12589	8235	9.38	606	370	
Strip	87	14.0	14.9	12963	8848	9.08	578	353	
LSD _{0.05}	11	0.7	1.0	2580	2499	0.78	54	36	
ANOVA (P > F)									
Stubble height	0.561	0.150	0.259	0.227	0.217	0.468	0.425	0.586	

¹Water use efficiency (lb of grain/inch of water use).

LSD = least significant difference. ANOVA = analysis of variance.

Table 2. Average corn yield, biomass, and yield components as affected by stubble height, Tribune, KS, 2007–2020

Stubble height	Yield	Plant	Ear	Biomass	Residue	1,000-	Kernels	WUE ¹	
		population	population			seed			weight
	bu/a	-----	1000/a	-----	lb/a	-----	oz	no./ear	lb/in.
Low	86 b	13.9	14.0	10408 b*	6346 b	10.90 b	531	316 b	
High	94 a	14.0	14.2	11262 a	6802 ab	11.21 a	526	347 a	
Strip	94 a	13.9	14.4	11638 a	7184 a	11.12 ab	548	347 a	
LSD _{0.05}	4	0.4	0.5	546	489	0.23	61	16	
ANOVA (P > F)									
Year	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
Stubble height	0.001	0.981	0.286	0.001	0.004	0.032	0.761	0.001	
Year × stubble height	0.989	0.993	0.981	0.351	0.084	0.910	0.968	0.949	

¹Water use efficiency (lb of grain/inch of water use).

LSD = least significant difference. ANOVA = analysis of variance.

* Means within a column with the same letter are not statistically different at $P = 0.05$.

CROPPING AND TILLAGE

Table 3. Sorghum yield and yield components as affected by stubble height, Tribune, KS, 2020

Stubble height	Yield	Head population	Biomass	Residue	1,000-	Kernels	WUE ¹
					seed weight		
	bu/a	1000/a	----- lb/a -----		oz	no./head	lb/in.
Low	106	69.8	14105	8894	0.82	1677 b*	428
High	111	68.9	14291	8845	0.80	1811 a	453
Strip	107	68.8	13518	8259	0.81	1727 b	435
LSD _{0.05}	7	5.4	2160	2277	0.04	83	23
ANOVA (P > F)							
Stubble height	0.273	0.898	0.716	0.792	0.680	0.015	0.100

¹Water use efficiency (lb of grain/inch of water use).

LSD = least significant difference. ANOVA = analysis of variance.

* Means within a column with the same letter are not statistically different at $P = 0.05$.

Table 4. Average sorghum yield, biomass, and yield components as affected by stubble height, Tribune, KS, 2007–2020

Stubble height	Yield	Head population	Biomass ²	Residue ²	1,000-	Kernels	WUE ¹
					seed weight		
	bu/a	1000/a	----- lb/a -----		oz	no./head	lb/in.
Low	105 b*	57.5	11462	6346	0.89	1882	403 b
High	110 a	59.3	11973	6604	0.89	1939	429 a
Strip	107 ab	58.6	11517	6273	0.88	1876	417 ab
LSD _{0.05}	4	1.9	465	421	0.02	87	16
ANOVA (P > F)							
Year	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Stubble height	0.016	0.160	0.062	0.268	0.169	0.300	0.005
Year × stubble height	0.999	0.936	0.990	0.922	0.751	0.013	0.980

¹Water use efficiency (lb of grain/inch of water use).

²2015 values not included in average - no samples collected.

LSD = least significant difference. ANOVA = analysis of variance.

* Means within a column with the same letter are not statistically different at $P = 0.05$.

Wheat and Grain Sorghum in Four-Year Rotations

A. Schlegel, J. Holman, and A. Burnett

Summary

In 1996, an effort began to quantify soil water storage, crop water use, and crop productivity on dryland systems in western Kansas. Research on 4-year crop rotations with wheat and grain sorghum was initiated at the Southwest Research-Extension Center near Tribune, KS. Rotations were wheat-wheat-sorghum-fallow (WWSF), wheat-sorghum-sorghum-fallow (WSSF), and continuous wheat (WW). Soil water at wheat planting averaged about 9 in. following sorghum, which is about 3 in. more than the average for the second wheat crop in a WWSF rotation. Soil water at sorghum planting was only about 1.5 in. less for the second sorghum crop compared with sorghum following wheat. Grain yields of sorghum in 2020 in all rotations were near the long-term average. For wheat, grain yields in 2020 were similar after fallow following sorghum, but much less after wheat. Grain yield of recrop wheat averaged about 75% of the yield of wheat following sorghum. Grain yield of continuous wheat averaged about 60% of the yield of wheat grown in a 4-year rotation following sorghum. Generally, wheat yields were similar following one or two sorghum crops; however, averaged across years, wheat yields were 2 bu/a greater following two sorghum crops than following one sorghum crop. Average sorghum yields were the same following one or two wheat crops. Yield of the second sorghum crop in a WSSF rotation averages ~65% of the yield of the first sorghum crop.

Introduction

In recent years, cropping intensity has increased in dryland systems in western Kansas. The traditional wheat-fallow system is being replaced by wheat-summer crop-fallow rotations. Research was conducted to better understand if more intensive cropping is feasible with concurrent increases in no-tillage. Objectives of this research were to quantify soil water storage, crop water use, and crop productivity of 4-year and continuous cropping systems.

Experimental Procedures

Research on 4-year crop rotations with wheat and grain sorghum was initiated in 1996 at the Tribune unit of the Southwest Research-Extension Center. Rotations were WWSF, WSSF, and WW. No-tillage was used for all rotations except for the first two years where reduced tillage was used for wheat following sorghum. Available water was measured in the soil profile (0 to 6 ft) at planting and harvest of each crop. The center of each plot was machine harvested after physiological maturity, and yields were adjusted to 12.5% moisture.

Results and Discussion

Soil Water

The amount of available water in the soil profile (0 to 6 ft) at wheat planting varied greatly from year to year (Figure 1). In 2020, available soil water was greater for wheat

following sorghum than following wheat. Soil water was similar for WW and the second wheat crop in WWSF. Water at planting of the second wheat crop in a WWSF rotation was generally less than at planting of the first wheat crop, except in 1997 and 2003. Soil water for the second wheat crop averaged about 3 in. (or approximately 40%) less than that for the first wheat crop in the rotation. Continuous wheat averaged approximately 0.8 in. less water at planting than the second wheat crop in a WWSF rotation.

Similar to wheat, the amount of available water in the soil profile at sorghum planting varied greatly from year to year (Figure 2) and available water at sorghum planting in 2020 was similar to the long-term average. Soil water was similar following one or two wheat crops. Water at planting of the second sorghum crop in a WSSF rotation was generally less than that at planting of the first sorghum crop. Averaged across the entire study period, the first sorghum crop had about 1.5 in. more available water at planting than the second crop.

Grain Yields

In 2020, wheat yields in both rotations following fallow were similar to the long-term average, while recrop or continuous wheat yields were much lower than the long-term average (Table 1). Averaged across 24 years, recrop wheat (the second wheat crop in a WWSF rotation) yielded about 75% of first-year wheat crop in WWSF. Before 2003, recrop wheat yielded about 70% of first-year wheat. Wheat yields following two sorghum crops are 2 bu/a greater than following one sorghum crop. In many years, continuous wheat yields have been similar to recrop wheat yields; however, in several years (2003, 2007, 2009, 2014, and 2018), recrop wheat yields were considerably greater than continuous wheat yields. On average, continuous wheat yields were 6 bu/a less than recrop wheat.

Sorghum yields in 2020 were near the long-term average yields (Table 2). Sorghum yields were similar following one or two wheat crops, which is consistent with the long-term average. The second sorghum crop yields were 67% of the first sorghum crop in 2020, which is similar to the long-term average of about 65%.

CROPPING AND TILLAGE

Table 1. Wheat response to dryland crop rotation, Tribune, KS, 1997–2020

Year	Rotation				ANOVA (P > F)			
	Wssf ¹	Wwsf	wWsf	WW	LSD 0.05	Rotation	Year	Year × rotation
	----- bu/a -----							
1997	57	55	48	43	8	0.017		
1998	70	64	63	60	12	0.391		
1999	74	80	41	43	14	0.001		
2000	46	35	18	18	10	0.001		
2001	22	29	27	34	14	0.335		
2002	0	0	0	0	---	---		
2003	29	27	66	30	14	0.001		
2004	5.7	6.1	0.4	0.5	1.6	0.001		
2005	45	40	41	44	10	0.690		
2006	28	26	7	2	8	0.001		
2007	75	61	63	41	14	0.004		
2008	40	40	5	6	5	0.001		
2009	37	39	50	24	15	0.029		
2010	63	60	29	23	9	0.001		
2011	25	22	25	17	8	0.152		
2012	14	20	10	9	15	0.380		
2013	0	0	0	0	---	---		
2014	51	45	31	12	18	0.004		
2015	49	36	24	24	12	0.001		
2016	78	77	58	52	12	0.001		
2017	20	20	4	6	4	0.001		
2018	52	51	24	24	9	0.001		
2019	88	96	71	63	6	0.001		
2020	38	39	9	11	5	0.001		
Mean	42 a*	40 b	30 c	24 d	2	0.001	0.001	0.001

¹W = wheat. S = sorghum. Capital letters denote current year's crop.

WSSF = Wheat-sorghum-sorghum-fallow. WWsf = wheat-wheat-sorghum-fallow. WW = continuous wheat.

ANOVA = analysis of variance.

LSD = least significant difference.

* Means within a row with the same letter are not statistically different at $P = 0.05$.

CROPPING AND TILLAGE

Table 2. Grain sorghum response to crop rotation, Tribune, KS, 1996–2020

Year	Rotation			LSD 0.05	ANOVA (P>F)		
	wSsf ¹	wsSf	wwSf		Rotation	Year	Year × rotation
	----- bu/a -----						
1996	58	35	54	24	0.117		
1997	88	45	80	13	0.001		
1998	117	100	109	12	0.026		
1999	99	74	90	11	0.004		
2000	63	23	67	16	0.001		
2001	68	66	73	18	0.673		
2002	0	0	0	---	---		
2003	60	41	76	18	0.009		
2004	91	79	82	17	0.295		
2005	81	69	85	20	0.188		
2006	55	13	71	15	0.001		
2007	101	86	101	9	0.008		
2008	50	30	57	12	0.005		
2009	89	44	103	53	0.080		
2010	98	52	105	24	0.004		
2011	119	47	105	34	0.005		
2012	0	0	0	---	---		
2013	105	98	100	23	0.742		
2014	91	5	84	29	0.001		
2015	125	82	124	22	0.005		
2016	134	98	139	10	0.001		
2017	147	119	157	15	0.002		
2018	125	64	137	13	0.001		
2019	134	91	137	15	0.001		
2020	94	64	98	20	0.001		
Mean	88 a*	57 b	89 a	3	0.001	0.001	0.001

¹W = wheat, S = sorghum. Capital letters denote current year's crop.

Wheat-sorghum-sorghum-fallow (WSSF) and wheat-wheat-sorghum-fallow (WWSF).

ANOVA = analysis of variance.

LSD = least significant difference.

* Means within a row with the same letter are not statistically different at $P = 0.05$.

CROPPING AND TILLAGE

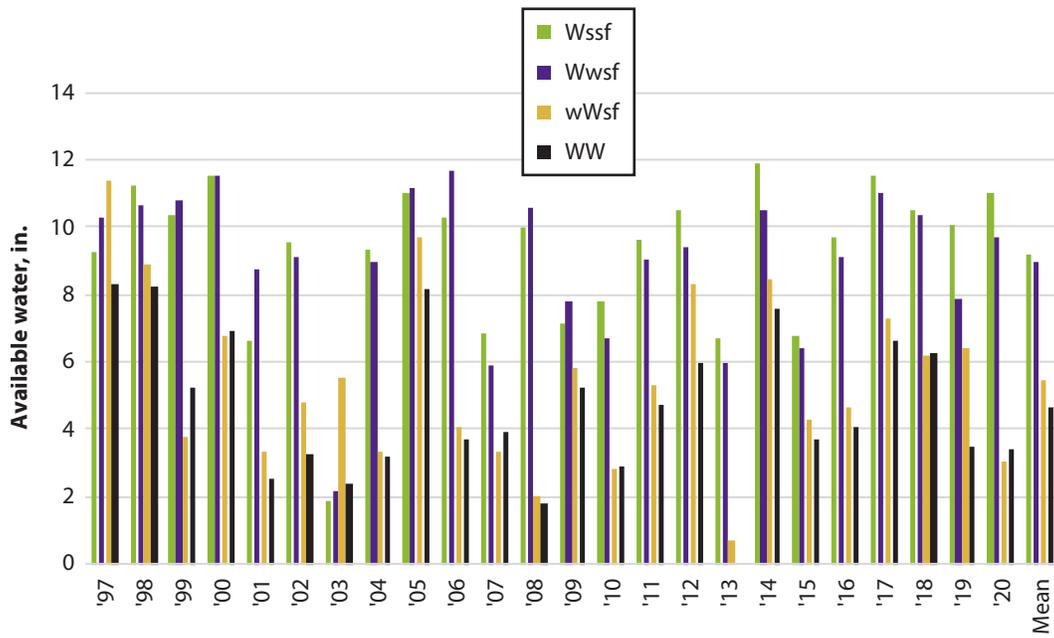


Figure 1. Available soil water in 6-ft profile at planting of wheat in several rotations at Tribune, KS, 1997–2020. Capital letter denotes current crop in rotation (W, wheat; S, sorghum). The last set of bars (Mean) is the average across years. Wheat-sorghum-sorghum-fallow (WSSF), wheat-wheat-sorghum-fallow (WWSF), and continuous wheat (WW).

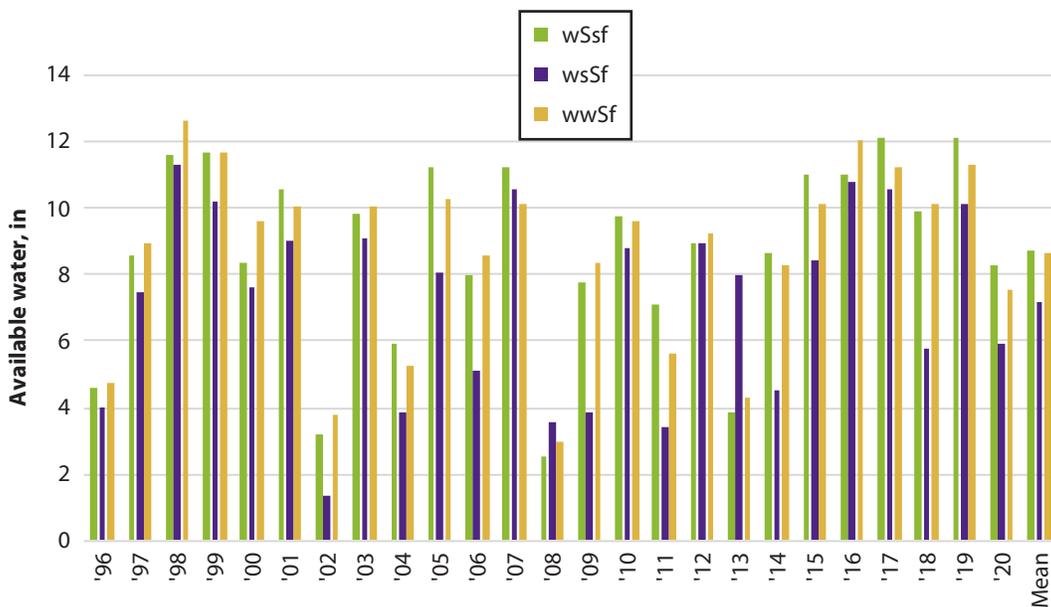


Figure 2. Available soil water in 6-ft profile at planting of sorghum in several rotations at Tribune, KS, 1996–2020. Capital letter denotes current crop in rotation (W, wheat; S, sorghum). The last set of bars (Mean) is the average across years. Wheat-sorghum-sorghum-fallow (WSSF) and wheat-wheat-sorghum-fallow (WWSF).

Large-Scale Dryland Cropping Systems

A. Schlegel, L. Haag, and A. Burnett

Summary

This study was conducted from 2008–2020 at the Kansas State University Southwest Research-Extension Center near Tribune, KS. The purpose of the study was to identify whether more intensive cropping systems can enhance and stabilize production in rainfed cropping systems to optimize economic crop production, more efficiently capture and utilize scarce precipitation, and maintain or enhance soil resources and environmental quality. The crop rotations evaluated were continuous grain sorghum (SS), wheat-fallow (WF), wheat-corn-fallow (WCF), wheat-sorghum-fallow (WSF), wheat-corn-sorghum-fallow (WCSF), and wheat-sorghum-corn-fallow (WSCF). All rotations were grown using no-tillage (NT) practices except for WF, which was grown using reduced-tillage. The efficiency of precipitation capture was not greater with more intensive rotations. Length of rotation had little effect on wheat yields. Corn and grain sorghum yields were approximately 50% greater when following wheat than when following corn or grain sorghum. Grain sorghum yields were approximately 40% greater than corn in similar rotations.

Introduction

The change from conventional tillage to no-tillage cropping systems has allowed for greater intensification of cropping in semi-arid regions. In the central High Plains, wheat-fallow (1 crop in 2 years) has been a popular cropping system for many decades. This system is being replaced by more intensive wheat-summer crop-fallow rotations (2 crops in 3 years). There has also been increased interest in further intensifying the cropping systems by growing 3 crops in 4 years or continuous cropping. This project evaluates several multi-crop rotations that are feasible for the region, along with alternative systems that are more intensive than 2- or 3-year rotations. The objectives were to 1) enhance and stabilize production of rainfed cropping systems using multiple crops and rotations, and using best management practices to optimize capture and utilization of precipitation for economic crop production; and 2) enhance adoption of alternative rainfed cropping systems that provide optimal profitability.

Experimental Procedures

The crop rotations are 2-year (wheat-fallow [WF]); 3-year (wheat-grain sorghum-fallow [WSF] and wheat-corn-fallow [WCF]); 4-year (wheat-corn-sorghum-fallow [WCSF], and wheat-sorghum-corn-fallow [WSCF]); and continuous sorghum [SS]. All rotations are grown using NT practices except for WF, which is grown using reduced-tillage (RT). All phases of each rotation are present each year. Plot size is a minimum of 100 × 450 ft. In most instances, grain yields were determined by harvesting the center 60 ft (by entire length) of each plot with a commercial combine and determining grain weight with a weigh-wagon or combine yield monitor. Soil water was measured in 12-inch increments to 96 inches near planting date and after harvest either gravimetrically (RT WF) or by neutron attenuation (NT plots).

Results and Discussion

Precipitation averaged 101% of normal (17.90 in.) across the 13-year study period and was near normal (+/- 15%) in 8 out of 13 years with three wet years (>20% above normal), one dry year (2020), and one exceptionally dry year (42% of normal in 2012) (Figure 1). Fallow accumulation, fallow efficiency, and profile available water at wheat planting was greater with WF than all other wheat rotations (Table 1). The fallow efficiencies of the 3- and 4-year NT rotations were only about 60–70% of WF under RT. With more water available, crop water use was also greater with WF than with wheat in other rotations. There were no differences in wheat water use among the 3- and 4-year rotations.

Fallow accumulation prior to corn planting and profile available soil water at planting was greater following wheat (WCF or WCSF) than following grain sorghum (WSCF) (Table 1). However, the fallow period following wheat was longer, resulting in low fallow efficiencies (~18%) following wheat and only 22% following sorghum. Similar to wheat, corn water use was greater with greater available soil water at planting. Grain sorghum responded similarly to corn, with greater fallow accumulation and soil water at planting (and greater crop water use) when following wheat than following corn or sorghum. Again, fallow efficiencies prior to grain sorghum were low (16–22%).

Wheat yields were near normal in 2020 with yields in the 24 to 39 bu/a range (Figure 2). The effect of cropping systems was not consistent across years, with WF sometimes in the highest yielding group and sometimes in the lowest yielding group. Averaged across the 13 years, cropping system had little effect (4 bu/a or less) on wheat yields.

Grain sorghum yields were also near normal in 2020 with yields greater when following wheat (Figure 3). Sorghum following corn produced 30 bu/a less yield than following wheat, and continuous sorghum yields were similar to yields following corn. Average grain sorghum yields following wheat were approximately 50% greater than following corn or sorghum.

Similar to grain sorghum, corn yields in 2020 were generally similar to the long-term average (Figure 4). Corn yields following wheat in either the 3- or 4-year rotations were always greater than corn yields following grain sorghum, except in 2015 where corn yields following sorghum (wsCf) were greater than wCf. On average, corn yields following wheat were about 50% greater than following grain sorghum.

When examining grain yields across crops, the greatest yields were produced by grain sorghum following wheat (either wSf or wScf) of ~85 bu/a (Figure 5). These yields were about 40% greater than corn following wheat (wCf or wCsf). Sorghum yields following wheat were about 50% greater than sorghum following corn or sorghum (wCsf or SS), while corn yields following wheat (wCf or wCsf) were also about 50% greater than following sorghum.

Acknowledgments

This research project received support from the U.S. Department of Agriculture, Agricultural Research Service Ogallala Aquifer Program.

CROPPING AND TILLAGE

Table 1. Fallow accumulation, fallow efficiency, profile (8 ft) available soil water at planting, and crop water use by wheat, corn, and grain sorghum in several crop rotations, Tribune, KS, 2008–2020

Crop	Rotation	Fallow accumulation	Fallow efficiency	Profile ASW at planting²	Crop water use
		inch	%	inch	inch
Wheat	W ^F	6.66 a	27 a	9.80 a	18.17 a
	W ^{sf}	3.15 bc	19 b	6.63 c	14.49 b
	W ^{cf}	2.78 c	16 c	6.60 c	14.47 b
	W ^{scf}	3.48 b	19 b	7.22 b	14.95 b
	W ^{csf}	3.28 b	19 b	6.66 c	14.56 b
LSD _{0.05}		0.42	2	0.56	0.48
Corn	wC ^f	2.58 a	18 b	6.10 a	14.00 a
	wC ^{sf}	2.56 a	18 b	6.04 a	13.97 a
	wsC ^f	1.61 b	22 a	5.19 b	13.13 b
LSD _{0.05}		0.31	3	0.50	0.31
Grain sorghum	wS ^f	2.50 b	16 c	6.08 b	13.48 b
	wS ^{cf}	3.03 a	19 b	6.67 a	13.85 a
	wcS ^f	1.48 d	15 c	5.29 c	12.84 c
	SS	2.01 c	22 a	5.44 c	12.90 c
LSD _{0.05}		0.32	3	0.50	0.31

¹Wheat-fallow rotation is reduced-tillage; all other rotations are no-tillage. Means within a column with the same letter for the same crop are not statistically different at $P = 0.05$. The capital letter in the rotation denotes the crop phase of the rotation.

²Available soil water (ASW) in an 8-ft profile at planting.

W = wheat. F = fallow. S = sorghum. C = corn. SS = continuous grain sorghum.

CROPPING AND TILLAGE

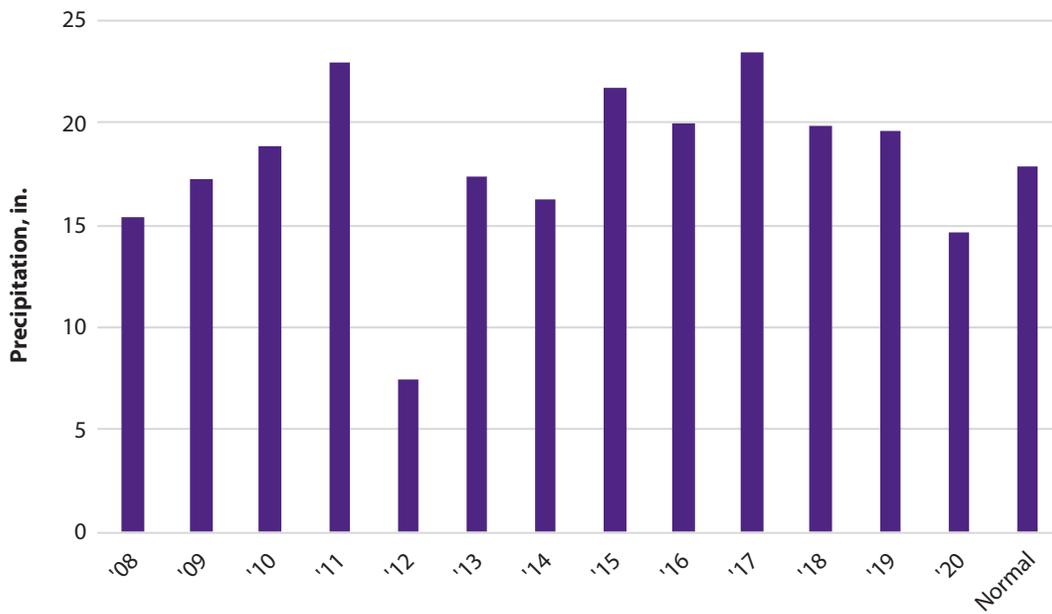


Figure 1. Annual (2008–2020) and normal precipitation (1981–2010, last bar), Tribune, KS.

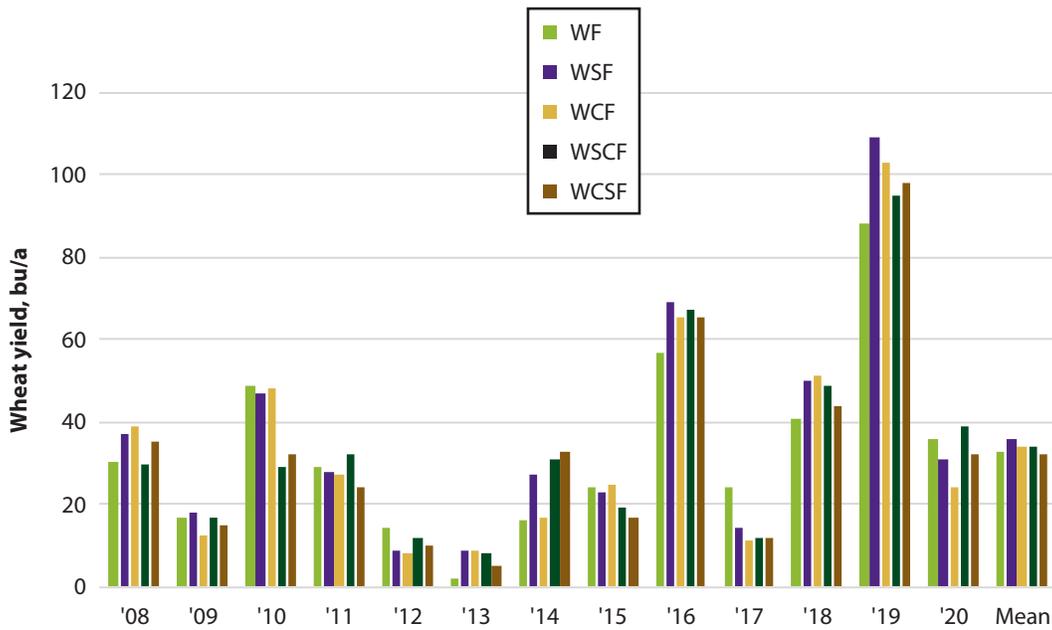


Figure 2. Wheat yields by cropping system, 2008–2020. Last set of columns are treatment means. Wheat-fallow (WF), wheat-sorghum-fallow (WSF), wheat-corn-fallow (WCF), wheat-corn-sorghum-fallow (WCSF), and wheat-sorghum-corn-fallow (WSCF).

CROPPING AND TILLAGE

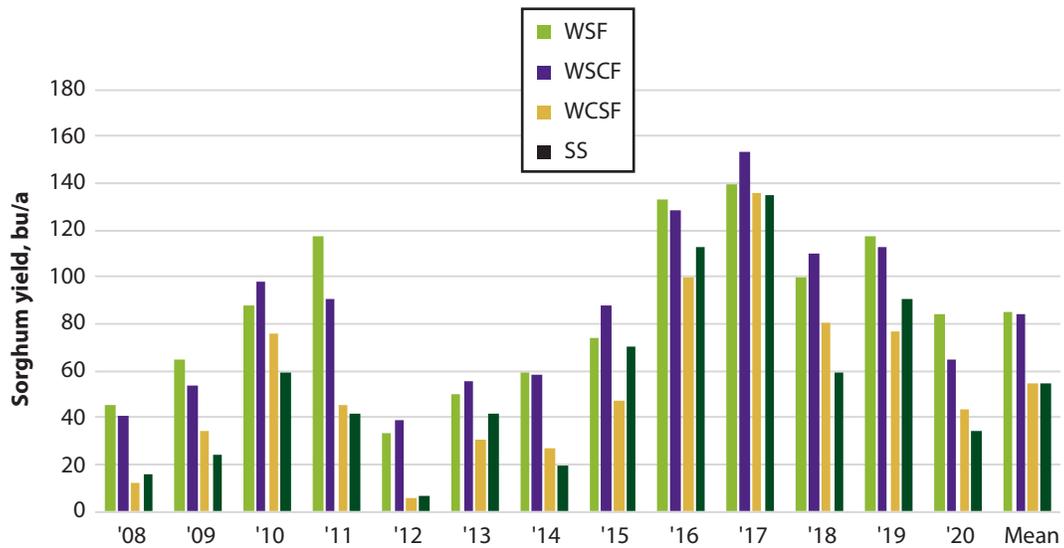


Figure 3. Grain sorghum yields by cropping system, 2008–2020. Last set of columns are treatment means. Wheat-sorghum-fallow (WSF), wheat-sorghum-corn-fallow (WSCF), wheat-corn-sorghum-fallow (WCSF), and continuous grain sorghum (SS).

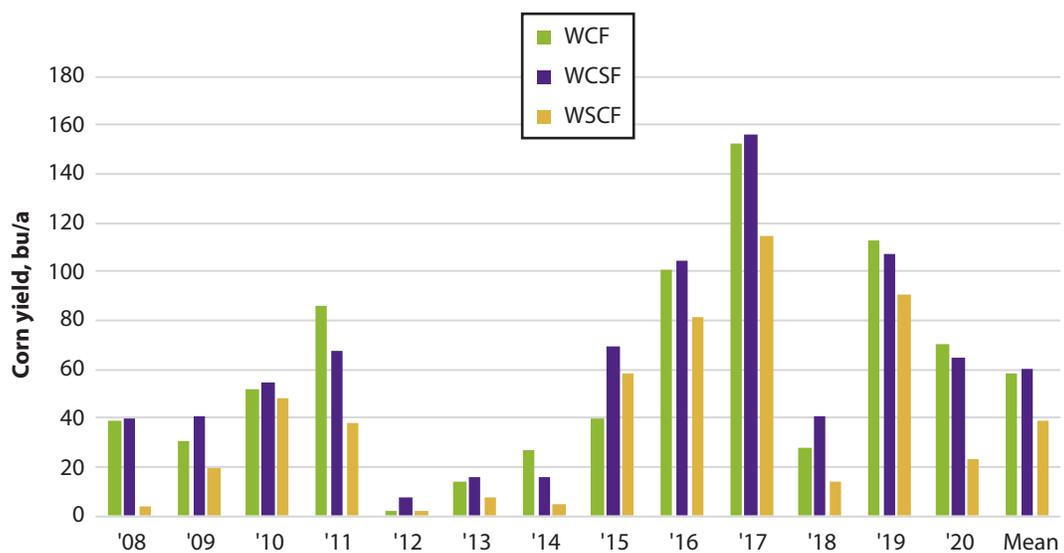


Figure 4. Corn yields by cropping system, 2008–2020. Last set of columns are treatment means. Wheat-corn-fallow (WCF), wheat-corn-sorghum-fallow (WCSF), and wheat-sorghum-corn-fallow (WCSF).

CROPPING AND TILLAGE

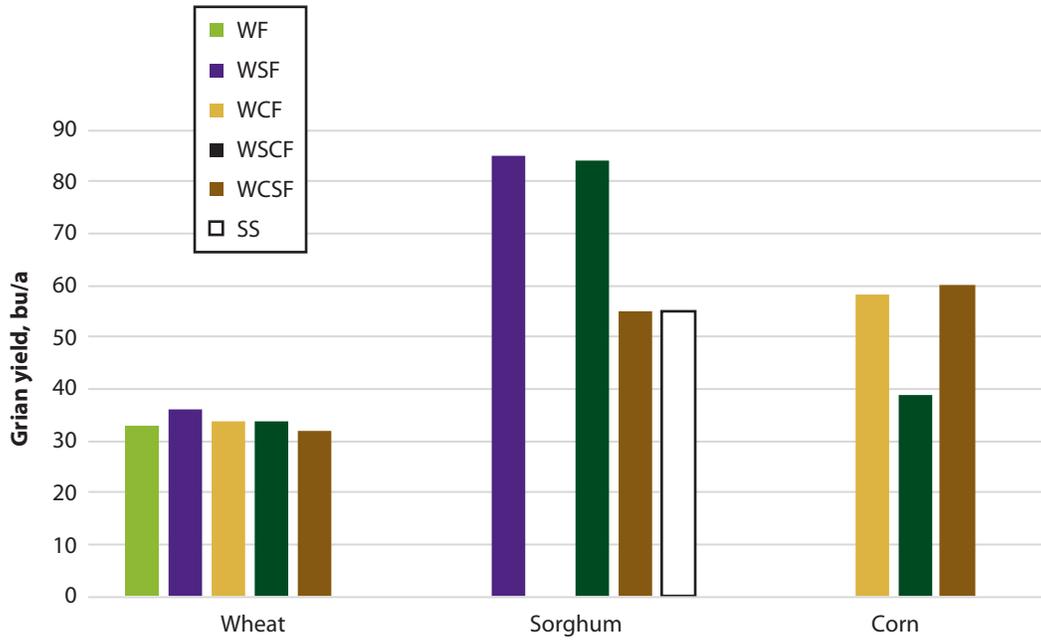


Figure 5. Average grain yields by cropping system, 2008–2020. Wheat-fallow (WF), wheat-sorghum-fallow (WSF), wheat-corn-fallow (WCF), wheat-sorghum-corn-fallow (WSCF), wheat-corn-sorghum-fallow (WCSF), and continuous grain sorghum (SS).

Tillage Intensity in a Long-Term Wheat-Sorghum-Fallow Rotation

A. Schlegel and A. Burnett

Summary

This study was initiated in 1991 at the Kansas State University Southwest Research-Extension Center near Tribune, KS. The purpose of the study was to identify the effects of tillage intensity on precipitation capture, soil water storage, and grain yield in a wheat-sorghum-fallow rotation. Grain yields of wheat and grain sorghum increased with decreased tillage intensity in a wheat-sorghum-fallow (WSF) rotation. In 2020, available soil water at sorghum planting was greater for no-tillage (NT) than reduced tillage (RT), which was greater than conventional tillage (CT). For wheat there was a similar pattern as sorghum, with available soil water at wheat planting being in the order of NT > RT > CT. Averaged across the 20-year study, available soil water at wheat planting was similar for NT and RT and approximately 1 inch greater than CT. Average available soil water at sorghum planting was greater in the order RT = NT > CT. Averaged across the past 20 years, NT wheat yields were 5 bu/a greater than RT and 8 bu/a greater than CT. Averaged across the past 20 years, sorghum yields with long-term NT have been 58% greater than with short-term NT (79 vs. 50 bu/a).

Experimental Procedures

Research on different tillage intensities in a WSF rotation at the Tribune, KS, unit of the Southwest Research-Extension Center was initiated in 1991. The three tillage intensities in this study are conventional, reduced, and no-tillage. The CT system was tilled as needed to control weed growth during the fallow period. On average, this resulted in 4 to 5 tillage operations per year, usually with a blade plow or field cultivator. The RT system originally used a combination of herbicides (1 to 2 spray operations) and tillage (2 to 3 tillage operations) to control weed growth during the fallow period; however, in 2001, the RT system was changed to using NT from wheat harvest through sorghum planting (short-term NT) and CT from sorghum harvest through wheat planting. The NT system exclusively used herbicides to control weed growth during the fallow period. All tillage systems used herbicides for in-crop weed control.

Results and Discussion

Soil Water

The amount of available water in the soil profile (0–8 ft) at wheat planting varied greatly from year to year (Figure 1). In 2020, available soil water at wheat planting was greater with NT than RT and least with CT. Averaged across the 20-year study, available soil water at wheat planting was similar for RT and NT (~ 8 inches) and approximately 1 inch greater than CT. Similar to wheat, the amount of available water in the soil profile at sorghum planting varied greatly from year to year (Figure 2). In 2020, available soil water at sorghum planting was greater with NT than RT and least with CT. On average, available soil water at sorghum planting was similar for NT and RT and about 1.5 inches greater than CT.

Grain Yields

Wheat yields in 2020 were near the long-term average (Table 1). Since 2001, wheat yields have been depressed in 11 of 20 years, primarily because of lack of precipitation, winterkill (2015), and disease (2017). Reduced tillage and NT increased wheat yields. On average, wheat yields were 8 bu/a higher for NT (30 bu/a) than CT (22 bu/a). Wheat yields for RT were 3 bu/a greater than CT even though both systems had tillage prior to wheat. Yields of NT were significantly less than CT or RT in only 1 of the 20 years.

Grain sorghum yields in 2020 were near the long-term average (Table 2). Sorghum yields were 70% greater with NT than RT (90 vs. 53 bu/a) while CT yields were the least (17 bu/a). The yield benefit from reducing tillage is greater for grain sorghum than wheat. Grain sorghum yields for RT averaged 21 bu/a more than CT, whereas NT averaged 29 bu/a more than RT. For sorghum, both RT and NT used herbicides for weed control during fallow, so the difference in yield could be attributed to short-term compared with long-term NT. This yield benefit with long-term vs. short-term NT has been observed in most years since the RT system was changed in 2001. Averaged across the past 20 years, sorghum yields with long-term NT have been 58% greater than with short-term NT (79 vs. 50 bu/a).

Acknowledgment

The U.S. Department of Agriculture, Agricultural Research Service Ogallala Aquifer Program partially supported this research project.

CROPPING AND TILLAGE

Table 1. Wheat response to tillage in a wheat-sorghum-fallow rotation, Tribune, KS, 2001–2020

Year	Tillage			LSD (0.05)	ANOVA ($P > F$)		
	Conventional	Reduced	No-tillage		Tillage	Year	Tillage × year
	----- bu/a -----						
2001	17	40	31	8	0.002		
2002	0	0	0	---	---		
2003	22	15	30	7	0.007		
2004	1	2	4	2	0.001		
2005	32	32	39	12	0.360		
2006	0	2	16	6	0.001		
2007	26	36	51	15	0.017		
2008	21	19	9	14	0.142		
2009	8	10	22	9	0.018		
2010	29	35	50	8	0.002		
2011	22	20	20	7	0.649		
2012	0	1	5	1	0.001		
2013	0	0	0	---	---		
2014	10	11	18	12	0.336		
2015	10	9	9	9	0.966		
2016	72	85	82	18	0.239		
2017	13	12	12	9	0.970		
2018	46	48	64	4	0.001		
2019	78	98	109	14	0.004		
2020	29	31	33	9	0.565		
Mean	22 c*	25 b	30 a	2	0.001	0.001	0.001

ANOVA = analysis of variance.

LSD = least significant difference.

* Means within a row with the same letter are not statistically different at $P = 0.05$.

CROPPING AND TILLAGE

Table 2. Grain sorghum response to tillage in a wheat-sorghum-fallow rotation, Tribune, KS, 2001–2020

Year	Tillage			LSD (0.05)	ANOVA ($P > F$)		
	Conventional	Reduced	No-tillage		Tillage	Year	Tillage × year
	----- bu/a -----						
2001	6	43	64	7	0.001		
2002	0	0	0	---	---		
2003	7	7	37	8	0.001		
2004	44	67	118	14	0.001		
2005	28	38	61	35	0.130		
2006	4	3	29	10	0.001		
2007	26	43	62	42	0.196		
2008	16	25	40	20	0.071		
2009	19	5	72	31	0.004		
2010	10	26	84	9	0.001		
2011	37	78	113	10	0.001		
2012	0	0	0	---	---		
2013	37	51	78	32	0.053		
2014	38	72	94	28	0.008		
2015	56	60	102	55	0.153		
2016	55	124	139	47	0.010		
2017	121	163	159	33	0.038		
2018	35	57	116	33	0.003		
2019	23	85	127	7	0.001		
2020	17	53	90	19	0.001		
Mean	29 c*	50 b	79 a	5	0.001	0.001	0.001

ANOVA = analysis of variance.

LSD = least significant difference.

* Means within a row with the same letter are not statistically different at $P = 0.05$.

CROPPING AND TILLAGE

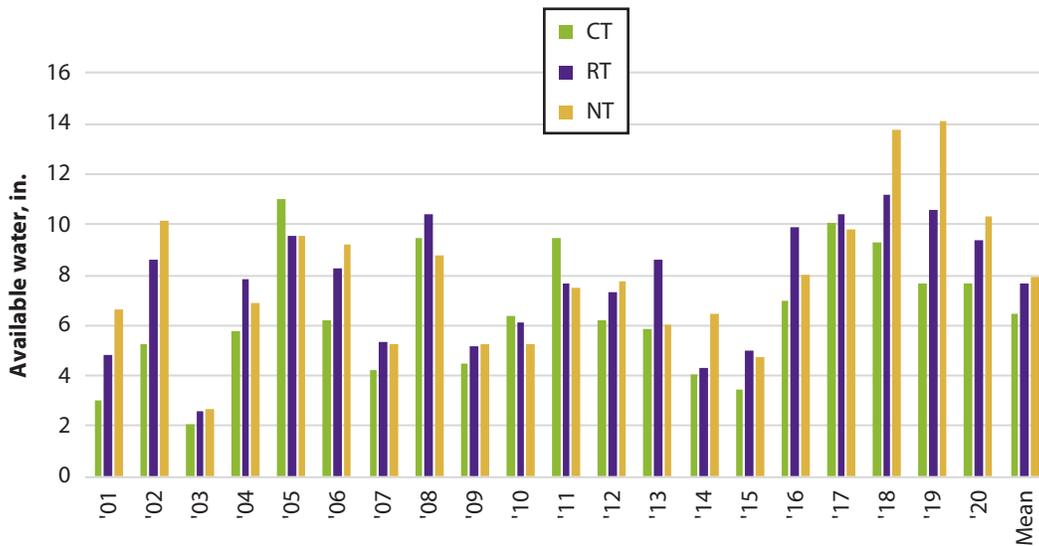


Figure 1. Available soil water in the 8-ft profile at planting of wheat in a wheat-sorghum-fallow rotation as affected by tillage intensity, Tribune, KS, 2001–2020. The last set of bars (Mean) is the average across years. CT = conventional tillage, RT = reduced tillage, NT = no-tillage.

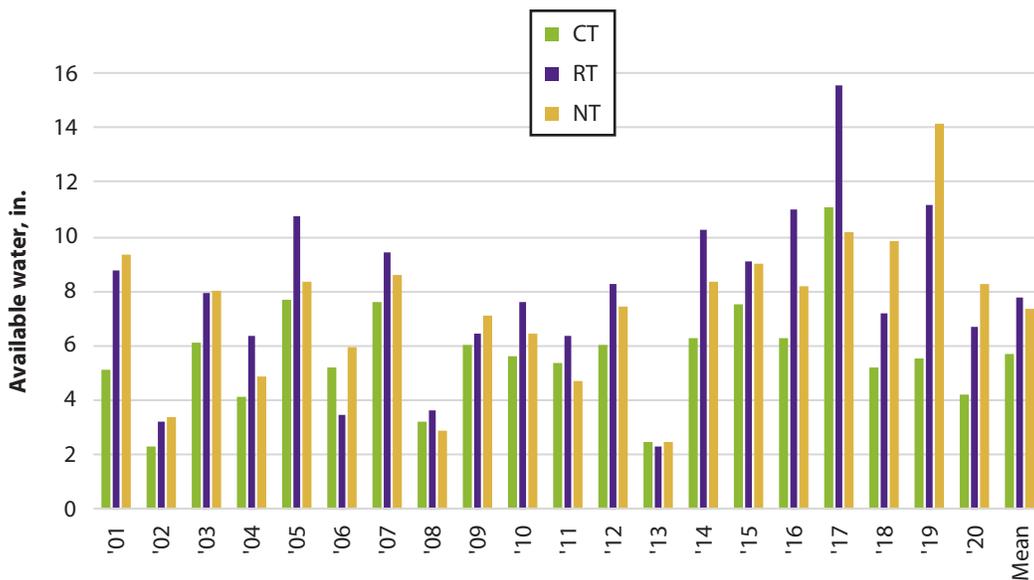


Figure 2. Available soil water in the 8-ft profile at planting of grain sorghum in a wheat-sorghum-fallow rotation as affected by tillage intensity, Tribune, KS, 2001–2020. The last set of bars (Mean) is the average across years. CT = conventional tillage, RT = reduced tillage, NT = no-tillage.

Irrigated Grain Sorghum Response to Long-Term Nitrogen, Phosphorus, and Potassium Fertilization

A. Schlegel and D. Bond

Summary

Long-term research shows that phosphorus (P) and nitrogen (N) fertilizer must be applied to optimize production of irrigated grain sorghum in western Kansas. In 2020, N applied alone increased yields 60 bu/a, whereas N and P applied together increased yields up to 83 bu/a. Averaged across the past 10 years, N and P fertilization increased sorghum yields up to 82 bu/a. The application of 160 lb/a N (with P) produced the maximum yield in 2020, which is slightly less than the 10-year average (2011–2020). The application of potassium (K) has had no effect on sorghum yield throughout the study period. The 10-year average grain N content reached a maximum of ~0.7 lb/bu while grain P content reached a maximum of 0.15 lb/bu (0.34 lb P₂O₅/bu) and grain K content reached a maximum of 0.19 lb/bu (0.23 lb K₂O/bu). At the highest N, P, and K rate, apparent fertilizer recovery in the grain was 33% for N, 69% for P, and 40% for K. Nitrogen fertilization increased soil organic matter and decreased soil pH. Phosphorus fertilization tended to maintain or increase soil test P levels.

Introduction

This study was initiated in 1961 to determine responses of continuous grain sorghum grown under flood irrigation to N, P, and K fertilization. The study is conducted on a Ulysses silt loam soil with an inherently high K content. The irrigation system was changed from flood to sprinkler in 2001.

Procedures

This field study is conducted at the Tribune Unit of the Kansas State University Southwest Research-Extension Center. Fertilizer treatments initiated in 1961 are N rates of 0, 40, 80, 120, 160, and 200 lb/a N without P and K; with 40 lb/a P₂O₅ and zero K; and with 40 lb/a P₂O₅ and 40 lb/a K₂O. All fertilizers are broadcast by hand in the spring and incorporated before planting. The soil is a Ulysses silt loam. Grain sorghum (Pioneer 85G46, 2011; Pioneer 84G62, 2012–2014; Pioneer 86G32, 2015; Pioneer 84G62, 2016–2017; Pioneer 85P44, 2018–2019; and Pioneer 86P33, 2020) was planted in late May or early June. Hail damaged the 2015, 2017, 2019, and 2020 crops. Irrigation is used to minimize water stress. Sprinkler irrigation has been used since 2001. The center two rows of each plot are machine harvested after physiological maturity. Grain yields are adjusted to 12.5% moisture. Grain samples were collected at harvest, dried, ground and analyzed for N, P, and K concentrations. Grain N, P, and K content (lb/bu) and removal (lb/a) were calculated. Apparent fertilizer N recovery in the grain (AFNR_g) was calculated as N uptake in treatments receiving N fertilizer minus N uptake in the unfertilized control divided by N rate. The same approach was used to calculate apparent fertilizer P recovery in the grain (AFPR_g) and apparent fertilizer K recovery (AFKR_g). After harvest in 2020, all plots were soil sampled (8 probes/plot) to a depth of 6 inches, dried, and ground. Servi-Tech Laboratories analyzed the

samples for soil pH, organic matter (OM), P (Bray-1 and Mehlich-3), K, zinc (Zn), manganese (Mn), and iron (Fe).

Results

Grain sorghum yields in 2020 were 5% lower than the 10-year average (Table 1). Nitrogen alone increased yields 60 bu/a, while P alone increased yields 9 bu/a. However, N and P applied together increased yields up to 83 bu/a. Averaged across the past 10 years, N and P applied together increased yields up to 82 bu/a. In 2020, 40 lb/a N (with P) produced about 75% of maximum yield, which is less than the 10-year average of 82%. The 10-year average for 80 lb/a N (with P) and 120 lb/a N (with P) was 93 and 94% of maximum yield, respectively. Sorghum yields were not affected by K fertilization, which has been the case throughout the study period.

The 10-year average grain N concentration (%) increased with N rates but tended to decrease when P was also applied, presumably because of higher grain yields diluting N content (Table 2). Grain N content reached a maximum of ~0.7 lb/bu. Maximum N removal (lb/a) was obtained with 160 lb N/a or greater with P. Similar to N, average P concentration increased with P application but decreased with higher N rates. Grain P content (lb/bu) of ~0.15 lb P/bu (0.34 lb P₂O₅/bu) was similar for all N rates when P was applied. Grain P removal was similar for all N rates of 40 lb/a or greater with P removal ranging from 19 to 23 lb/a. Average K concentration (%) and content (lb/bu) tended to decrease with increased N rates. Similar to P, K removal was similar for all N rates of 40 lb/a or greater plus K ranging from 23 to 27 lb/a. At the highest N, P, and K rate, apparent fertilizer recovery in the grain was 33% for N, 69% for P, and 40% for K.

After 60 years, pH of the surface soil was decreased up to 1 unit by N fertilization (Table 3). Nitrogen fertilization increased soil OM, Mn, and Fe concentrations while decreasing P, K, and Zn concentrations. Phosphorus fertilization increased P (both Bray-1 and Mehlich-3) and Zn concentrations with little effect on other soil properties. The original soil test P level (in 1961) was about 17 ppm (Bray-1), so annual applications of 40 lb/a P₂O₅ tended to maintain or increase soil test P levels. Potassium fertilization only affected the K content of the soil.

Acknowledgment

The former International Plant Nutrition Institute and Servi-Tech Laboratories partially supported this research project.

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SOIL FERTILITY

Table 1. Nitrogen (N), phosphorus (P), and potassium (K) fertilizers on irrigated grain sorghum yields, Tribune, KS, 2011–2020

Fertilizer			Grain yield										
N	P ₂ O ₅	K ₂ O	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Mean
----- lb/a -----			----- bu/a -----										
0	0	0	75	78	62	90	89	80	70	77	68	71	76
0	40	0	83	90	77	94	102	91	79	87	74	80	86
0	40	40	88	93	72	96	97	91	80	83	67	75	84
40	0	0	106	115	94	115	122	106	87	93	94	93	103
40	40	0	121	140	114	144	160	142	120	126	113	115	130
40	40	40	125	132	110	142	155	137	118	131	114	124	129
80	0	0	117	132	102	120	133	120	104	103	109	101	114
80	40	0	140	163	136	151	173	154	123	144	145	142	147
80	40	40	138	161	133	164	178	160	129	140	139	147	149
120	0	0	116	130	100	116	127	108	93	91	102	97	108
120	40	0	145	172	137	162	177	164	121	128	139	141	149
120	40	40	147	175	142	170	178	170	131	143	150	147	155
160	0	0	124	149	117	139	150	135	120	107	129	125	130
160	40	0	152	178	146	171	181	173	137	134	153	154	158
160	40	40	151	174	143	176	179	161	131	139	142	142	154
200	0	0	128	147	119	139	155	151	123	121	134	131	135
200	40	0	141	171	136	165	177	167	131	134	140	147	151
200	40	40	152	175	138	170	179	170	131	130	149	151	154

continued

SOIL FERTILITY

Table 1. Nitrogen (N), phosphorus (P), and potassium (K) fertilizers on irrigated grain sorghum yields, Tribune, KS, 2011–2020

Fertilizer			Grain yield										
N	P ₂ O ₅	K ₂ O	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Mean
----- lb/a -----			----- bu/a -----										
ANOVA (P>F)													
Nitrogen			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
P-K			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Zero P vs. P			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
P vs. P-K			0.278	0.826	0.644	0.117	0.806	0.943	0.727	0.549	0.789	0.731	0.700
N × P-K			0.542	0.186	0.079	0.012	0.002	0.001	0.084	0.003	0.001	0.001	0.001
MEANS													
Nitrogen, lb/a													
0			82 d	87 d	70 d	94 e	96 d	87 d	76 d	82 c	70 d	75 d	82 d
40			117 c	129 c	106 c	134 d	146 c	129 c	108 c	117 b	107 c	111 c	120 c
80			132 b	152 b	124 b	145 c	161 b	145 b	119 b	129 a	131 b	130 b	137 b
120			136 ab	159 ab	126 b	149 bc	161 b	147 b	115 bc	121 ab	130 b	128 b	137 b
160			142 a	167 a	135 a	162 a	170 a	156 a	129 a	127 a	142 a	140 a	147 a
200			141 a	165 a	131 ab	158 ab	170 a	163 a	129 a	128 a	141 a	143 a	147 a
LSD _(0.05)			8	9	8	9	8	8	9	9	7	8	6
P ₂ O ₅ -K ₂ O, lb/a													
0 - 0			111 b	125 b	99 b	120 b	129 b	117 b	99 b	99 b	106 b	103 b	111 b
40 - 0			130 a	152 a	124 a	148 a	162 a	149 a	119 a	126 a	127 a	130 a	137 a
40 - 40			133 a	152 a	123 a	153 a	161 a	148 a	120 a	128 a	127 a	131 a	138 a
LSD _(0.05)			6	6	5	6	5	6	6	6	5	6	5

Different letters in the same column indicate significant differences ($P < 0.05$).

Hail events occurred on 8/18/2017, 9/20/2019, and 8/10/2020.

SOIL FERTILITY

Table 2. Nitrogen (N), phosphorus (P), and potassium (K) fertilizers on grain nutrient content and removal by irrigated grain sorghum, Tribune, KS, 2011–2020

Fertilizer			Grain						Grain removal			Grain		
N	P ₂ O ₅	K ₂ O	N	P	K	N	P	K	N	P	K	*AFNR _g	*AFPR _g	*AFKR _g
-----lb/a-----			-----%-----			-----lb/bu-----			-----lb/a-----			-----%-----		
0	0	0	1.00	0.244	0.354	0.49	0.119	0.174	38	9	13	---	---	---
0	40	0	1.00	0.311	0.382	0.49	0.152	0.187	42	13	16	---	23	---
0	40	40	1.00	0.310	0.382	0.49	0.152	0.187	41	13	16	---	21	8
40	0	0	1.13	0.217	0.340	0.55	0.106	0.167	56	11	17	47	---	---
40	40	0	1.10	0.314	0.366	0.54	0.154	0.179	70	20	23	80	63	---
40	40	40	1.09	0.308	0.364	0.53	0.151	0.178	69	19	23	78	60	30
80	0	0	1.35	0.202	0.337	0.66	0.099	0.165	75	12	19	46	---	---
80	40	0	1.20	0.288	0.351	0.59	0.141	0.172	86	21	25	61	67	---
80	40	40	1.17	0.300	0.354	0.58	0.147	0.173	86	22	26	60	74	38
120	0	0	1.40	0.186	0.334	0.69	0.091	0.164	74	10	18	30	---	---
120	40	0	1.29	0.272	0.349	0.63	0.133	0.171	94	20	25	47	62	---
120	40	40	1.31	0.295	0.351	0.64	0.144	0.172	100	22	27	52	77	41
160	0	0	1.39	0.216	0.342	0.68	0.106	0.167	88	14	22	32	---	---
160	40	0	1.39	0.297	0.354	0.68	0.146	0.173	107	23	27	43	80	---
160	40	40	1.34	0.267	0.346	0.66	0.131	0.170	101	20	26	40	64	39
200	0	0	1.40	0.222	0.345	0.69	0.109	0.169	92	15	23	27	---	---
200	40	0	1.38	0.274	0.353	0.68	0.134	0.173	102	20	26	32	65	---
200	40	40	1.38	0.278	0.351	0.67	0.136	0.172	104	21	26	33	69	40

continued

SOIL FERTILITY

Table 2. Nitrogen (N), phosphorus (P), and potassium (K) fertilizers on grain nutrient content and removal by irrigated grain sorghum, Tribune, KS, 2011–2020

Fertilizer			Grain			Grain removal			Grain					
N	P ₂ O ₅	K ₂ O	N	P	K	N	P	K	N	P	K	*AFNR _g	*AFPR _g	*AFKR _g
-----lb/a-----			-----%-----			-----lb/bu-----			-----lb/a-----			-----%-----		
ANOVA (P>F)														
Nitrogen			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic			0.001	0.004	0.001	0.001	0.004	0.001	0.001	0.001	0.001	0.053	0.001	0.001
P-K			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.774	---
Zero P vs. P			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	---	---	---
P vs. P-K			0.412	0.958	0.597	0.412	0.958	0.597	0.934	0.812	0.865	---	---	---
N × P-K			0.010	0.009	0.019	0.010	0.009	0.019	0.104	0.001	0.001	0.048	0.028	---
MEANS														
Nitrogen, lb/a														
0			1.00 e	0.288 a	0.373 a	0.49 e	0.141 a	0.183 a	40 e	12 d	15 d	---	22 c	8 c
40			1.10 d	0.280 a	0.357 b	0.54 d	0.137 a	0.175 b	65 d	17 c	21 c	68 a	61 b	30 b
80			1.24 c	0.263 b	0.347 c	0.61 c	0.129 b	0.170 c	82 c	18 abc	23 b	56 b	71 a	38 a
120			1.34 b	0.251 b	0.345 c	0.65 b	0.123 b	0.169 c	89 b	17 bc	23 b	43 c	69 ab	41 a
160			1.37 ab	0.260 b	0.347 c	0.67 ab	0.127 b	0.170 c	99 a	19 a	25 a	38 c	72 a	39 a
200			1.39 a	0.258 b	0.350 c	0.68 a	0.126 b	0.171 c	99 a	19 ab	25 a	31 d	67 ab	40 a
LSD _(0.05)			0.04	0.014	0.006	0.02	0.007	0.003	5	2	1	7	9	5
P ₂ O ₅ -K ₂ O, lb/a														
0 - 0			1.28 a	0.215 b	0.342 b	0.63 a	0.105 b	0.168 b	71 b	12 b	18 b	37 b	---	---
40 - 0			1.23 b	0.293 a	0.359 a	0.60 b	0.143 a	0.176 a	84 a	20 a	24 a	53 a	60	---
40 - 40			1.22 b	0.293 a	0.358 a	0.60 b	0.144 a	0.175 a	83 a	20 a	24 a	52 a	61	---
LSD _(0.05)			0.03	0.010	0.004	0.01	0.005	0.002	4	1	1	5	5	---

*AFNR_g, AFPR_g, and AFKR_g = Apparent Fertilizer N Recovery (grain), Apparent Fertilizer P Recovery (grain), and Apparent Fertilizer K Recovery (grain). Different letters in the same column indicate significant differences ($P < 0.05$).

SOIL FERTILITY

Table 3. Effect of 60 years of nitrogen (N), phosphorus (P), and potassium (K) fertilizers to irrigated grain sorghum on soil properties (0–6 inch), Tribune, KS, 2020

N	P ₂ O ₅	K ₂ O	pH	OM	Mehlich		K	Zn	Mn	Fe
					Bray 1 P	3P				
----- lb/acre -----				%	----- ppm -----					
0	0	0	7.8	1.9	5	9	600	0.62	5.8	5
0	40	0	7.7	2.0	44	59	607	0.80	6.2	7
0	40	40	7.7	2.0	35	51	687	0.74	6.2	6
40	0	0	7.7	2.0	5	11	580	0.52	6.2	6
40	40	0	7.7	2.3	36	47	620	0.74	7.4	8
40	40	40	7.6	2.2	35	42	688	0.70	7.4	9
80	0	0	7.4	2.2	5	9	588	0.50	8.4	7
80	40	0	7.5	2.3	24	31	568	0.62	8.0	9
80	40	40	7.5	2.3	28	34	684	0.68	8.2	8
120	0	0	7.3	2.1	4	8	579	0.48	8.0	7
120	40	0	7.5	2.2	13	21	580	0.62	7.2	6
120	40	40	7.5	2.3	28	34	653	0.66	8.4	8
160	0	0	6.7	2.2	8	15	546	0.52	11.2	10
160	40	0	7.1	2.3	26	31	525	0.66	10.8	10
160	40	40	7.2	2.2	14	20	622	0.52	9.8	8
200	0	0	6.6	2.3	11	14	543	0.56	16.6	14
200	40	0	6.9	2.2	26	32	545	0.58	12.2	12
200	40	40	6.8	2.4	31	34	616	0.66	13.2	12

continued

SOIL FERTILITY

Table 3. Effect of 60 years of nitrogen (N), phosphorus (P), and potassium (K) fertilizers to irrigated grain sorghum on soil properties (0–6 inch), Tribune, KS, 2020

N	P ₂ O ₅	K ₂ O	pH	OM	Mehlich					
					Bray 1 P	3P	K	Zn	Mn	Fe
----- lb/acre -----				%	----- ppm -----					
ANOVA (P>F)										
Nitrogen			0.001	0.001	0.008	0.001	0.001	0.001	0.001	0.001
Linear			0.001	0.001	0.016	0.001	0.001	0.001	0.001	0.001
Quadratic			0.013	0.037	0.004	0.001	0.419	0.001	0.006	0.019
P-K			0.120	0.002	0.001	0.001	0.001	0.001	0.569	0.742
Zero P vs. P			0.043	0.001	0.001	0.001	0.001	0.001	0.314	0.442
P vs. P-K			0.740	0.307	0.914	0.714	0.001	0.557	0.741	0.963
N × P-K			0.556	0.202	0.030	0.001	0.721	0.002	0.626	0.537
MEANS										
Nitrogen										
0 lb/a			7.8 a	2.0 c	28 a	40 a	631 a	0.72 a	6.1 d	6 c
40			7.7 ab	2.2 b	25 ab	33 ab	629 ab	0.65 b	7.0 cd	8 bc
80			7.5 b	2.3 ab	19 bc	24 c	614 ab	0.60 c	8.2 c	8 bc
120			7.5 b	2.2 b	15 c	21 c	604 b	0.59 c	7.9 cd	7 c
160			7.0 c	2.2 ab	16 c	22 c	564 c	0.57 c	10.6 b	9 b
200			6.7 d	2.3 a	23 abc	27 bc	568 c	0.60 c	14.0 a	13 a
LSD _{0.05}			0.2	0.1	8	7	26	0.05	2.0	2
P ₂ O ₅ -K ₂ O										
0 lb/a			7.3	2.1 b	6 b	11 b	573 b	0.53 b	9.4	8
40 - 0			7.4	2.2 a	28 a	37 a	574 b	0.67 a	8.6	9
40 - 40			7.4	2.2 a	29 a	36 a	658 a	0.66 a	8.9	9
LSD _{0.05}			0.2	0.1	5	5	18	0.03	1.4	1

Zn = zinc. Mn = manganese. Fe = iron.

Different letters in the same column indicate significant differences ($P < 0.05$).

Zest Application Timings for Efficacy in Grain Sorghum

R.S. Currie and P.W. Geier

Summary

This study was conducted to compare Zest (nicosulfuron) herbicide at two rates and two application timings for efficacy in grain sorghum. Palmer amaranth control was best when a preemergence (PRE) herbicide was followed by a late postemergence (LPOST) treatment. Zest at 0.67 or 1.33 oz/a provided the best velvetleaf and shattercane control. Either rate of Zest applied early postemergence (EPOST) controlled green foxtail more than 90%, but the higher rate was required for greater than 90% control when applications were delayed until LPOST.

Introduction

Zest (nicosulfuron) is an acetolactase synthase-inhibiting (ALS) herbicide used in corn to control grasses and small seeded broadleaf weeds. Grain sorghum would normally be severely injured by Zest, but ALS-tolerant grain sorghum has been under development for several years. The potential to use Zest postemergence in grain sorghum would allow growers another option for controlling troublesome weeds such as shattercane, Johnsongrass, and foxtail species. The objective of this study was to compare Zest at two rates and two application timings for weed control in ALS-tolerant grain sorghum.

Materials and Methods

An experiment was conducted at the Kansas State University Southwest Research-Extension Center near Garden City, KS, to compare Zest at two rates and two application timings for efficacy in acetolactase synthase-tolerant grain sorghum. All herbicides (Table 2) were applied using a tractor-mounted, compressed CO₂ sprayer delivering 19.4 gpa at 30 psi and 4.1 mph. Application, environmental, and weed information are shown in Table 1. Plots were 10 by 35 feet and arranged in a randomized complete block design with four replications. Soil was a Ulysses silt loam with 3.4% organic matter and pH of 7.9. Visual weed control was determined on July 6, 2020, which was 10 days after the early postemergence treatments (10 DAB); and again on August 4, 2020, which was 28 days after the late postemergence treatments (28 DAC).

Results and Discussion

Common sunflower control was similar among all herbicides tested, and was 90% or more regardless of rating date (data not shown). Late-season Palmer amaranth control was best when Cinch ATZ (*S*-metolachlor/atrazine) was applied PRE and followed by Zest plus atrazine LPOST, but did not exceed 75% (Table 2). The poor Palmer amaranth control with the postemergence treatments was the result of the weed biotype being resistant to ALS (Zest) and triazine (atrazine) herbicides. Zest plus atrazine applied EPOST or LPOST controlled velvetleaf 88 to 93% regardless of rate at 28 DAC. Green foxtail control at 10 DAB was best when Cinch ATZ PRE was applied alone or followed by Zest at 1.33 oz/a plus atrazine EPOST. Either rate of Zest applied EPOST and Zest at 1.33 oz/a applied LPOST were the only treatments to control

green foxtail more than 90% at 28 DAC. Cinch ATZ applied PRE controlled shattercane the best at 10 DAB. However, Zest at both rates and application timings provided complete shattercane control later in the season.

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Table 1. Application, environmental, and weed data for the Zest in sorghum trial

Application timing	Preemergence	Early postemergence	Late postemergence
Application date	June 3, 2020	June 26, 2020	July 7, 2020
Air temperature (°F)	73	84	76
Relative humidity	44	41	62
Soil temperature (°F)	73	72	77
Wind speed (mph)	3 to 7	2 to 6	3 to 7
Wind direction	Northwest	West-southwest	South
Soil moisture	Dry	Good	Good
Grain sorghum			
Height (inches)	---	4 to 6	6 to 9
Leaves (no.)	0	3 to 5	4 to 6
Palmer amaranth			
Height (inches)	---	1 to 4	2 to 7
Density (plants/10 ft ²)	0	20	10
Velvetleaf			
Height (inches)	---	5 to 5	4 to 6
Density (plants/10 ft ²)	0	5	1
Green foxtail			
Height (inches)	---	1 to 3	1 to 4
Density (plants/10 ft ²)	0	5	3
Shattercane			
Height (inches)	---	3 to 5	4 to 6
Density (plants/10 ft ²)	0	3	2

WEED SCIENCE

Table 2. Weed control with Zest in grain sorghum

Treatment ¹	Rate	Timing ²	Palmer amaranth		Velvetleaf		Green foxtail		Shattercane	
			10	28	10	28	10	28	10	28
			DAB ³	DAC ³	DAB	DAC	DAB	DAC	DAB	DAC
	oz/a		----- % Visual -----							
Cinch ATZ	32	PRE	79	55	85	78	85	73	95	88
Cinch ATZ	32	PRE	68	75	75	88	78	93	75	100
Zest	0.67	LPOST								
Atrazine	24	LPOST								
COC	2.0%	LPOST								
AMS	1.94%	LPOST								
Cinch ATZ	32	PRE	75	65	83	93	80	91	83	100
Zest	1.33	LPOST								
Atrazine	24	LPOST								
COC	2.0%	LPOST								
AMS	1.94%	LPOST								
Zest	0.67	EPOST	55	23	61	88	70	83	73	100
Atrazine	24	EPOST								
COC	2.0%	EPOST								
AMS	1.94%	EPOST								
Zest	1.33	EPOST	55	35	70	95	70	98	73	100
Atrazine	24	EPOST								
COC	2.0%	EPOST								
AMS	1.94%	EPOST								
LSD (0.05)			9	9	14	11	6	7	14	4

¹ COC = crop oil concentrate. AMS = ammonium sulfate.

² PRE = preemergence. EPOST = early postemergence. LPOST = late postemergence.

³ 10 DAB = 10 days after the early postemergence treatments. 28 DAC = 28 days after the late postemergence treatments.

Weed Control with Imazamox Rates and Timings in Herbicide-Tolerant Grain Sorghum

R.S. Currie and P.W. Geier

Summary

The objective of this trial was to evaluate weed control and crop response using imazamox (KFD-365-02) in herbicide-resistant grain sorghum. Palmer amaranth control was 80% or less late in the season due to the herbicide-resistant weed biotype in the experiment. Both velvetleaf and shattercane control exceeded 90% with most herbicides late in the year. Using KFD-365-02 at the 9.0 oz/a rate applied preemergence alone or with atrazine or Moccasin II Plus controlled green foxtail and puncturevine the best. Most early postemergence treatments caused minor sorghum necrosis 6 days after treatments, but sorghum recovered fully within one week.

Introduction

Postemergence (POST) weed control in grain sorghum has always been challenging, especially when those weeds are grasses. With the recent introductions of herbicide-tolerant grain sorghum, chemicals that would normally injure or kill the crop have potential to expand herbicide options in sorghum. One such introduction is Igrowth sorghum, which has tolerance to imazamox herbicide, and is currently under development. The objective of this study was to evaluate imazamox at two rates and two application timings for weed control in grain sorghum.

Experimental Procedures

An experiment was conducted at the Kansas State University Southwest Research-Extension Center near Garden City, KS, to evaluate imazamox (KFD-356-02) rates, application timings, and tank mix partners for efficacy in imazamox-resistant grain sorghum. Herbicides were applied POST using a tractor-mounted, compressed CO₂ sprayer delivering 19.4 gpa at 30 psi and 4.1 mph. Application, environmental, and weed information are shown in Table 1. Plots were 10 by 35 feet and arranged in a randomized complete block design with four replications. Soil was a Ulysses silt loam with 3.4% organic matter and pH of 7.9. Visual weed control was determined on July 6 and August 11, 2020. These dates were 6 days after the preemergence treatments (6 DAB) and 35 days after the late postemergence treatments (35 DAD), respectively. Crop injury ratings were taken on July 6 and July 14, 2020, and these dates were 6 days after the early postemergence treatments (6 DAB) and 7 DAD, respectively.

Results and Discussion

Common sunflower control was complete with all herbicide treatments regardless of rating date (data not shown). Early season Palmer amaranth control was similar among all herbicides except KFD-365-02 plus atrazine preemergence (PRE) followed by 2,4-D early postemergence (EPOST), and KFD-365-02 PRE followed by atrazine EPOST (Table 2). These treatments, along with KFD-365-02 plus Moccasin II Plus (*S*-meto-

lachlor) PRE followed by atrazine EPOST were the least effective on Palmer amaranth at 35 DAD as well. However, since the Palmer amaranth biotype in this study was resistant to several herbicide modes-of-actions, no herbicide treatment provided more than 80% control at 35 DAD. Velvetleaf control was 93% or more with all herbicides except Bicep II Magnum (*S*-metolachlor/atrazine) PRE at 6 DAC. Similarly, velvetleaf control was best (93 to 100%) with all herbicides except Coyote (*S*-metolachlor/mesotrione) PRE followed by KFD-365-02 alone, or with atrazine EPOST and Moccasin II Plus plus atrazine PRE followed by 2,4-D EPOST at 7 DAD. Treatments of Coyote at 10 days preplant (10 DPP) followed by KFD-365-02 EPOST or KFD-365-02 PRE provided greater than 90% green foxtail control early, but only the 9.0 oz/a rate of KFD-365-02 applied PRE controlled foxtail more than 90% at 35 DAD. Similarly, only the high rate of KFD-365-02 applied PRE provided adequate puncturevine control at 35 DAD (Table 3). Shattercane control was good with all herbicide treatments except Bicep II Magnum PRE followed by Kochiavore (fluroxypyr/2,4-D/bromoxynil) (Table 2). Most herbicide treatments caused 8 to 14% sorghum necrosis at 6 DAC; however, injury did not persist (Table 3).

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Table 1. Application, environmental, and weed data for the imazamox grain sorghum study

Application timing	14 DPP¹	PRE¹	EPOST¹	LPOST¹
Application date	May 18, 2020	June 3, 2020	June 30, 2020	July 7, 2020
Air temperature (°F)	81	75	73	76
Relative humidity	36	44	41	62
Soil temperature (°F)	81	73	74	77
Wind speed (mph)	0 to 4	3 to 7	3 to 6	3 to 7
Wind direction	South	Northwest	South	South
Soil moisture	Dry	Dry	Fair	Fair
Grain sorghum				
Height (inches)	---	---	6 to 8	7 to 9
Leaves (no.)	0	0	3 to 5	4 to 6
Palmer amaranth				
Height (inches)	---	---	3 to 6	3 to 7
Density (plants/10 ft ²)	0	0	5	20
Velvetleaf				
Height (inches)	---	---	2 to 4	2 to 6
Density (plants/10 ft ²)	0	0	1	2
Puncturevine				
Diameter (inches)	---	---	6	8
Density (plants/10 ft ²)	0	0	1	2
Green foxtail				
Height (inches)	---	---	2 to 5	---
Density (plants/10 ft ²)	0	0	2	0
Shattercane				
Height (inches)	---	---	3 to 6	3 to 5
Density (plants/10 ft ²)	0	0	1	2

¹ 14 DPP = 14 days preplant. PRE = preemergence. EPOST = early postemergence. LPOST = late postemergence.

WEED SCIENCE

Table 2. Weed control with imazamox in imazamox-tolerant grain sorghum

Treatment ¹	Rate oz/a	Timing ²	% Visual							
			Palmer amaranth		Velvetleaf		Green foxtail		Shattercane	
			6 DAB ³	35 DAD ³	6 DAB	35 DAD	6 DAB	35 DAD	6 DAB	35 DAD
Coyote KFD-356-02 COC	64 6.0 1.0%	14 DPP EPOST EPOST	89	75	98	88	93	85	99	95
Coyote KFD-356-02 Atrazine COC	64 6.0 32 1.0%	14 DPP EPOST EPOST EPOST	91	70	96	90	91	80	98	98
Coyote KFD-356-02 2,4-D ester KFD-356-02 Atrazine 2,4-D ester KFD-356-02 Moccasin II Plus Atrazine COC	64 6.0 8.0 9.0 32 8.0 9.0 16 32 1.0%	14 DPP EPOST EPOST PRE PRE EPOST PRE PRE EPOST EPOST	91	70	100	100	90	70	100	100
KFD-356-02 Moccasin II Plus Atrazine COC	9.0 16 32 1.0%	PRE PRE EPOST EPOST	70	35	100	100	100	100	100	100
KFD-356-02 Moccasin II Plus Atrazine COC	9.0 16 32 1.0%	PRE PRE EPOST EPOST	91	80	100	100	100	95	100	100
KFD-356-02 Moccasin II Plus Atrazine COC	6.0 16 32 1.0%	PRE PRE EPOST EPOST	86	63	100	100	98	85	98	100
KFD-356-02 Atrazine COC	9.0 32 1.0%	PRE EPOST EPOST	71	20	100	100	100	95	100	100
Moccasin II Plus Atrazine KFD-356-02 COC	16 32 6.0 1.0%	PRE PRE EPOST EPOST	86	68	98	100	88	83	96	100
Moccasin II Plus Atrazine KFD-356-02 2,4-D ester	16 32 6.0 8.0	PRE PRE EPOST EPOST	89	73	96	98	83	73	100	100
Moccasin II Plus Atrazine 2,4-D ester	16 32 8.0	PRE PRE EPOST	88	73	93	83	85	60	93	95
Bicep II Magnum Kochiavore	67 24	PRE LPOST	90	80	78	93	86	63	88	85
LSD (0.05)			10	15	8	10	9	8	6	7

¹ COC = crop oil concentrate.

² 14 DPP = 14 days preplant. PRE = preemergence. EPOST = early postemergence. LPOST = late postemergence.

³ 6 DAB = days after 6 days after the preemergence treatments. 35 DAD = 35 days after the late postemergence treatments.

Table 3. Puncturevine control and crop response in the imazamox-tolerant grain sorghum study

Treatment ¹	Rate oz/a	Timing ²	Puncturevine	Sorghum necrosis	
			35 DAD ³	6 DAC ³	7 DAD ³
			----- % Visual -----		
Untreated	---	---	---	0	0
Coyote	64	14 DPP	40	10	0
KFD-356-02	6.0	EPOST			
COC	1.0%	EPOST			
Coyote	64	14 DPP	55	14	0
KFD-356-02	6.0	EPOST			
Atrazine	32	EPOST			
COC	1.0%	EPOST			
Coyote	64	14 DPP	43	10	0
KFD-356-02	6.0	EPOST			
2,4-D ester	8.0	EPOST			
KFD-356-02	9.0	PRE	90	10	0
Atrazine	32	PRE			
2,4-D ester	8.0	EPOST			
KFD-356-02	9.0	PRE	90	14	0
Moccasin II Plus	16	PRE			
Atrazine	32	EPOST			
COC	1.0%	EPOST			
KFD-356-02	6.0	PRE	75	8	0
Moccasin II Plus	16	PRE			
Atrazine	32	EPOST			
COC	1.0%	EPOST			
KFD-356-02	9.0	PRE	93	14	0
Atrazine	32	EPOST			
COC	1.0%	EPOST			
Moccasin II Plus	16	PRE	30	10	0
Atrazine	32	PRE			
KFD-356-02	6.0	EPOST			
COC	1.0%	EPOST			
Moccasin II Plus	16	PRE	33	10	0
Atrazine	32	PRE			
KFD-356-02	6.0	EPOST			
2,4-D ester	8.0	EPOST			
Moccasin II Plus	16	PRE	30	5	0
Atrazine	32	PRE			
2,4-D ester	8.0	EPOST			
Bicep II Magnum	67	PRE	48	0	0
Kochiavore	24	LPOST			
LSD (0.05)			16	6	NS

¹ COC = crop oil concentrate.

² 14 DPP = 14 days preplant. PRE = preemergence. EPOST = early postemergence. LPOST = late postemergence.

³ 35 DAD = 35 days after the late postemergence treatments. 6 DAC = days after 6 days after the early postemergence treatments. 7 DAD = 7 days after the late postemergence treatments.

Weed Control with Single and Split Herbicide Applications in Corn

R.S. Currie and P.W. Geier

Summary

The objective of the study was to compare season-long weed control from single and sequential herbicide applications in corn. Kochia control was 90% or more late in the season, and did not differ among herbicides. All herbicides except Lumax EZ provided 90% or more Russian thistle control by the season's end. Palmer amaranth control was lowest when Bicep II Magnum was applied preemergence (PRE) and followed by Lexar EZ postemergence (POST), and when Acuron was applied PRE and again POST. Compared to the untreated control, corn receiving herbicide treatments yielded more than three times as much grain, but yields did not differ among herbicides.

Introduction

Early season weed control in corn is critical to prevent competition during crop establishment. Herbicides with residual activity are typically used near planting time to achieve this, but extending the length of residual activity can be accomplished by delaying some of the preemergence herbicide until after the crop emerges. The objective of this study was to compare single preemergence herbicide treatments with sequential split applications for efficacy in corn.

Experimental Procedures

An experiment was conducted at the Kansas State University Southwest Research-Extension Center near Garden City, KS, to evaluate single versus split application of herbicide premixtures (Table 2) for efficacy in corn. Herbicides were applied using a tractor-mounted, compressed CO₂ sprayer delivering 19.4 gpa at 30 psi and 4.1 mph. Application, environmental, and weed information are shown in Table 1. Plots were 10 by 35 feet and arranged in a randomized complete block design with four replications. Soil was a Beeler silt loam with 2.4% organic matter and pH of 7.6. Visual estimates of weed control were taken on June 24 and August 14, 2020. These dates were 34 and 85 days after the postemergence treatments (DAB). Corn yields were determined on October 1, 2020, by mechanically harvesting the center two rows of each plot and adjusting grain weights to 15.5% moisture.

Results and Discussion

Early season control of all weed species was 90% or more with all preemergence (PRE) herbicides, and did not differ between treatments (data not shown). Control of common sunflower and green foxtail remained 90% or more throughout the season regardless of herbicide. Bicep II Magnum (*S*-metolachlor/atrazine) applied PRE followed by Lexar EZ (*S*-metolachlor/atrazine/mesotrione) POST and Acuron (*S*-metolachlor/atrazine/mesotrione/bicyclopyrone) applied PRE and POST provided less than 90% kochia and Palmer amaranth control at 34 DAB (Table 2). Kochia control was similar among all herbicides at 85 DAB, but Palmer amaranth control remained less than 90% with the previously mentioned treatments as well as with

Bicep II Magnum PRE followed by Halex GT (*S*-metolachlor/glyphosate/mesotrione) POST. All herbicides controlled Russian thistle similarly at 34 DAB, but Lumax EZ (*S*-metolachlor/atrazine/mesotrione) alone PRE was less efficacious than other treatments on Russian thistle at 85 DAB. Grain yields did not differ among herbicide-treated plots. However, yields increased 85 to 104 bu/a with herbicide-treated plots compared to the untreated controls (40.9 bu/a).

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Table 1. Application, environmental, and weed information for the single and sequential treatment study in corn

Application timing	Preemergence	Postemergence
Application date	May 1, 2020	May 21, 2020
Air temperature (°F)	59	67
Relative humidity	51	80
Soil temperature (°F)	58	66
Wind speed (mph)	3 to 7	6 to 10
Wind direction	Northwest	Southeast
Soil moisture	Fair	Good
Corn		
Height (inches)	---	2 to 5
Leaves (no.)	0	1 to 2
Russian thistle		
Height (inches)	---	4 to 6
Density (plants/10 ft ²)	0	2
Kochia		
Height (inches)	---	1 to 3
Density (plants/10 ft ²)	0	2
Palmer amaranth		
Height (inches)	---	1 to 2
Density (plants/10 ft ²)	0	1
Sunflower		
Height (inches)	---	2 to 3
Density (plants/10 ft ²)	0	0.5
Green foxtail		
Height (inches)	---	0.5 to 1
Density (plants/10 ft ²)	0	1

Table 2. Weed control and corn yield from the single and sequential treatment study in corn

Treatment ¹	Rate	Timing ²	Kochia		Russian thistle		Palmer amaranth		Grain yield
			34 DAB ³	85 DAB ³	34 DAB	85 DAB	34 DAB	85 DAB	
	oz/a		----- % Visual -----						bu/a
Untreated	---	---	---	---	---	---	---	---	40.9
Lumax EZ	86	PRE	95	97	84	77	94	93	138.9
Acuron	96	PRE	100	95	94	95	100	94	132.5
Lexar EZ	48	PRE	99	98	98	90	100	98	144.3
Acuron	48	POST							
AMS	1.0%	POST							
Bicep II Magnum	67	PRE	95	95	94	90	93	88	143.2
Halex GT	58	POST							
NIS	0.25%	POST							
AMS	1.0%	POST							
Bicep II Magnum	48	PRE	89	90	98	93	85	83	140.2
Lexar EZ	56	POST							
NIS	0.25%	POST							
AMS	1.0%	POST							
Acuron	48	PRE	86	90	98	93	85	80	125.6
Acuron	48	POST							
Resicore	80	PRE	98	95	90	90	95	95	145.3
Resicore	40	PRE	100	98	93	90	100	99	129.6
Resicore	40	POST							
Corvus	5.6	PRE	100	100	98	98	98	93	142.1
Atrazine	32	PRE							
Harness Max	40	POST							
Glyphosate	28	POST							
AMS	1.0%	POST							
LSD (0.05)			10	NS	NS	10	10	12	30.2

¹ AMS = ammonium sulfate. NIS = nonionic surfactant.

² PRE = preemergence. POST = postemergence.

³ DAB = days after the postemergence treatments.

Impact and Liberty Rates and Mixtures for Efficacy in Corn

R.S. Currie and P.W. Geier

Summary

The objective of the study was to compare Impact (topramezone), Liberty (glufosinate) and a premixture of the two herbicides (Sinate) for efficacy in corn. Rates for each herbicide were 0.75 and 1.0 oz/a for Impact, 22 and 30 oz/a for Liberty, and 21 and 28 oz/a for Sinate. Impact and Sinate, each at the high rates, and Status plus glyphosate provided the best kochia control for corn late in the season. These treatments, along with the low rate of Impact controlled crabgrass the best. Status was also the best treatment for Russian thistle, Palmer amaranth, and green foxtail control. The high rate of Impact also controlled Russian thistle well, whereas the high rate of Sinate provided good foxtail control. Most herbicide treatments increased grain yields relative to the untreated control, but yields were decidedly greater with Status plus glyphosate.

Introduction

The recent development of glyphosate-resistant (GR) weeds has caused many producers to seek new ways of controlling weeds postemergence (POST) in corn. Two potential herbicides that may help control GR weeds are Impact and Liberty. Impact controls many broadleaf and select grass weeds, whereas Liberty has broad-spectrum efficacy on both grasses and broadleaves. The objective of this study was to compare Impact and Liberty alone or as a premixture at two rates for postemergence efficacy in corn.

Material and Methods

An experiment was conducted at the Kansas State University Southwest Research-Extension Center near Garden City, KS, to evaluate Impact (topramezone) and Liberty (glufosinate) rates alone and in a premix for postemergence efficacy in glufosinate-tolerant corn. Herbicides (Table 2) were applied using a tractor-mounted, compressed CO₂ sprayer delivering 19.4 gpa at 30 psi and 4.1 mph. Application, environmental, and weed information are shown in Table 1. Plots were 10 by 35 feet and arranged in a randomized complete block design with four replications. Soil was a Beeler silt loam with 2.4% organic matter and pH of 7.6. Visual estimates of weed control were taken on June 11 and July 1, 2020. These dates were 8 and 28 days after treatment (DAT), respectively. Corn yields were determined on October 3, 2020 by mechanically harvesting the center two rows of each plot and adjusting grain weights to 15.5% moisture.

Results and Discussion

At 8 DAT, only Sinate (topramezone/glufosinate) at 28 oz/a controlled kochia as much as 80% (Table 2). This treatment, along with Impact alone at 1.0 oz/a and Status (dicamba/diflufenzopyr) plus glyphosate, controlled kochia best at 28 DAT. No treatment controlled Russian thistle more than 81% at 8 DAT, but the high rate of Impact alone and Status plus glyphosate each provided greater than 90% control at 28 DAT. Likewise, Palmer amaranth control was less than 85% regardless of treatment at 8 DAT.

Only Status plus glyphosate controlled Palmer amaranth more than 75% at 28 DAT. Sinate at 28 oz/a and Status provided the best green foxtail control at 28 DAT (Table 3). These treatments along with Impact alone at either rate were the most efficacious treatments for crabgrass control at 28 DAT. In most cases, increasing the rate of Impact, Liberty, or Sinate did not improve control of the weed species studied. All herbicide treatments, except Sinate at the low rate, resulted in higher grain yields than the untreated control. However, only the treatment of Status with glyphosate resulted in yields higher (115.2 bu/a) than 62 bu/a.

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Table 1. Application, environmental, and weed information for the Impact and Liberty study in corn

Application timing	Postemergence
Application date	June 3, 2020
Air temperature (°F)	97
Relative humidity	24
Soil temperature (°F)	84
Wind speed (mph)	2 to 6
Wind direction	North
Soil moisture	Fair
Corn	
Height (inches)	5 to 8
Leaves (no.)	3 to 4
Kochia	
Height (inches)	2 to 6
Density (plants/10 ft ²)	20
Palmer amaranth	
Height (inches)	1 to 5
Density (plants/10 ft ²)	30
Russian thistle	
Height (inches)	3 to 6
Density (plants/10 ft ²)	5
Green foxtail	
Height (inches)	1 to 3
Density (plants/10 ft ²)	10
Crabgrass	
Height (inches)	0.5 to 1
Density (plants/10 ft ²)	3

Table 2. Broadleaf weed control in the Impact and Liberty corn trial

Treatment ¹	Rate	Kochia		Russian thistle		Palmer amaranth	
		8 DAT ²	28 DAT	8 DAT	28 DAT	8 DAT	28 DAT
	oz/a	----- % Visual -----					
Impact MSO AMS	0.75 1.0% 3.0	70	78	68	83	65	68
Impact MSO AMS	1.0 1.0% 3.0	73	80	73	93	68	75
Liberty AMS	22 3.0	63	65	68	68	75	65
Liberty AMS	30 3.0	70	65	75	70	83	68
Sinate MSO AMS	21 1.0% 3.0	73	75	73	78	75	65
Sinate MSO AMS	28 1.0% 3.0	80	80	81	85	83	75
Status Glyphosate NIS AMS	5.0 32 0.25% 3.0	60	88	60	95	65	88
LSD (0.05)		7	8	9	8	8	8

¹ MSO = methylated seed oil. AMS = ammonium sulfate. NIS = nonionic surfactant.

² DAT = days after treatment.

Table 3. Grass weed control and corn yield in the Impact and Liberty trial

Treatment ¹	Rate	Green foxtail		Crabgrass		Corn yield
		8 DAT ²	28 DAT	8 DAT	28 DAT	
	oz/a	----- % Visual -----				bu/a
Untreated	---	---	---	---	---	8.4
Impact	0.75	63	83	65	88	43.4
MSO	1.0%					
AMS	3.0					
Impact	1.0	63	85	63	90	61.2
MSO	1.0%					
AMS	3.0					
Liberty	22	78	70	65	73	35.7
AMS	3.0					
Liberty	30	83	80	80	80	41.1
AMS	3.0					
Sinate	21	80	75	78	83	34.1
MSO	1.0%					
AMS	3.0					
Sinate	28	81	90	80	88	45.0
MSO	1.0%					
AMS	3.0					
Status	5.0	78	96	73	91	115.2
Glyphosate	32					
NIS	0.25%					
AMS	3.0					
LSD (0.05)		9	11	8	7	26.5

¹ MSO = methylated seed oil. AMS = ammonium sulfate. NIS = nonionic surfactant.

² DAT = days after treatment.

Fallow Weed Control with Vida Tank Mixtures

R.S. Currie and P.W. Geier

Summary

The objective of the study was to compare Vida (pyraflufen) with various tank mix partners for glyphosate-resistant kochia control. Flixweed control was complete in fallow with all herbicides by 28 days after treatment. Kochia control was best when Vida was applied with glyphosate and Spartan. However, due in part to the extremely dry conditions, no treatment controlled kochia by more than 83% at 28 days after treatment, and kochia control began to decline after this 28 DAT.

Introduction

Due to the development of herbicide resistance, kochia has become one of the most difficult weeds to control in fallow. This ubiquitous Kansas weed has developed resistance to at least four herbicide modes-of-action. Therefore, the use of novel herbicides for its control is paramount. The objective of this study was to compare Vida tank mixed with various herbicides for weed control in fallow.

Materials and Methods

An experiment was conducted at the Kansas State University Southwest Research-Extension Center near Garden City, KS, to compare Vida (pyraflufen) tank mixed with various herbicides (Table 2) for control of glyphosate-resistant kochia in fallow. Herbicides were applied postemergence using a tractor-mounted, compressed CO₂ sprayer delivering 19.4 gpa at 30 psi and 4.1 mph. Application, environmental, and weed information is shown in Table 1. Plots were 10 by 35 feet and arranged in a randomized complete block design with four replications. Soil was a Ulysses silt loam with 3.4% organic matter and pH of 7.9. Visual weed control was determined on May 13, May 19, and June 2, 2020. These dates were 8, 14, and 28 days after treatment (DAT), respectively.

Results and Discussion

The trial was conducted under severe drought conditions, such that less than 25% of normal precipitation was received from the time of herbicide application until the final evaluation date. Vida plus glyphosate alone, or with 2,4-D, controlled kochia less than 40% at 8 DAT (Table 2). The combination of Vida with glyphosate, 2,4-D, and Spartan (sulfentrazone) provided 50% kochia control 8 DAT. By 14 DAT, kochia control was best when Vida was mixed with Spartan (68 to 73%). At 28 DAT, only those treatments containing Spartan provided more than 75% kochia control. Kochia control reached a high point (83%) at 28 DAT, and plants soon began to recover (data not shown). Vida tank mixed with glyphosate, 2,4-D and Spartan controlled flixweed 70% by 8 DAT. Vida plus glyphosate and Spartan, with or without 2,4-D, controlled flixweed 90% at 14 DAT. However, all herbicides completely controlled flixweed at 28 DAT. More research is needed to test these herbicides under more favorable growing conditions.

Brand names appearing in this publication are for product identification purposes only. No endorsement is intended, nor is criticism implied of similar products not mentioned. Persons using such products assume responsibility for their use in accordance with current label directions of the manufacturer.

Table 1. Application, environmental, and weed data for the Vida tank mix study in fallow

Application date	May 5, 2020
Air temperature (°F)	67
Relative humidity	28
Soil temperature (°F)	62
Wind speed (mph)	7 to 10
Wind direction	Northeast
Soil moisture	Dry
Kochia	
Height (inches)	1 to 4
Density (plants/10 ft ²)	25
Flixweed	
Height (inches)	8 to 12
Density (plants/10 ft ²)	3

Table 2. Weed control with Vida tank mixtures in fallow

Treatment ¹	Rate	Kochia			Flixweed		
		8 DAT ²	14 DAT	28 DAT	8 DAT	14 DAT	28 DAT
	oz/a	----- % Visual -----					
Vida	2.0	35	50	70	38	65	100
Glyphosate	24						
COC	1.0 %						
AMS	3.0 lb						
Vida	2.0	30	45	68	48	75	100
Glyphosate	24						
2,4-D amine	8.0						
COC	1.0 %						
AMS	3.0 lb						
Vida	2.0	45	68	83	55	90	100
Glyphosate	24						
Spartan	6.0						
COC	1.0 %						
AMS	3.0 lb						
Glyphosate	24	40	63	78	48	83	100
Spartan	6.0						
COC	1.0 %						
AMS	3.0 lb						
Vida	2.0	50	73	80	70	90	100
Glyphosate	24						
2,4-D amine	8.0						
Spartan	6.0						
COC	1.0 %						
AMS	3.0 lb						
LSD (0.05)		5	8	9	7	7	NS

¹ COC = crop oil concentrate. AMS = ammonium sulfate.

² DAT = days after herbicide treatment.

Novel Sorghum Herbicides for Grass Control in Fallow

R.S. Currie and P.W. Geier

Summary

This study was conducted to compare herbicides for use in herbicide-tolerant grain sorghum for grass control in fallow. Imazamox applied preemergence (PRE) was generally the most effective herbicide regardless of weed species or evaluation date. Postemergence (POST) treatments did not control green foxtail more than 78% late in the season. Imazamox, Assure II (quizalofop), and Accent (nicosulfuron) applied PRE or early POST controlled shattercane and crabgrass 90% or more late in the season. Assure II applied late POST also controlled shattercane 93 to 95% late in the year.

Introduction

Due to a lack of registered herbicides, postemergence grass control in grain sorghum has always been challenging. However, recent advances in the development of herbicide-tolerant sorghum have led to potential new herbicides for postemergence grass control. Currently, sorghum technologies with resistance to imazamox, Accent, and Assure II are in development. The objective of this study was to evaluate herbicides for new sorghum technologies for grass control in fallow.

Materials and Methods

An experiment was conducted at the Kansas State University Southwest Research-Extension Center near Garden City, KS, to compare herbicides (Table 2) from three herbicide-tolerant sorghum technologies: imidazolinone-, ALS- and ACCase-tolerant technologies, in fallow. Herbicides were applied using a tractor-mounted, compressed CO₂ sprayer delivering 19.4 gpa at 30 psi and 4.1 mph. Application, environmental, and weed information is shown in Table 1. Plots were 10 by 35 feet and arranged in a randomized complete block design with four replications. Soil was a Ulysses silt loam with 3.4% organic matter and pH of 7.9. Visual weed control was determined on July 16 and August 13, 2020. These dates were 14 days after the early postemergence treatments (14 DAB) and 26 days after the late postemergence treatments (26 DAC), respectively.

Results and Discussion

Imazamox at 6 or 9 oz/a applied PRE provided good control of green foxtail, shattercane, and crabgrass, and was among the best treatments for each of these species at both rating dates (Table 2). No POST treatment controlled green foxtail more than 78% at 26 DAC. In addition to imazamox PRE, Assure II (quizalofop) applied early postemergence (EPOST) at 10 oz/a controlled shattercane more than 90% at 14 DAB. By 26 DAC, shattercane control exceeded 90% with either rate of imazamox PRE or EPOST, Accent (nicosulfuron) at either rate EPOST, and Assure II at either rate EPOST or late postemergence (LPOST). Early season crabgrass control was 90% or more with all PRE herbicides, Accent at both rates EPOST, and the high rate of Assure II EPOST. However, by 28 DAC, all PRE and EPOST herbicides provided similar

crabgrass control. These treatments of Accent or the low rate of Assure II applied LPOST were significantly better than imazamox.

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Table 1. Application, environmental, and weed data for the sorghum herbicide fallow study

Application date	Preemergence	Early postemergence	Late postemergence
Air temperature (°F)	May 27, 2020	July 2, 2020	July 18, 2020
Relative humidity	64	74	75
Soil temperature (°F)	51	87	57
Wind speed (mph)	58	78	74
Wind direction	3 to 6	3 to 7	1 to 5
Soil moisture	North-northwest	East	South
Green foxtail	Dry	Fair	Good
Height (inches)	---	1 to 6	6 to 18
Density (plants/10 ft ²)	0	25	20
Shattercane			
Height (inches)	---	3 to 6	8 to 18
Density (plants/10 ft ²)	0	3	2
Crabgrass			
Height (inches)	---	0.5 to 1	12 to 20
Density (plants/10 ft ²)	0	1	2

WEED SCIENCE

Table 2. Weed control in the sorghum herbicide fallow study

Treatment ¹	Rate	Timing ²	Green foxtail		Shattercane		Crabgrass	
			14 DAB ³	26 DAC ³	14 DAB	26 DAC	14 DAB	26 DAC
	oz/a		----- % Visual -----					
Imazamox	6.0	PRE	94	88	90	93	93	90
Imazamox	9.0	PRE	98	89	100	98	96	90
Dual II Magnum	24	PRE	86	70	65	60	94	93
Warrant	64	PRE	75	58	63	60	90	89
Outlook	18	PRE	80	60	73	63	91	90
Imazamox	6.0	EPOST	70	70	80	95	85	98
COC	1.0%	EPOST						
Imazamox	9.0	EPOST	80	75	83	95	88	98
COC	1.0%	EPOST						
Assure II	6.0	EPOST	73	65	89	100	83	98
COC	1.0%	EPOST						
Assure II	10.0	EPOST	85	78	93	100	94	95
COC	1.0%	EPOST						
Accent	0.68	EPOST	73	53	88	98	93	100
COC	1.0%	EPOST						
AMS	4.0	EPOST						
Accent	1.0	EPOST	80	58	88	90	93	100
COC	1.0%	EPOST						
AMS	4.0	EPOST						
Imazamox	6.0	LPOST	---	45	---	78	---	70
COC	1.0%	LPOST						
Imazamox	9.0	LPOST	---	48	---	73	---	65
COC	1.0%	LPOST						
Assure II	6.0	LPOST	---	45	---	93	---	70
COC	1.0%	LPOST						
Assure II	10.0	LPOST	---	60	---	95	---	83
COC	1.0%	LPOST						
Accent	0.68	LPOST	---	35	---	55	---	45
COC	1.0%	LPOST						
AMS	4.0	LPOST						
Accent	1.0	LPOST	---	38	---	70	---	63
COC	1.0%	LPOST						
AMS	4.0	LPOST						
LSD (0.05)			9	14	11	13	7	14

¹ COC = crop oil concentrate. AMS = ammonium sulfate.

² PRE = preemergence. EPOST = early postemergence. LPOST = late postemergence.

³ 14 DAB = 14 days after the early postemergence treatments. 26 DAC = 26 days after the late postemergence treatments.

Outlook Alone and in Mixtures for Efficacy in Corn

R.S. Currie and P.W. Geier

Summary

The objective of the study was to compare Outlook (dimethenamid) alone and in various tank mixtures for season-long weed control in corn. Kochia control with most herbicides was 95% or more late in the season. However, Russian thistle control did not exceed 83% with any herbicide tested. Palmer amaranth control at 59 days after the postemergence treatments was similar among all herbicides, while green foxtail control was 93% or more with each treatment. All herbicides increased grain yields relative to the untreated control, but corn treated with Outlook or Verdict alone yielded less grain than the best yielding plots.

Introduction

Preemergence (PRE) weed control is an important component in any cropping system. Allowing corn to become established prior to competition from weeds is no exception. Several dozen different herbicides are currently labeled for PRE use in Kansas corn, and these herbicides vary in their efficacy and length of residual activity. The objective of this study was to compare several PRE herbicides alone and in combinations for efficacy in corn.

Materials and Methods

An experiment was conducted at the Kansas State University Southwest Research-Extension Center near Garden City, KS, to evaluate Outlook (dimethenamid) alone or with various mixtures for efficacy in corn. Herbicides (Table 2) were applied using a tractor-mounted, compressed CO₂ sprayer delivering 19.4 gpa at 30 psi and 4.1 mph. Application, environmental, and weed information is shown in Table 1. Plots were 10 by 35 feet and arranged in a randomized complete block design with four replications. Soil was a Beeler silt loam with 2.4% organic matter and pH of 7.6. Visual estimates of weed control were taken on June 17 and August 10, 2020. These dates were 5 and 59 days after the postemergence treatment (DAB), respectively. Corn yields were determined on October 6, 2020, by mechanically harvesting the center two rows of each plot and adjusting grain weights to 15.5% moisture.

Results and Discussion

Common sunflower control was 83 to 95% at 5 DAB and 80 to 93% control at 59 DAB, and did not differ between herbicide treatments (data not shown). All herbicides controlled kochia more than 90% at 5 DAB except Verdict (dimethenamid/saflufenacil) applied PRE followed by Zidua SC (pyroxasulfone) postemergence (POST) (Table 2). Verdict alone, or with a drift control agent (DCA) PRE, and Verdict followed by Zidua SC controlled kochia less than 90% at 59 DAT. Zidua SC with Sharpen (saflufenacil) and Callisto (mesotrione) or Verdict PRE controlled Russian thistle the best at each rating date. However, no herbicide provided more than 81% Russian thistle control. Outlook alone, or with a DCA PRE, and Verdict

plus Callisto PRE controlled Palmer amaranth 100% at 5 DAB; however, no difference occurred among herbicides for Palmer amaranth control at 59 DAB. Similarly, green foxtail control did not differ among herbicides at 5 DAT, and only Verdict alone PRE provided less than 95% foxtail control later in the season. Grain yields were 68 to 108 bu/a higher from herbicide-treated plots than from untreated plots (37.5 bu/a). However, yields were generally lowest when Outlook alone or Verdict alone were applied (105 to 108 bu/a).

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Table 1. Application, environmental, and weed information for the Outlook study in corn

Application timing	Preemergence	Postemergence
Application date	May 14, 2020	June 12, 2020
Air temperature (°F)	80	70
Relative humidity	49	41
Soil temperature (°F)	64	68
Wind speed (mph)	5 to 9	7 to 10
Wind direction	North-northwest	Southwest
Soil moisture	Good	Good
Corn		
Height (inches)	---	5 to 8
Leaves (no.)	0	3 to 4
Kochia		
Height (inches)	---	---
Density (plants/10 ft ²)	0	0
Palmer amaranth		
Height (inches)	---	2 to 4
Density (plants/10 ft ²)	0	1
Russian thistle		
Height (inches)	---	3 to 6
Density (plants/10 ft ²)	0	2
Green foxtail		
Height (inches)	---	---
Density (plants/10 ft ²)	0	0
Shattercane		
Height (inches)	---	3 to 5
Density (plants/10 ft ²)	0	1

Table 2. Weed control and grain yield from the Outlook in corn trial

Treatment ¹	Rate	Timing ²	Kochia		Russian thistle		Palmer amaranth		Green foxtail		Grain yield
			5 DAB ³	59 DAB	5 DAB	59 DAB	5 DAB	59 DAB	5 DAB	59 DAB	
	oz/a		----- % Visual -----								bu/a
Untreated			---	---	---	---	---	---	---	---	37.5
Outlook	14	PRE	100	98	70	53	100	85	98	100	108.5
Verdict	10	PRE	95	83	68	53	95	88	98	93	105.1
Outlook	14	PRE	95	95	73	58	100	90	98	100	137.4
DCA-DA	32	PRE									
Verdict	10	PRE	95	88	73	55	95	93	98	100	131.4
DCA-DA	32	PRE									
Zidua SC	3.3	PRE	98	98	74	63	85	93	93	95	148.8
Callisto	4.0	PRE									
Zidua SC	4.4	PRE	100	98	79	70	90	88	100	98	154.1
Callisto	4.0	PRE									
Zidua SC	3.3	PRE	100	100	83	73	98	98	100	98	144.3
Sharpen	2.0	PRE									
Callisto	4.0	PRE									
MSO	1.0%	PRE									
AMS	2.5%	PRE									
Verdict	10	PRE	100	98	81	80	100	95	100	100	141.5
Zidua SC	3.3	PRE									
Verdict	10	PRE	90	85	70	68	95	88	94	100	136.8
Zidua SC	3.3	POST									
LSD (0.05)			7	8	8	8	8	NS	NS	6	25.4

¹ DCA-DA = a drift control agent/deposition aid. MSO = methylated seed oil. AMS = ammonium sulfate.

² PRE = preemergence. POST = postemergence.

³ DAB = days after the postemergence treatments.

Fallow Weed Control with Liberty and Enlist One Tank Mixtures and Application Timings

R.S. Currie and P.W. Geier

Summary

This study evaluated Liberty (glufosinate) and Enlist One (2,4-D choline) at three application timings and with various tank mix partners for weed control in fallow. Most herbicides tested controlled 94% or more of volunteer sorghum 17 days after the late postemergence treatments in the season. Conversely, Palmer amaranth and crabgrass control was less than 90% with most herbicides. However, control of these species was good when Tricor, or Zidua plus OpTill were applied preemergence followed by Liberty or Liberty and Enlist One late postemergence.

Introduction

Development of glyphosate-resistant weed biotypes has prompted producers to find alternative control methods. Herbicides such as Liberty and 2,4-D have potential to aid in controlling resistant weeds. Also, the use of residual herbicides prior to weed emergence can decrease the abundance of resistant weeds present in the crop. The objective of this study was to compare Liberty plus 2,4-D choline alone, and with other herbicides, at various application timings for efficacy in a fallow situation.

Materials and Methods

An experiment was conducted at the Kansas State University Southwest Research-Extension Center near Garden City, KS, to compare Liberty plus Enlist One tank mixtures at various application timings for weed control in fallow. Herbicides (Table 2) were applied using a tractor-mounted, compressed CO₂ sprayer delivering 19.4 gpa at 30 psi and 4.1 mph. Application, environmental, and weed information is shown in Table 1. Plots were 10 by 35 feet and arranged in a randomized complete block design with four replications. Soil was a Beeler silt loam with 2.4% organic matter and pH of 7.6. Visual estimates of weed control were taken on August 3 and August 21, 2020. These dates were 24 days after the early postemergence treatments (DAB), and 17 days after the late postemergence treatments (DAC), respectively.

Results and Discussion

Only four treatments controlled Palmer amaranth 90% or throughout the season: Liberty plus Enlist One and Tricor DF (metribuzin) preemergence (PRE) followed by Liberty plus Enlist One late postemergence (LPOST); Liberty plus Enlist One and Zidua SC (pyroxasulfone) PRE followed by Liberty plus Enlist One LPOST; Zidua (pyroxasulfone) plus OpTill (imazethapyr/saflufenacil); and glyphosate PRE followed by Liberty alone or with Enlist One LPOST (Table 2). Conversely, the only treatments that did not control volunteer sorghum at 90% or more, regardless of rating date, were glyphosate PRE followed by glyphosate LPOST and Liberty plus Enlist One PRE followed by Liberty plus Enlist One LPOST. At 17 DAC, crabgrass was controlled 89

to 98% by Liberty plus Enlist One and Tricor DF PRE followed by Liberty plus Enlist One LPOST; Zidua plus OpTill and glyphosate PRE followed by Liberty alone or with Enlist One; and Liberty plus glyphosate alone or with Enlist One PRE followed by Liberty plus glyphosate alone or with Enlist One LPOST.

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Table 1. Application, environmental, and weed information for the glufosinate and 2,4-D choline experiment in fallow

Application timing	Preemergence	Early postemergence	Late postemergence
Application date	June 24, 2020	July 10, 2020	August 4, 2020
Air temperature (°F)	93	73	65
Relative humidity	32	77	66
Soil temperature (°F)	83	76	64
Wind speed (mph)	6 to 10	2 to 7	6 to 11
Wind direction	South	East	Southeast
Soil moisture	Good	Good	Good
Palmer amaranth			
Height (inches)	---	2 to 15	2 to 60
Density (plants/10 ft ²)	0	40	25
Volunteer sorghum			
Height (inches)	---	2 to 6	2 to 16
Density (plants/10 ft ²)	0	2	1
Crabgrass			
Height (inches)	---	0.5 to 1	1 to 6
Density (plants/10 ft ²)	0	10	1

WEED SCIENCE

Table 2. Weed control with glufosinate and 2,4-D choline mixtures in fallow

Treatment	Rate	Timing ¹	Palmer amaranth		Volunteer sorghum		Crabgrass	
			24	17	24	17	24	17
			DAB ²	DAC ²	DAB	DAC	DAB	DAC
		oz/a	----- % Visual -----					
Glyphosate	32	PRE	0	33	0	80	0	83
Ammonium sulfate	3 lb	PRE						
Glyphosate	32	LPOST						
Ammonium sulfate	3 lb	LPOST						
Liberty	32	PRE	23	28	0	78	0	80
Enlist One	32	PRE						
Ammonium sulfate	3 lb	PRE						
Liberty	32	LPOST						
Enlist One	32	LPOST						
Ammonium sulfate	3 lb	LPOST						
Liberty	32	PRE	91	90	95	95	95	83
Enlist One	32	PRE						
Zidua SC	3	PRE						
Ammonium sulfate	3 lb	PRE						
Liberty	32	LPOST						
Enlist One	32	LPOST						
Ammonium sulfate	3 lb	LPOST						
Liberty	32	PRE	84	86	95	94	88	75
Enlist One	32	PRE						
Sonic	5	PRE						
Ammonium sulfate	3 lb	PRE						
Liberty	32	LPOST						
Enlist One	32	LPOST						
Ammonium sulfate	3 lb	LPOST						
Liberty	32	PRE	74	79	100	100	83	70
Enlist One	32	PRE						
Trivence	6	PRE						
Ammonium sulfate	3 lb	PRE						
Liberty	32	LPOST						
Enlist One	32	LPOST						
Ammonium sulfate	3 lb	LPOST						
Liberty	32	PRE	93	91	100	100	96	90
Enlist One	32	PRE						
Tricor DF	16	PRE						
Ammonium sulfate	3 lb	PRE						
Liberty	32	LPOST						
Enlist One	32	LPOST						
Ammonium sulfate	3 lb	LPOST						
Zidua	1.5	PRE	95	93	100	98	99	96
OpTill	1.5	PRE						
Glyphosate	32	PRE						
Liberty	32	LPOST						
Enlist One	32	LPOST						
Ammonium sulfate	3 lb	LPOST						

Table 2. Weed control with glufosinate and 2,4-D choline mixtures in fallow

Treatment	Rate	Timing ¹	Palmer amaranth		Volunteer sorghum		Crabgrass	
			24	17	24	17	24	17
			DAB ²	DAC ²	DAB	DAC	DAB	DAC
		oz/a	----- % Visual -----					
Zidua	1.5	PRE	96	93	99	99	99	98
OpTill	1.5	PRE						
Glyphosate	32	PRE						
Liberty	32	LPOST						
Ammonium sulfate	3 lb	LPOST						
Sharpen	1	PRE	81	86	93	100	85	73
Tricor DF	16	PRE						
Glyphosate	32	PRE						
Ammonium sulfate	3 lb	PRE						
Liberty	32	LPOST						
Enlist One	32	LPOST						
Ammonium sulfate	3 lb	LPOST						
Liberty	32	EPOST	69	45	98	100	83	73
Ammonium sulfate	3 lb	EPOST						
Liberty	32	LPOST						
Ammonium sulfate	3 lb	LPOST						
Liberty	32	EPOST	71	68	100	98	85	65
Enlist One	32	EPOST						
Ammonium sulfate	3 lb	EPOST						
Liberty	32	LPOST						
Enlist One	32	LPOST						
Ammonium sulfate	3 lb	LPOST						
Liberty	32	EPOST	81	70	100	100	88	85
Dual II Magnum	16	EPOST						
Ammonium sulfate	3 lb	EPOST						
Liberty	312	LPOST						
Ammonium sulfate	3 lb	LPOST						

continued

Table 2. Weed control with glufosinate and 2,4-D choline mixtures in fallow

Treatment	Rate	Timing ¹	Palmer amaranth		Volunteer sorghum		Crabgrass	
			24 DAB ²	17 DAC ²	24 DAB	17 DAC	24 DAB	17 DAC
		oz/a	----- % Visual -----					
Liberty	32	EPOST	85	85	99	100	83	83
Enlist One	32	EPOST						
Dual II Magnum	16	EPOST						
Ammonium sulfate	3 lb	EPOST						
Liberty	32	LPOST						
Enlist One	32	LPOST						
Ammonium sulfate	3 lb	LPOST						
Liberty	32	EPOST	74	78	100	100	85	91
Glyphosate	32	EPOST						
Ammonium sulfate	3 lb	EPOST						
Liberty	32	LPOST						
Glyphosate	32	LPOST						
Ammonium sulfate	3 lb	LPOST						
Liberty	32	EPOST	81	71	93	95	93	89
Enlist One	32	EPOST						
Glyphosate	32	EPOST						
Ammonium sulfate	3 lb	EPOST						
Liberty	32	LPOST						
Enlist One	32	LPOST						
Glyphosate	32	LPOST						
Ammonium sulfate	3 lb	LPOST						
LSD (0.05)			6	10	9	11	8	10

¹ PRE = preemergence. EPOST = early postemergence. LPOST = late postemergence.

² 24 DAB = 24 days after early postemergence treatment. 17 DAC = 17 days after late postemergence treatment.

Pixxaro Alone and in Combination for Weed Control in Fallow

P.W. Geier and R.S. Currie

Summary

The objective of this study was to compare Pixxaro (halauxifen/fluroxypyr) alone and in combinations for weed control in fallow. Pixxaro alone was equal to or better than Banvel, Starane Ultra, or glyphosate alone for kochia control. However, the best kochia control occurred when these herbicides were mixed in various combinations. Similarly, Pixxaro controlled flixweed equally as well as Banvel, Starane Ultra, or glyphosate at 7 days after treatment but flixweed control was complete regardless of herbicide later in the season.

Introduction

Kochia populations in the Central Great Plains have demonstrated resistance to multiple herbicide modes-of-action in recent years, making weed control challenging. Incorporating novel modes-of-action and tank mixtures is key in controlling this troublesome weed. The objective of this study was to compare Pixxaro alone and in combinations for weed control in fallow.

Experimental Procedures

An experiment was conducted at the Kansas State University Southwest Research-Extension Center near Garden City, KS, to compare Pixxaro alone or with competitive standards for weed control in fallow. All herbicides (Table 2) were applied postemergence using a tractor-mounted, compressed CO₂ sprayer delivering 19.4 gpa at 30 psi and 4.1 mph. Application, environmental, and weed information are shown in Table 1. Plots were 10 by 35 feet and arranged in a randomized complete block design with four replications. Soil was a Beeler silt loam with 2.4% organic matter and pH of 7.6. Visual weed control estimates were determined on May 15, May 27, and June 10, 2020. These dates were 9, 21, and 35 days after herbicide treatment (DAT).

Results and Discussion

This trial was conducted under severe drought conditions, with only 25% of normal precipitation received from the time of application until the final evaluation date. Kochia control with Pixxaro alone was equal to or better than Banvel (dicamba), Starane Ultra (fluroxypyr), or glyphosate alone at each rating date. At 35 DAT, Pixxaro alone provided 80% kochia control, whereas the tank mixtures of Banvel plus glyphosate, Starane Ultra plus dicamba and glyphosate, and Pixxaro plus Banvel and glyphosate controlled kochia 94 to 98%. Pixxaro alone controlled flixweed similarly to Banvel, Starane Ultra, and glyphosate alone early in the season. The addition of Banvel and/or glyphosate to Pixxaro alone improved flixweed control at 21 DAT, but all herbicides provided complete flixweed control by 35 DAT. More research is needed to test Pixxaro for efficacy under favorable growing conditions.

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Table 1. Application, environmental, and weed data for the Pixxaro study in fallow

Application date	May 6, 2020
Air temperature (°F)	55
Relative humidity	40
Soil temperature (°F)	59
Wind speed (mph)	1 to 4
Wind direction	North-northeast
Soil moisture	Dry
Kochia	
Height (inches)	2 to 4
Density (plants/10 ft ²)	> 100
Flixweed	
Height (inches)	8 to 12
Density (plants/10 ft ²)	20

WEED SCIENCE

Table 2. Pixxaro comparisons for efficacy in fallow

Treatment ¹	Rate oz/a	Kochia			Flixweed		
		9 DAT ²	21 DAT	35 DAT	9 DAT	21 DAT	35 DAT
		----- % Visual -----					
Pixxaro	6.0	28	63	80	20	85	100
NIS	0.25%						
Banvel	4.0	10	55	75	20	78	100
NIS	0.25%						
Pixxaro	6.0	33	73	91	28	91	100
Banvel	4.0						
NIS	0.25%						
Starane Ultra	6.4	25	63	75	20	70	100
NIS	0.25%						
Starane Ultra	6.4	23	75	93	28	85	100
Banvel	4.0						
NIS	0.25%						
Glyphosate	22	0	45	55	23	85	100
NIS	0.25%						
AMS	1.0%						
Pixxaro	6.0	30	73	89	25	91	100
Glyphosate	22						
NIS	0.25%						
AMS	1.0%						
Starane Ultra	6.4	28	73	88	28	94	100
Glyphosate	22						
NIS	0.25%						
AMS	1.0%						
Banvel	4.0	33	68	94	30	90	100
Glyphosate	22						
NIS	0.25%						
AMS	1.0%						
Starane Ultra	6.4	35	81	98	35	96	100
Banvel	4.0						
Glyphosate	22						
NIS	0.25%						
AMS	1.0%						
Pixxaro	6.0	38	81	98	35	96	100
Banvel	4.0						
Glyphosate	22						
NIS	0.25%						
AMS	1.0%						
LSD (0.05)		7	6	5	7	6	NS

¹ NIS = nonionic surfactant. AMS = ammonium sulfate.

² DAT = days after herbicide treatment.

Testing Irrigated Cotton Production

J. Aguilar, R.S. Currie, D. Tomsicek, L. Haag, and S. Duncan

Summary

Cotton research was initiated in Garden City, KS, which is the northern rim of the typical cotton production area. Initial results showed that with specific seed varieties and strategic irrigation management, cotton could be grown and provide decent yield in this region. There is still additional research that needs conducted, particularly with regards to germination and seeding rates.

Introduction

Irrigated cotton production has been predominantly centered in the Texas Panhandle. In the past several years, the production area has been moving north and into the southwest corner of Kansas. New improved varieties and the drought-tolerant characteristics of the cotton are two major reasons for this expansion in acreage. Valuable traits include short/early season varieties and tolerance to herbicide drift (e.g., 2,4-D choline, glyphosate, and glufosinate herbicides). The objective of this study was to test if irrigated cotton would thrive north of the typical cotton production area, and if it did, test its response to different planting dates and irrigation treatments.

Experimental Procedures

An experiment was conducted at the Kansas State University Southwest Research-Extension Center's Finnup Farm (38°01'20.87"N, 100°49'26.95"W, elevation of 2,910 feet above mean sea level) near Garden City, KS. The soil at the study site is a deep, well-drained Ulysses silt loam with water holding capacity of 2 in./ft. Two planting dates were evaluated each with at least 10 days apart and centered around May 15 (typical planting date), whenever the soil temperature is above 65°F. PhytoGen 210 cotton variety was planted for both years. Previous crops for the plots were either corn, grain sorghum, or wheat. The plot treatments were five irrigated (full, 60% ET, 30% ET, 1 inch at match head square (MHS), and 1 inch at MHS and another inch at boll formation) and one dryland, in a randomized complete block replicated at least 3 times. Irrigation was applied using a linear move sprinkler system (Model: Valley 8000 series, Valmont Industries, Inc., Valley, NE) with four spans and each span serving as a replicate. Each irrigation event applied 1 in. for all treatments irrigated on a given day, and irrigation treatments were based on frequency and soil water monitoring. Harvest was done using a 4-row mechanical cotton stripper and the samples were sent to Fiber and Biopolymer Research Institute in Texas for fiber analysis.

Results and Discussion

In 2019, only the later planted plot (May 30) was continued since the earlier planted plot (May 15) had a very low germination rate (<10%) and was abandoned. One of the most likely reasons for the low germination rate is the weather condition after planting, when the temperature dipped below 50°F for several days. The germination rate at the later planted plot was 43%. In 2020, the conditions were flipped, this time the germination rate of the earlier planted plot was better (53%) than the later planted plot (39%).

Results show that there were no significant differences in the lint value, lint yield, and other yield parameters across the different irrigation treatments, including dryland (Tables 1 and 2). However, there are notable numerical differences in some treatments. Fully irrigated cotton did show a diminished yield compared with other treatments. On the other hand, the strategic irrigation of 1 inch at match head square did show a consistently higher yield and lint value against other treatments.

Total soil water measurements showed that there was an aggressive use of water for the whole profile (Figure 1). By harvest time, there were not any noticeable differences in available soil water across treatments. There was a strong correlation between water productivity and lint yield, as shown in Figure 2c. A much stronger correlation existed between water use efficiency and lint yield (Figure 2d). In both cases, the higher the productivity and efficiency, the higher the lint yield.

Thus, going back to the objective of this study, it could be concluded that irrigated cotton can be grown in this region. Since the planting window for cotton is very narrow in this region, planting issues, such as the optimum condition and emergence rate, need further research. Based on this initial research, the emergence rate was spotty and poor, which was less than 50% (36% if we include the abandoned plots).

Acknowledgments

This research project received support from the U.S. Department of Agriculture Agricultural Research Service, Ogallala Aquifer Program, and USDA Natural Resources Conservation Service Conservation Innovation Grant.

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IRRIGATION

Table 1. Irrigation treatment averages on irrigation amount, loan average, lint yield, Micronaire (MIC), and lint value in 2019

Treatments	Total irrigation	Loan average	Lint yield	Average of MIC	Lint value
	in.	\$/lb	lb/a		\$/a
Fully irrigated (100% ET)	5	0.36	658	2.61	238
Partially irrigated (66% ET)	4	0.41	845	2.87	344
Limited irrigated (33% ET)	1	0.48	1,061	3.46	507
Dryland	0	0.48	787	3.67	379
One irrigation (1.00 in.) at match head square only	1	0.45	902	3.28	408
One irrigation (1.00 in.) at match head square and at boll formation	2	0.41	820	2.89	334
Average		0.43	845	3.13	368

ET = evapotranspiration. Loan average = adjusted loan rate average.

Table 2. Water treatment effect on cotton lint yield, water productivity, irrigation water use efficiency (IWUE), Micronaire, loan value, and lint value in 2020

Factors	Micronaire	Lint yield	Productivity	IWUE	Loan value	Lint value
	Mass/length	lb/a	lb/a-in.		\$/lb	\$/a
Water treatments						
1. 100% ET	2.2	638.7	62.3	851.5	0.3	195.0
2. One irrigation MHS and Boll	2.2	735.4	71.8	980.5	0.3	220.9
3. 66% ET	2.1	387.7	39.2	516.9	0.3	115.7
4. One Irrigation MHS Only	2.4	766.6	82.1	1022.2	0.4	292.4
5. 33% ET	2.2	434.3	46.9	579.0	0.3	130.2
6. Dryland	2.4	683.9	81.5	---	0.4	290.6
HSD ¹	NS	NS	NS	NS	NS	NS
Type 3 test						
Pr > F	0.3912	0.5886	0.5759	0.2623	0.4511	0.5326

¹HSD = Tukey's Honest Significant Difference Test. HSD is the minimum difference between two treatments used to declare they are significantly different at $P < 0.05$.

Bold treatments and numbers represent results that are relatively low, even though the statistical test showed no significant difference. MHS = match head square. ET = evapotranspiration.

IRRIGATION

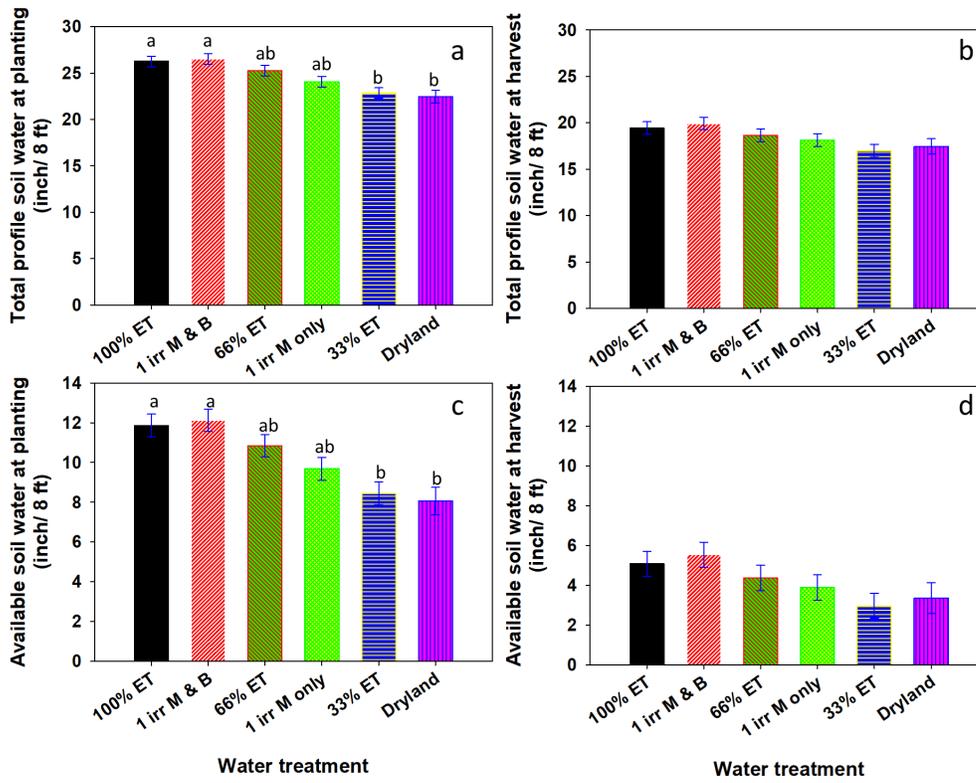


Figure 1. Total soil water (a) at planting and (b) at harvest; and available soil water (c) at planting and (d) at harvest of cotton across water treatments. Error bars are standard errors and bars with the same letters or no letter are not significantly different ($P < 0.05$). M = match head square. B = boll. ET = evapotranspiration.

IRRIGATION

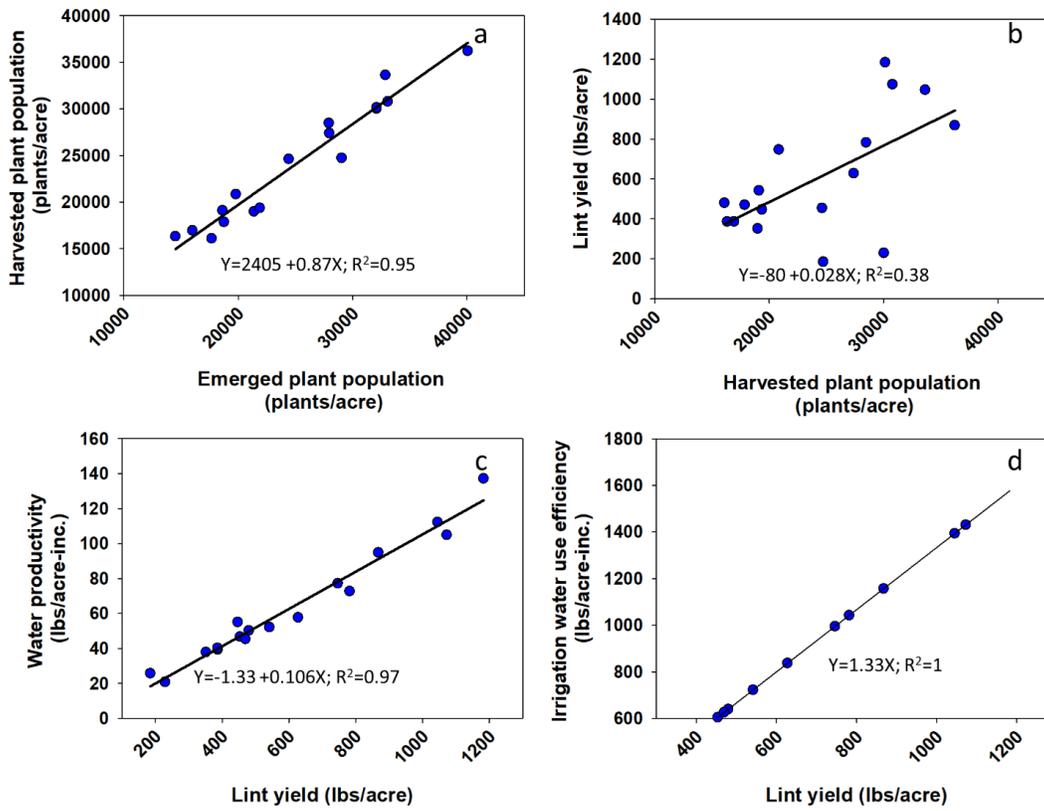


Figure 2. Simple linear relationships between (a) emerged plant population and harvested plant population, (b) harvested plant population and lint yield, (c) lint yield and productivity, and (d) lint yield and irrigation water use efficiency.

Working with Less Water for Corn Production

A. Schlegel, F. Lamm, and D. O'Brien

Summary

Research was conducted at Colby and Tribune, KS, from 2018–2020 to evaluate irrigation strategies, hybrid maturity, and seeding rate on corn production. Irrigation strategies were a combination of irrigation frequency/timing (weekly or bi-weekly) applied pre- and post-silking, and irrigation amounts (1 and 1.5 inch/week). Hybrid maturities were 108- and 111-day hybrids planted at 25,000 and 30,000 seeds/a. Average irrigation amounts ranged from 7.33 to 12.50 in. at Colby and 8.41 to 13.44 in. at Tribune. At Colby, average corn yields were not affected by irrigation strategies or seeding rate but were 8 bu/a greater with the 108-day hybrid. At Tribune, average corn yields were greater with weekly post-silking irrigation and with the higher seeding rate but not affected by hybrid maturity. The water limitations in this study are relatively severe and these results might not replicate under less stressful irrigation regimes.

Introduction

As producers move to deficit irrigation strategies, evapotranspiration-based irrigation scheduling can be useful in alerting the producer to soil water conditions and can help the producer decide when to allocate their limited water supply. Institutional constraints (Local Enhanced Management Area (LEMAs)) will require producers to adjust and adapt their irrigation management. The objective of this study was to determine corn grain yield and yield component response, water use, and crop water use efficiency as affected by irrigation amounts and timing (4 treatments), 2 corn hybrids, and 2 plant populations.

Procedures

Research was initiated in 2018 at the Kansas State University Southwest Research-Extension Center near Tribune and at the Northwest Research-Extension Center near Colby on deep silt loam soils. For the purposes of this study the irrigation season was separated into the pre-silking and post-silking periods. The specific goal was not to mimic the actual pumping capacities of the wells but to manage total amount of applied irrigation that may be restricted by institutional constraints (e.g., LEMAs, water conservation areas). Overall, two well capacities were simulated for the peak irrigation need during any period.

Higher capacity well, equivalent to 505 gpm/125 acres

1. Apply as needed: 1.5 inches of irrigation weekly during the pre-silking period, and 1.5 inches every two weeks for the post-silking period.
2. Apply as needed: 1.5 inches of irrigation every two weeks during the pre-silking period, and 1.5 inches weekly for the post-silking period.

Lower capacity well, equivalent to 337 gpm/125 acres

3. Apply as needed: 1.0 inch of irrigation weekly during the pre-silking period, and 1.0 inch every two weeks for the post-silking period.
4. Apply as needed: 1.0 inch of irrigation every two weeks during the pre-silking period, and 1.0 inches weekly for the post-silking period.

The experimental design used irrigation treatment as the whole plot, with hybrid (108- and 111-day hybrids) and plant density (25,000 and 30,000 seeds/a) as subplots with 4 replications. Soil water was measured in the complete root zone with a neutron probe to help quantify periods of water stress and to determine crop water use. Weather data were measured using the automated Kansas Mesonet weather stations located on the research centers (<https://mesonet.k-state.edu/>). Corn grain yield was determined by harvesting a representative sample after physiological maturity, which enabled the determination of all corn yield components (grain yield, plant density, ears/plant, kernels/ear, and kernel mass).

Results and Discussion

Annual and average (2018–2020) corn yields for Colby are shown in Tables 1 and 3. Averaged across all treatments, corn yields were greater in 2019 (228 bu/a) than in 2018 (207 bu/a) and 2020 (201 bu/a). Average seasonal irrigation amounts were 10.00, 12.50, 7.33, and 9.33 inches for treatments 1, 2, 3, and 4, respectively. Averaged across years, there were no yield differences among irrigation treatments or plant population (Table 3). However, the 108-day hybrid yielded 8 bu/a more than the 111-day hybrid (216 vs. 208 bu/a) primarily due to increased number of kernels/ear. The number of kernels/ear decreased with increased seeding rate, but was compensated for by the greater plant density. Water use increased with increases in irrigation amounts while water use efficiency tended to decrease.

At Tribune, corn yields (averaged across all treatments) were greater in 2018 (213 bu/a) than 2019 (194 bu/a) and 2020 (202 bu/a) (Table 2). Average seasonal irrigation amounts were 11.81, 10.65, 9.02, and 9.71 inches for treatments 1, 2, 3, and 4, respectively. Averaged across years, the irrigation treatments with weekly irrigation post-silking (treatment 2 at 211 bu/a and treatment 4 at 207 bu/a) produced the highest yields, primarily due to increased kernel mass (Table 4). Hybrid maturity had no effect on grain yield, while increasing the seeding rate from 25,000 to 30,000 seeds/a increased yields by 6 bu/a even though there was a decrease in the number of kernels/ear. Similar to Colby, water use increased with increased irrigation amounts but there were no significant differences in water use efficiency.

In this study with limited water allocations, there tended to be an advantage to shifting water to the post-silking period with these hybrids at these seeding rates. In general, the higher seeding rate (30,000/a) produced similar or greater yields. Averaged across the two locations, the shorter season hybrid obtained greater yields. The water limitations in this study are relatively severe and these results might not repeat under less stressful irrigation regimes.

Acknowledgment

The project was funded in part by the Kansas Corn Commission.

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Table 1. Grain yields by across years, Colby, KS, 2018–2020

Trt	in./wk	Frequency	Hybrid	Seed rate 1000/a	Year			Average
					2018	2019	2020	
		Pre - Post			----- bu/a -----			
1	1.5	wk - 2 wk	P0801	25	210	244	220	224
				30	232	250	209	230
			P1197	25	206	220	199	208
				30	230	210	196	212
2	1.5	2 wk - wk	P0801	25	196	234	214	215
				30	197	237	196	210
			P1197	25	211	215	201	209
				30	190	228	210	209
3	1.0	wk - 2 wk	P0801	25	192	218	183	198
				30	230	219	189	213
			P1197	25	178	239	218	212
				30	210	223	199	211
4	1.0	2 wk - wk	P0801	25	230	226	188	214
				30	210	244	220	224
			P1197	25	232	250	209	230
				30	206	220	199	208

IRRIGATION

Table 2. Grain yields by across years, Tribune, KS, 2018–2020

Trt	in./wk	Frequency	Hybrid	Seed rate	Year			Average
					2018	2019	2020	
		Pre - Post		1000/a	----- bu/a -----			
1	1.5	wk - 2 wk	P0801	25	204	189	206	199
				30	209	208	206	208
			P1197	25	203	193	203	200
				30	216	180	208	201
2	1.5	2 wk - wk	P0801	25	210	205	190	202
				30	225	211	207	214
			P1197	25	225	216	196	212
				30	223	220	206	216
3	1.0	wk - 2 wk	P0801	25	198	187	188	191
				30	196	198	204	199
			P1197	25	220	165	188	191
				30	197	158	196	183
4	1.0	2 wk - wk	P0801	25	218	185	203	202
				30	213	205	206	208
			P1197	25	220	187	209	205
				30	231	197	216	215

IRRIGATION

Table 3. Irrigation frequency, hybrid, and population on corn yield and yield components, Colby, KS, 2018–2020

Trt	in./wk	Frequency	Hybrid	Seed rate	Yield	WUE*	Plant pop.	Ear/plant	1000 seed	Kernels	Water use
		Pre - Post		1000/a	bu/a	lb/a-in.	1000/a		oz	No./ear	in.
1	1.5	wk - 2 wk	P0801	25	224	501	26.1	0.96	11.66	692	25.10
				30	230	520	29.8	0.98	11.53	615	24.82
			P1197	25	208	476	26.4	0.98	12.29	593	24.58
				30	212	477	29.5	0.99	11.88	550	24.95
2	1.5	2 wk - wk	P0801	25	214	472	25.6	0.99	11.45	671	25.37
				30	215	469	29.3	0.98	11.25	598	25.67
			P1197	25	210	449	26.5	0.97	11.98	618	26.21
				30	209	455	29.5	0.98	12.22	535	25.80
3	1.0	wk - 2 wk	P0801	25	209	506	25.8	0.97	11.47	667	23.15
				30	211	506	29.1	0.97	11.36	596	23.29
			P1197	25	198	487	26.1	0.97	12.12	585	22.79
				30	213	510	29.5	0.99	11.78	557	23.34
4	1.0	2 wk - wk	P0801	25	212	503	25.8	1.00	11.56	647	23.72
				30	211	487	29.3	0.98	11.29	588	24.33
			P1197	25	203	471	26.4	0.97	12.23	583	24.09
				30	214	496	29.0	0.97	11.93	575	24.23
MEANS											
1					219	494 a	28.0	0.98	11.84	613	24.86 b
2					212	461 b	27.7	0.98	11.72	606	25.76 a
3					208	502 a	27.6	0.97	11.68	601	23.14 d
4					210	489 a	27.6	0.98	11.76	598	24.09 c
LSD _{0.05}					NS	19	NS	NS	NS	NS	0.47
			P0801		216 a	495	27.6	0.98	11.45 b	634 a	24.43
			P1197		208 b	478	27.9	0.97	12.05 a	575 b	24.50
			LSD _{0.05}		6	NS	NS	NS	0.16	15	NS
				25	210	483	26.1 b	0.98	11.85	632 a	24.37
				30	214	490	29.4 a	0.98	11.66	577 b	24.56
			LSD _{0.05}		NS	NS	0.3	NS	NS	15	NS

Note: WUE = water use efficiency. July 23 was the average silking date.

Average irrigation levels by treatment were 1 = 10.00 in., 2 = 12.50 in., 3 = 7.33 in., 4 = 9.33 in.

Irrigation Treatment

1 = 1.5 in. weekly pre-silk; every 2 weeks post-silk.

2 = 1.5 in. every 2 weeks pre-silk; weekly post-silk.

3 = 1.0 in. weekly pre-silk; every 2 weeks post-silk.

4 = 1.0 in. every 2 weeks pre-silk; weekly post-silk.

Means within a column with the same letter are not statistically different at $P = 0.05$.

IRRIGATION

Table 4. Irrigation frequency, hybrid, and population on corn yield and yield components, Tribune, KS, 2018–2020

Trt	in./wk	Frequency	Hybrid	Seed rate	Yield	WUE*	Plant pop.	Ear/plant	1000 seed	Kernels	Water use
		Pre - Post		1000/a	bu/a	lb/a-in.	1000/a		oz	no./ear	in.
1	1.5	wk - 2 wk	P0801	25	199	411	22.5	1.01	12.27	640	27.21
				30	208	431	26.9	0.99	11.95	586	27.06
			P1197	25	200	410	23.6	1.02	12.92	575	27.38
				30	201	408	28.4	1.00	12.37	516	27.79
2	1.5	2 wk - wk	P0801	25	202	413	22.7	1.00	12.36	641	27.53
				30	214	430	26.9	1.00	12.03	596	28.09
			P1197	25	212	423	23.7	1.04	12.91	596	28.23
				30	216	426	28.3	1.02	12.67	531	28.57
3	1.0	wk - 2 wk	P0801	25	191	431	22.8	1.00	11.78	638	24.97
				30	199	454	27.4	0.98	11.68	570	24.62
			P1197	25	191	426	23.6	1.03	12.42	568	25.22
				30	183	407	28.4	0.99	11.87	489	25.37
4	1.0	2 wk - wk	P0801	25	202	448	22.9	1.00	12.14	651	25.28
				30	208	448	27.5	0.99	11.86	578	26.02
			P1197	25	205	443	23.9	1.05	12.91	570	26.24
				30	215	465	28.6	1.01	12.30	545	25.91
MEANS											
1					202 b	415	25.4	1.01	12.38 a	579	27.36 ab
2					211 a	423	25.4	1.02	12.49 a	591	28.11 a
3					191 c	430	25.6	1.00	11.94 b	566	25.04 c
4					207 ab	451	25.7	1.01	12.30 a	586	25.86 bc
LSD _{0.05}					9	26	0.5	0.01	0.26	22	1.64
			P0801		203	433	25.0 b	1.00 b	12.01 b	613 a	26.35 b
			P1197		203	426	26.1 a	1.02 a	12.55 a	548 b	26.84 a
			LSD _{0.05}		4	10	0.3	0.01	0.12	11	0.32
				25	200 b	425	23.2 b	1.02 a	12.46 a	610 a	26.51
				30	206 a	434	27.8 a	1.00 b	12.09 b	551 b	26.68
				LSD _{0.05}	4	10	0.3	0.01	0.12	11	0.32

Note: WUE = water use efficiency. July 21 was the average silking date.

Average irrigation levels by treatment were 1 = 11.61 in., 2 = 13.44 in., 3 = 8.41 in., 4 = 9.79 in.

Irrigation Treatment

1 = 1.5 in. weekly pre-silk; every 2 weeks post-silk.

2 = 1.5 in. every 2 weeks pre-silk; weekly post-silk.

3 = 1.0 in. weekly pre-silk; every 2 weeks post-silk.

4 = 1.0 in. every 2 weeks pre-silk; weekly post-silk.

Means within a column with the same letter are not statistically different at $P = 0.05$.

Alternative Cropping Systems with Limited Irrigation

A. Schlegel and D. Bond

Summary

A limited irrigation study involving four cropping systems and evaluating four crop rotations was initiated at the Southwest Research-Extension Center near Tribune, KS, in 2012. The cropping systems were two annual systems (continuous corn and continuous grain sorghum) and two 2-year systems (corn-grain sorghum and corn-winter wheat). In 2020, corn yields were similar for all rotations, although averaged across the past 8 years, corn yields were greater following wheat than following corn. There were no significant differences in grain sorghum yields in 2020, which was similar to the multi-year average. Wheat yields were below the multi-year average.

Experimental Procedures

A crop rotation study under sprinkler irrigation at the Kansas State University Southwest Research-Extension Center near Tribune, KS, was initiated in the spring of 2012. The study evaluates four different crop rotations with a limited irrigation allocation. The rotations include 1- and 2-year rotations. The crop rotations are 1) continuous corn; 2) corn-winter wheat; 3) corn-grain sorghum; and 4) continuous grain sorghum (a total of 6 treatments). All rotations are limited to 10 inches of irrigation water annually. All crops are grown no-till, while other cultural practices (hybrid selection, fertility practices, weed control, etc.) are selected to optimize production. All phases of each rotation are present each year and replicated four times. Irrigations are scheduled to supply water at the most critical stress periods for the specific crops and limited to 1.5 inches per week. Soil water is measured at planting, during the growing season, and at harvest in 1-ft increments to a depth of 8 ft. Grain yields are determined by machine harvest. Nitrogen fertilizer (UAN) was surface applied (stream) in March to all crops (240 lb N/a for corn, 160 lb N/a for sorghum, and 120 lb N/a for wheat). Corn was planted on May 4, 2020, and harvested on September 29, 2020. Grain sorghum was planted on May 20, 2020, and harvested on October 20, 2020. Wheat was planted on September 26, 2019, and harvested on July 1, 2020.

Results and Discussion

Wheat yields in 2020 (33 bu/a) were less than the long-term average (51 bu/a) (Tables 1 and 2). Precipitation was near normal from April through September (13.13 inches in 2020 vs. normal of 12.93 inches). Corn yields in 2020 were slightly below the long-term average with no differences among rotations. Grain sorghum yields were near the long-term average with no differences among rotations. On average, corn yields were greatest following wheat and least following corn, with little difference in grain sorghum yields following corn or sorghum (Table 2).

Available soil water at corn and sorghum planting and harvest was similar for all rotations in 2020 (Table 3). Fallow accumulation prior to corn was greatest following wheat and least following sorghum, reflecting the available water at previous harvest

IRRIGATION

and length of the fallow periods. Fallow efficiency prior to corn was greater following corn than sorghum, possibly because of the lower amount of available soil water at corn harvest in 2019 compared with sorghum harvest. Averaged across the 8-year period, fallow accumulation prior to corn was greater following wheat than following sorghum or corn; however, fallow efficiency was greatest following sorghum (shortest fallow period) [Table 4]. For sorghum in 2020, fallow accumulation and efficiency were greater following corn than sorghum. Fallow accumulation prior to sorghum was also greater following corn than sorghum when averaged across the 8-year period. There were no differences in crop water use due to rotation for either crop in 2020 or averaged across years.

Acknowledgment

The project was funded in part by the Western Kansas Groundwater Management District No. 1.

Table 1. Grain yield of three crops under limited irrigation as affected by rotation in 2020

Rotation	Corn	Wheat	Sorghum
	----- bu/a -----		
Continuous corn	163	---	---
Corn-wheat	187	33	---
Corn-sorghum	180	---	132
Continuous sorghum	---	---	140
LSD _{0.05}	27	---	11
ANOVA (P > F)			
System	0.158	---	0.111

LSD = least significant difference. ANOVA = analysis of variance.

IRRIGATION

Table 2. Grain yields of three crops under limited irrigation as affected by rotation across years 2013–2020

Rotation	Corn	Wheat	Sorghum
	----- bu/a -----		
Continuous corn	175 b*	---	---
Corn-wheat	199 a	51	---
Corn-sorghum	187 ab	---	137
Continuous sorghum	---	---	135
LSD _{0.05}	17	---	6
ANOVA (P > F)			
System	0.041	---	0.585

LSD = least significant difference. ANOVA = analysis of variance.

* Means within a column with the same letter are not statistically different at $P = 0.05$.

Table 3. Profile available soil water, crop water use, and fallow accumulation for crop rotations under limited irrigation, Tribune, KS, 2020

Crop	Rotation	Available water			Crop water use	Fallow accumulation	Fallow efficiency
		Previous harvest	Planting	Harvest			
		----- inches -----					%
Corn	C-C	11.06	13.10	10.60	25.70	2.04 b*	40 a
	C-W	8.05	12.97	9.89	26.29	4.93 a	47 a
	C-GS	12.24	12.91	10.19	25.92	0.67 c	14 b
	LSD _{0.05}	4.44	4.70	3.52	2.15	1.35	26
ANOVA (P > F)							
System		0.136	0.995	0.886	0.801	0.001	0.048
Wheat	C-W	9.15	9.15	9.16	14.05	---	---
ANOVA (P > F)							
System		---	---	---	---	---	---
Sorghum	C-GS	9.15 b	12.01	9.57	24.34	2.86 a	47 a
	GS-GS	11.24 a	13.01	9.57	25.33	1.77 b	31 b
	LSD _{0.05}	1.97	2.22	0.81	2.48	0.60	10
ANOVA (P > F)							
System		0.043	0.248	0.979	0.294	0.011	0.016

Note: All crops received ~10 inches of irrigation.

In-season rainfall for corn (5/05 to 9/28) = 13.06 in.; sorghum (5/20 to 10/20) = 12.06 in.; and wheat (9/25/2019 to 6/29/2020) = 8.75 in.

C = corn. W = wheat. GS = grain sorghum. LSD = least significant difference. ANOVA = analysis of variance.

* Means within a column for a crop with the same letter are not statistically different at $P = 0.05$.

IRRIGATION

Table 4. Profile available soil water, crop water use, and fallow accumulation for crop rotations under limited irrigation across years, Tribune, KS, 2013–2020

Crop	Rotation	Available water			Crop water use	Fallow accumulation	Fallow efficiency
		Previous harvest	Planting	Harvest			
		----- inches -----					%
Corn	C-C	11.66	13.96 a*	11.88 a	26.28	2.30 b	26 ab
	C-W	10.83	13.94 a	11.59 a	26.55	3.11 a	23 b
	C-GS	11.05	12.62 b	10.49 b	26.33	1.57 c	30 a
LSD _{0.05}		0.76	0.63	0.72	0.58	0.41	6
ANOVA (P > F)							
System		0.089	0.001	0.001	0.613	0.001	0.048
Year		0.001	0.001	0.001	0.001	0.001	0.001
System × year		0.001	0.001	0.004	0.006	0.001	0.001
Wheat	C-W	11.48	11.48	10.73	19.21	---	---
ANOVA (P > F)							
System		---	---	---	---	---	---
Year		0.001	0.001	0.001	0.001	--	--
System × year		---	---	---	---	---	---
Sorghum	C-GS	10.06	13.42	11.54	23.56	3.36 a	31
	GS-GS	10.71	13.22	11.25	23.66	2.52 b	29
LSD _{0.05}		0.74	0.60	0.64	0.37	0.42	6
ANOVA (P>F)							
System		0.085	0.515	0.363	0.591	0.001	0.530
Year		0.001	0.001	0.001	0.001	0.001	0.001
System × year		0.001	0.001	0.496	0.049	0.001	0.001

Note: All crops received ~10 inches of irrigation each year.

C = corn, W = wheat, GS = grain sorghum, LSD = least significant difference, ANOVA = analysis of variance.

* Means within a column with the same letter are not statistically different at $P = 0.05$.

Irrigated Corn Response to Long-Term Nitrogen and Phosphorus Fertilization

A. Schlegel and D. Bond

Summary

Long-term research shows that phosphorus (P) and nitrogen (N) fertilizer must be applied to optimize production of irrigated corn in western Kansas. In 2020, N applied alone increased yields by 85 bu/a, whereas P applied alone increased yields 10 bu/a. Nitrogen and P applied together increased yields up to 136 bu/a which is 11 bu/a less than the 10-year average of 147 bu/a. The application of 120 lb N/a (with highest P rate) produced 98% of maximum yield in 2020, which is greater than the 10-year average (2011–2020). The application of 80 instead of 40 lb P₂O₅/a increased average yields 1 bu/a. The 10-year average grain N content reached a maximum of 0.6 lb/bu while grain P content reached a maximum of 0.15 lb/bu (0.34 lb P₂O₅/bu). At the highest N and P rate, apparent fertilizer nitrogen recovery in the grain (AFNR_g) was 43% and apparent fertilizer phosphorus recovery in the grain (AFPR_g) was 63%. Nitrogen fertilization increased soil organic matter and decreased soil pH. Phosphorus fertilization at 40 lb/a P₂O₅ was not sufficient to maintain soil test levels.

Introduction

This study was initiated in 1961 to determine responses of continuous corn and grain sorghum grown under flood irrigation to N, P, and potassium (K) fertilization. The study is conducted on a Ulysses silt loam soil with an inherently high K content. No yield benefit to corn from K fertilization was observed in 30 years, and soil K levels remained high, so the K treatment was discontinued in 1992 and replaced with a higher P rate.

Procedures

This field study is conducted at the Tribune Unit of the Kansas State University Southwest Research-Extension Center. Fertilizer treatments initiated in 1961 are N rates of 0, 40, 80, 120, 160, and 200 lb/a without P and K; with 40 lb/a P₂O₅ and zero K; and with 40 lb/a P₂O₅ and 40 lb/a K₂O. The treatments were changed in 1992; the K variable was replaced by a higher rate of P (80 lb/a P₂O₅). All fertilizers were broadcast by hand in the spring and incorporated before planting. The soil is a Ulysses silt loam. The corn hybrids (Pioneer 1151XR, 2011; Pioneer 0832, 2012–2013; Pioneer 1186AM, 2014; Pioneer 35F48 AM1, 2015; Pioneer 1197, 2016; Pioneer 0801, 2017–2018; Pioneer 0339, 2019; and Mycogen 10Z29, 2020) were planted at about 32,000 seeds/a in late April or early May. Hail damaged the 2017, 2019, and 2020 crops. The corn is irrigated to minimize water stress. Sprinkler irrigation has been used since 2001. The center two rows of each plot are machine harvested after physiological maturity. Grain yields are adjusted to 15.5% moisture. Grain samples were collected at harvest, dried, ground, and analyzed for N and P concentrations. Grain N and P content (lb/bu) and removal (lb/a) were calculated. Apparent fertilizer N recovery in the grain (AFNR_g) was calculated as N uptake in treatments receiving N fertilizer minus N uptake in the unfertilized control divided by N rate. The same approach was used to calculate

apparent fertilizer P recovery in the grain (AFPR_g). After harvest in 2020, all plots were soil sampled (8 probes/plot) to a depth of 6 inches, dried, and ground. Servi-Tech Laboratories analyzed the samples for soil pH, organic matter (OM), P (Bray-1 and Mehlich-3), K, zinc (Zn), manganese (Mn), and iron (Fe).

Results

Corn yields in 2020 were only 1% higher than the 10-year average (Table 1). Nitrogen alone increased yields 85 bu/a, whereas P alone increased yields 10 bu/a. However, N and P applied together increased corn yields up to 136 bu/a. Maximum yield was obtained with 200 lb/a N with 80 lb/a P₂O₅. Corn yields in 2020 (averaged across all N rates) were 1 bu/a greater with 80 than with 40 lb/a P₂O₅.

The 10-year average grain N concentration (%) increased with N rates but tended to decrease when P was also applied, presumably because of higher grain yields diluting N content (Table 2). Grain N content reached a maximum of 0.6 lb/bu. Nitrogen removal (lb/a) was greater at the higher yield levels. Maximum N removal (121 lb/a), was attained with 200 lb N and 80 lb P₂O₅/a. At the highest N and P rate, AFNR_g was 43% and AFPR_g was 63%. Similar to N, the average P concentration increased with increased P rates but decreased with higher N rates. Grain P content (lb/bu) of about 0.15 lb P/bu (0.34 lb P₂O₅/bu) was greater at the highest P rate with low N rates. Grain P removal averaged 31 lb P/a at the highest yields.

After 60 years, pH of the surface soil was decreased up to 0.5 unit by N fertilization (Table 3). Nitrogen fertilization increased soil OM, Mn, and Fe concentrations while decreasing P and Zn concentrations. Phosphorus fertilization slightly increased OM and substantially increased P (both Bray-1 and Mehlich-3) and Zn concentrations with little effect on other soil properties. The original soil test P level (in 1961) was about 17 ppm (Bray-1), so annual applications of 40 lb/a P₂O₅ was not sufficient to maintain soil test P levels but 80 lb/a increased soil test P levels.

Acknowledgment

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IRRIGATION

Table 1. Nitrogen (N) and phosphorus (P) fertilization on irrigated corn yields, Tribune, KS, 2011–2020

Fertilizer		Yield										
N	P ₂ O ₅	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Mean
---- lb/a ----		----- bu/a -----										
0	0	92	86	70	86	92	74	44	82	76	79	78
0	40	111	85	80	95	103	78	47	93	86	88	87
0	80	105	94	91	98	104	86	52	99	83	89	90
40	0	114	109	97	106	113	105	60	110	93	98	100
40	40	195	138	125	153	164	145	92	160	156	168	150
40	80	194	135	126	149	162	135	90	159	154	153	146
80	0	136	128	112	117	131	118	70	117	117	121	117
80	40	212	197	170	187	195	196	132	212	183	191	187
80	80	220	194	149	179	193	193	129	207	189	191	184
120	0	119	134	114	115	124	109	62	102	95	100	107
120	40	222	213	204	213	212	212	142	218	193	205	204
120	80	225	211	194	216	216	223	162	243	201	210	210
160	0	157	158	122	128	144	142	84	139	133	129	133
160	40	229	227	199	211	215	226	154	230	196	206	209
160	80	226	239	217	233	216	238	165	251	191	208	218
200	0	179	170	139	144	162	159	114	158	147	164	154
200	40	218	225	198	204	214	216	148	231	186	205	205
200	80	231	260	220	238	221	235	174	243	207	215	225

continued

IRRIGATION

Table 1. Nitrogen (N) and phosphorus (P) fertilization on irrigated corn yields, Tribune, KS, 2011–2020

Fertilizer		Yield										
N	P ₂ O ₅	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Mean
---- lb/a ----		----- bu/a -----										
ANOVA (P>F)												
Nitrogen		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Phosphorus		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
N × P		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
MEANS												
Nitrogen, lb/a												
0		103 d	88 f	80 e	93 e	100 e	79 e	48 e	91 d	82 d	85 e	85 e
40		167 c	127 e	116 d	136 d	146 d	129 d	81 d	143 c	135 c	140 d	132 d
80		189 b	173 d	143 c	161 c	173 c	169 c	110 c	179 b	163 b	168 c	163 c
120		189 b	186 c	171 b	181 b	184 b	182 b	122 b	188 b	163 b	172 bc	174 b
160		204 a	208 b	179 ab	190 ab	192 ab	202 a	134 a	207 a	173 ab	181 b	187 a
200		209 a	218 a	186 a	196 a	199 a	203 a	145 a	211 a	180 a	195 a	194 a
LSD _(0.05)		13	10	10	10	9	10	11	13	13	13	8
P ₂ O ₅ , lb/a												
0		133 b	131 c	109 b	116 c	128 b	118 b	72 c	118 c	110 b	115 b	115 b
40		198 a	181 b	163 a	177 b	184 a	179 a	119 b	191 b	167 a	177 a	173 a
80		200 a	189 a	166 a	186 a	185 a	185 a	129 a	200 a	171 a	178 a	179 a
LSD _(0.05)		9	7	7	7	6	7	8	9	9	9	6

Different letters in the same column indicate significant differences ($P < 0.05$).

Hail events occurred on 8/18/2017, 9/20/2019, and 8/10/2020.

IRRIGATION

Table 2. Nitrogen (N) and phosphorus (P) fertilization on grain N and P content of irrigated corn, Tribune, KS, 2011–2020

Fertilizer		Grain				Grain removal			
N	P ₂ O ₅	N	P	N	P	N	P	*AFNR _g	*AFPR _g
----- lb/a -----		----- % -----		----- lb/bu -----		----- lb/a -----		----- % -----	
0	0	0.96	0.231	0.46	0.109	36	9	---	---
0	40	0.91	0.312	0.43	0.148	37	13	---	24
0	80	0.91	0.324	0.43	0.153	39	14	---	15
40	0	1.15	0.187	0.55	0.088	54	9	47	---
40	40	0.93	0.300	0.44	0.142	66	21	77	71
40	80	0.94	0.319	0.44	0.151	65	22	74	38
80	0	1.25	0.182	0.59	0.086	68	10	41	---
80	40	1.02	0.250	0.48	0.118	90	22	69	76
80	80	0.99	0.307	0.47	0.145	86	27	64	51
120	0	1.28	0.175	0.60	0.083	64	9	24	---
120	40	1.10	0.228	0.52	0.108	106	22	59	75
120	80	1.06	0.293	0.50	0.139	106	29	59	58
160	0	1.25	0.180	0.59	0.085	78	11	27	---
160	40	1.15	0.241	0.54	0.114	114	24	49	86
160	80	1.13	0.273	0.53	0.129	116	28	51	55
200	0	1.21	0.190	0.57	0.090	87	14	26	---
200	40	1.14	0.232	0.54	0.110	110	23	38	79
200	80	1.14	0.290	0.54	0.137	121	31	43	63

continued

IRRIGATION

Table 2. Nitrogen (N) and phosphorus (P) fertilization on grain N and P content of irrigated corn, Tribune, KS, 2011–2020

Fertilizer		Grain				Grain removal			
N	P ₂ O ₅	N	P	N	P	N	P	*AFNR _g	*AFPR _g
----- lb/a -----		----- % -----		----- lb/bu -----		----- lb/a -----		----- % -----	
ANOVA (P>F)									
Nitrogen		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001	0.001	0.001	---	0.001
Quadratic		0.001	0.001	0.001	0.001	0.001	0.001	---	0.001
Phosphorus		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001	0.001	0.001	0.001	---
Quadratic		0.001	0.001	0.001	0.001	0.001	0.001	0.001	---
N × P		0.001	0.001	0.001	0.001	0.001	0.001	0.047	0.056
MEANS									
Nitrogen, lb/a									
0		0.93 d	0.289 a	0.44 d	0.137 a	37 e	12 e	---	20 c
40		1.01 c	0.269 b	0.48 c	0.127 b	62 d	17 d	66 a	55 b
80		1.09 b	0.246 c	0.51 b	0.117 c	82 c	20 c	58 b	64 a
120		1.15 a	0.232 d	0.54 a	0.110 d	92 b	20 bc	47 c	67 a
160		1.17 a	0.231 d	0.56 a	0.109 d	103 a	21 ab	42 c	71 a
200		1.16 a	0.237 cd	0.55 a	0.112 cd	106 a	22 a	35 d	71 a
LSD _(0.05)		0.03	0.011	0.01	0.005	4	1	5	9
P ₂ O ₅ , lb/a									
0		1.18 a	0.191 c	0.56 a	0.090 c	65 b	10 c	33 b	---
40		1.04 b	0.260 b	0.49 b	0.123 b	87 a	21 b	58 a	69 a
80		1.03 b	0.301 a	0.49 b	0.143 a	89 a	25 a	58 a	47 b
LSD _(0.05)		0.02	0.008	0.01	0.004	3	1	4	5

*AFNR_g, AFPR_g = Apparent Fertilizer N Recovery (grain), Apparent Fertilizer P Recovery (grain).
 Different letters in the same column indicate significant differences (P < 0.05).

IRRIGATION

Table 3. Effect of 60 years of nitrogen (N) and phosphorus (P) fertilizers to irrigated corn on soil properties (0–6 inch), Tribune, KS, 2020

N	P ₂ O ₅	pH	OM	Mehlich		K	Zn	Mn	Fe
				Bray 1 P	3P				
----- lb/acre -----			%	----- ppm -----					
0	0	8.0	1.7	5	11	589	0.74	4.2	5.2
0	40	8.1	1.8	26	49	586	0.92	4.4	5.6
0	80	8.0	1.8	54	86	597	0.94	4.6	5.6
40	0	8.0	1.8	6	16	576	0.74	4.2	5.0
40	40	7.9	1.9	17	34	640	0.88	4.8	5.6
40	80	7.9	2.0	43	74	668	1.00	5.0	6.2
80	0	7.9	1.9	5	11	615	0.68	4.8	5.8
80	40	7.9	2.0	10	22	620	0.70	4.8	5.6
80	80	7.9	2.0	30	55	641	0.92	5.0	5.8
120	0	7.8	1.9	4	10	571	0.66	4.4	5.2
120	40	7.9	2.0	10	22	623	0.72	5.0	5.4
120	80	7.8	2.1	26	52	643	0.92	4.8	6.0
160	0	7.6	1.9	6	14	594	0.70	5.4	5.8
160	40	7.6	2.0	10	22	622	0.78	5.6	6.2
160	80	7.9	2.0	20	39	632	0.74	4.6	5.4
200	0	7.4	2.0	5	11	595	0.72	6.6	7.2
200	40	7.6	2.1	11	20	631	0.76	6.2	6.8
200	80	7.6	2.1	22	36	623	0.84	6.0	6.8

continued

IRRIGATION

Table 3. Effect of 60 years of nitrogen (N) and phosphorus (P) fertilizers to irrigated corn on soil properties (0–6 inch), Tribune, KS, 2020

N	P ₂ O ₅	pH	OM	Mehlich		K	Zn	Mn	Fe
				Bray 1 P	3P				
----- lb/acre -----			%	----- ppm -----					
ANOVA (P>F)									
Nitrogen		0.001	0.001	0.001	0.001	0.080	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001	0.305	0.001	0.001	0.001
Quadratic		0.011	0.028	0.001	0.011	0.062	0.053	0.006	0.005
P ₂ O ₅		0.230	0.001	0.001	0.001	0.001	0.001	0.586	0.436
Linear		0.090	0.001	0.001	0.001	0.001	0.001	0.735	0.204
Quadratic		0.814	0.257	0.001	0.004	0.303	0.761	0.330	0.854
Zero P vs. P		0.175	0.001	0.001	0.001	0.001	0.001	0.435	0.233
40 P vs. 80 P		0.291	0.142	0.001	0.001	0.140	0.001	0.499	0.632
N × P		0.111	0.697	0.001	0.001	0.326	0.056	0.380	0.384
MEANS									
0		8.0 a	1.8 c	28 a	49 a	591	0.87 a	4.4 c	5.5 b
40		8.0 ab	1.9 b	22 b	41 b	628	0.87 a	4.7 bc	5.6 b
80		7.9 b	2.0 b	15 c	30 c	625	0.77 b	4.9 bc	5.7 b
120		7.9 b	2.0 ab	13 c	28 c	613	0.77 b	4.7 bc	5.5 b
160		7.7 c	2.0 ab	12 c	25 c	616	0.74 b	5.2 b	5.8 b
200		7.5 d	2.1 a	12 c	23 c	616	0.77 b	6.3 a	6.9 a
LSD _{0.05}		0.1	0.1	5	7	26	0.07	0.6	0.6
	0	7.8	1.9 b	5 c	12 c	590 b	0.71 c	4.9	5.7
	40	7.8	2.0 a	14 b	28 b	620 a	0.79 b	5.1	5.9
	80	7.9	2.0 a	32 a	57 a	634 a	0.89 a	5.0	6.0
	LSD _{0.05}	0.1	0.1	3	5	18	0.05	0.4	0.4

K = potassium. Zn = zinc. Mn = manganese. Fe = iron.
 Different letters in the same column indicate significant differences ($P < 0.05$).

2020 Kansas Summer Annual Forage Hay and Silage Variety Trial

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Summary

In 2020, summer annual forage variety trials were conducted across Kansas near Garden City, Hays, and Scandia. All sites evaluated hay and silage entries. Companies were able to enter varieties into any possible combinations of research sites, so not all sites had all varieties. Across the sites, a total of 98 hay varieties, 78 sorghum silage varieties, and 11 dual-purpose sorghum silage varieties were evaluated.

Introduction

Annually, there are approximately 35,000,000 acres of hay and haylage harvested in the U.S. for a total of 96,000,000 dry matter tons of production. Yields in Kansas averaged 2.77 tons of dry matter per acre. Of this total, about 13,600,000 acres were alfalfa, which averaged 3.76 dry matter tons per acre, and all other crops averaged 2.13 dry matter tons/a.

In Kansas, there were 2,400,000 acres of hay and haylage harvested with an average yield of 2.24 dry matter tons per acre. Of this total, 650,000 acres were alfalfa with an average yield of 3.72 dry matter tons per acre, and 1,770,000 acres were crops other than alfalfa with an average yield of 1.69 dry matter tons/a. Kansas ranked 6th in the U.S. for hay and haylage production. This largely supports the state dairy (ranked 19th in the U.S. and valued at \$483,000,000) and cattle (feedlot, background, and cow/calf) industries (ranked second in the U.S. and valued at \$10,200,000,000). Dairy and beef cattle represented 58% of the total agricultural product of Kansas. Hay and grain commodities that support these two industries are critical for the state.

Study Objectives

The objectives of the Kansas Summer Annual Forage Variety Trial are to evaluate the performance of released and experimental varieties, determine where these varieties are best adapted, and increase the visibility of summer annual forages in Kansas. Breeders, marketers, and producers use data collected from the trials to make informed variety selections. The Summer Annual Forage Trial is planted at locations across Kansas based on the interest of those entering varieties into the test.

Procedures

The Summer Annual Forage Variety Test was conducted near Garden City, Hays, and Scandia, KS. All of the sites evaluated hay and silage entries. Companies were able to enter varieties into any possible combinations of research sites, so not all sites had all varieties. In the hay test, there were 34 entries at Garden City, 40 at Hays, and 24 at Scandia. In the silage test, there were 29 sorghum entries at Garden City, 24 sorghum at Hays, and 25 sorghum at Scandia (Table 1). Information on the varieties is shown in Tables 2 and 3.

Management guidelines were provided to cooperators; however, previous growing experience influenced final management decisions. All trials were planted in small research plots (approximately 225 ft²) with three replications. Cultural practices (Table 5), growing season temperature, and precipitation (Figures 1, 2, and 3) are provided for each site. Results are listed alphabetically by seed supplier. Forage samples were dried, ground, and analyzed for nutrient contents using NIR (near infrared reflectance) by Sevitech Laboratories in Dodge City, KS. Nutrient contents measured were crude protein (CP), adjusted crude protein (Adj_CP), nitrogen free neutral detergent fiber (NDFn), acid detergent fiber (ADF), neutral detergent fiber organic matter basis (aNDFom), lignin, undigested aNDFom remaining after in vitro digestion at 240 hr (uNDFom240), neutral detergent fiber-digestible at 240 hr (NDFD240), water soluble carbohydrates (WSC), starch, total fatty acids (TFA), ash, calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K), sulfur (S), non-fiber carbohydrates (NFC), total digestible nutrients using Ohio Agricultural Research and Development Center (OARDC) calculation (TDN_OARDC), net energy for lactation 3x intake using OARDC (NEL3x_OARDC), net energy for gain using OARDC (NEG_OARDC), net energy for maintenance using OARDC (NEM_OARDC), and relative feed value (RFV).

2020 Growing Conditions

Temperature and precipitation (Figures 1, 2, and 3) for each site is shown. Thick black lines on the temperature graphs represent long-term average high and low temperatures (°F) for the location. The upper thin line represents actual daily high temperatures, and the lower thin line represents actual daily low temperatures. On the precipitation graph, the line labeled “normal” represents long-term average precipitation (1980–2020), and the line labeled “2020” represents actual precipitation.

In general, the 2020 growing season saw near normal temperatures across all locations. Precipitation was near normal at Scandia, above average at Hays, and below average at Garden City. However, Garden City was irrigated so moisture was not limiting.

Results and Discussion

Since all entries were not evaluated across all sites, data were analyzed by location. All locations had a control entry of Rox Orange (Waconia) and Sumac for the hay test, and a control entry of Kansas Orange for the silage test.

Hay Test

Top performing varieties varied by cutting and when comparing a single cutting compared to total yield. These results indicate performance evaluation needs to consider single or multiple cuttings, and the regrowth potential of varieties.

At Garden City, Qualimax, Fullgraze II, Excel II, and 18180 were in the top LSD (least significant difference at $P \leq 0.05$) group in the first cutting (Table 5). In the second cutting, more separation occurred between entries; F75FS13, ADV XS167, Cadan 99 B WMR, Sweet Sioux BMR, Dynagraze II, Super Sweet 10, 18179, 18182, and Three Little Indians were in the highest yielding LSD group. Combined across cuttings, F75FS13, ADV XS167, AS6401, Cadan 99 B WMR, Headless Wonder, Qualimax,

Dynagraze II, Fullgraze II, Super Sweet 10, Excel II, 18180, 18182, 19102, 19186 were in the top LSD group.

At Hays, Magnum Ultra BMR, ADV S6504, ADV XS007, Headless Wonder, Qualimax, Excell II, 10459, and 12003 had the greatest yield in the top LSD group in the first cutting (Table 6). There was no second cutting due to little regrowth and frost in early October.

At Scandia, Fullgraze II was in the top LSD group in the first cutting (Table 7). Only a subset of entries had regrowth and ADV XS167, Dynagraze II, Super Sweet 10, 18179, and 19011 were in the highest yielding LSD group. Combined across cuttings, Fullgraze II had the greatest yield.

Sorghum Silage Test

At Garden City, ADV F8322, F72FS05, Super Sile 20, Super Sile 30, Top Ton, Magnum Ultra BMR, Packer, 19038, 19040, and 19042 were in the top LSD group for silage (Table 8).

At Hays, ADV F7232, AF7201, F72FS05, F74FS23 BMR, F75FS13, Super Sile 30, TopTon, KS Orange, Magnum Ultra BMR, Packer, and 18096 were in the top LSD group for silage (Table 9).

At Scandia, ADV F7232, ADV F8322, F71FS72 BMR, F72FS05, F74FS23 BMR, TopTon, Packer, 20163, 18072, 18087, 18096, 18153, and 18567 were in the top LSD group for silage (Table 10).

Dual-Purpose Grain Yield

Similar varieties were tested at Garden City and Hays and some minor differences occurred across locations for the varieties. At Garden City, all the varieties were in the top LSD group except 20277 which yielded less (Table 11). At Hays, 18567 was in the top LSD group and 18087 and 18096 were in the lowest LSD group (Table 12).

Recommendation

Inestimable differences in soil type, weather, and environmental conditions play a part in increasing experimental error, therefore one should use more than one location and year to make an informed variety selection decision. Please refer to previous years' forage reports to see how a variety performed across years (https://newprairiepress.org/kaesrr/all_issues.html).

Acknowledgments

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FORAGE REPORT 2020

Brand names appearing in this publication are for product identification purposes only. No endorsement is intended, nor is criticism implied of similar products not mentioned. Persons using such products assume responsibility for their use in accordance with current label directions of the manufacturer.

Table 1. Number of hay and silage entries for each location

Location	Hay	Silage	Grain
Garden City	34	29	6
Hays	40	24	5
Scandia	24	25	0
Total	98	78	11

Table 2. 2020 Hay entries

Company	Variety/Entry	Type	BMR	Dwarf	Male sterile	Dry stalk	Photo-period sensitive	Aphid resistance	Maturity
Alta Seeds	ADV S6504	SS	Y	N	N	N	Y	N	PPS
Alta Seeds	ADV XS007	SS	Y	N	N	N	N	N	ML
Alta Seeds	ADV XS008	SS	Y	Y	N	N	N	N	ML
Alta Seeds	ADV XS167	SS	Y	N	N	N	Y	N	PPS
Alta Seeds	AS6401	SS	Y	N	N	N	N	N	ML
Alta Seeds	AS6402	SS	Y	Y	N	N	N	N	ML
Browning Seed	CADAN 99 B WMR	SS	N	N	N	Y	N	M	M
Browning Seed	HEADLESS WONDER	SS	N	N	N	N	Y	N	PPS
Browning Seed	MAXI PEARL MT	MT	N	N	N	n	N	Y	M
Browning Seed	SWEET SIOUX BMR	SS	Y	N	N	N	N	N	M
Browning Seed	Three Little Indians	SS, FS & S blend (45/45/10)	N	N	N	N	N	N	ML

continued

FORAGE REPORT 2020

Table 2. 2020 Hay entries

Company	Variety/Entry	Type	BMR	Dwarf	Male sterile	Dry stalk	Photo-period sensitive	Aphid resistance	Maturity
Browning Seed	TIFF LEAF 3	MT	N	N	N	N	N	Y	M
Channel Seed	Qualimax	SS	N	N	N	N	N	NA	ML
Dyna-Gro Seed	Danny Boy II BMR	SS	Y	N	N	N	Y	N	PPS
Dyna-Gro Seed	Dynagraze II	SS	N	N	N	N	N	N	EM
Dyna-Gro Seed	F75FS13	FS	N	N	N	N	N	N	M
Dyna-Gro Seed	Fullgraze II	SS	N	N	N	N	N	N	MF
Dyna-Gro Seed	Fullgraze II BMR	SS	Y	N	N	N	N	N	MF
Dyna-Gro Seed	PearlMil	MT	N	N	N	N	N	N	EM
Dyna-Gro Seed	Super Sweet 10	SS	N	N	N	N	N	N	EM
KSU (check)	Early Sumac	FS	N	N	N	N	N	N	M
KSU (check)	Rox Orange	FS	N	N	N	N	N	N	M
S & W Seed Co	Sordan 79	SS	N	N	N	N	Y	NA	M
S & W Seed Co	SP4555	SS	Y	N	N	N	N	N	M
S & W Seed Co	SPX8001	SS	Y	N	N	N	N	N	M
S & W Seed Co	SPX8002	FS	N	N	N	N	N	N	M
Star Seed	Drylander BMR	SS	Y	N	N	N	Y	NA	PPS
Star Seed	Excel II	SS	N	N	N	N	N	NA	L
Star Seed	Magnum Ultra BMR	FS	Y	N	Y	N	N	NA	L
Star Seed	Nutrimaxx BMR	SS	Y	N	N	N	N	NA	L
Ward Seed	18119	FS	Y	N	Y	N	N	NA	ME
Ward Seed	18164	FS	N	N	Y	N	N	NA	M
Ward Seed	18177	FS	Y	N	Y	Y	N	NA	M
Ward Seed	18179	SS	-	-	-	-	-	-	-
Ward Seed	18180	SS	-	-	-	-	-	-	-
Ward Seed	18182	SS	-	-	-	-	-	-	-
Ward Seed	19011	SS	-	-	-	-	-	-	-
Ward Seed	19055	FS	N	N	Y	N	N	NA	EM
Ward Seed	19102	SS	-	-	-	-	-	-	-
Ward Seed	19186	SS	-	-	-	-	-	-	-
Ward Seed	20263	SS	-	-	-	-	-	-	-
Ward Seed	20480	SS	-	-	-	-	-	-	-
Ward Seed	Tifleaf III	MT	-	-	-	-	-	-	-

Hybrid information was provided by seed companies.

Abbreviations: Forage sorghum (FS), sorghum sudan (SS), sorghum (S), dual-purpose (DP), brown mid-rib (BMR), photoperiod sensitive (PS), not applicable (NA). Maturity groups: Early (E), medium early (ME), medium (M), medium late (ML), late (L), and full (F).

FORAGE REPORT 2020

Table 3. 2020 Silage Entries

Company	Variety/Entry	Type	BMR	Dwarf	Male sterile	Dry stalk	Photo-period sensitive	Aphid resistance	Maturity	Grams /1000 seeds
Alta Seeds	ADV F7232	FS	Y	Y	N	N	N	NA	M	26.98
Alta Seeds	ADV F8322	FS	N	N	N	N	N	N	M	34.52
Alta Seeds	ADV XF025	FS	Y	N	N	Y	N	N	M	27.60
Alta Seeds	AF7201	FS	Y	N	N	Y	N	N	ME	31.30
Browning Seed	BROWNING 300	FS	Y	N	N	Y	N	N	ME	31.30
Dyna-Gro Seed	F70FS91 BMR	FS	Y	N	N	Y	N	N	E	37.81
Dyna-Gro Seed	F71FS72 BMR	FS	Y	N	N	Y	N	N	E	24.38
Dyna-Gro Seed	F72FS05	FS	N	N	N	N	N	N	EM	35.56
Dyna-Gro Seed	F74FS23 BMR	FS	Y	N	N	N	N	N	M	33.67
Dyna-Gro Seed	F74FS72 BMR	FS	Y	Y	N	Y	N	N	M	33.67
Dyna-Gro Seed	F75FS13	FS	N	N	N	N	N	N	M	23.42
Dyna-Gro Seed	Super Sile 20	FS	N	N	N	N	N	N	ML	28.42
Dyna-Gro Seed	Super Sile 30	FS	N	N	N	N	N	N	M	29.10
Dyna-Gro Seed	TopTon	FS	N	N	N	N	N	N	L	34.86
Fontanelle	Nutri-Chomp	FS	Y	N	N	N	N	NA	ML	29.50
KSU (check)	KS Orange	FS	N	N	N	N	N	N	M	20.58
Star Seed	Magnum Ultra BMR	FS	Y	N	Y	N	N	NA	L	29.30
Star Seed	Packer	FS	N	N	N	N	N	NA	ML	32.90
Ward Seed	18072	DP	-	-	-	-	-	-	-	28.41
Ward Seed	18087	DP	-	-	-	-	-	-	-	33.47
Ward Seed	18096	DP	-	-	-	-	-	-	-	26.61
Ward Seed	18153	DP	-	-	-	-	-	-	-	32.38
Ward Seed	18567	DP	-	-	-	-	-	-	-	27.33
Ward Seed	19038	FS	-	-	-	-	-	-	-	38.94
Ward Seed	19040	FS	-	-	-	-	-	-	-	32.68
Ward Seed	19042	FS	-	-	-	-	-	-	-	32.04
Ward Seed	19156	FS	-	-	-	-	-	-	-	29.90
Ward Seed	19181	FS	-	-	-	-	-	-	-	32.65
Ward Seed	20163	FS	-	-	-	-	-	-	-	29.22
Ward Seed	20277	DP	-	-	-	-	-	-	-	34.79

Hybrid information was provided by seed companies.

Abbreviations: Forage sorghum (FS), sorghum sudan (SS), sorghum (S), dual-purpose (DP), brown mid-rib (BMR), photoperiod sensitive (PS), not applicable (NA).

Maturity groups: Early (E), medium early (ME), medium (M), medium late (ML), late (L), and full (F).

FORAGE REPORT 2020

Table 4. Irrigation, plant, harvest, and fertilizer details for hay and silage variety tests near Garden City, Hays, and Scandia, KS, in 2019

Location	Irrigation (inch)	Planting date	1st Harvest date	2nd Harvest date	Seeding rate	Harvest area (ft ²)	N Fertilizer (lb N/a)	P Fertilizer (lb P ₂ O ₅ /a)
Hay Test								
Garden City	12.77	11-Jun	13-Aug 3-Sep	4-Nov	20 (lb/acre)	360 /150	160	0
Hays	-	2-Jun	19-Aug 4-Sep	-	15 (lb/acre)	60 /45	50	0
Scandia	-	12-Jun	12-Aug 17-Aug 26-Aug 4-Sep 15-Sep	23-Oct	20 (lb/acre)	60	50	0
Silage Test								
Garden City	12.77	11-Jun	21-Sep 10-Oct 16-Oct	-	80000 (seeds/acre)	225	160	0
Hays	-	2-Jun	16-Sep 12-Oct	-	50000 (seeds/acre)	25	50	0
Scandia	-	12-Jun	4-Sep 15-Sep 22-Sep 29-Sep 6-Oct	-	50000 (seeds/acre)	50	50	0

FORAGE REPORT 2020

Table 5. Hay performance test near Garden City

Brand	Name	Performance					
		1st Cutting	2nd Cutting	Total yield	1st Cutting	2nd Cutting	1st Height
		----- lb DM/a -----			----- % moisture -----		in
Forage sorghum							
Dyna-Gro Seed	F75FS13	7188	4944	12132	0.85	0.47	96
KSU (check)	Early Sumac	5745	3824	9569	0.86	0.42	93
KSU (check)	Rox Orange	6243	3654	9897	0.86	0.36	91
Star Seed	Magnum Ultra BMR	9395	555	9950	0.84	0.16	94
Millet							
Browning Seed	MAXI PEARL MILLET	7181	2649	9830	0.84	0.24	99
Browning Seed	TIFF LEAF 3	6558	3625	10183	0.85	0.28	74
Dyna-Gro Seed	PearlMil	6125	3552	9677	0.85	0.28	78
Sorghum sudan							
Alta Seeds	ADV S6504	8615	1846	10462	0.85	0.19	89
Alta Seeds	ADV XS007	8725	1814	10539	0.81	0.16	97
Alta Seeds	ADV XS008	8484	1218	9702	0.80	0.14	71
Alta Seeds	ADV XS167	6460	4787	11247	0.87	0.40	96
Alta Seeds	AS6401	8598	2640	11237	0.82	0.16	97
Alta Seeds	AS6402	7848	1449	9296	0.79	0.20	69
Browning Seed	CADAN 99 B WMR	6061	6130	12190	0.84	0.44	101
Browning Seed	HEADLESS WONDER	9272	1965	11237	0.84	0.16	97
Browning Seed	SWEET SIOUX BMR	5361	4264	9626	0.85	0.46	94
Channel Seed	Qualimax	10892	2705	13598	0.82	0.21	106

continued

Table 5. Hay performance test near Garden City

Brand	Name	Performance					
		1st Cutting	2nd Cutting	Total yield	1st Cutting	2nd Cutting	1st Height
Dyna-Gro Seed	Danny Boy II BMR	8595	1363	9959	0.85	0.23	94
Dyna-Gro Seed	Dynagraze II	6782	4668	11450	0.83	0.46	100
Dyna-Gro Seed	Fullgraze II	11653	931	12585	0.79	0.16	111
Dyna-Gro Seed	Fullgraze II BMR	8668	2010	10678	0.83	0.25	93
Dyna-Gro Seed	Super Sweet 10	6586	5121	11707	0.83	0.44	102
Star Seed	Drylander BMR	8900	767	9667	0.84	0.15	88
Star Seed	Excel II	10410	1749	12159	0.81	0.20	106
Star Seed	Nutrimaxx BMR	9355	839	10194	0.83	0.12	92
Ward Seed	18179	6187	4662	10849	0.83	0.47	104
Ward Seed	18180	10707	2844	13552	0.81	0.19	106
Ward Seed	18182	7266	4729	11995	0.82	0.45	101
Ward Seed	19011	6246	2153	8399	0.83	0.33	79
Ward Seed	19102	9976	1793	11769	0.84	0.18	97
Ward Seed	19186	9942	1578	11520	0.83	0.25	101
Ward Seed	20263	5392	2460	7853	0.83	0.37	89
Ward Seed	20480	6860	3891	10751	0.86	0.40	92
Sorghum sudan and forage sorghum blend							
Browning Seed	Three Little Indians	6785	4168	10954	0.84	0.44	112
	Average	7914	2863	10777	0.83	0.29	94
	LSD (0.05)	1437	2070	2462			
Plant date: 6/11/2020							
Days to harvest:*		63,83	146				

Values in bold are in the top LSD group.

*See Table 4 for dates.

Abbreviations for this table and following tables: Crude protein (CP), adjusted crude protein (Adj_CP), nitrogen free neutral detergent fiber (NDFn), acid detergent fiber (ADF), neutral detergent fiber organic matter basis (aNDFom), lignin, undigested aNDFom remaining after in vitro digestion at 240 hr (uNDFom240), neutral detergent fiber-digestible at 240 hr (NDFD240), water soluble carbohydrates (WSC), starch, total fatty acids (TFA), ash, calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K), sulfur (S), non-fiber carbohydrates (NFC), total digestible nutrients (TDN), net energy for lactation (NEL), net energy for gain (NEG), net energy for maintenance (NEM), and relative feed value (RFV).

Table 5b. 2020 Garden City, Kansas Hay Performance Test, Finney County

Brand	Name	Nutritive value											
		CP	ADF	aNDF	aNDFom	Lignin	NDFD-240	uND-Fom240	Starch	ESC (Sugar)	WSC (Sugar)	EE (Fat)	TFA
Forage sorghum													
Dyna-Gro Seed	F75FS13	11.22	40.78	63.27	60.74	4.04	71.15	17.52	4.99	2.66	3.48	2.58	0.81
KSU (check)	Early Sumac	12.12	39.81	61.97	58.40	4.04	71.77	16.48	4.47	3.09	4.06	2.91	0.97
KSU (check)	Rox Orange	13.29	38.04	58.65	55.66	3.78	71.45	15.90	5.14	3.07	4.03	2.91	0.95
Star Seed	Magnum Ultra BMR	8.55	40.08	60.84	58.46	3.78	72.99	15.82	4.82	4.91	5.56	2.36	0.72
Millet													
Browning Seed	MAXI PEARL MILLET	14.21	39.56	59.48	56.29	4.42	72.71	15.35	6.07	1.99	2.58	2.49	0.93
Browning Seed	TIFF LEAF 3	14.65	39.41	59.39	56.69	4.01	75.83	13.68	5.67	1.94	2.50	2.53	0.92
Dyna-Gro Seed	PearlMil	15.03	38.82	58.30	56.08	4.12	74.99	14.01	5.66	2.08	2.69	2.55	0.98
Sorghum sudan													
Alta Seeds	ADV S6504	11.12	41.49	61.25	58.78	3.85	68.96	18.25	3.70	2.15	2.78	2.51	0.65
Alta Seeds	ADV XS007	10.91	40.53	60.51	57.74	4.07	70.62	16.97	3.83	2.92	3.82	2.49	0.75
Alta Seeds	ADV XS008	10.98	40.46	60.20	57.58	4.05	71.99	16.13	4.34	2.95	3.86	2.51	0.80
Alta Seeds	ADV XS167	13.04	40.33	59.14	56.92	3.60	74.25	14.67	4.46	1.98	2.56	2.66	0.82
Alta Seeds	AS6401	10.46	40.32	59.73	56.38	4.04	69.41	17.27	4.55	3.04	3.99	2.39	0.67
Alta Seeds	AS6402	11.49	38.51	60.05	56.72	3.86	71.23	16.32	4.70	3.61	4.75	2.69	0.87
Browning Seed	CADAN 99 B WMR	12.49	41.05	61.65	58.08	4.38	70.98	16.85	4.83	2.11	2.73	2.68	0.87
Browning Seed	HEADLESS WONDER	10.95	42.77	62.58	60.02	4.71	68.66	18.81	3.88	1.97	2.54	2.42	0.67
Browning Seed	SWEET SIOUX BMR	12.08	39.49	59.82	56.43	3.75	72.65	15.43	5.21	2.72	3.56	2.81	0.89
Channel Seed	Qualimax	9.61	44.03	63.66	60.94	5.14	67.20	20.00	4.56	2.59	3.38	2.05	0.61

continued

Table 5b. 2020 Garden City, Kansas Hay Performance Test, Finney County

Brand	Name	Nutritive value											
		CP	ADF	aNDF	aNDFom	Lignin	NDFD-240	uND-Fom240	Starch	ESC (Sugar)	WSC (Sugar)	EE (Fat)	TFA
Dyna-Gro Seed	Danny Boy II BMR	11.26	41.51	59.94	57.82	3.95	71.05	16.74	3.66	1.97	2.54	2.43	0.61
Dyna-Gro Seed	Dynagraze II	12.52	40.17	61.12	58.49	4.27	69.24	18.01	4.43	2.71	3.55	2.80	0.98
Dyna-Gro Seed	Fullgraze II	9.27	43.09	67.58	64.86	4.85	65.98	22.07	3.57	2.09	2.71	2.44	0.55
Dyna-Gro Seed	Fullgraze II BMR	10.87	41.07	62.44	60.04	4.02	71.04	17.38	3.82	2.07	2.68	2.52	0.64
Dyna-Gro Seed	Super Sweet 10	12.36	40.97	62.13	59.02	4.40	71.45	16.85	4.63	2.45	3.19	2.65	0.90
Star Seed	Drylander BMR	10.16	41.35	63.92	61.76	3.89	72.36	17.07	4.77	2.00	2.58	2.41	0.70
Star Seed	Excel II	9.91	43.12	63.37	61.34	4.90	68.06	19.59	4.51	2.99	3.93	2.12	0.66
Star Seed	Nutrimaxx BMR	10.07	40.74	61.69	59.43	3.87	73.61	15.69	4.55	3.10	4.06	2.38	0.73
Ward Seed	18179	12.56	40.86	62.62	60.01	4.42	70.02	17.99	4.80	2.39	3.11	2.63	0.92
Ward Seed	18180	10.07	41.38	62.20	59.25	4.88	68.99	18.36	4.52	3.28	4.32	2.16	0.71
Ward Seed	18182	12.37	39.66	60.40	57.95	3.64	73.02	15.63	4.58	2.43	3.17	2.70	0.88
Ward Seed	19011	12.86	37.86	58.48	55.67	3.53	73.48	14.76	4.30	2.96	3.89	2.85	0.95
Ward Seed	19102	9.73	43.75	65.80	62.67	4.96	69.03	19.41	4.04	1.94	2.50	2.18	0.59
Ward Seed	19186	9.88	44.37	65.19	62.18	5.03	67.68	20.09	4.44	1.94	2.50	2.06	0.58
Ward Seed	20263	12.84	40.41	61.72	58.95	4.09	72.13	16.43	4.52	2.24	2.92	2.61	0.90
Ward Seed	20480	12.88	38.64	59.86	57.41	3.39	74.35	14.72	4.51	2.47	3.21	2.96	0.97
Sorghum sudan and forage sorghum blend													
Browning Seed	Three Little Indians	12.56	45.18	66.46	65.00	6.46	68.76	20.31	4.94	2.08	2.69	2.55	0.78
	Average	11.60	40.87	61.63	58.93	4.24	71.09	17.08	4.57	2.56	3.31	2.53	0.79

Table 5b, continued. 2020 Garden City, Kansas Hay Performance Test, Finney County

Brand	Name	Nutritive value											
		Ash	Ca	P	Mg	K	S	NFC	RFV	TDN	NEG	NEM	NEL
Forage sorghum													
Dyna-Gro Seed	F75FS13	10.76	0.41	0.32	0.24	2.05	0.27	18.16	84.03	57.14	25.81	51.14	58.25
KSU (check)	Early Sumac	10.08	0.44	0.34	0.26	1.94	0.28	20.10	86.79	57.89	26.64	52.04	59.09
KSU (check)	Rox Orange	10.72	0.59	0.34	0.28	2.11	0.31	21.16	94.02	59.26	28.38	53.93	60.62
Star Seed	Magnum Ultra BMR	10.27	0.33	0.30	0.23	2.00	0.20	24.00	88.47	57.68	25.89	51.22	58.85
Millet													
Browning Seed	MAXI PEARL MILLET	11.61	0.59	0.37	0.36	2.57	0.32	18.96	90.81	58.08	28.35	53.89	59.30
Browning Seed	TIFF LEAF 3	11.90	0.64	0.39	0.34	2.81	0.31	18.29	91.13	58.20	28.53	54.09	59.44
Dyna-Gro Seed	PearlMil	11.63	0.67	0.40	0.36	2.82	0.31	18.65	93.51	58.66	29.10	54.71	59.95
Sorghum sudan													
Alta Seeds	ADV S6504	13.33	0.50	0.34	0.26	2.35	0.27	18.20	85.96	56.58	26.60	51.99	57.63
Alta Seeds	ADV XS007	12.27	0.44	0.34	0.25	2.21	0.24	20.64	88.35	57.33	26.82	52.24	58.46
Alta Seeds	ADV XS008	12.18	0.49	0.32	0.26	1.92	0.25	20.74	88.68	57.39	26.98	52.41	58.53
Alta Seeds	ADV XS167	13.15	0.56	0.35	0.28	2.29	0.29	18.45	90.45	57.48	28.10	53.62	58.64
Alta Seeds	AS6401	12.08	0.46	0.33	0.22	2.16	0.23	22.62	89.65	57.49	26.99	52.42	58.64
Alta Seeds	AS6402	11.57	0.44	0.33	0.24	1.98	0.26	21.41	91.33	58.90	27.20	52.65	60.22
Browning Seed	CADAN 99 B WMR	11.11	0.42	0.35	0.23	2.27	0.27	19.26	85.92	56.93	26.89	52.31	58.01
Browning Seed	HEADLESS WONDER	11.41	0.42	0.32	0.23	2.31	0.26	18.71	82.59	55.58	25.99	51.34	56.52
Browning Seed	SWEET SIOUX BMR	11.55	0.43	0.35	0.23	2.17	0.26	20.75	90.46	58.14	27.50	52.97	59.37
Channel Seed	Qualimax	10.67	0.35	0.28	0.22	2.07	0.23	20.02	79.87	54.60	25.10	50.37	55.42

continued

Table 5b, continued. 2020 Garden City, Kansas Hay Performance Test, Finney County

Brand	Name	Nutritive value											
		Ash	Ca	P	Mg	K	S	NFC	RFV	TDN	NEG	NEM	NEL
Dyna-Gro Seed	Danny Boy II BMR	13.19	0.50	0.34	0.26	2.34	0.27	19.32	87.70	56.56	27.18	52.62	57.61
Dyna-Gro Seed	Dynagraze II	10.42	0.46	0.33	0.24	2.11	0.28	19.25	87.76	57.61	27.12	52.56	58.77
Dyna-Gro Seed	Fullgraze II	9.91	0.26	0.30	0.18	2.23	0.27	16.73	76.08	55.33	23.39	48.53	56.24
Dyna-Gro Seed	Fullgraze II BMR	12.01	0.48	0.33	0.23	2.11	0.26	18.48	84.84	56.91	26.03	51.38	58.00
Dyna-Gro Seed	Super Sweet 10	10.53	0.46	0.33	0.24	2.07	0.28	18.94	85.41	56.98	26.66	52.06	58.08
Star Seed	Drylander BMR	11.48	0.33	0.34	0.25	2.35	0.25	17.87	82.62	56.69	25.19	50.47	57.75
Star Seed	Excel II	10.55	0.39	0.28	0.22	1.97	0.23	19.32	81.18	55.31	25.32	50.62	56.21
Star Seed	Nutrimaxx BMR	11.17	0.39	0.31	0.24	2.15	0.25	20.66	86.12	57.17	26.06	51.41	58.28
Ward Seed	18179	10.37	0.42	0.32	0.24	2.10	0.28	17.83	84.80	57.07	26.52	51.91	58.17
Ward Seed	18180	10.16	0.35	0.30	0.21	2.14	0.23	21.67	84.77	56.66	25.86	51.19	57.72
Ward Seed	18182	12.24	0.45	0.34	0.25	2.08	0.27	18.48	89.34	58.01	27.36	52.82	59.22
Ward Seed	19011	12.04	0.52	0.36	0.27	2.13	0.27	20.64	94.56	59.41	28.30	53.84	60.78
Ward Seed	19102	11.07	0.34	0.31	0.23	2.37	0.25	17.62	77.63	54.82	24.28	49.48	55.67
Ward Seed	19186	11.21	0.32	0.31	0.22	2.32	0.24	17.94	77.69	54.34	24.57	49.80	55.13
Ward Seed	20263	11.30	0.44	0.33	0.25	2.04	0.28	17.91	86.65	57.42	26.98	52.41	58.57
Ward Seed	20480	12.14	0.54	0.36	0.27	2.12	0.28	18.55	91.48	58.80	27.75	53.25	60.11
Sorghum sudan and forage sorghum blend													
Browning Seed	Three Little Indians	10.60	0.44	0.33	0.22	2.20	0.28	12.81	75.36	53.70	21.11	46.07	54.43
	Average	11.37	0.45	0.33	0.25	2.20	0.27	19.24	86.35	57.06	26.49	51.88	58.17

Table 6. Hay performance test near Hays

Brand	Name	Performance		
		1st Cutting lb DM/a	1st Cutting % moisture	1st Height in
Forage sorghum				
Dyna-Gro Seed	F75FS13	8057	0.69	91
KSU (check)	Early Sumac	7333	0.69	95
KSU (check)	Rox Orange	8192	0.72	89
S & W Seed Co	SPX8002	7407	0.64	72
Star Seed	Magnum Ultra BMR	11722	0.68	89
Millet				
Browning Seed	MAXI PEARL MILLET	4388	0.62	103
Browning Seed	TIFF LEAF 3	5991	0.69	77
Dyna-Gro Seed	PearlMil	4796	0.65	72
Sorghum sudan				
Alta Seeds	ADV S6504	11021	0.69	96
Alta Seeds	ADV XS007	9987	0.66	110
Alta Seeds	ADV XS008	7867	0.68	86
Alta Seeds	ADV XS167	9619	0.68	89
Alta Seeds	AS6401	9081	0.69	109
Alta Seeds	AS6402	8239	0.67	88
Browning Seed	CADAN 99 B WMR	7501	0.65	109
Browning Seed	HEADLESS WONDER	10042	0.70	99
Browning Seed	SWEET SIOUX BMR	8527	0.67	101
Channel Seed	Qualimax	11859	0.65	112
Dyna-Gro Seed	Danny Boy II BMR	9058	0.71	99
Dyna-Gro Seed	Dynagraze II	7013	0.63	104
Dyna-Gro Seed	Fullgraze II	8464	0.66	112
Dyna-Gro Seed	Fullgraze II BMR	9532	0.68	100
Dyna-Gro Seed	Super Sweet 10	8132	0.62	95

continued

FORAGE REPORT 2020

Table 6. Hay performance test near Hays

Brand	Name	Performance		
		1st Cutting	1st Cutting	1st Height
S & W Seed Co	Sordan 79	9084	0.66	110
S & W Seed Co	SP4555	7839	0.68	109
S & W Seed Co	SPX8001	6067	0.66	85
Star Seed	Drylander BMR	9784	0.69	87
Star Seed	Excel II	10019	0.65	111
Star Seed	Nutrimaxx BMR	9136	0.70	103
Ward Seed	18119	7535	0.65	88
Ward Seed	18164	7881	0.69	98
Ward Seed	18177	7822	0.67	84
Ward Seed	18179	6858	0.63	87
Ward Seed	18180	9432	0.67	114
Ward Seed	18182	8705	0.64	105
Ward Seed	19011	7700	0.64	104
Ward Seed	19055	10459	0.63	90
Ward Seed	19102	9636	0.69	105
Ward Seed	19186	12003	0.67	113
Sorghum sudan and forage sorghum blend				
Browning Seed	Three Little Indians	7334	0.64	115
	Average	8528	0.67	98
	LSD (0.05)	2060		
Plant date: 6/2/2020				
Days to harvest:*		78,94		

Values in bold are in the top LSD group.

*See Table 4 for dates.

Table 6b. 2020 Hays, Kansas Forage Hay Performance Test, Ellis County

Brand	Name	Nutritive value											
		CP	ADF	aNDF	aNDFom	Lignin	NDFD-240	uNDFom-240	Starch	ESC (Sugar)	WSC (Sugar)	EE (Fat)	TFA
Forage sorghum													
Dyna-Gro Seed	F75FS13	6.18	36.03	55.19	53.12	3.24	72.26	14.73	5.72	10.84	11.77	2.63	0.98
KSU (check)	Early Sumac	6.52	36.56	57.45	55.20	3.31	72.41	15.23	4.48	8.21	10.13	2.62	0.90
KSU (check)	Rox Orange	6.66	35.35	56.13	53.58	3.17	70.85	15.58	3.70	10.24	11.88	2.52	0.80
S & W Seed Co	SPX8002	7.01	36.92	57.24	54.98	3.17	72.42	15.17	5.72	7.46	9.17	2.73	0.96
Star Seed	Magnum Ultra BMR	7.07	37.96	60.26	57.91	3.10	73.37	15.47	3.42	5.83	7.75	2.83	0.93
Millet													
Browning Seed	MAXI PEARL MILLET	6.97	39.30	57.49	55.36	4.10	70.65	16.25	6.82	6.53	8.70	2.22	0.99
Browning Seed	TIFF LEAF 3	8.65	38.95	61.51	59.78	3.70	75.85	14.46	4.74	4.77	6.33	2.60	1.04
Dyna-Gro Seed	PearlMil	8.27	39.06	59.66	57.40	3.66	76.55	13.45	4.81	5.24	6.96	2.72	1.20
Sorghum sudan													
Alta Seeds	ADV S6504	5.95	40.13	60.48	58.46	3.48	71.41	16.70	3.79	5.01	6.65	2.49	0.69
Alta Seeds	ADV XS007	5.13	38.51	58.55	56.59	3.09	73.59	14.94	5.24	7.12	9.51	2.42	0.73
Alta Seeds	ADV XS008	6.17	37.60	59.33	57.21	2.82	73.96	14.93	5.47	6.33	8.44	2.57	0.81
Alta Seeds	ADV XS167	8.72	36.91	58.00	55.98	2.89	75.58	13.66	3.65	4.62	6.13	3.01	1.01
Alta Seeds	AS6401	6.55	37.42	58.84	56.44	3.18	73.41	14.98	4.24	7.38	8.95	2.59	0.87
Alta Seeds	AS6402	7.54	36.09	58.74	56.86	2.78	74.62	14.43	5.29	6.48	8.64	2.83	0.94
Browning Seed	CADAN 99 B WMR	6.29	36.87	56.33	53.81	3.63	70.83	15.70	7.03	8.47	10.50	2.55	0.98
Browning Seed	HEADLESS WONDER	6.63	40.21	62.90	60.71	4.05	72.44	16.75	4.68	5.48	7.29	2.16	0.70
Browning Seed	SWEET SIOUX BMR	7.61	36.51	58.36	55.68	3.20	73.56	14.73	5.63	6.74	8.33	2.62	0.98
Channel Seed	Qualimax	6.73	36.25	55.75	54.45	3.42	72.50	14.99	6.37	8.12	10.15	2.56	0.96
Dyna-Gro Seed	Danny Boy II BMR	6.75	40.28	59.48	57.32	3.32	74.06	14.87	3.31	4.15	5.49	2.59	0.73

continued

Table 6b. 2020 Hays, Kansas Forage Hay Performance Test, Ellis County

Brand	Name	Nutritive value											
		CP	ADF	aNDF	aNDFom	Lignin	NDFD-240	uNDFom-240	Starch	ESC (Sugar)	WSC (Sugar)	EE (Fat)	TFA
Dyna-Gro Seed	Dynagraze II	6.61	36.60	55.85	53.49	3.60	70.48	15.79	8.06	8.30	10.28	2.51	1.00
Dyna-Gro Seed	Fullgraze II	6.13	39.45	62.69	60.75	3.72	71.65	17.38	3.94	6.79	8.62	2.62	0.80
Dyna-Gro Seed	Fullgraze II BMR	8.17	36.29	58.51	56.27	2.92	73.86	14.72	4.35	5.16	6.86	2.96	0.97
Dyna-Gro Seed	Super Sweet 10	7.32	37.15	57.41	55.90	3.56	72.31	15.46	7.31	7.03	9.38	2.68	1.05
S & W Seed Co	Sordan 79	6.62	38.19	59.34	57.06	3.67	71.35	16.35	5.03	6.22	8.28	2.67	0.90
S & W Seed Co	SP4555	7.86	36.73	58.26	55.68	3.27	73.06	15.03	5.30	5.62	7.48	2.86	1.04
S & W Seed Co	SPX8001	6.12	35.25	52.91	50.32	2.75	72.44	13.86	7.35	10.00	11.17	2.58	0.93
Star Seed	Drylander BMR	6.43	38.79	63.15	60.94	3.18	76.70	14.20	3.39	4.70	6.24	2.69	0.85
Star Seed	Excel II	7.86	37.72	58.84	56.93	3.35	72.87	15.45	5.13	5.93	7.89	2.50	0.86
Star Seed	Nutrimaxx BMR	7.51	37.17	60.22	58.15	3.20	76.41	13.74	4.24	5.95	7.92	2.49	0.85
Ward Seed	18119	7.65	36.08	56.20	53.86	2.61	74.59	13.67	5.14	6.89	9.20	2.92	1.02
Ward Seed	18164	6.60	36.54	57.62	55.70	3.31	72.98	15.04	5.18	8.43	10.49	2.50	0.88
Ward Seed	18177	7.39	36.04	55.58	53.38	2.67	74.02	13.87	4.75	7.98	9.73	2.98	1.03
Ward Seed	18179	10.55	34.44	56.76	54.47	2.84	74.24	13.99	4.84	5.99	7.97	3.14	1.24
Ward Seed	18180	6.52	38.55	61.25	59.47	3.52	72.09	16.70	5.07	6.33	8.44	2.34	0.70
Ward Seed	18182	8.13	35.40	56.01	54.10	2.73	72.89	14.52	8.60	6.14	8.18	2.94	1.08
Ward Seed	19011	7.15	35.64	54.51	52.42	3.36	70.22	15.55	9.08	6.96	9.29	2.70	1.05
Ward Seed	19055	7.19	37.37	57.89	55.79	3.33	73.31	14.85	5.07	7.66	9.17	2.48	0.83
Ward Seed	19102	6.12	39.39	62.31	60.69	3.64	72.82	16.50	4.35	5.87	7.81	2.31	0.73
Ward Seed	19186	5.95	38.44	60.24	58.26	3.48	74.16	15.05	3.80	6.39	8.52	2.50	0.79
Sorghum sudan and forage sorghum blend													
Browning Seed	Three Little Indians	8.70	40.68	62.86	61.37	4.88	70.14	18.32	4.51	5.42	7.21	2.79	1.01
	Average	7.10	37.47	58.50	56.40	3.32	73.07	15.18	5.21	6.72	8.57	2.64	0.92

Table 6b, continued. 2020 Hays, Kansas Forage Hay Performance Test, Ellis County

Brand	Name	Nutritive value											
		Ash	Ca	P	Mg	K	S	NFC	RFV	TDN	NEG	NEM	NEL
Forage sorghum													
Dyna-Gro Seed	F75FS13	7.78	0.23	0.27	0.15	1.66	0.12	33.24	102.50	60.84	27.41	52.87	62.37
KSU (check)	Early Sumac	8.36	0.27	0.29	0.14	2.01	0.13	30.40	97.92	60.42	26.60	51.99	61.91
KSU (check)	Rox Orange	7.62	0.27	0.29	0.14	1.70	0.12	33.04	101.67	61.36	27.19	52.64	62.96
S & W Seed Co	SPX8002	8.62	0.18	0.29	0.16	1.79	0.14	29.63	97.92	60.14	26.85	52.27	61.59
Star Seed	Magnum Ultra BMR	9.26	0.25	0.30	0.16	1.89	0.14	26.30	91.90	59.33	25.63	50.94	60.70
Millet													
Browning Seed	MAXI PEARL MILLET	8.60	0.36	0.25	0.20	1.98	0.16	28.71	94.45	58.29	26.73	52.13	59.53
Browning Seed	TIFF LEAF 3	9.00	0.34	0.30	0.19	2.34	0.19	22.46	88.71	58.56	25.66	50.98	59.83
Dyna-Gro Seed	PearlMil	9.70	0.33	0.33	0.19	2.46	0.16	24.49	91.26	58.47	26.28	51.65	59.74
Sorghum sudan													
Alta Seeds	ADV S6504	10.35	0.28	0.29	0.12	2.34	0.13	25.63	88.66	57.64	25.16	50.44	58.81
Alta Seeds	ADV XS007	9.28	0.27	0.28	0.14	1.76	0.10	29.53	93.62	58.90	25.67	50.99	60.21
Alta Seeds	ADV XS008	9.10	0.33	0.27	0.15	1.82	0.14	27.86	93.95	59.61	25.70	51.03	61.00
Alta Seeds	ADV XS167	11.11	0.39	0.34	0.17	2.40	0.15	24.54	96.51	60.15	27.12	52.56	61.60
Alta Seeds	AS6401	9.09	0.26	0.29	0.15	1.82	0.12	28.51	94.69	59.75	26.03	51.38	61.16
Alta Seeds	AS6402	9.30	0.35	0.28	0.17	1.65	0.16	26.36	96.28	60.78	26.41	51.79	62.31
Browning Seed	CADAN 99 B WMR	7.71	0.22	0.26	0.16	1.54	0.13	32.31	99.56	60.18	26.98	52.41	61.64
Browning Seed	HEADLESS WONDER	8.25	0.41	0.25	0.17	1.78	0.15	24.53	85.28	57.58	24.40	49.62	58.74
Browning Seed	SWEET SIOUX BMR	8.84	0.24	0.31	0.17	1.78	0.14	28.08	96.46	60.46	26.59	51.99	61.95
Channel Seed	Qualimax	7.77	0.42	0.24	0.19	1.46	0.16	30.95	101.28	60.67	27.36	52.83	62.18
Dyna-Gro Seed	Danny Boy II BMR	11.08	0.33	0.32	0.14	2.49	0.14	25.34	90.07	57.52	25.85	51.18	58.68
Dyna-Gro Seed	Dynagraze II	7.71	0.25	0.26	0.16	1.50	0.13	32.20	100.51	60.39	27.28	52.74	61.87

continued

Table 6b, continued. 2020 Hays, Kansas Forage Hay Performance Test, Ellis County

Brand	Name	Nutritive value											
		Ash	Ca	P	Mg	K	S	NFC	RFV	TDN	NEG	NEM	NEL
Dyna-Gro Seed	Fullgraze II	7.73	0.23	0.25	0.14	1.61	0.14	25.51	86.94	58.17	24.32	49.53	59.40
Dyna-Gro Seed	Fullgraze II BMR	10.07	0.37	0.31	0.17	2.09	0.16	25.76	96.73	60.63	26.72	52.13	62.14
Dyna-Gro Seed	Super Sweet 10	7.66	0.35	0.25	0.18	1.49	0.16	28.88	97.30	59.96	26.88	52.30	61.39
S & W Seed Co	Sordan 79	8.45	0.23	0.29	0.14	1.87	0.14	28.19	92.98	59.15	25.85	51.19	60.49
S & W Seed Co	SP4555	9.33	0.26	0.31	0.16	1.86	0.15	27.29	96.76	60.29	26.71	52.12	61.76
S & W Seed Co	SPX8001	9.56	0.23	0.30	0.14	1.77	0.10	34.65	108.90	61.44	28.34	53.88	63.04
Star Seed	Drylander BMR	9.11	0.22	0.31	0.16	2.23	0.14	23.88	86.59	58.68	24.23	49.43	59.97
Star Seed	Excel II	8.74	0.51	0.25	0.20	1.52	0.17	26.44	94.12	59.52	26.48	51.86	60.90
Star Seed	Nutrimaxx BMR	8.96	0.31	0.29	0.21	1.95	0.17	26.18	92.63	59.94	25.80	51.12	61.38
Ward Seed	18119	9.56	0.30	0.30	0.17	1.76	0.16	28.97	100.54	60.79	27.49	52.96	62.32
Ward Seed	18164	7.65	0.24	0.27	0.15	1.81	0.14	30.27	97.65	60.43	26.56	51.95	61.92
Ward Seed	18177	9.69	0.23	0.31	0.15	1.94	0.14	29.77	101.90	60.82	27.66	53.15	62.36
Ward Seed	18179	9.35	0.35	0.34	0.19	1.80	0.19	25.93	101.89	62.07	28.23	53.77	63.75
Ward Seed	18180	8.40	0.35	0.25	0.16	1.75	0.15	25.74	90.19	58.87	25.04	50.32	60.18
Ward Seed	18182	9.23	0.28	0.31	0.15	1.66	0.16	28.61	103.04	61.33	27.73	53.23	62.92
Ward Seed	19011	8.44	0.25	0.28	0.16	1.55	0.13	32.11	104.73	61.14	28.02	53.54	62.70
Ward Seed	19055	8.31	0.34	0.27	0.17	1.75	0.15	29.18	96.41	59.79	26.64	52.04	61.21
Ward Seed	19102	8.46	0.29	0.27	0.16	1.93	0.14	24.88	86.97	58.21	24.47	49.69	59.45
Ward Seed	19186	8.48	0.26	0.28	0.14	1.95	0.12	27.61	91.10	58.96	25.26	50.55	60.28
Sorghum sudan and forage sorghum blend													
Browning Seed	Three Little Indians	9.13	0.24	0.29	0.16	1.79	0.16	20.83	84.78	57.21	21.30	46.28	58.33
	Average	8.87	0.30	0.29	0.16	1.86	0.14	27.87	95.38	59.71	26.27	51.64	61.12

FORAGE REPORT 2020

Table 7. Hay performance test near Scandia

Brand	Name	Performance					
		1st Cutting	2nd Cutting	Total yield	1st Cutting	2nd Cutting	1st Height
		(lb DM/a)			(% moisture)		(in.)
Forage sorghum							
Dyna-Gro Seed	F75FS13	12176	1736	13911	0.81	0.77	100
KSU (check)	Early Sumac	5928	0	5928	0.81	-	88
KSU (check)	Rox Orange	7174	0	7174	0.81	-	90
Millet							
Dyna-Gro Seed	PearlMil	8727	0	8727	0.83	-	72
Ward Seed	Tifleaf III	9181	0	9181	0.83	-	71
Sorghum sudan							
Alta Seeds	ADV S6504	12714	0	12714	0.76	-	111
Alta Seeds	ADV XS007	6993	0	6993	0.75	-	104
Alta Seeds	ADV XS008	8312	0	8312	0.75	-	79
Alta Seeds	ADV XS167	6381	2837	9218	0.83	0.79	93
Alta Seeds	AS6401	6684	1771	8455	0.79	0.70	100
Alta Seeds	AS6402	5634	0	5634	0.74	-	76
Dyna-Gro Seed	Danny Boy II BMR	10849	0	10849	0.76	-	103
Dyna-Gro Seed	Dynagraze II	7531	2672	10203	0.80	0.73	96
Dyna-Gro Seed	Fullgraze II	20911	0	20911	0.67	-	129
Dyna-Gro Seed	Fullgraze II BMR	13041	0	13041	0.74	-	109
Dyna-Gro Seed	Super Sweet 10	9206	3253	12459	0.80	0.74	91
Star Seed	Drylander BMR	11441	0	11441	0.75	-	96
Star Seed	Excel II	9609	0	9609	0.70	-	107
Star Seed	Nutrimaxx BMR	12709	0	12709	0.73	-	97
Ward Seed	18179	7834	2634	10468	0.80	0.75	97
Ward Seed	18180	11660	1387	13047	0.75	0.62	106
Ward Seed	18182	7480	2468	9948	0.81	0.74	103
Ward Seed	19011	7555	2244	9799	0.78	0.70	80
Ward Seed	19102	16037	0	16037	0.74	-	109
	Average	9824	875	10699			
	LSD (0.05)	3094	1104	3093			
Plant date: 6/12/20							
Days to harvest:*		61,66,75,84,95	133				

Values in bold are in the top LSD group.

*See Table 4 for dates.

Table 7b. 2020 Scandia, Kansas Forage Hay Performance Test, Republic County

Brand	Name	Nutritive value											
		CP	ADF	aNDF	aNDFom	Lignin	NDFD-240	uNDFom-240	Starch	ESC (Sugar)	WSC (Sugar)	EE (Fat)	TFA
Forage sorghum													
Dyna-Gro Seed	F75FS13	9.05	37.53	61.83	59.17	3.68	74.72	14.96	3.88	6.54	8.10	2.75	1.04
KSU (check)	Early Sumac	10.53	34.07	58.25	55.86	3.20	76.74	13.00	4.19	7.33	9.79	2.90	1.23
KSU (check)	Rox Orange	10.69	32.81	57.02	54.93	2.99	75.93	13.22	4.09	8.82	10.71	2.96	1.17
Millet													
Dyna-Gro Seed	PearlMil	12.63	38.92	61.80	59.52	3.78	79.94	11.94	3.26	2.38	3.10	2.88	1.38
Ward Seed	Tifleaf III	13.24	38.31	62.60	60.45	3.62	80.78	11.64	3.32	2.57	3.35	3.01	1.44
Sorghum sudan													
Alta Seeds	ADV S6504	6.49	36.83	58.44	56.43	3.22	72.80	15.38	4.53	9.52	11.22	2.28	0.76
Alta Seeds	ADV XS007	10.77	32.90	55.36	52.87	2.70	77.64	11.83	4.07	9.47	10.71	3.01	1.20
Alta Seeds	ADV XS008	12.46	33.04	58.96	56.20	2.76	79.22	11.69	3.18	5.86	7.80	3.19	1.29
Alta Seeds	ADV XS167	10.20	36.85	57.65	55.66	3.11	77.87	12.34	3.55	4.15	5.49	3.05	1.10
Alta Seeds	AS6401	11.38	34.32	56.01	53.08	3.04	77.29	12.05	3.96	6.35	8.46	2.95	1.15
Alta Seeds	AS6402	12.97	32.43	56.85	54.12	2.71	78.05	11.89	3.12	5.85	7.79	3.49	1.40
Dyna-Gro Seed	Danny Boy II BMR	8.66	35.41	57.62	55.82	3.06	75.76	13.54	3.37	7.08	9.44	2.72	0.98
Dyna-Gro Seed	Dynagraze II	11.28	38.27	61.65	58.30	4.05	74.01	15.16	3.66	4.41	5.85	2.81	1.07
Dyna-Gro Seed	Fullgraze II	4.74	41.23	66.22	64.88	4.59	68.83	20.21	5.42	8.45	10.03	2.10	0.66
Dyna-Gro Seed	Fullgraze II BMR	6.72	35.93	59.44	57.48	3.28	73.25	15.37	4.05	9.30	10.86	2.45	0.79
Dyna-Gro Seed	Super Sweet 10	12.67	37.09	60.66	58.31	3.82	74.79	14.70	3.16	4.48	5.93	3.11	1.24
Star Seed	Drylander BMR	6.66	35.08	61.39	58.96	2.83	78.28	12.81	3.91	8.53	10.73	2.50	0.90
Star Seed	Excel II	6.39	35.46	57.16	55.03	3.53	72.95	14.87	6.32	12.00	13.26	2.53	1.06
Star Seed	Nutrimaxx BMR	9.10	32.27	57.00	54.49	2.58	79.74	11.03	4.49	9.05	11.02	2.82	1.21
Ward Seed	18179	11.18	39.21	63.70	60.98	4.06	73.91	15.91	3.13	4.06	5.37	2.80	1.11
Ward Seed	18180	8.37	35.26	57.98	55.78	3.50	74.42	14.27	5.26	9.52	10.92	2.72	1.12
Ward Seed	18182	11.09	37.16	60.35	57.88	3.21	76.06	13.87	3.50	4.08	5.40	2.99	1.03
Ward Seed	19011	11.74	33.21	56.72	53.81	2.85	76.27	12.76	4.15	6.46	8.61	3.14	1.29
Ward Seed	19102	6.49	38.10	61.67	59.26	4.02	72.76	16.16	4.25	8.69	9.89	2.35	0.86
	Average	9.81	35.90	59.43	57.05	3.34	75.92	13.77	3.99	6.87	8.49	2.81	1.10

Table 7b, continued. 2020 Scandia, Kansas Forage Hay Performance Test, Republic County

Brand	Name	Nutritive value											
		Ash	Ca	P	Mg	K	S	NFC	RFV	TDN	NEG	NEM	NEL
Forage sorghum													
Dyna-Gro Seed	F75FS13	7.75	0.29	0.31	0.16	1.87	0.17	24.27	89.73	59.66	25.67	50.99	61.07
KSU (check)	Early Sumac	7.34	0.43	0.31	0.22	1.59	0.19	26.67	99.77	62.36	27.61	53.10	64.07
KSU (check)	Rox Orange	7.01	0.35	0.33	0.19	1.67	0.19	27.71	103.48	63.34	28.17	53.70	65.17
Millet													
Dyna-Gro Seed	PearlMil	10.48	0.35	0.41	0.25	3.37	0.24	17.47	88.29	58.58	26.88	52.30	59.86
Ward Seed	Tifleaf III	10.32	0.40	0.42	0.27	3.22	0.26	16.12	87.94	59.06	26.76	52.17	60.39
Sorghum sudan													
Alta Seeds	ADV S6504	8.16	0.30	0.28	0.14	1.53	0.12	29.45	96.05	60.21	26.18	51.54	61.68
Alta Seeds	ADV XS007	8.61	0.44	0.33	0.22	1.65	0.19	28.45	106.28	63.27	28.87	54.47	65.09
Alta Seeds	ADV XS008	8.95	0.49	0.35	0.23	1.66	0.22	22.91	99.58	63.16	27.98	53.49	64.96
Alta Seeds	ADV XS167	10.76	0.38	0.37	0.18	2.68	0.17	23.90	97.29	60.19	27.75	53.24	61.65
Alta Seeds	AS6401	9.57	0.47	0.35	0.20	2.11	0.19	26.65	103.29	62.17	28.82	54.40	63.85
Alta Seeds	AS6402	9.42	0.52	0.36	0.23	2.00	0.22	23.94	104.46	63.63	29.00	54.61	65.49
Dyna-Gro Seed	Danny Boy II BMR	8.90	0.39	0.30	0.18	1.84	0.16	27.08	99.05	61.32	27.25	52.69	62.91
Dyna-Gro Seed	Dynagraze II	9.49	0.34	0.35	0.18	2.13	0.20	21.49	89.17	59.09	26.48	51.87	60.42
Dyna-Gro Seed	Fullgraze II	5.32	0.10	0.24	0.10	1.31	0.12	25.12	79.84	56.78	22.39	47.46	57.86
Dyna-Gro Seed	Fullgraze II BMR	7.30	0.29	0.28	0.15	1.55	0.13	29.00	95.40	60.91	25.84	51.17	62.45
Dyna-Gro Seed	Super Sweet 10	9.27	0.40	0.36	0.20	2.11	0.22	20.26	92.15	60.01	27.35	52.81	61.45
Star Seed	Drylander BMR	6.79	0.22	0.29	0.19	1.63	0.14	28.19	93.40	61.57	25.02	50.29	63.19
Star Seed	Excel II	6.22	0.28	0.26	0.20	1.29	0.13	32.33	99.75	61.27	26.67	52.07	62.86
Star Seed	Nutrimaxx BMR	7.78	0.43	0.31	0.25	1.50	0.17	29.11	104.31	63.77	27.65	53.14	65.64
Ward Seed	18179	9.11	0.31	0.33	0.18	2.04	0.20	19.15	85.22	58.36	25.62	50.94	59.61
Ward Seed	18180	6.89	0.30	0.29	0.20	1.52	0.16	29.13	98.57	61.43	27.00	52.43	63.03
Ward Seed	18182	10.67	0.36	0.37	0.17	2.46	0.20	20.90	92.36	59.95	26.95	52.37	61.39
Ward Seed	19011	8.98	0.44	0.35	0.21	1.89	0.20	25.87	103.65	63.03	28.65	54.22	64.82
Ward Seed	19102	6.64	0.23	0.28	0.17	1.62	0.12	27.93	89.26	59.22	24.86	50.11	60.57
	Average	8.41	0.35	0.33	0.19	1.93	0.18	25.13	95.76	60.93	26.89	52.32	62.48

FORAGE REPORT 2020

Table 8. Silage performance test near Garden City

Brand	Variety	Performance							
		Yield	Harvest moisture	Stand	Vigor	Flowering date	Days to harvest	Height	Lodging
		lb DM/a	%					in.	%
Forage sorghum									
Alta Seeds	ADV F7232	14039	0.72	10.0	10.0	9/17/20	119	67	0
Alta Seeds	ADV F8322	16641	0.69	10.0	9.7	10/1/20	127	86	0
Alta Seeds	ADV XF025	11116	0.71	10.0	9.3	9/10/20	102	95	0
Alta Seeds	AF7201	12443	0.71	10.0	10.0	9/10/20	102	96	0
Dyna-Gro Seed	F70FS91 BMR	13132	0.70	10.0	10.0	9/10/20	102	100	0
Dyna-Gro Seed	F71FS72 BMR	12734	0.74	10.0	9.7	9/10/20	102	81	0
Dyna-Gro Seed	F72FS05	15921	0.69	10.0	10.0	10/1/20	127	89	0
Dyna-Gro Seed	F74FS23 BMR	15319	0.72	10.0	10.0	9/17/20	119	97	63
Dyna-Gro Seed	F74FS72 BMR	14403	0.71	10.0	9.7	10/1/20	127	70	0
Dyna-Gro Seed	F75FS13	11655	0.75	10.0	10.0	9/10/20	102	107	0
Dyna-Gro Seed	Super Sile 20	17643	0.73	10.0	10.0	9/17/20	119	115	0
Dyna-Gro Seed	Super Sile 30	18082	0.70	10.0	10.0	9/17/20	119	103	0
Dyna-Gro Seed	TopTon	16182	0.71	10.0	10.0	10/1/20	127	115	13
Fontanelle	Nutri-Chomp	13555	0.75	10.0	10.0	10/1/20	127	113	32
KSU (check)	KS Orange	11034	0.66	9.7	9.0	10/1/20	127	108	0
Star Seed	Magnum Ultra BMR	16729	0.73	9.7	9.7	10/1/20	127	113	0
Star Seed	Packer	18138	0.68	10.0	9.7	9/17/20	119	87	0
Wards	19038	17594	0.72	10.0	10.0	9/17/20	119	85	0
Wards	19040	15693	0.70	10.0	10.0	9/17/20	119	78	0
Wards	19042	17763	0.72	10.0	9.7	9/17/20	119	93	0
Wards	19181	15281	0.69	10.0	10.0	10/1/20	127	81	0
Wards	20163	14405	0.68	10.0	10.0	9/17/20	119	70	0
Wards	20249	10682	0.67	10.0	9.7	9/10/20	102	83	0
Grain sorghum dual-purpose									
Wards	18072	9724	0.71	10.0	10.0	9/1/20	102	54	0
Wards	18087	10973	0.70	10.0	10.0	9/1/20	102	60	0
Wards	18096	11499	0.68	10.0	10.0	9/10/20	119	62	0
Wards	18153	11729	0.73	10.0	10.0	9/1/20	102	62	0
Wards	18567	11520	0.73	10.0	10.0	9/1/20	102	55	0
Wards	20277	10198	0.75	10.0	10.0	9/1/20	102	66	0
Average		13994	0.71	9.98	9.86		115	86	4
LSD (0.05)		2737							
Planting Date: 6/11/20									
Emergence Date: 6/19/20									

Values in bold are in the top LSD group.

Table 8b. 2020 Garden City, Kansas Silage Performance Test, Finney County

Brand	Variety	Nutritive value											
		CP	ADF	aNDF	aNDFom	Lignin	NDFD-240	uNDFom-240	Starch	ESC (Sugar)	WSC (Sugar)	EE (Fat)	TFA
Forage sorghum													
Alta Seeds	ADV F7232	8.75	30.19	47.43	44.71	2.79	66.20	15.11	10.98	2.31	12.84	2.98	1.17
Alta Seeds	ADV F8322	9.20	31.63	49.25	46.78	2.58	69.66	14.21	8.70	2.30	12.18	2.74	0.97
Alta Seeds	ADV XF025	9.30	31.33	50.39	47.66	2.98	68.54	14.96	9.85	2.23	11.22	2.79	1.17
Alta Seeds	AF7201	7.55	32.75	51.34	49.39	3.92	66.86	16.35	12.94	1.78	10.81	2.64	1.03
Dyna-Gro Seed	F70FS91 BMR	7.85	31.99	50.30	48.52	3.51	66.40	16.31	11.92	1.64	13.08	2.59	1.08
Dyna-Gro Seed	F71FS72 BMR	7.11	33.65	51.74	49.90	3.65	66.62	16.66	9.08	1.65	16.05	2.38	0.89
Dyna-Gro Seed	F72FS05	7.67	32.63	50.67	48.65	3.33	66.70	16.14	9.39	1.82	15.86	2.31	0.89
Dyna-Gro Seed	F74FS23 BMR	8.55	31.98	47.58	45.97	2.74	68.61	14.38	9.28	2.40	14.78	2.65	0.98
Dyna-Gro Seed	F74FS72 BMR	8.68	30.98	49.17	46.38	3.00	65.47	16.04	9.66	2.23	13.67	2.87	1.12
Dyna-Gro Seed	F75FS13	8.76	32.26	49.15	47.07	3.14	65.90	16.05	10.91	1.98	13.82	2.51	0.94
Dyna-Gro Seed	Super Sile 20	9.25	31.85	49.10	46.73	2.81	68.21	14.88	9.77	2.35	12.25	2.67	1.03
Dyna-Gro Seed	Super Sile 30	8.67	29.48	47.07	44.35	2.46	67.20	14.55	12.12	2.57	12.00	3.16	1.23
Dyna-Gro Seed	TopTon	8.43	32.99	51.37	49.14	3.43	68.65	15.40	10.23	2.25	10.24	2.95	1.12
Fontanelle	Nutri-Chomp	7.22	33.75	53.90	52.13	3.09	72.87	14.12	5.03	2.02	17.95	2.50	0.86
KSU (check)	KS Orange	6.82	32.35	52.03	50.01	3.42	65.38	17.31	8.50	1.95	15.84	2.72	0.85
Star Seed	Magnum Ultra BMR	7.19	32.61	53.44	51.60	2.88	73.84	13.41	5.41	1.51	20.33	2.34	0.76
Star Seed	Packer	8.23	33.22	50.98	48.45	3.58	69.09	14.91	9.68	1.65	12.36	2.43	0.94
Wards	19038	8.03	36.74	57.10	55.10	3.86	69.06	17.00	5.10	1.26	12.17	2.29	0.86
Wards	19040	9.17	33.68	52.23	50.16	3.36	69.09	15.33	8.00	1.45	14.05	2.41	0.90
Wards	19042	8.06	35.49	54.39	52.23	3.57	67.21	17.13	3.85	1.70	14.44	2.60	0.94
Wards	19181	9.34	31.87	49.27	46.69	2.63	66.90	15.45	7.64	2.28	14.05	2.85	1.04
Wards	20163	9.06	33.04	50.89	49.06	3.37	69.19	15.11	9.45	2.06	12.13	2.57	0.94
Wards	20249	8.52	32.46	51.69	48.76	3.10	67.06	16.05	9.05	1.73	10.96	2.89	1.04
Grain sorghum dual-purpose													
Wards	18072	10.43	31.21	48.45	45.96	3.77	66.69	15.30	12.57	2.59	7.51	3.01	1.16
Wards	18087	9.21	30.39	47.68	46.11	3.72	67.47	14.98	17.13	2.67	5.54	3.25	1.34
Wards	18096	9.05	32.70	50.35	47.56	3.90	66.65	15.85	10.38	2.20	9.84	2.80	1.12
Wards	18153	9.74	32.84	50.32	48.29	3.42	67.68	15.58	11.27	2.32	6.95	2.81	1.14
Wards	18567	10.43	30.97	47.94	45.19	3.55	65.56	15.49	12.92	2.38	8.05	2.75	1.08
Wards	20277	10.13	34.80	55.75	52.87	3.66	71.19	15.31	5.40	1.58	8.80	2.58	0.99
Average		8.63	32.48	50.72	48.46	3.28	67.93	15.50	9.52	2.03	12.41	2.69	1.02

Table 8b, continued. 2020 Garden City, Kansas Silage Performance Test, Finney County

Brand	Variety	Nutritive value											
		Ash	Ca	P	Mg	K	S	NFC	RFV	TDN	NEG	NEM	NEL
Forage sorghum													
Alta Seeds	ADV F7232	11.28	0.28	0.20	0.21	2.32	0.14	34.99	128.23	66.83	32.22	58.13	68.97
Alta Seeds	ADV F8322	12.88	0.34	0.24	0.24	2.64	0.15	30.98	121.41	66.39	31.61	57.45	68.48
Alta Seeds	ADV XF025	11.74	0.32	0.21	0.24	2.31	0.15	31.17	119.16	66.48	31.18	56.98	68.58
Alta Seeds	AF7201	10.19	0.27	0.18	0.23	2.10	0.11	32.38	114.86	66.04	30.33	56.06	68.09
Dyna-Gro Seed	F70FS91 BMR	10.67	0.26	0.19	0.23	2.30	0.12	32.57	118.88	66.28	30.82	56.59	68.36
Dyna-Gro Seed	F71FS72 BMR	10.43	0.33	0.16	0.24	2.24	0.12	32.21	112.75	65.76	30.05	55.75	67.78
Dyna-Gro Seed	F72FS05	10.45	0.38	0.15	0.28	2.01	0.13	32.97	116.83	66.08	30.63	56.38	68.14
Dyna-Gro Seed	F74FS23 BMR	12.53	0.41	0.20	0.24	2.38	0.15	32.85	125.37	66.28	32.11	58.00	68.36
Dyna-Gro Seed	F74FS72 BMR	10.75	0.24	0.20	0.20	2.24	0.13	34.02	123.05	66.59	31.51	57.34	68.70
Dyna-Gro Seed	F75FS13	11.34	0.39	0.18	0.27	2.31	0.14	32.62	120.59	66.19	31.54	57.37	68.26
Dyna-Gro Seed	Super Sile 20	12.65	0.34	0.23	0.24	2.62	0.15	31.31	121.57	66.32	31.69	57.54	68.40
Dyna-Gro Seed	Super Sile 30	11.46	0.27	0.23	0.21	2.37	0.14	35.16	130.36	67.05	32.35	58.26	69.22
Dyna-Gro Seed	TopTon	10.68	0.26	0.20	0.19	2.04	0.13	31.36	114.51	65.97	30.56	56.30	68.01
Fontanelle	Nutri-Chomp	11.41	0.31	0.17	0.25	2.65	0.11	28.95	108.10	65.73	29.21	54.83	67.75
KSU (check)	KS Orange	8.88	0.24	0.14	0.21	1.89	0.11	34.03	113.90	66.16	29.85	55.54	68.23
Star Seed	Magnum Ultra BMR	9.94	0.38	0.14	0.28	2.15	0.11	31.13	110.84	66.09	29.39	55.03	68.14
Star Seed	Packer	11.43	0.36	0.18	0.26	2.16	0.13	31.64	115.00	65.90	30.66	56.42	67.93
Wards	19038	11.48	0.28	0.19	0.21	2.40	0.13	25.21	98.33	64.81	28.16	53.69	66.72
Wards	19040	11.46	0.40	0.17	0.27	2.05	0.15	29.11	112.01	65.76	30.41	56.14	67.78
Wards	19042	10.96	0.26	0.18	0.19	2.45	0.12	28.67	105.01	65.20	29.24	54.86	67.15
Wards	19181	12.40	0.31	0.26	0.22	2.85	0.16	31.13	121.04	66.31	31.64	57.49	68.40
Wards	20163	11.60	0.38	0.19	0.26	2.11	0.15	30.05	115.56	65.95	30.92	56.70	67.99
Wards	20249	11.18	0.27	0.19	0.22	2.39	0.14	31.29	114.42	66.13	30.46	56.19	68.20
Grain sorghum dual-purpose													
Wards	18072	10.57	0.30	0.24	0.22	2.22	0.16	32.74	124.18	66.52	32.26	58.16	68.62
Wards	18087	10.42	0.26	0.24	0.21	2.28	0.15	33.63	127.66	66.78	32.24	58.14	68.91
Wards	18096	11.05	0.29	0.20	0.21	2.09	0.14	32.18	117.17	66.06	31.12	56.92	68.11
Wards	18153	12.59	0.29	0.25	0.22	2.65	0.16	29.19	117.19	66.01	31.33	57.14	68.06
Wards	18567	11.08	0.28	0.23	0.22	2.23	0.15	33.18	126.18	66.60	32.47	58.39	68.71
Wards	20277	11.54	0.29	0.21	0.24	2.57	0.15	25.67	104.86	65.41	29.28	54.91	67.39
Average		11.21	0.31	0.20	0.23	2.31	0.14	31.46	117.21	66.13	30.87	56.65	68.19

FORAGE REPORT 2020

Table 9. Silage performance test near Hays

Brand	Variety	Performance							
		Yield	Harvest moisture	Stand	Vigor	Flowering date	Days to harvest	Height	Lodging
		lb DM/a	%					in.	%
Forage Sorghum									
Alta Seeds	ADV F7232	16311	0.67	8.0	8.3	9/13/20	132	72	0
Alta Seeds	ADV F8322	15046	0.65	8.0	8.0	9/13/20	132	80	0
Alta Seeds	ADV XF025	14798	0.60	8.0	9.3	8/25/20	106	106	0
Alta Seeds	AF7201	16173	0.62	8.0	9.0	8/27/20	106	102	0
Browning Seed	BROWNING 300	14891	0.63	7.3	8.3	8/19/20	106	80	0
Dyna-Gro Seed	F70FS91 BMR	13172	0.64	8.0	8.7	8/25/20	106	107	0
Dyna-Gro Seed	F71FS72 BMR	13232	0.68	9.0	9.3	8/25/20	106	83	0
Dyna-Gro Seed	F72FS05	18833	0.65	8.0	8.3	9/13/20	132	76	0
Dyna-Gro Seed	F74FS23 BMR	16099	0.72	8.7	9.3	9/5/20	106	108	12
Dyna-Gro Seed	F74FS72 BMR	13338	0.65	8.7	9.0	9/16/20	132	69	0
Dyna-Gro Seed	F75FS13	17719	0.66	8.7	9.7	8/14/20	106	119	0
Dyna-Gro Seed	Super Sile 20	15308	0.66	8.3	9.3	9/16/20	132	113	0
Dyna-Gro Seed	Super Sile 30	19964	0.65	9.0	9.3	9/11/20	132	104	0
Dyna-Gro Seed	TopTon	18115	0.69	8.3	9.0	9/13/20	132	116	0
Fontanelle	Nutri-Chomp	15703	0.68	8.3	8.7	9/17/20	132	111	0
KSU (check)	KS Orange	16283	0.62	7.7	9.0	8/27/20	106	118	0
Star Seed	Magnum Ultra BMR	17467	0.70	8.3	9.7	9/16/20	132	116	0
Star Seed	Packer	20260	0.62	9.0	10.0	9/13/20	132	87	0
Wards	19156	15950	0.59	8.7	10.0	8/25/20	106	119	0
Grain Sorghum Dual-Purpose									
Wards	18072	15092	0.60	8.3	8.7	8/19/20	106	63	0
Wards	18087	15595	0.60	9.0	9.0	8/13/20	106	68	0
Wards	18096	16558	0.67	7.7	8.0	8/19/20	106	69	0
Wards	18153	15616	0.61	9.0	9.7	8/18/20	106	70	0
Wards	18567	15175	0.62	9.0	8.0	8/18/20	106	60	0
Average		16112	0.65	8	9		117	92	0
LSD (0.05)		4275							
Planting date: 6/2/20									
Emergence date: 6/8/20									

Values in bold are in the top LSD group.

Table 9b. 2020 Hays, Kansas Silage Performance Test, Ellis County

Brand	Variety	Nutritive value											
		CP	ADF	aNDF	aNDFom	Lignin	NDFD-240	uNDFom-240	Starch	ESC (Sugar)	WSC (Sugar)	EE (Fat)	TFA
Forage sorghum													
Alta Seeds	ADV F7232	6.02	27.27	41.25	39.45	2.66	65.82	13.47	18.11	2.26	16.02	3.08	1.08
Alta Seeds	ADV F8322	5.44	29.16	45.86	43.95	3.65	66.88	14.53	18.01	1.54	15.15	2.91	1.08
Alta Seeds	ADV XF025	6.69	29.45	40.89	39.61	4.16	61.39	15.23	28.29	2.27	4.75	3.15	1.42
Alta Seeds	AF7201	5.23	33.23	48.10	46.25	4.20	65.56	15.79	21.20	1.35	6.11	3.07	1.24
Browning Seed	BROWNING 300	6.61	26.17	35.96	33.91	4.53	61.83	12.90	34.72	2.66	4.04	2.97	1.60
Dyna-Gro Seed	F70FS91 BMR	6.34	32.67	44.55	42.84	4.49	62.64	15.99	24.64	1.44	5.06	2.61	1.26
Dyna-Gro Seed	F71FS72 BMR	6.43	30.93	43.39	41.38	3.85	63.39	15.16	22.61	1.48	7.74	3.10	1.24
Dyna-Gro Seed	F72FS05	5.57	28.36	44.39	42.43	3.62	66.09	14.38	18.96	1.70	15.06	2.89	1.11
Dyna-Gro Seed	F74FS23 BMR	6.44	31.01	47.09	45.22	3.17	66.31	15.09	15.14	1.57	12.77	2.80	1.05
Dyna-Gro Seed	F74FS72 BMR	6.25	29.38	45.33	43.50	3.30	68.12	13.78	17.76	1.79	13.25	3.03	1.14
Dyna-Gro Seed	F75FS13	6.38	29.44	41.35	39.14	4.16	60.46	15.46	24.71	1.81	9.14	3.00	1.27
Dyna-Gro Seed	Super Sile 20	6.04	29.16	44.71	42.54	3.95	63.82	15.39	20.27	1.57	14.17	2.72	1.13
Dyna-Gro Seed	Super Sile 30	6.01	30.27	46.52	43.86	3.61	61.97	16.66	16.88	1.58	15.17	2.73	1.03
Dyna-Gro Seed	TopTon	4.70	30.98	49.44	47.28	3.36	66.90	15.65	8.63	1.04	23.34	2.66	0.74
Fontanelle	Nutri-Chomp	4.66	30.57	52.28	50.12	2.92	75.34	12.34	5.94	0.99	24.23	2.59	0.77
KSU (check)	KS Orange	5.24	31.79	47.09	45.33	4.56	61.97	17.25	20.12	1.36	11.62	2.87	1.12
Star Seed	Magnum Ultra BMR	4.90	29.69	51.55	49.53	2.59	72.99	13.35	4.94	1.20	25.09	2.74	0.76
Star Seed	Packer	6.07	28.43	42.28	40.33	3.84	66.36	13.55	20.33	1.98	15.13	2.98	1.17
Wards	19156	6.01	33.53	48.32	46.76	4.85	60.79	18.20	22.57	1.05	7.36	2.52	1.14
Grain sorghum dual-purpose													
Wards	18072	5.79	28.51	40.46	38.86	4.39	60.72	14.97	29.96	2.31	5.83	3.40	1.55
Wards	18087	6.26	24.62	32.93	31.66	4.31	56.92	13.50	38.28	3.00	4.92	3.31	1.78
Wards	18096	7.23	25.54	34.89	33.45	4.13	57.35	14.11	35.01	2.91	4.26	3.10	1.64
Wards	18153	6.42	26.81	36.33	35.06	4.25	59.87	13.92	35.08	2.47	3.19	3.32	1.65
Wards	18567	6.65	25.36	33.41	31.94	4.17	56.14	13.96	38.04	2.39	3.08	3.04	1.71
Average		5.84	29.26	43.27	41.43	3.86	63.73	14.78	22.51	1.82	11.10	2.94	1.24

Table 9b, continued. 2020 Hays, Kansas Silage Performance Test, Ellis County

Brand	Variety	Nutritive value											
		Ash	Ca	P	Mg	K	S	NFC	RFV	TDN	NEG	NEM	NEL
Forage sorghum													
Alta Seeds	ADV F7232	7.35	0.24	0.22	0.13	1.71	0.10	46.38	153.27	67.74	34.03	60.11	69.98
Alta Seeds	ADV F8322	6.71	0.24	0.20	0.14	1.59	0.10	42.93	134.49	67.15	31.98	57.85	69.33
Alta Seeds	ADV XF025	6.87	0.24	0.24	0.12	1.52	0.10	45.48	150.67	67.06	34.35	60.46	69.23
Alta Seeds	AF7201	8.57	0.24	0.23	0.12	1.90	0.10	38.79	124.64	65.90	31.02	56.82	67.93
Browning Seed	BROWNING 300	5.82	0.24	0.23	0.14	1.56	0.10	52.23	178.30	68.07	36.38	62.71	70.36
Dyna-Gro Seed	F70FS91 BMR	7.79	0.24	0.23	0.12	1.78	0.10	41.89	133.72	66.07	32.75	58.71	68.12
Dyna-Gro Seed	F71FS72 BMR	8.33	0.24	0.23	0.12	1.51	0.10	42.94	139.02	66.60	33.24	59.24	68.72
Dyna-Gro Seed	F72FS05	6.43	0.24	0.20	0.16	1.76	0.10	44.59	140.41	67.40	32.62	58.56	69.60
Dyna-Gro Seed	F74FS23 BMR	9.05	0.24	0.22	0.13	1.76	0.10	38.86	131.51	66.58	31.77	57.64	68.69
Dyna-Gro Seed	F74FS72 BMR	8.24	0.24	0.22	0.13	1.70	0.10	41.13	136.96	67.08	32.42	58.34	69.25
Dyna-Gro Seed	F75FS13	7.15	0.24	0.22	0.12	1.53	0.10	46.24	148.49	67.07	34.08	60.16	69.23
Dyna-Gro Seed	Super Sile 20	6.37	0.24	0.21	0.15	1.72	0.10	44.12	138.10	67.15	32.60	58.54	69.33
Dyna-Gro Seed	Super Sile 30	7.31	0.24	0.21	0.14	1.97	0.10	42.18	131.35	66.81	31.87	57.74	68.95
Dyna-Gro Seed	TopTon	6.72	0.24	0.16	0.12	1.72	0.10	40.78	121.84	66.59	30.33	56.05	68.70
Fontanelle	Nutri-Chomp	7.33	0.24	0.16	0.16	2.19	0.10	37.29	116.25	66.72	29.17	54.79	68.84
KSU (check)	KS Orange	5.81	0.24	0.17	0.12	1.31	0.10	42.74	127.27	66.34	31.43	57.26	68.42
Star Seed	Magnum Ultra BMR	7.00	0.24	0.17	0.15	1.97	0.10	38.08	119.26	66.99	29.53	55.19	69.15
Star Seed	Packer	6.31	0.24	0.21	0.14	1.56	0.10	46.21	147.92	67.38	33.61	59.65	69.58
Wards	19156	7.21	0.24	0.20	0.12	1.69	0.10	39.05	123.64	65.80	31.14	56.95	67.83
Grain sorghum dual-purpose													
Wards	18072	6.39	0.24	0.21	0.12	1.41	0.10	47.44	159.54	67.35	34.32	60.44	69.55
Wards	18087	5.13	0.24	0.20	0.12	1.07	0.10	55.10	200.76	68.55	37.60	64.05	70.89
Wards	18096	6.25	0.24	0.24	0.14	1.28	0.11	51.51	189.67	68.27	37.04	63.43	70.58
Wards	18153	6.43	0.24	0.23	0.12	1.36	0.10	50.36	178.02	67.88	36.20	62.51	70.14
Wards	18567	5.94	0.24	0.25	0.12	1.43	0.10	53.65	193.38	68.32	37.49	63.92	70.64
Average		6.94	0.24	0.21	0.13	1.62	0.10	44.58	146.60	67.12	33.21	59.21	69.29

FORAGE REPORT 2020

Table 10. Silage performance test near Scandia

Brand	Variety	Performance					
		Yield	Harvest moisture	Heading date	Days to harvest	Height	Lodging
		lb DM/a	%			in.	%
Forage sorghum							
Alta Seeds	ADV F7232	14442	0.68	9/2/20	116	69	0
Alta Seeds	ADV F8322	16596	0.70	9/2/20	109	83	0
Alta Seeds	ADV XF025	11370	0.69	8/14/20	84	102	0
Alta Seeds	AF7201	11908	0.69	8/15/20	84	101	0
Dyna-Gro Seed	F70FS91 BMR	12387	0.68	8/14/20	84	102	0
Dyna-Gro Seed	F71FS72 BMR	14417	0.70	9/3/20	109	73	0
Dyna-Gro Seed	F72FS05	16052	0.65	9/4/20	116	78	0
Dyna-Gro Seed	F74FS23 BMR	15011	0.70	8/28/20	109	106	10
Dyna-Gro Seed	F74FS72 BMR	10284	0.72	8/16/20	84	75	0
Dyna-Gro Seed	F75FS13	9276	0.75	8/15/20	84	109	0
Dyna-Gro Seed	Super Sile 20	12594	0.69	9/3/20	116	109	3
Dyna-Gro Seed	Super Sile 30	14088	0.69	8/31/20	109	104	3
Dyna-Gro Seed	TopTon	16700	0.69	9/7/20	116	119	23
KSU (check)	KS Orange	9890	0.72	8/24/20	95	121	13
Star Seed	Packer	16154	0.70	9/1/20	109	90	0
Wards	19038	13917	0.69	9/12/20	116	71	0
Wards	19040	11791	0.72	8/26/20	102	68	0
Wards	19042	10293	0.74	9/14/20	116	84	0
Wards	19181	11355	0.67	9/2/20	116	79	0
Wards	20163	15288	0.71	8/21/20	102	73	0
Grain sorghum dual-purpose							
Wards	18072	14832	0.71	8/17/20	95	59	0
Wards	18087	16520	0.67	8/15/20	95	68	0
Wards	18096	14898	0.73	8/20/20	95	65	0
Wards	18153	16037	0.70	8/18/20	95	65	0
Wards	18567	14792	0.69	8/21/20	95	56	0
Average		13636	0.70		102	85	2
LSD (0.05)		2461					
Planting date: 6/12/20							

Values in bold are in the top LSD group.

Table 10b. 2020 Scandia, Kansas Silage Performance Test, Republic County

Brand	Variety	Nutritive value											
		CP	ADF	aNDF	aNDFom	Lignin	NDFD-240	uNDFom-240	Starch	ESC (Sugar)	WSC (Sugar)	EE (Fat)	TFA
Forage sorghum													
Alta Seeds	ADV F7232	9.43	30.25	51.38	49.33	3.18	72.89	13.37	6.00	2.34	16.02	2.91	1.20
Alta Seeds	ADV F8322	9.04	31.15	50.47	47.73	2.80	74.98	11.94	6.58	2.43	13.52	3.01	1.13
Alta Seeds	ADV XF025	7.23	33.64	54.27	51.86	3.74	72.11	14.46	4.50	1.39	17.40	2.62	0.91
Alta Seeds	AF7201	8.14	30.68	50.19	48.52	2.70	74.24	12.50	5.67	2.27	16.49	3.02	1.16
Dyna-Gro Seed	F70FS91 BMR	7.37	33.07	52.52	50.05	3.36	71.44	14.29	4.91	1.48	17.80	2.65	0.90
Dyna-Gro Seed	F71FS72 BMR	9.39	28.42	46.26	43.79	2.41	74.84	11.03	8.08	2.56	17.22	2.95	1.23
Dyna-Gro Seed	F72FS05	8.18	29.43	48.43	46.50	2.49	73.62	12.25	7.38	2.14	16.79	3.15	1.15
Dyna-Gro Seed	F74FS23 BMR	8.99	30.96	50.22	47.99	3.06	74.33	12.26	6.06	2.25	20.40	2.68	0.92
Dyna-Gro Seed	F74FS72 BMR	7.84	32.89	52.19	50.26	3.24	74.50	12.83	4.66	2.08	16.36	2.91	1.04
Dyna-Gro Seed	F75FS13	6.15	32.06	50.11	48.30	3.43	69.94	14.52	8.55	1.68	17.96	2.63	0.91
Dyna-Gro Seed	Super Sile 20	8.80	32.60	53.47	50.91	3.75	73.26	13.60	6.16	2.00	13.19	2.80	1.06
Dyna-Gro Seed	Super Sile 30	8.84	31.88	51.48	49.48	2.72	75.65	12.06	3.06	2.24	15.52	3.11	1.09
Dyna-Gro Seed	TopTon	6.22	33.24	52.66	51.15	3.11	70.24	15.22	5.35	1.63	20.09	2.58	0.79
KSU (check)	KS Orange	6.97	33.25	54.52	52.63	3.59	70.02	15.75	2.86	1.56	20.68	2.50	0.71
Star Seed	Packer	7.48	32.54	51.36	48.99	3.43	73.91	12.78	4.82	1.50	17.84	2.72	1.03
Wards	19038	6.75	34.31	56.23	54.05	3.48	74.32	13.87	2.79	1.63	17.35	2.60	0.83
Wards	19040	9.29	32.44	52.36	50.19	3.43	75.25	12.42	3.61	2.55	16.99	2.77	1.00
Wards	19042	6.97	32.06	51.32	48.88	3.05	72.22	13.57	2.14	1.67	20.36	2.70	0.92
Wards	19181	8.38	31.83	51.10	49.26	2.87	75.30	12.14	5.22	2.19	16.41	2.93	1.01
Wards	20163	7.81	33.67	52.51	50.36	3.22	72.90	13.66	4.88	1.73	16.18	2.61	1.01
Grain sorghum dual-purpose													
Wards	18072	8.60	34.53	55.04	52.75	4.04	71.88	14.83	5.46	1.74	10.41	3.00	1.11
Wards	18087	8.05	32.22	50.16	47.55	4.34	71.41	13.53	13.78	1.64	9.68	2.93	1.19
Wards	18096	8.51	34.85	56.22	53.86	3.91	73.64	14.20	2.88	1.61	12.61	2.85	1.04
Wards	18153	8.00	35.48	56.42	54.21	3.97	71.36	15.53	5.31	1.31	11.76	2.72	0.97
Wards	18567	7.98	33.84	55.54	53.51	3.79	71.28	15.32	8.17	1.99	10.72	2.96	1.01
Average		8.02	32.45	52.26	50.09	3.32	73.02	13.52	5.56	1.90	15.99	2.81	1.01

Table 10b, continued. 2020 Scandia, Kansas Silage Performance Test, Republic County

Brand	Variety	Nutritive value											
		Ash	Ca	P	Mg	K	S	NFC	RFV	TDN	NEG	NEM	NEL
Forage sorghum													
Alta Seeds	ADV F7232	9.67	0.26	0.19	0.20	2.22	0.14	31.14	118.35	66.82	30.82	56.58	68.95
Alta Seeds	ADV F8322	10.89	0.28	0.21	0.21	2.30	0.14	32.02	119.25	66.54	31.08	56.87	68.64
Alta Seeds	ADV XF025	8.87	0.24	0.14	0.21	2.11	0.11	31.54	107.60	65.77	29.07	54.68	67.79
Alta Seeds	AF7201	9.44	0.24	0.18	0.17	2.22	0.13	33.34	120.46	66.68	30.95	56.73	68.81
Dyna-Gro Seed	F70FS91 BMR	9.51	0.24	0.15	0.19	2.05	0.11	32.59	111.89	65.95	29.81	55.48	67.99
Dyna-Gro Seed	F71FS72 BMR	9.94	0.25	0.21	0.20	2.11	0.14	36.38	134.42	67.38	32.87	58.83	69.58
Dyna-Gro Seed	F72FS05	9.96	0.24	0.19	0.18	2.08	0.13	34.78	126.84	67.07	31.66	57.51	69.24
Dyna-Gro Seed	F74FS23 BMR	8.78	0.40	0.15	0.29	1.88	0.14	34.03	120.23	66.59	31.17	56.97	68.71
Dyna-Gro Seed	F74FS72 BMR	10.17	0.28	0.17	0.19	2.31	0.13	31.36	112.86	66.00	30.06	55.76	68.04
Dyna-Gro Seed	F75FS13	8.53	0.24	0.14	0.17	1.72	0.10	36.18	118.76	66.26	30.44	56.18	68.33
Dyna-Gro Seed	Super Sile 20	10.17	0.28	0.17	0.22	2.08	0.14	29.83	110.62	66.09	29.81	55.49	68.14
Dyna-Gro Seed	Super Sile 30	11.30	0.29	0.19	0.20	2.45	0.15	30.07	116.07	66.31	30.62	56.37	68.39
Dyna-Gro Seed	TopTon	8.99	0.27	0.14	0.21	1.86	0.11	33.10	111.38	65.90	29.44	55.08	67.93
KSU (check)	KS Orange	7.82	0.24	0.12	0.17	1.87	0.10	32.49	107.43	65.89	28.90	54.49	67.92
Star Seed	Packer	9.78	0.26	0.15	0.22	2.22	0.12	33.05	115.11	66.11	30.30	56.02	68.17
Wards	19038	8.83	0.24	0.16	0.19	2.23	0.11	30.00	103.00	65.56	28.16	53.69	67.56
Wards	19040	9.82	0.34	0.17	0.25	2.05	0.15	30.30	113.12	66.14	30.39	56.12	68.20
Wards	19042	9.18	0.24	0.14	0.16	2.08	0.10	34.55	116.00	66.26	30.18	55.89	68.33
Wards	19181	9.75	0.26	0.18	0.20	1.99	0.14	32.00	117.01	66.33	30.65	56.41	68.41
Wards	20163	10.53	0.27	0.19	0.22	2.45	0.13	30.85	111.15	65.76	29.93	55.62	67.78
Grain sorghum dual-purpose													
Wards	18072	9.84	0.24	0.21	0.18	2.43	0.14	28.54	104.78	65.50	29.14	54.76	67.48
Wards	18087	8.53	0.24	0.21	0.18	1.97	0.11	35.02	119.27	66.20	30.94	56.73	68.27
Wards	18096	9.67	0.25	0.20	0.18	2.45	0.13	27.67	102.13	65.39	28.64	54.21	67.37
Wards	18153	9.81	0.24	0.20	0.17	2.17	0.13	27.53	101.01	65.20	28.43	53.98	67.15
Wards	18567	9.16	0.24	0.20	0.16	2.13	0.12	28.96	105.64	65.71	28.77	54.35	67.72
Average		9.56	0.26	0.17	0.20	2.14	0.13	31.89	113.78	66.14	30.09	55.79	68.20

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Table 11. Dual-purpose grain sorghum performance near Garden City

Brand	Variety	Performance				
		Yield	Harvest moisture	Test weight	Stand	Vigor
		bu/a	%			
Wards	18072	51.1	12.0	58.3	10.0	10.0
Wards	18087	73.0	11.9	60.0	10.0	10.0
Wards	18096	51.1	12.0	57.9	10.0	10.0
Wards	18153	75.6	12.4	59.6	10.0	10.0
Wards	18567	78.1	12.3	59.4	10.0	10.0
Wards	20277	39.3	12.1	57.6	10.0	10.0
Average		61	12	59	10	10
LSD (0.05)		28				

Values in bold are in the top LSD group.

Table 12. Dual-purpose grain sorghum performance near Hays

Brand	Variety	Performance				
		Yield	Harvest moisture	Test weight	Stand	Vigor
		bu/a	%			
Wards	18072	87.4	10.8	55.6	8.3	8.7
Wards	18096	62.0	10.8	55.8	7.7	8.0
Wards	18567	100.4	11.2	58.3	9.0	8.0
Wards	18087	65.3	10.8	57.2	9.0	9.0
Wards	18153	82.7	11.5	57.8	9.0	9.7
Average		80	11	57	9	9
LSD (0.05)		8				

Values in bold are in the top LSD group.

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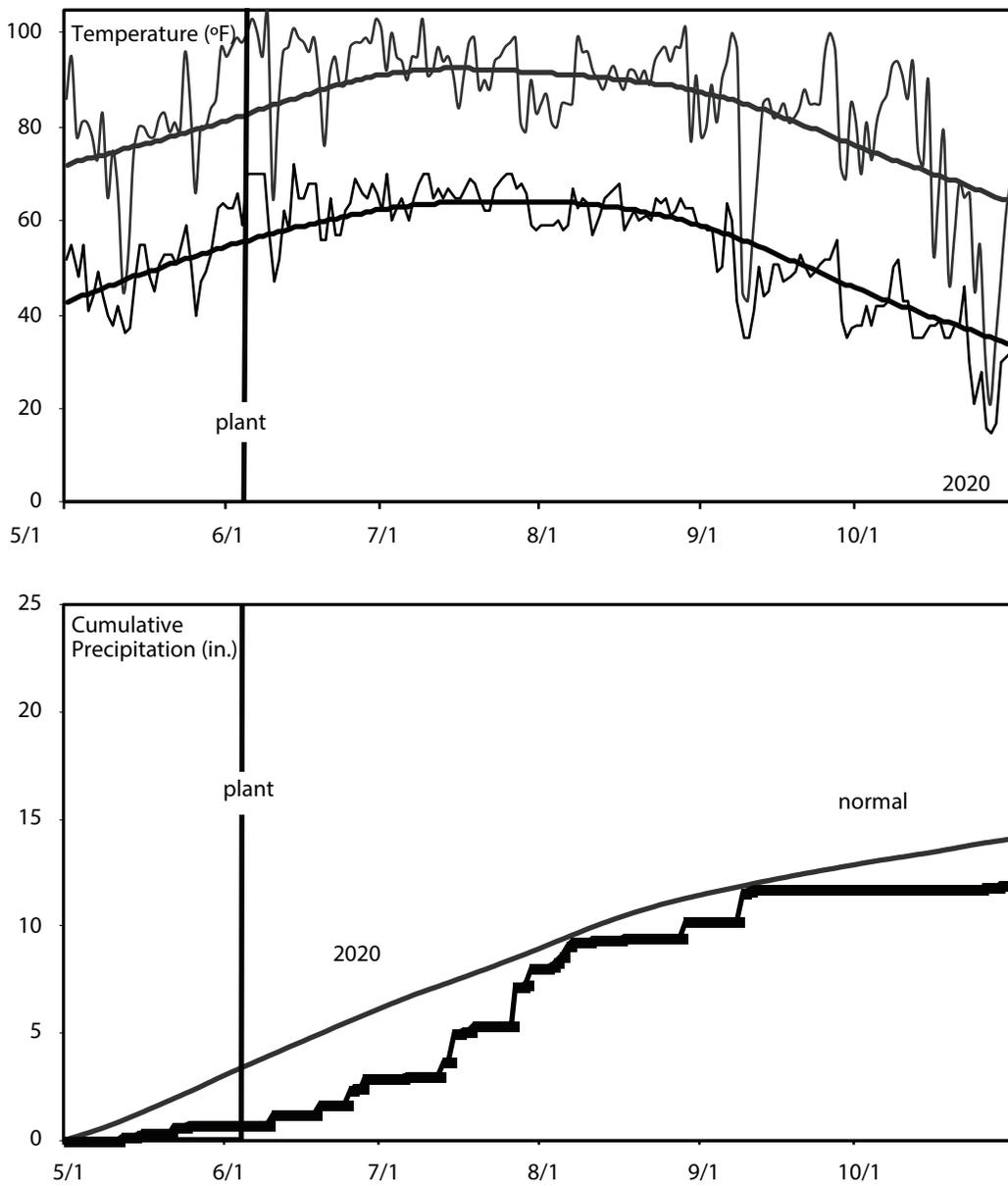


Figure 1. Precipitation and temperature during the 2020 growing season near Garden City, KS. Top pane: daily and mean (1981 to 2010) high and low temperature. Bottom pane: daily and mean (1981 to 2010) cumulative precipitation.

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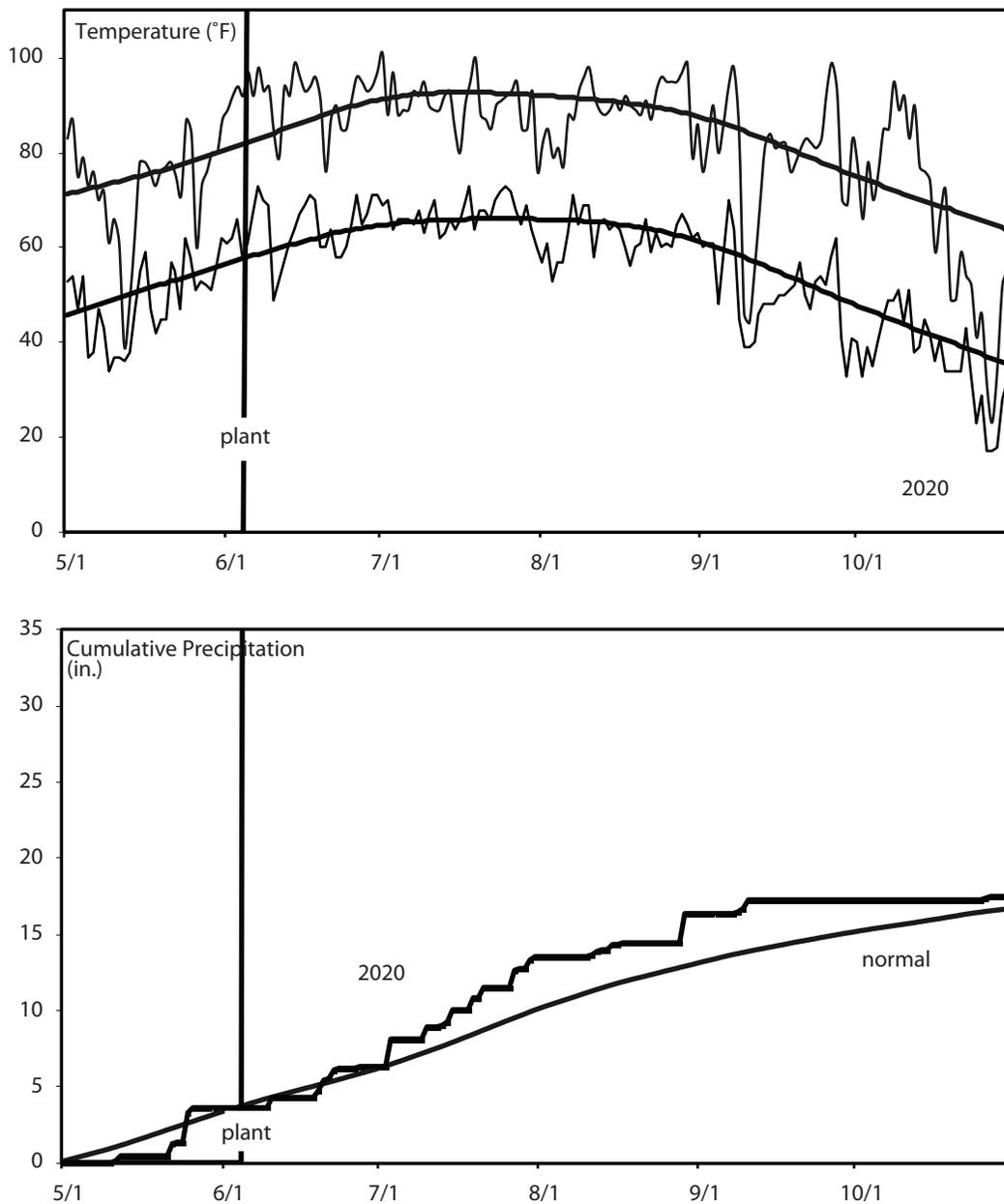


Figure 2. Precipitation and temperature during the 2020 growing season near Hays, KS. Top pane: daily and mean (1981 to 2010) high and low temperature. Bottom pane: daily and mean (1981 to 2010) cumulative precipitation.

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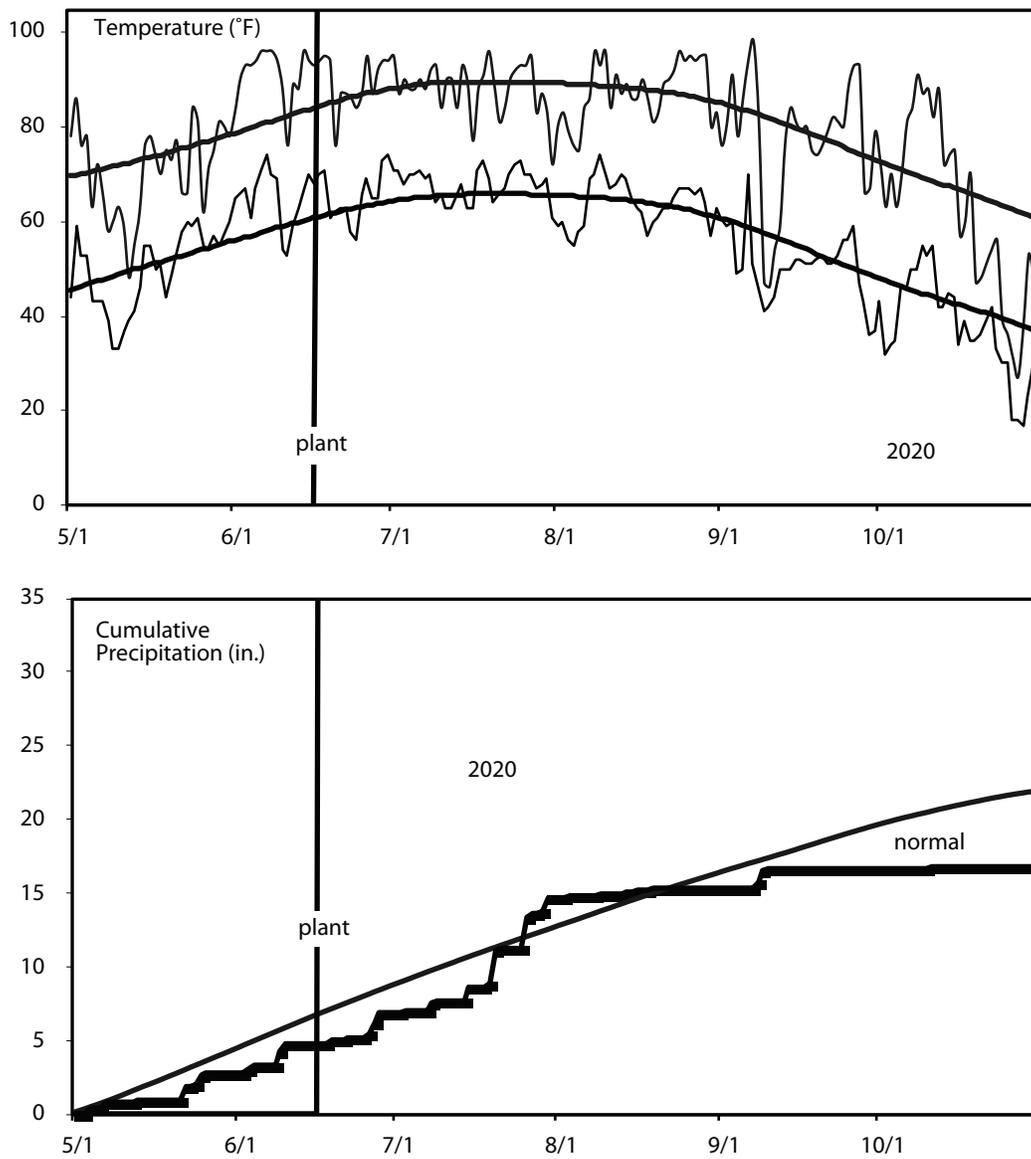


Figure 3. Precipitation and temperature during the 2020 growing season near Scandia, KS. Top pane: daily and mean (1981 to 2010) high and low temperature. Bottom pane: daily and mean (1981 to 2010) cumulative precipitation.

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Commerce Bank	Pioneer Hi-Bred
Crop Quest	Pioneer Seed
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Ehmke Seed	Servi-Tech
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Wilber Ellis	Star Seed
Fontanelle	Walter Moss Seed
Gayland Ward Seed	Winfield United
Mojo Seed	W-L Alfalfa



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