SOUTHWEST RESEARCH-EXTENSION CENTER

FIELD DAY 2013

Report of Progress 1088

K·STATE
Research and Extension

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

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Ph.D., Oregon State University

Dr. Gillen was appointed head of the Western Kansas Agricultural Research Centers (Colby, Garden City, Hays, and Tribune) in 2006. His research interests include grazing management systems, grassland ecology, and forage establishment.

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Ph.D., University of Kentucky

Phil joined the staff in 1981. His extension emphasis is insect pests of field crops.

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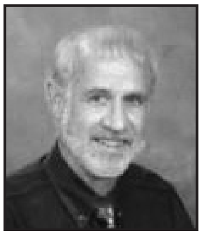
Debra works with county agents on various projects, program development and training. Her research focuses on families in their environments, rural social systems, and community developmental processes.



***Rod Buchele**, Extension Specialist, 4-H Youth Development*
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Weather Information for Garden City

J. Elliott

Precipitation for 2012 totaled 12.14 in. This was 7.10 in. below the 30-year average of 19.24 in. and similar to the 12.12 in. recorded in 2011. May and June were particularly dry, with precipitation totaling 22% of normal. Combined precipitation for 2011 and 2012 was 63% of normal. The largest daily precipitation was 1.86 in. on July 9. Minimal dime-size hail was noted on March 19.

Measurable snowfall occurred in February and December 2012. Annual snowfall totaled 4.1 in.; the average is 19.7 in. The largest event was 2.0 in. recorded on the last day of the year. Seasonal snowfall (2011–2012) was 9.3 in.

Average daily wind speed was 4.54 mph compared with the 30-year average of 5.10 mph. Our linear sprinkler was upset during a wind storm on June 15. Open-pan evaporation was measured daily from April through October and totaled 87.75 in. This was 17.49 in. above the 30-year mean and was nearly 10 times the precipitation for the same 7-month period.

Warm conditions were the story for 2012, as they were the previous year. We had the second-highest annual mean temperature (56.9°F) since our records began in 1915. March of 2012 was the warmest on record.

Triple-digit temperatures were observed on 35 days in 2012, with the highest being 112°F on June 28. This broke our previous all-time record high of 111°F on July 13, 1913, and July 13, 1934. Twelve record-high temperatures were equaled or exceeded in 2012: 85°F on March 14, 86°F on March 17, 93°F on April 2, 96°F on April 25, 93°F on April 26, 96°F on May 5, 98°F on May 6, 108°F on June 25 and 26, 109°F on June 27, 112°F on June 28, and 109°F on June 29.

Sub-zero temperatures occurred three times in 2012. The lowest temperature was -2°F noted on December 10, 11, and 26. One record low was set: 52°F on August 17.

The last spring freeze was 32°F on April 16, which was 13 days earlier than the 30-year average. The first fall freeze was 29°F on October 8, which was 4 days earlier than normal. This resulted in a 175-day frost-free period, which is 10 days longer than the 30-year average.

The 2012 climate information for Garden City is summarized in Table 1.

Table 1. Climate data, Southwest Research-Extension Center, Garden City

			Monthly temperatures									
	Precipitation		2012 avg.				2012 extreme		Wind		Evaporation	
Month	2012	Avg.	Max	Min	Mean	30-year avg.	Max	Min	2012	30-year avg.	2012	30-year avg.
	---------- in. -----------		-- °F --						-------- mph ---------		---------- in. -----------	
January	0.00	0.46	49.4	20.8	35.1	30.4	70	12	4.20	4.50	---	---
February	0.59	0.55	48.6	21.6	35.1	33.9	74	8	5.50	5.24	---	---
March	1.92	1.31	69.3	34.6	52.0	42.9	86	15	5.69	6.31	---	---
April	1.77	1.74	71.4	42.2	56.8	52.3	96	32	4.98	6.42	7.72	8.21
May	0.30	2.98	85.2	50.7	68.0	62.8	100	38	4.44	5.76	13.05	10.04
June	1.03	3.12	95.3	61.7	78.5	72.6	112	47	6.06	5.37	18.08	11.96
July	2.41	2.80	98.5	66.7	82.6	77.9	105	61	4.51	4.59	17.91	13.22
August	1.22	2.51	92.6	59.2	75.9	76.3	105	48	3.85	4.11	14.27	11.28
September	1.19	1.42	85.2	50.6	67.9	67.7	105	37	3.32	4.73	10.74	9.22
October	0.98	1.21	68.3	35.6	52.0	54.9	90	20	3.86	4.89	5.98	6.33
November	0.00	0.55	65.4	25.9	45.7	41.6	82	14	4.11	4.80	---	---
December	0.73	0.59	48.3	17.7	33.0	31.4	69	-2	3.93	4.45	---	---
Annual	12.14	19.24	73.1	40.6	56.9	53.7	112	-2	4.54	5.10	87.75	70.26

Normal latest spring freeze (32°F): April 29. In 2012: April 16.
Normal earliest fall freeze (32°F): October 12. In 2012: October 8.
Normal frost-free period (>32°F): 165 days. In 2012: 175 days.
30-year averages are for the period 1981–2010. All recordings were taken at 8:00 a.m.

Weather Information for Tribune

D. Bond and J. Slattery

In 2012, record-low annual precipitation of 7.49 in. was recorded, which is 10.41 in. below normal. The previous record of 7.76 in. was set in 1934. Ten months had below-normal precipitation. April (2.21 in.) was the wettest month. The largest single amount of precipitation was 1.12 in. on April 3. November, the driest month, recorded no precipitation. Snowfall for the year totaled 4.5 in.; February, March, and December had 0.2, 0.5, and 3.8 in., respectively, for a total of 12 days of snow cover. The longest consecutive period of snow cover, 5 days, occurred January 1 through 5.

Record-high temperatures were recorded on 16 days: March 7 (80°F), 14 (80°F), and 17 (84°F); April 25 (94°F); May 6 (96°F) and 23 (97°F); June 20 (106°F), 24 (109°F), 25 (111°F), 26 (108°F), 27 (111°F), and 28 (111°F); July 30 (106°F); August 2 (108°F) and 7 (104°F); and November 22 (76°F). Record-high temperatures were tied on 5 days: March 16 (79°F); June 19 (105°F) and 29 (107°F); and July 20 (106°F) and 29 (105°F). Record-low temperatures were recorded on August 17 (49°F) and December 26 (-10°F). Three record-low temperatures were tied on August 5 (51°F) and 19 (45°F) and on September 8 (43°F). July was the warmest month, with a mean temperature of 81.9°F. The hottest days of the year (111°F) occurred on June 25, 27, and 28. This broke the previous record of 109°F that was set on July 25, 1940. The coldest day of the year (-10°F) was December 26. December was the coldest month with a mean temperature of 31.4°F. The record for average annual maximum temperature, set in 1934, was broken in 2012.

Mean air temperature was above normal for 11 months. March had the greatest departure above normal (8.7°F), and October had the only departure below normal (-1.5°F). Temperatures were 100°F or higher on 39 days, which is 28 days above normal. Temperatures were 90°F or higher on 88 days, which is 25 days above normal. The latest spring freeze was April 16, which is 20 days earlier than normal; the earliest fall freeze was October 7, which is the normal date. This produced a frost-free period of 174 days, which is 20 days more than the normal of 154 days.

Open-pan evaporation from April through September totaled 84.01 in., which is 12.61 in. above normal. Wind speed for this period averaged 4.9 mph, which is 0.4 mph less than normal.

The 2012 climate information for Tribune is summarized in Table 1.

Table 1. Climatic data, Southwest Research-Extension Center, Tribune, KS, 2012

			Monthly average temperatures (°F)									
	Precipitation (in.)		2012		Normal		2012 extreme		Wind (mph)		Evaporation (in.)	
Month	2012	Normal	Max	Min	Max	Min	Max	Min	2012	Normal	2012	Normal
January	0.05	0.49	49.4	20.4	44.0	16.2	69	8	---	---	---	---
February	0.30	0.52	49.0	19.6	47.5	19.4	71	9	---	---	---	---
March	0.86	1.22	68.2	32.3	56.3	26.8	86	13	---	---	---	---
April	2.21	1.45	69.9	41.2	65.7	34.9	94	30	5.0	6.0	9.07	8.27
May	0.21	2.38	82.3	47.4	75.1	46.4	98	38	4.3	5.6	14.02	11.75
June	0.59	2.94	95.5	59.7	85.7	56.6	111	42	6.7	5.2	18.54	14.04
July	0.39	2.85	99.3	64.4	91.8	61.7	106	56	5.5	5.2	19.10	15.58
August	0.65	2.33	93.3	57.1	89.4	60.4	108	45	4.4	4.7	13.25	12.16
September	0.98	1.18	84.7	49.2	81.5	50.6	100	36	3.7	5.0	10.03	9.60
October	0.71	1.49	67.9	35.2	68.9	37.1	89	18	4.1*	4.5*	6.12*	6.19*
November	0.00	0.55	64.4	26.5	54.9	25.7	79	12	---	---	---	---
December	0.54	0.50	47.4	15.4	44.7	17.0	71	-10	---	---	---	---
Annual	7.49	17.90	72.7	39.1	67.1	37.7	111	-10	4.9	5.3	84.01	71.40

Normal latest freeze (32°F) in spring: May 6. In 2012: April 16.

Normal earliest freeze (32°F) in fall: October 7. In 2012: October 7.

Normal frost-free (>32°F) period: 154 days. In 2011: 174 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 10-year average (2001–2010) from Tribune weather data; October not included in annual totals.

Fallow Replacement Crops (Cover Crops, Annual Forages, and Grain Pea) Impact on Wheat Yield

J. Holman, T. Roberts, and S. Maxwell

Summary

Producers are interested in growing cover crops and reducing fallow. Growing a crop during the fallow period would increase profitability if crop benefits exceeded expenses. Limited information is available on growing crops in place of fallow in the semiarid Great Plains. A study from 2007–2012 evaluated cover crops, annual forages, and grain peas grown in place of fallow in a no-till wheat-fallow system. Wheat yield was not affected by the previous crop, whether it was hayed or left as cover. Wheat yield following the previous crop was dependent on precipitation during fallow and the growing season. In the dry years (2011 and 2012), growing a crop during the fallow period reduced wheat yields, yet in wet years (2008, 2009, and 2010) growing a crop during the fallow period had little impact on wheat yield. The length of the fallow period also affected yields of the following wheat crop. Growing a cover or hay crop until June 1 affected wheat less than if continuous wheat or grain peas were grown until grain harvest, which was approximately the first week of July. Cover crops did not improve wheat yield. Winter and spring lentil had the least negative impact on wheat yield, and yielded similar to fallow when averaged across years. Winter crop treatments tended to reduce yield more than spring crop treatments, which was due to more moisture available in the spring crop treatments at wheat planting. To be successful, the benefits of growing a crop during the fallow period must be greater than the expense of growing it plus compensate for any negative yield impacts on the subsequent crop. Cover crops always resulted in less profit than fallow, whereas forages and grain peas often increased profit compared to fallow. The negative effects on wheat yields might be minimized with flex-fallow, which is the process of only growing a crop in place of fallow in years when there is ample soil moisture at the time of making the decision to plant.

Introduction

Interest in replacing fallow with a cash crop or cover crop has necessitated research on soil water and wheat yields following a shortened fallow period. Fallow stores moisture, which helps stabilize crop yields and reduce the risk of crop failure; however, only 25 to 30% of the precipitation received during the fallow period of a no-till wheat-fallow rotation is stored. The remaining 85 to 70% precipitation is lost, primarily to evaporation. Moisture storage in fallow is more efficient earlier in the fallow period, when the soil is dry, and during the winter months when the evaporation rate is lower. It may be possible to increase cropping intensity without reducing winter wheat yield. This study evaluated replacing part of the fallow period with a cover, annual forage, or short-season grain crop on plant-available water at wheat planting and winter wheat yield.

Procedures

Fallow replacement crops (cover, annual forage, or short-season grain crop) were grown during the fallow period of a no-till wheat-fallow cropping system every year from

2007 through 2011. Fallow replacement crops were either grown as cover, harvested for forage (annual forage crop), or harvested for grain. Both winter and spring crop species were evaluated. Winter species included yellow sweet clover (*Melilotus officinalis* (L.) Lam.) hairy vetch (*Vicia villosa* Roth ssp.), lentil (*Lens culinaris* Medik.), Austrian winter forage pea (*Pisum sativum* L. ssp.), Austrian winter grain pea (*Pisum sativum* L. ssp.), and triticale (×*Triticosecale* Wittm.). Spring species included lentil (*Lens culinaris* Medik.), forage pea (*Pisum sativum* L. ssp.), grain pea (*Pisum sativum* L. ssp.), and triticale (×*Triticosecale* Wittm.). Crops were grown in monoculture and in two-species mixtures of each legume plus triticale. Crops grown for grain were grown in monoculture only. Winter lentil was grown in place of yellow sweet clover beginning in 2008. Crops grown in place of fallow were compared with a wheat-fallow and continuous wheat rotation for a total of 16 treatments (Table 1). The study design was a split-split-plot randomized complete block design with four replications; crop phase (wheat-fallow) was the main plot, fallow replacement was the split-plot, and fallow replacement method (forage, grain, or cover) was the split-split-plot. The main plot was 480 ft wide and 120 ft long, the split-plot was 30 ft wide and 120 ft long, and the split-split plot was 15 ft wide and 120 ft long.

Winter crops were planted approximately October 1. Winter cover and forage crops were chemically terminated or forage-harvested approximately May 15. Spring crops were planted from the end of February through the middle of March. Spring cover and forage crops were chemically terminated or forage-harvested approximately June 1. Biomass yields for both cover crops and forage crops were determined from a 3-ft × 120-ft area cut 3 in. high using a small plot Carter forage harvester from within the split-split-plot managed for forage. Winter and spring grain peas and winter wheat were harvested with a small plot Wintersteiger combine from a 6.5-ft × 120-ft area at grain maturity, which occurred approximately the first week of July.

Volumetric soil moisture content was measured at cover crop and winter wheat planting and termination using a Giddings Soil Probe in 1-ft increments to a 6-ft soil depth. In addition, volumetric soil content was measured in the 0–3-in. soil depth at wheat planting to quantify moisture in the seed planting depth. Grain yield was adjusted to 13.5% moisture content, and test weight was measured using a grain analysis computer. Grain samples were analyzed for nitrogen content.

Results and Discussion

Winter Wheat Yield

In 2008, hail damaged the wheat crop 1 week before harvest; therefore, no statistical separation was made between treatments. Winter wheat yield following a fallow crop ranged from 21 through 26 bu/a, wheat yield following wheat was 13 bu/a, and wheat yield following fallow was 22 bu/a (Figure 1).

In 2009, grain pea and winter clover/triticale yielded 7 and 9 bu/a less than fallow (83 bu/a), and spring pea yielded 7 bu/a more than fallow (Figure 2). Continuous wheat yielded least of all (57 bu/a). All other treatments yielded similar to fallow.

In 2010, winter pea/triticale and winter triticale yielded 5 and 7 bu/a less than fallow (70 bu/a), and spring lentil/triticale and spring pea/triticale yielded 4 and 6 bu/a less than fallow (Figure 3). Continuous wheat yielded least of all (43 bu/a). All other treatments yielded similar to fallow. Wheat following cover crops yielded an average of 2.9 bu/a more than wheat following a hay crop.

In 2011, only 6.77 in. of precipitation occurred between October 1, 2010, and July 1, 2011. This drought resulted in low wheat yields and a greater impact of the preceding crop on wheat yield. Wheat grown following a winter cover or forage crop yielded less than fallow with the exception of winter lentil (22 bu/a), which yielded similar to fallow (23 bu/a) (Figure 4). Wheat yield following all other winter crops was reduced by 4 to 10 bu/a. Wheat yield following spring cover or forage crops was not affected as much as winter crops. Wheat yield following spring lentil, triticale, and lentil/triticale was similar to fallow, and wheat following spring pea and pea/triticale was reduced 7 and 3 bu/a, respectively. Wheat following spring grain pea was reduced 11 bu/a, and wheat following wheat was reduced 16 bu/a compared with fallow.

In 2012, only 6.01 in. of precipitation occurred between October 1, 2011, and July 1, 2012. The normal precipitation during this period was 12.5 in. The second year of drought conditions resulted in low wheat yields and the preceding crop reducing wheat yield more than in previous years. Winter cover or forage crops reduced wheat yield 24 bu/a, and spring cover or forage crops reduced wheat yield 23 bu/a compared with fallow (Figure 5). Continuous wheat yielded 20 bu/a less than wheat-fallow. Wheat grown following grain peas yielded the least with yields being reduced to 3 bu/a following winter grain pea and 5 bu/a following spring grain pea.

Averaged over years from 2009 through 2012 (2008 was excluded due to hail damage), there was no difference whether the previous crop was grown as forage or cover ($P = 0.09$). Wheat yields following a cover crop tended to yield more than a forage crop. This difference was due to slightly more soil moisture following a cover crop than a forage crop. With the exception of winter and spring lentil (53 bu/a) replacing fallow with a cover or grain crop reduced yield compared with fallow (56 bu/a) (Figure 6). Winter crop treatments tended to reduce wheat yields more than spring crop treatments. Winter triticale and triticale/legume mixtures yielded 9 to 12 bu/a less than fallow. Winter legume monocultures yielded more than triticale/legume mixtures. Winter pea and hairy vetch yielded 6 and 4 bu/a less than fallow, respectively. Spring triticale, triticale/legume mixtures, and spring pea yielded between 6 and 8 bu/a less than fallow. Grain pea yielded 12 bu/a less than fallow, and continuous winter wheat yielded 23 bu/a less than fallow.

Cover vs. Annual Forage

Across years (2009–2012), there was no difference in wheat yield whether the previous crop was left as cover or harvested for forage. This indicates the previous crop can be harvested for forage rather than left standing as a cover crop without negatively affecting wheat yield.

Conclusions

Fallow helps stabilize crops in dry years. Annual precipitation in this study ranged from 12.1 to 21.7 in. In the dry years (2011 and 2012), growing a crop during the fallow period reduced wheat yields, but in wet years (2008, 2009, and 2010), growing a crop during the fallow period had little impact on wheat yield. The length of the fallow period also affected yields of the following wheat crop. Growing a cover or hay crop until June 1 affected wheat less than if continuous wheat or grain peas were grown until grain harvest, which was approximately the first week of July.

After the first year, winter lentil was grown in place of yellow sweet clover because the growth of yellow sweet clover was too slow to fit this cropping system. Winter peas and hairy vetch often winter-killed when grown in monoculture, but when grown in combination with triticale, they survived the winter better. Winter lentil grown in monoculture or with triticale survived the winter well. Cover crops did not improve wheat yield. Winter and spring lentil had the least negative impact on wheat yield, and averaged across years yielded similar to fallow. Winter crop treatments tended to reduce yield more than spring crop treatments, which was due to more moisture available in the spring crop treatments at wheat planting.

Forages provided an economic return, whereas cover crops were an expense to grow. The cropping system can be intensified by replacing part of the fallow period with annual forages or spring grain pea to increase profit and improve soil quality; however, in semiarid environments, wheat yields will be reduced slightly. This yield reduction was compensated for by the value of a forage or grain crop, but not cover crop. The negative impacts on wheat yields might be minimized with flex-fallow. Flex-fallow is the concept of only planting forage or grain pea when soil moisture levels are adequate and the precipitation outlook is favorable. Under drought conditions such as 2011 and 2012, using flex-fallow, a crop would have not been grown in place of fallow. Implementing flex-fallow may minimize the negative impacts of reduced fallow. Future research needs to evaluate replacing fallow with forage or spring grain pea in a wheat-summer crop-fallow rotation.

Table 1. Crop treatments

		Year produced				
Season	Crop	2007	2008	2009	2010	2011
Winter	Yellow sweet clover	x	x			
	Yellow sweet clover/winter triticale		x			
	Hairy vetch	x	x	x	x	x
	Hairy vetch/winter triticale		x	x	x	x
	Winter lentil			x	x	x
	Winter lentil/winter triticale			x	x	x
	Winter pea	x	x	x	x	x
	Winter pea/winter triticale		x	x	x	x
	Winter triticale	x	x	x	x	x
	Winter pea (grain)		x	x		x
Spring	Spring lentil	x	x	x	x	x
	Spring lentil/spring triticale		x	x	x	x
	Spring pea	x	x	x	x	x
	Spring pea/spring triticale		x	x	x	x
	Spring triticale		x	x	x	x
	Spring pea (grain)				x	x
Other	Chem-fallow	x	x	x	x	x
	Continuous winter wheat	x	x	x	x	x

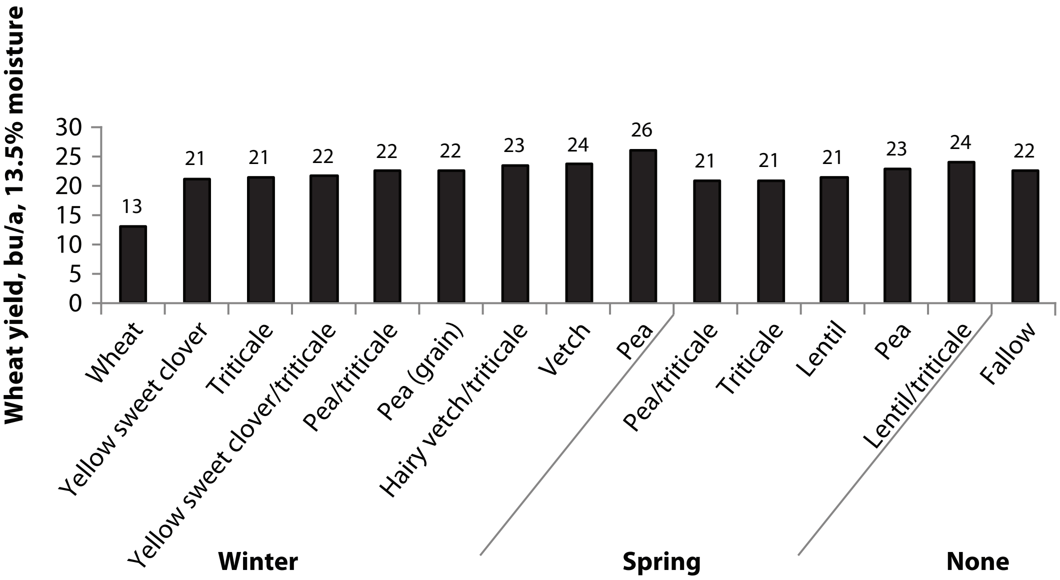

Figure 1. 2008 winter wheat yield following 2007 cover crops.

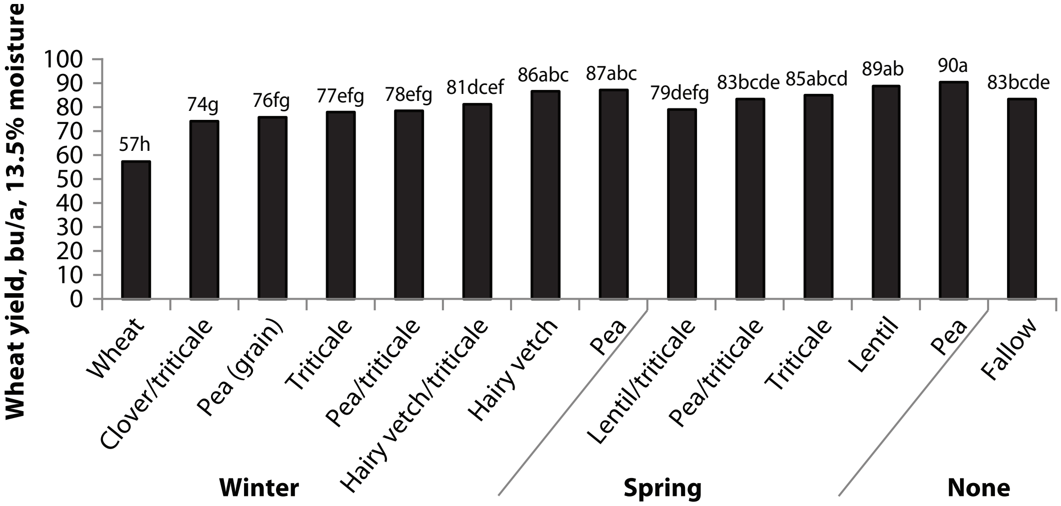

Figure 2. 2009 winter wheat yield following 2008 cover crops. Letters within a column represent differences at LSD 0.05.

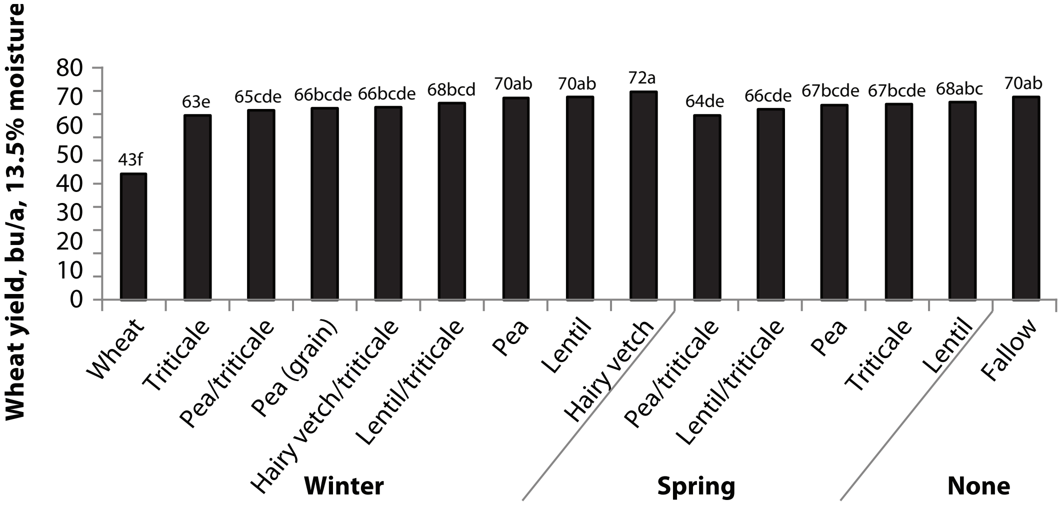

Figure 3. 2010 winter wheat yield following 2009 cover crops. Letters within a column represent differences at LSD 0.05.

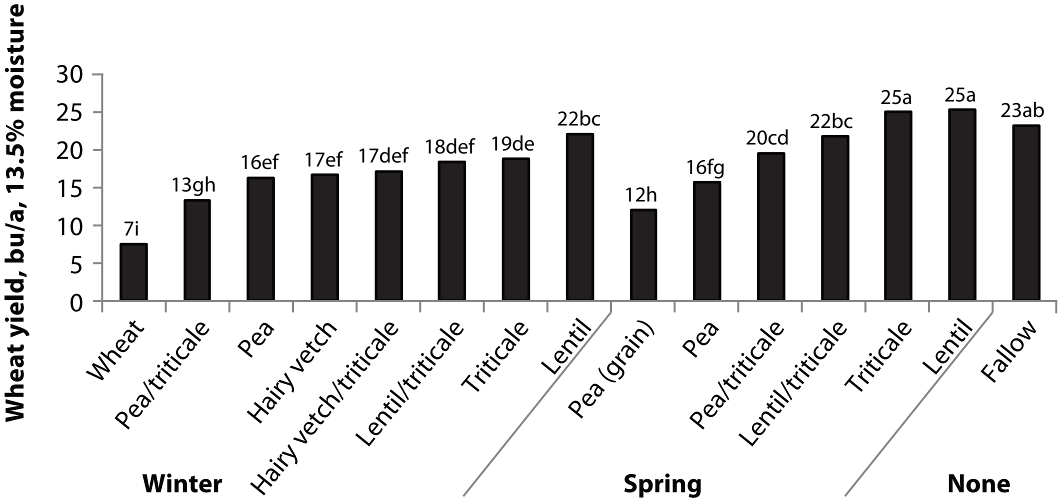

Figure 4. 2011 winter wheat yield following 2010 cover crops. Letters within a column represent differences at LSD 0.05.

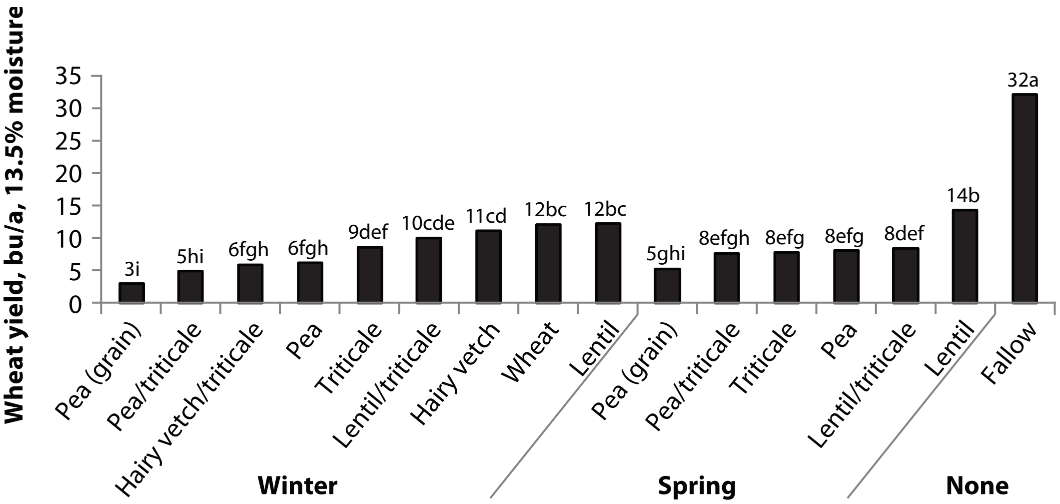

Figure 5. 2012 winter wheat yield following 2011 cover crops.
Letters within a column represent differences at LSD 0.05.

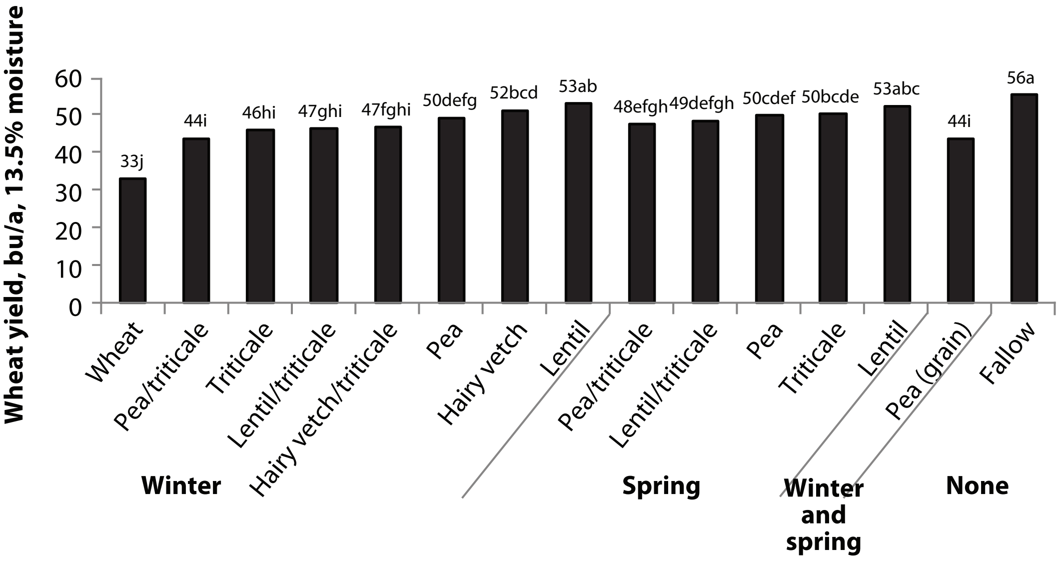

Figure 6. 2009–2012 winter wheat yield following cover crops.
Letters within a column represent differences at LSD 0.05.

Cover Crop, Annual Forages, and Grain Pea Effects on Soil Water in Wheat-Fallow and Wheat-Sorghum-Fallow Cropping Systems

J. Holman, A. Schlegel, T. Roberts, and S. Maxwell

Summary

Producers are interested in growing cover crops and reducing fallow. Limited information is available on growing crops in place of fallow in the semiarid Great Plains. Between 2007 and 2012, winter and spring cover, annual forage, and grain crops were grown in place of fallow in a no-till wheat-fallow (WF) rotation. A second study was initiated beginning in 2011, with spring cover, annual forage, and grain crops grown in place of fallow in a no-till wheat-sorghum-fallow (WSF) rotation. Growing a cover, hay, or grain crop in place of fallow reduced the amount of stored soil moisture at wheat planting. On average, cover crops stored slightly more moisture than hay crops, but this soil moisture difference did not affect wheat yields. Soil moisture following grain crops was less than cover or hay crops, and this difference resulted in reduced wheat yields. Stored soil moisture was lowest among winter crops that produced a lot of biomass or the cover crop cocktail (six-species mixture). Spring crops and low biomass crops had the least negative effect on stored soil moisture. These results do not support the claims that cover crops increase soil moisture compared with fallow. Crops grown in place of fallow must compensate for the expense of growing the crop plus the reduction in soil moisture for the following crop.

Introduction

Interest in replacing fallow with a cash crop or cover crop has necessitated research on soil water and wheat yields following a shortened fallow period. Fallow stores moisture, which helps stabilize crop yields and reduce the risk of crop failure; however, only 25 to 30% of the precipitation received during the fallow period of a no-till wheat-fallow rotation is stored. The remaining 75 to 70% precipitation is lost, primarily to evaporation. Moisture storage in fallow is more efficient earlier in the fallow period, when the soil is dry, and during the winter months when the evaporation rate is lower. It may be possible to increase cropping intensity without reducing winter wheat yield. This study evaluated replacing part of the fallow period with a cover, annual forage, or short-season grain crop on plant-available water at wheat planting and winter wheat yield.

Procedures

Wheat-Fallow

See "Fallow Replacement Crops (Cover Crops, Annual Forages, and Grain Pea) Impact on Wheat Yield" (page 5) for treatments (Table 1) and study methods.

Wheat-Sorghum-Fallow

Beginning in 2011, the wheat-fallow (WF) crop rotation was modified to a wheat-sorghum-fallow (WSF) crop rotation. Fallow replacement crops (cover, forage, and grain) were grown during the spring of the fallow year. The study design was a split-

split-plot randomized complete block design with 4 replications; crop phase (wheat-sorghum-fallow) was the main plot, fallow replacement was the split-plot, and fallow replacement method (forage, grain, or cover) was the split-split-plot. The main plot was 450 ft wide and 120 ft long, the split-plot was 30 ft wide and 120 ft long, and the split-split plot was 15 ft wide and 120 ft long. Spring cover crop and forage crop treatments included forage pea (*Pisum sativum* L. ssp.), triticale (×*Triticosecale* Wittm.), oat (*Avena sativa* L.), a mixture of forage pea plus triticale, a mixture of forage pea plus oat, and a cocktail mixture of oat, triticale, pea, buckwheat var. Mancan (*Fagopyrum esculentum* M.), purple top turnip (*Brassica campestris* L.), and forage radish (*Raphanus sativus* L.). In addition, spring grain pea (*Pisum sativum* L. ssp.) and safflower (*Carthamus tinctorius* L.) were grown for grain. Spring cover crop treatments were grown in 2011, and winter wheat was planted in the fall of 2012. First-year plant-available soil water results at wheat planting in 2012 are reported. Because only one year of data for the WSF rotation is available, caution must be used in drawing conclusions.

Results and Discussion

Wheat-Fallow (2007–2012)

Year. Fallow and growing-season precipitation varied greatly during the course of this study. Average precipitation during the fallow period (July–December plus January–September) was 25.97 in., and growing season precipitation (October–June) was 12.51 in. Fallow precipitation was above average preceding the 2008–09 growing season (27.64 in.), about average preceding the 2009–10 growing season (25.36 in.), and below average preceding the 2007–08 (20.3 in.), 2010–11 (14.42 in.), and 2011–12 (16.66 in.) growing seasons. Growing-season precipitation was above average in 2008–09 (16.24 in.) and 2009–10 (14.1 in.) and below average in 2007–08 (9.46 in.), 2010–11 (6.77 in.), and 2011–12 (8.5 in.). These differences affected plant-available soil water at wheat planting and wheat yields (Table 2). Plant-available soil water in the 0–3-in. and 0–6-ft profile were greatest in 2008 and 2009 and least in 2010 and 2011.

Cover vs. Annual Forage. Plant-available soil water in the 0–3-in. soil depth averaged 0.03 in. greater among cover crop treatments (0.09 in.) than hay treatments (0.06 in.) (Table 3). In the 0–6-ft profile, plant-available soil water averaged 0.8 in. more following cover crops (5.76 in.) than hay crops (4.96 in.). More surface residue in the cover crop treatments compared with hay treatments likely reduced evaporation near the soil surface and might have reduced water runoff.

Fallow Crop (0–3-in. soil depth). Soil moisture in the top 0–3 in. is important for seed germination and seedling establishment. Plant-available soil water varied among treatments. Those treatments with winter triticale (hairy vetch/winter triticale, winter pea/winter triticale, winter lentil/winter triticale, and winter triticale) had the most soil moisture (Table 4). Legume monocultures, mixtures with spring triticale, spring triticale, and fallow had the second highest amount of soil moisture. There was a tendency for more soil moisture with increased amounts of biomass (Figure 1), and winter triticale produced the most amount of biomass. Increased levels of biomass likely reduced soil water evaporation. Thus, those treatments with winter triticale had more soil moisture than lower biomass treatments. Continuous winter wheat and grain pea had the least amount of surface soil moisture. Continuous winter wheat and grain pea also had the least amount of soil moisture at deeper depths, which likely kept soil near the surface dry.

Fallow Crop (0–6-ft soil depth). Moisture in the 0–6-ft soil profile is important for growing a crop, particularly in semiarid climates. Fallow had the greatest amount of soil moisture, and all other treatments had less (Table 5). Those treatments that produced less biomass (hairy vetch, spring pea, winter lentil, spring lentil, spring triticale, and winter pea) had more available soil moisture than the other treatments. Also, winter triticale and winter triticale mixtures had less soil moisture than spring triticale and spring triticale mixtures. Soil moisture was affected by both the amount of biomass and length of time the cover crop was grown. More soil water was used to grow cover crops that produced large amounts of biomass and had a long growing season. Grain pea and continuous wheat had the least amount of soil moisture, which was due to their longer growing season and shorter fallow period.

Wheat-Sorghum-Fallow (2012)

Cover vs. Annual Forage. Plant-available soil water in the 0–3-in. soil depth was 0.09 in. greater among cover crop treatments (0.17 in.) than hay treatments (0.08 in.) at wheat planting in 2012. There was no difference in available soil water between cover and hay treatments in the 0–6-ft profile. More surface residue in the cover crop treatments compared with hay treatments likely reduced evaporation near the soil surface and might have reduced water runoff.

Fallow Crop (0–3-in. soil depth). No differences occurred between treatments at the 0–3-in. soil depth in 2012.

Fallow Crop (0–6-ft soil depth). These results are similar to the findings from the 5-year WF rotation study. Fallow had 6.38 in. of plant-available soil water in the 0–6-ft profile at wheat planting, which was greater than all other treatments (Table 6). Of the fallow replacement crops, grain pea (3.26 in.) and forage pea (3.04 in.) had more plant-available soil water than safflower (1.11 in.). All other fallow replacement treatments had plant-available soil water similar to pea or safflower. Of all the cover or hay treatments, the cocktail had the least amount of stored soil water. The combination of species in the cocktail had different rooting architecture and maturities, which likely helped to increase soil water use more than a single- or two-species crop. Compared with previous years in the WF study, grain pea had more soil moisture at wheat planting than expected. The drought and heat in 2012 resulted in low grain pea yield (12.4 bu/a) and an early harvest. The early harvest resulted in a longer fallow period and more time for moisture storage than normal. Safflower matures later than grain pea and had the shortest fallow period of any treatment. The short fallow period resulted in less soil moisture storage ahead of wheat planting.

Conclusions

Fallow is important for storing precipitation and stabilizing crop yields, particularly in semiarid climates such as the central Great Plains. Growing a cover, hay, or grain crop in place of fallow reduced the amount of stored soil moisture at wheat planting. On average, cover crops stored 0.08 in. more moisture than hay crops, but this soil moisture difference did affect wheat yield. Soil moisture following grain crops was less than cover or hay crops, and this difference resulted in reduced wheat yield. Increasing surface residue tended to increase the amount of soil moisture in soil surface (0–3 in.), which could help improve stand establishment in dry years. Stored soil moisture was lowest among winter crops that produced a lot of biomass or a cover crop cocktail (six-species mixture). Spring crops and low-biomass crops had the least negative effect on stored soil moisture. Crops grown in place of fallow must compensate for the expense of growing the crop plus the reduction in soil moisture for the following crop.

Table 1. Crop treatments

		Year produced				
Season	Crop	2007	2008	2009	2010	2011
Winter	Yellow sweet clover	x	x			
	Yellow sweet clover/winter triticale		x			
	Hairy vetch	x	x	x	x	x
	Hairy vetch/winter triticale		x	x	x	x
	Winter lentil			x	x	x
	Winter lentil/winter triticale			x	x	x
	Winter pea	x	x	x	x	x
	Winter pea/winter triticale		x	x	x	x
	Winter triticale	x	x	x	x	x
	Winter pea (grain)		x	x		x
Spring	Spring lentil	x	x	x	x	x
	Spring lentil/spring triticale		x	x	x	x
	Spring pea	x	x	x	x	x
	Spring pea/spring triticale		x	x	x	x
	Spring triticale		x	x	x	x
	Spring pea (grain)				x	x
Other	Chem-fallow	x	x	x	x	x
	Continuous winter wheat	x	x	x	x	x

Table 2. Plant-available soil water in the 0–3-in. and 0–6-ft soil depth at wheat planting, growing season precipitation, and fallow precipitation at Garden City, KS, 2007–2012

Growing season	Plant-available water (0–3 in.)		Plant-available water (0–6 ft)		Growing season precipitation (Oct.–June)	Fallow precipitation (July–Sept.)
	--------------------	--------------------	--------------------	in.	--------------------	--------------------
2007–08	---	---	---	---	9.46	20.30
2008–09	0.04	b[1]	4.38	c	16.24	27.64
2009–10	0.28	a	7.58	a	14.10	25.36
2010–11	-0.06	d	5.84	b	6.77	14.42
2011–12	0.00	c	2.84	d	8.50	16.66
		ANOVA P>F				
Source of variation						
LSD 0.05	0.03		0.46			

[1] Different letters within a column represent differences at LSD 0.05.

Table 3. Cover crop method (cover crop or hay harvest) effects on plant-available soil water in the 0–3-in. and 0–6-ft soil depth at wheat planting

Cover crop method	Plant-available water (0–3 in.)		Plant-available water (0–6 ft)	
	--------------------	-------------------- in.	--------------------	
Cover	0.09	a[1]	5.76	a
Hay	0.06	b	4.96	b
		ANOVA P>F		
Source of variation				
LSD 0.05	0.03		0.45	

[1] Different letters within a column represent differences at LSD 0.05.

Table 4. Fallow, cover crop, and grain crop effects on plant-available soil water in the 0–3-in. soil depth at wheat planting

Fallow method	Plant-available water (0–3 in.)	
	------------------------- in. -------------------------	
Hairy vetch/winter triticale	0.14	a[1]
Winter pea/winter triticale	0.12	ab
Winter lentil/winter triticale	0.10	abc
Winter triticale	0.09	abcd
Spring triticale	0.07	bcde
Winter pea	0.07	bcde
Hairy vetch	0.06	cde
Spring pea/spring triticale	0.06	cde
Spring lentil/spring triticale	0.06	cde
Fallow	0.06	cde
Spring pea	0.05	cde
Spring lentil	0.04	de
Winter lentil	0.04	ef
Winter wheat	-0.01	fg
Pea (grain)	-0.02	g
	ANOVA P>F	
Source of variation		
LSD 0.05	0.05	

[1] Different letters within a column represent differences at LSD 0.05.

Table 5. Fallow, cover crop, and grain crop effects on plant-available soil water in the 0–6-ft soil depth profile and the difference in soil moisture compared with fallow at wheat planting

Fallow method	Plant-available water (0–6 ft)		Difference in fallow plant-available water (0–6 ft)
	------------------- in. -------------------		
Fallow	7.91	a[1]	0.00
Hairy vetch	6.24	b	-1.68
Spring pea	6.16	b	-1.75
Winter lentil	6.06	bc	-1.85
Spring lentil	5.68	bcd	-2.24
Spring triticale	5.49	bcd	-2.43
Winter pea	5.40	bcd	-2.51
Spring pea/s triticale	5.24	cde	-2.68
Spring lentil/s triticale	5.17	cdef	-2.75
Hairy vetch/w triticale	5.15	def	-2.76
Winter pea/w triticale	4.95	defg	-2.97
Winter lentil/w triticale	4.49	efg	-3.42
Winter triticale	4.29	fg	-3.62
Pea (grain)	4.09	gh	-3.82
Winter wheat	3.28	h	-4.64
	ANOVA P>F		
Source of variation			
LSD 0.05	0.90		

[1] Different letters within a column represent differences at LSD 0.05.

Table 6. Fallow, cover crop, and grain crop effects on plant-available soil water in the 0–6-ft soil profile and the difference in soil moisture compared with fallow at wheat planting in a wheat-sorghum-fallow rotation in 2012

Fallow method	Plant-available water (0–6 ft)		Difference in fallow plant-available water (0–6 ft)
	------------------ in. ------------------		
Fallow	6.38	a[1]	0.00
Spring pea (grain)	3.26	b	-3.12
Spring pea	3.04	b	-3.34
Spring oat	2.77	bc	-3.61
Spring pea/triticale	2.61	bc	-3.77
Spring triticale	2.04	bc	-4.33
Spring pea/oat	2.03	bc	-4.35
Cocktail	1.95	bc	-4.42
Safflower	1.11	c	-5.27
	ANOVA P>F		
Source of variation			
LSD 0.05	1.90		

[1] Different letters within a column represent differences at LSD 0.05.

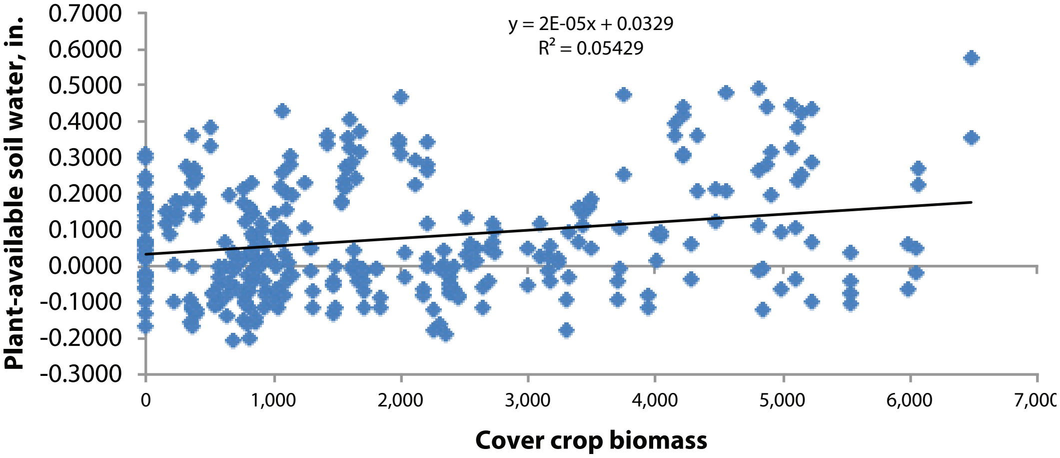

Figure 1. Plant-available soil water in the 0–3-in. soil depth correlated to cover and hay crop treatment biomass.

2011 Grain Filling Rates of Irrigated and Dryland Corn in Southwest Kansas

J. Holman, T. Roberts, S. Maxwell, and M. Zarnstorff

Summary

Due to the warm and dry conditions during the 2011 growing season, the dryland corn crop prematurely quit growing mid-season (VT stage) due to drought stress. Irrigated corn produced grain, with accumulation consistently increasing from early R3 through R6 with a final yield of 191.5 bu/a. Both grain and cob moisture content decreased throughout the season, ending up at 147.6 and 461.3 g/kg, respectively. This information can be used to estimate corn yield or help make determinations for when to harvest corn for silage.

Introduction

A field experiment was conducted at the Kansas State University Southwest Research-Extension Center at Garden City, KS, to compare the grain fill rates of a corn hybrid under irrigation and dryland (rainfed) cropping conditions. Understanding the rate of grain yield development and change in moisture content is important for making management decisions about when to plan and implement silage harvest and for determining grain yield potential. This experiment evaluated grain yield and moisture throughout the reproductive growth stages of a corn crop grown under both irrigated and dryland conditions.

Procedures

A field with center pivot irrigation was selected for the irrigated plot area, and the non-irrigated corner of the field was selected for the dryland plot area. Corn in both areas was grown following wheat. The soil type was a Ulysses Silt Loam.

On May 5, 2011, Pioneer 33B54 (113-day comparative relative maturity, or CRM) was planted in both the irrigated and dryland portions of the field at seeding rates of 34,300 and 18,000 seeds/a, respectively, on 30-in. row spacing. A preplant application of nitrogen (N) was applied at a rate of 200 lb/a N as urea in the irrigated field and 80 lb/a N as urea in the dryland field. An area consisting of 4 50-ft-long rows was marked in both the irrigated and dryland areas adjacent to each other to be used for sample collections.

On August 3, the irrigated corn was at the milk stage (R3) (Table 1). Beginning at this time interval, 5 ears were hand-harvested on a weekly basis at random from the sample collection area through physiological maturity (R6) and grain harvest. Observations of husk greenness, crop canopy color, and intactness were recorded at each time interval (Table 2). On August 3, plants in the dryland plots were in the mid-tassel (VT) stage of growth and showing drought stress. At each time interval, 5 ears were collected at random, weighed wet, photographed, broken in half to check the progression of the starch line, and the starch line was recorded with a photograph. The ears were then placed in a drying oven and dried at 104°F for 96 or more hours until dry. Dried ears were then shelled and a weight of the grain, cob, and 250 kernels were measured. When the corn reached the R5 stage, the ears were shelled before drying so a wet weight of the grain and cob could be measured separately; dry weights were measured after drying. These measurements were then used to obtain the change in moisture of the grain and cob.

2011 Growing Conditions

The 2011 growing season was exceptionally warmer and dryer than normal. The amount of precipitation received from wheat harvest in 2010 to corn planting in 2011 was 6.64 in., which is 4.89 in. below average and resulted in planting into dry soils with very little profile moisture. During the 2011 corn growing season (May 1–Oct. 1), precipitation was 55% of the 30-year average (14.57 in.) and temperatures averaged 2.5° warmer than the 30-year average of 68.3 (Table 3). These conditions led to a failed crop in the dryland field and reduced yield in the irrigated field even with supplemental irrigation.

Results

The warm, dry weather conditions from the previous wheat harvest through the corn growing season resulted in conditions that kept the corn crop stressed throughout the growing season. These conditions caused the dryland corn crop to prematurely quit growing at tassel (VT) and not produce any ears. The stressful environmental conditions also reduced the yield potential of the irrigated corn.

Grain yield development was linear from early milk (R3) on August 3 until physiological maturity (R6) on September 21. The last sampling period showed a slight decrease in yield, which was likely due to the random chance of collecting shorter ears at the last sampling period than in earlier sampling periods (based on photographs). Yields started at 31.4 bu/a during the first sample collection and increased to 191.5 bu/a at maturity, with an average daily grain accumulation of 2.9 bu/a per day (Figure 1). Grain and cob moisture showed a linear trend of decreasing moisture content from early sampling until maturity (Figure 2). Grain moisture decreased from 431 g/kg on August 24 to 148 g/kg on September 28, a decrease of 8 g/kg per day. Cob moisture decreased from 653 g/kg to 461 g/kg, a decrease of 5 g/kg per day.

Table 1. Crop growth stage

Stage	Reproductive stages
R1	Silking: silks visible outside the husks
R2	Blister: kernels are white and resemble a blister in shape
R3	Milk: kernels are yellow on the outside with a milky inner fluid
R4	Dough: milky inner fluid thickens to pasty consistency
R5	Dent: nearly all kernels are denting
R6	Physiological maturity: black abscission layer has formed

Table 2. Plant health observations

Date	Growth stage	Husk greenness	Canopy greenness	Canopy intactness
August 3	R3	100%	100%	100%
August 10	R4	100%	100%	100%
August 17	Early R5	95%	95%	95%
August 24	Mid R5	80%	90%	90%
August 31	Late R5	50%	75%	75%
September 7	Late R5	25%	50%	50%
September 14	R6	10%	25%	30%
September 21	R6	5%	10%	30%
September 28	R6	0	5%	25%

Table 3. Weather and irrigation data for the 2011 corn maturity line study

Month	Precipitation	30-yr. avg. precipitation	Average air temperature	30-yr. avg. temperature	Irrigation
	--------------- in.	---------------	--------------- °F	---------------	in.
April	1.79	1.74	53.8	52.3	0
May	1.14	2.98	61.2	62.8	0.61
June	1.69	3.12	76.6	72.6	4.45
July	0.54	2.8	84.9	77.9	6.92
August	2.43	2.51	82.0	76.3	6.4
September	0.37	1.42	66.4	67.7	0.91
Total moisture	7.96	14.57	---	---	19.29
Avg. temperature	---	---	70.8	68.3	---

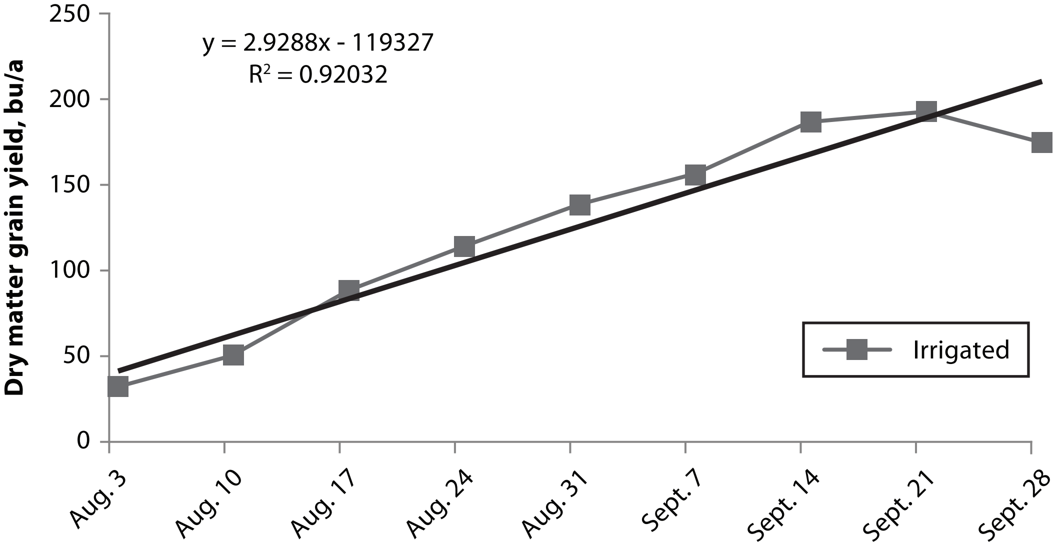

Figure 1. Accumulation of corn dry matter grain yield of irrigated corn at Garden City, KS, 2011. Dryland corn failed to produce grain, so no data were available for dryland corn.

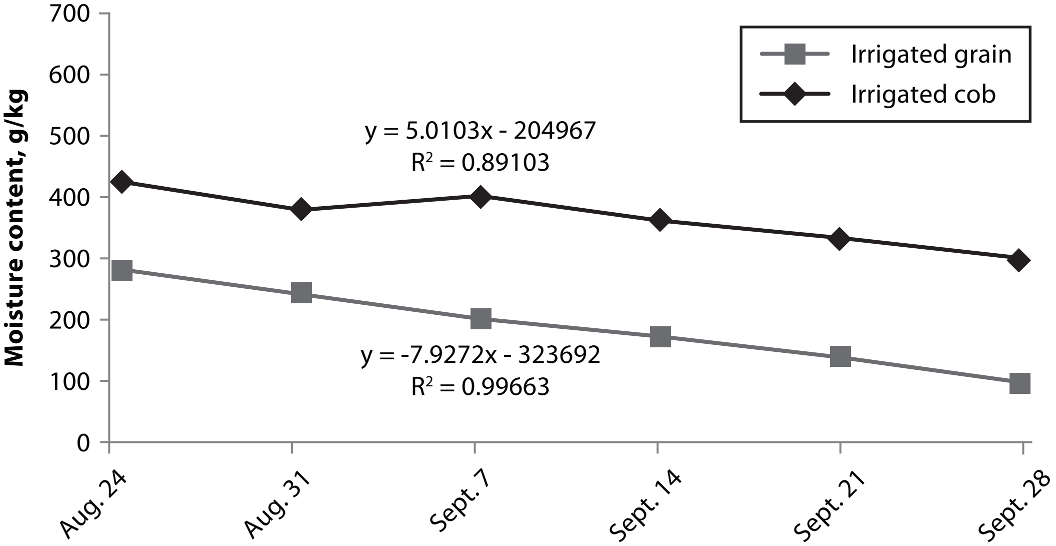

Figure 2. Grain and cob moisture content of irrigated corn at Garden City, KS, 2011. Dryland corn failed to produce grain, so no data were available for dryland corn.

2012 Grain Filling Rates of Irrigated and Dryland Corn in Southwest Kansas

J. Holman, T. Roberts, S. Maxwell, and M. Zarnstorff

Summary

2012 was the second growing season of extreme heat and drought conditions in Southwest Kansas. Despite the poor conditions, a corn crop was grown under both irrigated and dryland conditions. The previous year, dryland corn died due to heat and drought stress prior to producing any ears. The stressful environmental conditions in 2012 reduced grain yield potential, particularly in dryland. Dryland yields reached a yield potential of 93.4 bu/a early in physiological maturity (R5–R6), but by grain harvest yield was 50 bu/a. Irrigated corn reached a yield potential of 135 bu/a early in physiological maturity and maintained this yield level until harvest. The moisture content of grain and cob showed similar declines for both the dryland and irrigated corn. From August 1 to September 13, dryland grain moisture decreased from 558.8 to 27.6 g/kg, a decrease of 15.5 g/kg per day, and irrigated grain moisture decreased from 581.3 to 53.4 g/kg, a decrease of 13.6 g/kg per day. During this same time period, dryland cob moisture decreased from 685.5 to 55.0 g/kg, a decrease of 21.3 g/kg per day, and irrigated cob moisture decreased from 695.5 to 63.9 g/kg, a decrease of 15.7 g/kg per day. This information can be used to estimate corn yield or help make determinations about when to harvest corn for silage.

Introduction

A field experiment was conducted at the Kansas State University Southwest Research-Extension Center at Garden City, KS, to compare the grain fill rates of a corn hybrid under irrigated and dryland cropping conditions. Understanding rate of grain yield development and change in moisture content is important for making management decisions about when to plan and implement silage harvest and for determining grain yield potential. This experiment evaluated grain yield and moisture content throughout the reproductive growth stages of a corn crop grown under both irrigated and dryland conditions.

Materials and Methods

A field with center-pivot irrigation was selected for the irrigated plot area, and the non-irrigated corner of the field was selected for the dryland plot area. Corn in both areas was grown following wheat. The soil type was a Ulysses Silt Loam.

On April 27, 2012, Dekalb DKC52-59 (102-day comparative relative maturity, or CRM) was planted in both the irrigated and dryland portions of the field at seeding rates of 34,300 and 18,000 seeds/a, respectively, on 30-in. row spacing. A preplant application of nitrogen (N) was applied at a rate of 160 lb/a N as urea in the irrigated field and 40 lb/a N as urea in the dryland field. An area consisting of 4 50-ft-long rows was marked out in the irrigated and dryland areas adjacent to each other to be used for sample collections.

On July 18, the irrigated corn was at an early milk stage (R3) and the dryland corn was at the R2 Stage (Table 1). Beginning at this time interval, 5 ears were collected at random from the sampling areas on a weekly basis through physiological maturity (R6) and grain harvest. Observations of husk greenness, crop canopy color, and intactness were recorded at each time interval (Table 2). At each time interval, 5 ears were collected at random, weighed wet, photographed, broken in half to check the progression of the starch line, and the starch line was recorded with a photograph. The ears were then placed in a drying oven and dried at 104°F for 96 or more hours until dry. Dried ears were then shelled and a weight of the grain, cob, and 250 kernels were measured. When the corn reached the R5 stage, the ears were shelled before drying so a wet weight of the grain and cob could be measured separately; dry weights were measured after drying. These measurements were then used to obtain the change in moisture of the grain and cob.

2012 Growing Conditions

Even though the drought from 2011 continued through the 2012 growing season, corn yields were higher in 2012 than 2011, in part due to some precipitation that occurred during the spring of 2012. From the preceding wheat crop harvest until corn planting (July 2011–April 2012) precipitation was 10.5 in., which was near the normal amount of 13.1 in., allowing an accumulation of moisture in the soil profile. This allowed the corn to be planted into good field conditions. After planting, the weather turned drier and warmer than average during the growing season, with precipitation at 54% of the 30-year average (14.57 in.), and temperature averaged 3.3° warmer than the 30-year average (68.3°F) (Table 3). These conditions resulted in corn developing fairly normally until August 16, but after that date both the dryland and irrigated corn began showing signs of stress and decreased yield potential.

Results

Grain development for both dryland and irrigated corn followed a linear pattern for grain accumulation from early milk stage (R3) through mid to late dent (R5); after this stage, grain yield potential leveled in irrigated and decreased in dryland. Early in the season, from July 18 through August 16, dryland corn accumulated an average of 2.9 bu/a per day up to a yield potential of 93.4 bu/a at R5. After this point, yield potential decreased to around 50 bu/a at harvest. Irrigated corn accumulated an average of 4.2 bu/a per day from early milk stage (R3) through mid to late dent (R5), reaching a yield potential of 135 bu/a (Figure 1). After R5, the yield potential of irrigated corn leveled off, unlike dryland corn which decreased until harvest. Yield potential was decreased after R5 due to heat and moisture stress.

Grain and cob moisture showed a linear trend of decreasing moisture content from early sampling until maturity for both the dryland and irrigated corn (Figure 2). From August 1 through September 13, dryland grain moisture decreased from 558.8 to 27.6 g/kg, a decrease of 15.5 g/kg per day, and irrigated grain moisture decreased from 581.3 to 53.4 g/kg, a decrease of 13.6 g/kg per day. During this same time period, dryland cob moisture decreased from 685.5 to 55.0 g/kg, a decrease of 21.3 g/kg per day, and irrigated cob moisture decreased from 695.5 to 63.9 g/kg, a decrease of 15.7 g/kg per day.

Table 1. Crop growth stage

Stage	Reproductive stages
R1	Silking: silks visible outside the husks
R2	Blister: kernels are white and resemble a blister in shape
R3	Milk: kernels are yellow on the outside with a milky inner fluid
R4	Dough: milky inner fluid thickens to pasty consistency
R5	Dent: nearly all kernels are denting
R6	Physiological maturity: black abscission layer has formed

Table 2. Plant health observations

Date		Growth stage	Husk greenness	Canopy greenness	Canopy intactness
July 18	Dryland	R2	100%	100%	100%
July 18	Irrigated	Early R3	100%	100%	100%
July 25	Dryland	R3	95%	90%	95%
July 25	Irrigated	Mid R3	85%	100%	100%
August 1	Dryland	Early R5	60%	25%	90%
August 1	Irrigated	Early R5	80%	95%	90%
August 8	Dryland	Mid R5	25%	10%	50%
August 8	Irrigated	Mid R5	80%	90%	75%
August 16	Dryland	R6	0	0	50%
August 16	Irrigated	Mid R5	50%	50%	50%
August 22	Dryland	R6	0	0	40%
August 22	Irrigated	Late R5	20%	40%	50%
August 31	Dryland	R6	0	0	30%
August 31	Irrigated	R6	0	10%	50%
September 5	Dryland	R6	0	0	20%
September 5	Irrigated	R6	0	5%	40%
September 13	Irrigated	R6	0	0	25%

Table 3. Weather and irrigation data for the 2012 corn maturity study

Month	Precipitation	30-yr. avg. precipitation	Average air temperature	30-yr. avg. temperature	Irrigation
	-------------- in.	--------------	-------------- °F	--------------	in.
April	1.77	1.74	56.8	52.3	0.52
May	0.3	2.98	68.0	62.8	2.02
June	1.03	3.12	78.5	72.6	8.6
July	2.41	2.8	82.6	77.9	8.2
August	1.22	2.51	75.9	76.3	5
September	1.19	1.42	67.9	67.7	0
Total moisture	7.92	14.57	---	---	24.34
Avg. temperature	---	---	71.6	68.3	---

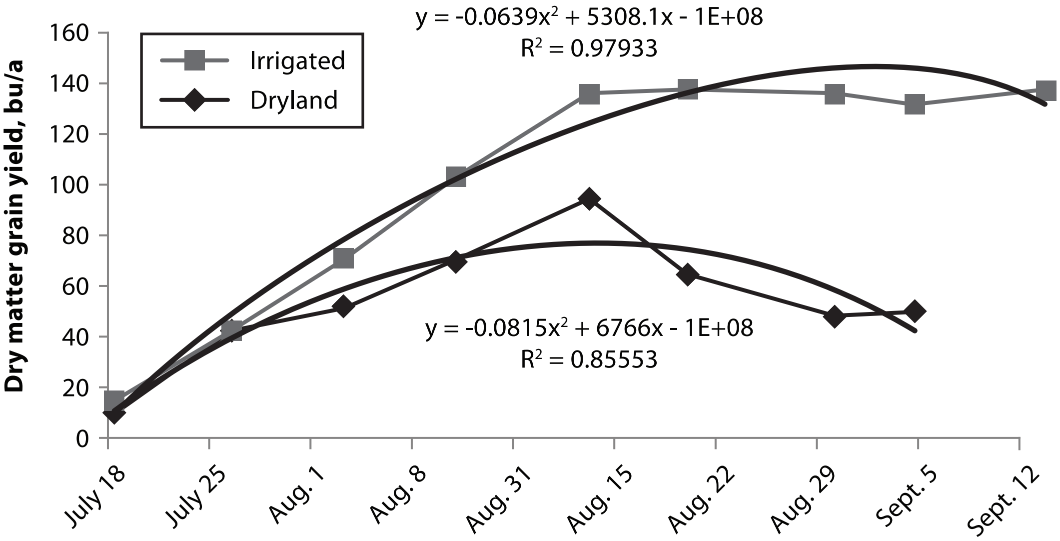

Figure 1. Accumulation of irrigated and dryland corn dry matter grain yield at Garden City, KS, 2012.

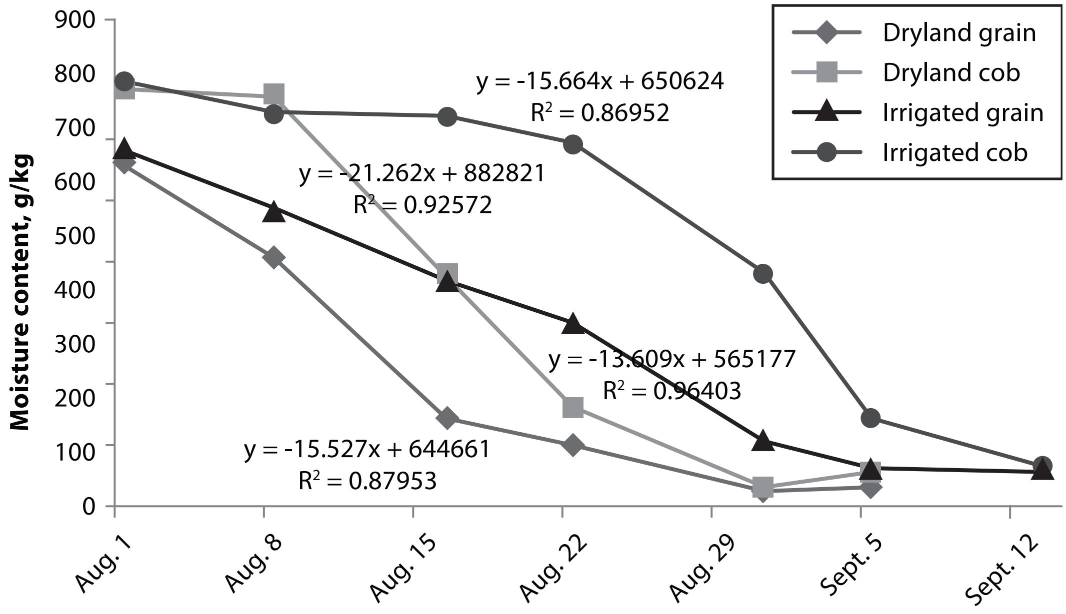

Figure 2. Grain and cob moisture content of irrigated and dryland corn at Garden City, KS, 2012.

Effects of Companion Cropping and Fall Grazing on Winter Canola

J. Holman, T. Roberts, S. Maxwell, and M. Stamm[1]

Summary

Winter canola (*Brassica napus* L.) is a relatively new crop to be grown in the southern Great Plains and is being grown in place of winter wheat within the crop rotation. Establishment and winter survival are challenges of growing winter canola in the region. Management practices were identified that improved establishment, winter survival, and grain yield (Holman et al., 2011), but information is still needed on how to best grow winter canola in the region.

Canola varieties Griffin and Wichita were grown with and without a companion crop (spring triticale, winter triticale, Daikon radish, and Shogoin turnip) and were managed with and without fall simulated grazing (hay). Treatment effects (variety, companion crop, and fall grazing) on winter canola fall plant density, fall vigor, winter survival, spring plant density, spring vigor, grain yield, forage yield, forage quality, and grain oil content were quantified.

Grazing or haying canola in the fall reduced grain yield 30–50% and decreased the yield of a more upright growth variety (Wichita) more than a prostrate growth variety (Griffin). Companion cropping decreased canola fall stand, winter survival, spring stand, and grain yield. Companion crops can improve fall forage production. The results from this study indicate canola grown for grain should not be grown with a companion crop or in a dual-purpose system.

Introduction

Growing a companion crop or grazing canola in the fall might affect winter survival and grain yield of canola, but it might also provide more options and economic incentive to growing the crop if winter survival or forage production are increased. This study evaluated the effects of companion cropping and fall grazing on winter canola survival, forage yield, and grain yield.

The southern Great Plains has sufficient growing degree days to produce 120 to 150 days of grazable wheat pasture that can be either grazed out in the spring or harvested for grain after grazing in a dual-purpose system. Producing winter wheat in a dual-purpose system is a unique and economically important resource. Winter wheat provides economical, high-quality forage at a time of the year when few other quality forage sources are available. It is estimated that 3.2 million ha (7.9 million acres) of winter wheat in the southern Great Plains are grazed annually in a dual-purpose system (Carver et al., 2001). Winter wheat that is harvested for grain can be grazed in the late fall and early spring without reducing grain production as long as cattle are removed before wheat development reaches first hollow stem, soil moisture is adequate, and recommended growing practices are implemented (Khalil et al., 2002; Redmon

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[1] Kansas State University Department of Agronomy.

et al., 1996; Virgona et al., 2006). Grazing occasionally increased yield of tall winter wheat varieties by reducing plant height, which resulted in less plant lodging (Redmon et al., 1995). Insufficient information is available on the effects of grazing canola, yet producers need this information. Previous research found companion-cropping winter annual legumes with winter triticale increased survival of the winter legume. Growing a companion crop with winter canola might affect its winter survival and forage yield.

Procedures

Field studies were conducted at the Kansas State University Southwest Research-Extension Center in Garden City, KS (37°59'7"N, 100°48'52"W, elevation 2,862 ft). Average annual precipitation was 19.3 in. Soil type was a Ulysses silt loam soil (fine-silty, mixed, superactive, mesic Aridic Haplustolls) with pH 7.8 and 1.8% organic matter in the top 6 in. of soil.

The experimental design was a randomized split-plot with four replications. Main plot treatment was canola variety (Griffin or Wichita) and companion crop treatment (none, spring triticale, winter triticale, radish, and turnip), and split-plot treatment was managed with or without simulated fall grazing (haying). Winter canola was planted in the fall on August 30, 2010, and September 6, 2011, into a conventional-tillage seedbed. Wheat was grown preceding canola in 2010, and corn was grown preceding canola in 2011. Both Griffin and Wichita were planted at 5 lb/a, 0.75 in. deep, using a double disk opener and fluted coulter with 8-in. row spacing. Companion crops were planted with canola in 2010. In 2011, canola and cover crops were planted in alternate 8-in. rows, so canola and companion crops were planted using 16-in. row spacing. Companion crops were seeded using 38 lb/a for spring triticale, 35 lb/a for winter triticale, 4.5 lb/a for Diakon radish, and 1.75 lb/a for Shogoin turnip. Preplant herbicides consisted of 1.43 lb a.i./a pendimethalin (Prowl) and 0.75 lb a.e./a glyphosate. On September 17, 2010, 0.094 lb a.i./a clethodim (Select) plus 1% v/v crop oil concentrate was applied to control volunteer wheat in the plots without triticale; on April 1, 2011, 0.055 lb a.i./a quizalofop (Assure II) plus 1% crop oil v/v concentrate was applied to control volunteer wheat and triticale in all plots; and on March 20, 2011, 0.094 lb a.i./a clethodim plus 1% v/v crop oil concentrate was applied to control volunteer wheat and triticale in all plots. On October 12, 2010, 0.062 lb a.i./a lambda-cyhalothrin (Warrior) was applied to control Diamondback moth. Insect pest densities were not great enough during the 2011–2012 growing season to require an insecticide application. One-half of each main plot was clipped 1.75 in. high and bagged (hay) to simulate grazing on October 26, 2010, and November 4, 2011.

Irrigation was applied with an overhead sprinkler throughout the growing season using an irrigation scheduling program with irrigation applied at 50% available soil water (Clark et al., 2002), with 12.68 in. applied in 2010–2011 and 14.58 in. applied in 2011–2012 (Figure 1). Fertilizer was applied based on soil test recommendations. In 2010, 5.5 lb nitrogen (N)/a and 26 lb phosphorus (P_2O_5)/a as monoammonium phosphate (11-52-0 N-P-K), plus 9 lb sulfur (S)/a was applied at seeding banded 1 in. to the side and 2 in. deep (1 × 2). An additional 70 lb N/a was broadcast-applied as urea (46-0-0) on October 18, 2010, and March 14, 2011, for a total of 140 lb N/a. In 2011, 5.5 lb N/a and 26 lb P_2O_5/a as monoammonium phosphate (11-52-0), plus 9 lb S/a was applied at seeding banded 1 in. to the side and 2 in. deep (1 × 2). An additional 110 lb N/a was broadcast-applied as urea (46-0-0) on February 29, 2012.

Within each plot, four permanently marked 3-ft rows were used for fall and spring plant density to determine winter survival. Fall plant density and vigor were quantified in mid-November, and spring plant density and vigor were quantified in early April. Plant vigor was visually determined using a scale of 1 to 10 (0 = dead and 10 = robust plant). Canola was harvested July 7, 2011, and June 19, 2012, from a 6.5-ft-wide by 30-ft-long area using a plot combine (Delta, Wintersteiger Inc., Salt Lake City, UT). A seed subsample was collected at harvest, and moisture content was measured with a grain analysis computer (GAC 2100, Dickey John, Auburn, IL). Data were analyzed with PROC MIXED, residual maximum likelihood method, in SAS (SAS Institute Inc., Cary, NC). Replication and replication × year were considered random effects, and all other effects including year were considered fixed in the model. Treatment effects were considered significant at $P \leq 0.05$, and least squares means were separated by independent pairwise *t*-tests at a significance level of $P \leq 0.05$ (PDIFF option).

Results and Discussion

Growing Season

The 30-year average cumulative precipitation from September 1 through July 1 (typical growing season) was 13.95 in., and the average total annual precipitation was 19.19 in. (Figure 1). Between 2010 and 2012, precipitation was well below average, and irrigation was necessary. During the 2010–2011 growing season, 12.68 in. of irrigation was applied and 6.21 in. of precipitation was received between planting and harvest, for a total of 18.9 in. of moisture. During the 2011–2012 growing season, 14.58 in. of irrigation was applied and 8.69 in. of precipitation was received between planting and harvest, for a total of 23.3 in. The winter of 2011–2012 was a more favorable winter growing season than 2010–2011 (Figure 2). During the winter of 2010–2011, temperatures fell below 0°F for 11 days on four separate occasions, reaching a low of -13°F. During 2011–2012 the lowest temperature reached was 0°F on only one occasion. Fall vigor, forage yield, winter survival, and spring stand were all greater in 2012 than 2011, which was likely due to warmer fall and winter conditions in 2011–2012 than 2010–2011 (Table 1). Grain yield was greater in 2011 than 2012, and test weight and 1,000-seed weight were greater in 2012 than 2011. Grain yield was likely greater in 2011 than 2012 due to a longer growing season in 2011. In 2012, temperatures increased early in the spring and canola was harvested about 3 weeks earlier than normal (canola was harvested July 7, 2011, and June 19, 2012). Temperature during grain fill was lower in 2012 than 2011, which created more favorable conditions for grain fill, resulting in greater test weight and seed weight in 2012.

Variety

Griffin grows more prostrate than Wichita, but both varieties are well adapted to being grown in Kansas. Griffin and Wichita had similar fall and spring stand densities, plant vigor, winter survival, test weight, and forage yield. Averaged across 2011 and 2012, Griffin yielded 162 lb/a more grain than Wichita (Table 2).

Simulated Grazing (Haying)

Haying reduced the yield of both varieties (Table 3), but the yield of Wichita was reduced more than Griffin. Haying reduced the yield of Griffin 34% and Wichita 48% (Table 2). Griffin's prostrate growth likely protected the plant more from the damage of haying than the more upright growth of Wichita. The apical meristem of canola is elevated above the ground, whereas in wheat it remains in the crown until it begins to elongate at first hollow stem. This difference in growth allows the growing point in wheat to be protected from fall grazing but makes canola susceptible to injury. Haying canola reduced fall stand density, winter survival, spring stand density, and grain yield (Table 3).

Companion Crop

Companion cropping reduced canola yield in 2011, so companion crops were planted in alternate rows with canola in 2012 to attempt reducing the negative impact of companion cropping on grain yield; however, both planting methods (planted within row or alternate row) reduced yield equally (Table 4). Spring triticale had the least negative effect on yield, and turnip had the most negative impact on yield. Spring triticale was terminated early in the fall with freezing temperatures plus herbicide applications. Some turnip and radish overwintered in 2012 due to the mild winter conditions and competed with canola. Turnip and radish reduced canola fall stand, winter survival, spring stand, and test weight (Table 4). Companion crops increased fall forage yield and varied by canola variety (Tables 2 and 4). Radish and turnip planted with Griffin produced more forage yield than radish or turnip planted with Wichita, and spring triticale and winter triticale planted with Griffin or Wichita produced similar forage yield (Table 2). The prostrate growth of Griffin might have allowed more growth of turnip and radish, resulting in greater forage yield.

Conclusions

This study found that grazing or haying canola in the fall would reduce grain yield at least 30% with currently grown varieties. Varieties with prostrate growth were affected less by grazing than varieties with more upright growth, yet grain yield of a prostrate growth variety was still reduced. At this time, growing canola in a dual-purpose system is not recommended unless a 30–50% decrease in crop yield is acceptable. If growing canola in a dual-purpose system, producers should select a variety with the most prostrate growth available. Companion cropping did not increase winter survival as it had with winter annual legumes and tended to decrease canola fall stand, winter survival, spring stand, and grain yield. Companion crops can improve fall forage production. Spring triticale had the least negative impact on grain yield, yet had some positive impact on fall forage production. Turnip and radish had the most negative impact on grain yield, but also increased fall forage production the most. Companion crops should not be grown with canola if the primary intent is to harvest canola for grain. The results of this study indicate canola grown for grain should not be grown with a companion crop or in a dual-purpose system.

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Table 1. Year effect on stand, survival, grain yield, test weight, 1,000-seed weight, and forage yield

Year	Canola fall vigor		Spring stand		Winter survival		Grain yield (9% moisture)		Test weight		1,000-seed wt		Forage yield (dry matter)	
	---- 0–10[1] ----		Plants/m row		------- % -------		------- lb/a -------		----- lb/bu -----		------- g -------		------- lb/a -------	
2011	5.5	b[2]	5.6	b	31.3	b	1,339.0	a	42.6	b	2.9	b	1,916.1	b
2012	9.5	a	15.7	a	80.8	a	1,167.8	b	51.2	a	3.9	a	3,241.1	a
	ANOVA P>F													
Source of variation	<0.0001		<0.0001		<0.0001						<0.0001			
LSD 0.05	0.4		1.4		4.8		104.2		0.7		0.1		371.7	

[1] Plant vigor was rated from 0 to 10, with 10 = high vigor and 0 = no vigor.

[2] Different letters within a column represent differences at LSD 0.05.

Table 2. Canola variety (Griffin and Wichita) stand, winter survival, grain yield, and forage yield differences affected by simulated fall grazing (haying) and companion crop

Canola variety	Spring stand		Winter survival		Grain yield (9% moisture)		Forage yield (dry matter)	
	Plants/m row		------- % -------		------------------- lb/a -------------------			
Griffin	9.6	a[1]	58.4	a	1,333.6	a	2,719.3	a
Wichita	9.9	a	53.7	a	1,170.9	b	2,437.9	a
	ANOVA P>F							
Source of variation	NS		<0.1					
LSD 0.05	1.4		4.8		104.1		371.7	
Variety × hay								
Griffin, not hayed	---	---	---	---	1,603.4	a	---	---
Griffin, hayed	---	---	---	---	1,056.7	b	---	---
Wichita, not hayed	---	---	---	---	1,542.3	a	---	---
Wichita, hayed	---	---	---	---	808.8	c	---	---
	ANOVA P>F							
Source of variation	NS		NS		<0.1		NS	
LSD 0.05	---		---		147.3		---	
Variety × companion								
Griffin, none	12.7	ab	---	---	---	---	2,313.1	c
Griffin, spring triticale	10.8	bcd	---	---	---	---	2,413.4	bc
Griffin, winter triticale	11.9	abc	---	---	---	---	1,996.3	c
Griffin, radish	6.6	e	---	---	---	---	3,199.2	ab
Griffin, turnip	10.1	bcd	---	---	---	---	3,854.8	a
Wichita, none	9.7	bcd	---	---	---	---	2,072.9	c
Wichita, spring triticale	12.5	abc	---	---	---	---	2,394.5	bc
Wichita, winter triticale	14.0	a	---	---	---	---	2,476.0	bc
Wichita, radish	9.5	cde	---	---	---	---	2,624.8	bc
Wichita, turnip	8.4	de	---	---	---	---	2,621.3	bc
	ANOVA P>F							
Source of variation	<0.1		NS		NS		<0.1	
LSD 0.05	3.0		---		---		832.4	

[1] Different letters within a column and heading represent differences at LSD 0.05.

Table 3. Simulated grazing (hay) effects on stand, survival, and grain yield

Hay	Fall stand		Spring stand		Winter survival		Grain yield (9% moisture)	
	--------------- Plants/m row ---------------				-------- % --------		------- lb/a -------	
Not hayed	20.0	a	13.7	a	67.9	a	1,572.8	a[1]
Hayed	17.6	b	7.5	b	44.2	b	929.6	b
	ANOVA P>F							
Source of variation	<0.01		<0.0001		<0.0001		<0.0001	
LSD 0.05	1.8		1.4		4.8		104.1	

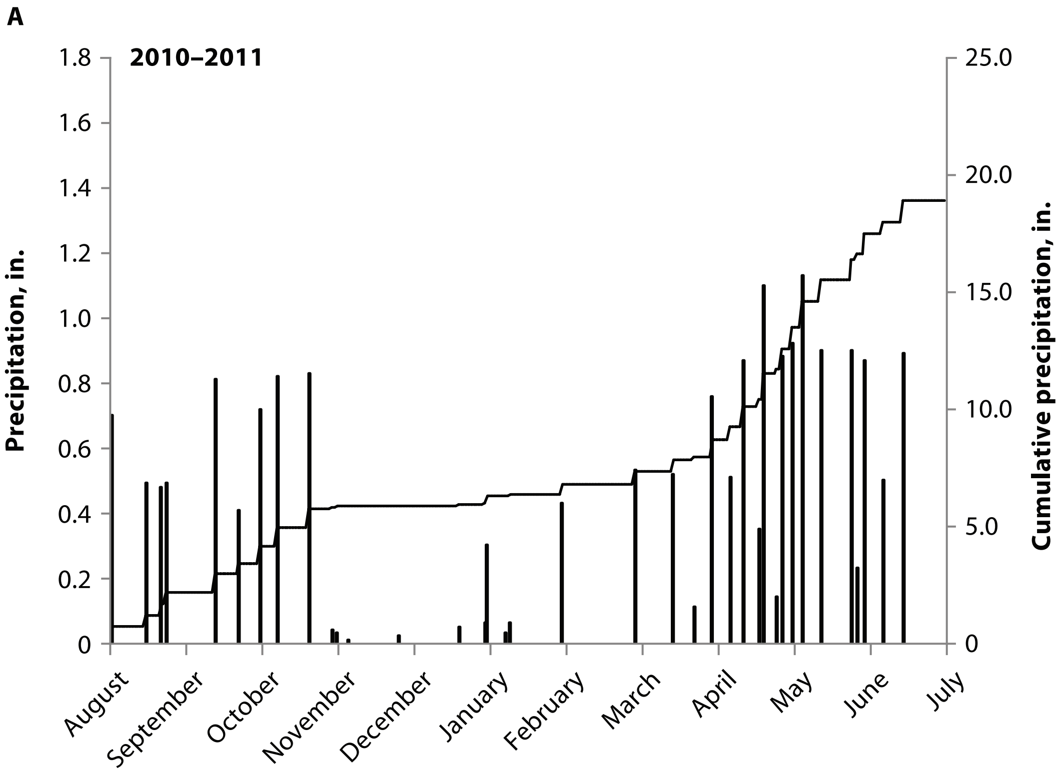
[1] Different letters within a column represent differences at LSD 0.05.

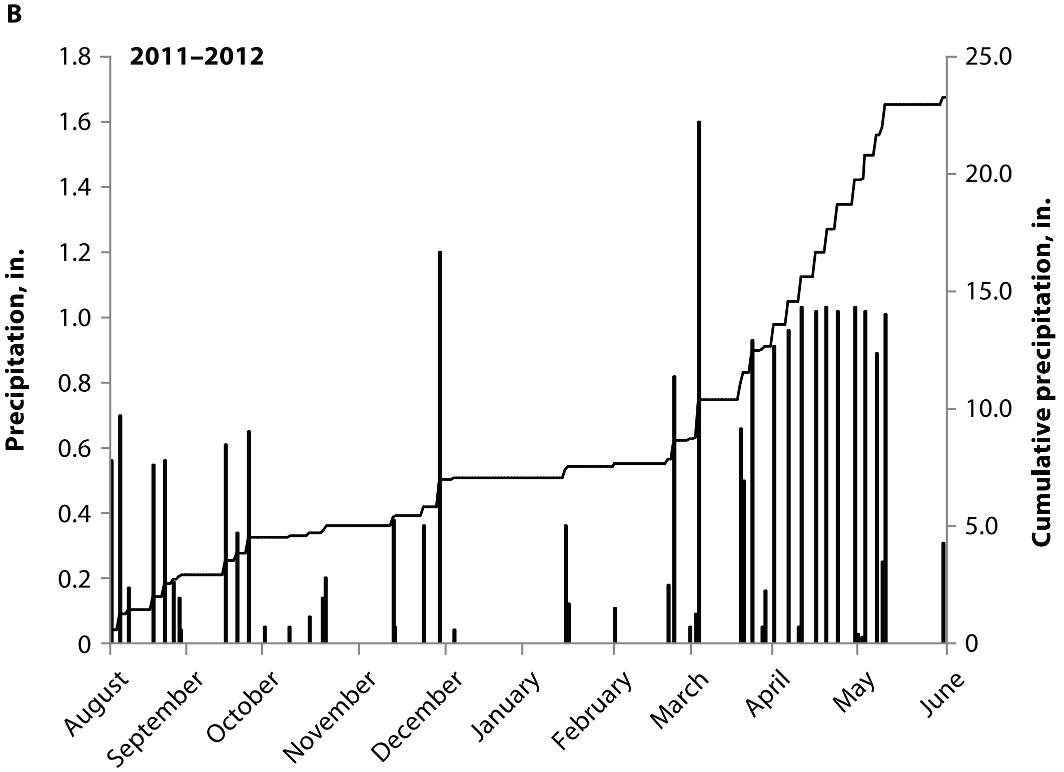
Table 4. Companion crop effects on stand, survival, grain yield, test weight, and forage yield

Companion	Canola fall vigor		Fall stand		Spring stand		Winter survival		Grain yield (9% moisture)		Test weight		Forage yield (dry matter)	
	---- 0–10[1] ----		----------- Plants/m row -----------				------ % ------		------ lb/a ------		----- lb/bu -----		------ lb/a ------	
None	8.6	a[2]	19.1	ab	11.2	ab	62.7	a	1,461	a	48	a	2,193	c
Spring triticale	7.3	bc	19.1	ab	11.6	a	60.0	a	1,321	ab	49	a	2,405	bc
Winter triticale	7.6	b	21.3	a	13.0	a	59.0	a	1,296	b	48	ab	2,236	c
Radish	6.9	c	17.4	b	8.1	c	47.7	b	1,240	b	47	c	2,912	ab
Turnip	7.0	bc	17.0	b	9.2	bc	50.5	b	914	c	47	bc	3,197	a
	ANOVA P>F													
Source of variation	<0.0001		<0.05		<0.001		<0.01		<0.0001		<0.001		<0.01	
LSD 0.05	0.7		2.9		2.2		7.6		165		1		588	

[1] Plant vigor was rated from 0 to 10, with 10 = high vigor and 0 = no vigor.

[2] Different letters within a column represent differences at LSD 0.05.


A
2010–2011
Precipitation, in.
Cumulative precipitation, in.
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
25.0
20.0
15.0
10.0
5.0
0
August
September
October
November
December
January
February
March
April
May
June
July


B
2011–2012
Precipitation, in.
Cumulative precipitation, in.
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
25.0
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August
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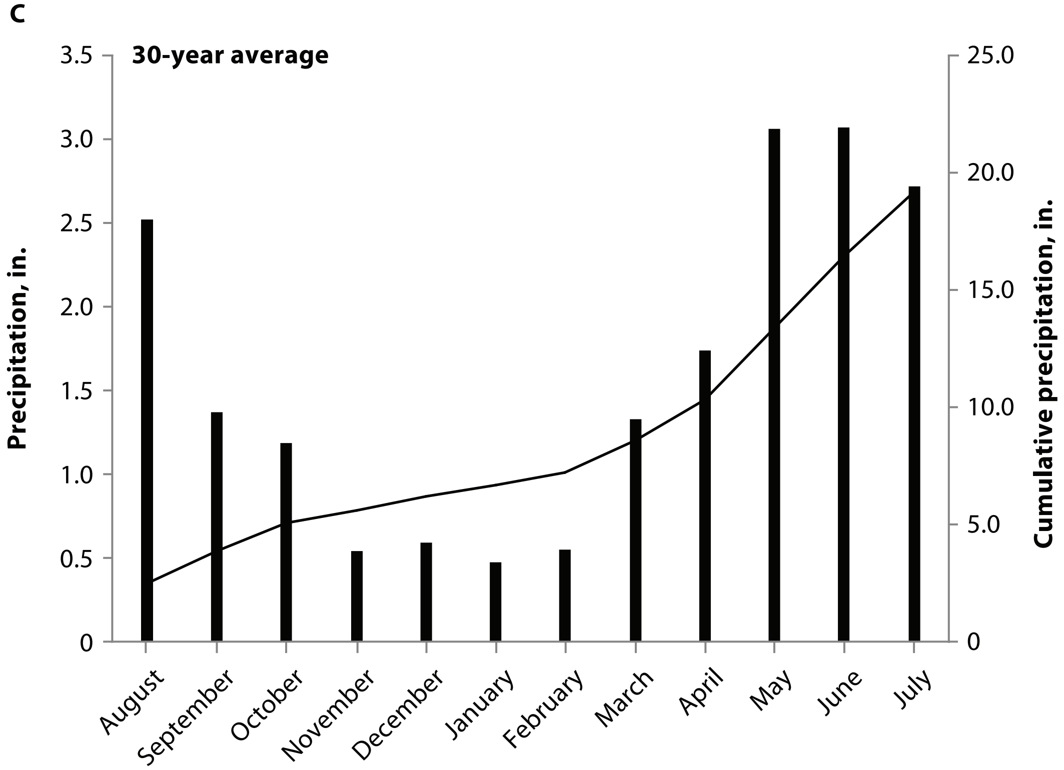
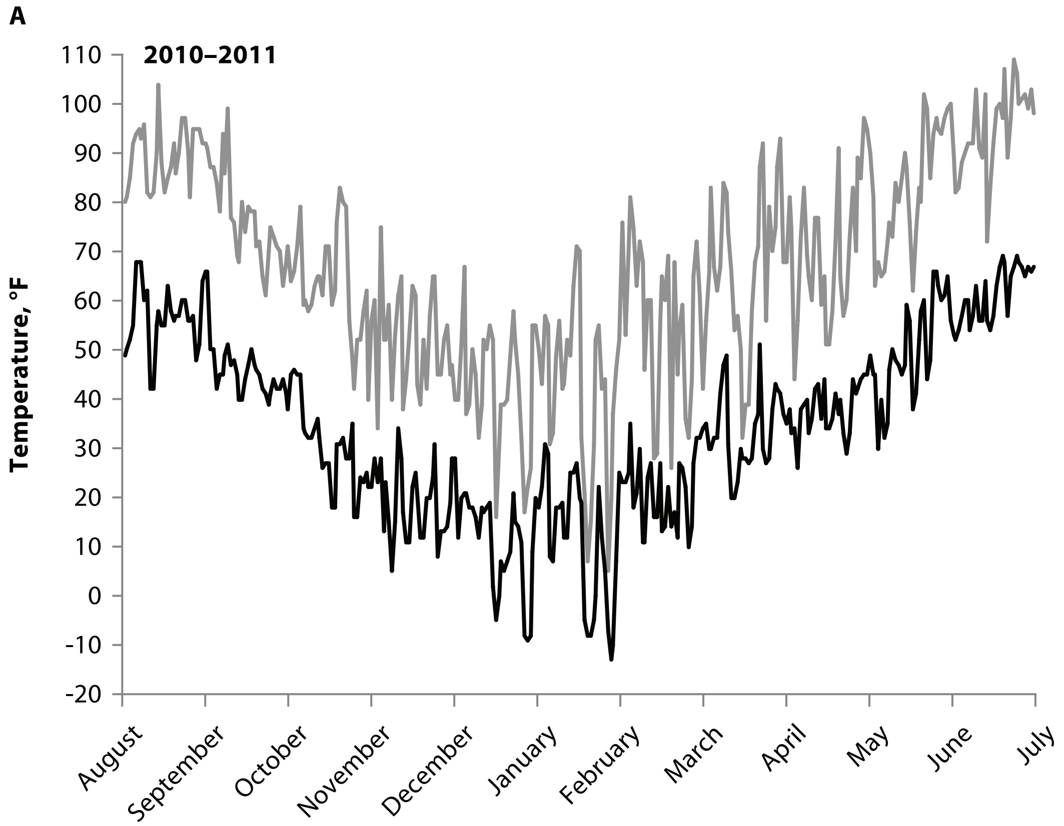


Figure 1. Cumulative (horizontal line) and daily (vertical bars) moisture from precipitation and irrigation from 2010–2011 (A) and 2011–2012 (B) and the 30-year (C) cumulative (horizontal line) and monthly average (wide vertical bars) precipitation from August through July.



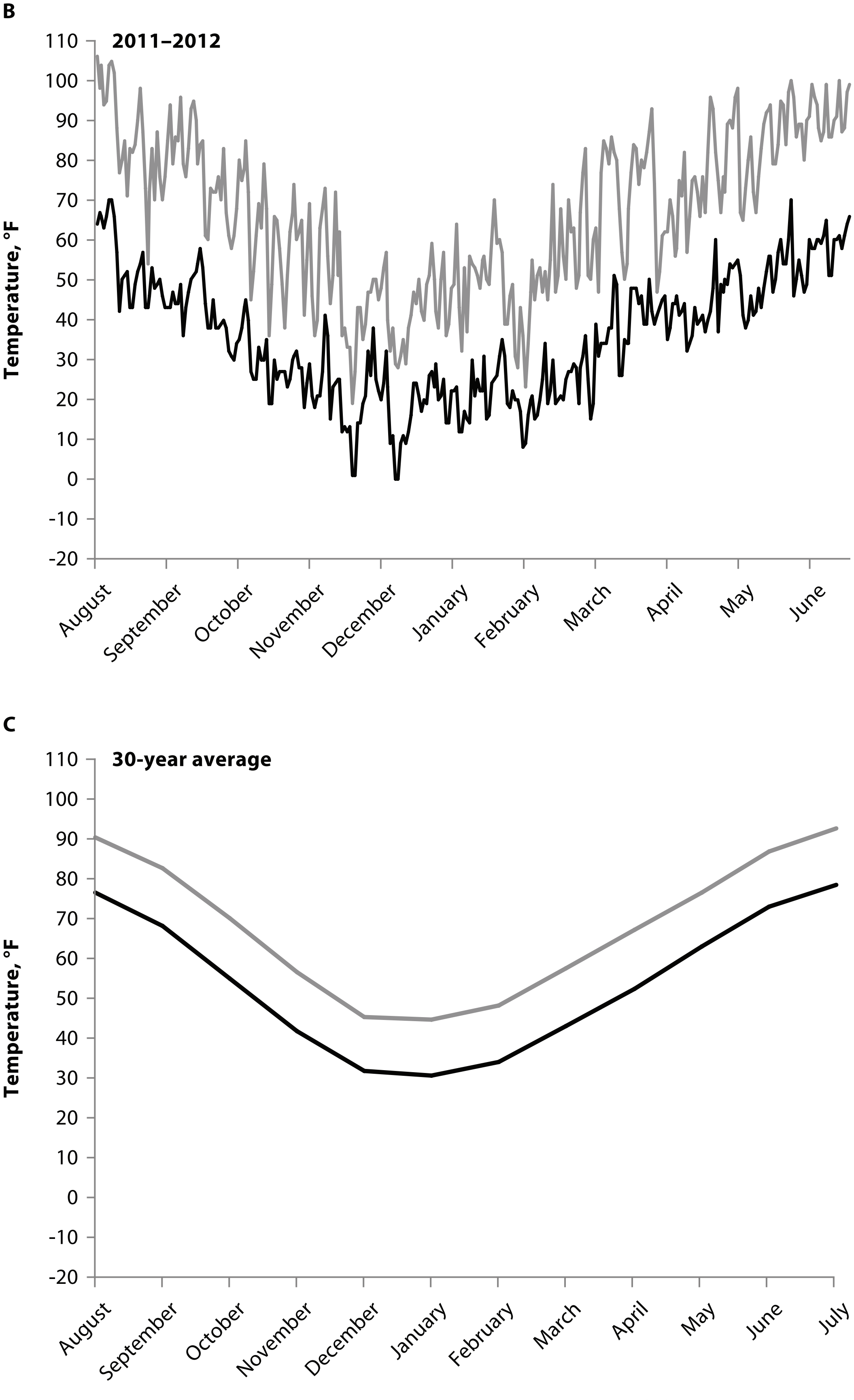


Figure 2. Maximum and minimum daily temperature in 2010–2011 (A) and 2011–2012 (B) and the maximum and minimum 30-year (C) monthly average temperature from August through July.

Large-Scale Dryland Cropping Systems

A. Schlegel

Summary

A large-scale rainfed cropping systems research and demonstration project evaluated two summer crops (corn and grain sorghum) along with winter wheat in crop rotations varying in length from 1 to 4 years. The crop rotations were continuous grain sorghum, wheat-fallow, wheat-corn-fallow, wheat-sorghum-fallow, wheat-corn-sorghum-fallow, and wheat-sorghum-corn-fallow. The objective of the study is to identify cropping systems that enhance and stabilize production in rainfed cropping systems to optimize economic crop production. Lack of precipitation during 2012 depressed grain yields of all crops. Averaged across the past five years, wheat yields tended to be less in four-year rotations than in two- and three-year rotations. Corn and grain sorghum yields (five-year average) were about twice as great when following wheat than when following corn or grain sorghum.

Introduction

The purpose of this project is to research and demonstrate several multicrop rotations that are feasible for the region along with several alternative systems that are more intensive than two- or three-year rotations. The objectives are to (1) enhance and stabilize production of rainfed cropping systems through the use of multiple crops and rotations 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.

Procedures

The crop rotations are two-year (wheat-fallow [WF]), three-year (wheat-grain sorghum-fallow [WSF] and wheat-corn-fallow [WCF]), and four-year rotations (wheat-corn-sorghum-fallow [WCSF] and wheat-sorghum-corn-fallow [WSCF]) and continuous sorghum (SS). All rotations are grown using no-till practices except for WF, which is grown using reduced-tillage. 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 in a weigh-wagon or combine yield monitor.

Results and Discussion

Grain yields of all crops were below average in 2012 because of lack of precipitation (Table 1). Total precipitation for 2012 was 7.49 in., setting a new record for the driest year on record. Wheat yields were less than 15 bu/a and were not affected by crop rotation. Corn yields were less than 10 bu/a for all rotations. Grain sorghum yields were greater following wheat (33–39 bu/a) than following corn or sorghum (less than 10 bu/a).

Wheat yields averaged across the past five years (2008–2012) tended to be slightly greater in two- and three-year rotations than in four-year rotations (Table 2). Corn yields following wheat averaged about twice as much than following sorghum. Similarly, sorghum yields following wheat were about twice as much than following corn or sorghum.

Acknowledgements

This research project received support from the Ogallala Aquifer Initiative.

Table 1. Grain yield response to crop rotation in large-scale cropping systems study, Tribune, KS, 2012

Crop rotation	Wheat	Corn	Sorghum
	bu/a		
Wheat-fallow[1]	14	---	---
Wheat-corn-fallow	8	2 b[2]	---
Wheat-sorghum-fallow	9	---	33 a
Wheat-corn-sorghum-fallow	10	8 a	6 b
Wheat-sorghum-corn-fallow	12	2 b	39 a
Sorghum-sorghum	---	---	7 b
LSD 0.05	8	3	14

[1] Wheat-fallow rotation is reduced-till; all other rotations are no-till.

[2] Within columns, means followed by the same letter are not significantly different at LSD 0.05.

Table 2. Grain yield response to crop rotation in large scale cropping systems study, Tribune, KS, 2008–2012

Crop rotation	Wheat	Corn	Sorghum
	bu/a		
Wheat-fallow[1]	28 a[2]	---	---
Wheat-corn-fallow	27 ab	42 a	---
Wheat-sorghum-fallow	28 a	---	70 a
Wheat-corn-sorghum-fallow	23 b	42 a	35 b
Wheat-sorghum-corn-fallow	24 b	22 b	64 a
Sorghum-sorghum	---	---	30
LSD 0.05	4	6	9

[1] Wheat-fallow rotation is reduced-till; all other rotations are no-till.

[2] Within columns, means followed by the same letter are not significantly different at LSD 0.05.

Effects of Wheat Stubble Height on Subsequent Corn and Grain Sorghum Crops

A. Schlegel

Summary

A field study initiated in 2006 was designed to evaluate the effects of three wheat stubble heights on subsequent grain yields of corn and grain sorghum. Grain yields of corn and grain sorghum in 2012 were substantially lower than the long-term average because of lack of precipitation. No effect from stubble height was observed in 2012 for either corn or grain sorghum. When averaged across 2007–2012, corn grain yields were 11 bu/a greater when planted into either tall or strip-cut stubble than into low-cut stubble. This increase was primarily due to an increase in the number of kernels per ear. Average grain sorghum yields were not significantly affected by wheat stubble height. Harvesting the previous wheat crop shorter than necessary results in a yield penalty for the subsequent dryland corn crop.

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. Use of stripper headers increases harvest capacity and provides taller wheat stubble than previously attainable with conventional small grains 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.

Procedures

This study was conducted at the Southwest Research-Extension Center dryland station near Tribune, KS. From 2007 through 2012, corn and grain sorghum were planted into standing wheat stubble of three heights. Optimal (high) cutterbar 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 cutterbar height, and the third treatment was stubble remaining after stripper header harvest. In 2012, these heights were 7, 14, and 21 in. Average stubble heights from 2007–2012 were 9, 18, and 27 in. In 2012, corn and grain sorghum were seeded at rates of 15,000 seeds/a and 50,000 seeds/a, respectively. Nitrogen was applied to all plots at a rate of 100 lb/a. Starter fertilizer (10-34-0 N-P-K) was applied in-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 in1-ft increments at seeding and harvest to determine water use and water use efficiency.

Results and Discussion

The 2012 growing season had above-normal temperatures and below-normal precipitation, which negatively affected grain yield. Corn grain yields were about 50 bu/a lower than the average yields from 2007–2012 (Tables 1 and 2). Stubble height did not affect grain yield or any of the other measured parameters in 2012; however, average corn yields from 2007–2012 were 11 bu/a greater when planted into high- or strip-cut stubble. This was primarily due to greater number of kernels per ear. Residue production and water use efficiency was also greater with the taller stubble.

Grain sorghum yields were similar to corn yields in 2012 and were not affected by stubble height (Table 3). When averaged across years from 2007–2012, the highest yields were obtained in the high-cut stubble but were not significantly greater than the other stubble heights. None of the other measured parameters for grain sorghum were affected by stubble height (Table 4).

Table 1. Corn yield and yield components as affected by stubble height, Tribune, KS, 2012

Stubble height	Yield	Plant population	Ear population	Biomass	Residue	1,000-seed weight	Kernels	WUE[1]
	bu/a	---------------- 10^3/a ----------------		---------------- lb/a ----------------		oz	no./ear	lb/in.
Low	21	13.9	9.4	4,298	3,281	9.64	206	126
High	34	13.8	11.2	5,587	3,996	9.34	288	190
Strip	31	14.0	11.1	5,303	3,838	9.22	263	176
LSD 0.05	16	0.9	3.2	1,837	1,377	0.97	94	80
				ANOVA (P > F)				
Stubble height	0.260	0.898	0.429	0.303	0.503	0.631	0.187	0.222

[1] Water use efficiency (lb of grain/in. of water use).

Table 2. Corn yield and yield components as affected by stubble height, Tribune, KS, 2007–2012

Stubble height	Yield	Plant population	Ear population	Biomass	Residue	1,000-seed weight	Kernels	WUE[1]
	bu/a	---------------- 10^3/a ----------------		---------------- lb/a ----------------		oz	no./head	lb/in.
Low	73 b	14.8	14.1	9,096 b	5,625 b	10.16	449 b	280 b
High	84 a	14.6	14.6	10,420 a	6,430 a	10.41	485 a	324 a
Strip	84 a	14.7	14.6	10,423 a	6,451 a	10.18	498 a	322 a
LSD 0.05	5	0.4	0.6	764	713	0.34	26	21
				ANOVA (P > F)				
Year	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Stubble height	0.001	0.583	0.163	0.001	0.036	0.282	0.001	0.001
Year × stubble height	0.335	0.378	0.389	0.862	0.791	0.470	0.808	0.442

[1] Water use efficiency (lb of grain/in. of water use).

Table 3. Sorghum yield and yield components as affected by stubble height, Tribune, KS, 2012

Stubble height	Yield	Head population	Biomass	Residue	1,000-seed weight	Kernels	WUE[1]
	bu/a	10^3/a	---------------- lb/a	----------------	oz	no./head	lb/in.
Low	22	11.8	5,538	4,453	0.87	2184	179
High	30	15.0	6,380	4,897	0.86	2623	268
Strip	33	22.4	6,432	4,808	0.90	1576	261
LSD 0.05	19	13.4	1,799	2,050	0.06	1085	160
				ANOVA (P > F)			
Stubble height	0.427	0.240	0.487	0.879	0.506	0.148	0.416

[1] Water use efficiency (lb of grain/in. of water use).

Table 4. Sorghum yield and yield components as affected by stubble height, Tribune, KS, across years 2007–2012

Stubble height	Yield	Head population	Biomass	Residue	1,000-seed weight	Kernels	WUE[1]
	bu/a	10^3/a	---------------- lb/a	----------------	oz	no./head	lb/in.
Low	94	47.1	10,770	6,177	0.89	2075	370
High	99	48.9	11,420	6,590	0.90	2139	401
Strip	95	48.1	10,869	6,190	0.87	2040	391
LSD 0.05	6	3.0	778	687	0.03	198	29
				ANOVA (P > F)			
Year	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Stubble height	0.247	0.453	0.207	0.402	0.146	0.602	0.111
Year × stubble height	0.938	0.360	0.994	0.979	0.442	0.047	0.813

[1] Water use efficiency (lb of grain/in. of water use).

Long-Term Nitrogen and Phosphorus Fertilization of Irrigated Corn

A. Schlegel

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 2012, N applied alone increased yields 84 bu/a, whereas P applied alone increased yields less than 10 bu/a. N and P applied together increased yields up to 174 bu/a. This is somewhat greater than the 10-year average, where N and P fertilization increased corn yields up to 145 bu/a. Application of 120 lb/a N (with P) produced about 82% of maximum yield in 2012, which was less than the 10-year average of 94%. Application of 80 instead of 40 lb P_2O_5/a increased average yields 8 bu/a.

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 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 P_2O_5 and zero K; and with 40 lb/a P_2O_5 and 40 lb/a K_2O. The treatments were changed in 1992; the K variable was replaced by a higher rate of P (80 lb/a P_2O_5). All fertilizers were broadcast by hand in the spring and incorporated before planting. The soil is a Ulysses silt loam. The corn hybrids [DeKalb C60-12 (2003), Pioneer 34N45 (2004 and 2005), Pioneer 34N50 (2006), Pioneer 33B54 (2007), Pioneer 34B99 (2008), DeKalb 61-69 (2009), Pioneer 1173H (2010), Pioneer 1151XR (2011), and Pioneer 0832 (2012)] were planted at about 30,000 to 32,000 seeds/a in late April or early May. Hail damaged the 2005 and 2010 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.

Results

Corn yields in 2012 were much greater than the 10-year average (Table 1). Nitrogen alone increased yields 84 bu/a, whereas P alone increased yields less than 10 bu/a; however, N and P applied together increased corn yields up to 174 bu/a. Maximum yield was obtained with 200 lb/a N with 80 lb/a P_2O_5. Reducing N or P rates reduced yields by at least 8%, which is greater than the 10-year average of 4%. Corn yields in 2012 (averaged across all N rates) were 8 bu/a greater with 80 than with 40 lb/a P_2O_5, which is slightly greater than the 10-year average of 5 bu/a.

Table 1. Effect of nitrogen (N) and phosphorus (P) fertilization on irrigated corn, Tribune, KS, 2003–2012

N	P_2O_5	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Mean
---------- lb/a ----------		---------- bu/a ----------										
0	0	79	67	49	42	49	36	85	20	92	86	60
0	40	95	97	60	68	50	57	110	21	111	85	75
0	80	93	98	51	72	51	52	106	28	105	94	75
40	0	107	92	63	56	77	62	108	23	114	109	81
40	40	147	154	101	129	112	105	148	67	195	138	130
40	80	150	148	100	123	116	104	159	61	194	135	129
80	0	122	118	75	79	107	78	123	34	136	128	100
80	40	188	209	141	162	163	129	179	85	212	197	167
80	80	186	205	147	171	167	139	181	90	220	194	170
120	0	122	103	66	68	106	65	117	28	119	134	93
120	40	194	228	162	176	194	136	202	90	222	213	182
120	80	200	234	170	202	213	151	215	105	225	211	193
160	0	127	136	83	84	132	84	139	49	157	158	115
160	40	190	231	170	180	220	150	210	95	229	227	190
160	80	197	240	172	200	227	146	223	95	226	239	197
200	0	141	162	109	115	159	99	155	65	179	170	135
200	40	197	234	169	181	224	152	207	97	218	225	190
200	80	201	239	191	204	232	157	236	104	231	260	205

continued

Table 1. Effect of nitrogen (N) and phosphorus (P) fertilization on irrigated corn, Tribune, KS, 2003–2012

N	P_2O_5	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	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		89	87	53	61	50	48	100	23	103	88	70
40		135	132	88	103	102	91	138	50	167	127	113
80		165	178	121	137	146	115	161	70	189	173	145
120		172	188	133	149	171	118	178	74	189	186	156
160		172	203	142	155	193	127	191	80	204	208	167
200		180	212	156	167	205	136	199	89	209	218	177
LSD 0.05		9	11	10	15	11	9	12	9	13	10	8
P_2O_5, lb/a												
0		116	113	74	74	105	71	121	36	133	131	97
40		168	192	134	149	160	122	176	76	198	181	156
80		171	194	139	162	168	125	187	81	200	189	161
LSD 0.05		6	8	7	11	8	6	9	7	9	7	6

Long-Term Nitrogen and Phosphorus Fertilization of Irrigated Grain Sorghum

A. Schlegel

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 2012, N applied alone increased yields almost 70 bu/a, whereas N and P applied together increased yields up to 100 bu/a. Averaged across the past 10 years, N and P fertilization increased sorghum yields more than 65 bu/a. Application of 40 lb/a N (with P) was sufficient to produce about 80% of maximum yield in 2012, which was slightly less than the 10-year average. Application of potassium (K) has had no effect on sorghum yield throughout the study period.

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 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 P_2O_5 and zero K; and with 40 lb/a P_2O_5 and 40 lb/a K_2O. All fertilizers are broadcast by hand in the spring and incorporated before planting. The soil is a Ulysses silt loam. Sorghum (Pioneer 8500/8505 from 2003–2007, Pioneer 85G46 in 2008–2011, and Pioneer 84G62 in 2012) was planted in late May or early June. 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.

Results

Grain sorghum yields in 2012 were 24% greater than the 10-year average yields (Table 1). Nitrogen alone increased yields 69 bu/a, whereas P alone increased yields 12 bu/a; however, N and P applied together increased yields up to 100 bu/a. Averaged across the past 10 years, N and P applied together increased yields more than 65 bu/a. In 2012, 40 lb/a N (with P) produced about 79% of maximum yields, which is slightly less than the 10-year average of 86%. Sorghum yields were not affected by K fertilization, which has been the case throughout the study period.

Table 1. Effect of nitrogen (N), phosphorus (P), and potassium (K) fertilizers on irrigated grain sorghum yields, Tribune, KS, 2003–2012

Fertilizer			Grain sorghum yield										
N	P_2O_5	K_2O	2003	2004	2005[1]	2006	2007	2008	2009	2010	2011	2012	Mean
---------------- lb/a ----------------			---------- bu/a ----------										
0	0	0	80	57	58	84	80	66	64	51	75	78	70
0	40	0	93	73	53	102	97	60	70	51	83	90	78
0	40	40	93	74	54	95	94	65	76	55	88	93	80
40	0	0	92	60	63	102	123	92	84	66	106	115	92
40	40	0	140	112	84	133	146	111	118	77	121	140	120
40	40	40	140	117	84	130	145	105	109	73	125	132	117
80	0	0	108	73	76	111	138	114	115	73	117	132	107
80	40	0	139	103	81	132	159	128	136	86	140	163	129
80	40	40	149	123	92	142	166	126	108	84	138	161	131
120	0	0	97	66	77	101	138	106	113	70	116	130	102
120	40	0	135	106	95	136	164	131	130	88	145	172	132
120	40	40	132	115	98	139	165	136	136	90	147	175	135
160	0	0	122	86	77	123	146	105	108	74	124	149	113
160	40	0	146	120	106	145	170	138	128	92	152	178	139
160	40	40	135	113	91	128	167	133	140	88	151	174	134
200	0	0	131	100	86	134	154	120	110	78	128	147	120
200	40	0	132	115	108	143	168	137	139	84	141	171	135
200	40	40	145	123	101	143	170	135	129	87	152	175	137

continued

Table 1. Effect of nitrogen (N), phosphorus (P), and potassium (K) fertilizers on irrigated grain sorghum yields, Tribune, KS, 2003–2012

Fertilizer			Grain sorghum yield										
N	P_2O_5	K_2O	2003	2004	2005[1]	2006	2007	2008	2009	2010	2011	2012	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	0.018	0.005	0.004	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			0.694	0.121	0.803	0.578	0.992	0.745	0.324	0.892	0.278	0.826	0.888
N × P-K			0.008	0.022	0.195	0.210	0.965	0.005	0.053	0.229	0.542	0.186	0.033
Means													
Nitrogen, lb/a													
0			88	68	55	93	91	64	70	52	82	87	76
40			124	96	77	121	138	103	104	72	117	129	109
80			132	100	83	128	155	123	120	81	132	152	122
120			121	96	90	125	156	124	126	82	136	159	123
160			134	107	92	132	161	125	125	83	142	167	128
200			136	113	98	140	164	131	126	84	141	165	131
LSD 0.05			10	11	10	11	9	7	11	5	8	9	5
P_2O_5-K_2O, lb/a													
0			105	74	73	109	130	101	99	68	111	125	101
40-0			131	105	88	132	151	117	120	80	130	152	122
40-40			132	111	87	130	151	117	116	79	133	152	122
LSD 0.05			7	7	7	7	6	5	7	4	6	6	4

[1] 2005 yields used only blocks 3, 4, and 5.

Economics of Tillage Options for Glyphosate-Resistant Kochia

T. Dumler, R. Currie, C. Thompson[1], P. Stahlman, and A. Schlegel

Summary

The growing resistance of kochia to glyphosate has caused crop producers in western Kansas to consider alternative methods of weed control. The primary alternatives to a glyphosate-based no-till herbicide program include using a diversified mix of additional herbicides or using tillage to control weeds. Because returns in dryland rotations that use no-till have been significantly higher than those that incorporate tillage, the relevant questions is: How much can farmers spend on additional herbicides and still earn greater returns than using tillage to control weeds? Results from a tillage intensity study in Tribune, KS, indicate that using an enhanced herbicide program to manage glyphosate resistance in a no-till wheat-sorghum-fallow rotation will cost about $30 per tillable acre more than a glyphosate-based program, but still return $50 per tillable acre more than using tillage in a reduced-till rotation.

Introduction

The growing resistance of kochia to glyphosate has led many producers to consider returning to tillage options for weed control in Western Kansas dryland crop rotations. Regardless of the path chosen, profitability will be decreased compared with the period prior to the advent of weed resistance. Long-term data from the Kansas State University Research Center in Tribune, KS, has indicated a significant economic advantage to incorporating no-till practices in a wheat-sorghum-fallow (WSF) rotation. With the growing difficulty of controlling kochia with a glyphosate-oriented herbicide program, the natural question becomes how much can be spent on herbicides for kochia control to maintain the economic advantage of no-till. Consequently, an example herbicide budget for kochia control was developed with the assistance of weed scientists at Kansas State University to compare the relative profitability of tillage systems in a WSF rotation to that of an herbicide program that used glyphosate as the primary herbicide option. The results indicate that although herbicide costs nearly double for the kochia control program, returns for the no-till rotation were nearly $50/a greater than reduced-till and $55/a greater than conventional-till; however, the profitability of the no-till rotation decreased by $30/a compared with cropping systems without glyphosate resistance.

Long-Term Tillage Intensity Study

A long-term tillage intensity study was established at the Kansas State University Research Center in Tribune, KS, in 1991 (see “Benefits of Long-Term No-Till in a Wheat-Sorghum-Fallow Rotation,” SRP 1070, Southwest Research-Extension Center Field Day 2012, p. 5–6). The study compared three weed control regimes in a wheat-sorghum-fallow (WSF) rotation. The weed control options included conventional tillage, reduced tillage, and no-till. Conventional tillage typically required 4 to 5 tillage operations per year to control weeds prior to planting. Reduced-till used a combination

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[1] Kansas State University Department of Agronomy.

of herbicides (1 to 2 spray operations) and tillage (2 to 3 operations) to control weeds prior to planting. No-till exclusively used herbicides for weed control. In 2001, the reduced-till component of the study was modified. Instead of including tillage operations prior to both wheat and sorghum, wheat was planted using conventional-till, whereas sorghum incorporated no-till. Thus, the rotation became a reduced-till rotation by including conventional-till and no-till components.

Table 1 shows the annual yields of the tillage intensity study for wheat and sorghum. From 2001–2011, no-till wheat and sorghum yields were approximately 8 bu/a and 43 bu/a higher, respectively, than with conventional-till. Similarly, no-till wheat and sorghum yields were 5 bu/a and 30 bu/a higher, respectively, than in a reduced-till rotation (conventional-till prior to wheat and no-till prior to sorghum). Average production costs for the three tillage scenarios are shown in Table 2. Without including harvest costs, reduced-till costs are approximately $26/a higher than conventional-till, whereas no-till costs are about $21 higher than reduced-till. Using market year average prices for 2011 of $7.02 for wheat and $5.99 for sorghum, the higher yields associated with no-till resulted in a $63/a advantage for no-till over reduced-till and an $83/a advantage for no-till over conventional-till (Figure 1).

Glyphosate-Resistant Kochia

Controlling kochia in no-till systems with glyphosate-oriented treatments has become problematic for many farmers in western Kansas; consequently, no-till crop producers have been considering alternative herbicide strategies or even using tillage as means to control kochia. Tables 3 and 4 show typical glyphosate-based herbicide treatments for no-till wheat and sorghum, respectively. Tables 5 and 6 show alternative herbicide treatments for wheat and sorghum to manage glyphosate-resistant kochia. As seen in the tables, herbicide expenses increase from $44/a to $82/a for wheat, whereas sorghum expenses increase from $56/a to $105/a. The question facing producers dealing with glyphosate-resistant kochia is whether the higher yields associated with no-till will outweigh the higher kochia-related herbicide costs. Figure 1 indicates that although the higher kochia-related herbicide costs decrease the profitability of the WSF rotation by nearly $30/a, the no-till rotation is still more profitable by nearly $50/a vs. the reduced-till rotation, and $55/a more than the conventional-till rotation.

Table 1. Wheat and sorghum yields in a wheat-sorghum-fallow rotation at Tribune, KS, 2001–2011

	Wheat yield (bu/a)			Sorghum yield (bu/a)		
Year	Conventional tillage	Reduced tillage	No-till	Conventional tillage	Reduced tillage	No-till
2001	17	40	31	6	43	64
2002	0	0	0	0	0	0
2003	22	15	30	7	7	37
2004	1	2	4	44	67	108
2005	32	32	39	28	38	61
2006	0	2	16	4	3	29
2007	26	36	51	26	43	62
2008	21	19	9	16	25	40
2009	9	10	22	19	5	72
2010	29	35	50	10	26	84
2011	22	20	20	37	78	113
Avg.	16.3	19.2	24.7	17.9	30.5	60.9

Table 2. Wheat-sorghum-fallow cost of production[1]

Tillage	Wheat	Sorghum	Total
	($/a)		
Conventional tillage	100.71	119.52	220.23
Reduced tillage	107.58	138.90	246.48
No-till	122.59	144.70	267.29

[1] Input costs do not include harvest costs, which vary with yield.

Table 3. No-till wheat herbicide program in wheat-sorghum-fallow rotation[1]

Treatment	Rate	Price	Cost	Timing
RT3 (+AMS)	16.5	$0.12/oz	$1.98	After sorghum harvest (fallow)
2,4-D	1	$3.12/pt	$3.12	
Total			$5.10	
Glyphosate (+AMS)	32	$0.09/oz	$2.88	Fallow
Glyphosate (+AMS)	32	$0.09/oz	$2.88	Fallow
Glyphosate (+AMS)	32	$0.09/oz	$2.88	Fallow
Ally (+NIS)	0.1	$13.93/oz	$1.39	In-crop
Dicamba	4	$0.33/oz	$1.32	
Total			$2.71	
Applications	5	$5.47	$27.35	
Total cost			$43.90	

[1] Surfactants and additives such as AMS and NIS can vary significantly in price and carrier volume and thus are excluded in cost estimates. Typical AMS costs range from $0.40/a to $0.80/a with glyphosate applications, whereas typical NIS applications range from $0.60/a to $2.30/a.

Table 4. No-till sorghum herbicide program in wheat-sorghum-fallow rotation

Treatment	Rate	Price	Cost	Timing
Glyphosate (+AMS)	32	$0.09/oz	$2.88	After wheat harvest (fallow)
RT3 (+AMS)	22	$0.12/oz	$2.64	Fallow
2,4-D	2	$3.12/pt	$6.24	
Atrazine	1.6	$3.51/oz	$5.62	
Total			$14.50	
Glyphosate (+AMS)	32	$0.09/oz	$2.88	Preplant
Bicep Lite II Magnum	1.5	$13.28/qt	$19.92	
Total			$22.80	
Applications	3	$5.47	$16.41	
Total cost			$56.59	

Table 5. No-till wheat herbicide program for kochia control in wheat-sorghum-fallow rotation

Treatment	Rate	Price	Cost	Timing
Dicamba	16	$0.33/oz	$5.28	After sorghum harvest (fallow)
Sencor	0.5	$14.50/lb	$7.25	
Total			$12.53	
Gramoxone (+NIS)	48	$0.23/oz	$11.04	Fallow
Glyphosate (+AMS)	32	$0.09/oz	$2.88	Fallow
2,4-D	1	$3.12/pt	$3.12	
Dicamba	16	$0.33/oz	$5.28	
Total			$11.28	
Glyphosate (+AMS)	32	$0.09/oz	$2.88	Fallow
2,4-D	1	$3.12/pt	$3.12	
Dicamba	8	$0.33/oz	$2.64	
Total			$8.64	
Glyphosate (+AMS)	32	$0.09/oz	$2.88	Fallow
Ally (+NIS)	0.1	$13.93/oz	$1.39	In-crop
Dicamba	4	$0.33/oz	$1.32	
Total			$2.71	
Applications	6	$5.47	$32.82	
Total cost			$81.90	

Table 6. No-till sorghum herbicide program for kochia control in wheat-sorghum-fallow rotation

Treatment	Rate	Price	Cost	Timing
Glyphosate (+AMS)	32	$0.09/oz	$2.88	After wheat harvest (fallow)
2,4-D	2	$3.12/pt	$6.24	
Dicamba	16	$0.33/oz	$5.28	
Total			$14.56	
Glyphosate (+AMS)	32	$0.09/oz	$2.88	Fallow
2,4-D	1	$3.12/pt	$3.12	
Total			$6.00	
Glyphosate (+AMS)	32	$0.09/oz	$2.88	Fallow
Dicamba	16	$0.33/oz	$5.28	
Atrazine	16	$0.11/oz	$1.76	
Total			$9.92	
Dual II Magnum	1.66	$14.26/pt	$23.67	Preplant
Atrazine	16	$0.11/oz	$1.76	
Gramoxone (+NIS)	48	$0.23/oz	$11.04	
Total			$36.47	
Huskie (+NIS)	13	$0.75/oz	$9.75	In-crop
Atrazine	8	$0.11/oz	$0.88	
Total			$10.63	
Applications	5	$5.47	$27.35	
Total cost			$104.93	

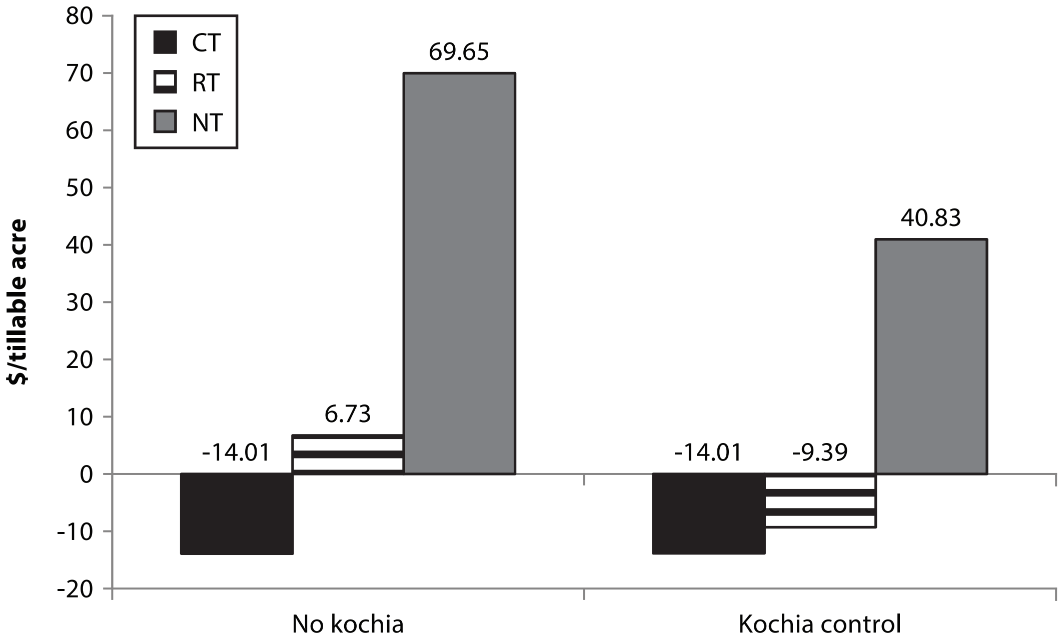

Figure 1. Average returns in a wheat-sorghum-fallow rotation with and without kochia resistance.

Irrigated Corn Response to High Rates of Balance Compared with Tank Mixes of Corvus, Clarity, Lumax, Halex, and Capreno Herbicide

R. Currie and J. Jester

Summary

No herbicide tank mix produced visual injury or depressed corn yield. Due to extreme heat and drought, weed pressure was very low. All herbicide treatments provided greater than 89% grass control. Broadleaf weed control was greater than 93% with all treatments.

Introduction

Corn was often injured by high rates of Balance herbicide prior to the introduction of Balance Flexx, which contains a safener to enhance tolerance to this herbicide. Now that the safener version is available, it is unknown how high rates of Balance Flexx compare to other products. The objective of this study was to compare such tank mixes.

Procedures

Broadleaf and grassy weed control were both evaluated in irrigated corn at the Kansas State University Research-Extension Center in Garden City, KS. Corn was planted on May 9, 2012, with preemergence herbicides applied within 24 hours of planting. Preemergent application conditions of air temperature, soil temperature, wind speed, and relative humidity were 78°F, 71°F, 3 mph, and 46%, respectively. Soil moisture conditions were poor. Soil was Ulysses silt loam, with organic matter, soil pH, and cation exchange capacity (CEC) of 1.4%, 8, and 18.4, respectively. All herbicide treatments were applied with a tractor-mounted CO_2 pressurized windshield sprayer calibrated to deliver 20 gal/a at 30 psi at 4.1 mph. Adjuvant and ammonium sulfate (AMS) were added per manufacturer recommendation. Postherbicide application was made on June 20, 2012. Postapplication conditions of air temperature, soil temperature, wind speed, and relative humidity were 91°F, 86°F, 11 mph, and 34%, respectively. Soil moisture was adequate. The trial was established as a randomized complete block design with four replications, and plots were 10 × 30 ft. Crop injury and percentage weed control were visually rated.

Results

No crop injury was observed with any herbicide tank mix. Due to inconsistent distribution of weeds, percentage weed control was rated as overall grassy (monocot) and broadleaf (dicot) control (Table 1). Monocot species observed were *Cenchrus longispinus* (Hack.) Fernald, *Digitaria sp*. L., and *Setaria veridis* (L.) P. Beauv. Dicot species observed were *Abutilon theophrasti* Medik., *Amaranthus palmeri* S. Watson, *Euphorbia maculata* L., *Kochia scoparia* L. Schrad., *Proboscidea louisianica* (Mill.) Thell., *Salsola kali* L., *Solanum rostratum* Dunal, and *Xanthium strumarium* L. Dicot control remained high at 96 days after planting (DAP), with all but treatment 11 maintaining greater than 95% control.

Monocot control at 96 DAP was between 85 and 95%. The highest control was found in treatments 7 and 8. Due to extreme heat and drought, weed pressure was very low, and corn yields in the control plots were not different from the herbicide-treated plots. This makes comparisons of these weed control products difficult, but it clearly demonstrates that even at high rates, these herbicides have very little potential to injure corn.

Table 1. Broadleaf (dicot) and grassy (monocot) weed control with high rates of Balance compared with tank mixes of Corvus, Clarity, Lumax, Halex, and Capreno herbicide

				% control				
				68 DAP[2]		96 DAP		Yield,
Treatment	Active ingredient	Rate	Timing[1]	Grassy	Broadleaf	Grassy	Broadleaf	bu/a
1	Untreated check			0	0	0	0	61
2	Corvus	5.6 oz/a	A	95	99	94	98	56
	Atrazine	1.5 qt/a	A					
3	Corvus	5.6 oz/a	A	95	98	89	96	64
	Clarity	0.5 pt/a	A					
4	Corvus	5.6 oz/a	A	96	99	89	97	64
	Clarity	1 pt/a	A					
5	Balance Flexx	6 oz/a	A	94	99	85	96	49
	Atrazine	1.5 qt/a	A					
6	Balance Flexx	6 oz/a	A	91	99	88	97	49
	Atrazine	1.5 qt/a	A					
	Harness	2.25 pt/a	A					
7	Capreno	3 oz/a	B	96	97	95	96	50
	Atrazine	2 pt/a	B					
	Roundup PowerMax	22 fl oz/a	B					
8	Capreno	3 oz/a	B	98	99	95	99	45
	Atrazine	2 pt/a	B					
	Roundup PowerMax	22 oz/a	B					
	Clarity	0.5 pt/a	B					
9	Capreno	3 oz/a	B	96	99	91	96	54
	Atrazine	2 pt/a	B					
	Roundup PowerMax	22 oz/a	B					
	Clarity	1 pt/a	B					
10	Lumax	3 qt/a	B	90	99	89	97	61
11	Halex GT	3.6 pt/a	B	94	97	90	93	58
LSD (*P* = 0.05)				5.41	1.34	6.46	3.84	25.59

[1] A is PRE, B is V4–V5.

[2] Days after planting.

Kochia Control with Increasing Rates of Preemergence Dicamba Followed by Tank Mixes of Paraquat

R. Currie, J. Jester, C. Thompson, and P. Stahlman

Introduction

In 2010, in response to an emerging threat of glyphosate-resistant kochia, a regional task force tested 9 preemergence and 14 postemergence non-glyphosate herbicide tank mixes for kochia control at six to nine locations (Stahlman et al., 2012). None of these tank mixes consistently provided 100% control of kochia, but preemergent applications of dicamba provided the best and most consistent preemergence control. It was unclear, however, what rate would provide the optimal level and duration of control. Among the postemergence applications, Paraquat and Atrazine tank mixes provided the highest and most consistent level of control. Therefore, the objective of this study was to measure the dose response relationship of several preemergence dicamba rates followed by postemergence tank mixes of Paraquat and Atrazine.

Procedures

Within the first week of March, a split-plot experiment with 0, 0.25, 0.5, 0.75, and 1 lb/a of dicamba as the main plot was established. During May, the main plot treatments began to fail. Subplots of Paraquat and Atrazine at 0.75 and 1 lb/a within the main plot were then applied. To reduce the possible interference of grassy weeds, 2 lb/a of S-metolachlor was included. These treatments were repeated at Hays and Tribune, KS. To expand the inference of this experiment to a wheat- fallow-wheat rotation at the Tribune location, an additional set of subplots were included in a tank mix of Paraquat + metribuzin at 0.75 and 0.5 lb/a.

Results

Control 30 DAT (days after treatment) ranged from 100% to 94% with 1 lb/a dicamba across all locations (Figures 1, 2, and 3). At this rate, control declined at 60 DAT from 94% to 83% across all locations. With 0.5 lb/a dicamba, control declined from 85% to 70% across all locations. At all but the Garden City location, a logistic model explained the dose response relationship with R-squares greater than 0.90 at all rating dates from 33 to 94 DAT. At the Garden City location, this was true until 47 DAT; however, from 68 to 110 DAT the rate of control at the Garden City location was best described by simple linear models with R-square values greater than 0.90 at all rating dates. At all rating dates, the rate of diminishing returns was seen at 0.5 lb/a dicamba. At this rate, control declined linearly with time at all three locations with R-squares ranging from 0.90 to 0.97 (Figures 4, 5, and 6). The slopes of these lines predicted from 0.56% to 0.86% decline in control per day during the first 60 days. At the Tribune and Hays locations, tank mixes with Paraquat and Atrazine or Metribuzin augmented control of dicamba-treated plots elevating control from 93% to 100% for greater than 88 DAT. Record heat and drought at the application at Garden City, coupled with beginning kochia populations of greater than 250 plants/in.^{2}, made coverage of postemergence treatments poor and led to atypically poor control compared with previous work. There was substantial kochia mortality in the control plots due to drought, and remaining plants were stunted and failed to reach a height of 12 in. at the end of the growing season. This limits inference of the later season postemergence treatments at this location. All locations support the early March application of 0.5 lb/a of dicamba for early season preemergence control of kochia, but additional postemergence treatments are needed. At two of the three locations, preemergence dicamba treatments followed by postemergence applications of Paraquat and Atrazine or Metribuzin provided excellent season-long control.

References

Stahlman, P.W., P.W. Geier, S.S. Reddy, R.S Currie, B.L. Olson, C.R. Thompson, J.L. Jester, A. Helm, P. Westra, R.G. Wilson, G.M. Sbatella, P. Jha, A.R. Kniss, and J.M. Tichota. 2012. Regional studies on managing kochia without glyphosate. Weed Sci. Soc. Am. Abst. 52:376. Weed Sci. Soc. Am., Lawrence, KS.

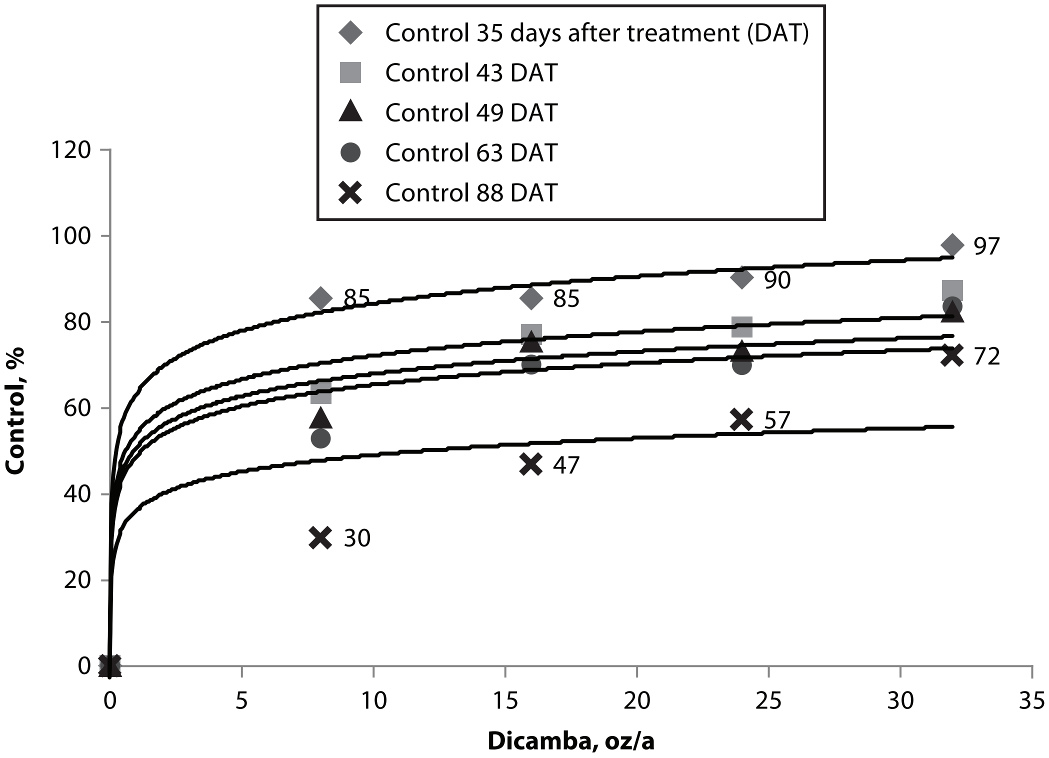

Figure 1. Dose response of dicamba at Tribune.

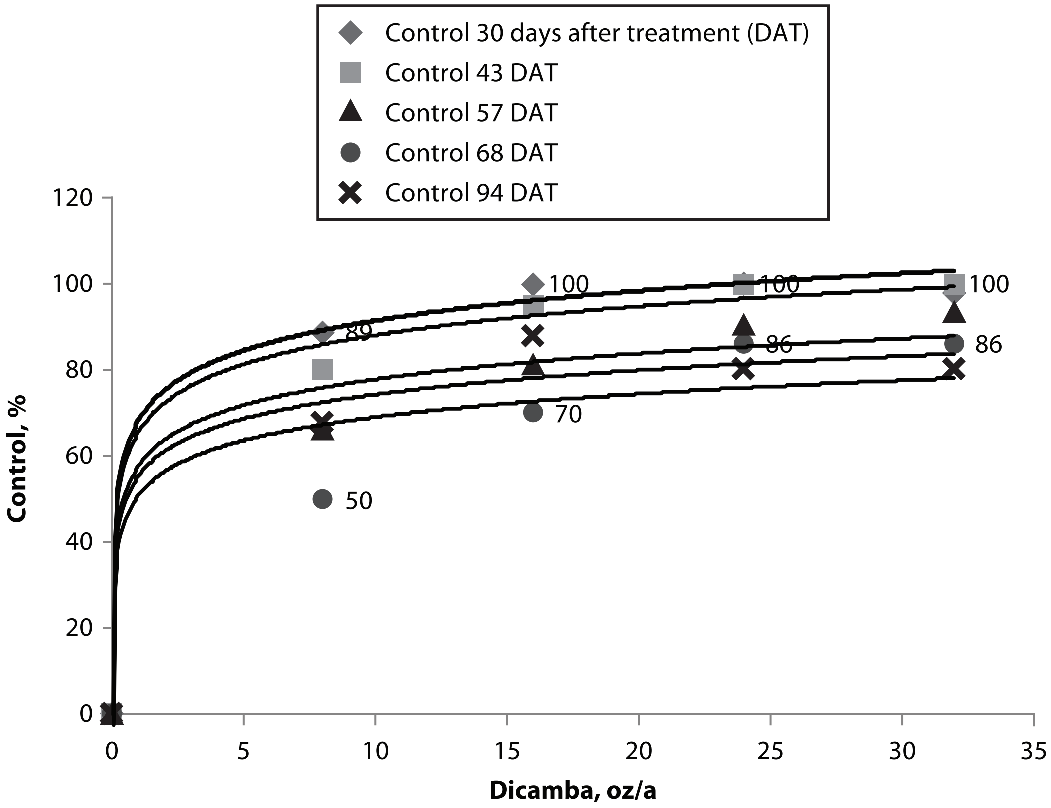

Figure 2. Dose response of dicamba at Hays.

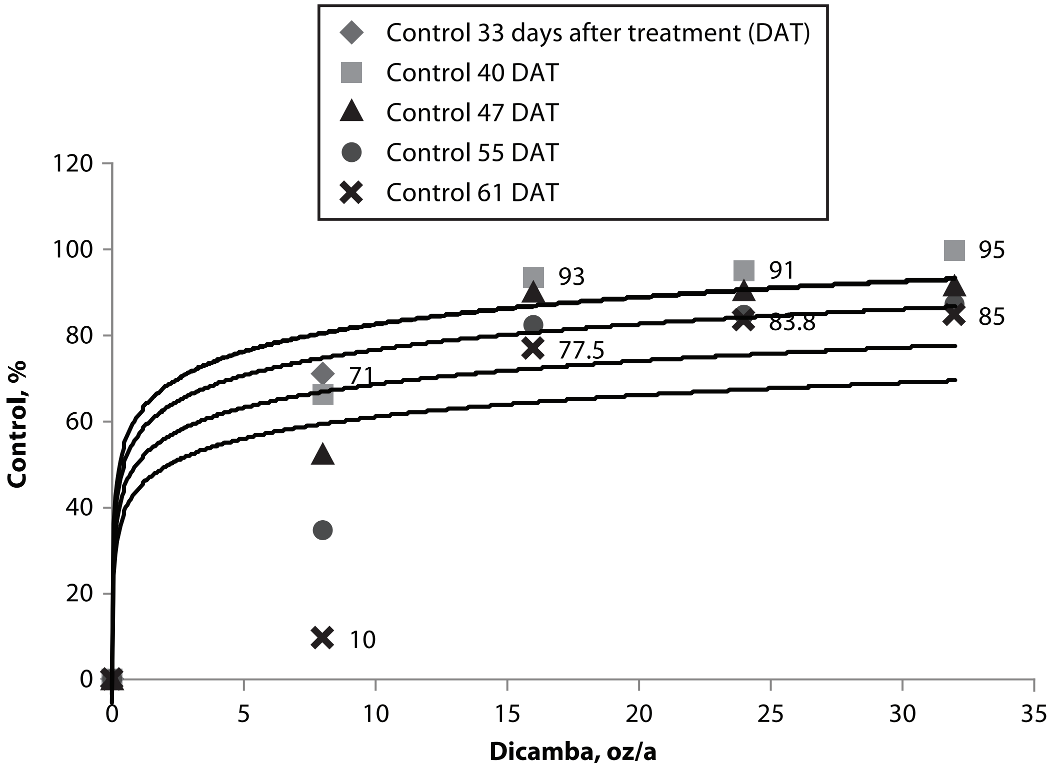

Figure 3. Dose response of dicamba at Garden City

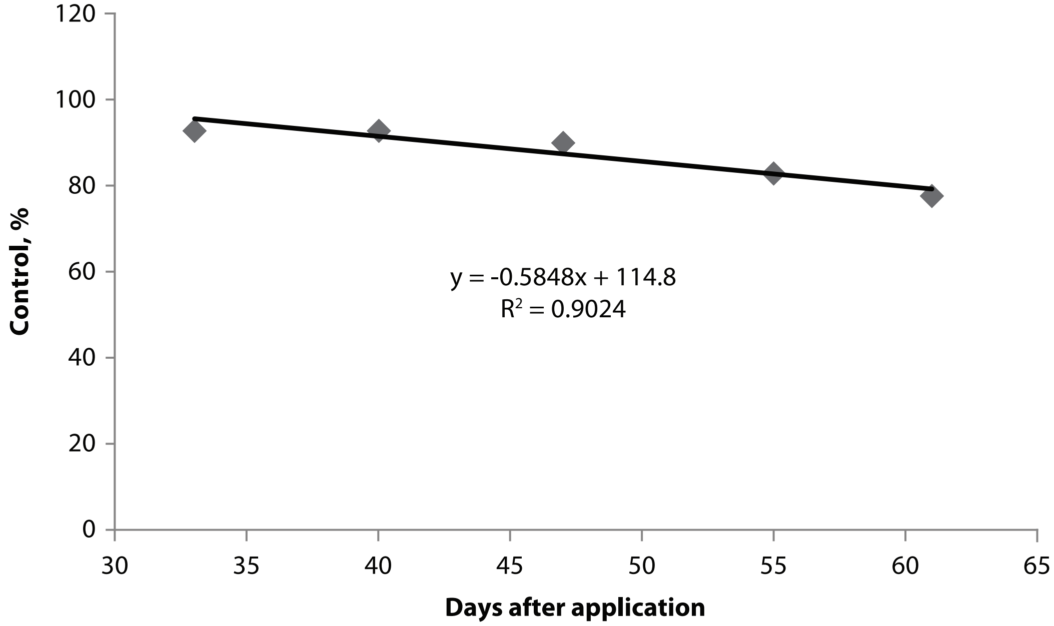

Figure 4. Decline in control of a pint of dicamba at Garden City.

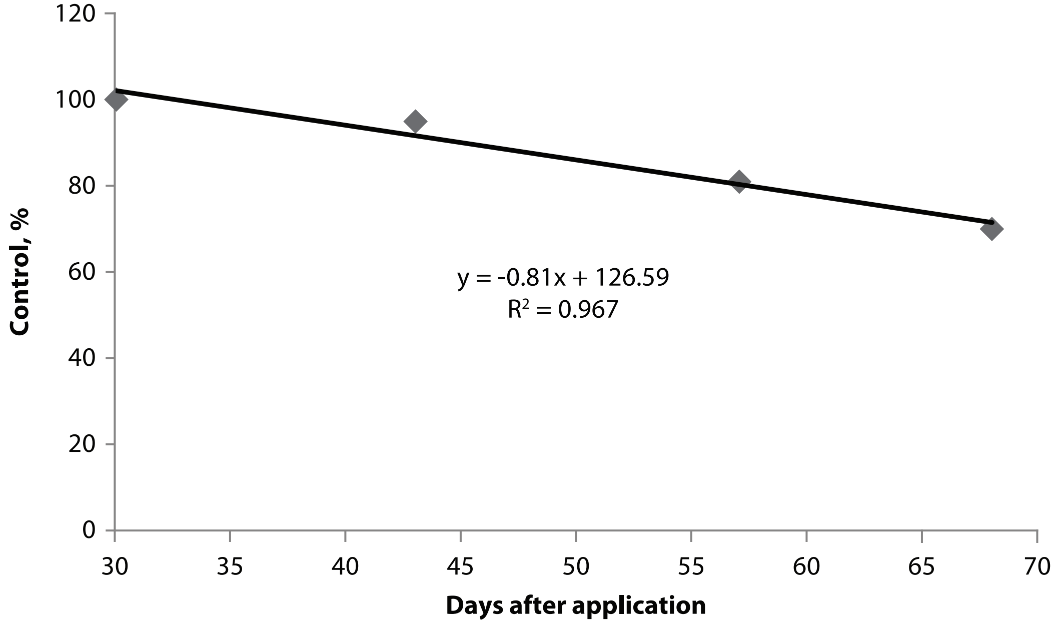

Figure 5. Decline in control of a pint of dicamba at Hays.

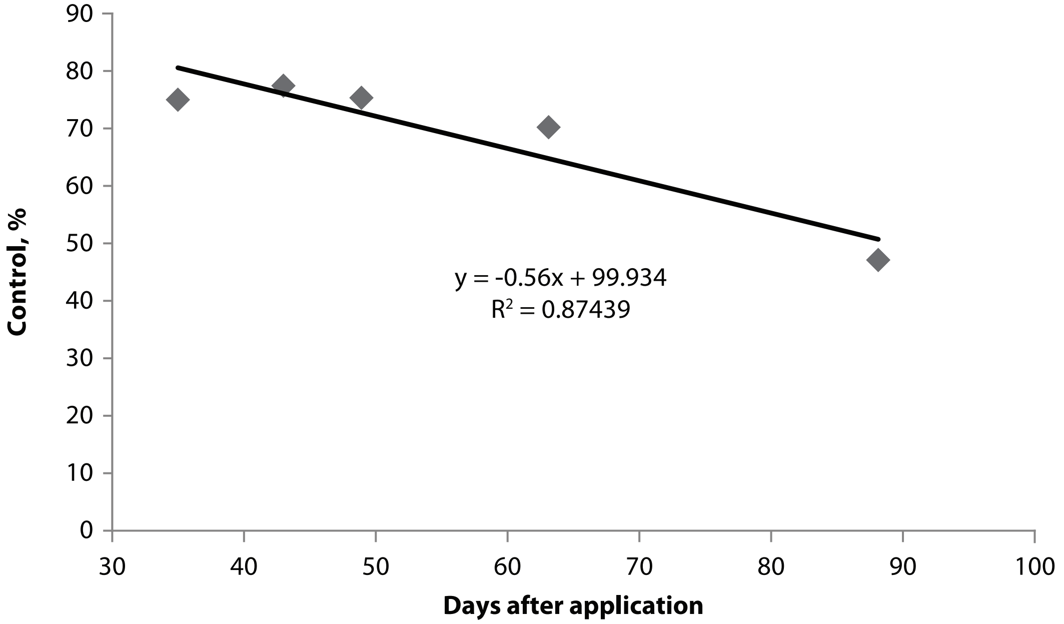

Figure 6. Decline in control of a pint of dicamba at Tribune.

Weed Control in Irrigated Glyphosate-Resistant Corn with Tank Mixes of Glyphosate or Ignite with Atrazine, Corvus, Laudis, Clarity, or Lumax

R. Currie and J. Jester

Summary

No herbicide tank mix produced visual injury or depressed corn yield. Due to extreme heat and drought, weed pressure was very low. All herbicide treatments provided greater than 96% control of all weed species 68 days after treatment (DAT).

Introduction

With the advent of glyphosate-resistant weed species, herbicide tank mix partners with multiple modes of actions are needed to augment glyphosate's weed control. The objective of this study was to test such tank mixes.

Procedures

Broadleaf and grassy weed control was evaluated in irrigated corn at the Kansas State University Research-Extension Center in Garden City, KS. Corn was planted on May 9, 2012, with preemergence herbicides applied within 24 hours of planting. Preemergent application conditions of air temperature, soil temperature, wind speed, relative humidity, and soil moisture were 78°F, 71°F, 3 mph, 46%, and inadequate, respectively. Soil was Ulysses silt loam, and organic matter, soil pH, and cation exchange capacity (CEC) were 1.4%, 8, and 18.4, respectively. All herbicide treatments were applied with a tractor-mounted CO_2-pressurized windshield sprayer calibrated to deliver 20 gal/a at 30 psi and 4.1 mph. Adjuvant and ammonium sulfate (AMS) were added per manufacturer recommendations. Postemergence herbicide applications were made on June 20, 2012. The conditions of air temperature, soil temperature, wind speed, relative humidity, and soil moisture were 91°F, 86°F, 11 mph, 34%, and adequate. The trial was established as a randomized complete block design with four replications, and plots were 10 × 30 feet. Crop injury and percentage weed control were visually rated.

Results

No crop injury was observed. Due to inconsistent distribution of weeds, percentage weed control was rated as overall grassy (monocot) and broadleaf (dicot) control (Table 1). Monocot species observed were *Cenchrus longispinus* (Hack.) Fernald, *Digitaria sp*. L., and *Setaria veridis* (L.) P. Beauv. Dicot species observed were *Abutilon theophrasti* Medik., *Amaranthus palmeri* S. Watson, *Euphorbia maculata* L., *Kochia scoparia* L. Schrad., *Proboscidea louisianica* (Mill.) Thell, *Salsola kali* L., *Solanum rostratum* Dunal, and *Xanthium strumarium* L. Due to extreme heat and drought, weed pressure was very low. All herbicide treatments provided greater than 96% control of all weed species 68 DAT. Although control of grassy weeds declined by 96 DAT to 88% in the poorest treatment, overall control remained excellent. The degree of broadleaf weed control seen at 68 DAT was maintained at or above 96%.

Table 1. Weed control in irrigated glyphosate-resistant corn with tank mixes of glyphosate or Ignite with atrazine, Corvus, Laudis, Clarity, or Lumax.

				% control				
				68 DAP[2]		96 DAP		
Treatment	Active ingredient	Rate	Timing[1]	Grassy	Broadleaf	Grassy	Broadleaf	Yield, bu/a
1	Untreated check			0	0	0	0	77
2	Corvus	3 oz/a	A	97	99.5	92	98	61
	Atrazine	1 qt/a	A					
	Roundup PowerMax	22 oz/a	B					
	Laudis	3 oz/a	B					
	Clarity	8 oz/a	B					
3	Corvus	3 oz/a	A	97	99.8	94	97	73
	Atrazine	1 qt/a	A					
	Roundup PowerMax	22 oz/a	B					
	Laudis	3 oz/a	B					
	Clarity	16 oz/a	B					
4	Corvus	3 oz/a	A	98	99.5	97	96	44
	Atrazine	1 qt/a	A					
	Roundup PowerMax	22 oz/a	B					
	Capreno	3 oz/a	B					
	Clarity	8 oz/a	B					
5	Corvus	3 oz/a	A	99	99.8	94	97	58
	Atrazine	1 qt/a	A					
	Roundup PowerMax	22 oz/a	B					
	Capreno	3 oz/a	B					
	Clarity	16 oz/a	B					
6	Balance Flexx	3 oz/a	A	97	99.3	91	96	52
	Atrazine	2 qt/a	A					
	Roundup PowerMax	22 oz/a	B					
	Laudis	3 oz/a	B					
	Clarity	8 oz/a	B					
7	Balance Flexx	3 oz/a	A	96	98.3	88	95	64
	Atrazine	2 pt/a	A					
	Roundup PowerMax	22 oz/a	B					
	Laudis	3 oz/a	B					
	Clarity	16 oz/a	B					

continued

Table 1. Weed control in irrigated glyphosate-resistant corn with tank mixes of glyphosate or Ignite with atrazine, Corvus, Laudis, Clarity, or Lumax.

				% control				
				68 DAP[2]		96 DAP		
Treatment	Active ingredient	Rate	Timing[1]	Grassy	Broadleaf	Grassy	Broadleaf	Yield, bu/a
8	Balance Flexx	3 oz/a	A	97	99.5	94	97	57
	Atrazine	2 pt/a	A					
	Roundup PowerMax	22 oz/a	B					
	Capreno	3 oz/a	B					
	Clarity	8 oz/a	B					
9	Balance Flexx	3 oz/a	A	98	99.3	95	98	69
	Atrazine	2 pt/a	A					
	Roundup PowerMax	22 oz/a	B					
	Capreno	3 oz/a	B					
	Clarity	16 oz/a	B					
10	Balance Flexx	3 oz/a	A	96	99.8	90	97	58
	Atrazine	2 pt/a	A					
	Ignite	22 oz/a	B					
	Laudis	3 oz/a	B					
11	Lumax	1.5 qt/a	A	99	99.3	99	98	62
	Halex GT	3.6 pt/a	B					
LSD (*P* = 0.05)				3.65	1.12	4.69	3.5	41.47

[1] A is PRE, B is V4–V5.

[2] Days after planting.

Weed Control with Anthem, Cadet, Balance, Harness, Callisto, Verdict, Armezon, Zidua, Atrazine, and Roundup

R. Currie, J. Jester

Introduction

The herbicide package mixes Anthem and Verdict have both recently received federal labels. Both are tank mixes of new active ingredient Pyrasulfotole and a second herbicide to extend the treated weed spectrum. The activity of Pyrasulfotole has been reported in previous years in our Field Day reports by the development code KIH-485. The objective of this study was to compare these products to several other herbicide tank mixes.

Procedures

Broadleaf and grassy weed controls were evaluated in irrigated corn at the Kansas State University Research-Extension Center in Garden City, KS. Corn was planted on May 15, 2012, with preemergence herbicides applied within 24 hours of planting. Preemergent application conditions of air temperature, soil temperature, wind speed, relative humidity, and soil moisture were 83°F, 70°F, 3 mph, 49%, and adequate, respectively. Soil was Ulysses silt loam, and organic matter, soil pH, and cation exchange capacity (CEC) were 1.4%, 8, and 18.4, respectively. All herbicide treatments were applied with a tractor-mounted CO_2 pressurized windshield sprayer calibrated to deliver 20 gal/a at 30 psi and 4.1 mph. Adjuvant and AMS were added per manufacturer recommendation. The first postemergence herbicide application was made on June 21, 2012. The first post-application conditions of air temperature, soil temperature, wind speed, relative humidity and soil moisture were 73°F, 73°F, 4 mph, 38%, and adequate, respectively. The second post-application was made on June 25, 2012. Second post-application conditions of air temperature, soil temperature, wind speed, relative humidity, and soil moisture were 85°F, 80°F, 2 mph, 30%, and adequate, respectively. The trial was established as a randomized complete block design with four replications, and plots were 10 × 30 feet.

Results

Crop injury and percentage weed control were both visually rated. No crop injury was observed. Due to inconsistent distribution of weeds, percentage weed control was rated as overall grassy (monocot) and broadleaf (dicot) control (Table 1). Monocot species observed were *Cenchrus longispinus* (Hack.) Fernald, *Digitaria sp*. L., and *Setaria veridis* (L.) P. Beauv. Dicot species observed were *Abutilon theophrasti* Medik., *Amaranthus palmeri* S. Watson, *Euphorbia maculata* L., *Kochia scoparia* L. Schrad., *Proboscidea louisianica* (Mill.) Thell, *Salsola kali* L., *Solanum rostratum* Dunal, and *Xanthium strumarium* L. Treatments that produced greater than 91.4% control 62 days after treatment (DAT) were not statistically superior to the best treatments. There were no differences between products for broadleaf control 62 and 83 DAT. Treatments providing greater than 79.8% grass control were not statistically superior to the best treatment 83 DAT.

Table 1. Weed control with Anthem, Cadet, Balance, Harness, Callisto, Verdict, Armezon, Zidua, Atrazine, and Roundup

				% control				
				62 DAP[2]		83 DAP		
Treatment	Active ingredient	Rate	Timing[1]	Grassy	Broadleaf	Grassy	Broadleaf	Yield, bu/a
1	Untreated check			0	0	0	0	51
2	Anthem	8 fl oz/a	A	93	98	91	99	54
	Cadet	0.75 fl oz/a	B					
	Roundup PowerMax	22 fl oz/a	B					
3	Anthem	2 pt/a	A	96	99.5	93	99	55
	Cadet	0.75 fl oz/a	B					
	Roundup PowerMax	22 fl oz/a	B					
4	Anthem	2.5 pt/a	A	92	99	93	99	62
	Cadet	0.75 fl oz/a	B					
	Roundup PowerMax	22 fl oz/a	B					
5	Anthem	8 fl oz/a	A	99	99.5	95	99	46
	Balance Flexx	2 fl oz/a	A					
	Cadet	0.75 fl oz/a	B					
	Roundup PowerMax	22 fl oz/a	B					
6	Anthem ATZ	2 pt/a	A	99	99.5	94	99	55
	Balance Flexx	2 fl oz/a	A					
	Cadet	0.75 fl oz/a	B					
	Roundup PowerMax	22 fl oz/a	B					
7	Lumax	3 qt/a	A	97	99.5	90	99	77
	Cadet	0.75 fl oz/a	B					
	Roundup PowerMax	22 fl oz/a	B					
8	Harness Xtra	2 oz/a	A	92	99	86	99	69
	Cadet	0.75 oz/a	B					
	Roundup PowerMax	22 fl oz/a	B					
9	Anthem	8 fl oz/a	A	73	99	60	99	56
	Cadet	0.75 fl oz/a	B					
	Callisto	3 fl oz/a	B					
	Aatrex	1 pt/a	B					

continued

Table 1. Weed control with Anthem, Cadet, Balance, Harness, Callisto, Verdict, Armezon, Zidua, Atrazine, and Roundup

Treatment	Active ingredient	Rate	Timing[1]	% control				Yield, bu/a
				62 DAP[2]		83 DAP		
				Grassy	Broadleaf	Grassy	Broadleaf	
10	Anthem	2 pt/a	A	85	99.3	85	99	73
	Cadet	0.75 fl oz/a	B					
	Callisto	3 fl oz/a	B					
	Aatrex	1 pt/a	B					
11	Anthem ATZ	2 pt/a	A	97	99.5	91	99	49
	Roundup PowerMax	22 fl oz/a	B					
	Callisto	3 fl oz/a	B					
12	Verdict	15 fl oz/a	A	89	99.8	89	99	51
	Atrazine	1 qu/a	A					
	Roundup PowerMax	22 fl oz/a	C					
	Status	5 oz/a	C					
13	Verdict	15 fl oz/a	A	89	99	85	99	62
	Atrazine	1 qu/a	A					
	Roundup PowerMax	22 fl oz/a	C					
	Armezon	0.75 fl oz/a	C					
	Atrazine	1 pt/a	C					
14	Zidua	2 oz wt/a	A	96	99	93	99	91
	Atrazine	1 qu/a	A					
	Roundup PowerMax	22 fl oz/a	C					
	Armezon	0.75 fl oz/a	C					
	Atrazine	1 pt/a	C					
15	Roundup PowerMax	22 fl oz/a	B	80	99	84	99	80
	G-Max Lite	3 pt/a	B					
	Armezon	0.75 fl oz/a	B					
16	Roundup PowerMax	22 fl oz/a	B	88	99	81	99	75
	Zidua	2 oz wt/a	B					
	Atrazine	22 fl oz/a	B					
LSD (*P* = 0.05)				7.59	0.98	15.2	0.87	35.57

[1] A is PRE, B is 2–4-in. weeds, C is 10–14-in. corn.

[2] Days after planting.

Acknowledgments

The staffs of the Southwest Research-Extension Center and Kansas State University appreciate and acknowledge the following companies, foundations, and individuals for their support of the research that has been conducted in the past year.

Donations

American Implement
BASF Corp.
Bayer Chemical
CPS – Crop Production Services
DeKalb Genetics Corp.
Dodge City Coop
Drussel Seed
Ehmke Seeds
Farm Credit of Southwest Kansas
Green Cover Seed
Garden City Coop
Helena Chemical
Kansas Wheat Alliance
Monsanto Company
Pioneer Hi-Bred Intl.
Security State Bank
Sharp Brothers Seed
Triumph Seed

Grant Support

AgXplore Inc.
Arysta Life Science Corporation
BASF Corp.
Bayer CropScience
Dow AgroSciences
DuPont Ag Products
Ehmke Seed
FMC Corporation
Gowan Company
Groundwater Management Disctrict #1
Great Plains Canola Association
Helena Chemical Company
International Plant Nutrition Institute
Kansas Grain Sorghum Commission
Kansas Water Authority
Kansas Wheat Commission
Monsanto
National Crop Insurance Services
National Sunflower Association
Stoller Enterprises Inc.
Syngenta
Tessenderlo Kerley Inc.
United Sorghum Checkoff Program
U.S. Canola Association
USDA/ARS
USDA Canola Project
USDA/Ogallala Aquifer Project
USDA Risk Management Agency
Valent BioSciences
Winfield Solutions

Cooperators/Collaborators

Colorado State University
Dodge City Community College
Kansas Division of Water Resources
Kansas Water Office
Kansas State University Research Foundation
South Dakota State University
Texas A&M University
University of Nebraska
University of Wyoming
USDA/ARS, Bushland, Lubbock, and Weslaco, TX; Akron, CO

Performance Tests

AgriPro Seeds Inc.
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Producers
Schillinger
Scott Seed
Stine Seed Farms
Syngenta Sorghum Lines
Triumph Seed Company Inc.
Watley
WestBred
W-L Research

Herbicide Premixes

Product (Manufacturer)	Ingredients
Accurate/Extra (Cheminova)	37.5% thifensulfuron, 18.8% tribenuron, and 15% metsulfuron
Affinity BroadSpec (DuPont)	25% thifensulfuron (Harmony) and 25% tribenuron (Express)
Affinity TankMix (DuPont)	40% thifensulfuron (Harmony) and 10% tribenuron (Express)
Agility SG (DuPont)	4.7% thifensulfuron (Harmony), 2.4% tribenuron (Express), 1.9% metsulfuron (Ally), and 58% dicamba (Banvel)
Ally Extra SG (DuPont)	27.3% thifensulfuron, 13.6% tribenuron (Harmony Extra), and 10.9% metsulfuron (Ally)
Anthem (FMC)	2.087 lb pyroxasulfone and 0.063 lb fluthiacet-methyl (Cadet)
Anthem ATZ (FMC)	0.485 lb pyroxasulfone, 0.014 lb fluthiacet-methyl (Cadet), and 4 lb atrazine
Authority Assist (FMC)	3.33 lb sulfentrazone (Spartan) and 0.67 lb imazethapyr (Pursuit)
Authority First (FMC)	62.1% sulfentrazone (Spartan) and 7.9% cloransulam (FirstRate)
Authority MTZ (FMC)	18% sulfentrazone (Spartan) and 27% metribuzin (Sencor)
Authority XL (FMC)	62% sulfentrazone (Sparton) and 7.8% chlorimuron (Classic)
Autumn Super (Bayer)	6% iodosulfuron (Autumn) and 45% thiencarbazone
Banvel K + Atrazine (Arysta)	1.1 lb potassium salt of dicamba and 2.1 lb atrazine per gal
Basis (DuPont)	50% rimsulfuron and 25% thifensulfuron (Harmony)
Basis Blend (DuPont)	20% rimsulfuron (Resolve) and 10% thifensulfuron (Harmony)
Bicep II Magnum (Syngenta)	3.1 lb atrazine and 2.4 lb S-metolachlor (Dual II Magnum) per gal
Bicep Lite II Magnum (Syngenta)	2.67 lb atrazine and 3.33 lb S-metolachlor (Dual II Magnum) per gal
Bison (Winfield)	2 lb bromoxynil (Moxy) and 2 lb MCPA per gal
Boundary (Syngenta)	5.25 lb S-metolachlor (Dual Magnum) and 1.25 lb metribuzin (Sencor) per gal
Brash (Winfield)	1 lb dicamba and 2.87 lb 2,4-D amine per gal
Breakfree ATZ (DuPont)	3 lb acetochlor + 2.25 lb atrazine per gal
Breakfree ATZ Lite (DuPont)	4 lb acetochlor + 1.5 lb atrazine per gal
Broadaxe (FMC)	0.7 lb sulfentrazone (Spartan) and 6.3 lb S-metolachlor (Dual Magnum) per gal
Bromox + Atrazine (MicroFlo)	1 lb bromoxynil and 2 lb atrazine per gal
Brozine (Platte Chemical)	1 lb bromoxynil and 2 lb atrazine per gal
Buctril + Atrazine (Bayer)	1 lb bromoxynil (Buctril) and 2 lb atrazine per gal
Bullet (Monsanto)	2.5 lb microencapsulated alachlor (Micro-Tech) and 1.5 lb atrazine per gal
Callisto Xtra (Syngenta)	0.5 lb mesotrione (Callisto) and 3.2 lb atrazine (AAtrex 4L)
Canopy (DuPont)	64.3% metribuzin and 10.7% chlorimuron (Classic)
Canopy EX (DuPont)	22.7% chlorimuron (Classic) and 6.8% tribenuron (Express)
Capreno (Bayer)	2.88 lb tembotrione (Laudis) and 0.57 lb thiencarbazone per gal

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[1] Co-packs consist of individual components packaged in separate containers or compartments and sold together.

Herbicide Premixes

Product (Manufacturer)	Ingredients
Capstone (Dow AS)	0.1 lb/gal aminopyralid and 1 lb/gal triclopyr
Carnivore (Winfield)	1.67 lb MCPA, 1.67 lb bromoxynil (Bactril), and 0.67 lb fluroxypyr (Starane) per gal
Chaparral (Dow AS)	0.525% aminopyralid (Milestone) and 0.0945% metsulfuron (Ally)
Charger Max ATZ (Winfield)	3.1 lb atrazine and 2.4 lb S-metolachlor (Dual II Magnum) per gal
Charger Max ATZ Lite (Winfield)	2.67 lb atrazine and 3.33 lb S-metolachlor (Dual II Magnum) per gal
Chism (Cheminova)	48% metsulfuron and 15% chlorsulfuron
Cimarron Max (DuPont)	1 lb dicamba and 2.87 lb 2,4-D per gal. and 60% metsulfuron co-pack[1]
Cimarron Plus (DuPont)	48% metsulfuron and 15% chlorsulfuron
Cimarron Xtra (DuPont)	30% metsulfuron (Ally) and 37.5% chlorsulfuron (Glean)
Cinch ATZ (DuPont)	3.1 lb atrazine and 2.4 lb S-metolachlor (Cinch) per gal
Cinch ATZ Lite (DuPont)	2.67 lb atrazine and 3.33 lb S-metolachlor (Cinch) per gal
Clearmax (BASF)	1 lb imazamox (Beyond) per gal. and 4 lb MCPA per gal. co-pack[1]
Confidence Xtra (Winfield)	4.3 lb acetochlor (Harness) and 1.7 lb atrazine per gal
Confidence Xtra 5.6L (Winfield)	3.1 lb acetochlor (Harness) and 1.5 lb atrazine per gal
Corvus (Bayer)	1.88 lb isoxaflutole (Balance Flexx) and 0.75 lb thiencarbazone per gal
Crossbow (Dow)	2 lb 2,4-D and 1 lb triclopyr (Remedy) per gal
Curtail (Dow)	2 lb 2,4-D and 0.38 lb clopyralid (Stinger) per gal
Degree Xtra (Monsanto)	2.7 lb acetochlor (Degree) and 1.34 lb atrazine per gal
Dicamba K + Atrazine (MicroFlo)	1.1 lb potassium salt of dicamba and 2.1 lb atrazine per gal
Display (FMC)	18% carfentrazone (Aim) and 4.75% fluthiacet (Cadet)
Distinct (BASF)	20% acid of diflufenzopyr and 50% acid of dicamba (Banvel SGF)
Enlite (DuPont)	2.85% chlorimuron (Classic), 36.2% flumioxazin (Valor), and 8.8% thifensulfuron (Harmony)
Envive (DuPont)	9.2% chlorimuron (Classic), 29.2% flumioxazin (Valor), and 2.9% thifensulfuron (Harmony)
Expert (Syngenta)	1.74 lb S-metolachlor (Dual Magnum), 2.14 lb atrazine, and 1.0 lb IPA salt of glyphosate per gal
Extreme (BASF)	0.17 lb ae imazethapyr (Pursuit) and 1.5 lb ae glyphosate per gal
Field Master (Monsanto)	0.75 lb IPA salt of glyphosate (Roundup), 2 lb acetochlor (Harness) and 1.5 lb atrazine per gal
Fierce (Valent)	33.5% flumiclorac (Valor) and 42.5% pyroxasulfone (Zidua)
Finesse (DuPont)	62.5% chlorsulfuron (Glean) and 12.5% metsulfuron (Ally)

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[1] Co-packs consist of individual components packaged in separate containers or compartments and sold together.

Herbicide Premixes

Product (Manufacturer)	Ingredients
Finesse Grass & Broadleaf (DuPont)	25% chlorsulfuron (Glean) and 47% flucarbazone (Everest)
Flexstar GT 3.5 (Syngenta)	0.56 lb fomesafen (Flexstar) and 2.26 lb ae glyphosate per gal
ForeFront HL (Dow)	0.41 lb aminopyralid (Milestone) and 3.33 lb 2,4-D per gal
FulTime (Dow)	2.4 lb microencapsulated acetochlor (TopNotch) and 1.6 lb atrazine per gal
Fusion (Syngenta)	2 lb fluazifop (Fusilade) and 0.66 lb fenoxaprop (Option II) per gal
Gangster (Valent)	51% flumioxazin (Valor) and 84% cloransulam (FirstRate) co-pack[1]
GlyMix MT (Dow)	4 lb glyphosate IPA salt and 0.4 lb 2,4-D per gal
G-Max Lite (BASF)	2.25 lb dimethenamid-P (Outlook) and 2.75 lb atrazine per gal
Grazon P&D (Dow)	2 lb 2,4-D and 0.54 lb picloram (Tordon) per gal
Guardsman Max (BASF)	1.7 lb dimethenamid-P (Outlook) and 3.3 lb atrazine per gal
Halex GT (Syngenta)	2.09 lb S-metolachlor (Dual Magnum), 2.09 lb glyphosate, and 0.21 lb mesotrione (Callisto) per gal
Harmony Extra SG (DuPont)	33.3% thifensulfuron (Harmony) and 16.7% tribenuron (Express)
Harness Xtra (Monsanto)	4.3 lb acetochlor (Harness) and 1.7 lb atrazine per gal
Harness Xtra 5.6L (Monsanto)	3.1 lb acetochlor (Harness) and 2.5 lb atrazine per gal
Hornet WDG (Dow)	18% flumetsulam (Python) and 60% clopyralid salt (Stinger)
Huskie (Bayer)	0.31 lb pyrasulfotole and 1.75 lb bromoxynil (Buctril) per gal
Journey (BASF)	8.13% imazapic (Plateau) and 21.94% glyphosate
Keystone (Dow)	3 lb acetochlor (Surpass) and 2.25 lb atrazine per gal
Keystone LA (Dow)	4 lb acetochlor (Surpass) and 1.5 lb atrazine per gal
Krovar (DuPont)	40% bromacil (Hyvar) and 40% diuron (Karmex)
Landmark (DuPont)	50% sulfometuron (Oust) and 25% chlorsulfuron (Glean)
Lariat (Monsanto)	2.5 lb alachlor (Lasso) and 1.5 lb atrazine per gal
Lexar EZ (Syngenta)	1.74 lb S-metolachlor (Dual II Magnum), 1.74 lb atrazine, and 0.22 lb mesotrione (Callisto) per gal
Lumax EZ (Syngenta)	2.49 lb S-metolachlor (Dual II Magnum), 0.249 lb mesotrione (Callisto), and 0.935 lb atrazine per gal
Nimble (Cheminova)	50% thifensulfuron (Harmony) and 25% tribenuron (Express)
NorthStar (Syngenta)	7.5% primisulfuron (Beacon) and 43.9% sodium salt of dicamba
Olympus Flex (Bayer)	6.75% propoxycarbazone (Olympus) and 4.5% mesosulfuron (Osprey)
Optill (BASF)	17.8% saflufenacil (Sharpen) and 50% imazethapyr (Pursuit)
Optill Pro (BASF)	6 lb dimethenamid-P (Outlook) per gal, and 17.8% saflufenacil (Sharpen) and 50% imazethapyr (Pursuit) co-pack[1]
Orion (Syngenta)	0.033 lb florasulam and 2.34 lb MCPA per gal

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Herbicide Premixes

Product (Manufacturer)	Ingredients
Overdrive (BASF)	20% acid of diflufenzopyr and 50% acid of dicamba
Pastora (DuPont)	56.2% nicosulfuron (Accent) and 15% metsulfuron (Ally)
PastureGard HL (Dow)	3 lb ae triclopyr (Remedy) and 1 lb ae fluroxypyr (Starane) per gal
Perspective (DuPont)	39.5% aminocyclopyrachlor and 15.8% chlorsulfuron (Glean)
Prefix (Syngenta)	4.34 lb S-metolachlor (Dual Magnum) and 0.95 lb fomesafen (Reflex) per gal
Prequel (DuPont)	15% rimsulfuron (Resolve) and 30% isoxaflutole (Balance)
Priority (Tenkoz)	12.5% carfentrazone (Aim) and 50% halosulfuron (Permit)
Propel ATZ (Rosens)	1.7 lb dimethenamid-P (Propel) and 3.3 lb atrazine per gal
Propel ATZ Lite (Rosens)	2.25 lb dimethenamid-P (Propel) and 2.75 lb atrazine per gal
Pulsar (Syngenta)	0.73 lb ae dicamba (Banvel) and 0.95 lb ae fluroxypyr (Starane) per gal
Pursuit Plus (BASF)	2.7 lb pendimethalin (Prowl) and 0.2 lb imazethapyr (Pursuit) per gal
Range Star (Albaugh)	1 lb dicamba and 2.87 lb 2,4-D amine per gal
Rave (Syngenta)	8.8% triasulfuron (Amber) and 50% dicamba (Banvel)
Ready Master ATZ (Monsanto)	2.0 lb glyphosate IPA salt and 2.0 lb atrazine per gal
Realm Q (DuPont)	7.5% rimsulfuron (Resolve) and 31.25% mesotrione (Callisto)
Redeem R&P (Dow)	2.25 lb triclopyr (Remedy Ultra) and 0.75 lb clopyralid (Stinger)
Report Extra (Cheminova)	62.5% chlorsulfuron (Glean) and 12.5% metsulfuron (Ally)
Require Q (DuPont)	6.25% rimsulfuron (Resolve) and 52.9% dicamba
Resolve Q (DuPont)	18.4% rimsulfuron (Resolve) and 4% thifensulfuron (Harmony)
Rezult B&G (BASF)	4 lb bentazon (Basagran) per gal. and 1 lb sethoxydim (Poast Plus) per gal. co-pack[1]
Sahara (BASF)	7.8% imazapyr (Arsenal) and 62.2% diuron (Karmex)
Sequence (Syngenta)	3 lb S-metolachlor (Dual Magnum) and 2.25 lb ae glyphosate per gal
Shotgun (United Agri Products)	2.25 lb atrazine and 1 lb iso-octyl ester of 2,4-D per gal
Sonic (Dow)	62.1 % sulfentrazone (Spartan) and 7.9% cloransulam (FirstRate)
Spartan Charge (FMC)	3.15 lb sulfentrazone (Spartan) and 0.35 lb carfentrazone (Aim) per gal
Spirit (Syngenta)	42.8% primisulfuron (Beacon) and 14.2% prosulfuron (Peak)
Status (BASF)	16% acid of diflufenzopyr, 44% sodium salt of dicamba, and isoxadifen safener
Steadfast ATZ (DuPont)	2.7% nicosulfuron (Accent), 1.3% rimsulfuron (Resolve), and 85.3% atrazine
Steadfast Q (DuPont)	25.2% nicosulfuron (Accent) and 12.5% rimsulfuron (Resolve)
Starane NXT (FMC)	0.58 lb fluroxypyr (Starane) and 2.33 lb bromoxynil per gal
Starane Plus Salvo (UAP)	0.75 lb fluroxypyr (Starane) and 3 lb 2,4-D (Salvo) per gal
Starane Plus Sword (UAP)	0.71 lb fluroxypyr (Starane) and 2.84 lb MCPA (Sword) per gal
Storm (United Phosphorus)	2.67 lb bentazon (Basagran) and 1.33 lb acifluorfen (Blazer) per gal

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Herbicide Premixes

Product (Manufacturer)	Ingredients
Stout (DuPont)	67.5% nicosulfuron (Accent) and 5% thifensulfuron (Harmony)
Stratos (Gharda)	1.1 lb potassium salt of dicamba and 2.1 lb atrazine per gal
Streamline (DuPont)	39.5% aminocyclopyrachlor and 12.6% metsulfuron methyl (Ally)
SureStart (Dow)	3.75 lb acetochlor (Surpass), 0.12 lb flumetsulam (Python), and 0.29 lb ae clopyralid (Stinger) per gal
Surmount (Dow)	0.67 lb picloram (Tordon) and 0.67 lb fluroxypyr (Starane)
Synchrony XP (DuPont)	21.5% chlorimuron (Classic) and 6.9% thifensulfuron (Harmony)
Tackle (Cheminova)	0.128 lb imazethapyr (Pursuit) and 3 lb ae glyphosate per gal
ThunderMaster (Albaugh)	0.17 lb imazethapyr (Pursuit) and 1.5 lb ae glyphosate per gal
Throttle (DuPont)	9% chlorsulfuron (Glean), 18% sulfometuron methyl (Oust), and 48% sulfentrazone (Spartan)
TNT Broadleaf (Gowan)	50% thifensulfuron (Harmony) and 25% tribenuron (Express)
Tordon RTU (Dow)	3% acid equivalent picloram (Tordon) and 11.2% 2,4-D ae per gal
TripleFlex (Monsanto)	3.75 lb acetochlor (Harness), 0.12 lb flumetsulam (Python), and 0.29 lb ae clopyralid (Stinger) per gal
Valor XLT (Valent)	30% flumioxazin (Valor) and 10.3% chlorimuron (Classic)
Velpar AlfaMax (DuPont)	35.3% hexazinone (Velpar) and 42.4% diuron (Karmex)
Velpar AlfaMax Gold (DuPont)	23.1% hexazinone (Velpar) and 55.4% diuron (Karmex)
Verdict (BASF)	0.57 lb saflufenacil (Sharpen) and 5 lb dimethenamid-P (Outlook) per gal
Viewpoint (DuPont)	31.6% imazapyr (Arsenal), 22.8% aminocyclopyrachlor, and 7.3% metsulfuron methyl (Ally)
Volley ATZ (Tenkoz)	3 lb acetochlor and 2.25 lb atrazine per gal
Volley ATZ Lite (Tenkoz)	4 lb acetochlor and 1.5 lb atrazine per gal
WeedMaster (NuFarm)	1 lb dicamba and 2.87 lb 2,4-D amine per gal
Weld (Winfield)	1.75 lb MCPA, 0.64 lb fluroxpyr (Starane), and 0.5 lb clopyralid (Stinger) per gal
WideMatch (Dow)	0.75 lb clopyralid (Stinger) and 0.75 lb fluroxypyr (Starane) per gal
Wildcard Xtra (Helena)	2 lb bromoxynil (Moxy) and 2 lb MCPA per gal
Yukon (Gowan)	12.5% halosulfuron (Permit) and 55% sodium salt of dicamba
Zemax (Syngenta)	3.34 lb S-metoloachlor (Dual II Magnum) and 0.33 lb mesotrione (Callisto) per gal

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SOUTHWEST RESEARCH-EXTENSION CENTER

FIELD DAY 2013

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KANSAS STATE UNIVERSITY AGRICULTURAL EXPERIMENT STATION
AND COOPERATIVE EXTENSION SERVICE

SRP1088 June 2013