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FIELD DAY 2011

Report of Progress 1052

K-State Kansas State University Research and Extension

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

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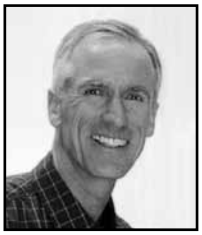

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Dr. Gillen was appointed head of the Western Kansas Agricultural Research Centers (Colby, Garden City, Hays, and Tribune) in 2006. His research interests include grazing management systems, grassland ecology, and forage establishment.

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2010 Weather Information for Garden City

J. Elliott

Precipitation for 2010 totaled 15.74 in. This was 3.50 in. below the 30-year average of 19.24 in. Precipitation was generally above average January through May, resulting in good 2010 wheat yields. Each month from June through December, with the exception of August, showed below average moisture, resulting in the driest second half of the year since 1980. We had poor 2011 wheat seeding conditions due to limited autumnal rainfall. The largest rainfall event was 3.36 in. on May 19 and 20. Minimal hail was recorded on April 22 and 24.

Measurable snowfall occurred in January, February, March, and December of 2010. Annual snowfall totaled 11.2 in. for the year, compared to 19.7 in. on average. Our largest snowfall event was 5 in. recorded on January 29. Seasonal snowfall (2009–2010) was 15.2 in.

Open-pan evaporation from April through October was 78.3 in., 8.04 in. above normal. Average daily wind speed was 4.56 mph, compared to the 30-year mean of 5.10 mph. Average monthly wind speeds ranged from 6.42 mph in April to 4.11 mph in August. January and July conformed to the 30-year average by being the coldest and warmest months, respectively. The months of June through October were generally warmer than average. Our annual mean temperature was 54.0°F, which was similar to the 30-year average of 53.7°F.

Four record high temperatures were set in 2010: 106°F on August 3, 104°F on September 6, 99°F on September 30, and 83°F on November 8. No record lows were recorded. Triple-digit temperatures were observed on 28 days in 2010; the highest was 106°F on July 14 and August 3. Sub-zero temperatures were noted on four days in January, with -9°F on January 8 being the lowest.

The last spring freeze (32°F) was on May 13, which was 14 days later than normal. The first fall freeze (31°F) was on October 27, which was 15 days later than normal. This resulted in a 167-day frost-free-period, which was one day longer than the 30-year average.

A summary of the 2010 climate information for Garden City is presented in Table 1.

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

	Precipitation		Monthly temperatures: 2010 avg.			Monthly temperatures	Monthly temperatures: 2010 extreme		Wind		Evaporation	
Month	2010	30-year avg.	Max	Min	Mean	30-year avg.	Max	Min	2010	30-year avg.	2010	30-year avg.
	---------- in. ----------		---------- °F ----------						--------- mph ---------		---------- in. ----------	
Jan.	0.71	0.46	45.5	13.7	29.6	30.4	64	-9	3.63	4.5	n/a	n/a
Feb.	0.36	0.55	41.5	18.5	30.0	33.9	59	6	4.23	5.24	n/a	n/a
Mar.	1.83	1.31	58.3	27.3	42.8	42.9	84	14	5.77	6.31	n/a	n/a
Apr.	2.25	1.74	70.6	40.5	55.5	52.3	89	28	6.26	6.42	8.50	8.21
May	3.93	2.98	75.5	46.4	61.0	62.8	93	32	5.21	5.76	9.58	10.04
June	1.47	3.12	92.2	62.5	77.3	72.6	104	51	5.34	5.37	14.27	11.96
July	1.30	2.8	94.3	65.7	80.0	77.9	106	59	4.36	4.59	14.05	13.22
Aug.	2.70	2.51	95.1	63.7	79.4	76.3	106	49	3.72	4.11	13.46	11.28
Sept.	0.31	1.42	89.5	54.5	72.0	67.7	104	42	4.25	4.73	10.96	9.22
Oct.	0.73	1.21	76.4	40.5	58.4	54.9	90	26	3.64	4.89	7.48	6.33
Nov.	0.08	0.55	58.7	23.7	41.2	41.6	83	5	4.65	4.8	n/a	n/a
Dec.	0.07	0.59	49.1	17.5	33.3	31.4	67	2	3.65	4.45	n/a	n/a
Annual	15.74	19.24	70.6	39.5	55.1	53.7	106	-9	4.56	5.10	78.30	70.26

Normal latest spring freeze (32°F): April 29. In 2010: May 13.
Normal earliest fall freeze (32°F): Oct. 12. In 2010: Oct. 27.
Normal frost-free period (>32°F): 166 days. In 2010: 167 days.
30-year averages are for the period 1981–2010.

2010 Weather Information for Tribune

D. Bond and D. Nolan

Total yearly precipitation was 18.88 in., which is 1.44 in. above normal. Seven months had above-normal precipitation. July (4.09 in.) was the wettest month. The largest single amount of precipitation was 2.56 in. on May 19. November was the driest month (0.11 in.). Snowfall for the year totaled 12.6 in.; January, February, March, and December had 4.5, 5.2, 1.5, and 1.4 in., respectively, for a total of 13 days of snow cover. The longest consecutive period of snow cover, 4 days, occurred from January 29 through February 1.

Record high temperatures were recorded on 4 days: March 31 (88°F), September 6 (104°F), September 30 (95°F), and December 4 (74°F). A record high temperature was tied on June 11 (102°F). No record low temperatures were recorded, but a record low temperature was tied on August 26 (47°F). July was the warmest month with a mean temperature of 78.3°F. The hottest day of the year (105°F) was July 18. The coldest day of the year (-10°F) was January 8. February was the coldest month with a mean temperature of 30.1°F.

Mean air temperature was above normal for ten months. September had the greatest departure above normal (5.0°F), and February had the greatest departure below normal (-2.7°F). Temperatures were 100°F or higher on 11 days, which is 1 day above normal. Temperatures were 90°F or higher on 78 days, which is 16 days above normal. The latest spring freeze was May 13, which is 7 days later than the normal date; and the earliest fall freeze was October 26, which is 23 days later than the normal date. This produced a frost-free period of 166 days, which is 16 days more than the normal of 150 days.

Open-pan evaporation from April through September totaled 77.63 in., which is 6.98 in. above normal. Wind speed for this period averaged 5.3 mph, which is 0.2 mph less than normal.

A summary of the 2010 climate information for Tribune is presented in Table 1.

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

	Precipitation		Monthly temperatures: 2010 avg.		Monthly temperatures: Normal		Monthly temperatures: 2010 extreme		Wind		Evaporation	
Month	2010	Normal	Max	Min	Max	Min	Max	Min	2010	Normal	2010	Normal
	---------- in. ---------		---------- °F ----------						------- mph -------		---------- in. ----------	
Jan.	0.47	0.45	46.1	15.3	42.2	12.8	65	-10	—	—	—	—
Feb.	0.53	0.52	40.4	19.7	48.5	17.1	58	4	—	—	—	—
Mar.	2.07	1.22	56.5	27.5	56.2	24.2	88	17	—	—	—	—
Apr.	1.49	1.29	66.8	38.4	65.7	33.0	85	24	5.6	6.3	8.83	8.28
May	3.48	2.76	73.0	43.5	74.5	44.1	92	30	5.8	5.8	12.94	10.88
June	1.92	2.62	89.5	58.2	86.4	54.9	103	48	5.3	5.3	14.93	13.88
July	4.09	3.10	93.2	63.5	92.1	59.8	105	55	5.4	5.4	15.80	15.50
Aug.	3.79	2.09	91.5	61.3	89.9	58.4	100	47	4.8	5.0	13.14	12.48
Sept.	0.34	1.31	87.5	52.9	81.9	48.4	104	42	4.9	5.2	11.99	9.63
Oct.	0.32	1.08	74.7	38.5	70.0	35.1	87	20	—	—	—	—
Nov.	0.11	0.63	59.3	24.1	53.3	23.1	80	6	—	—	—	—
Dec.	0.27	0.37	49.8	19.3	44.4	15.1	74	-1	—	—	—	—
Annual	18.88	17.44	69.2	38.6	67.1	35.5	105	-10	5.3	5.5	77.63	70.65

Normal latest spring freeze (32°F): May 6. In 2010: May 13.
Normal earliest fall freeze (32°F): Oct. 3. In 2010: Oct. 26.
Normal frost-free period (>32°F): 150 days. In 2010: 166 days.
Normal for precipitation and temperature is the 30-year average (1971–2000) from the National Weather Service.
Normal for latest freeze, earliest freeze, wind, and evaporation is the 30-year average (1971–2000) from Tribune weather data.

Volunteer Corn in Fallow

J. Holman, T. Dumler, S. Maxwell, B. Olson[1], T. Roberts, A. Schlegel, and C. Thompson[2]

Summary

Field studies were conducted at three Kansas State University Research-Extension Centers in western Kansas—Colby, Garden City, and Tribune—in a three-year period from 2006 to 2010 to evaluate the impact of volunteer corn on soil moisture storage in fallow and the succeeding winter wheat crop. These impacts were evaluated at eight different populations of volunteer corn: 0, 250, 500, 1,000, 2,000, 4,000, 6,000, and 8,000 corn plants/a.

Volunteer corn reduced available soil water by 1 in. for each 2,500 plants/a (Figure 1). Wheat tillers were decreased by 1/ft for every 170 volunteer corn plants/a (Figure 2) and yield was reduced 1 bu/a for every 500 volunteer corn plants/a (Figure 3). However, when wheat yields were above 70 bu/a or below 35 bu/a, other factors affected wheat yield more than the preceding volunteer corn population or available soil water at wheat planting. When wheat yields were very high (greater than 70 bu/a), growing season precipitation was sufficient to overcome the negative impact of volunteer corn during the previous fallow period. On the other hand, when wheat yields were very low (less than 35 bu/a), the impact of volunteer corn on wheat yield was not detected because growing season precipitation was too low.

Introduction

Glyphosate-resistant volunteer corn is not controlled by glyphosate in fallow. The impact of volunteer corn on soil moisture and following winter wheat crop yield was unknown. This research evaluated the impact of volunteer corn growing during the fallow period on soil moisture storage and winter wheat yield. The findings from this study were used to calculate the economic threshold, or density of volunteer corn that reduced winter wheat yield enough to pay for the cost of control (herbicide plus application).

Procedures

The experimental design was a randomized complete block with four replications. Plots were 30 ft wide by 35 ft long. F2 corn seed was collected from a glyphosate-resistant corn crop the previous year and planted mid-May of 2007, 2008, and 2009 into the fallow phase of a dryland winter wheat-summer crop-fallow rotation to simulate volunteer corn. Only glyphosate (0.75 lb/a) was used to control weeds (applied as needed based on weed growth) during the fallow period. Some of the volunteer corn was susceptible to glyphosate. Volunteer glyphosate-resistant corn was planted at 200% of the targeted plant density and hand-thinned (generally about one month after planting) to the desired plant density after glyphosate-susceptible plants were killed. Targeted volunteer glyphosate-resistant corn densities were 0, 250, 500, 1,000, 2,000, 4,000, 6,000, and 8,000 plants/a. An adapted winter wheat variety was planted in late Septem-

[1] Kansas State University Northwest Research-Extension Center.
[2] Kansas State University Department of Agronomy.

ber and harvested at the beginning of July in 2008, 2009, and 2010. Wheat was planted at 60 lb/a (recommended rate) with a no-till drill in 7.5 in. row spacing directly into the standing volunteer glyphosate-resistant corn. In-crop herbicides were used according to the weed spectrum, and fertilizer was applied based on soil test results and Kansas State University recommendations.

Soil samples (one core per plot) were collected using a soil probe (Giddings Machine Co., Windsor, CO) at volunteer glyphosate-resistant corn and wheat planting to a 5-ft depth using 1-ft increments to determine soil moisture content. Soil moisture was determined gravimetrically and was adjusted to plant-available soil water (ASW) using soil bulk density and water-holding capacity values from previous studies. Wheat tillers were measured from two 3-ft row sections per plot in March each year; data were not collected at Tribune in 2008. Two wheat grain samples were collected and averaged per plot using a plot combine (Delta, Wintersteiger Inc., Salt Lake City, UT) from an area 6.5 ft wide by 35 ft long. A seed subsample was collected at harvest and moisture content was measured with a grain analysis computer (GAC 2100, Dickey John, Auburn, IL) with grain yields adjusted to 12.5% moisture content.

Results and Discussion

Survey of volunteer corn in producer fields

A three-year survey was conducted to determine what populations of volunteer corn typically exist in producers' fields. The fields that were sampled would have been considered a low to very moderate infestation of volunteer corn. Population densities averaged from 120 to 1,250 plants/a, and the average of all fields across years was 500 plants/a. Within a field densities were variable and reached up to 2,800 plants/a in certain areas. Fields can exceed 3,000 plants/a when a lot of kernels remain in the field because of hail damage or an improperly adjusted combine.

Economic Threshold to Justify Control

The economic threshold needed to control volunteer glyphosate-tolerant corn will vary depending on wheat yield, the price of wheat, and the cost of herbicide application. Table 1 shows the net value of herbicide application based on the volunteer corn population and wheat price. The analysis assumes a yield goal of 45 bu/a and herbicide cost of $13.00/a (including application cost). According to the results in Table 1, controlling volunteer corn at 500 plants/a does not pay, and control pays at 1,000 plants/a only if the price of wheat is $8.00/bu. Controlling volunteer corn is economically feasible at 1,500 plants/a when the price of wheat is $5.00 and higher. At 2,000 plants/a, controlling volunteer corn is feasible when the price of wheat is higher than $3.00/bu. Substantial returns can be earned if volunteer corn populations are above 2,500 plants/a and the price of wheat is above the historical average.

Table 1. Net value ($/a) of herbicide application based on volunteer corn population and wheat price

Volunteer corn	Wheat price ($/bu)					
plants/a	$3.00	$4.00	$5.00	$6.00	$7.00	$8.00
500	-11.90	-10.90	-9.90	-8.90	-7.90	-6.90
1,000	-8.90	-6.90	-4.90	-2.90	-0.90	1.10
1,500	-5.90	-2.90	0.10	3.10	6.10	9.10
2,000	-2.90	1.10	5.10	9.10	13.10	17.10
2,500	0.10	5.10	10.10	15.10	20.10	25.10
3,000	3.10	9.10	15.10	21.10	27.10	33.10
3,500	6.10	13.10	20.10	27.10	34.10	41.10
4,000	9.10	17.10	25.10	33.10	41.10	49.10
4,500	12.10	21.10	30.10	39.10	48.10	57.10
5,000	15.10	25.10	35.10	45.10	55.10	65.10

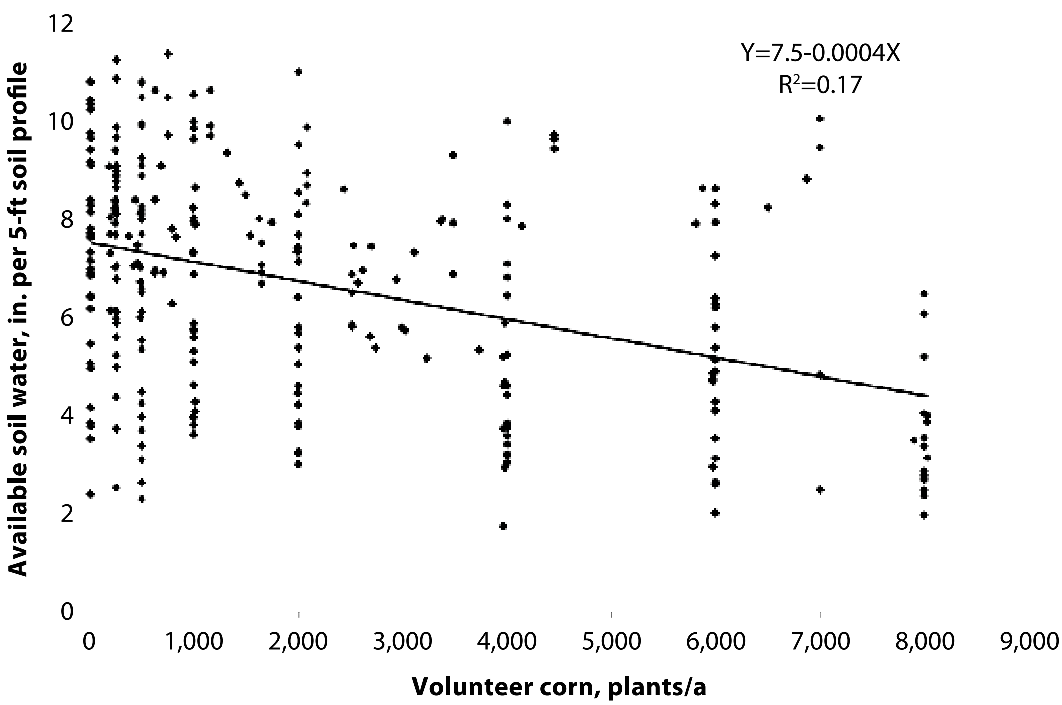

Figure 1. Impact of volunteer corn on available soil moisture. Volunteer corn reduced available soil water by 1 in. for each 2,500 plants/a.

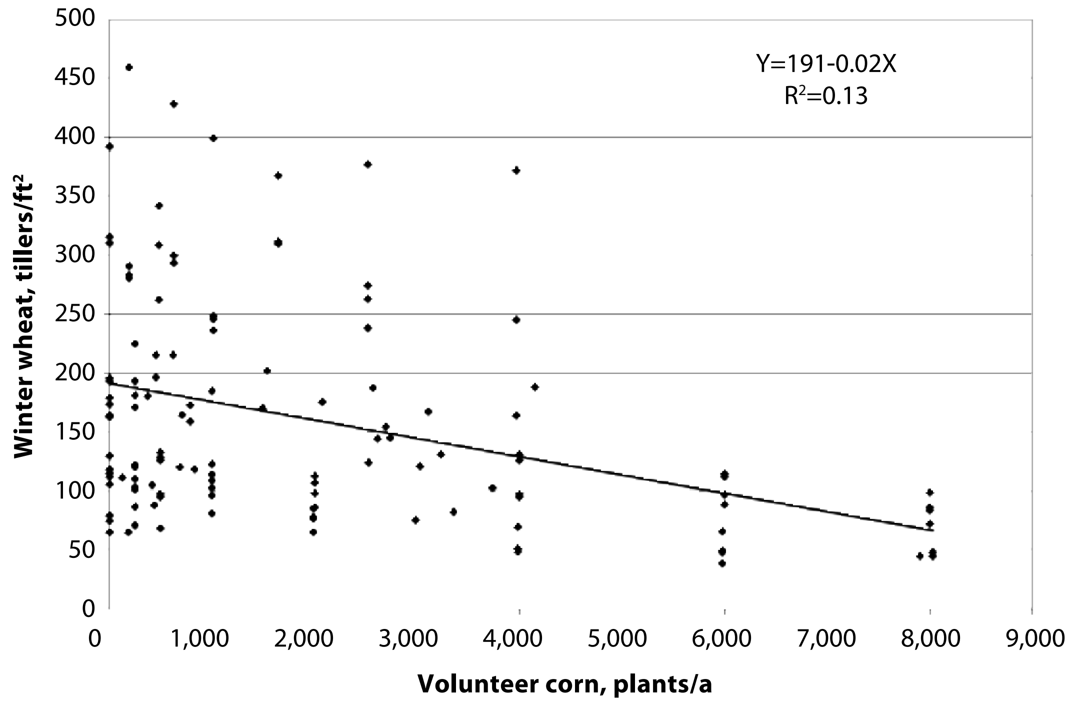

Figure 2. Impact of volunteer corn on available winter wheat tillers. Wheat tillers were decreased by 1/ft for every 170 volunteer corn plants/a.

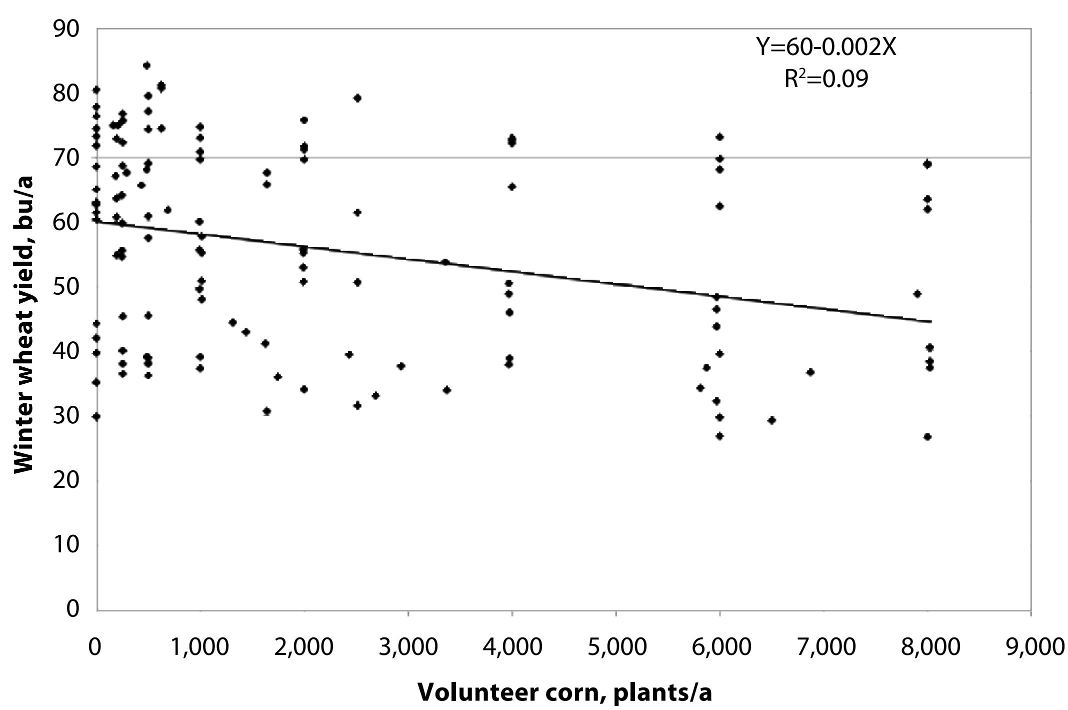

Figure 3. Impact of volunteer corn on available winter wheat yield. Wheat yield was reduced 1 bu/a for every 500 volunteer corn plants/a.

Influence of Precipitation, Temperature, and 55 Years on Winter Wheat Yields in Western Kansas

J. Holman, A. Schlegel, C. Thompson[1], and J. Lingenfelser[1]

Summary and Procedures

Historical winter wheat yield trends and yield response to environmental and climatic conditions may help estimate future yields. Data were compiled across the four Research-Extension Centers in western Kansas (Colby, Garden City, Hays, and Tribune) from variety trials from 1955 through 2010. Across this time period, irrigation increased yields 18 bu/a, and reported freeze damage reduced yields 8 bu/a. Warm fall (October and November), early spring (April), and June temperatures tended to reduce yield, whereas late spring (May) temperatures tended to increase yield. In dryland, precipitation in months prior to May (October through April) increased yield. Across all of western Kansas, yields increased about 0.5 bu/a per year. At Colby and Hays dryland yields increased 0.8 bu/a per year, and at Garden City and Tribune dryland yields increased 0.3 bu/a per year. October precipitation and April temperature affected yields more at Garden City and Tribune than year. Future wheat breeding and cropping systems research should work to improve stand establishment and minimize freeze injury.

Results and Discussion

From 1955 through 2010, irrigation improved wheat yields at the irrigated sites (Colby, Garden City, and Tribune) 18 bu/a (Table 1). Of the 41 site years with reported freeze damage, 24 of those had yield data available. Of those 24 site years, freeze damage reduced wheat yield an average of 8 bu/a. Freeze damage likely reduced wheat yields greater than 8 bu/a for those 17 site years in which no yield data were reported. Therefore, the average freeze incident in this time period likely reduced wheat yield more than 8 bu/a.

The effect of monthly temperature and precipitation on wheat yield is not fully understood. Warm fall (October and November), early spring (April), and June temperatures tended to reduce yields, whereas late spring (May) temperatures tended to increase yield. Warm fall temperatures cause more fall growth. Excessive fall growth can deplete soil moisture, increase susceptibility to freeze injury, increase pest (weed, disease, and insect) problems, and increase spring lodging, which reduces yield potential. Grazing wheat in the fall can help limit wheat growth and improve yield under these conditions. Warm early spring (April) temperatures can cause wheat to break dormancy and initiate spring growth too early, which can result in freeze injury. Warm late spring (May) temperature increases wheat growth and development and enables the plant to initiate anthesis and maturation during a cooler period of the year. Warm June temperature increases leaf senescence and reduces kernel mass and kernel fill, reducing yield.

[1] Kansas State University Department of Agronomy.

In dryland environments, precipitation in months prior to May (October through April) increased yield. Like other studies, fall precipitation tended to increase yield more than spring precipitation. Fall and very early spring precipitation increases tillers per plant and kernels per tiller. Precipitation after April might help improve kernel mass, but is too late in the growing season to improve yield.

Across all of western Kansas, dryland and irrigated wheat yields increased an average of 0.5 bu/a per year from 1954 through 2010 (Figure 1). This yield trend for western Kansas was slightly higher than the yield improvement (0.38 bu/a per year) for the entire southern Great Plains from 1959 through 2008. Graybosch and Peterson (2010) reported no improvement in southern Great Plains wheat yields since 1984, but wheat yields in western Kansas have continued to increase since 1984 at a rate of 0.5 bu/a per year (Table 2). But year explained only 2% of the variability in wheat yield from 1984 through 2010 (Table 2), compared to 20% from 1954 through 2010 (Table 1). From 1984 through 2010 more variability in wheat yield was explained by irrigation, freeze injury, October precipitation, and April temperature than year (Table 2). The greater wheat yield trend since 1984 in this study compared to the findings of Graybosch and Peterson might be because their analysis evaluated the same set of varieties across the entire southern Great Plains, whereas this study evaluated varieties bred and likely best adapted to a more local region. In addition, their analysis did not consider the effect of precipitation and temperature. By including precipitation and temperature in their analysis, more variability in wheat yield could have been explained and year might have been significant in their analysis.

Across western Kansas, irrigated wheat yield increased 0.5 bu/a per year. At Colby and Hays dryland wheat yields increased 0.8 bu/a per year, and at Garden City and Tribune dryland wheat yields increased 0.3 bu/a per year. October precipitation (stand establishment) and April temperature (freeze injury) affected wheat yields more at Garden City and Tribune than year. These results suggest future wheat breeding and cropping systems research should work to improve stand establishment and minimize freeze injury.

References

Graybosch, R.A. and C.J. Peterson. 2010. Genetic improvement in winter wheat yields in the Great Plains of Northern America, 1959–2008. Crop Sci. 50:1882–1890.

Table 1. Dryland and irrigated winter wheat yield response at Colby, Garden City, Hays, and Tribune, 1955–2010

Model[1]	Variable	Parameter estimate (P-value)	R^2	F	n
		Winter wheat yield (bu/a)			
1	Intercept	42.1 (<.0001)			
	Irrigation	17.7 (<.0001)	0.23	90	310
2	Intercept	26.5 (<.0001)			
	Year	0.5 (<.0001)			
	Irrigation	18.5 (<.0001)	0.43	114	310
3	Intercept	24.0 (<.0001)			
	Year	0.5 (<.0001)			
	Irrigation	19.2 (<.0001)			
	October precip	3.2 (<.0001)	0.47	90	310
4	Intercept	59.7 (<.0001)			
	Year	0.5 (<.0001)			
	Irrigation	19.0 (<.0001)			
	October precip	3.3 (<.0001)			
	April temp	-0.7 (<.01)	0.49	72	310
5	Intercept	61.0 (<.0001)			
	Year	0.5 (<.0001)			
	Irrigation	19.0 (<.0001)			
	Freeze	-8.5 (<.01)			
	October precip	3.2 (<.0001)			
	April temp	-0.7 (<.01)	0.50	61	310
6	Intercept	96.1 (<.0001)			
	Year	0.4 (<.0001)			
	Irrigation	18.6 (<.0001)			
	Freeze	-8.8 (<.01)			
	October precip	2.8 (<.0001)			
	October temp	-0.6 (<.01)			
	April temp	-0.7 (.001)	0.51	53	310

continued

Table 1. Dryland and irrigated winter wheat yield response at Colby, Garden City, Hays, and Tribune, 1955–2010

Model[1]	Variable	Parameter estimate (P-value)	R^2	*F*	*n*
		Winter wheat yield (bu/a)			
7	Intercept	124.7 (<.0001)			
	Year	0.5 (<.0001)			
	Irrigation	18.3 (<.0001)			
	Freeze	-9.7 (<.001)			
	October precip	2.5 (.0001)			
	October temp	-0.6 (<.05)			
	April temp	-0.6 (<.05)			
	June temp	-0.5 (<.05)	0.52	47	310
8	Intercept	120.2 (<.0001)			
	Year	0.5 (<.0001)			
	Irrigation	18.5 (<.0001)			
	Freeze	-9.0 (<.01)			
	October precip	2.4 (<.001)			
	Feb precip	2.8 (.05)			
	October temp	-0.6 (<.05)			
	April temp	-0.6 (<.05)			
	June temp	-0.5 (.05)	0.53	42	310
9	Intercept	91.5 (<.0001)			
	Year	0.4 (<.0001)			
	Irrigation	18.9 (<.0001)			
	Freeze	-7.4 (<.01)			
	October precip	2.8 (<.0001)			
	November precip	2.2 (<.05)			
	February precip	3.3 (<.05)			
	October temp	-0.7 (<.01)			
	April temp	-0.6 (<.01)	0.53	42	310

continued

Table 1. Dryland and irrigated winter wheat yield response at Colby, Garden City, Hays, and Tribune, 1955–2010

Model[1]	Variable	Parameter estimate (P-value)	R^2	F	n
		Winter wheat yield (bu/a)			
10[2]	Intercept	114.1 (<.0001)			
	Year	0.4 (<.0001)			
	Irrigation	18.7 (<.0001)			
	Freeze	-8.2 (<.01)			
	October precip	2.6 (<.0001)			
	November precip	1.9 (.06[3])			
	February precip	3.0 (<.05)			
	October temp	-0.6 (<.01)			
	April temp	-0.5 (<.05)			
	June temp	-0.4 (.09[3])	0.53	38	310

[1] Models of wheat yield response with increasing significant (P=0.05) variables and R^2.
[2] In model 8 June temp is included, in model 9 June temp is removed and November precip is included, and in model 10 both June temp and November precip are included.
[3] Not significant at P=0.05.

Table 2. Dryland and irrigated winter wheat yield response at Colby, Garden City, Hays, and Tribune, 1984–2010

Model[1]	Variable	Parameter estimate (P-value)	R^2	F	n
		Winter wheat yield (bu/a)			
1	Intercept	49.6 (<.0001)			
	Irrigation	17.1 (<.0001)	0.21	40	147
2	Intercept	44.2 (<.0001)			
	Irrigation	18.1 (<.0001)			
	October precip	3.3 (<.001)	0.28	28	147
3	Intercept	101.7 (<.0001)			
	Irrigation	17.5 (<.0001)			
	October precip	3.7 (<.0001)			
	April temp	-1.1 (<.01)	0.33	23	147
4	Intercept	101.9 (<.0001)			
	Irrigation	17.6 (<.0001)			
	Freeze	-13.4 (<.01)			
	October precip	3.4 (<.0001)			
	April temp	-1.1 (<.01)	0.36	20	147

continued

Table 2. Dryland and irrigated winter wheat yield response at Colby, Garden City, Hays, and Tribune, 1984–2010

Model[1]	Variable	Parameter estimate (P-value)	R^2	F	n
		Winter wheat yield (bu/a)			
5	Intercept	89.8 (<.0001)			
	Year	0.3 (.05)			
	Irrigation	18.0 (<.0001)			
	Freeze	-12.9 (<.01)			
	October precip	3.0 (<.001)			
	April temp	-1.1 (<.01)	0.38	17	147
6	Intercept	91.0 (<.0001)			
	Year	0.4 (<.05)			
	Irrigation	18.0 (<.0001)			
	Freeze	-11.7 (<.05)			
	October precip	2.8 (<.01)			
	December temp	-0.5 (<.07[2])			
	April temp	-0.9 (<.05)	0.40	15	147
7	Intercept	134.0 (<.0001)			
	Year	0.5 (<.01)			
	Irrigation	17.5 (<.0001)			
	Freeze	-13.7 (<.01)			
	October precip	1.9 (<.05)			
	December temp	-0.8 (<.01)			
	June temp	-1.2 (<.01)	0.41	16	147
8	Intercept	145.4 (<.0001)			
	Year	0.5 (<.001)			
	Irrigation	17.2 (<.0001)			
	Freeze	-13.6 (<.01)			
	April precip	2.8 (<.01)			
	December temp	-0.7 (<.01)			
	June temp	-1.4 (<.001)	0.43	17	147

continued

Table 2. Dryland and irrigated winter wheat yield response at Colby, Garden City, Hays, and Tribune, 1984–2010

Model[1]	Variable	Parameter estimate (P-value)	R^2	*F*	*n*
		Winter wheat yield (bu/a)			
9	Intercept	150.2 (<.0001)			
	Year	0.5 (<.001)			
	Irrigation	17.5 (<.0001)			
	Freeze	-13.1 (<.01)			
	September precip	2.1 (<.05)			
	April precip	3.1 (<.01)			
	December temp	-0.8 (<.01)			
	June temp	-1.5 (<.0001)	0.44	16	147

[1] Models of wheat yield response with increasing significant (P=0.05) variables and R^2.
[2] Not significant at P=0.05.

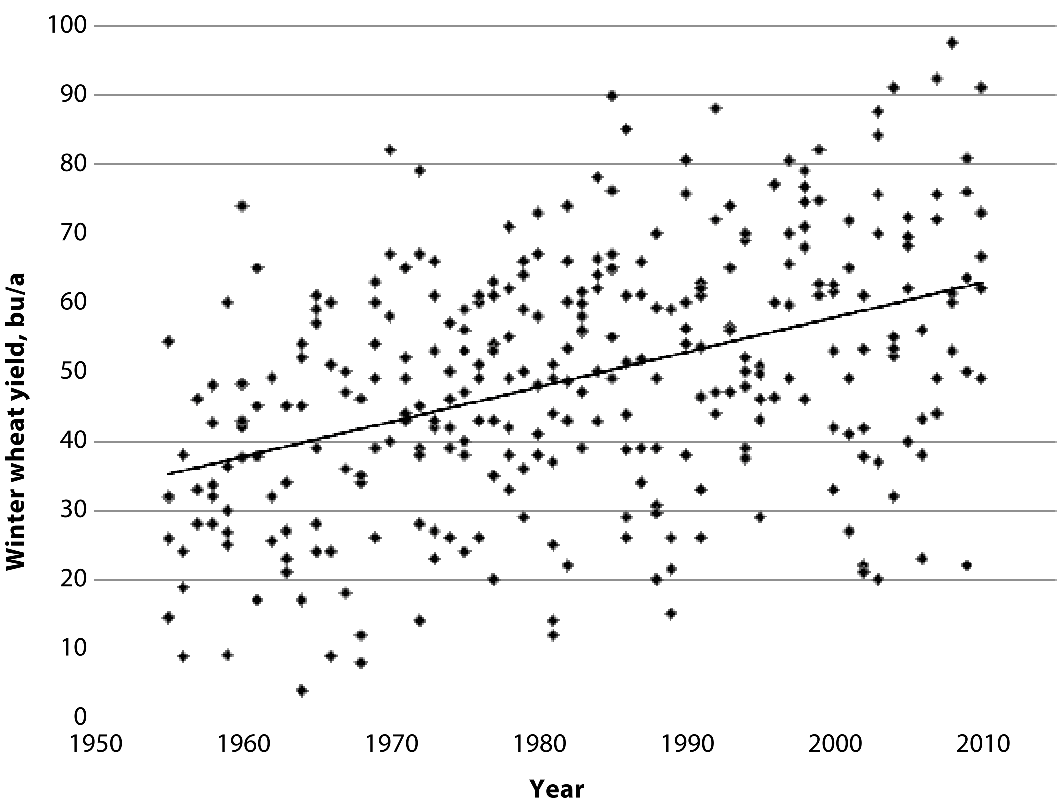

Figure 1. Winter wheat yield trend across dryland and irrigated variety trials in western Kansas, 1955-2010.

Effects of Planting Date and Tillage on Winter Canola

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

Summary
Establishment and winter survival are two major challenges of growing winter canola (*Brassica napus* L.) in the central Great Plains. This study evaluated five planting dates from August 15 to October 15 and two tillage methods (conventional tillage and no-till) on winter canola fall plant density, fall crown height, fall vigor, winter survival, spring plant density, spring vigor, and yield. Planting date affected all measurements whereas tillage affected only yield. Conventional tillage yielded 8% more than no-till. Canola needs to be planted earlier than previously recommended, from August 15 to September 1, for successful winter survival and seed production in western Kansas.

Introduction
This study evaluated the effect of planting date and tillage method on winter canola survival, vigor and yield to determine if planting practices could overcome production challenges.

Procedures
Winter canola was seeded with conventional tillage and no-till every two weeks from August 15 through October 15 from 2007 through 2009 in a randomized complete block with four replications. Winter canola was measured in each plot for fall plant density, vigor, and crown height. The same plot region was resampled for winter survival, and spring plant density and vigor. Plots were harvested with a small plot combine and yield was adjusted to 12% moisture content using a grain analysis computer.

Results and Discussion
Fall growth
Plant density was greatest at later planting dates (Table 1). Earlier planting dates had larger plants and more intraspecific competition, which resulted in fewer plants. Final plant density is more critical for determining yield than fall density, but fall density and winter survival need to be sufficient for an adequate final plant density.

Crown height decreased with later planting dates (Table 1), because later planted canola was smaller. Canola planted September 15 or later did not have an elevated crown. Crown height averaged across years was 0.69 in. when planted August 15 and 0.17 in. when planted September 1.

Winter survival
Winter survival is one of the greatest challenges of producing canola. Winter injury was greatest in 2009 (89%), although the earliest fall killing freeze and coldest tempera-

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tures occurred in 2010. In 2009 only the earliest planting date, August 15, had survival greater than 50%. The optimum planting date for winter wheat in the region is October 1, and winter canola was thought to be similar. Averaged across years, winter survival was greatest for planting dates of August 15 (57%) and September 1 (56%). Winter survival decreased with a later planting date, and no canola survived any year when planted October 15 (Table 2).

Producers reported greater canola winter injury when plant crowns were elevated above the soil surface. In this study higher crown heights caused by large plants and abundant fall growth did not cause winter injury ($P<0.05$); rather, large plants and abundant fall growth improved winter survival. This study indicated that planting early and establishing a large plant was more critical to winter survival than crown height.

Tillage did not affect winter survival, although several other studies found survival improved with tillage. In Oklahoma, minimum tillage improved winter survival compared to no-till and was similar to conventional tillage. Oklahoma on-farm evaluations of a high-disturbance seed opener increased winter canola survival in no-till. In this study planting canola into soybean residue rather than winter wheat residue and using a coulter ahead of the seeding disk might have increased no-till winter survival.

Spring growth

Canola spring plant density is determined by fall plant density and winter survival. Spring plant density was greatest when planted from August 15 to September 15 (Table 2). Winter injury appeared to be caused primarily by canola breaking dormancy in the spring when temperatures start to warm (February and March) followed by temperatures dropping below freezing as in 2009. The slower spring regrowth of the earliest planted canola might have helped it avoid the early spring temperature fluctuations, thus suffer less winter injury.

Yield

Canola planted after September 15 did not consistently survive the winter or produce seed. Yields were greater when canola was planted September 1 (2,000 lb/a) than August 15 (1,700 lb/a) or September 15 (1,700 lb/a) (Table 3). In 2009 plots were not harvested because the border area planted on September15, 2008, winter-killed. In 2009, based on winter survival and spring plant density, only the August 15 or September 1 planting dates would have produced enough seed to harvest.

Yields were reduced 8% with no-till (1,434 lb/a) compared to conventional tillage (1,556 lb/acre) ($P<0.05$, LSD 93).

Conclusions

This study found that using best planting practices and growing a variety adapted to the region winter survival can overcome stand establishment challenges. Establishing canola in the semi-arid region of the central Great Plains without irrigation will be challenging due to canola's shallow seeding requirement and the region's frequently dry soil conditions. Winter survival was affected by environment and planting practice. The largest factor that affected winter survival was planting date. In this region, canola must be seeded one month earlier than winter wheat or from August 15 to September 1 for successful production. In this study tillage did not impact winter survival, although other research found tillage or high disturbance seed openers increased winter survival. The high residue disturbance seed opener used in this study might have improved winter survival in no-till. Yield was affected most by winter survival. Yields in conventional tillage were 8% more than no-till. With more research, no-tillage winter canola yields might be increased and similar to convention-tillage.

Table 1. Effect of planting date and year on canola fall plant density, fall crown height, and fall vigor, 2008–2010

Planting date	2008	2009	2010	Planting date average[2]
		Fall plant density, plants/a		
August 15	187,000d	189,000d	223,000c	204,000c
September 1	270,000c	285,000bc	274,000c	283,000b
September 15	255,000c	302,000ab	329,000b	301,000b
October 1	362,000b	330,000a	494,000a	402,000a
October 15	484,000a	255,000c	514,000a	423,000a
LSD (0.05)[1]	46,000	38,000	54,000	26,000
Year average	311,000b	303,000b	368,000a	
		Fall crown height, in.		
August 15	0.7	0.6	0.7	0.7a
September 1	0.2	0.1	0.2	0.2b
September 15	0.0	0.0	0.0	0.0c
October 1	0.0	0.0	0.0	0.0c
October 15	0.0	0.0	0.0	0.0c
LSD (0.05)	0.1	0.1	0.1	0.1
Year average	0.2a	0.1b	0.2a	
		Fall vigor (0-10)		
August 15	9.5a	8.0a	7.5b	8.4a
September 1	9.3a	7.5a	8.8a	8.5a
September 15	8.3a	7.3a	7.4b	7.7b
October 1	6.3b	2.3b	4.3c	4.3c
October 15	2.0c	0.8c	4.0c	2.3d
LSD (0.05)	1.3	0.9	0.7	0.5
Year average	7.1a	4.7c	6.4b	

[1] Average of years 2008, 2009, and 2010.
[2] Planting date means in columns or year means in rows followed by different letters are statistically different at P=0.05.

Table 2. Effect of planting date and year on canola winter survival, spring plant density, and spring vigor, 2008–2010

Planting date	2008	2009	2010	Planting date average[1]
		Winter survival, %		
August 15	65b	54a	50b	57a
September 1	78a	19b	72a	56a
September 15	74ab	7bc	67a	49b
October 1	52c	0c	0c	17c
October 15	0d	0c	0c	0d
LSD (0.05)[2]	12	16	9	6
Year average	54a	11c	37b	
		Spring plant density, plants/a		
August 15	119,000b	112,000a	110,000c	114,000b
September 1	209,000a	62,000ab	196,000b	156,000a
September 15	189,000a	25,000bc	224,000a	143,000a
October 1	188,000a	0d	0d	63,000c
October 15	0c	0d	0d	0d
LSD (0.05)	56,000	5,000	19,000	21,000
Year average	141,000a	30,000c	103,000b	
		Spring vigor (0-10)		
August 15	6.3a	6.7a	7.0b	6.6a
September 1	6.8a	4.0b	8.3a	6.3a
September 15	6.5a	2.0c	6.9b	5.0b
October 1	4.5b	0.0d	0.0c	1.5c
October 15	0.0c	0.0d	0.0c	0.0d
LSD (0.05)	1.4	1.9	1.1	0.7
Year average	4.8a	1.8b	4.4a	

[1] Planting date means in columns or year means in rows followed by different letters are statistically different at P=0.05.

[2] Average of years 2008, 2009, and 2010.

Table 3. Effect of planting date and year on canola yield in 2008 and 2010

Planting date	2008	2009	2010	Planting date average[1]
	Yield, lb/a			
August 15	1,249	-[3]	2,196	1,744b
September 1	1,443	-	2,550	2,032a
September 15	1,172	-	2,344	1,745b
October 1	941	-	0	942c
October 15	0	-	0	0d
LSD (0.05)[2]	148	-	319	156
Year average	962b	-	1,427a	

[1] Average of years 2008 and 2010.
[2] Planting date means in columns or year means in rows followed by different letters are statistically different at P=0.05.
[3] Canola was not harvested in 2009.

Switchgrass Stand Establishment, Iron Chlorosis, and Biomass Yield under Irrigation

J. Holman and S. Maxwell

Summary

Ten switchgrass cultivars, five public ('Alamo,' 'Blackwell,' 'Cave-in-Rock,' 'Kanlow,' and 'Trailblazer') and five private ('CERES-54,' 'CERES-55,' 'CERES-56,' 'CERES-57,' and 'CERES-58') were evaluated for stand establishment, iron chlorosis, and biomass yield from 2007 through 2009. Stand density increased 37% the year following establishment, and upland types had 19% greater stand density than lowland types. Varieties varied in their susceptibility to iron chlorosis. Yield increased 416% the year following establishment, and under irrigation lowland types had 30% greater biomass yield than upland types. Switchgrass can be successfully grown in western Kansas under irrigation and established stands can produce biomass yields greater than 12,000 lb/a.

Introduction

Interest in bioenergy crops has increased from rising energy costs and a desire to ensure U.S. national security. The U.S. Energy Independence and Security Act of 2007 requires that 36 billion gallons of biofuels be added to gasoline by 2022, up from 4.7 billion gallons in 2007. Approximately 44% of biofuels are expected to come from cellulosic feedstock. Switchgrass was identified as a potential feedstock.

Procedures

The experimental design was a randomized complete block with six replications. Ten switchgrass cultivars, five public ('Alamo,' 'Blackwell,' 'Cave-in-Rock,' 'Kanlow,' and 'Trailblazer') and five private ('CERES-54,' 'CERES-55,' 'CERES-56,' 'CERES-57,' and 'CERES-58') were evaluated for stand establishment (Table 1), iron chlorosis (Table 2), and biomass yield (Table 3) from 2007 through 2009. Upland cultivars were 'Blackwell,' 'Cave-in-Rock,' 'EXP-58,' and 'Trailblazer.' Lowland cultivars were 'Alamo,' 'EXP-54,' 'EXP-55,' 'EXP-56,' 'EXP-57,' and 'Kanlow.' Plot size was 12 ft wide by 15 ft long. Seed was planted in 6-in. rows. Switchgrass was seeded at a targeted depth of 0.25 in. and stand density of 1 plant/ft^2 on May 21, 2007, at the Southwest Research-Extension Center (SWREC) near Garden City, KS.

Urea (46-0-0) was broadcast at 100 lb nitrogen (N)/a on May 1, 2007; 50 lb N/a on June 27, 2008; and 50 lb N/a on March 20, 2009. Soil test levels were sufficient in phosphorus and potassium. Weeds were managed throughout the study with a combination of metsulfron, 2,4-D, dicamba, atrazine, and fluroxypyr at labeled rates.

Soil moisture at SWREC was monitored using gypsum blocks placed every foot to a 3-ft soil depth, and basin irrigation was applied to minimize moisture stress when dry soil conditions were indicated. Irrigation began at the end of May, with 8.1 in. applied in 2007, 28.9 in. applied in 2008, and 17.3 in. applied in 2009. Switchgrass plant density was measured annually using a frequency grid. Chlorosis was visually estimated on a scale of 1 to 10 (0 = no chlorosis and 10 = severe chlorosis) every spring. Yield was determined after a killing freeze every fall. Switchgrass was harvested approximately 4 in. above the soil surface from an area 6 ft wide by 15 ft long with a small plot forage harvester (Carter Manufacturing Company, Inc., Brookston, IN). The remainder of the plot area was clipped uniformly to the same height after plot harvest. A homogenized subsample was collected from the biomass harvested, weighed wet, dried at 50°C in a forced-air oven for 96 hours, and weighed dry to determine dry matter yield.

Results and Discussion

Weed control during the establishment year was challenging; few herbicide options were available. After the switchgrass stand was established, the stand competed well with weeds, and more herbicide options and increased herbicide rates were available for use. Producers should try to seed switchgrass in areas with minimal weed pressure and to control weeds prior to seeding. Irrigation can help establish stands in the semi-arid regions of the Great Plains. Several cultivars showed susceptibility to iron chlorosis. Although iron chlorosis did not affect biomass yield in this study, producers should be cautious and select a cultivar with low iron chlorosis susceptibility in areas with high soil pH.

Table 1. Switchgrass plant density, 2007–2009

Cultivar	2007	2008	2009	Cultivar average
		Plant density, plants/ft^2		
Alamo	1.6	2.4	2.1	2.0e
Blackwell	2.1	2.8	2.6	2.5ab
Cave-in-Rock	2.2	2.8	2.7	2.6a
CERES-54	1.8	2.2	2.4	2.1dce
CERES-55	1.6	2.4	2.3	2.1dce
CERES-56	1.7	2.4	2.0	2.0de
CERES-57	1.9	2.6	2.1	2.2dce
CERES-58	2.5	2.7	2.4	2.5a
Kanlow	1.8	2.6	2.4	2.3dc
Trailblazer	1.5	2.8	2.6	2.3bc
LSD (0.05)[1]	0.4	0.6	0.3	0.2
Year average	1.9b	2.6a	2.4a	2.3
Type				
Lowland				2.1b
Upland				2.5a
LSD (0.05)				0.1

[1] Means in columns or rows followed by different letters are statistically different at the P<0.05 level.

Table 2. Switchgrass chlorosis ratings between 0 and 10, with 0 having no chlorosis and 10 having severe chlorosis, 2007–2009

Cultivar	2007	2008	2009	Cultivar average
		Chlorosis, (0-10)		
Alamo	1.7bc	-	0.8dc	0.8cd
Blackwell	2.0bc	-	0.2e	0.7cd
Cave-in-Rock	8.0a	-	1.8a	3.3a
CERES-54	2.0bc	-	0.2e	0.7cd
CERES-55	3.3bc	-	0.3de	1.2bc
CERES-56	3.7b	-	1.5ab	1.7b
CERES-57	2.3bc	-	1.0bc	1.1bc
CERES-58	8.0a	-	1.3abc	3.1a
Kanlow	2.0bc	-	0.0e	0.7cd
Trailblazer	0.7c	-	0.2e	0.3d
LSD (0.05)[1]	2.7	-	0.7	0.8
Year average	3.4a	-	0.7b	1.4
Type				
Lowland				1.0b
Upland				1.8a
LSD (0.05)				0.6

[1] Means in columns or rows followed by different letters are statistically different at the P<0.05 level.

Table 3. Switchgrass dry matter biomass yields, 2007–2009

Cultivar	2007	2008	2009	Cultivar average
		Yield, lb/a		
Alamo	2,502a	13,108ab	14,504a	10,038a
Blackwell	1,736a	11,225bc	10,307b	7,756d
Cave-in-Rock	2,490a	10,253bc	9,779b	7,507d
CERES-54	1,875a	11,328abc	13,039a	8,748c
CERES-55	2,324a	14,130a	13,575a	10,010a
CERES-56	2,719a	12,750ab	13,684a	9,718ab
CERES-57	3,206a	11,632abc	14,881a	9,907ab
CERES-58	2,236a	9,044c	9,240b	6,840d
Kanlow	1,697a	12,056ab	13,193a	8,982bc
Trailblazer	1,681a	10,473bc	9,919b	7,358d
LSD (0.05)[1]	1,048	2,875	2,533	968
Year average	2,247b	11,600a	12,212a	8,686
Type				
Lowland				9,567a
Upland				7,365b
LSD (0.05)				514

[1] Means in columns or rows followed by different letters are statistically different at the P<0.05 level.

Long-Term Nitrogen and Phosphorus Fertilization of Irrigated Corn[1]

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 2010, hail severely damaged the corn in late July. However, N applied alone still increased yields about 45 bu/a, whereas P applied alone increased yields about 8 bu/a. Nitrogen and P applied together increased yields up to 80 bu/a. Averaged across the past 10 years, N and P fertilization increased corn yields up to 140 bu/a. Application of 120 lb/a N (with P) was sufficient to produce greater than 90% of maximum yield in 2010, which was similar to the 10-year average. Application of 80 instead of 40 lb P_2O_5/a increased yields 5 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 [Pioneer 33R93 (2001 and 2002), DeKalb C60-12 (2003), Pioneer 34N45 (2004 and 2005), Pioneer 34N50 (2006), Pioneer 33B54 (2007), Pioneer 34B99 (2008), DeKalb 61-69 (2009), and Pioneer 1173H (2010)] were planted at about 30,000 to 32,000 seeds/a in late April or early May. Hail damaged the 2002, 2005, and 2010 crops. The corn is irrigated to minimize water stress. 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 2010 were much less than the 10-year average because of considerable hail damage in late July (Table 1). Nitrogen alone increased yields 45 bu/a, whereas P alone increased yields less than 10 bu/a. However, N and P applied together increased corn yields up to 80 bu/a. Only 120 lb/a N with P was required to obtain greater than 90% of maximum yield, which is similar to the 10-year average. Corn yields in 2010 (averaged across all N rates) were 5 bu/a greater with 80 than with 40 lb/a P_2O_5, which is similar to the 10-year average.

[1] This project was partially supported by the International Plant Nutrition Institute.

Table 1. Effect of nitrogen and phosphorus fertilization on irrigated corn, Tribune, 2001–2010

N	P_2O_5	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Mean
---------- lb/a ----------		---------- bu/a ----------										
0	0	54	39	79	67	49	42	49	36	85	20	52
0	40	43	43	95	97	60	68	50	57	110	21	64
0	80	48	44	93	98	51	72	51	52	106	28	64
40	0	71	47	107	92	63	56	77	62	108	23	71
40	40	127	69	147	154	101	129	112	105	148	67	116
40	80	129	76	150	148	100	123	116	104	159	61	117
80	0	75	53	122	118	75	79	107	78	123	34	86
80	40	169	81	188	209	141	162	163	129	179	85	151
80	80	182	84	186	205	147	171	167	139	181	90	155
120	0	56	50	122	103	66	68	106	65	117	28	78
120	40	177	78	194	228	162	176	194	136	202	90	164
120	80	191	85	200	234	170	202	213	151	215	105	177
160	0	76	50	127	136	83	84	132	84	139	49	96
160	40	186	80	190	231	170	180	220	150	210	95	171
160	80	188	85	197	240	172	200	227	146	223	95	177
200	0	130	67	141	162	109	115	159	99	155	65	120
200	40	177	79	197	234	169	181	224	152	207	97	172
200	80	194	95	201	239	191	204	232	157	236	104	185

continued

Table 1. Effect of nitrogen and phosphorus fertilization on irrigated corn, Tribune, 2001–2010

N	P_2O_5	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Mean
		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	0.007	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
N × P		0.001	0.133	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Means												
Nitrogen, lb/a												
0		48	42	89	87	53	61	50	48	100	23	60
40		109	64	135	132	88	103	102	91	138	50	101
80		142	73	165	178	121	137	146	115	161	70	131
120		142	71	172	188	133	149	171	118	178	74	139
160		150	71	172	203	142	155	193	127	191	80	148
200		167	80	180	212	156	167	205	136	199	89	159
LSD (0.05)		15	8	9	11	10	15	11	9	12	9	8
P_2O_5, lb/a												
0		77	51	116	113	74	74	105	71	121	36	84
40		147	72	168	192	134	149	160	122	176	76	140
80		155	78	171	194	139	162	168	125	187	81	146
LSD (0.05)		10	6	6	8	7	11	8	6	9	7	5

Long-Term Nitrogen and Phosphorus Fertilization of Irrigated Grain Sorghum[1]

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 2010, N applied alone increased yields about 25 bu/a, whereas N and P applied together increased yields up to 35 bu/a despite considerable hail damage in late July. Averaged across the past 10 years, N and P fertilization increased sorghum yields up to 60 bu/a. Application of 40 lb/a N (with P) was sufficient to produce about 85% of maximum yield in 2010, 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 in 1998–2007 and Pioneer 85G46 in 2008–2010) is planted in late May or early June. Irrigation is used to minimize water stress. Furrow irrigation was used through 2000, and 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 2010 were reduced because of hail in late July (Table 1). Nitrogen alone increased yields about 25 bu/a whereas P alone had no effect on yields. However, N and P applied together increased yields up to 35 bu/a. Averaged across the past 10 years, N and P applied together increased yields up to 60 bu/a. In 2010, 40 lb/a N (with P) produced about 85% of maximum yields, which is slightly less than the 10-year average. Sorghum yields were not affected by K fertilization, which has been the case throughout the study period.

[1] This project was partially supported by the International Plant Nutrition Institute.

Table 1. Effect of nitrogen (N), phosphorus (P), and potassium (K) fertilizers on irrigated grain sorghum yields, Tribune, 2001–2010

Fertilizer			Grain sorghum yield										
N	P_2O_5	K_2O	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Mean
lb/a			bu/a										
0	0	0	76	73	80	57	58	84	80	66	64	51	69
0	40	0	81	81	93	73	53	102	97	60	70	51	77
0	40	40	83	82	93	74	54	95	94	65	76	55	78
40	0	0	92	82	92	60	63	102	123	92	84	66	87
40	40	0	124	120	140	112	84	133	146	111	118	77	118
40	40	40	119	121	140	117	84	130	145	105	109	73	116
80	0	0	110	97	108	73	76	111	138	114	115	73	103
80	40	0	138	127	139	103	81	132	159	128	136	86	125
80	40	40	134	131	149	123	92	142	166	126	108	84	127
120	0	0	98	86	97	66	77	101	138	106	113	70	96
120	40	0	134	132	135	106	95	136	164	131	130	88	126
120	40	40	135	127	132	115	98	139	165	136	136	90	128
160	0	0	118	116	122	86	77	123	146	105	108	74	109
160	40	0	141	137	146	120	106	145	170	138	128	92	133
160	40	40	136	133	135	113	91	128	167	133	140	88	128
200	0	0	132	113	131	100	86	134	154	120	110	78	117
200	40	0	139	136	132	115	108	143	168	137	139	84	131
200	40	40	142	143	145	123	101	143	170	135	129	87	133

continued

Table 1. Effect of nitrogen (N), phosphorus (P), and potassium (K) fertilizers on irrigated grain sorghum yields, Tribune, 2001–2010

Fertilizer			Grain sorghum yield										
N	P_2O_5	K_2O	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Mean
			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	0.018	0.005	0.004	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			0.619	0.920	0.694	0.121	0.803	0.578	0.992	0.745	0.324	0.892	0.968
N × P-K			0.058	0.030	0.008	0.022	0.195	0.210	0.965	0.005	0.053	0.229	0.007
Means													
Nitrogen, lb/a													
0			80	79	88	68	55	93	91	64	70	52	75
40			112	108	124	96	77	121	138	103	104	72	107
80			127	119	132	100	83	128	155	123	120	81	118
120			122	115	121	96	90	125	156	124	126	82	117
160			132	129	134	107	92	132	161	125	125	83	123
200			138	131	136	113	98	140	164	131	126	84	127
LSD (0.05)			8	9	10	11	10	11	9	7	11	5	5
P_2O_5-K_2O, lb/a													
0			104	94	105	74	73	109	130	101	99	68	97
40-0			126	122	131	105	88	132	151	117	120	80	118
40-40			125	123	132	111	87	130	151	117	116	79	118
LSD (0.05)			6	6	7	7	7	7	6	5	7	4	4

Four-Year Rotations with Wheat and Grain Sorghum

A. Schlegel, T. Dumler, J. Holman, and C. Thompson

Summary
Research on 4-year crop rotations with wheat and grain sorghum was initiated at the Southwest Research-Extension Center near Tribune, KS, in 1996. Rotations were wheat-wheat-sorghum-fallow (WWSF), wheat-sorghum-sorghum-fallow (WSSF), and continuous wheat (WW). Soil water at wheat planting averaged about 9 in. following sorghum, which is about 3 in. more than that for the second wheat crop in a WWSF rotation. Soil water at sorghum planting was approximately 1.4 in. less for the second sorghum crop compared with sorghum following wheat. Grain yield of recrop wheat averaged about 80% of the yield of wheat following sorghum. Grain yield of continuous wheat averaged about 65% of the yield of wheat grown in a 4-year rotation following sorghum. Wheat yields were similar following one or two sorghum crops. Similarly, average sorghum yields were the same following one or two wheat crops. Yield of the second sorghum crop in a WSSF rotation averaged 68% of the yield of the first sorghum crop.

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

Procedures
Research on 4-year crop rotations with wheat and grain sorghum was initiated at the Tribune Unit of the Southwest Research-Extension Center in 1996. Rotations were WWSF, WSSF, and WW. No-till was used for all rotations. Available water was measured in the soil profile (0 to 8 ft) at planting and harvest of each crop. The center of each plot was machine harvested after physiological maturity, and yields were adjusted to 12.5% moisture.

Results and Discussion
Soil water
The amount of available water in the soil profile (0 to 6 ft) at wheat planting varied greatly from year to year (Figure 1). Soil water was similar following fallow after either one or two sorghum crops and averaged about 9 in. across the 14-year study period. Water at planting of the second wheat crop in a WWSF rotation generally was less than that at planting of the first wheat crop, except in 1997 and 2003. Soil water for the second wheat crop averaged more than 3 in. (or about 40%) less than that for the first wheat crop in the rotation. Continuous wheat averaged about 0.7 in. less water at planting than the second wheat crop in a WWSF rotation.

Similar to wheat, the amount of available water in the soil profile at sorghum planting varied greatly from year to year (Figure 2). Soil water was similar following fallow after either one or two wheat crops and averaged about 8.4 in. over 14 years. Water at planting of the second sorghum crop in a WSSF rotation was generally less than that at planting of the first sorghum crop. Averaged across the entire study period, the first sorghum crop had about 1.4 in. more available water at planting than the second crop.

Grain yields

In 2010, wheat yields were above average for wheat following fallow but slightly below average for wheat following wheat (Table 1). Averaged across 14 years, recrop wheat (the second wheat crop in a WWSF rotation) yielded about 83% of the yield of first-year wheat in WWSF. Before 2003, recrop wheat yielded about 70% of the yield of first-year wheat. In 2003 and 2009, however, recrop wheat yields were much greater than the yield in all other rotations. For 2003 recrop wheat, this is possibly a result of failure of the first-year wheat in 2002, which resulted in a period from 2000 sorghum harvest to 2003 wheat planting without a harvested crop. However, this was not the case for the 2009 recrop wheat. Generally, little difference has occurred in wheat yields following one or two sorghum crops. In most years, continuous wheat yields have been similar to recrop wheat yields; however, in several years (2003, 2007, and 2009), recrop wheat yields were considerably greater than continuous wheat yields.

Sorghum yields in 2010 were greater than average for sorghum following wheat but average for sorghum following sorghum (Table 2). Sorghum yields were similar following one or two wheat crops, which is consistent with the long-term average. The second sorghum crop typically averages about 70% of the yield of the first sorghum crop, but in 2010, recrop sorghum yields were only about 50% of the yield of the first sorghum crop.

Table 1. Wheat response to rotation, Tribune, 1997–2010

	Wheat yield														
Rotation[1]	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Mean
	bu/a														
Wssf	57	70	74	46	22	0	29	6	45	28	75	40	37	63	42
Wwsf	55	64	80	35	29	0	27	6	40	26	61	40	39	60	40
wWsf	48	63	41	18	27	0	66	1	41	7	63	5	50	29	33
WW	43	60	43	18	34	0	30	1	44	2	41	6	24	23	26
LSD (0.05)	8	12	14	10	14	—	14	2	10	8	14	5	15	9	3

[1] W, wheat; S, sorghum; F, fallow; capital letters denote current year's crop.

Table 2. Grain sorghum response to rotation, Tribune, 1996–2010

	Grain sorghum yield															
Rotation[1]	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Mean
	bu/a															
wSsf	58	88	117	99	63	68	0	60	91	81	55	101	50	89	98	75
wsSf	35	45	100	74	23	66	0	41	79	69	13	86	30	44	52	51
wwSf	54	80	109	90	67	73	0	76	82	85	71	101	57	103	105	77
LSD (0.05)	24	13	12	11	16	18	—	18	17	20	15	9	12	53	24	4

[1] W, wheat; S, sorghum; F, fallow; capital letters denote current year's crop.

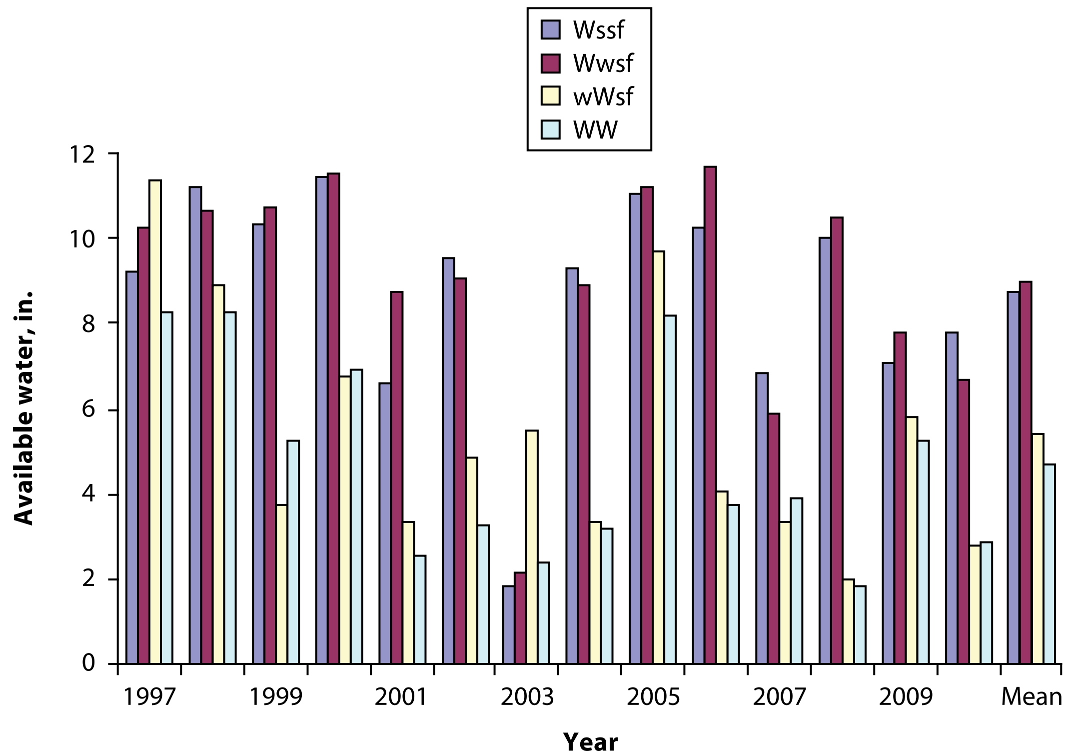

Figure 1. Available soil water at planting of wheat in several rotations, Tribune, 1997–2010.
Capital letter denotes current crop in rotation (W, wheat; S, sorghum; F, fallow). The last set of bars (Mean) is the average across years.

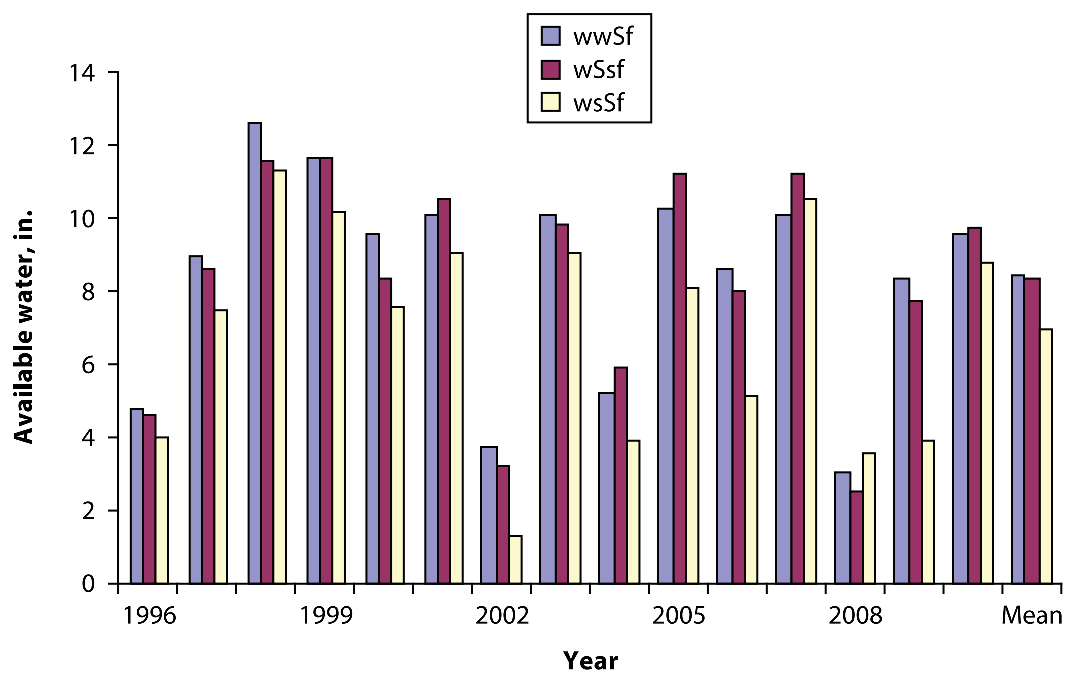

Figure 2. Available soil water at planting of sorghum in several rotations, Tribune, 1996–2010.
Capital letter denotes current crop in rotation (W, wheat; S, sorghum; F, fallow). The last set of bars (Mean) is the average across years.

Conservation Tillage in a Wheat-Sorghum-Fallow Rotation[1]

A. Schlegel, L. Stone[2], and T. Dumler

Summary
Grain yields of wheat and grain sorghum increased with decreased tillage intensity in a wheat-sorghum-fallow (WSF) rotation. Averaged over the past 10 years, no-till (NT) wheat yields were 6 bu/a greater than reduced tillage and 9 bu/a greater than conventional tillage. Grain sorghum yields in 2010 were 58 bu/a greater with long-term NT than short-term NT. Averaged across the past 10 years, sorghum yields with long-term NT have been twice as great as short-term NT (57 vs. 26 bu/a).

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

Results and Discussion
Since 2001, wheat yields have been severely depressed in 5 of 10 years, primarily because of lack of precipitation. Reduced tillage and no-till increased wheat yields (Table 1). On average, wheat yields were 9 bu/a higher for NT (25 bu/a) than CT (16 bu/a). Wheat yields for RT were 3 bu/a greater than CT even though both systems had tillage prior to wheat. NT yields were less than CT or NT in only 1 of the 10 years (although the difference was not significant).

The yield benefit from RT was greater for grain sorghum than wheat. Grain sorghum yields for RT averaged 10 bu/a more than CT, whereas NT averaged 31 bu/a more than RT (Table 2). For sorghum, both RT and NT used herbicides for weed control during fallow, so the difference in yield could be attributed to short-term compared with long-term no-till. In 2010, sorghum yields were 58 bu/a greater with long-term NT than short-term NT. This consistent yield benefit with long-term vs. short-term NT has been observed since the RT system was changed in 2001. Averaged across the past 10 years, sorghum yields with long-term NT have been twice as great as short-term NT (57 vs. 26 bu/a).

[1] This research project was partially supported by the Ogallala Aquifer Initiative.
[2] Kansas State University Department of Agronomy.

Table 1. Wheat response to tillage in a wheat-sorghum-fallow rotation, Tribune, 2001–2010

	Tillage				ANOVA (P > F)		
Year	Conventional	Reduced	No-till	LSD (0.05)	Tillage	Year	Tillage × year
	------------------ bu/a -----------------						
2001	17	40	31	8	0.002		
2002	0	0	0	---	---		
2003	22	15	30	7	0.007		
2004	1	2	4	2	0.001		
2005	32	32	39	12	0.360		
2006	0	2	16	6	0.001		
2007	26	36	51	15	0.017		
2008	21	19	9	14	0.142		
2009	8	10	22	9	0.018		
2010	29	35	50	8	0.002		
Mean	16	19	25	2	0.001	0.001	0.001

Table 2. Grain sorghum response to tillage in a wheat-sorghum-fallow rotation, Tribune, 2001–2010

	Tillage				ANOVA (P > F)		
Year	Conventional	Reduced	No-till	LSD (0.05)	Tillage	Year	Tillage × year
	------------------ bu/a -----------------						
2001	6	43	64	7	0.001		
2002	0	0	0	---	---		
2003	7	7	37	8	0.001		
2004	44	67	118	14	0.001		
2005	28	38	61	65	0.130		
2006	4	3	29	10	0.001		
2007	26	43	62	42	0.196		
2008	16	25	40	20	0.071		
2009	19	5	72	31	0.004		
2010	10	26	84	9	0.001		
Mean	16	26	57	6	0.001	0.001	0.001

Effect of Stubble Height in a No-Till Wheat-Corn/Grain Sorghum-Fallow Rotation[1]

L.A. Haag[2] and A.J. Schlegel

Summary
Various studies have been conducted since 2001 to evaluate the effect of wheat stubble height on subsequent grain yield of summer crops. Corn grain yields increased as stubble height increased. Grain sorghum yield response to stubble height was less apparent in any individual year but exhibited a quadratic response in an analysis across years. Corn grain yields, averaged over previous studies starting in 2005 through the current study in 2010, were 66, 75, and 78 bu/a for the short cut, tall cut, and stripped stubble treatments, respectively. From 2001 through the present, neither tall cut nor stripped stubble has resulted in lower corn grain yields than short cut stubble. Data from this study and others show producers should increase cutting heights with conventional headers or adopt stripper header technology.

Introduction
Seeding of summer row crops throughout the west-central Great Plains typically occurs after a fallow period following wheat. Wheat residue provides numerous benefits including evaporation suppression, delayed weed growth, improved capture of winter snowfall, and reduced soil erosion. Stubble height affects wind velocity profile, surface radiation interception, and surface temperatures, all of which affect evaporation suppression and winter snow catch. Taller wheat stubble is also beneficial to pheasants in postharvest and overwinter fallow periods. Using stripper headers increases harvest capacity and provides taller wheat stubble than previously attainable with conventional small 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 was to evaluate the effect of wheat stubble height on subsequent summer row crop yields.

Procedures
Studies were conducted from 2007 through 2010 at the Southwest Research-Extension Center dryland station near Tribune, KS. Corn and grain sorghum were planted into standing wheat stubble of three heights: optimal, short, and stripped. Optimal cutter bar height is the height necessary to maximize both grain harvested and standing stubble remaining (typically two-thirds of total plant height), the short cut treatment was half of optimal cutter bar height, and the third treatment was stubble remaining after stripper header harvest. In 2007, these heights were 7, 14, and 22 in. In 2008, heights of 10, 20, and 30 in. were obtained. In 2009 the heights were 7, 14, and 23 in. In 2010 the stubble measured 8, 16, and 25 in. Corn and grain sorghum were seeded at rates of 15,000 and 33,000 seeds/a, respectively. In 2010 the sorghum plots were split and an additional seeding rate of 41,000 seeds/a was added to the study. Nitrogen was applied to all plots at a rate of 80 to 100 lb/a N. Starter fertilizer (10-34-0) was applied in-row

[1] This project received support from the Kansas Department of Wildlife and Parks.
[2] Graduate Student, Kansas State University Department of Agronomy.

at rates of 7 and 9 gal/a for corn and sorghum, respectively. Plots measured 40 ft × 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 by neutron attenuation to a depth of 6 ft in 1-ft increments at seeding and harvest to determine water use and water use efficiency.

Results and Discussion

2010

The 2010 growing season had good rainfall with April, May, July, and August all above normal. High temperatures during kernel set, however, likely limited corn grain yields. Corn grain yields ranged from 97 to 104 bu/a (Table 1). Stubble height treatments produced no significant differences in corn grain yield or any of the other measured parameters. This is the first year since 2001, when studies began, that stubble height has not affected corn production at Tribune. The underlying numerical trend of higher corn grain yields, higher residue production, higher kernels per ear, and higher water use efficiency (WUE) with increasing stubble height is consistent with data from previous years.

Sorghum yields ranged from 109 to 123 bu/a (Table 2). Sorghum planted into stripped stubble at a rate of 34,000 seeds/a produced less grain than any other treatment in the study. This was driven primarily by a reduction in the kernels per head yield component, which was lowest for the 34,000 seeding rate in stripped stubble. Sorghum planted into stripped stubble at 41,000 seeds/a produced the highest kernels per head but yielded the same as sorghum planted at either population in high or low cut stubble due to an accompanying offset in the heads per plant yield component. Sorghum planted at 41,000 seeds/a into any stubble height produced fewer tillers than sorghum planted at 34,000 seeds/a, as evidenced in the heads per plant yield component.

Data from prior years suggested that sorghum planted into stripped stubble was yielding less than sorghum planted into tall cut stubble due to reduced tillering. The addition of the 41,000 seeding rate was designed to further investigate this possibility. Interestingly, in 2010 the increased seeding rate resulted in only a very small increase in plant and head population.

2007–2010 Across Years

An across-years analysis was conducted with data from this study. Over the 4 years, corn grain yield increased from 80 to 92 bu/a as stubble height increased (Table 3). Increased grain yields are the result of the effect of stubble height on one primary yield component, kernels per ear, which increased with increasing stubble height from 467 for the low cut to 521 for the stripped stubble treatment. Another key yield component, ear population, also increased numerically with increasing stubble height, suggesting that increasing stubble height also may reduce in-season plant mortality and ear abortion. Corn grown in stripped or tall cut stubble resulted in higher WUE, which increased from 305 lb/in. in short cut stubble to 361 lb/in. in the stripped stubble treatment.

Over the 4 years, sorghum grain yields exhibited a quadratic response to stubble height with high cut stubble producing grain yields 4 to 5 bu/a higher than either the stripped or short cut treatment (Table 4). An examination of yield components revealed that kernels per head generally increased with increasing stubble height. Although no statistical differences were observed, heads per plant exhibited a positive response to increasing stubble height. Future efforts in this study will involve more emphasis on yield components, specifically tillers per plant, in an effort to identify any interaction between tillering and the production environment created by stripped stubble.

Conclusions

Increasing stubble height has improved subsequent corn grain yields and WUE. The impact of stubble height on grain sorghum yields is less apparent at this time and requires further study. Surprisingly, this study has found little impact of stubble height on profile available soil water. This is in direct contrast to other studies and anecdotal field observations. Corn grain yield differences in the absence of differences in available soil water at planting indicate a more pronounced impact of stubble harvest height on in-season plant-water dynamics than previously thought. Acquiring long-term datasets is important for evaluating the effects of stubble height across a wide range of environments. Additional years of observation are needed to identify any potential effect of stubble height on the yield components of grain sorghum and to provide a more robust dataset across multiple years in which to evaluate the effects of stubble height on soil water storage.

Table 1. Corn grain yield and yield components as affected by stubble height, Tribune, 2010

Stubble height	Grain yield	Moisture	Test weight	Plant population	Ear population	Residue	Residue yield	Kernel weight	Kernels/ear	WUE[1]
	bu/a	%	lb/bu	1,000 plants/a	1,000 ears/a	lb/a	lb/lb	oz/1,000		lb/in.
Strip	103.9	13.1	58.7	19.4	19.2	7010	1.17	9.15	548	399
High	102.7	13.7	58.5	19.3	19.0	6440	1.13	9.24	528	389
Low	96.7	12.6	58.8	19.3	19.1	5535	1.03	8.82	511	306
Source										
Stubble	0.2018	0.1030	0.2124	0.9846	0.9236	0.0695	0.3598	0.3870	0.3462	0.3458

[1] WUE = water use efficiency.

Table 2. Grain sorghum yield and yield components as affected by stubble height and seeding rate, Tribune, 2010

Stubble height	Seeding rate	Grain yield	Moisture	Test weight	Plant population	Head population	Residue[2]	Residue yield[2]	Kernel weight	Kernels/ head	Heads/ plant	WUE[1]
		bu/a	%	lb/bu	1,000 plants/a	1,000 heads/a	lb/a	lb/lb	oz/1,000			lb/in
Strip		112.9	13.3	55.9	18.4	53.1	6911	1.14	0.9354	2,054	3.05	392
High		121.4	11.9	56.7	19.4	56.8	6896	1.01	0.9644	1,997	2.97	421
Low		116.4	11.8	56.9	19.2	54.8	6513	1.00	0.9425	2,030	2.92	396
	41,000/a	117.5	12.0	56.7	19.8a	54.7	-	-	0.9513	2,043	2.80b	-
	34,000/a	116.2	12.6	56.3	18.2b	55.1	-	-	0.9436	2,011	3.16a	-
Strip	41,000/a	116.4a	12.3b	56.6a	19.7	52.5	-	-	0.9315	2,157a	2.72	-
	34,000/a	109.4b	14.4a	55.2b	17.1	53.7	-	-	0.9393	1,952b	3.39	-
High	41,000/a	119.9a	11.7ab	56.8ab	20.0	56.6	-	-	0.965	1,981ab	2.86	-
	34,000/a	122.9a	12.0ab	56.6ab	18.9	57.0	-	-	0.9637	2,013ab	3.08	-
Low	41,000/a	116.4a	12.1ab	56.6ab	19.8	55.0	-	-	0.9572	1,990ab	2.84	-
	34,000/a	116.5a	11.5ab	57.1ab	18.6	54.5	-	-	0.9277	2,069ab	3.00	-
ANOVA P>F												
Source												
Stubble		0.0228	0.5383	0.6244	0.7030	0.3432	0.8102	0.4842	0.0984	0.8268	0.8009	0.2480
Seeding rate		0.4120	0.0917	0.1025	0.0093	0.7052	-	-	0.4465	0.4020	0.0461	-
Stubble × seeding rate		0.0476	0.0147	0.0155	0.5119	0.7926	-	-	0.2993	0.0130	0.3939	-
LSD (0.05)		6.5	2.9	2.0	1.2	-	-	-	-	202	-	-

[1] WUE = water use efficiency.
[2] Biomass and water use information was only collected on the 34,000 population plots.
Within columns, means followed by the same letter are not significantly different at LSD (0.05).

Table 3. Corn grain yield and yield components as affected by stubble height, Tribune, 2007–2010

Stubble height	Grain yield	Moisture	Test weight	Plant population	Ear population	Residue	RY ratio	Kernel weight	Kernels/ear	Ears/plant	WUE[1]
	bu/a	%	lb/bu	1,000 plants/a	1,000 ears/a	lb/a	lb/lb	oz/1,000			lb/in.
Stripped	92.0a	15.7	58.2	15.5	15.7	6175	1.22	10.42	521a	1.01	361a
High	89.9a	15.9	58.2	15.4	15.4	6421	1.35	10.54	504a	1.00	350a
Low	80.3b	15.6	58.1	15.5	15.1	5550	1.30	10.33	467b	0.98	305b
ANOVA P>F											
Source											
Stubble	0.0002	0.3536	0.8489	0.7306	0.2322	0.0781	0.4029	0.4837	0.0023	0.1571	0.0003
LSD (0.05)	5.5	-	-	-	-	-	-	-	30	-	27

[1] WUE = water use efficiency.
Within columns, means followed by the same letter at not significantly different at LSD (0.05).

Table 4. Grain sorghum yield and yield components as affected by stubble height, Tribune, 2007–2010

Stubble height	Grain yield	Moisture	Test weight	Plant population	Head population	Residue	RY ratio	Kernel weight	Kernels/ head	Heads/ plant	WUE[1]
	bu/a	%	lb/bu	1,000 plants/a	1,000 heads/a	lb/a	lb/lb	oz/1,000			lb/in.
Stripped	101.9	12.8	57.6	18.3	50.0	5968	1.08	0.88	2109	2.87	419
High	107.4	12.2	58.1	18.9	51.9	6389	1.08	0.92	2069	2.84	432
Low	102.9	11.9	58.0	19.2	50.2	5978	1.09	0.91	2073	2.69	413
ANOVA P>F											
Source											
Stubble	0.0761	0.1633	0.3327	0.2879	0.1735	0.3395	0.9723	0.1479	0.6713	0.3172	0.1673

[1] WUE = water use efficiency.

Vertical Tillage Effects in Corn Production in Southwest Kansas[1]

K.L. Martin, A. Whitehair[2], D. Presley[2]

Summary

A tillage study was initiated in 2010 on a producer field near Copeland, KS, to evaluate the effects of vertical tillage on corn production in southwest Kansas. Three vertical tillage implements including Great Plains, Case International, and Landoll were compared to no-till. At this site, the only parameter that was influenced by vertical tillage was soil moisture. No-till areas maintained greater soil moisture than those in which tillage occurred.

Introduction

Vertical tillage has been gaining popularity recently as a tool for residue management and seedbed preparation. In this study, these tools were evaluated on second-year corn to determine the effects on residue, soil moisture, water infiltration, bulk density, plant stands, disease levels, and grain yield.

Procedures

Vertical tillage was performed April 28, 2010, in strips oriented in an east-west direction on a field with center pivot irrigation near Copeland, KS. The strips were replicated four times in a side-by-side orientation. The implements were set according to manufacturer specifications and generally tilled to a depth of 1.5 to 2 in. The following week, corn was planted in the strips. Residue, soil, and plant production measurements were taken during the growing season.

Results and Discussion

This study showed that residue cover for any implement or no-till was not statistically different (Table 1). This was likely the result of a large amount of residue from the previous corn crop. Although large amounts of residue may be expected to reduce stand counts, stands were not affected in this study. Infiltration was not statistically different between implements or no-till, but variability in these numbers that may contribute to a masking of significant differences is notable. Bulk density also was not affected. Diseases were evaluated because disease suppression could result from disturbing the previous corn residue. No differences were found in disease incidence or severity, but disease pressure was notably high in this field. The only parameter that was altered by tillage was soil moisture. When tillage occurred, soil moisture decreased. This should not be surprising because no-till production systems have been shown to preserve moisture. In this system, corn grain yield was not affected by vertical tillage. This study is ongoing in other locations to evaluate location-specific differences from vertical tillage.

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[1] This study was funded by the Kansas Corn Commission. Thanks to Gibson Farms for providing a site for this study.

[2] Kansas State University Department of Agronomy.

Table 1. Effect of vertical tillage and no-till on residue, soil properties, and corn production

	Tillage tool			
	No-till	Case	Landoll	Great Plains
Residue, %	94.8	90.5	91.4	89.3
Stand count, plants/a	29,900	30,300	29,700	29,800
Infiltration, mm/hour	0.72	0.4	0.89	0.18
Soil moisture, %	35.4a	30.7b	29.3b	30.7b
Bulk density, g/cm^3	1.06	1.06	1.09	1.08
Disease incidence, %	90.0	89.5	91.8	89.3
Disease severity (number of lesions)	78.5	83.8	96	89.8
Yield, bu/a	195	204	190	204

Letters indicate significant differences. Absence of letters indicates no statistical differences.

Effect of Manure, Iron, and Zinc Application Methods on Grain Sorghum Yield[1]

K.L. Martin and D. Ruiz-Diaz[2]

Summary
Grain sorghum production in western Kansas is often limited by iron and zinc chlorosis. This study was conducted to evaluate the effects of iron and zinc application methods on grain sorghum yield. Manure, seed treatment, and foliar application methods were used. This study showed that manure and foliar applications were not effective at reducing iron and zinc chlorosis. Iron seed treatment significantly increased yield at one site, but was not effective at the other site. Zinc seed treatment decreased yield at one site, but did not affect yield at the other site.

Introduction
Grain sorghum is typically grown on less productive, rainfed, or limited irrigation fields, whereas other crops, such as corn, take premium production acres. In many of these areas in western Kansas, iron and zinc are the two most limiting micronutrients that are typically deficient in high-pH, low-organic matter soils or in eroded or leveled areas. Common recommendations are to apply foliar iron or zinc; however, these applications are not effective at controlling iron or zinc chlorosis.

Procedures
Locations of varying iron and zinc nutrient deficiencies were identified for this study. One was located at the Southwest Research-Extension Center (SWREC) at Garden City (Finney County, KS) on a Ulysses and Richfield complex soil. The other site was on Funk Farms property north of Lowe Elevator (Finney County, KS) on a Ulysses silt loam.

Manure was evenly applied to the required plots at a rate of 5 tons/a. At planting, seed was treated either with iron or zinc chelated powder. Seed treatments were accomplished using a conventional cement mixer to mix the seed with each treatment. About 0.5 grams of polymer was used on all seed treatments to help the chelated powder adhere to the seed. The equivalent of 0.6 lb/a of iron and 1.0 lb/a zinc was used for the seed treatment.

When the plants reached the 4- to 7-leaf stage, foliar iron and zinc were applied to determine if foliar fertilization affected the chlorosis. Chlorosis persisted, so an additional application followed 2 weeks after the initial application.

Results and Discussion
Data from this study indicate that manure did not have significant effects at these locations. Although the 5-ton manure application rate was sufficient for application of

[1] This study was funded by the Kansas Grain Sorghum Commission. Thanks to Funk Farms for providing a site for this study.
[2] Kansas State University Department of Agronomy.

iron and zinc, higher manure rates may show different results. Seed treatment of zinc was difficult because the product made the seed shape difficult for the planter to get consistent seed spacing and populations. As a result, plant stand counts were collected to evaluate if population was significantly affected by zinc seed treatment. The iron seed treatment fed through the planter much easier, although the iron product may accumulate if humidity is high. Seed treatment appeared to significantly reduce the population when iron was applied and dramatically reduced population where zinc seed treatment was used. Nevertheless, iron seed treatment increased plant height in some plots. The more severe the chlorosis, the easier it was to notice the plant height difference. This was an encouraging find for two reasons: (1) the relationship between plant height and yield is often significant (which was confirmed in this study), and (2) the difference in height indicates the iron seed treatment is affecting the plant, which means the plant is able to utilize some of the iron applied. When foliar iron or zinc was applied to the chlorotic plants, no physical change was evident, even after the second application.

Manure and foliar application did not affect yield at these sites (Figures 1 and 2). However, seed treatment of iron increased yield more than 500 lb/a at the SWREC site (Figure 1). Iron seed treatment at the Funk location did not affect crop yields (Figure 2). Zinc seed treatment decreased yield at the Funk location and did not affect yield at SWREC (Figures 1 and 2).

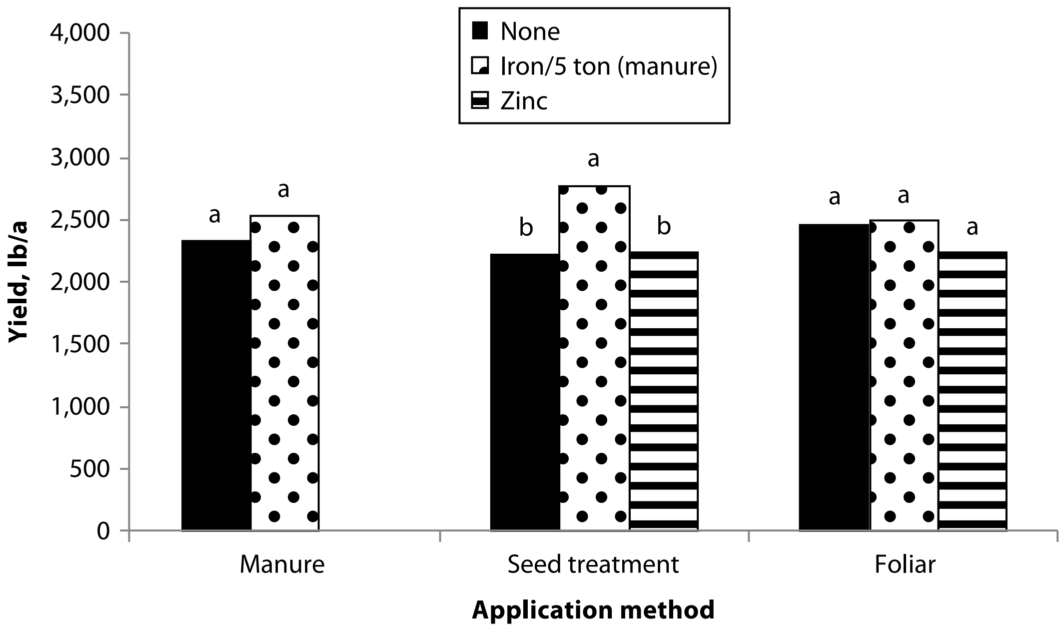

Figure 1. Manure, seed treatment, and foliar application of iron and zinc effects on grain sorghum yield at SWREC.

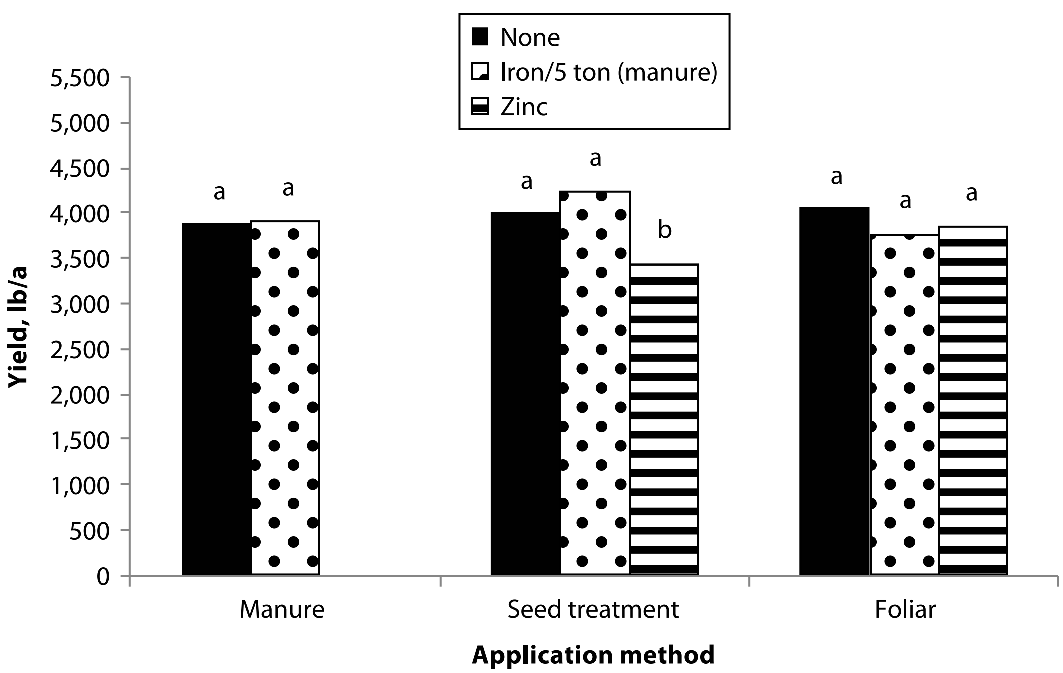

Figure 2. Manure, seed treatment, and foliar application of iron and zinc effects on grain sorghum yield at Funk Farms.

Scheduling for Deficit Irrigation: Crop Yield Predictor

N.L. Klocke, L.R. Stone, S. Briggemann[1]

Summary
Maximum net economic returns for irrigators with adequate water supplies usually have corresponded to irrigation management geared toward obtaining maximum crop yields. Irrigation in excess of crop water needs reduces net economic return, but the marginal increases in crop yields usually are more than marginal production costs. When the water supply for irrigation is less than the water required for non-stressed crops, water deficits can be anticipated. Irrigation schedules for deficit irrigation need to forecast the potential crop yields and net economic returns prior to and during the growing season. Major scheduling questions for deficit irrigation include: (1) whether pre-season irrigation is beneficial, and (2) when irrigation should be started and stopped during the growing season.

Introduction
A computerized decision-making tool, the Crop Yield Predictor (CYP) has been developed to forecast yields from alternative irrigation schedules and designed to assist irrigators, crop consultants, and extension personnel as they make management decisions. Users of CYP determine soil water status before or during the cropping season and formulate potential schedules of irrigation dates and amounts. Soil water-holding capacity and irrigation system water delivery capacity are constraints on the ability to supply water to the crop. CYP uses a daily soil water balance coupled with computations of evapotranspiration (ET) to predict crop yields from regional yield-ET relationships. Multiple executions of CYP with alternative irrigation schedules lead to schedules that project optimum net economic returns from management scenarios. CYP is an example of adapting a crop simulation model into a decision-making tool.

The CYP program can be downloaded from www.mobileirrigationlab.com.

Description of the Crop Yield Predictor
The CYP was designed as an interactive decision-making tool to predict crop yields and economic returns for deficit irrigated crops. CYP users can designate potential irrigation schedules to optimize yields and net returns. These schedules can be tested for a range of annual precipitation to find yield and income risks from several input scenarios including wet, average, and dry years; different dates and amounts of irrigation events; inclusion or exclusion of pre-season irrigation; different soil types; different irrigation system application efficiencies; or different soil water contents before or during the growing season.

The CYP is structured with a series of tabs and sub-tabs that activate screens for input and output information (Figure 1). The first level of tabs is for General Input and Results. The General Input tab activates a series of sub-tabs, including Location and

[1] Sprout Software, Kansas City, MO.

Rainfall, Soil Information, Irrigation Efficiency, Crop Selection and Irrigation Schedule, and Runoff and Soil Water, that require the user to enter the information needed to execute the program.

The CYP user pre-determines an irrigation schedule by manually entering irrigation amounts on the date of each irrigation event or by importing trial irrigation schedules developed in Excel. CYP can also develop irrigation schedules with uniform frequency of irrigation events between two dates during the growing season. When pumping capacity is the limiting factor, CYP calculates the number of irrigation events that are possible between the starting date and ending dates. When the total irrigation amount controls the schedule, all of the water is applied between the two designated dates with a uniform frequency without regard to the pumping capacity. The uniform frequency schedules can be modified after they are entered into the scheduling table.

The CYP user can enter a value for available soil water (ASW) on any date during the growing season and the daily soil water balance is adjusted from that date forward. If the user does not define an ASW value on the starting date of the growing season, the software generates a default value. Variable costs are needed to estimate the net economic return of each scenario. The CYP user can fill out tables for input costs, operation costs, and irrigation costs or use CYP default costs.

Conclusions

The CYP is an example of translating a crop simulation model into a decision-making tool for those who make irrigation scheduling decisions for deficit irrigation management. CYP uses a simulation model that normally is not accessible by the decision-makers in the field and is a vehicle for technology transfer. CYP has been developed for a specific region, western Kansas, but it demonstrates the type of information needed to execute many crop simulation models. CYP users can ask "what if" questions to find the effects of input variables on outcomes rather than finding optimum solutions without the knowledge of effects of those input variables.

The CYP makes yield predictions with a crop simulation model adapted from the Kansas Water Budget (KSWB) to become an interactive model into which the user can enter a western Kansas location, annual precipitation, soil type, crop type, a potential irrigation schedule, runoff, initial ASW content, crop production costs, and commodity prices to predict effective ET, grain yield, relative grain yield, daily SW content, daily drainage, daily crop ET, and net economic returns. Alternative irrigation schedules and annual precipitation can be entered into CYP to predict changes in results. CYP users can test the effects of input variables on the program outputs. The alternative schedules can guide CYP users in choosing irrigation starting dates ending dates and irrigation frequencies.

Acknowledgments

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

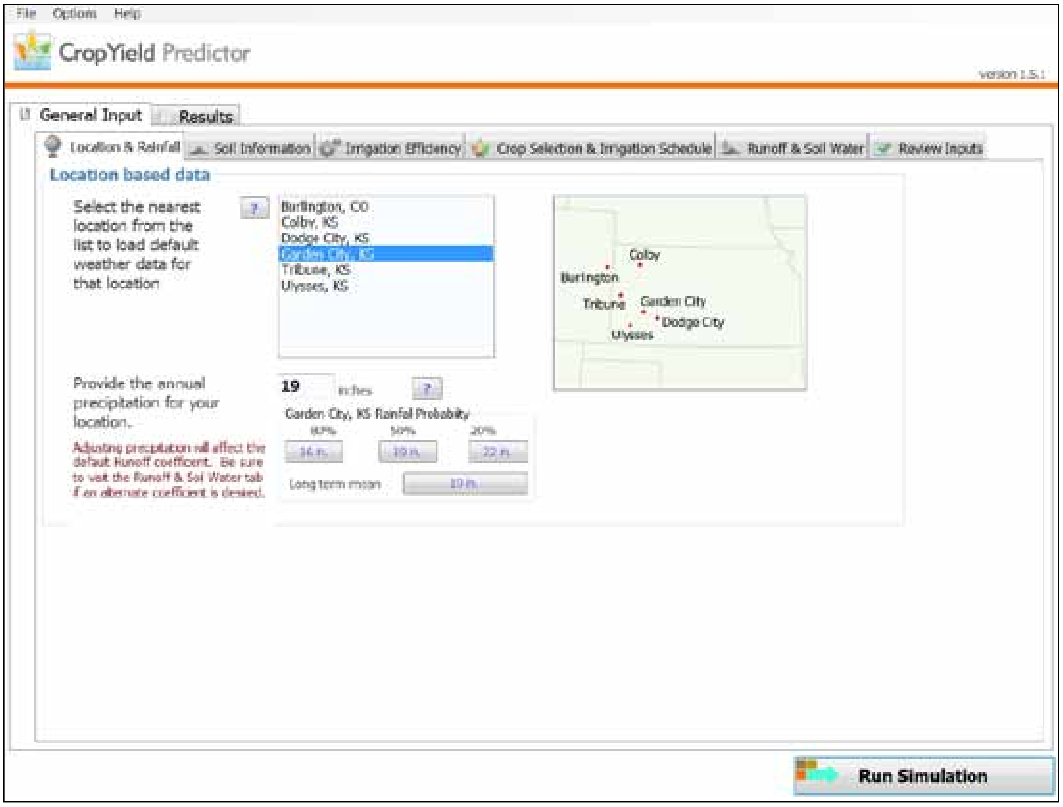

Figure 1. Input screen for location and annual rainfall. Other tabs show screens for additional information needed by CYP.

Crop Selections and Irrigation Allocations for Limited Irrigation: Crop Water Allocator

N.L. Klocke, L.R. Stone, and T. Dumler

Summary
Many irrigators face the prospect that they will not be able to irrigate their crops fully. They are under pressure to develop cropping strategies as pumping capacities dwindle or water supplies become more restricted. Multiple crops in rotation can be an economically viable strategy compared with monoculture when water is limited, but these alternatives need to be evaluated. The Crop Water Allocator (CWA) has been developed for irrigators to allocate limited water among selected crops. CWA calculates net economic returns from all possible combinations of crops and irrigation allocations among crops then ranks the net returns from maximum to minimum values. Users also can account for net return shifts in response to a range of input variables such as rainfall, production costs, commodity prices, irrigation costs, irrigation efficiency, and maximum yields. The CWA is an example of transferring research-based technology to cropping decisions for limited irrigation.

The CWA program can be downloaded from www.mobileirrigationlab.com.

Introduction
The Crop Water Allocator (CWA) is an example of translating a crop simulation model into a decision-making tool for those who make crop rotation and irrigation allocation decisions for limited irrigation management. The CWA has been developed for a specific region, western Kansas, but it demonstrates the type of information needed to execute many crop simulation models. CWA can ask "what if" questions to find the effects of input variables on yield net return outcomes rather than finding optimum solutions without knowledge of the effects of various input variables.

Description of the Crop Water Allocator
The CWA has been developed to assist irrigators in evaluating an array of crop rotations and water allocations to each crop. It is an agronomic and economic model that predicts the net economic returns from all possible crop and irrigation combination. The user needs to enter input values for the execution of CWA: geographic location, soil type, irrigation costs, irrigation application efficiency, annual precipitation, annual irrigation amount, land split, commodity price, and maximum yield (Figure 1).

Net return to land, management, and irrigation equipment is:

$$(\text{Crop price} \times \text{Crop yield}) - (\text{Production costs}) - (\text{Irrigation costs})$$

Crop production costs can come from the CWA user or from the software's internal default production costs from Kansas State University's agricultural economists (www.agmanager.info).

The CWA determines crop yields from irrigation and precipitation (11 to 24 in.) for alfalfa, corn, soybean, grain sorghum, wheat, and sunflower. The data for the yield vs.

irrigation and precipitation were developed from field research plots using conventionally tilled management in western Kansas. CWA assumes that farming practices are carried out with good crop management in dryland, limited irrigation, and full irrigation, and that production inputs other than irrigation do not limit yields. The yield relationships with irrigation that are the foundation for the model are based on research and management practices in "best management" crop production. Crop management that does not meet best management practices criteria will not achieve the predicted results of CWA.

The user of CWA can choose a rotation scheme for five possible land splits: 50%-50%, 75%-25%, 33%-33%-33%, 50%-25%-25%, or 25%-25%-25%-25%. The user can choose one land split for each execution of CWA or hold land split constant as other inputs are changed. The program will assign every combination of every selected crop to each part of the land split. More crops than land splits can be selected for CWA analysis. One crop may be in more than one part or in all parts of the rotation. CWA then allocates water to each crop in each combination of selected crops for the rotation.

Net return results from all combinations of crops in each part of the rotation and irrigation are "stacked" from maximum to minimum. The user can scroll through approximately 20 of the largest net return results displayed on the output screen. Some of the crop combinations in the rotation may not be feasible for users even though certain crops have more net return than others. For example, soybean in all parts of the rotation would not be feasible because continuous soybean is not recommended.

If the CWA user chooses to evaluate the net returns in a range of an input variable such as commodity prices, production costs, irrigation costs, maximum crop yields, precipitation, or irrigation system efficiency, multiple executions of CWA will produce a range of net returns. The output of multiple executions will indicate the income risk when an input varies. The trend processing feature of CWA automates multiple executions to obtain ranges of net returns from user-chosen ranges of these input variables. For example, the program user may be interested in the net returns if the price of two crops varies. CWA executes a series of calculations over the range of each crop's price and produces a two-way table of net returns in an Excel spreadsheet.

Conclusions

The Crop Water Allocator (CWA) has application for those producers who have limited water supplies that are not sufficient to fully irrigate crops such as corn and alfalfa, which have high economic returns. The major question in these situations is whether other crops with lower water needs should be brought into rotation with corn. Commodity prices, production costs, and yield potential are important factors for answering this question. In addition to choosing combinations of crops for rotation, decisions about how much water to apply to each crop comes into play. For example, corn needs to be irrigated to full yields because of the high economic return whereas other crops in the rotation such as sorghum and wheat can receive limited water and still respond well.

Producers, crop consultants, a banker, extension agents, extension crops specialists, NRCS personnel, and Groundwater Management District professionals received training to operate CWA and then evaluated its strengths, weaknesses, and needed features. The users responded positively and said that CWA was straightforward, user-friendly, and helped answer important questions. Their input led to modifications and improvements in CWA.

Acknowledgments

This research was supported in part by the Ogallala Aquifer Program, a consortium among USDA-Agricultural Research Service, Kansas State University, Texas AgriLife Research, Texas AgriLife Extension Service, Texas Tech University, and West Texas A&M University.

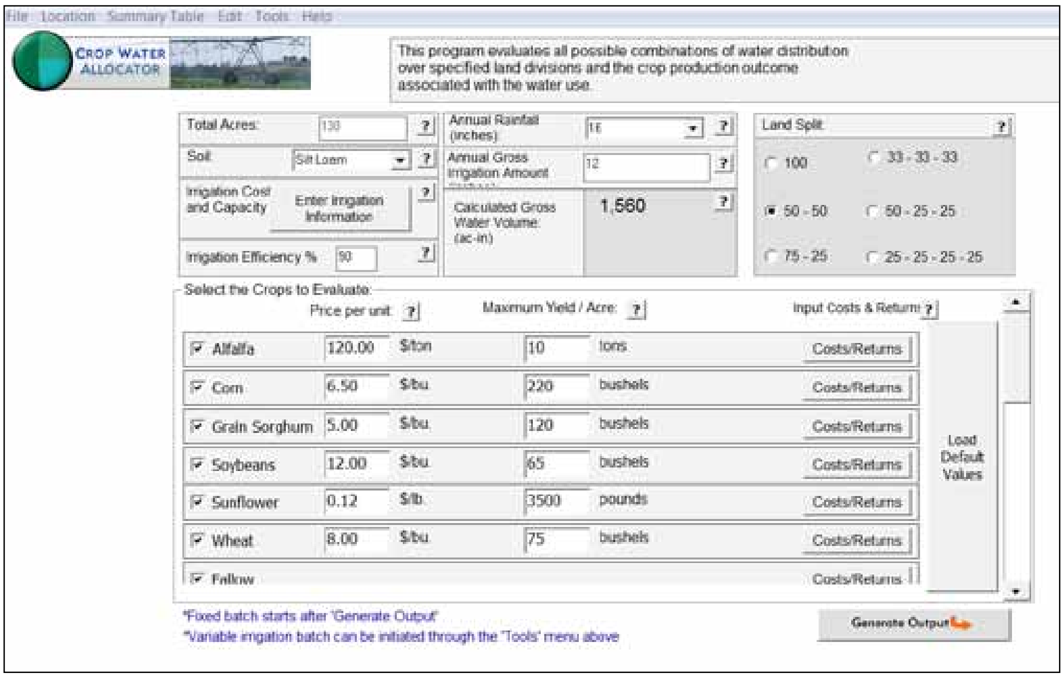

Figure 1. User input screen for the Crop Water Allocator.

Dormant Season Precipitation Capture and Soil Water Evaporation with Crop Residues

N. Klocke, R. Currie, and L. Stone[1]

Summary
Irrigators need crop residue management strategies using no-till practices to make the best use of precipitation during the dormant season between crops. In our study of crop residues and irrigation, wheat and corn roots apparently grew deeper into the soil during the growing season to extract more soil water in deficit-irrigated treatments than in fully irrigated treatments. During the following dormant season more water accumulated following the deficit-irrigated corn than the fully irrigated crop. However, soil water accumulations in wheat stubble during the dormant season were the same across the irrigation treatments. Soil water evaporation was the same across irrigation treatments in corn and wheat stubble, possibly due to the extended time between precipitation events.

Introduction
Irrigators need to understand the impacts of accumulated soil water during the dormant season between crops. Tillage systems that leave crop residues have the potential to reduce soil water evaporation before and during the growing season. Crop residues can enhance the capture and retention of precipitation by intercepting snow, reducing runoff, and increasing infiltration. Additional soil water accumulations can be available for crop production; however, drainage during the non-growing season may reduce available soil water during the following growing season. If the irrigator accounts for dormant season soil water storage, water applications can be reduced during the next growing season. Field measurements of dormant season soil water accumulations can help irrigators select crops and strategically plan for the timing of cropping season irrigation schedules. The irrigator needs as much information as possible about the impacts of soil water accumulations on management decisions.

The objectives of this study were to (1) measure soil water during the dormant season between irrigated corn and the next corn crop and between winter wheat and grain sorghum when corn stubble and wheat stubble were left on the surface, (2) determine accumulation of soil water during the dormant seasons and calculate the storage efficiency of precipitation, and (3) calculate soil water evaporation and drainage below the root zone during the dormant season.

Procedures
The study was conducted at the Southwest Research-Extension Center near Garden City, KS. The soil type was Ulysses Silt Loam with an available water-holding capacity of 2.2 in. of water per ft of soil. Six levels of irrigation were applied to crops in a 5-year rotation of corn-corn-wheat-sorghum-sunflower. Irrigation treatments were replicated 4 times within each crop in a randomized complete block design. Soil water content was measured to the depth of 6 ft with the neutron attenuation method during the dormant

[1] Kansas State University Department of Agronomy.

seasons between corn and the next corn crop and between wheat and grain sorghum (2005–2006, 2006–2007, 2007–2008, 2008–2009, and 2009–2010). Corn was harvested from September 22 to October 6 over the five years and wheat was harvested from June 19 to July 1. Soil water accumulations during the dormant season were calculated from the differences in soil water contents from harvest of the previous crop and planting of the next crop. Soil water storage efficiency during the dormant season was calculated as the ratio of soil water accumulations to precipitation. Drainage was calculated with an exponential function of soil water content that was calibrated for the Ulysses silt loam soil at the study location. Soil water evaporation (E) was calculated with the following equation:

$$\text{Evaporation} = \text{Precipitation} - \text{Soil water gain} - \text{Drainage}$$

Results and Discussion

Corn was irrigated with three amounts of irrigation (Table 1). Corn with the most irrigation (11 in. averaged over 5 years) was managed for full production, which required that no more than 50% of available water in the top 4 ft of soil was removed before irrigation occurred. This irrigation management is consistent with current best management practices. The other two irrigation treatments caused the crop to experience water deficits. Soil water measurements started after corn harvest (October 1) and ended before corn was planted the following spring (April 22), which was designated as the dormant period. Precipitation during the dormant period was 8.5 in., averaged over the 5 years of the study. Available soil water was defined as the percentage of the soil water held between field capacity and permanent wilting. Available soil water after corn harvest decreased as irrigation decreased, indicating that the roots extended deeper into the soil (data not shown) and extracted more water in the drier plots. Available soil water and storage efficiency, the ratio of gained soil water and precipitation, decreased as irrigation in the prior crop decreased, but drier plots showed somewhat more gain. Drainage was a minor factor for all levels of irrigation, but decreased with decreasing irrigation. Minimal drainage indicated that irrigation management was appropriate in the fully irrigated plots. Soil water evaporation was the same across irrigation treatments even though dry matter yields, which became the residue on the surface, decreased with irrigation. The consistency in evaporation amount showed that residue quantity was not the only controlling factor. Apparently, significant precipitation events were infrequent enough that soil characteristics, the ability of water to migrate to the surface, also influenced evaporation.

Evaluation of the dormant period between wheat harvest and the following grain sorghum crop followed the same research protocols, measurement techniques, and data interpretations as the dormant period for corn stubble (Table 1). The first measurements of soil water occurred on June 21 and the last measurements on May 6. The duration of the dormant season after wheat was longer than after corn, so precipitation, soil water gain, drainage, and total evaporation cannot be compared directly between the two residue types. Available soil water after wheat harvest and before sorghum planting decreased with less irrigation in the wheat, but the beginning available soil water was less and ending soil water was more than in the corn. Wheat had the ability to extract more soil water than corn and had more time to accumulate soil water in the wheat stubble. In addition, there was more room to store water in the soil following wheat. Storage efficiency between the corn and sorghum was similar. Evaporation rate (E/day) was more in the wheat stubble than the corn stubble, but evaporation occurred during the summer in wheat stubble when the corn crop was growing. The consistency of total evaporation across wheat stubble amounts also indicated that soil characteristics were factors in dormant season results.

Table 1. Dormant season results

Crop	Irrigation[1]	Precipitation[2]	Dry matter[3]	ASW[4]	ASW[5]	SW gain[6]	Storage efficiency[7]	Drainage[8]	Evaporation[9]	Days[10]	Evaporation/ day[11]
	in.	in.	tons/a	%	%	in.	%	in.	in.		in./day
Corn stubble	11	8.5	4.19a	50.1a	79.0a	3.7b	43.4	0.082a	4.73a	276	0.023
	6	8.5	3.34b	26.0b	59.9b	4.3a	50.9	0.002b	4.17a	276	0.020
	3	8.5	2.97c	18.1c	49.5c	4.0ab	47.1	0.000b	4.5a	276	0.022
	LSD (0.05)		0.318			0.59		0.015	0.55		
Wheat stubble	8	12.4	4.30a	39.5a	87.5a	6.1a	49.6	0.204a	6.02a	314	0.029
	4	12.4	3.59b	22.5b	73.9b	6.6a	53.1	0.095b	5.7a	314	0.028
	2	12.4	3.05c	20.5c	69.9c	6.3a	51.1	0.106b	5.95a	314	0.029
	LSD (0.05)		0.428			0.5		0.088	0.5		

[1] Irrigation on the previous crop.
[2] Dormant season precipitation, including snow.
[3] Plant dry matter, excluding grain left as surface residue.
[4] First available soil water (ASW) measurement after harvest (6 ft soil profile).
[5] Last available soil water (ASW) measurement before planting next crop.
[6] Soil water gained during the dormant season (6 ft soil profile).
[7] Soil water storage efficiency (soil water gain/precipitation).
[8] Drainage below 6 ft of soil during the dormant season.
[9] Soil water evaporation during the dormant season.
[10] Number of days during the dormant season.
[11] Average daily soil water evaporation during the dormant season.
Values with the same letter in the same column and within the same section are not significantly different for P=0.05.

Prowl Tank Mixes for Grass Control in Sorghum

R. Currie

Summary
All tank mixes of Prowl with preemergence compounds produced greater than 90% control of crabgrass and foxtail. Treatments of Prowl applied while sorghum was emerging (spike stage) produced no injury as seen from visual observation and plant height measurements. In contrast, treatments containing Prowl applied to sorghum that was 12 in. (30 cm) tall had significant height reductions compared to the control and spike treatments. Tank mixes of Verdict followed by spike applications of Prowl had the highest grain yield.

Introduction
Early preemergence applications of Prowl on sorghum are only labeled for use east of the Mississippi River, within a few states and areas adjacent to the Missouri river, and in the state of Arizona. The current study at Garden City, KS, was conducted to explore the possibility of expanding the coverage of this label to western states.

Procedures
To produce a robust weedy grass population, the entire plot area was seeded to winter wheat blended with green foxtail seed in the fall of 2006. After wheat harvest in 2007, the entire plot area was kept free of broadleaf weeds with applications of 2,4-D and dicamba. Early in 2008, the area was in fallow; light tillage and applications of 2,4-D were utilized as needed to produce a dense stand of green foxtail. The entire plot area was planted to winter wheat in the fall of 2008. On May 17, 2008, the wheat was terminated with a 1 qt/a application of glyphosate 30 days prior to planting sorghum. Sorghum was planted without tillage on June 9 at a rate of 40,000 kernels/a. Preemergence herbicide applications were applied immediately after planting followed by a 1-in. sprinkler irrigation to ensure uniform emergence. Within 6 days of any herbicide application, 1 in. of irrigation water was applied with the sprinkler system to ensure herbicide incorporation. Sorghum was irrigated as needed to simulate a good dryland crop for this region. Experimental design was a randomized complete block with four replications

Results and Discussion
Foxtail and crabgrass were predominate weed species, and no postemergence broadleaf compound performed well (Table 1). Low rates of atrazine in these postemergence treatments produced measureable, albeit poor, control on both grass species. All preemergence grass control compounds produced greater than 90% control. Treatments with spike applications of Prowl produced no injury as indexed by visual observation and plant height. In contrast, treatments containing Prowl applied to 12-in. sorghum had significant height reductions compared to the control and spike treatments. Tank mixes followed by spike applications of Prowl had the highest grain yield. This yield was significantly higher than some standard treatments. These results represent only one location and one year, but they strongly suggest that further work is needed on the timing and use of Prowl in grain sorghum.

Table 1. Effects of 12 herbicide tank mixes on grass control and sorhum grain yield and quality

Treatment	Rate	Growth stage[1]	Foxtail	Crabgrass	Sorghum height	Grain moisture	Yield
			Days after planting				
			70	55	43		
	oz/a		----------- % control -----------		in.	%	bu/a
Untreated check	0		0	0	30	14	28
Verdict+GMaxL+ATRA	13+19+21	PRE	91	94	27	19	71
Verdict+GMaxL+ATRA	10+19+16	PRE	93	94	30	17	63
GMaxL +Sharpen	44+2	PRE	94	96	30	17	63
Lumax	80	PRE	95	98	32	16	73
BicepL II Magnum	48	PRE	95	96	29	20	71
Sharpen	2	PRE	24	36	29	16	43
Atrazine+Buctril	16+16	Mpost	0	24	30	15	32
Aim+2,4-D+nis	0.5+8	Mpost	0	4	30	12	22
Ally+2,4-D	0.05+8	Mpost	0	0	27	14	21
Verdict+Prowl	10+32	PRE fb spk	95	95	29	17	75
Verdict+Prowl	10+32	PRE fb V3	95	98	29	18	74
Verdict+Prowl	10+32	PRE fb 12 in.	95	95	25	18	73
LSD (P=0.10)			9	18	4	3	9

[1] PRE = applications at planting on June 9, 2010; Mpost = mid-post applied June 22, 2010; fb = followed by; spk = spike applied on June 16, 2010; V3 = V3 growth stage applied on July 2, 2010; 12 in. = sorghum 12 in. tall applied on July 22, 2010.

Efficacy of Foliar Treatments for Managing Dectes Stem Borer in Soybean, 2010

A. Joshi and L. Buschman

Summary
Foliar treatments of insecticides were evaluated for management of the Dectes stem borer in soybean. Fipronil was extremely effective and reduced entry nodes by 87 to 90%, tunneling by 88%, and survival of larvae by 93%. Other treatments such as rynaxypyr and cyazypyr reduced these variables significantly, but not as effectively as fipronil. Fipronil, rynaxypyr, and cyazypyr may be useful technologies for protecting plants from Dectes stem borer, but they are not currently registered for use on soybean.

Procedures
Soybean was machine planted at the Southwest Research-Extension Center at Garden City, KS. Pioneer 93M92, maturity group III, was planted on May 25, and NK 33K5 was planted at the Department of Agronomy Experiment Field at Scandia, KS, on May 28. Plots were 4 rows wide at 30-in. row spacing and 25 ft long with 5-ft alleys (27 ft long with 3-ft alleys at Scandia). Insecticide treatments were applied on July 16 and 28 at Garden City and on July 14 and 29 at Scandia using a CO_2 backpack sprayer with a two-nozzle handheld boom. The sprayer was calibrated to deliver 20 gpa at 30 psi and 1.75 mph walking speed. Dectes stem borer infestation was recorded in late September by dissecting 10 plants per plot. Two groups of five consecutive plants were collected from the center two rows; entry nodes, stem tunneling, and the number of live larvae were recorded. Yield was based on harvesting all four rows and adjusting to 12% moisture. The experiment was a randomized complete block design with four replicates. The ANOVA procedure was used to analyze the data and means were separated using LSD ($P<0.05$). Data transformations did not improve the analysis.

Results
At the end of the season about 78% of plants were tunneled in the check plots at both locations (Tables 1 and 2). Two applications of fipronil gave 87 to 100% control (Tables 1 and 2). At Garden City, single applications of fipronil gave 58 to 64% control for the first application and 75 to 77% control for the second application. At Scandia, single applications of fipronil gave 44 to 49% control for the first application and only 26 to 34% control for the second application. This suggests the treatment timing at Scandia was late. Rynaxypyr and cyazypyr appeared to have some efficacy at Garden City, but at Scandia only the double treatment of rynaxypyr gave a significant reduction in Dectes stem borer variables. The yields were difficult to interpret because the plots with the lowest Dectes stem borer did not have the best yields, but all the treatments that were treated twice tended to have higher yields.

The fipronil foliar treatments were effective in reducing Dectes stem borer survival in soybean plants. Rynaxypyr and cyazypyr appeared to have some promise, but additional work is needed to identify treatment times for Scandia, and higher treatment rates may be necessary.

Table 1. List of chemical treatments and their efficacies against infestation, tunneling activity, and survival of Dectes stem borer in soybean at Garden City, 2010

Treatment/ formulation	Insecticide	Rate/acre	Timing[1]	Entry nodes (number/10 plants)	Stem tunneling (number/10 plants)	Live larvae (number/10 plants)
Check	--	--	--	11.8a	7.8a	7.8a
DPX-HGW86	Cyazypyr	10.1 oz	A	9.8ab	7.5a	7.0ab
Coragen	Rynaxypyr	5 oz	A	7.3ab	3.3bc	3.8b
Calypso	Thiacloprid	4 oz	A	9.8ab	5.5ab	5.3ab
Regent	Fipronil	4.2 oz	A	5.0b	3.0bc	2.8bc
DPX-HGW86	Cyazypyr	10.1 oz	B	8.3ab	5.0b	4.3b
Coragen	Rynaxypyr	5 oz	B	10.3ab	5.8ab	5.5ab
Calypso	Thiacloprid	4 oz	B	16.5a	7.0ab	6.3ab
Regent	Fipronil	4.2 oz	B	3.0b	2.0c	1.8bc
DPX-HGW86	Cyazypyr	10.1 oz	AB	6.8ab	4.0bc	3.8b
Coragen	Rynaxypyr	5 oz	AB	4.8b	2.8bc	2.8b
Calypso	Thiacloprid	4 oz	AB	7.8ab	4.5bc	3.3bc
Regent	Fipronil	4.2 oz	AB	1.0b	0.8c	0.5c
P-value <	-	-	-	0.0001	0.0001	0.0004

[1] Timing of treatments: A, July 16; B, July 28; AB, both July 16 and July 28.
Within column, means without a common superscript are significantly different ($P<0.05$).

Table 2. List of chemical treatments and their efficacies against infestation, tunneling activity, and survival of Dectes stem borer in soybean in Scandia, 2010

Treatment	Insecticide	Rate/acre	Timing[1]	Entry nodes (number/10 plants)	Stem tunneling (number/10 plants)	Live larvae (number/10 plants)	Yield, bu/a
Check	--	--	--	12.8a	7.8a	5.0a	60.3abc
DPX-HGW86	Cyazypyr	10.1 oz	A	10.0a	6.5ab	4.2a	60.1abc
Coragen	Rynaxypyr	5 oz	A	8.8a	5.7ab	3.0ab	63.5bc
Calypso	Thiacloprid	4 oz	A	8.8a	5.8ab	4.0a	64.4bc
Regent	Fipronil	4.2 oz	A	6.8a	4.0bc	2.8ab	59.5ab
DPX-HGW86	Cyazypyr	10.1 oz	B	8.0a	6.5ab	4.5a	65.2bc
Coragen	Rynaxypyr	5 oz	B	9.0a	5.0ab	3.5a	55.6a
Calypso	Thiacloprid	4 oz	B	9.0a	5.5ab	4.0a	63.0bc
Regent	Fipronil	4.2 oz	B	8.8a	5.8ab	3.3a	62.4bc
DPX-HGW86	Cyazypyr	10.1 oz	AB	9.5a	6.5ab	5.0a	66.4c
Coragen	Rynaxypyr	5 oz	AB	8.3a	4.5b	3.3a	64.1bc
Calypso	Thiacloprid	4 oz	AB	8.8a	6.3ab	5.3a	62.3bc
Regent	Fipronil	4.2 oz	AB	1.0 b	1.0c	0.0b	65.2bc
P-value <	-	-	-	0.0739	0.0229	0.0004	0.0498

[1] Timing of treatments: A, July 16; B, July 28; AB, both July 16 and July 28.
Within columns means with common letters are not significantly different ($P<0.05$).

Winter Canola: Potential Pests and Monitoring Methods

A. Joshi, L. Buschman, and J. Holman

Summary
This year the diamondback moth catch was nearly twice that of the same period the previous year (716 vs. 441). Diamondback moths, aphids, false chinch bugs, and lygus bugs appear have the potential to become economic pests of canola grown in Kansas. High populations of lygus bugs, false chinch bug, cabbage worm, and thrips occur in mid-June and can probably be avoided by early harvest. Successful canola production will require insect pest management by careful scouting and precise timing of treatments.

Introduction
Winter canola could become a new crop in the southern Great Plains and this potential has captured the interest of growers and researchers. Canola is an oilseed crop that can be grown for cooking oil or bio-diesel, and it has value as a protein supplement for livestock. Canola also offers agronomic diversity in the cropping system and allows the use of herbicides that can control weedy grasses in the winter cropping system. Winter canola also has a yield advantage over spring canola because the flowering stage escapes some of the high summer temperatures. Agronomic trials have been initiated in Kansas to evaluate various factors limiting canola production in the region. This survey was conducted to identify potential insect pests of canola in Kansas.

Procedure
Canola seed (KS9135) was planted using a Fabro planter (5 lb/a, 8-in. row spacing) on September 11, 2009, at the Southwest Research-Extension Center at Garden City, KS. Daily and weekly average air temperatures were recorded by a weather station at the research site.

This insect pest survey focused on diamondback moth (DBM; *Plutella xylostella*), but other insect pests were recorded when present. Six canola plants (> 4 ft tall, early pod stage) were randomly pulled from each plot on June 3, 2010, and placed in large 76-liter Berlese funnels. The alcohol samples were filtered on ruled white filter paper and a binocular microscope was used to record insect numbers and species. A DBM pheromone wing trap was installed October 26, 2009, in the canola field. Trap bottoms were replaced weekly and pest numbers recorded. The pheromone lure (Pherocon CAP, Trece Inc., Adair, OK) was installed October 26 2009. The trap bottoms were replaced weekly and the lure was replaced every 3 weeks. Traps were maintained until canola was harvested in July 2010. Yellow sticky cards (3 × 5 in.) attached to wire flags were installed in four different plots of canola. These traps were maintained and cards were replaced weekly between March 15 and June 25, 2010, and insect numbers and species were recorded. Glue boards (7 × 9 in., commonly used for pheromone wing traps) were pinned to the ground at four different locations to record ambulatory insects. They were maintained and monitored for three weeks from June 7–25, 2010.

Result and Discussion

A total of 716 DBM were collected in the pheromone traps with a peak catch of 161 moths on June 7, 2010 (Table 1). During the winter of 2008–09, the presence of DBM was continuously detected, albeit at a low level (Figure 1). However, during this winter the pheromone trap did not register the presence of DBM (Figure 1). The DBM catch in 2010 was nearly twice that in the previous year (716 vs. 441). Colder temperatures were observed during the winter of 2009–10 compared to the previous year (Figure 1). Freezing air temperatures during the winter may explain the absence of DBM activity in the field. Our two years of data show that overwintering DBM adults become active at the beginning of April when temperatures warm to highs in the 40s (°F). During both years the first flight (peak) was observed in the second week of May when average air temperature reached the 60s, and highest numbers were recorded in mid-June when temperature reached the 70s. Higher temperatures in April explain higher numbers of DBM in spring 2010. Clearly, DBM have multiple generations during the season, as demonstrated by the many different peaks (Figure 1). The period between the peaks may vary depending on the temperatures; however, 4 weeks seemed to be an average period. This information will be useful to determine the timing for treatment applications that target the DBM population in larval stages.

We recorded a mixed population of turnip (*Lipaphis erysimi*) and cabbage aphids (*Brevicoryne brassicae*), 19 aphids per stem. In 2009, aphid infestations were heavy (519/plant; see "Insect Pests of Winter Canola in Kansas," Report of Progress 1034, p. 55–56). We also detected cabbage worms (1.8 larvae/plant) in the field 2 weeks before population damage was noticed. Harlequin bugs (*Murgantia histrionica*) were observed in canola during the spring of 2008 but not in 2009 or 2010. Crucifer flea beetles (*Phyllotreta* spp.) were noted only occasionally. In 2010, the pest pressure from aphids, lygus bugs, FCB, and thrips was very low during early stages of canola growth. When peak populations of lygus bugs, false chinch bug, cabbage worm, and thrips occur during bloom and early pod fill, canola yield can be reduced, but pest pressure that develops during mid-June can be avoided by early harvest.

Yellow sticky cards were effective for monitoring more insects than any other method we tried. Most insects on the cards were collected June 7–25. Pheromone traps were effective in monitoring DBM population. The Burlease funnels were effective in recording aphid populations and in early detection of the cabbage worms (2 weeks before defoliation was observed). Glue boards pinned to the ground failed to record anything of importance until the third week (June 20–25), when the lygus bugs appeared and 217 adults were recorded per glue board.

Currently, DBM, aphids, FCB, and lygus bugs appear to have potential as economic pest pests on canola in Kansas and warrant further studies. Successful management of canola pests will require careful selection of scouting methods, continuous monitoring, and precise timing of treatments.

Table 1. Total number of insects and species as registered by different scouting methods in winter canola, 2009–2010

Scouting method	DBM	Lygus	Aphid	False chinch bugs	Cabbage worm	Thrips	Flea beetles
Pheromone trap[1]	716	-	-	-	-	-	-
Yellow sticky card[2]	44	30	21	835	-	777	38
Glue boards[3]	-	217	-	-	-	-	-
Burlese funnel[4]	1.2	-	39	-	1.8	31.6	-

[1] Pheromone wing trap for DBM was installed October 26, 2009, and was maintained until canola was harvested in July 2010.
[2] Yellow sticky cards (3 × 5 in.) attached to a wire flag were maintained from March 15 to June 25, 2010.
[3] Glue boards (7 × 9 in., commonly used for pheromone wing traps) were pinned to ground and were maintained from June 14–25, 2010, to record ambulatory insects.
[4] Six canola plants from each plot were placed in a large 76-liter Berlese funnels on June 3, 2010, to detect pest number and species.

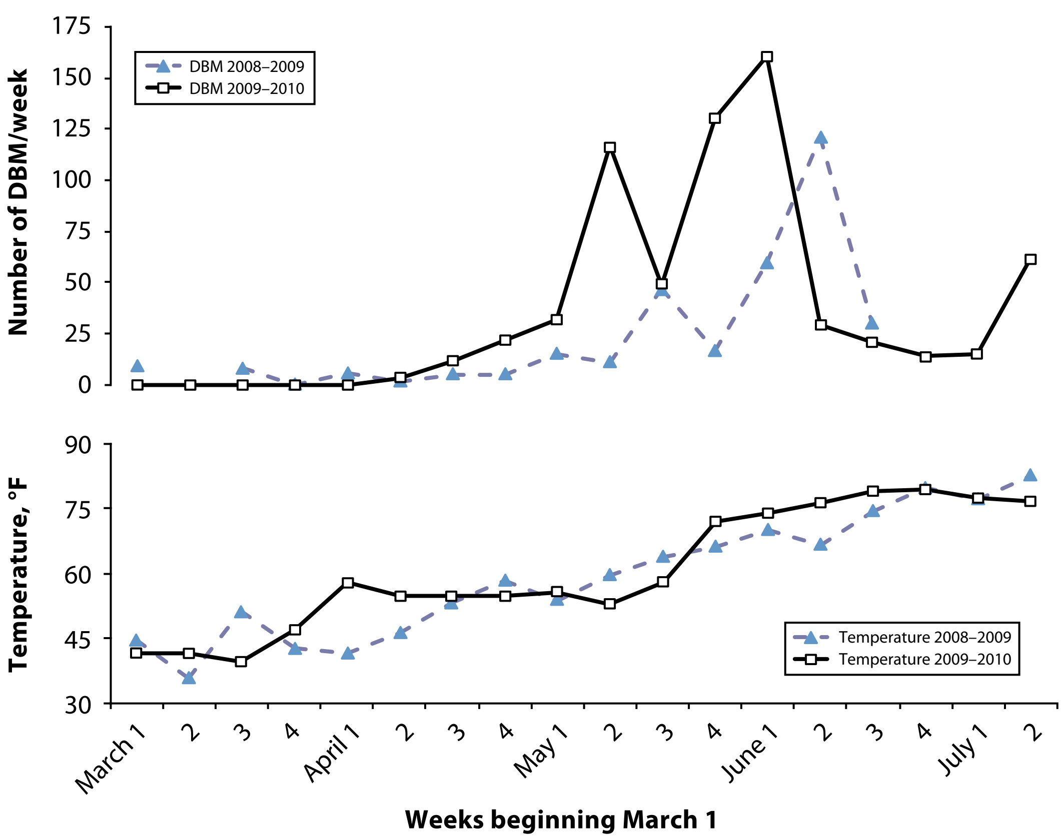

Figure 1. Population of diamondback moth (DBM) monitored weekly using pheromone traps and daily averages of ambient temperatures from September 1 to July 1 for two years (2008–09 and 2009–10).

Efficacy of SmartStax Corn Hybrids on Corn Earworm

L. Buschman and A. Joshi

Summary
SmartStax (GENSS) gave excellent control of corn earworm (CEW) (88%) with significant suppression of larval development and 100% protection of corn ears. Other events gave fair control of CEW (44 to 56%). Early planting gave better yields than later planting, but differences were not significant.

Procedures
Corn seed (supplied by Monsanto) was planted on May 24 and June 8, 2010, in corn stubble under a center pivot irrigation system at the Southwest Research-Extension Center (Field 34N) in Finney County, KS. Four varieties with different combinations of transgenic traits ("events") were planted with four replications and two planting dates in a split-plot design. Plots were eight rows (20 ft) wide and 40 ft long with a four-row (10-ft) border of untreated corn on each side and a 10-ft alley at each end.

Ear damage was recorded on August 3 (reps 1 and 2) and August 6 (reps 3 and 4) only in the early planting. Ten ears were collected randomly from rows 2 and 7 (non-yield rows; 20 ears total), and the number of CEW, their instars, and ear tip damage (in cm) was recorded. Harvest plant population and gaps were recorded on October 4, 2010. Yield data were collected from the four center rows (3 to 6) on October 6 (reps 1 and 2) and October 14 (reps 3 and 4). Yield data were corrected for moisture and missing row-ft. Yield was analyzed as a two-factor ANOVA with four treatments and two planting dates. The CEW variables (one planting date) were analyzed as a Randomized Complete Block Design ANOVA. All means were separated by Fisher's protected LSD ($P \leq 0.05$).

Results and Discussion
All Bt hybrids (treatments 2, 3, and 4) gave significant reduction of CEW (44 to 88%; Table 1). However, SmartStax (GENSS) gave the best control of CEW (88%) as evidenced by suppression of larval development and protection (100%) from corn ear damage. European and southwestern corn borer pressure in the ears was too low to make meaningful conclusions. No western bean cutworms were found in treatments 3 and 4, but a few were found in treatments 1 and 2.

Yield was significantly higher for the early planting (Table 1). Yield was higher for the Bt hybrids (lower corn earworm damage), but not significantly higher (Table 1). Plant populations varied widely across the experiment.

Table 1. Corn earworm infestation and related ear damage recorded on August 3 from a set of 20 ears, and yield recorded October 6, Garden City, 2010

Treatment	Treatment/hybrid	Trade name	Planting date	Corn earworm	CEW instar	Ear tip damage	Damaged ears	Yield
				number/ear		cm/ear	%	bu/a
1	NE5723HTT1	CK[1]		1.6a	3.0a	1.9a	0.8a	142.0
2	DKC57-66	VT3[2]		0.9b	2.1a	0.5b	0.4b	161.8
3	NE5723QQR1	GENSS[3]		0.2c	1.2b	00b	00c	155.7
4	35F44	HXX[4]		0.7bc	2.6a	0.8b	0.4b	154.6
-	P-value <	-	-	0.0007	0.0054	0.0142	0.0031	0.0890
1	Early planting	-	May 24	-	-	-	-	166.7a
2	Late planting	-	June 8	-	-	-	-	140.4b
-	P-value <	-	-	-	-	-	-	0.0001

[1] Non-Bt untreated check, Roundup Ready NK603.
[2] YGVT 3 = YieldGard VT Triple; MON88017 (corn rootworm active) and MON810 (corn borer active).
[3] GENSS = SmartStax; MON 89034 (corn borer and corn earworm active), TC1507 (corn borer active), and MON88017 (rootworm) + DAS59122 (rootworm) + several herbicide events.
[4] HXX = Herculex XTRA; DAS95122 (corn rootworm active), TC1507 (corn borer active), and several herbicide events.
Within columns means followed by the same letter are not significantly different (P<0.05).

Miticide Experiment 1: Efficacy of Miticides Applied at Pre-Tassel Stage for Control of Spider Mites in Corn, 2010

L. Buschman and A. Joshi

Summary
Populations of Banks grass mites (BGM) and twospotted spider mites (TSM) peaked at 488 spider mites per two plants on August 13 (5 weeks after treatment; WAT). The mite population was mainly BGM (94 to 100%) until 3 WAT. The higher rate of Onager (1E) gave consistent control of BGM (up to 90%) until 3 WAT. Oberon gave better control of TSM than other miticides. Populations of TSM and predatory mites were nearly absent at the beginning of the season but slowly increased over the five weeks of the experiment and reached 399 and 49 per two plants, respectively.

Procedures
Field corn, Dyna-Gro 57V07 (113 days to maturity, YGVT3), was planted May 13, 2010, in corn stubble under a center-pivot irrigation system at the Southwest Research-Extension Center (Field 34N) in Finney County, KS. A test with five treatments was set up in a randomized complete block design with four replications. Plots were four rows (10 ft) wide and 50 ft long with a four-row (10-ft) border of untreated corn on each side and a 10-ft alley at each end.

Plots were manually infested with BGM on July 2 by tying mite-infested leaves collected from a cornfield from Seaward County to four plants in each plot, two for each of the two center rows. Treatments were applied July 10 with a high-clearance sprayer with two nozzles directed upward at each row. The sprayer was calibrated to deliver 12 gpa at 2 mph and 30 psi. Crop oil concentrate (COC) was added to each treatment at 1.17% v/v.

Spider mites were sampled by collecting half the leaves from four plants (equal to two plants) near infested plants in each plot. The plant material was then placed in large 76-liter Berlese funnels with 100-watt light bulbs to dry the vegetation and drive arthropods down into collecting jars containing 70% methanol. The alcohol samples were filtered on ruled white filter paper and spider mites and predator mites were counted under a binocular microscope. A subsample of spider mites (about 25) was mounted on a microscope slide. The slides were examined with a phase contrast compound microscope to determine the ratio of BGM to TSM in each plot. Pretreatment spider mite samples were collected July 9, and post-treatment samples were collected July 16 (1 WAT), July 23 (2 WAT), July 30 (3 WAT), and August 13 (5 WAT). Spider mite counts were transformed with Taylor's power transformation for statistical analysis and back-transformed means were used for presentation. Data were analyzed by two-way ANOVA, and means were separated by Fisher's protected LSD ($P \leq 0.05$).

Results and Discussion

In untreated plots, total spider mite populations (BGM and TSM combined) increased through the season and reached a peak of 488 mites per two plants on August 18 (data not shown). Initially the population was 100% BGM, but by August 13 the population was 98% TSM. Overall, the spider mite population pressure during this trial was moderate during grain fill, but mites completely covered the corn plants in some areas during dent stage.

Onager gave significant control of BGM (Table 1). The percentage control for BGM for both rates of Onager was 62 to 79% (Table 1). Oberon gave better control for TSM (Table 2); however, the percentage control was not as high as it was for BGM. This may be due to the long delay between treatment application and the occurrence of TSM population or differential susceptibility of the two species. Unfortunately, we used the 2.25-pt rate rather than the 3-pt rate as is recommended by the manufacturer (Chemtura Corp.) for late-season applications.

Populations of predatory mites were nearly absent at the beginning of the experiment, but they slowly increased in five weeks to 49 per two plants (data not shown). Predatory mite population was a mix of pale predatory mites (*Galendromus* and *Neoseiulus* spp.) and brown predatory mites (*Phytoseiulus* spp.).

Table 1. Number of Banks grass mites (BGM) in the untreated check and the percentage control for BGM in plots treated with miticides, experiment 1; Garden City, 2010

Treatment/ formulation	Insecticide	Rate/acre	July 16 1 WAT[1]	July 23 2 WAT	July 30 3 WAT	August 13 5 WAT	Season total
Untreated check[2]	-	-	29	91	189	8	450
			BGM control, %				
Onager 1E	Hexythiazox	10 oz	69	67	70	00	62
Onager 1E	Hexythiazox	12 oz	83	89	90	00	79
Comite II 6EC	Propergite	2.25 pt	48	34	16	12	16
Oberon 4SC	Spiromesifen	4.25 oz	79	80	66	00	53

[1] WAT = week after treatment. Treatments applied June 10, 2010.
[2] Actual number of Banks grass mites in the check plot that were used to calculate the percentage control for other treatments.
Taylor's power transformation was used for statistical analysis. Back-transformed means are presented here.

Table 2. Number of twospotted spider mites in plots treated with miticides and percentage of their season-long control compared with mite numbers in the untreated check, experiment 1; Garden City, 2010

			Number of twospotted spider mites/2 corn plants			
Treatment/ formulation	Insecticide	Rate/acre	July 30 3 WAT[1]	August 13 5 WAT	Season total	Season-long reduction (%)
Untreated check	-	-	11a	399a	420a	00
Onager 1E	Hexythiazox	10 oz	00b	186b	189b	55
Onager 1E	Hexythiazox	12 oz	00b	133b	138b	68
Comite II 6EC	Propergite	2.25 pt	00b	175b	176b	58
Oberon 4SC	Spiromesifen	4.25 oz	00b	107b	111b	74
P-value <	-	-	0.0057	0.0142	0.0116	-

[1] WAT = weeks after treatment. Treatments applied June 10, 2010.
Within columns, means followed by the same letter are not significantly different ($P \leq 0.05$).
No or very low numbers of twospotted mites were recorded until 3 WAT (data not shown).
Taylor's power transformation was used for statistical analysis. Back-transformed means are presented here.

Miticide Experiment 2: Efficacy of Miticides Applied at Tassel and Post-Tassel Stages for Control of Spider Mites in Corn, 2010

L. Buschman and A. Joshi

Summary
Spider mite population peaked at 486 spider mites (Banks and twospotted combined) per two plants on August 4 (3 weeks after treatment; WAT) before declining to 273 5 WAT. The mite population was mainly Banks grass mites (BGM) (84 to 100%) until 3 WAT. Both rates of Oberon 4SC gave good BGM control (77 to 87%). Onager 1E applied at tassel gave some control (52%). Populations of twospotted spider mites (TSM) and predatory mites were nearly absent at the beginning of the season but slowly increased in five weeks and reached 204 and 55 per two plants, respectively.

Procedures
Field corn, Dyna-Gro 57V07 (113 days to maturity, YGVT3), was planted May 13, 2010, in corn stubble under a center-pivot irrigation system at the Southwest Research-Extension Center (Field 34N) in Finney County, KS. A test with ten treatments was set up in a randomized complete block design with four replications. Plots were four rows (10 ft) wide and 50 ft long with a four-row (10-ft) border of untreated corn on each side and a 10-ft alley at each end.

Plots were manually infested with BGM on July 2 by tying mite-infested leaves collected from a cornfield from Seaward County to four plants in each plot, two for each of the two center rows. Treatments 2 through 5 were applied July 16 and 6 through 9 were applied July 30 with a high-clearance sprayer with two nozzles directed upward at each row. The sprayer was calibrated to deliver 12 gpa at 2 mph and 30 psi. Crop oil concentrate (COC) was added to each treatment at 1.17% v/v.

Spider mites were sampled by collecting half the leaves from four plants (equal to two plants) near infested plants in each plot. The plant material was then placed in large 76-liter Berlese funnels with 100-watt light bulbs to dry the vegetation and drive arthropods down into collecting jars containing 70% methanol. The alcohol samples were filtered on ruled white filter paper and spider mites and predator mites were counted under a binocular microscope. A subsample of spider mites (about 25) was mounted on a microscope slide. The slides were examined with a phase contrast compound microscope to determine the ratio of BGM to TSM in each plot. Pretreatment spider mite samples were collected July 14, and post-treatment samples were collected July 21 (1 WAT), July 28 (2 WAT), August 4 (3 WAT), August 11 (4 WAT), and August 18 (5 WAT). Spider mite counts were transformed with Taylor's power transformation for statistical analysis and back-transformed means were used for presentation. Data were analyzed by two-way ANOVA, and means were separated by Fisher's protected LSD ($P \leq 0.05$).

Results and Discussion

Populations of BGM and TSM increased through the season and reached a peak of 486 mites per two plants on August 4 (data not shown). Initially the population was 100% BGM, but by August 18 the population was 86% TSM. Overall, the spider mite population pressure during this trial was moderate during grain fill, but during dent stage mites completely covered the corn plants in some areas.

Both rates of Oberon applied at tassel stage gave early control of BGM and maintained it well WAT5 (77 to 88%; Table 1). Early application of Onager gave significant control of BGM; however, it was a little later and lower than the control given by Oberon. Later treatments of Oberon gave immediate control of BGM at 3 days after treatment (DAT). By August 18 (5 WAT), BGM population was replaced by TSM and the treatment effect shown in Table 1 for 5 WAT may not be accurate. Comite and Capture treatments failed to show significant control of BGM regardless of timing. Unfortunately, we used the 2.25-pt rate rather than the 3-pt rate as is recommended by the manufacturer (Chemtura Corp.) for late-season applications.

Only Oberon treatments gave good control of TSM, whether applied at tassel or post-tassel stage (Table 2). A lower rate of Oberon gave slightly better control (75 to 81%). Other treatment means for TSM failed to separate statistically from the untreated check.

Populations of predatory mites were nearly absent at the beginning of the experiment but they slowly increased over five weeks and reached 55 per two plants (data not shown). Predatory mite populations were a mix of pale (*Galendromus* and *Neoseiulus* spp.) and brown predatory mites (*Phytoseiulus* spp.). Oberon, Onager, and Capture treatments appeared to reduce the populations of pale predatory mites a week before they reduced the brown mites. Also, the treatments appeared to reduce the season total for both predatory mites; however, this result should be interpreted cautiously due to the dramatic shift in host mite populations (BGM and TSM).

Table 1. Number of Banks grass mites (BGM) in the untreated check and the percentage for control in plots treated with miticides, experiment 2; Garden City, 2010

Treatment/formulation	Insecticide	Rate/acre	July 21 (1 WAT)[1]	July 28 (2 WAT)	August 4 (3 WAT)	August 11 (4 WAT)	August 18 (5 WAT)	Season total
Untreated check[2]	-	-	33	82	404	241	9	974
			BGM control, %					
Oberon 4SC	Spiromesifen	4 oz	86	91	92	49	99	77
Oberon 4SC	Spiromesifen	6 oz	60	88	90	71	51	80
Onager 1E	Hexythiazox	10 oz	00	83	62	50	00	52
Comite II 6EC	Propergite	2.25 pt	20	42	45	00	77	21
			-	-	3 DAT[3]	10 DAT	17 DAT	-
Oberon 4SC	Spiromesifen	4 oz	-	-	82	74	100	81
Oberon 4SC	Spiromesifen	6 oz	-	-	86	86	96	87
Comite II 6EC	Propergite	2.25 pt	-	-	45	41	75	55
Capture 2EC	Bifenthrin	5.12 oz	-	-	00	00	00	00

[1] WAT, weeks after treatment.
[2] Actual number of mites in the check plot that were used to calculate the percentage of control for other treatments.
[3] DAT, days after treatment.
Crop oil concentrate was added to treatments at 1.169% v/v. Treatments 2–5 were applied June 16, 2010, and 6–9 were applied July 30, 2010.
Taylor's power transformation was used for statistical analysis and Henderson's correction formula was used to calculate percentage control. Back-transformed means are presented here.

Table 2. Number of twospotted spider mites (TSM) in plots treated with miticides, experiment 2; Garden City, 2010

			Number of TSM per 2 corn plants				
Treatment/ formulation	Insecticide	Rate/acre	August 4 (3 WAT)[1]	August 11 (4 WAT)	August 18 (5 WAT)	Season total	Season-long control, %
Untreated check	-	-	27	14	204 a	318 a	00
Oberon 4SC	Spiromesifen	4 oz	0	22	28 c	62 d	81
Oberon 4SC	Spiromesifen	6 oz	0	7	67 abc	99 abcd	69
Onager 1E	Hexythiazox	10 oz	4	16	77 abc	146 abcd	54
Comite II 6EC	Propergite	2.25 pt	0	15	144 ab	294 ab	08
			3 DAT[2]	10 DAT	17 DAT	-	-
Oberon 4SC	Spiromesifen	4 oz	0	29	46 bc	78 cd	75
Oberon 4SC	Spiromesifen	6 oz	0	6	80 abc	92 bcd	71
Comite II 6EC	Propergite	2.25 pt	6	14	100 abc	169 abcd	47
Capture 2EC	Bifenthrin	5.12 oz	2	57	161 a	266 abc	16
P-value <			0.3315	0.9779	0.0577	0.0752	-

[1] WAT, weeks after treatment.
[2] DAT, days after treatment.
Within columns, means followed by the same letter are not significantly different ($P \leq 0.05$).
No or very low number of twospotted mites were recorded until 3 WAT (data not shown).
Crop oil concentrate was added to treatments at 1.169% v/v. Treatments 2–5 were applied June 16, 2010, and 6–9 were applied July 30, 2010.
Taylor's power transformation was used for statistical analysis. Back-transformed means are presented here.

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