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FIELD DAY 2010

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Kansas State University
Research and Extension

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

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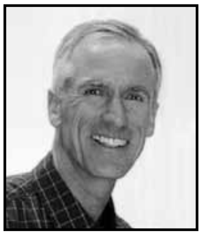

Robert (Bob) Gillen, *Research Center Head*
B.S., Colorado State University
Ph.D., Oregon State University

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

Phil Sloderbeck, *Interim Southwest Area Extension Director*
M.S., Purdue University
Ph.D., University of Kentucky

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

Debra Bolton, *Extension Specialist, Family and Consumer Sciences*
B.S., English, St. Mary of the Plains College
M.S., Fort Hays State University

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

Larry Buschman, *Entomologist*
M.S., Emporia State University
Ph.D., University of Florida

Larry joined the staff in 1981. His research includes studies of the biology, ecology, and management of insect pests, with emphasis on pests of corn, including spider mites.

Rod Buchele, *Extension Specialist, 4-H Youth Development*
B.S., Economics, Iowa State University
M.S., Guidance and Counseling, University of Wisconsin-Platteville

Rod joined the staff in fall of 2003 from Colorado State University Cooperative Extension. He previously held positions with University of Florida Cooperative Extension and University of Wisconsin Extension, all in 4-H Youth Development.

Randall Currie, *Weed Scientist*
B.S., Kansas State University
M.S., Oklahoma State University
Ph.D., Texas A&M University

Randall joined the staff in 1991. His research focus is on weed control in corn.

Troy Dumler, *Extension Agricultural Economist*
B.S., M.S., Kansas State University

Troy joined the staff in 1998. His extension program focuses primarily on crop production and machinery economics.

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Contents

2010 Southwest Research-Extension Center Staff

Robert Gillen	Head
Phil Sloderbeck	Interim Area Extension Director
Conall Addison	Instructor Emeritus
Debra Bolton	Extension Specialist, Family and Consumer Sciences
Dewayne Bond	Assistant Scientist
Rod Buchele	Extension Specialist, 4-H Youth Development
Larry Buschman	Corn Entomologist
Randall Currie	Weed Scientist
Troy Dumler	Extension Agricultural Economist
Jeff Elliott	Research Farm Manager
Gerald Greene	Professor Emeritus
Lucas Haag	Assistant Scientist, Tribune
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Johnathon Holman	Assistant Professor
Kurt Hudson	Assistant Scientist
Ankush Joshi	Assistant Scientist
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Charles Norwood	Professor Emeritus
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Justin Waggoner	Extension Specialist, Animal Production
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Ramon Servantez	Plant Science Technician II
Jeff Slattery	Plant Science Technician II, Tribune
Monty Spangler	Agricultural Technician
Dennis Tomsicek	Plant Science Technician II

Southwest Research-Extension Center
4500 East Mary, Bldg. 947
Garden City, KS 67846
Phone: 620-276-8286
Fax: 620-276-6028

2009 Weather Information for Garden City

J. Elliott

Precipitation for 2009 totaled 21.68 in. This was 2.89 in. above the 30-year average of 18.79 in. Rainfall was timely for the summer crops. April, June, and July received above-average rainfall. Above-normal precipitation in September and October aided fall wheat seeding. The largest daily rainfall was 1.91 in. of hard rain with considerable runoff on June 14. Pea- to dime-size hail and some crop damage were recorded on July 17, and nickel-size hail fell on September 7.

Measurable snowfall occurred in January, March, November, and December 2009. Annual snowfall totaled 15.5 in.; the 30-year average is 19.5 in. The largest snowfall event was 6.0 in. recorded on March 27. Seasonal snowfall (2008–2009) was 12.8 in. Open-pan evaporation from April through October was 60.6 in., which is 10.0 in. below the 30-year average. Average daily wind speed was 4.63 mph; the 30-year average is 5.25 mph.

In 2009, December was the coldest month and July was the warmest month. February and November were considerably warmer than average. October and December were considerably cooler than average. The annual mean temperature was 53.0°F, which is similar to the 30-year average of 53.1°F.

Two record high temperatures were set in 2009: 78°F on February 7 and 96°F on October 1. The record low temperatures were 28°F on October 3 (2 days after setting a record high) and 25°F on October 10. Triple-digit temperatures were observed on 14 days in 2009; the highest temperature, 102°F, was recorded on July 10, 12 and 15 and August 4. Subzero temperatures were noted on 3 consecutive days starting December 9, and the lowest temperature, -11°F, was recorded on December 10.

The last spring freeze was 23°F on April 11, which is 16 days earlier than the 30-year average. The first fall freeze was 28°F on October 3, which is 8 days earlier than the 30-year average. This resulted in a 175-day frost-free-period, which is 8 days longer than the 30-year-average.

A summary of the 2009 climate information for Garden City is presented in Table 1.

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

			Monthly temperatures									
			2009 avg.				2009 extreme		Wind		Evaporation	
Month	Precipitation		Max	Min	Mean	30-year avg.	Max	Min	2009	30-year avg.	2009	30-year avg.
	--------in.--------		------------------------------°F------------------------------						-------mph-------		--------in.--------	
Jan.	0.06	0.43	49.9	15.5	32.7	28.4	72	4	4.85	4.68	—	—
Feb.	0.07	0.48	58.4	19.0	38.7	33.7	78	7	4.86	5.39	—	—
Mar.	1.15	1.38	60.4	26.9	43.6	42.3	83	9	6.46	6.72	—	—
Apr.	4.36	1.65	65.4	35.7	50.5	52.1	90	17	6.50	6.73	6.46	8.35
May	1.84	3.39	74.3	48.1	61.0	62.0	91	39	4.91	6.04	9.54	9.93
June	3.70	2.88	87.8	58.6	73.2	72.4	101	44	3.72	5.59	10.07	12.32
July	3.16	2.59	92.7	62.2	77.5	77.4	102	55	3.23	4.85	12.48	13.41
Aug.	2.21	2.56	89.3	60.2	74.7	75.5	102	51	4.35	4.17	10.96	11.19
Sept.	1.58	1.25	78.5	51.5	65.0	67.0	92	38	3.56	4.63	6.79	8.88
Oct.	2.95	0.91	59.5	35.1	47.3	54.9	96	25	4.67	4.84	4.30	6.52
Nov.	0.39	0.86	60.3	30.7	45.5	40.5	83	19	3.82	4.86	—	—
Dec.	0.21	0.41	39.5	12.9	26.2	31.3	62	-11	4.62	4.47	—	—
Annual	21.68	18.79	68.0	38.0	53.0	53.1	102	-11	4.63	5.25	60.60	70.60

Normal latest spring freeze (32°F): April 26. In 2009: April 11.
Normal earliest fall freeze (32°F): Oct. 11. In 2009: Oct. 3.
Normal frost-free period (>32°F): 167 days. In 2009: 175 days.
30-year averages are for the period 1971–2000. All recordings were taken at 8:00 a.m.

2009 Weather Information for Tribune

D. Bond and D. Nolan

Total yearly precipitation was 17.28 in., which is 0.16 in. below normal. Six months had below-normal precipitation. June (2.83 in.) was the wettest month. The largest single amount of precipitation was 1.12 in. on July 30. January was the driest month (0.30 in.). Snowfall for the year totaled 24.7 in.; January, March, November, and December had 4.0, 7.5, 6.5, and 6.7 in., respectively, for a total of 17 days of snow cover. The longest consecutive periods of snow cover, 5 straight days, occurred from January 24 through 28 and December 8 through 12.

Record high temperatures were recorded on 4 days: January 23 (73°F), March 4 (79°F), March 5 (82°F), and November 7 (83°F). A record high temperature was tied on March 7 (76°F). Record low temperatures were recorded on 3 days: April 7 (15°F), October 10 (21°F), and October 11 (20°F). July was the warmest month with a mean temperature of 75.7°F. The hottest days of the year (102°F) were June 26 and August 4 and 24. The coldest day of the year (-11°F) was December 10. December was the coldest month with a mean temperature of 26.1°F.

Mean air temperature was above normal for 6 months. February had the greatest departure above normal (6.2°F), and October had the greatest departure below normal (-7.0°F). Temperatures were 100°F or higher on 8 days, which is 2 days below normal. Temperatures were 90°F or higher on 55 days, which is 7 days below normal. The latest spring freeze was April 18, which is 18 days earlier than the normal date, and the earliest fall freeze was October 2, which is 1 day earlier than the normal date. This produced a frost-free period of 167 days, which is 17 days more than the normal of 150 days.

Open-pan evaporation from April through September totaled 66.21 in., which is 4.44 in. below normal. Wind speed for this period averaged 4.4 mph, which is 1.1 mph less than normal.

A summary of the 2009 climate information for Tribune is presented in Table 1.

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

	Precipitation		Monthly temperatures: 2009 avg.		Monthly temperatures: Normal		Monthly temperatures: 2009 extreme		Wind		Evaporation	
Month	2009	Normal	Max	Min	Max	Min	Max	Min	2009	Normal	2009	Normal
	----------in.---------		------------------------°F------------------------						-------mph-------		----------in.----------	
Jan.	0.30	0.45	48.6	18.0	42.2	12.8	73	1	—	—	—	—
Feb.	0.46	0.52	56.4	21.7	48.5	17.1	73	8	—	—	—	—
Mar.	0.93	1.22	59.6	25.2	56.2	24.2	82	6	—	—	—	—
Apr.	2.17	1.29	63.3	34.3	65.7	33.0	88	15	5.8	6.3	6.71	8.28
May	1.00	2.76	74.5	47.4	74.5	44.1	91	35	4.9	5.8	13.00	10.88
June	2.83	2.62	85.2	56.5	86.4	54.9	102	43	3.7	5.3	12.51	13.88
July	2.22	3.10	91.4	60.1	92.1	59.8	100	54	4.1	5.4	14.71	15.50
Aug.	2.66	2.09	88.5	58.3	89.9	58.4	102	49	4.4	5.0	11.80	12.48
Sept.	0.78	1.31	78.2	50.4	81.9	48.4	95	37	3.9	5.2	7.48	9.63
Oct.	2.48	1.08	57.7	33.6	70.0	35.1	93	20	—	—	—	—
Nov.	0.93	0.63	58.7	29.9	53.3	23.1	83	19	—	—	—	—
Dec.	0.52	0.37	38.9	13.3	44.4	15.1	64	-11	—	—	—	—
Annual	17.28	17.44	66.8	37.5	67.1	35.5	102	-11	4.4	5.5	66.21	70.65

Normal latest spring freeze (32°F): May 6. In 2009: April 18.
Normal earliest fall freeze (32°F): Oct. 3. In 2009: Oct. 2.
Normal frost-free period (>32°F): 150 days. In 2009: 167 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.

Dryland Wheat and Row Crop Yields as Affected by Tillage and Rotation in a Long-Term, Large-Scale, Dryland Cropping Systems Study[1]

L. Haag and A. Schlegel

Summary

Various tillage and crop rotation systems have been evaluated in production-scale plots since 1993. Each incremental decrease in tillage intensity increased wheat yields 8 to 9 bu/acre in a wheat-fallow (W-F) system up to an increase of 16.7 bu/acre, a 53% increase. Use of either corn or grain sorghum in a wheat-summer annual-fallow rotation resulted in equivalent subsequent wheat yields. Wheat yields in rotations containing one or two summer crops (other than sunflower) were similar to yields in a reduced-till wheat-fallow rotation. Inclusion of sunflower at any phase in dryland rotations reduced subsequent wheat yields by approximately one third.

Introduction

This study was established in 1993 on cropland that had been native sod until 1988. The purposes of this study are to use production-scale plots to research and demonstrate current crop rotations and tillage systems that are feasible for the region and to investigate opportunities for further cropping system intensification. From inception of the plots through 1998, the primary focus was to compare the impact of tillage systems in a W-F production system and evaluate potential summer annual crops for use in a two-crop/3-year rotation. From 1999 though the present, the focus has been on intensifying cropping systems by evaluating various three-crop/4-year scenarios. In 1999, no-till was adopted for all treatments except a reduced-till W-F rotation that serves as a long-term comparative check. In 2007, all treatments involving sunflower were removed because of their detrimental effects on subsequent crop yields. Current research efforts involve wheat, corn, and grain sorghum in various rotation configurations.

Procedures

Crop rotations are 2-year W-F and 3- or 4-year rotations with wheat followed by one or two summer annuals then fallow. The 3- and 4-year rotations are no-till production systems, and the 2-year W-F rotation uses a reduced-till system. All phases of each rotation are present each year. Plots are a minimum of 100 ft by 450 ft and replicated three times. Grain yields are determined by harvesting the center 60 ft (by plot length) of each plot with a commercial combine and weighing grain with a weigh wagon. The 60-ft width consists of three 20-ft-wide subplots representing various varieties and hybrids. Fertilizer applications are made using no-till methods in amounts necessary to maximize dryland crop yields. Soil moisture measurements are obtained with neutron attenuation methods in 1-ft increments to a depth of 8 ft. An across-years statistical analysis was conducted using the MIXED and GLIMMIX procedures within SAS version 9.1.3.

[1] This research project receives support from the USDA-ARS Ogallala Aquifer Program.

Results and Discussion

Wheat Yields and Available Soil Water at Planting as Affected by Fallow Tillage and Rotation

From 1995 through 1998, wheat was grown in a W-F rotation under three tillage systems: no-till, reduced till (in which herbicides were used for postharvest weed control and sweep tillage was used for summer fallow weed control), and conventional till (in which sweep tillage was used for both postharvest and summer fallow weed control). Wheat was also grown in rotation with corn (C), sunflower (SF), and grain sorghum (S). Wheat yields were highest for no-till W-F and then reduced-till W-F (Table 1). Wheat yielded the same when grown in rotation with sorghum or corn or as conventional-till W-F. Wheat grown in rotation with sunflower resulted in the lowest yields. The impact of tillage on available soil water at planting in a W-F rotation is evident in Figure 1; no-till and reduced-till systems had more available soil water than conventional-till systems at almost every depth. No-till had the highest amounts of available soil water at the deeper depths of the profile. Summer annual selection played a role in available soil water at wheat planting; wheat grown in rotation with sunflower had the lowest amounts of available soil water at every depth (Figure 2). Corn and grain sorghum in the rotation resulted in equivalent amounts of available soil water at wheat planting except at the 3-ft depth, at which sorghum resulted in additional soil water compared with corn. The reduced-till W-F system most closely resembles the wheat production practices used in the wheat-summer annual-fallow rotations. As shown in Figure 1, reduced-till W-F had higher amounts of available soil water most depths. This additional soil water is reflected in higher wheat yields for reduced-till W-F than for any of the intensified rotations.

Wheat Yield and Available Soil Water at Planting as Affected by Intensified Rotations

Inclusion of additional summer annual crops in intensified rotations affected available profile water at wheat planting and wheat yields. The reduced-till W-F treatment, which serves as a long-term comparative treatment, had the highest level of available profile soil water at 13.97 in. (Table 2). Profile water in a W-S-F rotation was higher than that in either of the treatments involving sunflower and numerically higher than that in any other intensified rotation. Addition of corn to the rotations followed by either soybean or grain sorghum resulted in similar levels of profile soil water at wheat planting. Rotations that included sunflower resulted in the lowest levels of available soil water at wheat planting. Yields numerically followed the same trend as available soil water but resulted in only two distinct classes (Table 2). Rotations involving sunflower yielded less than the other rotations in the study, which all produced very similar yields.

Row Crop Yields as Affected by Rotation

Intensified rotations, which involve stacking multiple row crops, were evaluated from 1998 to the present. In this study, sorghum planted following a corn crop yielded 42% less when compared with sorghum after wheat; however, subsequent wheat yields were unaffected (Table 3).

When corn was used as the first of two row crops in a 4-year rotation, grain yield of the subsequent corn crop was not affected by the second row crop. Use of soybean or grain sorghum as the second row crop produced identical corn yields, whereas use of sunflower resulted in slightly less yield numerically in the subsequent corn crop and reduced yields in the subsequent wheat crop. Although a W-C-F rotation was not explicitly included in the study, averages over the same years from an adjacent study and from single-case instances in this study produced W-C-F yields of approximately 50.9 bu/acre. These results suggest that stacking soybean, grain sorghum, or sunflower following corn has the potential to reduce yield of the next corn crop by 32%.

Sunflower yields were similar regardless whether the crop was placed as the first or second row crop in the rotation (Table 3). This is likely due to the ability of sunflower to extract soil water and nutrients located deep in the profile. The subsequent reduction in wheat yields was the same regardless whether corn was included prior to sunflower. A producer who is committed to producing sunflower may wish to consider growing them in a W-C-SF-F rotation because a corn crop can be raised, sunflower yields are not affected by inclusion of the corn, and wheat yield reductions are the same as those found in a W-SF-F rotation.

It is extremely important to note that time period of this study includes some of the driest periods on record. Additional years of data will be necessary to gain a more representative view of the performance of intensified rotations.

Table 1. Wheat yield as affected by fallow tillage and rotation, Tribune, 1995–1998

Rotation	Tillage	Yield
		bu/acre
Wheat-Fallow	No-till	48.2a
Wheat-Fallow	Reduced till	40.5b
Wheat-Fallow	Conventional till	31.5cd
Wheat-Sorghum-Fallow	Combination	35.5c
Wheat-Corn-Fallow	Combination	34.4c
Wheat-Sunflower-Fallow	Combination	28.1d

Within a column, letters represent differences at LSD (0.05).

Table 2. Available soil water and wheat planting and wheat yields as affected by intensified rotations, Tribune, 1998–2009

Rotation	Tillage	Available profile water	Wheat yield
		in.	bu/acre
Wheat-Fallow	Reduced till	13.97a	30.6a
Wheat-Sorghum-Fallow	No-till	11.07b	30.4a
Wheat-Corn-Soybean-Fallow	No-till	10.10bc	28.6a
Wheat-Corn-Sorghum-Fallow	No-till	9.55bc	26.5a
Wheat-Sunflower-Fallow	No-till	8.60cd	19.9b
Wheat-Corn-Sunflower-Fallow	No-till	7.51d	19.4b

Within a column, letters represent differences at LSD (0.05).

Table 3. Row crop yields as affected by rotation, Tribune, 1998–2009

Crop	Rotation	Row crop grain yield	Subsequent wheat yield
		bu/acre	bu/acre
Grain sorghum	Wheat-Sorghum-Fallow	60.0a	30.4a
	Wheat-Corn-Sorghum-Fallow	35.1b	26.5a
		lb/acre	
Sunflower	Wheat-Sunflower-Fallow	646.2 ns	19.9b
	Wheat-Corn-Sunflower-Fallow	630.5 ns	19.4b
		bu/acre	
Corn	Wheat-Corn-Soybean-Fallow	35.9 ns	28.6a
	Wheat-Corn-Sorghum-Fallow	35.9 ns	26.5a
	Wheat-Corn-Sunflower-Fallow	32.4 ns	19.4b
	Wheat-Corn-Fallow[1]	50.5	
	Wheat-Corn-Fallow[2]	51.2	

[1] W-C-F yields are the average of like crop sequences in this study, 1998–2002.
[2] W-C-F yields are the average of an adjacent study, 2001–2006.
Within a crop and column, letters represent differences at LSD (0.05).

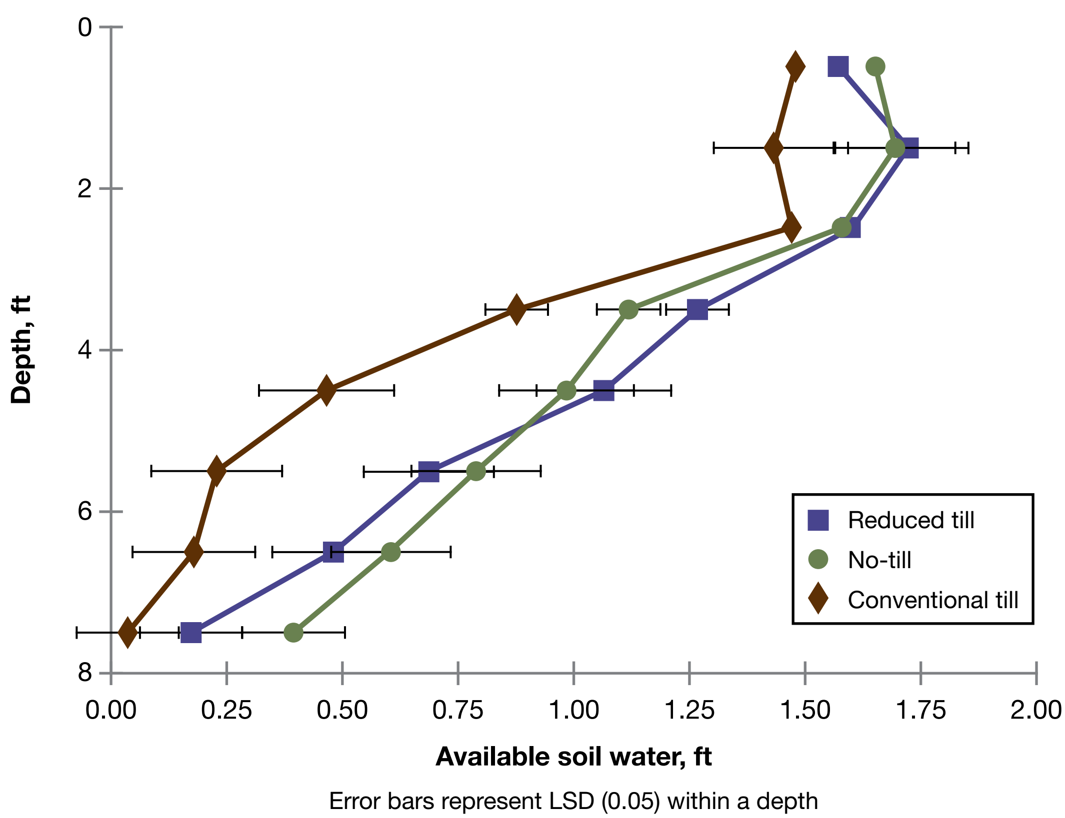

Figure 1. Available soil water at wheat planting in a wheat-fallow rotation under conventional-till, reduced-till, and no-till production systems, Tribune, 1995–1998.

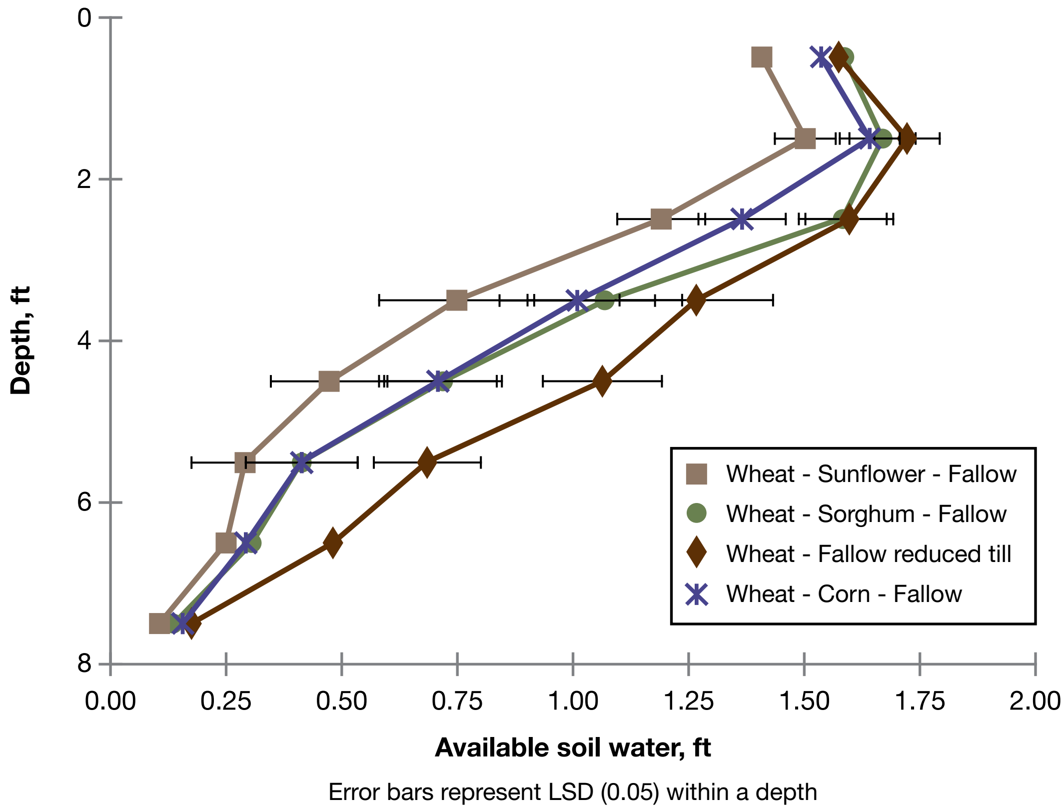

Figure 2. Available soil water at wheat planting in wheat-fallow and wheat-corn/sorghum/sunflower-fallow rotations, Tribune, 1995–1998.

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 1.2 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 70% of the yield of wheat grown in a 4-year rotation following sorghum. In most years, recrop wheat and continuous wheat yielded similarly. In 2009, however, recrop wheat yielded more than wheat following sorghum. Wheat yields were similar following one or two sorghum crops. Average sorghum yields also were the same following one or two wheat crops. Yield of the second sorghum crop in a WSSF rotation averaged about 70% 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 13-year study period. Water at planting of the second wheat crop in a WWSF rotation generally was less than that at planting of 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 0.75 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 in. over 13 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 but was slightly greater in 2008. Averaged across the entire study period, the first sorghum crop had about 1.2 in. more available water at planting than the second crop.

Grain yields

In 2009, wheat yields were average for wheat following fallow but considerably higher for recrop wheat (Table 1). Averaged across 13 years, recrop wheat (the second wheat crop in a WWSF rotation) yielded about 84% 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 the 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, there has been little difference 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 2009 were greater than average, although variable, for sorghum following wheat (Table 2) and also 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 2009, recrop sorghum yields were only about 50% of the yield of the first sorghum crop.

Table 1. Wheat response to rotation, Tribune, 1997–2009

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

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

Table 2. Grain sorghum response to rotation, Tribune, 1996–2009

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

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

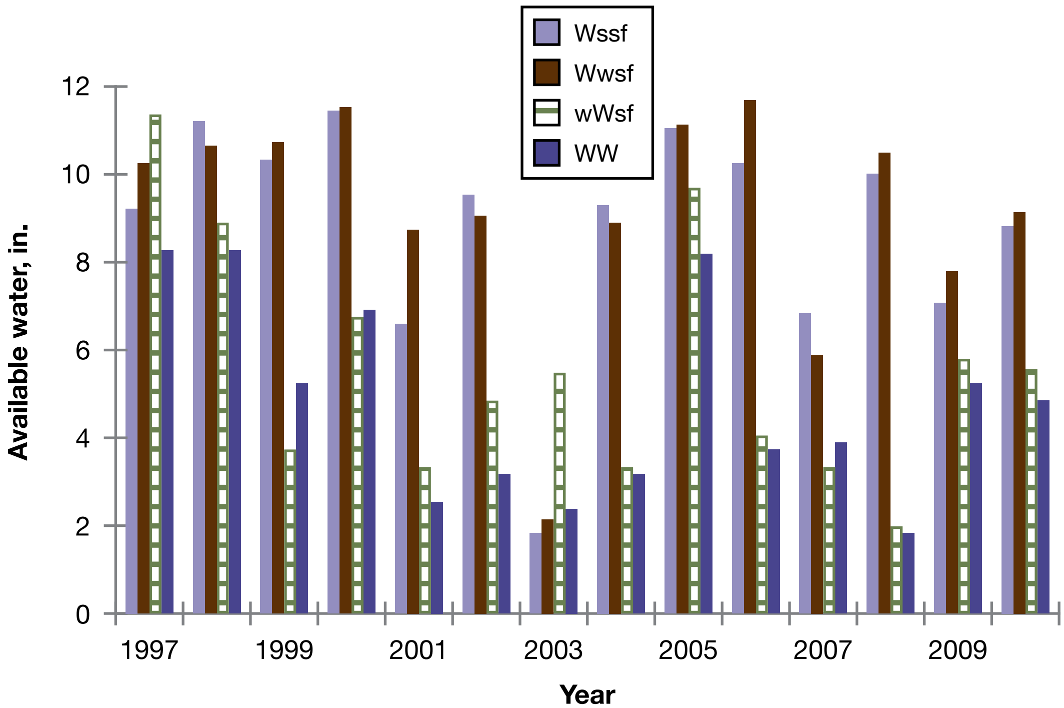

Figure 1. Available soil water at planting of wheat in several rotations, Tribune, 1997–2009.
Capital letter denotes current crop in rotation (W, wheat; S, sorghum; F, fallow). Last set of bars is average across years.

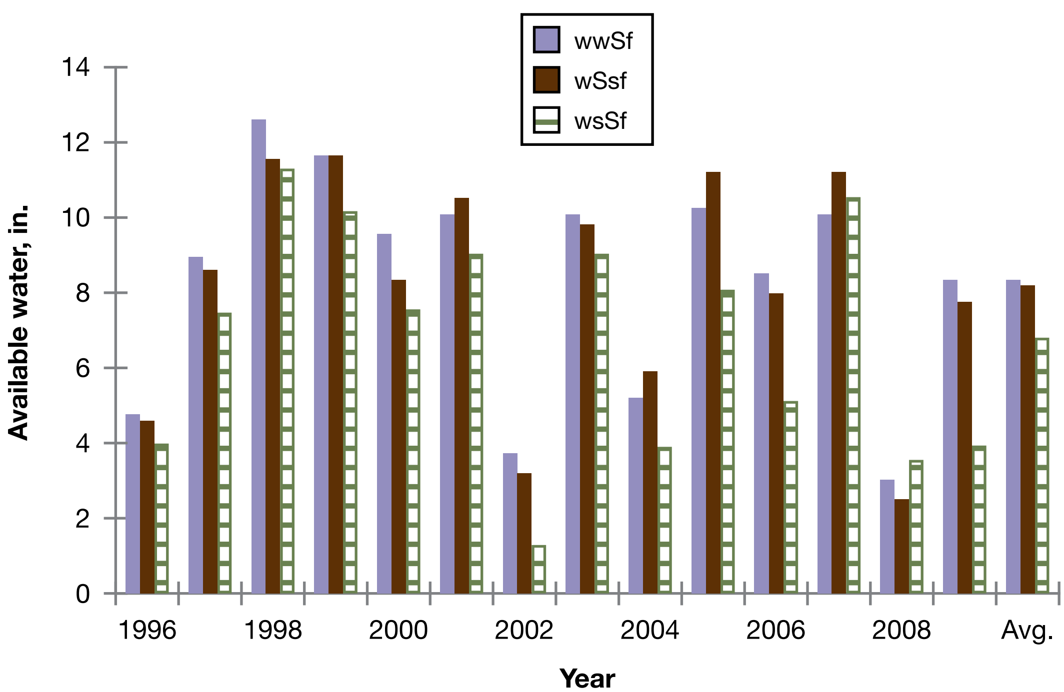

Figure 2. Available soil water at planting of sorghum in several rotations, Tribune, 1996–2009.
Capital letter denotes current crop in rotation (W, wheat; S, sorghum; F, fallow).

Long-Term Nitrogen and Phosphorus Fertilization of Irrigated Grain Sorghum

A. Schlegel

Summary
Long-term research shows that phosphorus (P) and nitrogen (N) fertilizer must be applied to optimize production of irrigated grain sorghum in western Kansas. In 2009, N and P applied alone increased yields about 45 and 6 bu/acre, respectively, whereas N and P applied together increased yields up to 75 bu/acre. Averaged across the past 9 years, N and P fertilization increased sorghum yields up to 65 bu/acre. Application of 40 lb/acre N (with P) was sufficient to produce about 85% of maximum yield in 2009. 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/acre N without P and K; with 40 lb/acre P_2O_5 and zero K; and with 40 lb/acre P_2O_5 and 40 lb/acre K_2O. All fertilizers are broadcast by hand in the spring and incorporated before planting. The soil is a Ulysses silt loam. Sorghum (Pioneer 8500/8505 from 1998–2007 and Pioneer 85G46 in 2008–2009) 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 2009 were similar to the average of the past 9 years (Table 1). Nitrogen alone increased yields about 45 bu/acre, and P alone increased yields only about 5 bu/acre. However, N and P applied together increased yields up to 75 bu/acre. Averaged across the past 9 years, N and P applied together increased yields up to 65 bu/acre. In 2009, 40 lb/acre N (with P) produced about 85% of maximum yields, which is about 5% less than the 9-year average. Sorghum yields were not affected by K fertilization, which has been the case throughout the study period.

Table 1. Effect of nitrogen, phosphorus, and potassium fertilizers on irrigated sorghum yield, Tribune, KS, 2001–2009

Fertilizer			Sorghum yield									
N	P_2O_5	K_2O	2001	2002	2003	2004	2005	2006	2007	2008	2009	Mean
------------ lb/acre ------------			------------ bu/acre ------------									
0	0	0	76	73	80	57	58	84	80	66	64	71
0	40	0	81	81	93	73	53	102	97	60	70	80
0	40	40	83	82	93	74	54	95	94	65	76	81
40	0	0	92	82	92	60	63	102	123	92	84	89
40	40	0	124	120	140	112	84	133	146	111	118	123
40	40	40	119	121	140	117	84	130	145	105	109	120
80	0	0	110	97	108	73	76	111	138	114	115	106
80	40	0	138	127	139	103	81	132	159	128	136	129
80	40	40	134	131	149	123	92	142	166	126	108	132
120	0	0	98	86	97	66	77	101	138	106	113	99
120	40	0	134	132	135	106	95	136	164	131	130	131
120	40	40	135	127	132	115	98	139	165	136	136	133
160	0	0	118	116	122	86	77	123	146	105	108	113
160	40	0	141	137	146	120	106	145	170	138	128	138
160	40	40	136	133	135	113	91	128	167	133	140	133
200	0	0	132	113	131	100	86	134	154	120	110	122
200	40	0	139	136	132	115	108	143	168	137	139	137
200	40	40	142	143	145	123	101	143	170	135	129	138
ANOVA (P>F)												
Nitrogen			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
Quadratic			0.001	0.001	0.001	0.018	0.005	0.004	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
Zero P vs. P			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	0.975
N × P-K			0.058	0.030	0.008	0.022	0.195	0.210	0.965	0.005	0.053	0.010

continued

Table 1. Effect of nitrogen, phosphorus, and potassium fertilizers on irrigated sorghum yield, Tribune, KS, 2001–2009

Fertilizer			Sorghum yield									
N	P_2O_5	K_2O	2001	2002	2003	2004	2005	2006	2007	2008	2009	Mean
------------------- lb/acre -------------------			------------------- bu/acre -------------------									
Means												
Nitrogen, lb/acre												
0			80	79	88	68	55	93	91	64	70	77
40			112	108	124	96	77	121	138	103	104	111
80			127	119	132	100	83	128	155	123	120	122
120			122	115	121	96	90	125	156	124	126	121
160			132	129	134	107	92	132	161	125	125	128
200			138	131	136	113	98	140	164	131	126	132
LSD (0.05)			8	9	10	11	10	11	9	7	11	6
P_2O_5-K_2O, lb/acre												
0			104	94	105	74	73	109	130	101	99	100
40-0			126	122	131	105	88	132	151	117	120	123
40-40			125	123	132	111	87	130	151	117	116	123
LSD (0.05)			6	6	7	7	7	7	6	5	7	4

Long-Term Nitrogen and Phosphorus Fertilization of Irrigated Corn

A. Schlegel

Summary

Long-term research shows that phosphorus (P) and nitrogen (N) fertilizer must be applied to optimize production of irrigated corn in western Kansas. In 2009, N applied alone increased yields about 60 bu/acre, whereas P applied alone increased yields about 25 bu/acre. However, N and P applied together increased yields up to 150 bu/acre. Averaged across the past 9 years, N and P fertilization increased corn yields up to 140 bu/acre. Application of 120 lb/acre N (with P) was sufficient to produce greater than 90% of maximum yield in 2009, which was similar to the 9-year average. In 2009, P increased corn yields more than 80 bu/acre when applied with at least 120 lb/acre N. Application of 80 instead of 40 lb P_2O_5/acre increased yields 11 bu/acre.

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/acre without P and K; with 40 lb/acre P_2O_5 and zero K; and with 40 lb/acre P_2O_5 and 40 lb/acre K_2O. The treatments were changed in 1992; the K variable was replaced by a higher rate of P (80 lb/acre P_2O_5). All fertilizers are 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), and DeKalb 61-69 (2009)] were planted at about 30,000 to 32,000 seeds/acre in late April or early May. Hail damaged the 2002 and 2005 crops. The corn is irrigated to minimize water stress. Furrow irrigation was used in 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 15.5% moisture.

Results

Corn yields in 2009 were greater than the 9-year average (Table 1). Nitrogen alone increased yields 60 bu/acre, whereas P alone increased yields 25 bu/acre. However, N and P applied together increased corn yields up to 150 bu/acre. Only 120 lb/acre N with P was required to obtain greater than 90% of maximum yield, which is similar to the 9-year average. Corn yields in 2009 (averaged across all N rates) were 11 bu/acre greater with 80 than with 40 lb/acre P_2O_5, which is greater than the 9-year average.

Table 1. Effect of nitrogen and phosphorus fertilization on irrigated corn yield, Tribune, KS, 2001–2009

N	P_2O_5	2001	2002	2003	2004	2005	2006	2007	2008	2009	Mean
--------- lb/acre ---------		---------- bu/acre ----------									
0	0	54	39	79	67	49	42	49	36	85	55
0	40	43	43	95	97	60	68	50	57	110	69
0	80	48	44	93	98	51	72	51	52	106	68
40	0	71	47	107	92	63	56	77	62	108	76
40	40	127	69	147	154	101	129	112	105	148	121
40	80	129	76	150	148	100	123	116	104	159	123
80	0	75	53	122	118	75	79	107	78	123	92
80	40	169	81	188	209	141	162	163	129	179	158
80	80	182	84	186	205	147	171	167	139	181	162
120	0	56	50	122	103	66	68	106	65	117	84
120	40	177	78	194	228	162	176	194	136	202	172
120	80	191	85	200	234	170	202	213	151	215	185
160	0	76	50	127	136	83	84	132	84	139	101
160	40	186	80	190	231	170	180	220	150	210	180
160	80	188	85	197	240	172	200	227	146	223	186
200	0	130	67	141	162	109	115	159	99	155	126
200	40	177	79	197	234	169	181	224	152	207	180
200	80	194	95	201	239	191	204	232	157	236	194
ANOVA (P>F)											
Nitrogen		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
Quadratic		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
Linear		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
N × P		0.001	0.133	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

continued

Table 1. Effect of nitrogen and phosphorus fertilization on irrigated corn yield, Tribune, KS, 2001–2009

N	P_2O_5	2001	2002	2003	2004	2005	2006	2007	2008	2009	Mean
--------- lb/acre ---------		------	------	------	------	------	bu/acre	------	------	------	------
Means											
Nitrogen, lb/acre											
0		48	42	89	87	53	61	50	48	100	64
40		109	64	135	132	88	103	102	91	138	107
80		142	73	165	178	121	137	146	115	161	137
120		142	71	172	188	133	149	171	118	178	147
160		150	71	172	203	142	155	193	127	191	156
200		167	80	180	212	156	167	205	136	199	167
LSD (0.05)		15	8	9	11	10	15	11	9	12	8
P_2O_5, lb/acre											
0		77	51	116	113	74	74	105	71	121	89
40		147	72	168	192	134	149	160	122	176	147
80		155	78	171	194	139	162	168	125	187	153
LSD (0.05)		10	6	6	8	7	11	8	6	9	6

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

L. Haag and A. 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 across-years analysis. Corn grain yields, averaged over previous studies starting in 2004 through the current study in 2008, were 60, 70, and 73 bu/acre 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 suggest producers should increase cutting heights 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 soil erosion reductions. Stubble height affects wind velocity profile, surface radiation interception, and surface temperatures, all of which affect evaporation suppression and winter snow catch. Taller wheat stubble is also beneficial to pheasants in postharvest and overwinter fallow periods. Use of stripper headers increases harvest capacity and provides taller wheat stubble than previously attainable with conventional small grains platforms. Increasing wheat cutting heights or using a stripper header should further improve the effectiveness of standing wheat stubble. The purpose of this study was to evaluate the effect of wheat stubble height on subsequent summer row crop yields.

Procedures
Studies were conducted from 2007 through 2009 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. Corn and grain sorghum were seeded at rates of 15,000 and 33,000 seeds/acre, respectively. Nitrogen was applied to all plots at a rate of 80 to 100 lb/acre N. Starter fertilizer (10-34-0) was applied in row at rates of 7 and 9 gal/acre for corn and sorghum, respectively. Plots measured 40 ft × 60 ft, and treatments were 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

[1] This project receives support from the Kansas Department of Wildlife and Parks.

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

2009

The 2009 growing season began with dry conditions at planting. Residue conditions were better than would typically be expected following 25 bu/acre wheat. Precipitation throughout the growing season (April to August) was 0.98 in. below normal; however, the timing of precipitation events and below-normal temperatures during kernel set and grain fill resulted in excellent corn yields. Corn grain yields ranged from 84 to 108 bu/acre (Table 1). The tall cut and stripped treatments produced grain yields and water use efficiencies significantly higher than those of the short cut treatment. This yield increase was primarily influenced by the numerical increase in kernels per ear of the tall and stripped treatments over the short cut treatment.

Sorghum yields were also excellent despite a shortage of accumulated heat units. Yields ranges from 115 to 118 bu/acre (Table 2) with no differences attributable to stubble height. Harvest moisture increased with increasing stubble height.

2007–2009 Across Years

An across-years analysis was conducted with data from this study. Over the 3 years, corn grain yield increased from 74 to 89 bu/acre 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 increased with increasing stubble height from 452 for the low cut to 512 for the stripped stubble treatment. Another key yield component, ear population, also increased numerically with increasing stubble height, suggesting that tall stubble may also reduce in-season plant mortality and ear abortion. Corn grown in stripped stubble produced higher grain yields without a proportional increase in water use as water use efficiency increased from 302 lb/in. for the short cut stubble to 363 lb/in. for the stripped stubble treatment.

Over the 3 years, sorghum grain yields exhibited a quadratic response to stubble height; high cut stubble produced grain yields 6 to 7 bu/acre higher than those of the stripped and short cut treatments (Table 4). An examination of yield components revealed that kernels per head increased with increasing stubble height. Although no statistical differences were observed, heads per plant also exhibited a quadratic response to 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. Such an interaction may need to be compensated for by increasing seeding rates.

Conclusions and Future Research Opportunities

Increasing stubble height has improved subsequent corn grain yields and water use efficiency. 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 data sets 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 provide a more robust dataset across multiple years with which to evaluate the effects of stubble height on soil water storage.

Table 1. Corn yield and yield components as affected by stubble height, Tribune, 2009

Stubble height	Grain yield	Moisture	Test weight	Plant population	Ear population	Residue	Residue/ Yield	Kernel weight	Kernels/ Ear	WUE[1]
	bu/acre	%	lb/bu	1,000 plants/ acre	1,000 ears/ acre	lb/acre	lb/lb	oz/1000		lb/in.
Strip	105.7a	16.4	59.0	13.5	13.0	5,529	0.96	11.45	639	399a
High	107.5a	16.0	59.7	13.8	13.4	5,636	0.94	11.53	624	389a
Low	83.5b	16.2	59.3	14.1	12.1	4,501	0.98	10.87	571	306b
	ANOVA (P>F)									
Source										
Stubble	0.0172	0.4913	0.0724	0.5645	0.3787	0.4757	0.9738	0.4819	0.1929	0.0196
LSD (0.05)	16.9	—	—	—	—	—	—	—	—	66

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

Table 2. Grain sorghum yield and yield components as affected by stubble height, Tribune, 2009

Stubble height	Grain yield	Moisture	Test weight	Plant population	Head population	Residue	Residue/ Yield	Kernel weight	Kernels/ Head	Heads/ Plant	WUE[1]
	bu/acre	%	lb/bu	1,000 plants/acre	1,000 heads/acre	lb/a	lb/lb	oz/1000			lb/in.
Strip	118.2	12.4a	58.1	18.9b	51.2	6,316	0.95	0.74669	2770	2.72	482
High	114.9	12.2ab	58.0	19.1b	51.5	7,445	1.16	0.76278	2621	2.70	455
Low	117.1	12.1b	57.7	20.3a	48.7	6,168	0.95	0.77306	2786	2.41	460
	ANOVA (P>F)										
Source											
Stubble	0.8820	0.0313	0.6699	0.0352	0.5780	0.3422	0.2281	0.7754	0.1888	0.2366	0.5565
LSD (0.05)	—	0.2	—	1.1	—	—	—	—	—	—	—

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

Table 3. Corn yield and yield components as affected by stubble height, Tribune, 2007–2009

Stubble height	Grain yield	Moisture	Test weight	Plant population	Ear population	Residue	Residue/ Yield	Kernel weight	Kernels/ Ear	Ears/ Plant	WUE[1]
	bu/acre	%	lb/bu	1,000 plants/acre	1,000 ears/ acre	lb/acre	lb/lb	oz/1000			lb/in.
Strip	88.6a	16.6	58.0	14.2	14.5	5,897	1.23	10.84	512a	1.02	363a
High	85.9a	16.5	58.2	14.2	14.2	6,415	1.42	10.97	496a	1.01	346a
Low	73.9b	16.6	57.8	14.1	13.8	5,555	1.38	10..8301	452b	0.98	302b
						ANOVA (P>F)					
Source											
Stubble	0.0007	0.8323	0.2070	0.7278	0.2058	0.2068	0.2794	0.7622	0.0072	0.1465	0.0006
LSD (0.05)	7.5	—	—	—	—	—	—	—	37	—	30

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

Table 4. Grain sorghum yield and yield components as affected by stubble height, Tribune, 2007–2009

Stubble height	Grain yield	Moisture	Test weight	Plant population	Head population	Residue	Residue/ Yield	Kernel weight	Kernels/ Head	Heads/ Plant	WUE[1]
	bu/acre	%	lb/bu	1,000 plants/acre	1,000 heads/acre	lb/a	lb/lb	oz/1000			lb/in.
Strip	99.4	12.2	58.4	18.7	48.8	5,654	1.06	0.86	2162	2.69	429
High	102.3	12.2	58.6	18.9	50.2	6,219	1.11	0.90	2087	2.76	436
Low	98.3	12.1	58.3	19.4	48.8	5,800	1.12	0.90	2074	2.59	419
	ANOVA (P>F)										
Source											
Stubble	0.4171	0.2480	0.4992	0.4677	0.4610	0.3082	0.6987	0.1773	0.2791	0.4350	0.3889

[1] WUE, water use efficiency.

Potential for Water Conservation When Using Stripper Combine Heads to Harvest Dryland and Irrigated Wheat in a No-Till Management System

N.L. Klocke and R.S. Currie

Summary
A field study was conducted from 2006 to 2009 to compare the effects of two combine headers, conventional and stripper, on wheat stubble height, soil water accumulation, fallow efficiency, and surface coverage by the stubble. The type of combine header did not cause differences in any of the measured parameters except stubble height, although there were differences among years and irrigation amounts. The stripper header apparently did not cause differences in the combined effects of non-growing-season soil water evaporation, capture of precipitation from snow between the wheat and sorghum crops, or growing-season soil water evaporation during the sorghum growing season. The two header treatments had similar amounts of available soil water at the beginning of the sorghum growing season, which contributed to similar grain sorghum yields.

Introduction
This study was conducted to determine how harvest method affects soil water accumulations and crop water use and grain yields of no-till grain sorghum following wheat harvest.

Specific objectives were to determine whether two wheat harvest techniques (a combine equipped with either a conventional reel/platform header or a stripper header) had different effects on (1) soil water accumulation during the non-growing season following wheat, (2) wheat residue surface coverage during the following spring, and (3) grain yield in the following sorghum crop.

The conventional reel/platform header cut the wheat straw and brought straw and wheat heads into the combine. The stripper header rotated in the opposite direction as the conventional reel header to provide a "combing" action that brought only wheat heads into the combine without the straw. The conventional header left 11.3-in.-high wheat stubble, whereas the stripper header left 22.5-in.-high stubble.

We hypothesized that the taller wheat stubble resulting from a stripper header would lead to more soil water accumulation and higher yield in the following crop and capture more precipitation and retain more soil water because of lower soil water evaporation.

Procedures
The study was conducted in a cropping rotation in which grain sorghum was planted with no-till techniques into the previous year's wheat stubble. Winter wheat following corn was one of four crops in a 5-year rotation (corn-corn-winter wheat-sorghum-

sunflower). Grain sorghum that followed wheat had time to accumulate and store precipitation in the root zone from wheat harvest until sorghum planting.

Six irrigation treatments were imposed across the study area in the wheat crop and during the following sorghum crop. Irrigation amounts ranged from full irrigation to meet crop water needs to annual application of 2 in. A seventh water treatment was a dryland rotation of wheat-sorghum-fallow in which soil water accumulated during the fallow year preceding wheat. Crops were grown every year in the irrigated portion of the study.

Plots (145 ft × 180 ft) were divided into subplots. A combine equipped with either a stripper head or a conventional reel header was used to harvest the wheat from each subplot.

Observations included:

- Wheat dry matter excluding grain measured just before wheat harvest
- Wheat stubble height measured just after harvest
- Soil water measured to a depth of 8 ft in 1-ft increments after wheat harvest and near the end of the following April (soil water accumulation was the difference in soil water content between these two dates)
- Fallow efficiency calculated as the ratio of soil water accumulation and precipitation during the same period and reported in terms of percentages
- Percentage of the soil surface covered with wheat stubble measured after sorghum was planted with no-till techniques during the spring following wheat
- Sorghum grain yield during the year following wheat

Results and Discussion

A summary of results is shown in Table 1.

Year

Differences in results among years were determined by averaging data over water treatments and header treatments. The lower amount of dry matter in the stubble before wheat harvest in 2007 and 2008 is an effect of hail damage during those years. The hail also apparently affected stubble height.

Available soil water measured after wheat harvest followed the pattern of precipitation during the wheat growing season. Growing-season precipitation was 7.1 in. during 2006, 9.8 in. during 2007, and 9.7 in. during 2008. Available soil water measured shortly after sorghum planting followed the pattern of precipitation accumulation from wheat harvest until sorghum planting (non-growing-season precipitation). Precipitation from July 1 through the following May was 22.3 in. during 2006–2007, 12.9 in. during 2007–2008, and 16.2 in. during 2008–2009 (long-term average for the study location is 15.9 in.).

Differences in wheat residue cover on the soil surface during years with or without hail did not result in differences in residue cover measured after planting sorghum the following year. Sorghum grain yields did not correlate with wet, normal, or dry non-growing seasons, indicating that soil water was not limiting production.

Irrigation Treatment
Differences in results among water treatments were determined by averaging data over years and header treatments. Dryland wheat and sorghum were in rotation with fallow following sorghum until wheat was planted the next year. Crops in the irrigation treatments were grown every year. Wheat stubble dry matter, stubble height, available soil water measured after wheat and shortly after sorghum planting, fallow efficiency, residue cover, and sorghum grain yield generally followed the pattern of decreasing irrigation amounts. Wheat stubble dry matter and height in the dryland treatment were nearly equal to those in irrigation treatments that received 3 to 4.5 in. of water. Soil water that accumulated during the fallow period preceding wheat helped wheat in that system produce more dry matter than wheat that received little irrigation in the continuous cropping system.

Harvest Method
Differences in results between harvest methods were determined by averaging data over years and water treatments. Wheat stubble dry matter and available soil water measured before imposing the two harvest techniques were not different between treatments. Stubble height data reflected the height differences after harvest between methods. There was no difference between the two harvest methods in available soil water shortly after sorghum planting, fallow efficiency, residue cover, or sorghum grain yield, and there was only a slight difference between harvest methods in soil water gain.

The hypothesis for the study was rejected. Type of combine header did not cause differences in the measured parameters, although there were differences among years and irrigation amounts. The stripper header apparently did not cause differences in non-growing-season soil water evaporation, capture of precipitation from snow between the wheat and sorghum crops, or growing-season soil water evaporation during the sorghum growing season. The two header treatments had similar amounts of available soil water at the beginning of the sorghum growing season, which contributed to similar grain sorghum yields.

Table 1. Data summary for conventional/stripper combine head study at Garden City

Item	Stubble dry matter[1]	Stubble height[2]	ASW[3] after wheat	ASW[3] before sorghum	Soil water gain[4]	Fallow efficiency[5]	Residue cover[6]	Sorghum grain yield
	ton/acre	in.	%	%	in.	%	%	bu/acre
Year								
2006–2007	4.42a	18.0a	3.0c	70.3a	11.7a	53.0a	76.1a	119.2b
2007–2008	2.78c	16.0c	22.1a	41.8c	3.4c	30.8b	76.2a	135.5a
2008–2009	3.01b	16.7b	18.2b	65.6b	8.2b	54.5a	72.9b	110.8c
LSD[7]	0.198	0.67	2.2	2.8	0.46	3.6	2.6	3.7
Irrigation[8], in.								
6	4.27a	17.8a	25.5a	72.9a	8.2a	49.6a	78.6a	127.5a
4.7	3.56bc	18.1a	—	—	—	—	80.2a	126.1b
3.7	3.67b	17.3ab	—	—	—	—	77.0ab	127.2a
3	3.24cd	16.3bc	12.4b	58.7b	8.1a	46.8ab	73.6bc	119.3b
2.3	2.92de	15.6c	—	—	—	—	69.9d	117.6 bc
1.3	2.84e	15.6c	10.7bc	55.7b	7.8a	45.4ab	71.1cd	113.3c
Dryland[9]	3.35bc	17.4ab	9.1c	49.6c	7.0b	42.7b	—	—
LSD[7]	0.375	1.19	2.6	3.2	0.56	4.3	3.6	5.2
Harvest method								
Conventional	3.41a	11.3b	14.3a	60.3a	8.0a	47.4a	75.9a	122.4a
Stripper	3.41a	22.5a	14.5a	58.1a	7.6b	44.8a	74.3a	121.3a
LSD[7]	0.2	0.64	1.8	2.3	0.4	2.9	2.1	3

[1] Wheat stubble dry matter before harvest.
[2] Stubble height after harvest.
[3] Available soil water between field capacity and permanent wilting.
[4] Soil water gain from wheat harvest through the following April.
[5] (Soil water gain)/(non-growing-season precipitation).
[6] Percentage of wheat residue covering the soil after planting sorghum.
[7] Least significant difference for P=0.10.
[8] Average irrigation of sorghum for 2007–2009.
[9] Dryland sorghum following wheat after fallow.
Within columns, means with the same letter are not significantly different.

Alfalfa Production with Limited Irrigation

N.L. Klocke, J. Holman, and R.S. Currie

Summary
Alfalfa yields are directly related to precipitation and irrigation; however, irrigation to support full yields may not be available. Alfalfa producers need to evaluate potential yields from limited irrigation to plan irrigation scheduling strategies and forecast economic returns. During a 2-year study (2008–2009), alfalfa yields decreased from 7 to 1.8 tons/acre as irrigation decreased from 24 to 0 in. More non-growing-season precipitation accumulated in the limited irrigation and dryland plots than in the plots receiving 24 in. of irrigation. Irrigating or not irrigating between the second and third cuttings did not affect yields. Alfalfa yield response to irrigation at Garden City from 1921 to 1930 was the same as in the current study.

Introduction
Irrigated alfalfa is an important cash crop for western Kansas, but irrigation water rights and pumping capacity limit the water available for alfalfa production. Producers need to understand the relationship between expected alfalfa yields and different amounts of irrigation to make sound economic decisions. Irrigation scheduling strategies are important tools to maximize production from limited water resources. The objectives of this study were to (1) determine the relationship between alfalfa yields and amount of water applied through irrigation and (2) compare the strategies of no irrigation between the second and third cutting and irrigation between all cuttings.

Procedures
This study was conducted near Garden City, KS, at the Southwest Research-Extension Center. Glyphosate-tolerant alfalfa was planted during August 2007 before a California district court band further planting. Glyphosate-tolerant alfalfa may be legally grown and marketed with some restrictions if planted before this date. Glyphosate was applied as needed between cuttings to control primarily amaranth and some winter annual grasses and tansy mustard.

Soil in the study area was a Ulysses silt loam with pH of 8.1 to 8.3. A linear-move irrigation system applied irrigation to plots (45 ft × 90 ft) arranged in a randomized complete block design. There were six irrigation treatments (Table 1):

1. 24 in. of irrigation applied during the growing season before the first cutting and between all other cuttings
2. 15 in. of irrigation applied during the growing season
3. 15 in. of irrigation applied during the growing season except between the second and third cuttings
4. 8 in. of irrigation applied during the growing season except between the second and third cuttings
5. 8 in. of irrigation applied during the growing season
6. Dryland

Results and Discussion

Off-season precipitation from the previous October 1 through the current March 31, growing-season precipitation for the current April 1 through September 30, and cropping-season precipitation total from the previous October 1 through the current September 30 were all below average in 2008 and above average in 2009 (Table 2). The difference in precipitation between the 2 years contributed to significantly more non-growing-season soil water accumulation, evapotranspiration, yield, and stem density during 2009 than during 2008 (Table 3).

Water treatments that received 0 or 8 in. of irrigation had significantly more soil water accumulation during the previous growing season than water treatments that received 15 and 24 in. of irrigation (Table 3). Less irrigation apparently caused deeper rooting (data not shown) and more soil water extraction during the preceding growing season, leaving more room for soil water accumulation. Evapotranspiration increased significantly as irrigation amount increased. None of the measured variables shown in Table 3 were significantly different between the 8-in. irrigation treatments with or without irrigation withheld between the second and third cuttings. This was also the case for the 15-in. irrigation treatments.

Alfalfa yield responses to irrigation for this study and an irrigation study conducted at Garden City, KS, from 1921 through 1930 are shown in Figure 1. The 1921–1930 study was conducted with surface irrigation. Gross irrigation amounts reported in the previous study were converted to net irrigation by assuming 50% application efficiency. Yield responses to net irrigation for the two studies were similar. Year-to-year yields at each irrigation level varied more in the 10-year study than in the 2008–2009 study, but year-to-year yield variation decreased with increasing amounts of irrigation in both studies. In the 1921–1930 study, yield decreased for net irrigation in excess of 24 in. The similar yield results for the two studies suggest that potential yields of irrigated alfalfa have not improved since the 1920s.

Table 1. Target irrigation amounts and timing

	Irrigation treatment[1]					
Irrigation period	1	2	3	4	5	6
	---------Irrigation amount (in.)--------					
Greenup to cutting 1	3	2	2	0	0	0
Between cutting 1 and 2	6	4	5	4	3	0
Between cutting 2 and 3	6	4	0	0	2	0
Between cutting 3 and 4	6	4	6	3	2	0
Between cutting 4 and 5	3	1	2	1	1	0
Total	24	15	15	8	8	0

[1] See procedures section for definitions of irrigation treatment groups.

Table 2. Precipitation (in.) at Garden City

Time period	Oct. –Mar.[1]	Apr.–Sept.[2]	Oct.–Sept.[3]	% of annual[4]
2008	2.8	11.1	13.9	74
2009	6.3	16.9	23.2	124
30-year long-term avg.	7.6	11.0	18.6	
2008–2009 avg.	7.1	11.2	18.7	
Study/long term (%)	93	102	101	

[1] Off-season precipitation from the previous October 1 through the current March 31.
[2] Growing-season precipitation for the current April 1 through September 30.
[3] Cropping-season precipitation total from the previous October 1 through the current September 30.
[4] Cropping-season precipitation total as a percentage of annual long-term average (18.7 in.).

Table 3. Alfalfa study results for Garden City, 2008 and 2009

Item	Soil water accumulation[1]	ETc[2]	Yield[3]	Density[4]
	in.	in.	tons/acre	stems/ft^2
Year				
2008	0.31b	23.6b	4.1b	57b
2009	0.6a	27.7a	5a	62a
LSD[5]	0.19	0.29	0.32	4.4
Irrigation[6], in.				
24	0.03b	36.8a	7a	67a
15	0.15b	29b	5.8b	63ab
15	0.02a	28.8b	5.3b	60abc
8	0.87a	22.5c	3.9c	58bc
8	0.91a	22.6c	3.7c	56bc
0	0.77b	14.3d	1.8d	53c
LSD[5]	0.32	0.51	0.55	

[1] Soil water accumulation during the previous non-growing season.
[2] Evapotranspiration during the growing season.
[3] Total yield from all cuttings.
[4] Stem density after the growing season.
[5] Least significant difference for P=0.05.
[6] Average irrigation of alfalfa for 2008–2009.
Within column, means with the same letter are not significantly different.

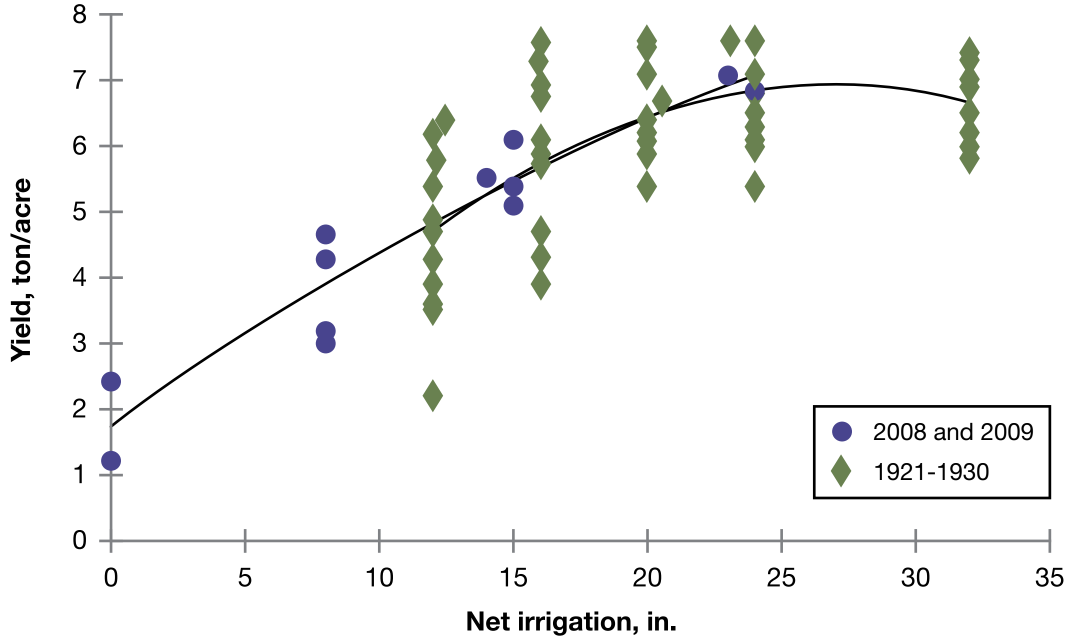

Figure 1. Alfalfa yield response to irrigation at Garden City, KS, for two field studies conducted in 1921–1930 and 2008–2009.
Data from the 1921–1930 study are from annual experiment station reports.

Soil Water Gain and Use in Deficit-Irrigated Corn

N.L. Klocke and R.S. Currie

Summary
Irrigators need management strategies to make the best use of stored soil water. Deficit irrigation caused crop roots to extract water from deeper in the soil. As a result, deficit irrigation led to more soil water storage during the non-growing season and more soil water use during the growing season than full irrigation.

Introduction
Producers who use irrigation need to understand the factors that affect soil water storage during the non-growing season and need as much information as possible about the effects of soil water accumulation to make management decisions. Tillage systems that leave crop residues have potential for reducing soil water evaporation before and during the growing season. Crop residues can enhance capture and retention of precipitation by increasing snow capture and rainfall infiltration and decreasing runoff. This additional soil water will be available for crop production if drainage below the crop root zone does not occur. If off-season soil water storage is accounted for, in-season water applications can be reduced. Knowing the amount of non-growing-season soil water accumulation can help determine crop selections and timing of the first irrigation in deficit-irrigation management. Therefore, the objectives of this study were to (1) measure non-growing-season soil water increases and growing-season soil water use in corn grown with no-till residue management and (2) calculate the fallow efficiency of no-till management.

Procedures
Soil water content was measured to an 8-ft depth with the neutron attenuation method. Access tubes were placed in no-till corn stover plots that received one of six different irrigation treatments the previous season. One treatment was fully irrigated to meet crop water needs, and five other treatments received various irrigation amounts that caused water deficits. The irrigation treatments were replicated four times, and soil water data were gathered at the end of one growing season and during the following growing season. Soil water accumulations during the non-growing season and soil water use during the growing season were calculated from the differences in soil water content. Fallow efficiency was calculated as the ratio of soil water accumulation to precipitation during the non-growing season.

Results and Discussion
Average non-growing-season precipitation (October 31 through April 1; Table 1) from 2005 to 2009 was 15% more than the long-term average. Average growing-season precipitation (May through September; Table 1) from 2005 to 2009 was 7% more than the long-term average. Average cropping-season precipitation (October 1 through September 30; Table 1) from 2005 to 2009 was near the long-term average.

Soil water gain during the non-growing season (Table 2) in the fully irrigated treatment (12.4 in. of irrigation) was significantly less than that in the five deficit-irrigation treatments. Crops in the deficit-irrigation treatments had deeper rooting than those in the fully irrigated treatment (data not shown), which created more soil water storage to hold precipitation. Soil water use during the following growing season in the fully irrigated treatment (12.4 in.) was significantly less than that in the five deficit-irrigation treatments. Soil water use in the deficit-irrigated plots significantly increased as irrigation decreased. Fallow efficiency was significantly less in the fully irrigated treatment (12.4 in.) than in the five deficit-irrigation treatments. These results show that deficit-irrigated crops can store and use more soil water than fully irrigated crops. The additional water is available to increase crop yields.

Table 1. Precipitation (in.) at Garden City

Time period	Oct.–Apr.[1]	May–Sept.[2]	Oct. –Sept.[3]	% of annual[4]
2005	5.3	12.1	17.4	91
2006	5.6	13.0	18.5	97
2007	13.2	10.1	23.3	122
2008	4.4	9.5	13.9	73
2009	10.7	12.5	23.2	118
Long-term avg.	6.8	12.3	19.1	
2005–2009 avg.	7.8	11.4	19.3	
Study/long term (%)	115	93	101	

[1] Off-season precipitation from the previous October 1 through the current April 30.
[2] Growing-season precipitation for the current May 1 through September 30.
[3] Cropping-season precipitation total from the previous October 1 through the current September 30.
[4] Cropping-season precipitation total as a percentage of annual long-term average (19.7 in).

Table 2. Non-growing-season soil water gain, growing-season soil water use, and fallow efficiency by irrigation treatments, 2005–2009

Irrigation amount	Soil water gain	Soil water use	Fallow efficiency
-----------------------------------	in.	-----------------------------------	%
12.4	3.16b	2.56d	33
9.9	3.98a	3.28c	42
8.7	4.13a	3.95b	41
6.5	4.3a	4.09b	43
4.7	3.92a	4.62a	39
3.2	3.99a	4.9a	40
LSD (0.05)	0.62	0.43	

Within columns, values with different letters are significantly different at P=0.05.

Managing Irrigation with Diminished-Capacity Wells[1]

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

Summary
Corn yields were increased an average of 16 bu/acre by preseason irrigation. As expected, grain yields increased with increased well capacity. Grain yields (averaged across preseason irrigation and plant population) were 28% greater when well capacity was increased from 0.1 to 0.2 in./day. Optimum plant population varied with irrigation level. A plant population of 22,500 plants/acre was adequate with the lowest well capacity and without preseason irrigation. When well capacity increased to 1.5 in./day, 27,500 plants/acre were required to optimize yields. With a well capacity of 0.2 in./day, 32,500 plants/acre provided greater yields with or without preseason irrigation. Preseason irrigation increased available soil water at planting by 1.7 in. Preseason irrigation is a viable practice when in-season well capacity cannot fully meet crop needs. Plant populations should be adjusted for irrigation level, taking into account both well capacity and preseason irrigation.

Procedures
A field study was conducted at the Tribune Unit of the Southwest Research-Extension Center to evaluate preplant irrigation (0 and 3 in.), well capacity (0.1, 0.15, and 0.2 in./day capacity), and plant population (22,500; 27,500; and 32,500 plants/acre). Irrigation treatments were whole plots; plant populations were subplots. Each treatment combination was replicated four times and applied to the same plot each year. Corn was planted in late April or early May each year. All plots were machine harvested, and grain yields were adjusted to 15.5% moisture. Plant populations were determined along with yield components. Soil water measurements (8-ft depth, 1-ft increments) were taken throughout the growing season by neutron attenuation. Crop water use was calculated by summing soil water depletion (soil water at planting less soil water at harvest) plus in-season irrigation and precipitation. In-season irrigations were 9.55, 12.61, and 19.01 in. in 2006; 7.21, 10.10, and 15.62 in. in 2007; 8.22, 10.96, and 14.77 in. in 2008; and 8.84, 11.77, and 17.85 in. in 2009 for the 0.1, 0.15, and 0.2 in./day well capacity treatments, respectively. In-season precipitation was 6.93, 8.08, 9.36, and 14.35 in. in 2006, 2007, 2008, and 2009, respectively. Water use efficiency was calculated by dividing grain yield (lb/acre) by crop water use.

Results and Discussion
Preseason irrigation increased grain yields an average of 16 bu/acre (Table 1). Although not significant, the effect was greater at lower well capacities. For example, with 27,500 plants/acre, preseason irrigation (3 in.) increased grain yield by 21 bu/acre with a well capacity of 0.1 in./day but only by 7 bu/acre with a well capacity of 0.2 in./day. As expected, grain yields increased with increased well capacity. Grain yields (averaged across preseason irrigation and plant population) were 28% greater when well capacity

[1] This research project was partially supported by the Ogallala Aquifer Initiative.

[2] Kansas State University Department of Agronomy.

increased from 0.1 to 0.2 in./day. Number of seeds per ear increased with increased well capacity and preseason irrigation.

Optimum plant population varied with irrigation level. A plant population of 22,500 plants/acre was adequate with the lowest well capacity and without preseason irrigation. However, if preseason irrigation was applied, a higher plant population increased yields even at the lowest well capacity. When well capacity increased to 0.15 in./day, 27,500 plants/acre were required to optimize yields. With a well capacity of 0.2 in./day, 32,500 plants/acre provided greater yields with or without preseason irrigation.

Crop water use increased with well capacity and preseason irrigation (Table 2). Water use efficiency tended to increase with increased well capacity and preseason irrigation (Table 1). Soil water at harvest increased with increased well capacity, but this caused less soil water to accumulate during the winter. Preseason irrigation (about 3 in.) increased available soil water at planting by 1.7 in. Seeding rate had a minimal effect on soil water at planting or crop water use, but increased seeding rate tended to decrease soil water at harvest and increase overwinter water accumulation.

Table 1. Crop parameters as affected by well capacity, preseason irrigation, and seeding rate, Tribune, 2006–2009

Well capacity	Preseason irrigation	Seed rate	Yield	WUE[1]	Plant pop.	Ear pop.	Barren	Ear weight	1000 seed	Kernel
in./day		10^3/acre	bu/acre	lb/in.	---10^3/acre---		%	lb	oz	no./ear
0.10	no	22.5	153	386	22.4	21.5	4	0.39	13.20	476
		27.5	158	397	26.7	24.7	8	0.35	12.75	442
		32.5	155	389	31.2	28.8	8	0.29	12.46	379
	yes	22.5	171	403	21.9	21.5	2	0.44	13.43	531
		27.5	179	416	26.7	25.3	5	0.39	13.15	478
		32.5	183	419	31.5	29.6	6	0.34	12.80	427
0.15	no	22.5	172	389	22.2	21.2	4	0.45	13.24	543
		27.5	173	395	27.0	25.9	4	0.37	12.93	465
		32.5	171	383	31.1	29.2	6	0.32	12.84	406
	yes	22.5	185	405	22.4	21.9	2	0.47	13.36	563
		27.5	197	431	27.0	26.2	3	0.42	13.08	512
		32.5	201	433	31.4	30.2	4	0.37	12.80	466
0.20	no	22.5	200	404	22.3	22.0	1	0.51	13.29	615
		27.5	211	414	27.0	26.8	1	0.44	13.02	544
		32.5	223	440	31.8	31.3	2	0.40	12.74	503
	yes	22.5	204	396	22.1	21.9	1	0.52	13.59	617
		27.5	218	414	27.0	26.8	1	0.46	13.27	551
		32.5	229	436	31.9	31.2	2	0.41	12.74	517

continued

Table 1. Crop parameters as affected by well capacity, preseason irrigation, and seeding rate, Tribune, 2006–2009

Well capacity	Preseason irrigation	Seed rate	Yield	WUE[1]	Plant pop.	Ear pop.	Barren	Ear weight	1000 seed	Kernel
in./day		10^3/acre	bu/acre	lb/in.	---10^3/acre---		%	lb	oz	no./ear
Means										
	Well capacity	0.10	167	402	26.8	25.2	6	0.37	12.97	456
		0.15	183	406	26.9	25.8	4	0.40	13.04	493
		0.20	214	417	27.0	26.6	1	0.46	13.11	558
		LSD (0.05)	11	25	0.2	0.5	2	0.02	0.35	21
	Preseason	no	180	400	26.9	25.7	4	0.39	12.94	486
		yes	196	417	26.9	26.1	3	0.42	13.14	518
		LSD (0.05)	9	21	0.2	0.4	1	0.02	0.28	17
	Seed rate	22,500	181	397	22.2	21.7	2	0.46	13.35	558
		27,500	189	411	26.9	25.9	4	0.40	13.03	499
		32,500	194	417	31.5	30.1	5	0.36	12.73	450
		LSD (0.05)	3	8	0.2	0.3	1	0.01	0.09	10

[1] WUE = water use efficiency.

Table 2. Soil profile available water for corn as affected by well capacity, preseason irrigation, and seeding rate, Tribune, 2006–2009

			Available water				
Well capacity	Preseason	Seed rate	Previous harvest	Planting	Harvest	Water use	Fallow accum.
in./day		10^3/acre	------------in./8 ft profile------------			in.	in./8 ft. profile
0.10	no	22.5	5.03	8.36	5.21	21.28	2.79
		27.5	4.89	8.24	4.83	21.55	2.73
		32.5	4.46	8.02	4.63	21.52	2.78
	yes	22.5	5.23	10.66	5.43	23.36	5.02
		27.5	4.77	10.52	4.88	23.78	5.30
		32.5	4.97	10.83	4.96	24.00	5.33
0.15	no	22.5	5.44	8.78	5.47	24.35	2.71
		27.5	6.06	9.17	6.08	24.13	2.56
		32.5	5.66	9.06	5.68	24.42	2.98
	yes	22.5	5.85	10.51	6.19	25.36	4.05
		27.5	5.59	10.46	6.15	25.35	4.77
		32.5	5.38	10.71	5.98	25.76	5.05
0.20	no	22.5	8.68	10.51	9.07	27.94	2.14
		27.5	7.15	9.95	7.86	28.59	3.02
		32.5	7.89	10.56	8.53	28.53	2.82
	yes	22.5	10.40	13.44	10.82	29.11	3.15
		27.5	9.57	13.22	10.13	29.58	3.68
		32.5	9.48	12.90	9.85	29.55	3.55
Means							
	Well capacity	0.10	4.89	9.44	4.99	22.58	3.99
		0.15	5.66	9.78	5.92	24.89	3.69
		0.20	8.86	11.76	9.37	28.88	3.06
		LSD (0.05)	1.72	1.49	1.77	0.39	0.38
	Preseason	no	6.14	9.18	6.37	24.70	2.73
		yes	6.81	11.47	7.15	26.21	4.43
		LSD (0.05)	1.40	1.22	1.44	0.32	0.31
	Seed rate	22.5	6.77	10.38	7.03	25.23	3.31
		27.5	6.34	10.26	6.65	25.50	3.68
		32.5	6.31	10.35	6.61	25.63	3.75
		LSD (0.05)	0.39	0.34	0.40	0.18	0.24

Previous harvest available water and fallow accumulation include only 2007, 2008, and 2009 data.

Effect of Volunteer Roundup Ready Corn on Winter Wheat[1]

J. Holman, A. Schlegel, B. Olson[2], S. Maxwell, Kent Martin, and T. Dumler

Summary
In a wheat-corn-fallow rotation, volunteer corn can be a problem when Roundup Ready hybrids are used. During the fallow period between corn harvest in the fall and wheat planting the following fall, producers often control weeds with glyphosate or tank mixes of glyphosate and 2,4-D or dicamba. None of those herbicide treatments will control Roundup Ready volunteer corn. Instead, a postemergence grass herbicide such as Select, Assure II, or Poast Plus must be used.

It is believed that volunteer corn will reduce the amount of soil moisture during the fallow period and subsequently affect the following winter wheat crop. In years with average precipitation and growing conditions, wheat yield was reduced 1 bu/acre for every 200 volunteer corn plants/acre at Colby, KS, and at Tribune, KS, the first bushel of wheat yield was lost when volunteer corn density was 75 plants/acre. In very dry or very wet years, volunteer corn did not affect the following winter wheat yield. Producers' fields averaged 500 volunteer corn plants/acre. On the basis of the test results from Colby and Tribune in 2008, a density of 500 plants/acre would cause an estimated wheat yield loss of 4.6 bu/acre. The estimated breakeven cost to apply a selective postemergence herbicide such as Select to volunteer corn would be approximately 250 plants/acre with the price of wheat at $5.00/bu and the cost of herbicide plus application at $14.00/acre.

Results and Discussion

Volunteer Corn Density in Production Fields

Volunteer corn populations in producers' fields ranged from 120 to 1,250 plants/acre. Volunteer corn density can vary greatly within a field, and volunteer corn densities ranged from 0 to 2,830 plants/acre. In 2007, whole-field populations ranged from 240 to 930 plants/acre with an average of 470 plants/acre. In 2008, whole-field populations ranged from 120 to 1,250 plants/acre with an average of 450 plants/acre. In 2009, whole-field populations ranged from 450 to 810 plants/acre with an average of 590 plants/acre. The 3-year average across producers' fields was 500 plants/acre.

Volunteer Corn Effects on Winter Wheat

Winter Wheat Tiller Density. Volunteer corn did not affect wheat tiller density at Tribune in 2008 or 2009, Garden City in 2009, or Colby in 2009. Volunteer corn reduced wheat tiller density at Colby and Garden City in 2008. Wheat tiller density has not been measured yet in 2010. Volunteer corn tended to reduce wheat tiller density in years with average precipitation and wheat yield. Wheat tiller density was reduced one

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[1] This research is funded in part by the Kansas State University Integrated Pest Management Implementation Mini-Grant.

[2] Kansas State University Northwest Research-Extension Center.

tiller per square foot for every 50 volunteer corn plants/acre at Colby in 2008 and for every 100 volunteer corn plants/acre at Garden City in 2008.

Winter Wheat Yield. In 2008, the first bushel of wheat yield was lost when volunteer corn density approached 75 plants/acre at Tribune. Yield loss at Tribune indicated a potential yield loss of up to 31% as volunteer corn density approaches infinity (*a*) and a 0.0003% yield loss as volunteer corn density approaches zero (*i*) (Figure 1). Population densities at Colby were not high enough to fit a nonlinear yield response function to volunteer corn, and each volunteer corn plant was estimated to reduce yield by 0.009 bu/acre, or 1 bu/acre for every 200 volunteer corn plants/acre. Fitting a linear response rather than a nonlinear response to wheat yield loss likely underestimated yield reduction at low volunteer corn densities and overestimated yield reduction at high volunteer corn densities. Wheat at Garden City was hailed out on June 20, 2008, and was not harvested for yield.

In 2009, volunteer corn did not affect wheat yield at Tribune or Colby. Wheat yields at Tribune were very low because of hail, disease, and a very dry year. Wheat yield at Tribune averaged 7.7 bu/acre in 2009. Wheat yield at Colby averaged 68.5 bu/acre, and wheat yield at Garden City averaged 80.8 bu/acre. In 2009, volunteer corn increased wheat yield slightly (1 bu/acre for every 1,000 volunteer corn plants/acre at Garden City). Wheat yield was likely not reduced by volunteer corn at Colby or Garden City in 2009 because of high wheat yields and sufficient growing-season precipitation. The slight increase in yield at Garden City might have been due to volunteer corn reducing fall wheat growth, which has been shown to use up moisture, and the volunteer corn might have acted as a cover crop, helping increase winter wheat winter survival by providing cover, recycling nutrients (nitrogen) to the soil surface, and reducing soil water evaporation by providing soil cover.

Winter Wheat Test Weight. Volunteer corn did not affect wheat test weight at Colby in 2008 or 2009 or at Tribune in 2009. Volunteer corn increased wheat test weight at Tribune in 2008 and Garden City in 2009. Test weight was likely increased at Tribune in 2008 because more resources were available for grain fill (i.e., because volunteer corn reduced wheat yield, there were fewer seeds to fill). At Garden City in 2009, wheat test weight was likely increased for the same reasons volunteer corn increased wheat yield.

Conclusions

1. In very dry years and low-yield environments, such as Tribune in 2009, volunteer corn did not affect wheat tiller density, grain yield, or test weight because crop performance was already very poor. In very wet years and high-yield environments, such as Colby and Garden City in 2009, volunteer corn did not affect wheat tiller density and had no effect to a slight increase in wheat grain yield and test weight. The positive effects of volunteer corn on wheat were likely some of the same positive benefits observed with cover crops in non-moisture-limiting environments. In "average" years, volunteer corn negatively affected wheat tiller density and grain yield and had a minimal effect on grain test weight.

2. Producers' fields averaged 500 volunteer corn plants/acre across the 3 years. In a year with average precipitation, this would result in a wheat yield loss of about 4.6 bu/acre.
3. The herbicide cost to treat the entire field for volunteer corn with a selective postemergence grass herbicide such as Select during the fallow period is about $10/acre (for the product only, excluding application cost). A volunteer corn density of 250 plants/acre would cause an estimated 2.7 bu/acre wheat yield loss. Wheat and herbicide prices will influence the amount that can be spent to control volunteer corn. With wheat at about $5.00/bu, a yield loss of 2.7 bu/acre would result in a loss of about $13.50/acre. That is near the break-even cost to apply herbicide to the entire field with a volunteer corn density of 250 plants/acre. A field could be spot sprayed to reduce the cost of herbicide, or a postemergence grass herbicide such as Select, Assure, or Poast Plus could be used in place of Roundup for sequential herbicide applications in fallow.

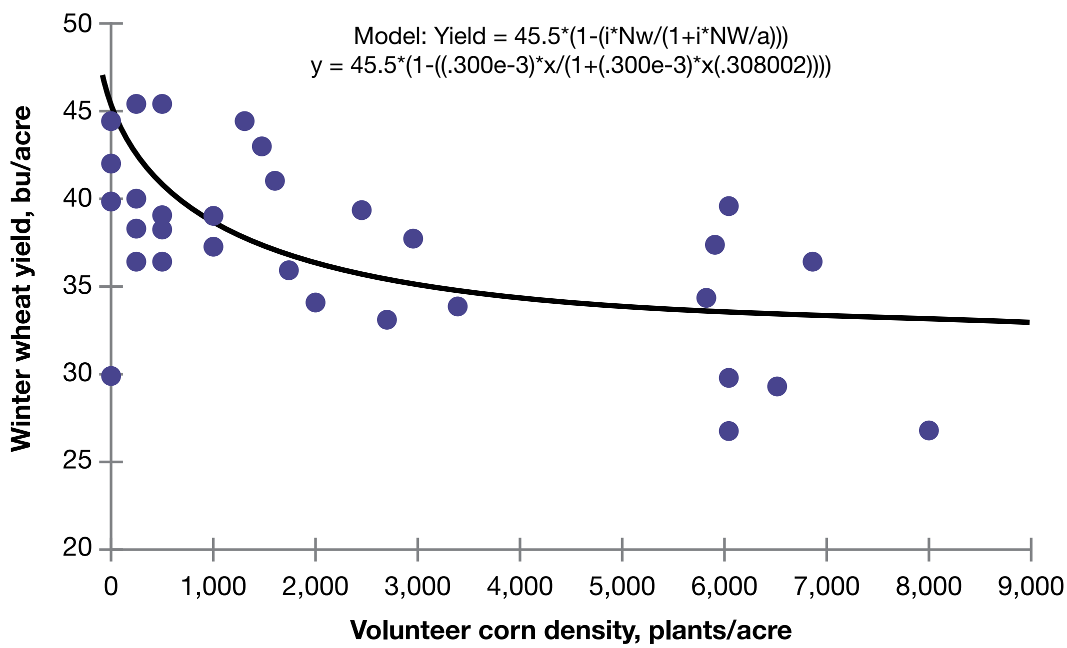

Figure 1. Wheat yield response to 2007 volunteer corn density at Tribune, 2008.

Comparisons of 43 Herbicide Tank Mixes for Weed Control in Irrigated Corn Injured by Hail

R. Currie

Summary
Hail defoliated 8- to 12-in. corn in the V5 stage. This allowed light to reach the ground, severely compromising the weed control of herbicide tank mixes with litte or no soil residual activity. Of all herbicide tank mixes that relied on only a preemergence application, only two resulted in corn yield statistically higher than that of the control. Corn in the best stand-alone preemergence herbicide tank mix yielded 24 bu less than corn in the best-yielding treatment. Corn yield of plots treated only with glyphosate (Roundup) was not significantly higher than yield in the untreated control plots. If the corn canopy is compromised allowing light to strike the ground after the V5 stage, both a preemergence and postemergence herbicide application may be required to obtain commercially viable yields.

Introduction
With the advent of glyphosate-resistant weeds, profit potential in herbicide development might be returning to crop protection companies. Therefore, many new non-glyphosate herbicides tank mixes are approaching the market. Many of these contain novel soil-persistent herbicides. Glyphosate has no persistent soil residual weed control. Regardless of the number of glyphosate applications, once corn is too tall to spray, health of the corn canopy is the sole source of weed control. An unexpected hailstorm damaged the corn canopy in this experiment. Therefore, the objective of this study was adjusted to compare the effectiveness of multiple herbicide tank mixes that have various levels of soil residual with two application of glyphosate alone in corn with a compromised canopy.

Procedures
Palmer amaranth (700,000 seeds/acre), yellow foxtail (344,124 seeds/acre), crabgrass (9,800,000 seeds/acre), sunflower (40,000 seeds/acre), and barnyard grass (817,000 seeds/acre) were seeded into prepared fields on May 20, 2008, just before corn was planted. All weeds were planted with a carrier mixture of cracked corn at a rate of 40 lb/acre with a 14-ft Great Plains Drill with tubes removed to allow weed seed to be dropped on the soil surface. Weed seed was planted in 10-in. rows, and soil moisture was ideal.

DeKalb DK-6019 RR corn was planted May 20, 2008, at 1.5 in. deep in 30-in. rows at a rate of 32,000 seeds/acre with a John Deere Max Emerge II planter. The experimental design was a randomized complete block with four replicates. The crop emerged on May 28 before the first major weed flush. Corn was irrigated using the Kanshed2 program. Corn was combine harvested, and yields were adjusted to 15.5% moisture.

Results and Discussion

Hail defoliated 8- to 12-in. corn in the V5 stage on June 20, 2008. This opened the corn canopy and allowed light to reach the ground, which severely compromised the weed control of herbicide tank mixes with litte or no soil residual activity. Of all tank mixes that relied on only a preemergence application, only treatments 10 and 11 resulted in corn yield statistically higher than that in the control (Table 1). Treatment 11 was the best stand-alone preemergence herbicide tank mix, and corn in that treatment yielded 24 bu less than corn in the best-yielding treatment. Corn yield was not statistically different between treatments with glyphosate alone and untreated controls.

If the corn canopy is compromised allowing light to strike the ground after V5 stage, both a preemergence and postemergence herbicide application may be required to obtain commercially viable yields.

Table 1. Comparisons of 43 herbicide tank mixes for weed control in irrigated corn

Treatment[1]		Rate	Unit	Growth stage[2]	Control (%) Palmer amaranth	Sunflower	Crabgrass	Yield (bu/a)
1	Control				0	0	0	52.8
2	Balance Flexx	3	oz/a	PRE	**100**	**100**	15	90.4
	Atrazine	1	qt/a	PRE				
	Laudis	3	oz/a	MPOST				
	Atrazine	1	pt/a	MPOST				
	COC	1	% v/v	MPOST				
	UAN 28%	1.5	qt/a	MPOST				
3	Balance Flexx	3	oz/a	PRE	**100**	**97.5**	37.5	**117.3**
	Atrazine	1	qt/a	PRE				
	Laudis	3	oz/a	MPOST				
	MSO	1	% v/v	MPOST				
	UAN 28%	1.5	qt/a	MPOST				
4	Lumax	1.5	qt/a	PRE	**100**	**100**	**100**	87.8
	Lumax	1.5	qt/a	MPOST				
	NIS	0.25	% v/v	MPOST				
5	Harness Xtra	2.1	qt/a	PRE	**98.8**	**100**	40	74.5
	Laudis	3	oz/a	MPOST				
	Atrazine	1	pt/a	MPOST				
	COC	1	% v/v	MPOST				
	UAN 28%	1.5	qt/a	MPOST				
6	Laudis	3	oz/a	MPOST	**100**	**98.8**	20	**117.1**
	Roundup	22	oz/a	MPOST				
	Atrazine	1	pt/a	MPOST				
	AMS	8.5	lb/100 gal	MPOST				

continued

Table 1. Comparisons of 43 herbicide tank mixes for weed control in irrigated corn

					Control (%)			
Treatment[1]		Rate	Unit	Growth stage[2]	Palmer amaranth	Sunflower	Crabgrass	Yield (bu/a)
7	Laudis	3	oz/a	MPOST	**97.5**	**100**	35	**112.7**
	Atrazine	1	qt/a	MPOST				
	AMS	8.5	lb/100 gal	MPOST				
	Roundup	11	oz/a	MPOST				
8	Laudis	3	oz/a	POST	**95**	**100**	17.5	82.8
	Atrazine	1	qt/a	POST				
	MSO	1	% v/v	POST				
	UAN 28%	1.5	qt/a	POST				
9	Capreno	3	oz/a	POST	**100**	**100**	20	80.9
	Atrazine	1	qt/a	POST				
	COC	1	% v/v	POST				
	UAN 28%	1.5	qt/a	POST				
10	Corvus	3.3	oz/a	PRE	**100**	80	17.5	99.1
	Atrazine	1	qt/a	PRE				
11	Corvus	4.5	oz/a	PRE	**97.5**	78.8	15	**108.8**
	Atrazine	1	qt/a	PRE				
12	Balance Flexx	4	oz/a	PRE	**100**	75	40	66
	Atrazine	1	qt/a	PRE				
13	Balance Flexx	5	oz/a	PRE	**95**	65	30	97
	Atrazine	1	qt/a	PRE				
14	Dual II Magnum	1.25	pt/a	PRE	**91.3**	**100**	20	88.3
	Roundup	22	oz/a	POST				
	AMS	8.5	lb/100 gal	POST				
	Roundup	22	oz/a	MPOST				
	AMS	8.5	lb/100 gal	MPOST				
15	Corvus	2.2	oz/a	PRE	**92.5**	**100**	15	86.2
	Ignite 280	22	oz/a	MPOST				
	Laudis	2	oz/a	MPOST				
	AMS	8.5	lb/100 gal	MPOST				
16	Corvus	2.2	oz/a	PRE	**98.8**	**100**	12.5	**133.2**
	Roundup	22	oz/a	MPOST				
	Laudis	3	oz/a	MPOST				
	AMS	8.5	lb/100 gal	MPOST				
17	Balance Flexx	3	oz/a	PRE	**100**	**100**	15	98.8
	Atrazine	1	qt/a	PRE				
	Ignite 280	22	oz/a	MPOST				
	Laudis	2	oz/a	MPOST				
	AMS	8.5	lb/100 gal	MPOST				

continued

Table 1. Comparisons of 43 herbicide tank mixes for weed control in irrigated corn

					Control (%)			
Treatment[1]		Rate	Unit	Growth stage[2]	Palmer amaranth	Sunflower	Crabgrass	Yield (bu/a)
18	Balance Flexx	4	oz/a	PRE	**100**	78.8	20	72.8
	Harness Xtra	1.5	qt/a	PRE				
19	Impact	0.73	oz/a	POST	**97.5**	**100**	22.5	101
	Atrazine	1	qt/a	POST				
	MSO	1	% v/v	POST				
	AMS	8.5	lb/100 gal	POST				
20	Impact	0.5	oz/a	POST	**95**	**100**	32.5	83.1
	Atrazine	1	qt/a	POST				
	Roundup	28.4	oz/a	POST				
	AMS	8.5	lb/100 gal	POST				
21	Keystone	2.8	qt/a	PRE	**97.5**	**98.8**	12.5	**117.3**
	Durango	24	oz/a	MPOST				
	AMS	16.7	lb/100 gal	POST				
22	Keystone	2	qt/a	PRE	57.5	**100**	17.5	79.9
	Durango	24	oz/a	MPOST				
	WideMatch	1	pt/a	MPOST				
	AMS	16.7	lb/100 gal	MPOST				
23	SureStart	2	pt/a	MPOST	**96.3**	**100**	35	**123.8**
	Durango	24	oz/a	MPOST				
	AMS	16.7	lb/100 gal	MPOST				
24	Rimsulfuron	0.5	oz/a	PRE	**97.5**	72.5	45	88.1
	Isoxaflutole	0.33	oz/a	PRE				
	Atrazine 90DF	17.8	oz/a	PRE				
25	Rimsulfuron	1	oz/a	PRE	**92.5**	92.5	45	98.2
	Isoxaflutole	0.67	oz/a	PRE				
	Atrazine 90DF	17.8	oz/a	PRE				
26	Rimsulfuron	1.5	oz/a	PRE	**100**	80	35	82.6
	Isoxaflutole	1	oz/a	PRE				
	Atrazine DF90	17.8	oz/a	PRE				
27	Rimsulfuron	0.5	oz/a	PRE	**93.8**	**100**	10	88.3
	Isoxaflutole	0.33	oz/a	PRE				
	Atrazine 90DF	17.8	oz/a	PRE				
	PowerMax	22	fl oz/a	MPOST				
	AMS	10	lb ai/100 gal	MPOST				
28	Rimsulfuron	1	oz/a	PRE	**92.5**	**98.8**	12.5	**109.3**
	Isoxaflutole	0.67	oz/a	PRE				
	Atrazine DF90	17.8	oz/a	PRE				
	PowerMax	22	fl oz/a	MPOST				
	AMS	10	lb ai/100 gal	MPOST				

continued

Table 1. Comparisons of 43 herbicide tank mixes for weed control in irrigated corn

					Control (%)			
Treatment[1]		Rate	Unit	Growth stage[2]	Palmer amaranth	Sunflower	Crabgrass	Yield (bu/a)
29	Rimsulfuron	1.5	oz/a	PRE	**97.5**	**100**	27.5	114.3
	Isoxaflutole	1	oz/a	PRE				
	Atrazine 90DF	17.8	oz/a	PRE				
	PowerMax	22	fl oz/a	MPOST				
	AMS	10	lb ai/100 gal	MPOST				
30	PowerMax	22	fl oz/a	POST	77.5	**100**	45	59.8
	AMS	10	lb ai/100 gal	POST				
31	PowerMax	22	fl oz/a	POST	77.5	**100**	37.5	80.7
	AMS	10	lb ai/100 gal	POST				
	PowerMax	22	fl oz/a	MPOST				
	AMS	10	lb ai/100 gal	MPOST				
32	PowerMax	22	fl oz/a	MPOST	67.5	**100**	42.5	79.6
	AMS	10	lb ai/100 gal	MPOST				
33	Dual II Magnum	1.25	pt/a	PRE	87.5	**100**	37.5	98.7
	PowerMax	22	fl oz/a	MPOST				
	AMS	10	lb ai/100 gal	MPOST				
34	Rimsulfuron	0.75	oz/a	EPOST	77.5	**100**	25	**106.7**
	Nicosulfuron	0.5	oz/a	EPOST				
	Isoxadifen-ethyl	0.25	oz/a	EPOST				
	Impact	0.5	oz/a	EPOST				
	Atrazine 90DF	8.9	oz/a	EPOST				
	MSO	1	% v/v	EPOST				
	AMS	10	lb ai/100 gal	EPOST				
35	Cinch ATZ	1	qt/a	PRE	87.5	**93.8**	15	**102.3**
	Rimsulfuron	0.75	oz/a	EPOST				
	Nicosulfuron	0.5	oz/a	EPOST				
	Isoxadifen-ethyl	0.25	oz/a	EPOST				
	Impact	0.5	oz/a	EPOST				
	Atrazine 90DF	8.9	oz/a	EPOST				
	MSO	1	% v/v	EPOST				
	AMS	10	lb ai/100 gal	EPOST				
36	Rimsulfuron	1	oz/a	EPOST	57.5	**100**	35	71.6
	Dicamba	2.75	oz/a	EPOST				
	Isoxadifen-ethyl	0.25	oz/a	EPOST				
	Atrazine 90DF	8.9	oz/a	EPOST				
	PowerMax	22	fl oz/a	EPOST				
	AMS	10	lb ai/100 gal	EPOST				

continued

Table 1. Comparisons of 43 herbicide tank mixes for weed control in irrigated corn

	Treatment[1]	Rate	Unit	Growth stage[2]	Control (%) Palmer amaranth	Sunflower	Crabgrass	Yield (bu/a)
37	Cinch ATZ	1	qt/a	PRE	87.5	**100**	35	79.1
	Rimsulfuron	1	oz/a	EPOST				
	Dicamba	2.75	oz/a	EPOST				
	Isoxadifen-ethyl	0.25	oz/a	EPOST				
	Atrazine 90DF	8.9	oz/a	EPOST				
	PowerMax	22	fl oz/a	EPOST				
	AMS	10	lb ai/100 gal	EPOST				
38	PowerMax	22	fl oz/a	EPOST	32.5	**100**	35	60.5
	AMS	10	lb ai/100 gal	EPOST				
39	Cinch ATZ	1	qt/a	PRE	75	**100**	25	90.3
	PowerMax	22	fl oz/a	EPOST				
	AMS	10	lb ai/100 gal	EPOST				
40	Rimsulfuron	1.5	oz/a	EPOST	86.3	**100**	15	96.4
	Isoxaflutole	1	oz/a	EPOST				
	PowerMax	22	fl oz/a	EPOST				
	AMS	10	lb ai/100 gal	EPOST				
41	Rimsulfuron	1.5	oz/a	PRE	**98.8**	**100**	15	**108.4**
	Isoxaflutole	1	oz/a	PRE				
	Rimsulfuron	1	oz/a	EPOST				
	Dicamba	2.75	oz/a	EPOST				
	Isoxadifen-ethyl	0.25	oz/a	EPOST				
	Atrazine 90DF	8.9	oz/a	EPOST				
	PowerMax	22	fl oz/a	EPOST				
	AMS	10	lb ai/100 gal	EPOST				
42	Roundup	22	oz/a	POST	50	**100**	37.5	63.1
	AMS	8.5	lb/100 gal	POST				
	Roundup	22	oz/a	MPOST				
	AMS	8.5	lb/100 gal	MPOST				
43	Roundup	22	oz/a	EPOST	45	**100**	32.5	68.9
	AMS	8.5	lb/100 gal	EPOST				
	ATRAZINE	1	qt/a	EPOST				
44	Impact	0.5	oz/a	POST	90	**98.8**	22.5	73.3
	ATRAZINE	1	qt/a	POST				
	Roundup	28.4	oz/a	POST				
	AMS	8.5	lb/100 gal	POST				
LSD (0.10)					9.53	7.16	14.41	31.67

[1] COC, crop oil concentrate; MSO, methylated seed oil; UAN, 28% urea-ammonium nitrate solution; AMS, ammonium sulfate.
[2] PRE, preemergence application within a few hours of planting on May 20, 2008; MPOST, mid-postemergence application on June 18, 2008, to 8- to 11-in. corn at the V6 stage; POST, postemergence application on June 12, 2008, to 5- to 8-in. corn at the V4 stage; EPOST, early postemergence application on June 10, 2008, to 3- to 6-in. corn at the V4 stage.
Within a column, data in bold print are not statistically different from the best treatment in that column.

Comparisons of Application Times and Rates of Huskie for Weed Control in Sorghum

R. Currie

Summary
Two applications of Huskie herbicide produced less than 5% sorghum injury. Early postemergence applications of Huskie and atrazine or Buctril and atrazine outperformed the same tank mixes applied later on larger weeds. If 2,4-D or Banvel was added to these late applications, weed control was greatly improved. Regardless of application timing, the increased rate of Huskie did not outperform the lower rate. The Starane treatment provided poor Palmer amaranth control. Huskie appears to provide excellent Palmer amaranth control if applied at the proper time.

Introduction
Huskie is an emerging compound for weed control in grain sorghum, and its ideal application rate and timing are unknown. We also don't know which herbicides might need to be added to Huskie to enhance its performance, and crop tolerance to Huskie has yet to be determined. This study was conducted to help provide some of this missing information. Huskie was applied at two rates and two timings with various tank mix partners, and a 2X application was also studied.

Procedures
The field was conventionally tilled to create a residue-free surface before bedding in fall 2008. On May 18, 2009, 1 lb/acre of glyhposate was applied to kill a uniform, dense stand of Kochia. This treatment provided less than 90% control. Therefore, glyphosate was reapplied at 1.5 lb/acre on June 1. This treatment appeared to be ineffective. A third application of 1 lb/acre 2,4-D tank mixed with 0.2 lb/acre Fluroxypyr was applied on June 4. This final treatment provided 100% control. DeKalb DK-37-07 sorghum was planted at 40,000 seeds/acre on June 24, 2009, into poor soil conditions (i.e., soil was dry because of the extended period of Kochia growth prior to planting). On June 25, 0.92 in. of rain provided sufficient moisture for crop emergence on June 28.

Naturally occurring weed populations were used. Although several types of weeds were present, Palmer amaranth was the primary competitor with the crop. Sorghum was combine harvested, and yields were statistically analyzed.

Results and Discussion
Compared with sorghum in the less efffective treatments, sorghum in the more effective treatments had larger, later-maturing heads that were damaged by an early fall freeze. This caused an inverse relationship between crop health and yield. This effect was highly variable across replications. Therefore, yield data are not presented.

Two applications of Huskie produced less than 5% sorghum injury. Early postemergence applications of Huskie and atrazine or Buctril and atrazine outperformed the same tank mixes applied later on larger weeds (Table 1). If 2,4-D or Banvel was added to these late applications, weed control was greatly improved. Regardless of application timing, the increased rate of Huskie did not outperform the lower rate. The Starane treatment provided poor Palmer amaranth control. This is consistent with recommendations presented in *2010 Chemical Weed Control* (Kansas State University Agricultural Experiment Station Report of Progress 1027). Huskie appears to provide excellent Palmer amaranth control if applied at the proper time.

Table 1. Comparison of application times and rates of Huskie for weed control in sorghum

Treatment		Rate	Unit	Application time[1]	Palmer amaranth control (%)	
					Aug. 4, 2009	Aug. 20, 2009
1	Untreated check				0	0
2	Outlook	1	pt/a	PRE	**95**	**95**
	Huskie	13	oz/a	EPOST		
	Atrazine	1	pt/a	EPOST		
	Ammonium sulfate	8.5	lb/100 gal	EPOST		
3	Outlook	1	pt/a	PRE	**95**	**95**
	Huskie	15	oz/a	EPOST		
	Atrazine	1	pt/a	EPOST		
	Ammonium sulfate	8.5	lb/100 gal	EPOST		
4	Outlook	1	pt/a	PRE	**96**	**95**
	Huskie	13	oz/a	EPOST		
	Atrazine	1	pt/a	EPOST		
	2,4-D Amine	8	oz/a	EPOST		
	Ammonium sulfate	8.5	lb/100 gal	EPOST		
5	Outlook	1	pt/a	PRE	**96**	**94**
	Huskie	13	oz/a	EPOST		
	Atrazine	1	pt/a	EPOST		
	2,4-D Ester	4	oz/a	EPOST		
	Ammonium sulfate	8.5	lb/100 gal	EPOST		
6	Outlook	1	pt/a	PRE	**96**	**95**
	Huskie	13	oz/a	EPOST		
	Atrazine	1	pt/a	EPOST		
	Banvel	4	oz/a	EPOST		
	Ammonium sulfate	8.5	lb/100 gal	EPOST		
7	Outlook	1	pt/a	PRE	**95**	**89**
	Atrazine	1	pt/a	EPOST		
	Buctril	1	pt/a	EPOST		

continued

Table 1. Comparison of application times and rates of Huskie for weed control in sorghum

Treatment		Rate	Unit	Application time[1]	Palmer amaranth control (%) Aug. 4, 2009	Palmer amaranth control (%) Aug. 20, 2009
8	Outlook	1	pt/a	PRE	**100**	**99**
	Huskie	13	oz/a	EPOST		
	Atrazine	1	pt/a	EPOST		
	Ammonium sulfate	8.5	lb/100 gal	EPOST		
	Huskie	13	oz/a	MPOST		
	Atrazine	1	pt/a	MPOST		
	Ammonium sulfate	8.5	lb/100 gal	MPOST		
9	Outlook	1	pt/a	PRE	69	84
	Huskie	13	oz/a	MPOST		
	Atrazine	1	pt/a	MPOST		
	Ammonium sulfate	8.5	lb/100 gal	MPOST		
10	Outlook	1	pt/a	PRE	68	83
	Huskie	15	oz/a	MPOST		
	Atrazine	1	pt/a	MPOST		
	Ammonium sulfate	8.5	lb/100 gal	MPOST		
11	Outlook	1	pt/a	PRE	**99**	**98**
	Huskie	13	oz/a	MPOST		
	Atrazine	1	pt/a	MPOST		
	2,4-D Amine	8	oz/a	MPOST		
	Ammonium sulfate	8.5	lb/100 gal	MPOST		
12	Outlook	1	pt/a	PRE	**99**	**98**
	Huskie	13	oz/a	MPOST		
	Atrazine	1	pt/a	MPOST		
	2,4-D Ester	4	oz/a	MPOST		
	Ammonium sulfate	8.5	lb/100 gal	MPOST		
13	Outlook	1	pt/a	PRE	**94**	**95**
	Huskie	13	oz/a	MPOST		
	Atrazine	1	pt/a	MPOST		
	Banvel	4	oz/a	MPOST		
	Ammonium sulfate	8.5	lb/100 gal	MPOST		
14	Outlook	1	pt/a	PRE	49	51
	Atrazine	1	pt/a	MPOST		
	Buctril	1	pt/a	MPOST		
15	Starane	21	oz/a	EPOST	71	63
	Durango	24	oz/a	EPOST		
	Ammonium sulfate	8.5	lb/100 gal	EPOST		
LSD (0.10)					18	11

[1] PRE, early preplant treatments applied June 24, 2009, within hours of planting sorghum; EPOST, applied to 6- to 8-in. sorghum on July 15, 2009; MPOST, applied to 10- to 12-in. sorghum on July 28, 2009.
Within a column, data in bold print are not statistically different from the best treatment in that column.

Effectiveness of Three New Herbicide Tank Mixes Compared with Standard Treatments for Weed Control in Grain Sorghum

R. Currie

Summary
Tank mixes of the new herbicides Huskie, Integrity, and Sharpen provided competitive levels of weed control compared with current standard treatments. Lambsquarters control was excellent with all early postemergence treatments, but mid-postemergence treatments did not provide good control of this weed. This result is consistent with the labels for these products, which warn that reduced control can be expected once lambsquarters exceeds a set size. Most treatments provided excellent sunflower control. All but one treatment provided good Palmer amaranth control.

Introduction
Herbicide development has increased with the advent of glyphosate-resistant weeds. New non-glyphosate herbicides, such as Huskie, Integrity, and Sharpen, are being developed for weed control in sorghum. The objective of this experiment was to compare standard herbicide treatments with tank mixes of these emerging compounds.

Procedures
The field was bedded for furrow irrigation in fall 2007. Sorghum was planted on June 12, 2008, into less-than-perfect soil moisture conditions, and preemergence treatments were applied. No significant rainfall occurred for the next 6 days, and only 10% of the sorghum seed had begun to emerge. Therefore, 6 in. of furrow irrigation was applied to promote uniform crop emergence. No further irrigation was applied.

Palmer amaranth (700,000 seeds/acre), yellow foxtail (344,124 seeds/acre), crabgrass (9,800,000 seeds/acre), sunflower (40,000 seeds/acre), barnyard grass (817,000 seeds/acre), and quinoa (119,000 seeds/acre) were seeded just before the sorghum was planted. Quinoa is a domesticated grain-type lambsquarters and was planted to simulate its wild relative. All weeds were planted with a carrier mixture of cracked corn at a rate of 40 lb/acre with a 14-ft Great Plains Drill with tubes removed to allow weed seed to be dropped on the soil surface. Sorghum was combine harvested, and yield data were statistically analyzed

Results and Discussion
Bird predation compromised sorghum yield to the point that comparisons between herbicide treatments were not useful. All herbicide treatments except treatment 16 increased sorghum yield 3 to 6 fold compared with the untreated control (data not shown).

The primary objective of this test was to measure broadleaf weed control. Treatment 16, Dual II Magnum, is primarily a grass control compound that does not consistently provide broadleaf control. Although this treatment increased sorghum yield 3 fold, this increase was not statistically significant (data not shown).

Quinoa (lambsquarters) control was excellent with all early postemergence treatments, but mid-postemergence treatments did not provide good control of this weed (Table 1). This result is consistent with the labels for these products, which warn that reduced control can be expected once lambsquarters exceeds a set size. All treatments except treatments 12 and 16 provided excellent sunflower control. All treatments except treatment 16 provided good Palmer amaranth control. Treatments that provided greater than 97% Palmer amaranth control were not statistically different from the perfect control. Tank mixes of the new herbicides Huskie, Integrity, and Sharpen provided competitive levels of weed control compared with current standard treatments.

Table 1. Comparisons of Integrity, Sharpen, and Huskie with standard treatments for weed control in sorghum

Treatment		Rate	Unit	Growth stage[1]	Control (%) Quinoa[2]	Sunflower[3]	Palmer amaranth
1	Untreated check				0	0	0
2	Dual II Magnum	1	pt/a	PRE	**100**	**100**	**100**
	Huskie	13	fl oz/a	EPOST			
	Atrazine	1	pt/a	EPOST			
	Ammonium sulfate	8.5	lb/100 gal	EPOST			
3	Dual II Magnum	1	pt/a	PRE	**100**	**100**	**100**
	Huskie	15	fl oz/a	EPOST			
	Atrazine	1	pt/a	EPOST			
	Ammonium sulfate	8.5	lb/100 gal	EPOST			
4	Dual II Magnum	1	pt/a	PRE	**100**	**100**	**100**
	Huskie	13	fl oz/a	EPOST			
	Atrazine	1	pt/a	EPOST			
	2,4-D Amine	8	fl oz/a	EPOST			
	Ammonium sulfate	8.5	lb/100 gal	EPOST			
5	Dual II Magnum	1	pt/a	PRE	**100**	**100**	**100**
	Huskie	13	fl oz/a	EPOST			
	Atrazine	1	pt/a	EPOST			
	Banvel	4	fl oz/a	EPOST			
	Ammonium sulfate	8.5	lb/100 gal	EPOST			
6	Dual II Magnum	1	pt/a	PRE	**100**	**100**	**98**
	Starane	10.6	fl oz/a	EPOST			
	Atrazine	1	pt/a	EPOST			
	Nonionic surfactant	6.4	fl oz/a	EPOST			

continued

Table 1. Comparisons of Integrity, Sharpen, and Huskie with standard treatments for weed control in sorghum

Treatment		Rate	Unit	Growth stage[1]	Control (%) Quinoa[2]	Sunflower[3]	Palmer amaranth
7	Dual II Magnum	1	pt/a	PRE	28.8	**100**	97.5
	Huskie	13	fl oz/a	MPOST			
	Atrazine	1	pt/a	MPOST			
	Ammonium sulfate	8.5	lb/100 gal	MPOST			
8	Dual II Magnum	1	pt/a	PRE	50	**99.5**	**99**
	Huskie	15	fl oz/a	MPOST			
	Atrazine	1	pt/a	MPOST			
	Ammonium sulfate	8.5	lb/100 gal	MPOST			
9	Dual II Magnum	1	pt/a	PRE	42.5	**100**	97.5
	Huskie	13	fl oz/a	MPOST			
	Atrazine	1	pt/a	MPOST			
	2,4-D Amine	8	fl oz/a	MPOST			
	Ammonium sulfate	8.5	lb/100 gal	MPOST			
10	Dual II Magnum	1	pt/a	PRE	38.8	**100**	**100**
	Huskie	13	fl oz/a	MPOST			
	Atrazine	1	pt/a	MPOST			
	Banvel	4	fl oz/a	MPOST			
	Ammonium sulfate	8.5	lb/100 gal	MPOST			
11	Dual II Magnum	1	pt/a	PRE	55	**90.8**	**99.5**
	Starane	10.6	fl oz/a	MPOST			
	Atrazine	1	pt/a	MPOST			
	Nonionic surfactant	6.4	fl oz/a	MPOST			
12	Bicep Lite II Magnum	35	fl oz/a	PRE	**100**	51.3	96
13	Lumax	2.5	qt/a	PRE	**100**	**97**	**100**
14	Roundup WeatherMax	22	fl oz/a	PRE	**100**	**95.8**	95
	Ammonium sulfate	8.5	lb/100 gal	PRE			
	Integrity	20	fl oz/a	PRE			
15	Roundup WeatherMax	22	fl oz/a	PRE	**100**	**100**	**98.8**
	Methylated seed oil	25.6	fl oz/a	PRE			
	Ammonium sulfate	8.5	lb/100 gal	PRE			
	Sharpen	3	fl oz/a	PRE			
	G-Max Lite	44	fl oz/a	PRE			
16	Treated check				47.5	25	85.8
	Dual II Magnum	1	pt/a	PRE			
LSD (0.10)					31.8	11.3	3

[1] PRE, preemergence treatment applied within hours of planting sorghum on June 12, 2008; EPOST, early postemergence treatment applied to 1- to 5-in. V4 sorghum on July 8, 2008; MPOST, mid-postemergence treatments applied to 5- to 11-in. V5 sorghum on July 16, 2008.
[2] Quinoa is a domesticated grain-type lambsquarters used as a proxy for wild lambsquarters.
[3] Field-harvested domesticated sunflower was used as a proxy for wild sunflower.
Within a column, data in bold print are not statistically different from the best treatment in that column.

Insect Pests of Winter Canola in Kansas

A. Joshi, L. Buschman, P. Sloderbeck, J. Holman, and M. Stamm[1]

Summary
Potential insect pests of winter canola were monitored by using pheromone traps and yellow sticky cards. Diamondback moth (*Plutella xylostella*) was continuously present throughout the winter at low levels. Their population spiked in May when warm temperatures returned. Aphid populations were recorded as 519 per receme of canola later in spring. Tarnished plant bugs (*Lygus* spp.) and false chinch bugs (*Nysius raphanus*) were also present in low numbers.

Introduction
Winter canola has captured interest of growers and researchers in the southern Great Plains. Canola is an oilseed crop that can add diversity to the rotational cropping system, provide herbicide options for controlling weedy grasses and oil for cooking and biodiesel, and be used as a feed protein supplement for livestock. It also has a yield advantage over spring canola because the flowering stage escapes some of the high summer temperatures. Agronomic trials have been initiated at three locations 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.

Procedures
This insect pest survey mainly focused on diamondback moth, false chinch bugs, and harlequin bugs (*Murgantia histrionica*) on canola grown for other agronomic research at the Southwest Research-Extension Center in Garden City, KS, and Agronomy Research Farm at Manhattan, KS. However, aphids, crucifer flea beetles (*Phyllotreta* spp.), and other insect pests were recorded when present.

We visited the two locations within 2 weeks of canola emergence (Sept. 29 to Oct. 1, 2008) to visually inspect plants and install diamondback moth pheromone traps and yellow sticky traps. These traps were replaced and pest numbers were recorded weekly; pheromone lure was replaced every 3 weeks. These traps were maintained through June 2009. Number of plants and number of damaged plants in a 10-ft row were randomly sampled three times in each of the four locations to calculate the percentage of damaged plants. Percentage of canola defoliation was measured by observing 10 random plants four times in each of the monitoring plots (see North Dakota State University Extension bulletin E-1234).

In the first week of June 2009, canola pests were also sampled at Garden City by beating the plants in 1 ft^2 on a clean plastic beat sheet. Plants were randomly selected at four locations in each plot. Four racemes were observed in each plot to record aphid numbers. Additionally, four whole plants from each plot were placed in large 76-liter Berlese funnels. The resultant alcohol samples were filtered on ruled white filter paper, and aphid populations were estimated by weight.

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[1] Kansas State University Department of Agronomy and Oklahoma State University Department of Plant and Soil Sciences.

Results and Discussion

Up to 25% of canola seedlings had damage at Garden City, but defoliation was minimal (3.9%). At Manhattan, damage was less than 3.5% and defoliation was negligible. No canola flea beetles were observed.

The pheromone trap at Garden City registered the continuous presence of diamondback moth through the winter season. A total of 441 diamondback moths were collected in the pheromone trap with a peak catch of 121 diamondback moths on June 1, 2009. At Manhattan, the pheromone trap was not monitored during winter; nevertheless, a season total of 802 diamondback moths were collected during the growing season with a peak catch of 231 diamondback moths on May 14, 2009.

Yellow sticky cards revealed the presence of aphids, diamondback moths, tarnished plant bugs, and imported cabbage worm (*Pieris rapae*) at both locations. In late spring, aphid populations increased to 519 per raceme of canola, up to 15,600 aphids per foot of row, and up to 8,600 aphids per plant in Garden City. The aphid populations were a mix of turnip (*Lipaphis erysimi*) and cabbage aphids (*Brevicoryne brassicae*), and they were difficult to separate. Populations of tarnished plant bugs and imported cabbage worm were relatively low, possibly because the fields had adequate populations of predators and parasitoids. Harlequin bugs were not seen during this season at Garden City. In Manhattan, false chinch bugs were present during late spring. Large populations of false chinch bugs were seen in some plots. False chinch bugs were recorded during bloom and early pod and can hurt canola yield. Clearly, sticky card was not the best method for monitoring false chinch bugs. Cabbage seedpod weevil (*Ceutorhynchus assimilis*) was noticed at Manhattan.

Poor canola emergence and winterkill at Garden City and in variety trials at Manhattan may have influenced this initial attempt at identifying potential pests of canola in Kansas. We can, however, conclude that aphids, diamondback moth, and false chinch bugs warrant further study.

Blended Refuge Versus Block Refuge: Efficacy in European Corn Borer Larval Production, 2009

L. Buschman and A. Joshi

Summary

In this study, 62% of European corn borer (ECB) larvae (31 of 50) were found on plants other than the natal plant, which suggests these larvae would be lost in a blended refuge. When single plants were infested, the blended refuge produced only 17% and 20% of the ECB larvae produced in the block refuge for the first and second generation, respectively. It appears that a much larger percentage of non-Bt seed in the blend would be required to yield the number of ECB that a block refuge would yield. In addition, when plants were infested naturally, the blended refuge produced 0% southwestern corn borer (SWCB) when the block refuge averaged 0.39 SWCB per plant. It is not clear if this result is due to natural infestation, to SWCB rather than ECB, or to random effects.

Introduction

Several companies are developing new stacked Bt corn hybrids that contain multiple Bt events active against corn borers and corn rootworm. These events are so effective that the refuge planting requirement can be reduced from 20% to 5%. In addition, there is interest in using the “blended refuge” or “refuge-in-the-bag” strategy, in which the refuge seed is mixed in the bag to replace the current block refuge. However, there are several concerns with this strategy including a potential suppression of ECB production on single susceptible plants planted among Bt plants. In a blended refuge, susceptible plants stand among Bt plants so larvae that move off a susceptible plant are likely to die when they move onto toxic Bt plants. In a standard block, refuge susceptible plants stand together so larvae moving off one plant will likely move onto another susceptible plant and have a better chance of surviving. This study was conducted to determine if ECB production in a blended refuge would be similar to that in a block refuge.

Procedures

A matched pair of Bt and non-Bt corn hybrids, Pioneer 32T84 (HXX and 32T82 (isoline)), was machine planted May 21, 2009. The plots were four rows wide and 65 ft long. Non-Bt seed (two each) was hand planted beside the row every 5 ft to produce the “refuge plants” in rows 2 and 3. This was done in both Bt and non-Bt plots. The hand-planted refuge plants were marked for identification. After the plants emerged, the refuge plants and adjacent companion plants in the row were thinned to one plant per 6 in. Each refuge plant was associated with two plants in the row for a set of five plants (i.e., the non-Bt refuge plant and four companion Bt or non-Bt plants). The 65-ft row could potentially yield 12 sets of refuge plants in each row (24 in each plot). We selected the best 18 out of 24 sets of plants in each plot for the experiment.

Newly hatched ECB larvae were applied with a bazooka applicator; the first generation received two shots for 45 larvae per plant, and the second generation received two shots for 25 larvae per plant. There were a total of nine sets of Bt and non-Bt plots; seven were infested with the first generation (seven replications), and two were infested with the second generation (two replications). We infested only one plant in each set of five plants to simulate a natural 20% plant infestation (the infested plant was marked for identification). This was equivalent to one egg mass laid on one of the five plants, which is the economic treatment threshold for ECB. Then we systematically infested the refuge plant, the first adjacent plant, or the second adjacent plant in a "group" of three sets (15 plants; Figure 1). There were six groups of 15 plants (three sets of five plants) in each plot and 18 infested plants among 90 plants dissected in plot. This method allowed us to measure infestation of ECB and SWCB in the non-Bt refuge plants adjacent to Bt or non-Bt plants. We also used these data to study movement of larvae away from the infested plant by evaluating infestation in plants at different distances from the infested plant (Figure 2). We dissected all 90 plants (six groups with three sets of five plants) in each plot on Aug. 3 through 5, 2009, for the first generation and Sept. 2 through 3, 2009, for the second generation to record larval survival, tunneling, and damage for each plant.

Results

ECB survival on non-Bt block refuge plants

For the first generation, ECB survival in the non-Bt block refuge averaged 0.06 ECB larvae per infested plant, and survival on the first, second, and third plants averaged 0.03, 0.02, and 0.0 larvae per plant, respectively (Figure 3). Of surviving larvae, 63% (12 of 19) were found on plants other than the infested plant. For the second generation, ECB survival averaged 0.53 ECB larvae per infested plant, and survival on the first, second, and third plants averaged 0.42, 0.06, and 0.04 larvae per plant, respectively. We found 62% of surviving larvae (31 of 50) on plants other than the infested plant.

These results mean the 63% and 62% of larvae that moved off the infested plant in a blended refuge would die because they would be moving onto a Bt plant. The only constraint would be if larvae were deterred from moving onto the Bt plant in some way. The blended refuge plant would lose 60% of the larvae that on the plant, whereas the insects would be expected to survive in a block refuge. Therefore, the blended refuge is not as effective as a block refuge in producing susceptible ECB.

ECB survival on blended versus block refuge plants

For the first generation, ECB survival in the block refuge was 0.10 larvae per plant (seven ECB larvae on 126 block refuge plants). Survival of ECB in the blended refuge was 0.02 larvae per plant (one ECB larvae on 42 blended refuge plants) (Table 1). So, the blended refuge plants yielded 43% of the yield of the block refuge plants for the first generation. During the first generation, companion plants in the block refuge yielded an average of 0.04 ECB per plant, whereas blended refuge plants yielded an average of 0.0 ECB per plant when the companion Bt plants were infested.

For the second generation, ECB survival was 0.53 larvae per plant in the block refuge (19 ECB larvae on 36 block refuge plants) (Table 2). Survival of ECB in the blended refuge was 0.08 larvae per plant (one ECB larvae on 12 blended refuge plants). So, the blended refuge plants yielded only 16% of the yield of the block refuge plants for the second generation. During the second generation, companion plants in the block refuge yielded an average of 0.34 larvae per plant, whereas blended refuge plants yielded an average of 0.04 larvae per plant when the companion Bt plants were infested. Therefore, blended refuge plants yielded an average of 0% of the yield of block refuge plants for the first generation and 12% of the yield of block refuge plants for the second generation.

Now we can consider overall ECB production from refuge plants, including infested and uninfested companion plants. During the first generation, refuge plants in the block refuge yielded an average of 0.04 ECB per plant, whereas blended refuge plants yielded an average of 0.01 ECB per plant. During the second generation, refuge plants in the block refuge yielded an average of 0.38 larvae per plant, whereas blended refuge plants yielded an average of 0.06 larvae per plant. For the first generation, overall yield was 20% for 126 infested plants out of 630 plants in the block refuge. For the second generation, overall yield was 17% for 12 infested plants out of 180 plants in the blended refuge.

SWCB survival on blended versus block refuge plants

The first-generation SWCB population was too small to detect in the 630 plants, so it was not considered further. For the second generation, native SWCB averaged 0.39 larvae per plant in the 180 non-Bt refuge plants in the block refuge. However, there were no larvae in the 32 blended non-Bt refuge plants.

Discussion

The relative yield of 17% and 20% for ECB for the first and second generation, respectively, is a worrisome finding. This means a much larger percentage of non-Bt seed in the blend would be required to yield anywhere near the number of ECB a block refuge would yield. Further study is required to determine whether these values are repeatable.

The 0% ECB yield for the blended refuge and the zero natural population of SWCB were also troubling. It is not clear if this result is due to natural infestation, to SWCB rather than ECB, or to random effects. The reduced yield of 17% to 20% may not be the full extent of the problem.

It is important to evaluate the blended refuge in realistic field conditions. These results suggest it will be important to use infestation rates that are within the natural range. A companion study with much higher infestation rates produced very different results (see article on pp. 67 of this report of progress).

Table 1. Observations, plants in observations, and means for infested isoline plants, companion isoline plants, and combined isoline plants planted with other non-Bt block refuge or with Bt plants in a blended refuge during the first generation with seven replications

Plants and insects[1]	Isoline plants in a block refuge			Isoline plants in a blended refuge			% Relative to block refuge
	Observations	Plants	Mean/plant	Observations	Plants	Mean/plant	
Infested isoline plants							
ECB larvae	7	126	0.06	1	42	0.02	43
SWCB larvae	0	126	—	0	42	—	—
Companion isoline plants							
ECB larvae	19	504	0.04	0	84	0.0	0
SWCB larvae	0	504	—	0	84	—	—
Combined isoline plants							
ECB larvae	26	630	0.04	1	126	0.01	20
SWCB larvae	0	630	—	0	126	—	—

[1] ECB, European corn borer, SWCB, southwestern corn borer.

Table 2. Observations, plants in observations, and means for infested isoline plants, companion isoline plants, and combined isoline plants planted with other non-Bt block refuge or with Bt plants in a blended refuge during the second generation with two replications

Plants and insects[1]	Isoline plants in a block refuge			Isoline plants in a blended refuge			% Relative to block refuge
	Observations	Plants	Mean/plant	Observations	Plants	Mean/plant	
Infested isoline plants							
ECB larvae	19	36	0.53	1	12	0.08	16
SWCB larvae	9	36	0.25	0	12	0	0
Companion isoline plants							
ECB larvae	49	144	0.34	1	24	0.04	12
SWCB larvae	61	144	0.42	0	24	0.0	0
Combined isoline plants							
ECB larvae	68	180	0.38	2	32	0.06	17
SWCB larvae	70	180	0.39	0	32	0	0

[1] ECB, European corn borer, SWCB, southwestern corn borer.

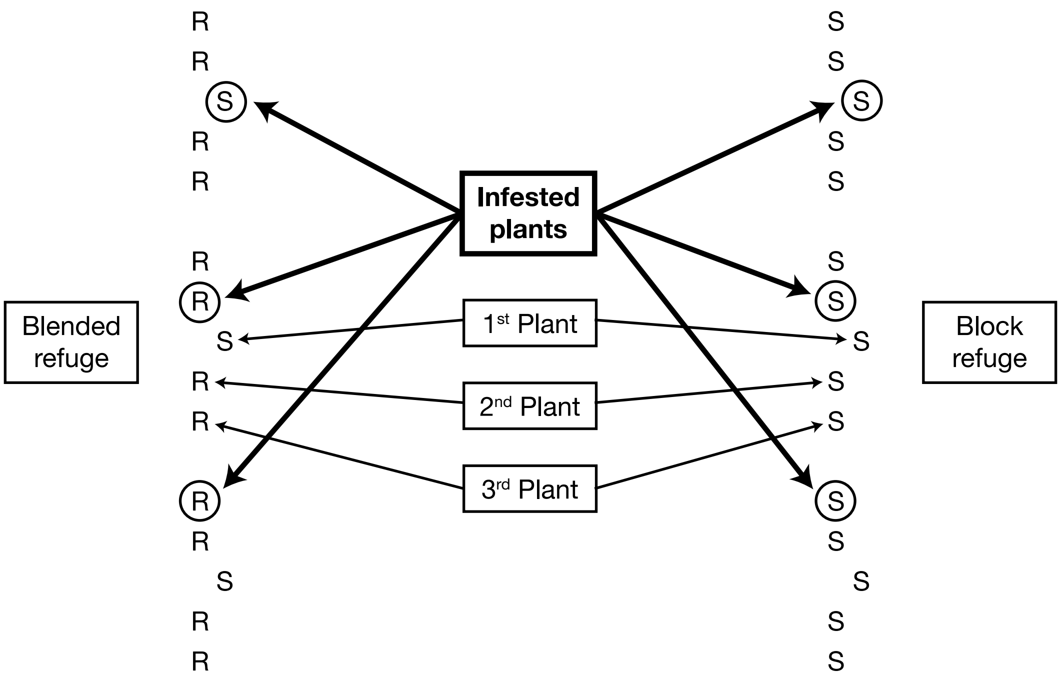

Figure 1. A planted group of 15 plants in a Bt plot (left) and a non-Bt plot (right). Infested plants are circled.

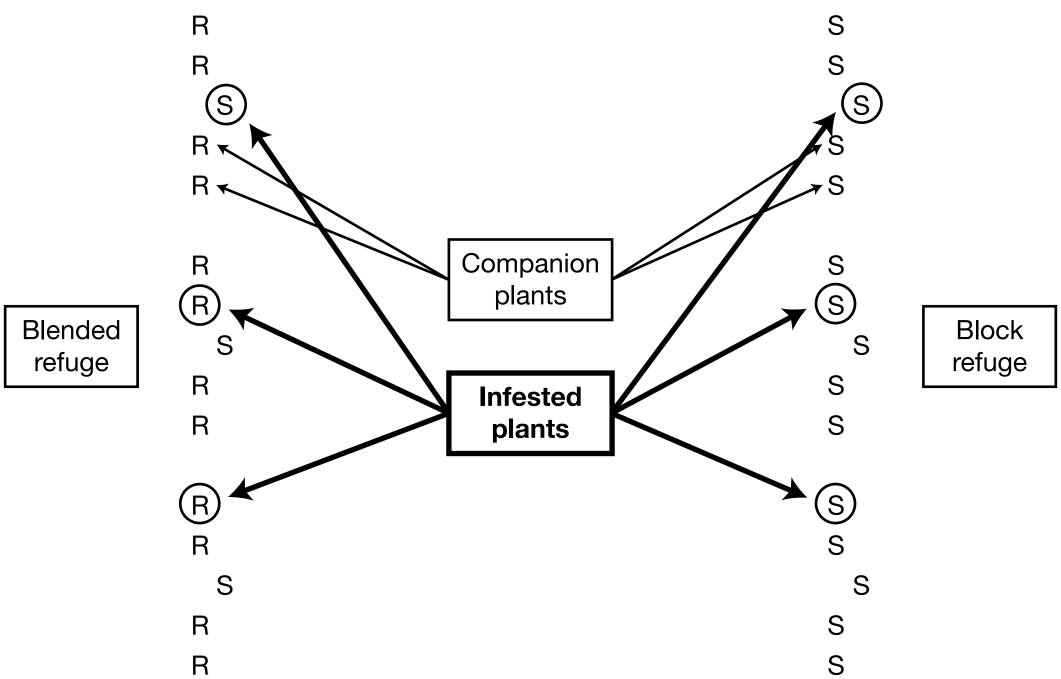

Figure 2. A planted group of 15 plants in a Bt plot (left) and a non-Bt plot (right). Infested plants are circled.

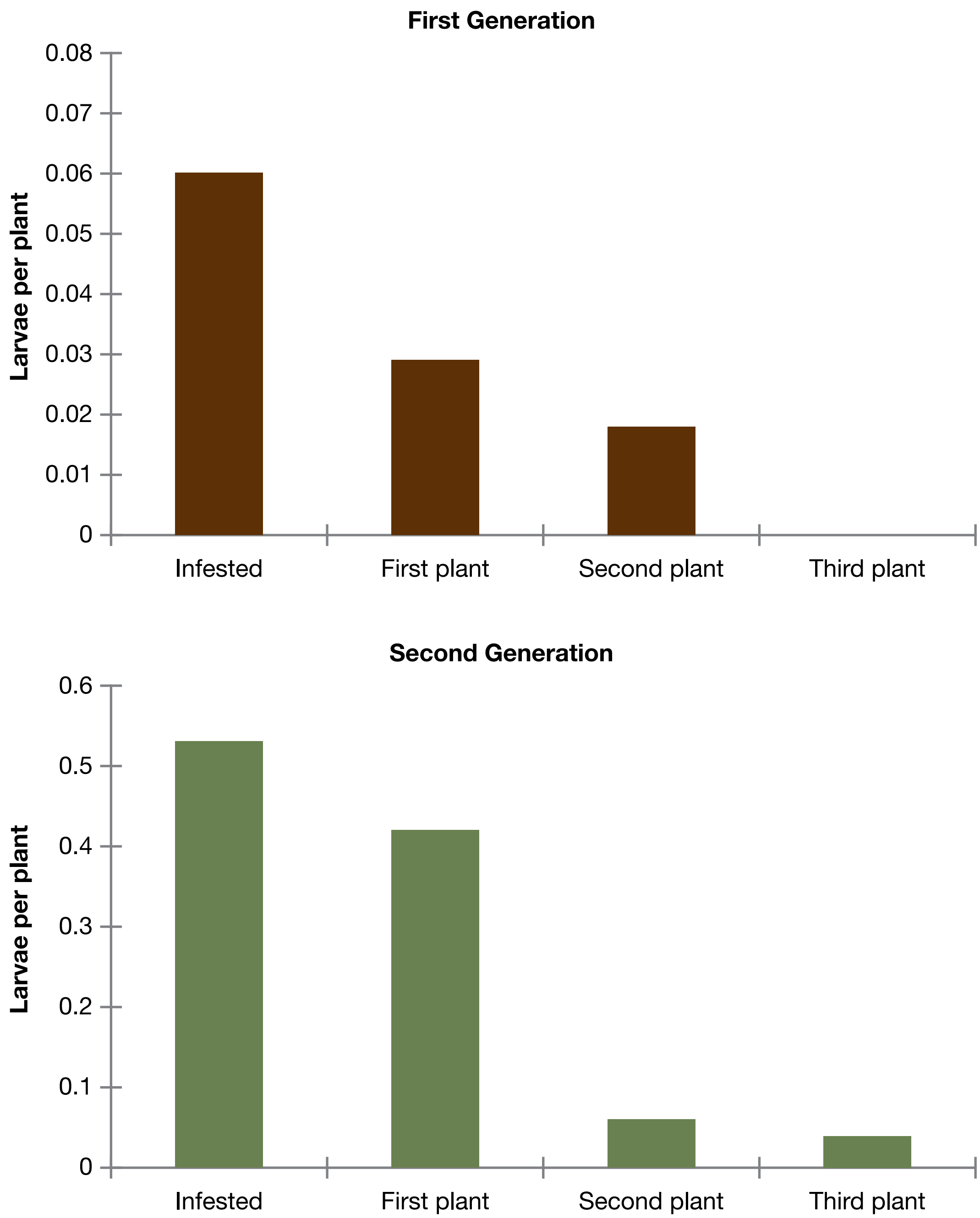

Figure 3. European corn borer larvae per plant on the infested plant or plants away from the infested plant showing the movement of larvae between plants.

Efficacy of New Hybrids for Control of Corn Earworm and Southwestern and European Corn Borer, 2009

A. Joshi and L. Buschman

Summary
Experimental corn hybrids including SmartStax and VT3P/HXX gave outstanding control of southwestern and European corn borers (SWCB and ECB); however, only YGVT3P appeared to control corn earworm (CEW). Feral populations of ECB, SWCB, and Western bean cutworm were low.

Introduction
Several companies are developing new stacked Bt corn hybrids that have multiple Bt events active against corn borers and corn rootworm. This trial was conducted to determine the efficacy of the SmartStax hybrid against southwestern and European corn borers (SWCB and ECB) and other lepidopteron pests of corn.

Procedures
Experimental corn seed (supplied by Monsanto) was machine planted on June 1, 2009, at the Southwest Research-Extension Center (Field 28) in Garden City, KS. Plots were eight rows wide and 30 ft long. There were 10-ft-wide alleys. The study was organized as a randomized block design with four replicates. There were six treatments: (1) control, (2) YieldGard VT3, (3) YieldGard VT Triple PRO (Monsanto), (4) Herculex XTRA (Dow AgroSciences) by YieldGard VT Triple PRO (Monsanto), and (5 and 6) SmartStax or YieldGard VT Triple PRO (Monsanto) by Herculex XTRA (Dow AgroSciences) (eight transgenic events in one plant including two corn borer active events, two western corn rootworm active events, and several herbicide resistance traits). Treatments 1 through 5 received a Poncho seed treatment at 250 g/100 kg seed, and treatment 6 received the same seed treatment at 500 g/100 kg seed. Treatment 1 also received a T-banded treatment of Force 3G at 113.4 g/1000 row-ft.

Ten ears were removed from row 2 of each plot on Aug. 17, 2009, to evaluate CEW and western bean cutworm larvae and damage in the ear. On Sept. 11, 2009, a set of 10 corn plants from rows 3 and 4 were split to record ECB, SWCB, and stalk tunneling, and the ears were examined to record CEW feeding injury by counting the number of damaged kernels. We relied on feral populations to infest the plots. Corn rootworm pressure was too low to collect data on root damage. Data were analyzed by one-way ANOVA, and means were separated by Fisher's protected LSD test ($P<0.05$).

Results and Discussion
Feral CEW pressure was high, so nearly all plants in the check were infested with CEW. Twenty-one CEW larvae of different sizes (small, medium, and large) and 138 cm of related ear tunneling were recorded per 10 ears in the check plot on August 17 (Table 1). Although the number of small CEW was significantly higher in some hybrids

(treatments 2 and 4), their feeding damage was limited. Treatments with many medium and large CEW larvae had much higher damage. Treatments 1 and 4 had the most medium and large larvae, but treatment 1 had the most damage. Most treatments had significantly fewer infested ears, CEW larvae, and tunneling than the check, treatment 1 (Table 1).

By the second week of September, most CEW had left the ears and there were few larvae present (Table 2). At this time, kernel damage was highest in treatments 1 and 4 and lowest in treatments 3, 4, and 5. Fungus infection and dusky sap beetles caused considerable damage to corn ears. None of the hybrids appeared to have efficacy against this insect. Nine western bean cutworms were observed in August (one in treatment 1, three in treatment 2, and four in treatment 5), but none were observed in September.

All Bt corn events (treatments 2 through 6) were very effective against stalk tunneling by SWCB and ECB, and tunneling was significantly reduced (Table 2). Eleven SWCB and five ECB were observed in the check plots. Overall, SmartStax and VT3P/HXX hybrids had outstanding efficacy against CEW.

Table 1. August 17 corn earworm infestation and related ear damage recorded from 10 ears in each plot, Garden City, 2009

Treatment[1]		Insect events present	Poncho seed treatment (g/100 kg seed)	Corn earworm (mean number)			Ear tunneling (cm)		
				Small	Medium	Large	Small	Medium	Large
1	RR2 + SAI	RR Force 3G	250	8.7b	3.5b	9.2	4.4	14.4b	119.2a
2	YGVT3	YieldGard VT Triple	250	23.7a	4.5b	0.2	11.5	9.6bc	2.2b
3	YGVT3P	YieldGard VT Triple PRO	250	7.0b	0.5b	0.0	1.0	0.2c	0.0b
4	HXX + RR2	Herculex XTRA	250	18.7a	11.5a	3.7	10.9	36.6a	26.2b
5	YGVT3P + HXX	SmartStax	250	7.7b	2.0b	3.2	7.1	6.5bc	38.2b
6	YGVT3P + HXX	SmartStax	500	10.0b	0.5b	0.0	4.2	0.5c	0.0b
P-value <		—		0.0012	0.0003	0.0562	0.0666	0.0002	0.0315
CV		—		40.3	71.5	156.8	77.7	74.9	162.5
LSD		—		3.6	1.9	3.0	3.6	5.9	35.6

[1] Treatment definitions: (1) RR2 (Roundup Ready) with planting-time application of soil-applied insecticide (SAI) of Force 3G at 113.4 g/1000 row-ft; (2) YieldGard VT (Event MON89034 (corn rootworm active)); (3) Combination of YieldGard VT Triple PRO (Events MON89034 (corn borer active) and MON88017 (corn rootworm active)); (4) Herculex XTRA (Events TC1507 (corn borer active) and DAS59122 (corn rootworm active)) technology; (5 and 6) Combination of YieldGard VT Triple PRO (Events MON89034 (corn borer active) and MON88017 (rootworm active)) and Herculex XTRA (Events TC1507 (corn borer active) and DAS59122 (corn rootworm active)) technologies.

Within columns, means followed by the same letter are not significantly different ($P \leq 0.05$).

Table 2. September 11 corn earworm infestation and related ear damage recorded from 10 plants in each plot, Garden City, 2009

Treatment[1]		Insect events present	Poncho seed treatment (g/100 kg seed)	Corn earworm	Kernels damaged	Stalk tunneling (cm)
1	RR2 + SAI	RR Force 3G	250	1.0	239.2ab	34.9a
2	YGVT3	YieldGard VT Triple	250	0.2	322.7a	0.0b
3	YGVT3P	YieldGard VT Triple PRO	250	0.0	125.7bc	0.7b
4	HXX + RR2	Herculex XTRA	250	0.5	238.5ab	0.2b
5	YGVT3P + HXX	SmartStax	250	1.2	113.7c	0.0b
6	YGVT3P + HXX	SmartStax	500	0.5	140.2bc	0.0b
P-value <		—		0.4088	0.0260	0.0001
CV		—		153.3	41.3	74.5
LSD		—		0.6	57.4	3.1

[1] Treatment definitions: (1) RR2 (Roundup Ready) with planting-time application of soil-applied insecticide (SAI) of Force 3G at 113.4 g/1000 row-ft; (2) YieldGard VT (Event MON89034 (corn rootworm active)); (3) Combination of YieldGard VT Triple PRO (Events MON89034 (corn borer active) and MON88017 (corn rootworm active)); (4) Herculex XTRA (Events TC1507 (corn borer active) and DAS59122 (corn rootworm active)) technology; (5 and 6) Combination of YieldGard VT Triple PRO (Events MON89034 (corn borer active) and MON88017 (rootworm active)) and Herculex XTRA (Events TC1507 (corn borer active) and DAS59122 (corn rootworm active)) technologies.
Within columns, means followed by the same letter are not significantly different (P<0.05).

Blended Versus Block Refuge: Pioneer Experiment, 2009

A. Joshi and L. Buschman

Summary
All corn hybrids were highly effective against European corn borer (ECB) or southwestern corn borer (SWCB) infestations. Blended refuge plants showed some potential for maintaining low populations of ECB and SWCB larvae. However, larval survival was significantly higher on block refuge plants than on blended refuge plants. Further testing is needed to determine the effectiveness of a blended refuge for resistance management.

Introduction
Several companies are developing new stacked Bt corn hybrids that contain multiple Bt events active against corn borers and corn rootworm. These events are so effective that the refuge planting requirement can be reduced from 20% to 5%. In addition, there is interest in using a "blended refuge" or "refuge-in-the-bag" approach, such as the AcreMax II concept proposed by Pioneer, in which the refuge seed can be mixed in the bag to replace the current block refuge. This experiment was designed to evaluate the AcreMax II concept as a refuge option in terms of plant damage and production of key lepidopteron of the Bt corn.

Procedures
Corn seed (supplied by Pioneer Hi-Bred) was machine planted at 32,000 seeds/acre on May 21, 2008, at the Southwest Research-Extension Center (Field 34N) in Garden City, KS. Plots were four rows wide and 20 ft long, and the rows were 30 in. apart. There were 10-ft-wide alleys between the plots. The study was organized as a randomized block design with three replicates. The first three treatments were Bt corn (HXX with/without YG), and treatments 4 and 5 were non-Bt plants (Base × NK603). The seed blend seed treatment (treatment 2) was simulated by hand planting non-Bt corn seeds 2 in. beside rows 2 and 3 (total of six locations; staked for identification). The non-Bt plants and adjacent plants were later thinned to one plant every 6 in. at six locations in rows 2 and 3. In the other treatments, six plants in rows 2 and 3 were identified. The designated plants were artificially infested with ECB larvae by using a handheld bazooka applicator on June 26 and 29 for the first generation and on July 27 and August 1 for the second generation. There were 18 infested plants in treatment 2 and 12 infested plants in treatments 1, 3, 4, and 5. There was also a natural infestation of SWCB. On July 14, 2009, foliar damage was visually rated for the first generation on a scale of 1 to 9 (1 = most leaves with long lesions, 9 = absence of damage). On September 9, stalks were split to record the number of ECB and SWCB larvae and their damage in stalk and ear. Data were analyzed by one-way ANOVA, and means were separated by Fisher's protected LSD test ($P<0.05$).

Results and Discussion

Foliar damage was low (6.7 to 6.8) in all non-Bt corn plants (Table 1). Poor establishment of the first generation of ECB may have been related to hot weather conditions. Stalk damage was significantly higher in non-Bt refuge corn plants. However, there was no difference in damage between blended and block refuge (Figure 1).

A similar pattern of infestation was observed for ECB larvae. Infestation was significantly higher in non-Bt corn plants (Table 1). The ECB infestation was significantly higher in block refuge plants than in blended refuge plants. No Bt corn plants were infested. The infestation of blended refuge plants was about half that of block refuge plants (Figure 2).

Ear damage due to tunneling at the tip or base (shank) by ECB was nearly absent in plots with Bt plants and significantly higher in block refuge plants (Table 1). Damage in the blended refuge was lower than that in the block refuge. Stalk tunneling was also lower in the blended refuge. Stalk tunneling was nearly absent in Bt corn plots and highest in block refuge plants (Figure 3).

Infestation of corn plants by feral SWCB was 60% to 80% in block refuge non-Bt corn plants but completely absent in plots with Bt corn plants (Table 1). Infestation was significantly lower in the blended refuge than in the block refuge (Figure 4).

Overall, Bt corn hybrids were highly effective against ECB and SWCB infestations. Blended refuge plants showed low potential for maintaining larvae of ECB and SWCB. Survival of ECB and SWCB larvae was significantly better in the block refuge than in the blended refuge. Further testing is needed to determine whether these data are repeatable and if blended refuge plants can produce enough ECB and SWCB for resistance management.

Table 1. European corn borer (ECB) and southwestern corn borer (SWCB) infestation and damage ratings for Bt and non-Bt corn in blended and block refuge configuration, Pioneer experiment, Garden City, 2009

Treatment[1]		ECB damage rating[2]	SWCB larvae	ECB larvae	Ear tip tunneling	Shank tunneling	Stalk tunneling
			----------no./plant----------		----------cm/ear----------		cm/plant
1	Bt	8.7a	0c	0c	0b	0b	0c
2a	Bt	8.9a	0c	0c	0b	0b	0c
3	Bt	8.8a	0c	0c	0b	0.2b	0.2c
4	Non-Bt	6.8b	0.8a	1.5a	2.4ab	0.4ab	15.6a
5	Non-Bt	6.8b	0.6a	1.7a	4.8a	1.1a	18.6a
2b	Non-Bt	6.6b	0.3b	0.7b	2.2ab	1.2a	7.9b
P-value		0.0007	0.0000	0.0002	0.0189	0.0253	0.0001
CV		7.5	41.0	53.6	99.84	87.9	45.95
LSD		0.47	0.09	0.28	1.2	0.25	2.64

[1] Treatment descriptions: (1) HXX × MON810 pure stand; (2a) HXX × MON810 with non-Bt blended refuge; (3) HXX pure stand; (4) Isoline (block refuge); (5) Isoline (block refuge) + Force 3G; (2b) Non-Bt blended refuge with HXX × MON810.
[2] Data for ECB foliar damage were collected on July 14, 2009, by visually rating damage on a scale of 1 (most leaves with long lesions) to 9 (no damage). The rest of the data were collected on Sept. 9, 2009.
Within columns, means without a common superscript differ (P<0.05).

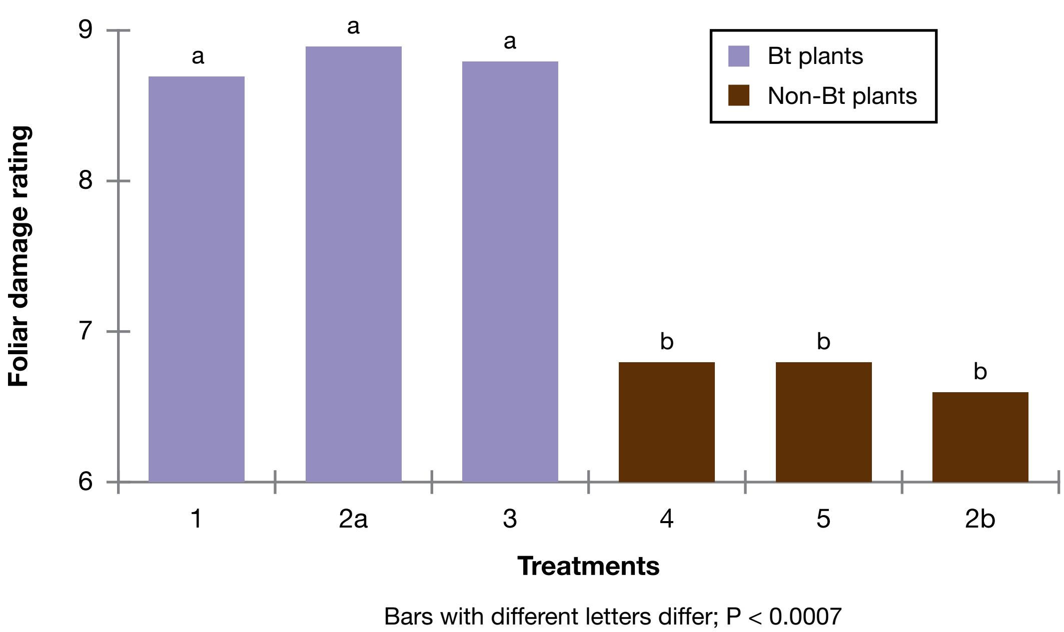

Figure 1. Mean damage rating per plant, July 14, 2009, Garden City.
Scale: 1 (most leaves with long lesions) to 9 (no damage). See Table 1 for treatment descriptions.

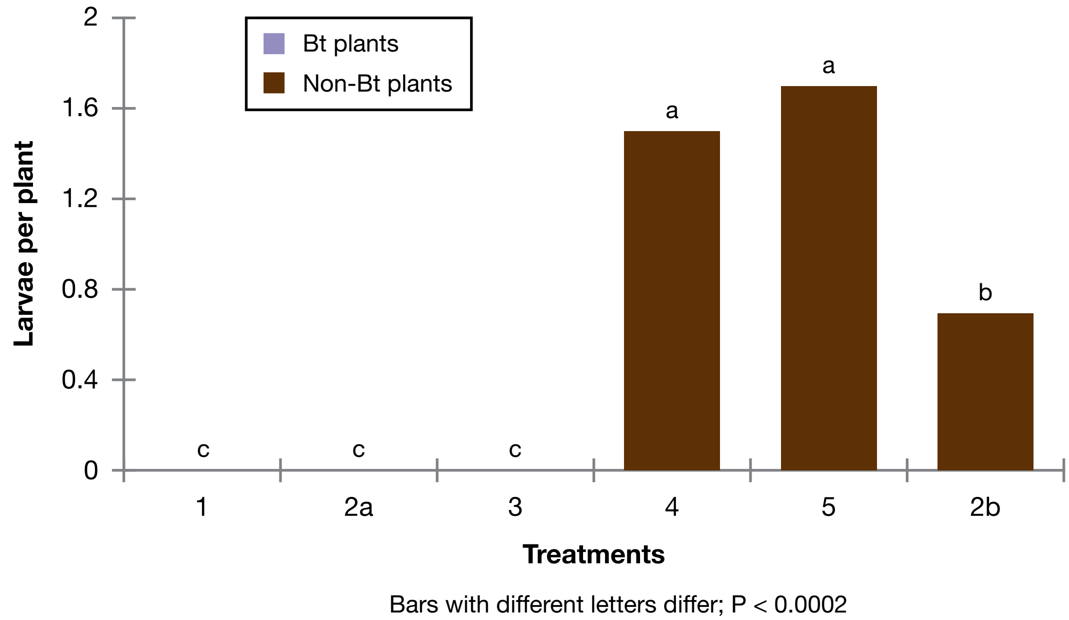

Figure 2. Mean number of European corn borer larvae per plant, Sept. 9, 2009, Garden City.
See Table 1 for treatment descriptions.

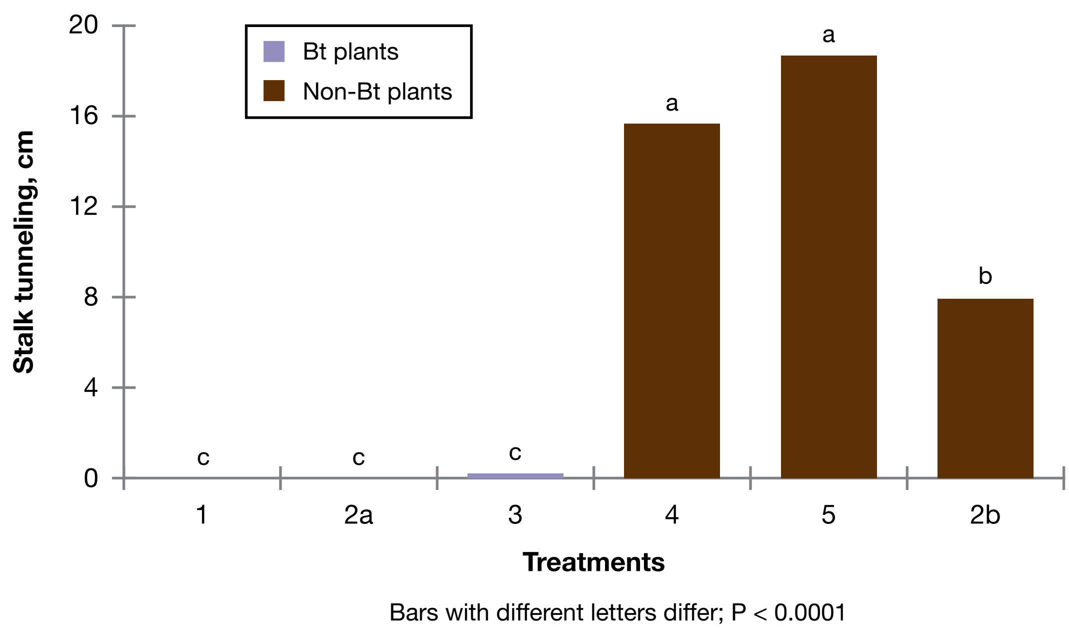

Figure 3. Mean stalk tunneling due to southwestern corn borer and European corn borer, Sept. 9, 2009, Garden City.
See Table 1 for treatment descriptions.

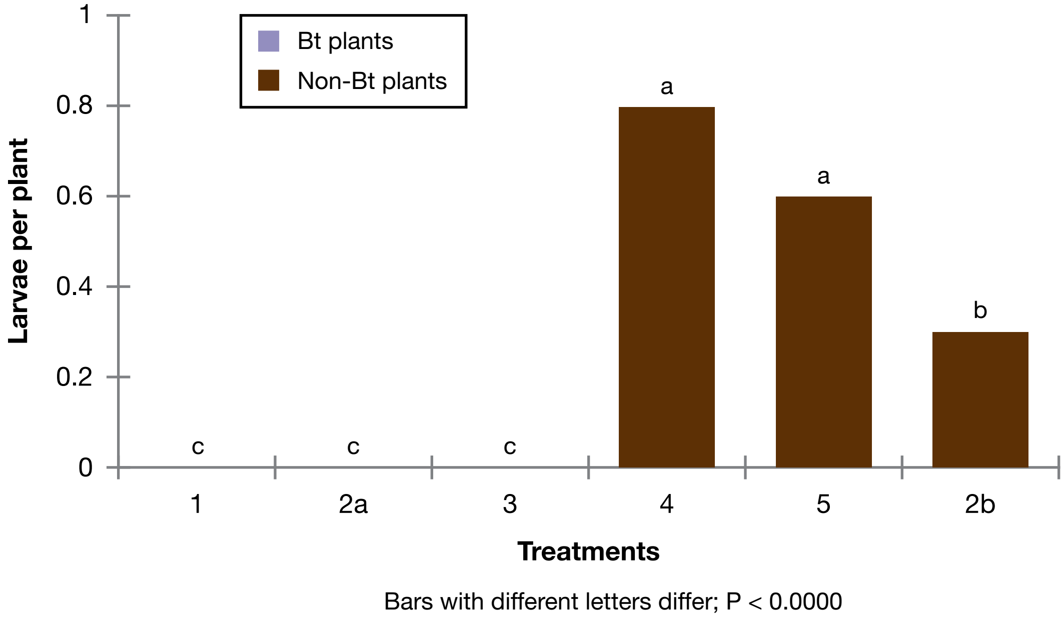

Figure 4. Mean number of southwestern corn borer larvae per plant, Sept. 9, 2009, Garden City.
See Table 1 for treatment descriptions.

Efficacy of Insecticides for Managing Head Moth and Stem Borer in Sunflower, 2009

A. Joshi and L. Buschman

Summary
Fipronil, Coragen, and Cyazypyr gave excellent (95% or better) control of sunflower head moth (*Homoeosoma electellum*). Fipronil and Cyazypyr gave excellent (90% and 86%, respectively) control of Dectes stem borer (*Dectes texanus*). Most other treatments including Asana, the conventional standard, gave moderate control of sunflower head moth. Fipronil seemed to have efficacy against sunflower root weevil.

Introduction
Foliar insecticides were evaluated for management of sunflower head moth and Dectes stem borer in sunflower.

Procedures
Plots were machine planted at 30,000 sunflower seeds/acre with 30-in. row spacing on June 10, 2009, in Garden City, KS. Plots were four rows wide (10 ft), 20 ft long, and buffered with 10-ft alleys. Chemical treatments were applied twice, August 1 and 11 (R2 and R3 stages), by using a CO_2 backpack sprayer with a two-nozzle handheld boom (Table 1). The sprayer was calibrated to deliver 25 gal/acre at 30 psi and 1.75 mph walking speed. The boom was 18 in. wide; one nozzle was directed at the head, and the other was directed at the plant foliage.

On Aug. 21, 2009, four half sunflower (R5) heads were removed from the two center rows in each plot and placed in large 76-liter Berlese funnels for 7 days. A 100-watt lightbulb was used to dry the heads and drive any arthropods in the head down into a collecting jar containing 70% methanol. The alcohol samples were filtered on ruled white filter paper, and sunflower head moth larvae were counted under a binocular microscope. Dectes stem borer observations were recorded on September 24 to 29 by dissecting five plants (R6) taken from each of the two center rows in each plot for a total of 10 plants per plot. All live larvae in the stem and base were recorded and then placed in a small vial with 70% methanol and brought to the laboratory for identification. The experiment was designed as a randomized complete block with four replicates. The ANOVA procedure was used to analyze data, and means were compared using LSD.

Results and Discussion
Fipronil, Coragen, and Cyazypyr gave excellent (95% or better) control of sunflower head moth. Fipronil and Cyazypyr gave excellent (90% to 86%, respectively) control of Dectes stem borer. Most other treatments including Asana, the conventional standard, gave only moderate control of sunflower head moth. Twenty-four Ataxia stem borers (*Ataxia hubbardi*) were recorded, but there were none in the Coragen and Cyazypyr treatments and only one in the Fipronil treatment. Thirty-three large lepidopteron larvae (*Pelochrista womanana*) were recorded, but there were none in the Coragen and

Cyazypyr treatments. Yellow elongate larvae of the tumbling flower beetle (*Mordellistena* spp.) were common (total of 33) in the cortex of the main stem in all treatments. There were 25 root weevil larvae (*Baris strenua*) in the lower stem and roots of all treatments except Fipronil and Calypso.

Table 1. Efficacies of chemical treatments for management of sunflower pests including sunflower head moth and Dectes stem borer in sunflower, Garden City, 2009

Treatment[1]	Rate/acre	Sunflower head moth[2]	*Dectes* stem borer	*Ataxia* stem borer	*Pelochrista* root moth	*Mordellistena* beetle	*Baris* root weevil
		per two heads	----------------------	----------------------	per plant	----------------------	----------------------
Check	—	116.0a	0.72a	0.15	0.12	0.10	0.12ab
Cyazypyr	3.37 oz	2.5d	0.40bc	0.15	0.12	0.10	0.05b
Cyazypyr	6.75 oz	6.0d	0.15cd	0.05	0.02	0.05	0.02b
Cyazypyr	10.1 oz	5.5d	0.15cd	0.07	0.0	0.07	0.05b
Cyazypyr	13.5 oz	18.7cd	0.20cd	0.02	0.02	0.07	0.05b
Cyazypyr + MSO[3]	6.75 oz + 0.5% v/v	12.2cd	0.10cd	0.0	0.02	0.05	0.02b
Coragen	10 oz	2.7d	0.37bcd	0.0	0.0	0.15	0.07b
Fipronil	4.2 oz	4.5d	0.07d	0.02	0.12	0.10	0.0b
Calypso	8 oz	90.0ab	0.27cd	0.2	0.17	0.05	0.0b
Asana	9.6 oz	37.0bc	0.65ab	0.1	0.2	0.07	0.22a
P-value <	—	0.0001	0.0008	0.1577	0.0612	0.9637	0.0341

[1] Treatments were applied twice: Aug. 2 and 11, 2009.
[2] Statistics based on transformed (log + 1) data. Untransformed means are presented.
[3] MSO, methylated seed oil.
Within columns, means without a common superscript are significantly different ($P<0.05$).

Efficacy of Insecticides for Managing Dectes Stem Borer in Soybean, 2009

A. Joshi and L. Buschman

Summary
Fipronil was extremely effective and reduced entry nodes by 88%, tunneling by 88%, and survival of larvae by 93%. Other treatments (e.g., Coragen, Calypso, Provado, and Cyazypyr) reduced these variables significantly but only in the 50% range. Fipronil and Cyazypyr may be useful technologies for protecting plants from Dectes stem borer (*Dectes texanus*); however, they are currently not registered for use on soybean.

Introduction
Foliar treatments of insecticides were evaluated for management of the Dectes stem borer in soybean.

Procedures
Soybean variety Pioneer 93M92 (maturity group III) was machine planted May 29, 2009, with 30-in. row spacing on a cooperator field near Garden City, KS. Plots were four rows wide and 20 ft long with 5-ft alleys. Chemical treatments were applied Aug. 4, 2009 (R1 stage) by using a CO_2 backpack sprayer with a two-nozzle handheld boom. The sprayer was calibrated to deliver 25 gal/acre at 30 psi and 1.75 mph walking speed. Dectes stem borer infestation was recorded on September 15 (R6) by dissecting 20 plants per plot. Groups of five consecutive plants were collected from the center of each of the four rows, and entry nodes, upper stem tunneling, and the number of live larvae were recorded. The experiment was designed as a randomized complete block with four replicates. The ANOVA procedure was used to analyze data, and means were separated using LSD ($P<0.05$).

Results and Discussion
A hailstorm on July 17 caused 40% to 50% defoliation in soybean plots. This reduction in oviposition site may have affected infestation levels of Dectes stem borer. Toward the end of the season, more than 95% of plants in the check plots were infested (Table 1). Several foliar treatments effectively reduced Dectes stem borers in soybean plants. Fipronil gave 92% control (Table 1). Other treatments (i.e., Coragen, Calypso, Provado, and Cyazypyr) reduced infestation by 40% to 50%. Some of these chemicals might have more efficacy if applied earlier in the season. The Fipronil foliar treatment was extremely effective at reducing Dectes stem borer survival in soybean plants. Cyazypyr appears to have some promise, but we need to test it again when it is applied earlier in the season.

Table 1. Chemical treatments and their efficacy against infestation, tunneling activity, and survival of Dectes stem borer in soybean, Garden City, 2009

Treatment	Chemical name	Rate/acre	Entry nodes	Stem tunneling	Live larvae
			-----------------------	no. per plant	-----------------------
Check	—	—	0.97a	0.82a	0.68a
Coragen	Rynaxypyr	5 oz	0.68cd	0.55bcde	0.46bcd
Coragen	Rynaxypyr	10 oz	0.68cd	0.61bcd	0.53abcd
Calypso	Thiacloprid	4 oz	0.68cd	0.53bcde	0.40cd
Calypso	Thiacloprid	8 oz	0.65cd	0.53bcde	0.48bcd
Provado	Imidacloprid	3.5 oz	0.72bcd	0.50cde	0.40cd
Provado	Imidacloprid	7.0 oz	0.85abc	0.63abc	0.52abcd
Fipronil	Fipronil	4.2 oz	0.12e	0.10f	0.05e
TM 44401	Clothianidin	0.48 oz	0.87abc	0.71ab	0.62ab
TM 44401	Clothianidin	0.96 oz	1.01a	0.72ab	0.58abc
Centric	Thiamethoxam	8 oz	0.92abc	0.67abc	0.52abcd
Centric	Thiamethoxam	16 oz	0.68cd	0.5bcde	0.43bcd
DPX-HGW86	Cyazypyr	10.1 oz	0.50d	0.42de	0.38d
DPX-HGW86	Cyazypyr	13.5 oz	0.50d	0.38e	0.36d
P-value <	—	—	0.0001	0.0001	0.0001

Within columns, means without a common superscript are significantly different (P<0.05).

Experiment 1: Efficacy of Miticides Applied at Pre-tassel Stage for Control of Spider Mites in Corn, Garden City, KS, 2009

A. Joshi and L. Buschman

Summary
Mite populations peaked at 211 mites (Banks, twospotted, and predatory mites combined) per two plants 5 weeks after treatment (August 14). The mite population was mainly Banks grass mites (BGM). Oberon and Onager gave excellent season-long control of spider mites. Experimental miticide GWN-1708 gave good control when combined with Onager. Combining higher rates of GWN-1708 with Onager did not improve the control. Combining Ultiflora or Nexter with Onager improved early control of spider mites.

Introduction
This trial was conducted to evaluate the efficacy of miticides applied to control BGM and twospotted spider mites in corn at the pre-tassel stage.

Procedures
Field corn was planted May 18, 2009, in wheat stubble under a center-pivot irrigation system at the Southwest Research-Extension Center (Field 34N) in Finney County, KS. A test with 10 treatments was set up in a randomized complete block design with four replications. Plots were four rows (10 ft) by 50 ft 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 June 24 by tying mite-infested leaves collected from an infested corn field in Stevens County to four plants in each plot (two in each of the two center rows). The treatments were applied July 10 with a high-clearance sprayer with two nozzles on 18-in. drop hoses directed upward at each row. The sprayer was calibrated to deliver 12 gal/acre at 2 mph and 30 psi.

Spider mites were sampled by collecting half the leaves from four plants (= two plants) near the infested plants in each plot. The plant material was then placed in large 76-liter Berlese funnels with 100-watt lightbulbs to dry the vegetation and drive arthropods into a collecting jar 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 twospotted spider mites in each plot. Pretreatment spider mite samples were collected July 6, and posttreatment samples were collected July 17, 24, and 31and August 14 (1, 2, 3, and 5 weeks after treatment, respectively). Spider mite counts were transformed with Taylor's power transformation for statistical analysis. Data were analyzed by two-way ANOVA, and means were separated by Fisher's protected LSD ($P<0.05$).

Results and Discussion

Populations of BGM in untreated plots increased with each sampling date until August 14, when they peaked at 178 per two plants (Table 1). Overall, spider mite population pressure during this trial was low to moderate, and there was no economic damage to plants.

Oberon (2SC) and Onager gave excellent season-long control (up to 91%) and held it for 5 weeks (Table 1). All rates of GWN-1708 gave good BGM control when combined with Onager. The lowest rate of GWN-1708 (treatment 6) gave excellent control (up to 99.9%) and held it for 5 weeks. Combining higher rates of GWN-1708 with Onager did not improve the control.

When Onager was used in combination with other miticides, season-long control was excellent (up to 91%). Onager combined with GWN-1708 or Ultiflora also gave excellent early control (up to 98.8%; Table 1). Until 3 weeks after application, the combination of Onager with GWN-1708, Nexter, or Ultiflora gave better control than Onager alone (between 96% and 100%). Three weeks after application, Onager alone was giving outstanding control and the benefit of combining miticides had diminished.

Populations of twospotted spider mites and predatory mites were nearly absent at the beginning of the experiment but slowly increased over the 5 weeks of the experiment (data not shown).

Table 1. Percentage of control of Banks grass mites in plots treated with miticides, experiment 1, Garden City, 2009

Treatment	Product	Rate/acre	July 17 (1 WAT)[1]	July 24 (2 WAT)	July 31 (3 WAT)	August 14 (5 WAT)	Season total
1	Check[2]	---	24.8	67.6	87.9	177.5	419.6
2	GWN -1708 (1.67E)	24 oz	55.9	67.7	84.1	82.3	75.3
3	Onager (1E) + GWN -1708	8 oz 12 oz	78.2	94.8	83.3	66.3	66.6
4	Onager (1E) + GWN -1708	8 oz 6 oz	94.5	95.6	99.5	96.4	93.3
5	Onager (1E) + GWN -1708	8 oz 3 oz	97.2	94.9	86.4	24.2	56.8
6	Onager (1E) + GWN -1708	8 oz 0.67 oz	88.8	100.0	99.2	89.5	89.6
7	Onager (1E) + Ultiflora 0.0775E	8 oz 32 oz	98.8	99.4	97.2	83.6	87.0
8	Onager (1E) + Nexter (75%WP)	8 oz 5.9 dry oz	92.5	98.3	99.6	90.7	91.3
9	Onager (1E)	8 oz	93.2	95.5	98.9	92.6	90.8
10	Oberon (2SC)	8.5 oz	99.0	99.9	98.4	91.4	91.7

[1] WAT, weeks after treatment. Treatments were made July 10, 2009, when corn was starting to tassel.
[2] Actual numbers of mites in the check plot that were used to calculate the percentage of control for other treatments are shown here.
Taylor's power transformation was used for statistical analyses, and Henderson's correction formula was used to calculate the percentage of control.

Experiment 2: Efficacy of Miticides Applied at Tassel Stage for Control of Spider Mites in Corn, Garden City, KS, 2009

A. Joshi and L. Buschman

Summary
Mite populations peaked at 225 mites (Banks, twospotted, and predatory mites combined) per two plants on August 5 (3 weeks after treatment; WAT). The mite population was mainly Banks grass mites (BGM). The effect of GWN-2106 declined 2 WAT and gave season-long control of 50%. Onager gave excellent season-long control; the higher rate of Onager gave better initial control. At-tassel application of Oberon gave better early control of mites (92%) than post-tassel application of Capture.

Introduction
This trial was conducted to evaluate the efficacy of miticides applied to control BGM and twospotted spider mites in corn at the tassel stage.

Procedures
A test with eight treatments was set up in a randomized complete block design with four replications. Procedures and methods were similar to those described for miticide experiment 1 (see pp. 77 in this report). Plots were manually infested with BGM on June 25. The first seven treatments were applied July 14, and the remaining treatment was applied on July 22 with a high-clearance sprayer.

Pretreatment spider mite samples for the first seven treatments were collected July 13, and posttreatment samples were collected on July 22 (1 WAT) and 29 (2 WAT) and August 5 (3 WAT). The pretreatment sample for the last treatment was collected on July 22, and posttreatment samples were collected on July 29 (1 WAT) and August 5 (2 WAT).

Results and Discussion
In untreated plots, the mite population increased until August 5, when it peaked at 203 mites per two plants (Table 1). The population initially was 100% BGM, but by August 5, there was 8% twospotted spider mites (data not shown). Overall, spider mite population pressure during this trial was low, and there was no economic damage to plants.

Oberon (2SC) and Onager gave excellent and consistent season-long control of mites (76% to 78%; Table 1). The later treatment of Capture (2EC) gave some initial control. Comite II gave good initial control only. The higher rate of GWN-2106 gave good control at 1 WAT, but control declined 2 WAT, and season-long control was 50%.

Populations of twospotted spider mites and predatory mites were nearly absent at the beginning of the experiment but slowly increased over the 7 weeks to 17.6 and 68.7, respectively, per two plants at 3 WAT (data not shown). Buildup in the population of predatory mites partially accounts for the decline in BGM and twospotted spider mite populations by 3 WAT (data not shown). Predatory mite population may have been higher than reported here because pale predatory mites (*Galendromus* and *Neoseiulus)* were difficult to spot under the microscope on white paper and probably escaped notice. The *Neozygotes* fungus also attacks during this time, although it was not observed.

Table 1. Percentage of control of Banks grass mites in plots treated with miticides, experiment 2, Garden City, 2009

Treatment	Product	Rate/acre	July 22 (1 WAT)[1]	July 29 (2 WAT)	August 5 (3 WAT)	Season total[2]
1	Check[3]	—	71.1	37.1	202.8	391.0
2	GWN -2106	2.22 oz	48.2	00	23.9	00
3	GWN -2106	2.67 oz	86.0	5.0	58.0	49.6
4	Onager 1E	10 oz	75.4	98.7	94.8	76.5
5	Onager 1E	12 oz	89.9	87.8	90.9	78.1
6	Comite II	2.25 pt	75.0	77.3	21.6	9.6
7	Oberon 2SC	8.5 oz	92.5	93.8	93.4	76.0
			Pretreat 2	1 WAT	2 WAT	
8	Capture 2EC	6.4 oz	46.7	48.6	00	00

[1] WAT, weeks after treatment. First seven treatments were made July 14, 2009; treatment 8 was made July 22, 2009, when corn was starting to tassel.

[2] Percentage of control for season total was influenced by the 7 WAT sample not shown here because of a crash in the population of Banks grass mite.

[3] Actual numbers of mites in the check plot that were used to calculate the percentage of control for other treatments are shown here.

Taylor's power transformation was used for statistical analyses, and Henderson's correction formula was used to calculate the percentage of control.

Experiment 3: Efficacy of Miticides Applied at Pre- and Post-Tassel Stage for Control of Spider Mites in Corn. Garden City, KS, 2009

A. Joshi and L. Buschman

Summary
In untreated plots, mite populations increased to 184 mites (Banks, twospotted, and predatory mites combined) per two plants at 5 weeks after treatment (WAT). The population initially was 100% Banks grass mites (BGM), but by 7 WAT, it was reduced to 0%. Both pre-tassel treatments, Oberon and Comite, gave excellent early control (85% to 96%, respectively) and held it for 2 to 3 weeks. Performance of post-tassel treatments was difficult to interpret because the BGM population was declining by the time treatments were applied.

Introduction
This trial was conducted to evaluate the efficacy of miticides applied to control BGM and twospotted spider mites in corn at the pre- and post-tassel stages.

Procedures
Procedures and methods were similar to those described for miticide experiment 1 (see pp. 77 in this report). Plots were manually infested with BGM on June 25. The first three treatments were applied on July 13, and the remaining six treatments were applied on August 3 with a high-clearance sprayer. For the first four treatments, pretreatment spider mite samples were collected on July 10, and posttreatment samples were collected on July 20 (1 WAT) and 27 (2 WAT) and August 3 (3 WAT) and 17 (5 WAT). For the last six treatments, pretreatment samples were collected on August 3, and there was a posttreatment sample on August17 (2 WAT).

Results and Discussion
In untreated plots (treatment 1), mite populations increased to 184 mites (Banks, twospotted, and predatory mites combined) per two plants at 5 WAT (data not shown). In treatment 5, the pretreatment BGM population increased to 395 mites per two plants by August 3 (data not shown). But BGM populations were declining by 5 WAT. Overall, spider mite population pressure during this trial was low, and there was no economic damage to plants.

Both pre-tassel treatments, Oberon and Comite, gave excellent early control (85% to 96%, respectively), and it held for 2 WAT (Table 1). At 5 WAT, when control was declining in other treatments, Oberon at 6 oz was still going strong. Performance of post-tassel treatments was good 2 WAT, but the population of BGM was declining during this time, so these results must be considered with caution.

The population of twospotted spider mites increased to151 mites per two plants in untreated plots by 5 WAT, nearly replacing the population of BGM (data not shown).

However, like the BGM population, the twospotted spider mite population also crashed by the end of August.

There was a gradual increase in the population of predatory mites (mostly *Phytoseiulus*). The predatory mite population peaked at 64 mites per two plants at 5 WAT (data not shown) and was highest in the Comite treatment. The predatory mite population may have been higher than reported here because pale predatory mites (*Galendromus* and *Neoseiulus*) were difficult to spot under the microscope on white paper and probably escaped notice. This increase partially explains the decrease in populations of BGM and twospotted spider mite. The *Neozygotes* fungus also attacks during this time, although it was not observed.

Table 1. Percentage of control of Banks grass mites in plots treated with miticides, experiment 3, Garden City, 2009

Treatment	Product	Rate/acre	July 20 (1 WAT)[1]	July 27 (2 WAT)	August 3 (3 WAT)	August 17 (5 WAT)
1	Check[2]	—	94.2	20.8	139.3	31.1
2	Oberon 2SC COC[3]	4 oz 2 pt	95.6	88.2	60.2	26.5
3	Oberon 2SC COC	6 oz 2 pt	95.9	81.5	90.9	98.0
4	Comite II	2.5 pt	85.5	95.5	18.3	00
			Sample II	Sample III	Pretreat	2 WAT
5	Oberon 2SC + COC	4 oz 2pt	—	—	—	67.7
6	Oberon 2SC + COC	6 oz 2pt	—	—	—	59.0
7	Acramite 4 SC + Nonionic adjuvant[4]	20 oz 0.25% v/v	—	—	—	95.6
8	Acramite 4 SC + Nonionic adjuvant	24 oz 0.25% v/v	—	—	—	00
9	Acramite 4 SC + COC	20 oz 1 pint	—	—	—	94.2
10	Acramite 4 SC + COC	24 oz 1 pint	—	—	—	79.4

[1] WAT, weeks after treatment. First four treatments made July 13, 2009; remaining six treatments made Aug. 3, 2009.
[2] Actual numbers of mites in the check plot that were used to calculate the percentage of control for other treatments are shown here.
[3] COC, crop oil concentrate. For treatments 2 and 3, AgriDex was used as COC. For treatments 5, 6, 9, and 10, CornBelt was used as COC.
[4] Buffer XtraStrength was used as nonionic surfactant.
Taylor's power transformation was used for statistical analyses, and Henderson's correction formula was used to calculate the percentage of control.

Winter Wheat Disease Severity and Control in 2009

K.L. Martin and J. Holman

Summary
Data from a wheat fungicide study at Garden City, KS, in 2009 show the importance of using disease pressure to justify fungicide application. In this study, disease pressure was low and progressed very slowly. We expected the wheat crop to mature before the flag leaf devastation was severe enough to significantly decrease yield. Fungicide application appeared to increase yields but could not be verified because of high variability between plots.

Introduction
Monitoring wheat disease severity and control with available fungicides is crucial for maintaining appropriate plant health and yield production. Although environmental conditions in western Kansas do not typically favor significant wheat disease development, accumulating data on frequency of response is needed to develop regional wheat disease prediction models. This study was initiated to evaluate the severity of wheat diseases and the effectiveness of common fungicides.

Procedures
This experiment was established at the Southwest Research-Extension Center at Garden City, KS, in fall 2008. It was designed as a randomized complete block design with four replications. Damby white winter wheat was planted on Oct. 1, 2008, at a seeding rate of 90 lb/acre. Fungicides were applied at 20 gal/acre with a backpack sprayer between 50% flag leaf emergence and heading. All plots were harvested with a plot combine, and yield, test weight, and moisture were obtained.

Results and Discussion
The dryland winter wheat in 2008–2009 at Garden City suffered from drought stress early in the season followed by freeze injury. When fungicides were applied, there was light leaf rust pressure in the lower canopy, indicating a fall infestation. Poor wheat in Oklahoma and Texas slowed progression of leaf rust through the states to the south. Therefore, leaf rust was not as severe as initially expected.

Fungicide application generally minimized the amount of the flag leaf area taken by rust. Of the treatments evaluated, Twinline was the only fungicide that did not appear to have any control over flag leaf rust (Table 1). All fungicide treatments increased yield over that in the untreated plots. However, these differences were not significant because of high variability between plots. In 2009, barley yellow dwarf virus created abnormally high variability all over Kansas, which affected our ability to detect differences in the study plots. Many fungicides are known to increase test weight and moisture, but this effect could not be verified in this study (Table 1).

Data from this study and studies from following years will be used to develop disease prediction methods to assist producers in making decisions regarding fungicide application. Although fungicides often are applied every year without regard to the presence of disease, this study shows that fungicide yield advantages are low without disease pressure.

Table 1. Dryland Damby winter wheat response to fungicide treatments

Treatment	Rate	Yield at 13% moisture	Test weight	Moisture	Flag leaf destruction
	fl oz/acre	bu/acre	lb/bu	-----------%-----------	
Untreated		70	61.8	9.6	5
Headline	9	73	62.2	9.7	0
Prosaro	6.5	73	63.0	9.6	<5
Quilt	14	77	63.0	9.8	<5
Stratego	10	75	61.5	9.4	0
Twinline	9	76	62.1	9.5	5
P-value		0.93	0.34	0.34	

Corn Disease and Fungicide Activity in 2009

K.L. Martin, R. Wolf[1], E. Blasi[2], and J. Holman

Summary
Corn leaf diseases in irrigated corn production are common in western Kansas. Studying fungicide activity in western Kansas is important for obtaining recent data and providing recommendations to producers. A study was conducted at Garden City, KS, under controlled research conditions to evaluate the efficacy of common fungicides for control of corn leaf diseases, specifically grey leaf spot. A complementary study was conducted in Meade County (north of Meade, KS) to evaluate the ability of Headline plus a triazole fungicide and Quilt to control established grey leaf spot in corn.

Introduction
In Kansas, irrigated corn requires more crop inputs than most crops grown in the area. One of these inputs is fungicide application to control corn leaf diseases. Of the major corn diseases in Kansas, grey leaf spot is the most common and most devastating to the corn crop. Therefore, corn producers are interested in products that provide the most effective control of this disease.

Procedures
An irrigated corn trial was planted on May 15, 2009, to Pioneer 33B54. Fungicides were applied on July 25, 2009, during tassel emergence. All treatments were applied with a backpack sprayer at a rate of 20 gal/acre. Treatments applied and rates are shown in Table 1. After application, disease ratings were determined visually. Corn was harvested with a Wintersteiger Delta plot combine. Grain samples were collected to determine plot yields, grain test weight, and moisture.

A second study was conducted in a producer field north of Meade, KS. For this study, an Air Tractor 401 was used to apply fungicide treatments to equivalent areas at a rate of 3 gal/acre. Each application strip was a total of 25 acres. Treatments applied are shown in Figure 1. After application, disease control ratings were evaluated three times, and yield was collected by using a conventional combine with GPS technology and yield monitoring. Yields were corrected to 15.5% moisture. Because this study is not replicated, no statistics accompany the data.

Results and Discussion
Garden City
Corn response to fungicide application at Garden City is displayed in Table 1. This site was damaged by two different hailstorms before the onset of grey leaf spot. Grey leaf spot started light and progressed through the season. Fungicide application controlled the severity of grey leaf spot by significantly controlling disease compared with the untreated controls. Most fungicides similarly controlled grey leaf spot. However, the low rate of Headline EC controlled grey leaf spot less than the rest of the fungicide treatments, indicating that a higher rate was needed.

[1] Kansas State University Department of Biological and Agricultural Engineering.
[2] Agricultural and natural resources agent, Meade County, Kansas.

Although there were differences in disease control and impressive nominal differences in yield, there were no significant differences in yield between treatments. The hail damage likely caused variability that masked the effects of the fungicides. In this study, fungicide application did not affect test weight or moisture.

Meade County

Figures 1 and 2 show the yield response and grey leaf spot control on the irrigated corn circle in Meade County. Yields from the four treatments ranged from 259 to 273 bu/acre. The three checks had a mean yield of 266 bu/acre. After we viewed the field, it was clear that yield responses should be compared with the nearest check. That is, Headline EC and Headline SC+COC should be compared with the first check, Headline+Caramba should be compared with the middle check, and Quilt should be compared with the last check.

When treatments were compared with the nearest neighboring check, corn in the Headline+Caramba treatment yielded the highest and had the greatest yield response, although it only produced three additional bushels per acre. The lowest-yielding treatment was Headline SC without Caramba, which indicates the importance of adding a triazole to the premix.

Figure 2 shows the disease control ratings, which indicate that Headline+Caramba did not control diseases as well as Headline SC alone. Either additional factors of the fungicide created a yield boost or random variability confused the effects of treatments. We don't know which of these scenarios occurred because the absence of replications prevented statistical analysis.

Table 1. Corn response to fungicide treatments at Garden City, KS, 2009

Treatment	Rate	Yield at 15.5% moisture	Test weight	Moisture	Disease control
	fl oz/acre	bu/a	lb/bu	----------%----------	
Untreated		196	60.1	17.9	0c
Headline EC	6	209	60.0	18.1	58.3b
Headline EC	9	216	60.1	18.1	65.8a
Headline SC	6	213	59.9	18.2	64.2a
Quilt	14	212	59.9	18.3	65.0a
Quilt/Quadris	14/2	211	60.0	17.8	65.8a
Stratego	10	211	59.9	18.2	65.0a
Tilt	4	208	60.0	18.0	65.0a
Caramba	6.8	200	60.2	17.8	61.7a
P-value		0.59	0.22	0.64	0.02

Within a column, letters indicate significant differences between treatments.

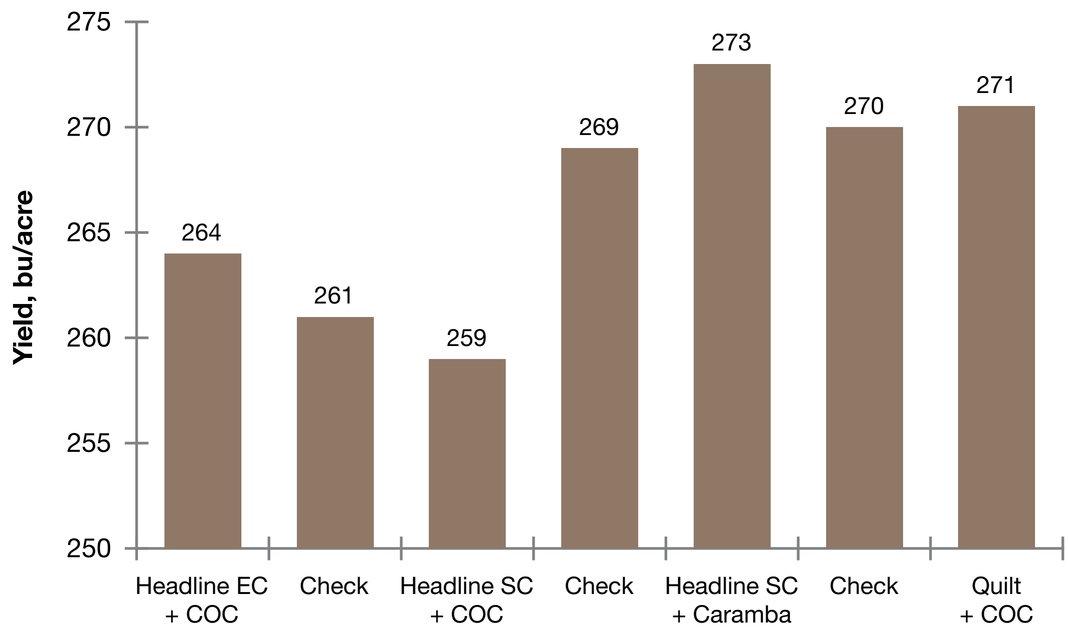

Figure 1. Corn yield response to fungicide application in Meade County, KS, 2009.

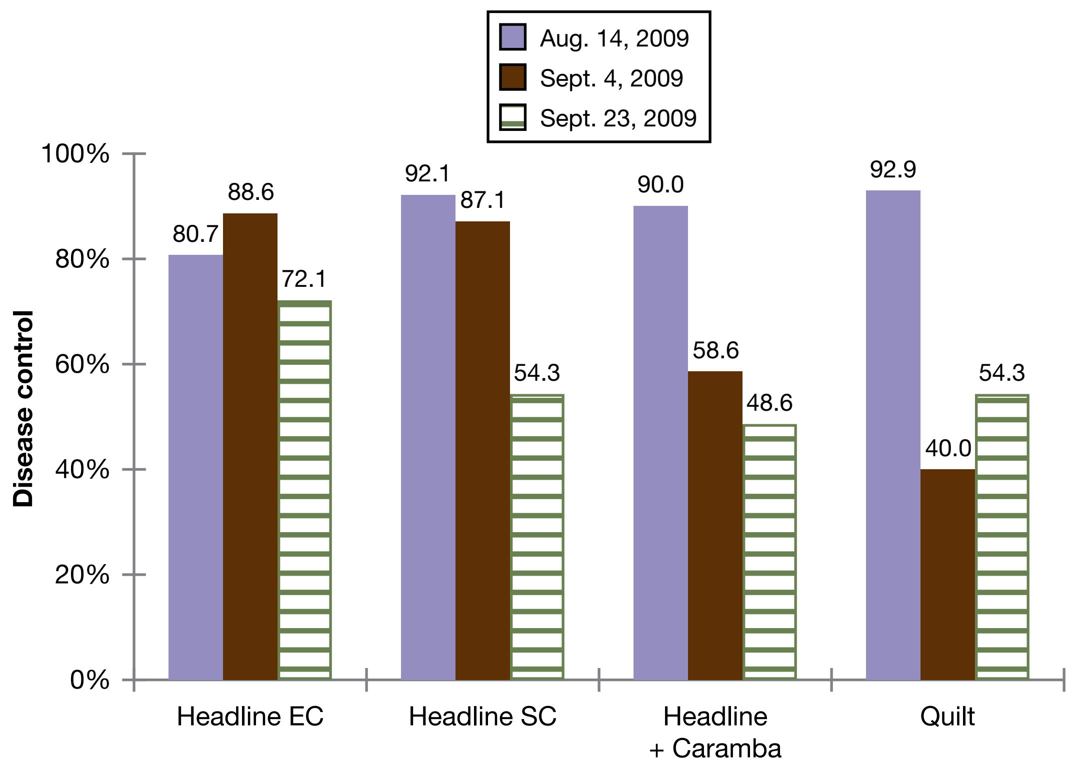

Figure 2. Corn disease control with fungicide application in Meade County, KS, 2009.

Effect of Iron Application Methods on Soybean at Garden City

K.L. Martin, D.A. Ruiz Diaz[1], A. Liesch[1], and J. Holman

Summary
A study was initiated at the Southwest Research-Extension Center in Garden City, KS, to evaluate methods of iron fertilization on soybean. Application methods included seed coating treatment and foliar application of two different chelated products. The effect of variety selection was also evaluated in combination with the fertilizer treatments. Preliminary results from this study suggest that a seed coating treatment with iron fertilizer would provide significant yield increases. Results from other locations suggest few additional benefits from foliar fertilizer application. In this study, there was no response to foliar fertilizer application.

Introduction
Iron chlorosis on soils with high pH and low organic matter is common in western Kansas. Traditional methods of overcoming this chlorosis have not been well received by producers primarily because the methods have a low success rate and relatively small portions of the field require iron application. As a result, yield is depressed on many field crops in Kansas.

Procedures
This study was established in spring 2009 at the Southwest Research-Extension Center in Garden City, KS, at the Finnup lease. The selected study area had been leveled in the past, resulting in very high pH, low organic matter, and low extractable iron. Two soybean varieties with different genetic tolerance to iron chlorosis were planted: AG2905 (very good chlorosis tolerance) and AG3205 (low tolerance). Iron chelate (FeEDDHA 6%) was used for seed coating. Two different iron chelates (Fe-EDDHA and Fe-HEDTA) were applied as foliar treatments at 0.1 lb Fe/acre at approximately the 2- to 3-trifoliate growth stage, and a second application was applied approximately 2 to 4 weeks later. These treatments were arranged in a factorial design with two soybean cultivars and five treatments plus a control.

Results and Discussion
Data showing the effects of iron application methods at Garden City are located in Figure 1. There was inconsistency within varieties and foliar application treatments. When seed treatments were applied, yields were as high with the susceptible variety as with the tolerant variety. Similarly, when no seed treatment or foliar fertilizer was applied, the susceptible variety yielded similarly to the tolerant variety. These results suggest variety did not influence yield under iron chlorosis conditions. When seed treatments were applied, there were generally higher yields across varieties and foliar applications, suggesting a heavy influence of iron applied as a seed coating. However, application of foliar iron (either source) on seed-treated plots did not consistently affect yield in either variety.

[1] Kansas State University Department of Agronomy.

These observations are general; because a portion of the experiment was lost, making definite conclusions is difficult. However, data from this location align with data from other locations and experiments, suggesting that seed coating treatment is a viable option for minimizing the effects of iron chlorosis on soybean.

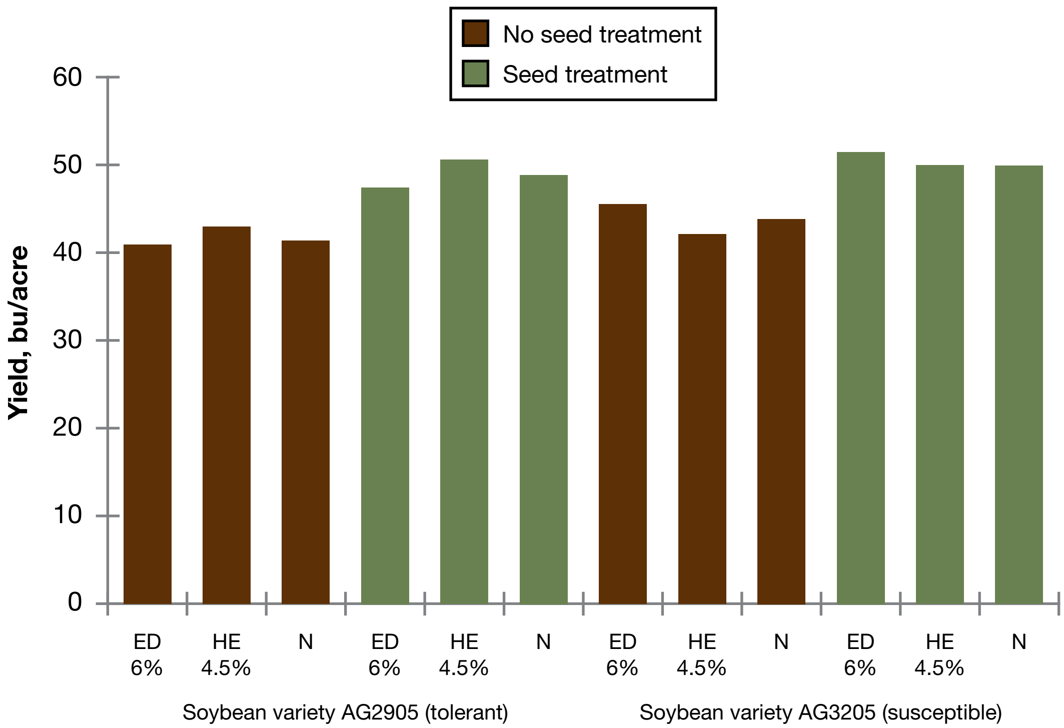

Figure 1. Effects of iron application method on soybean yield, Garden City, 2009.
ED 6%, HE 4.5%, and N represent EDDHA 6%, HEDTA 4.5%, and no foliar application, respectively.

Forage Yield and Nutritive Value of Hard Red and Hard White Winter Wheat

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

Summary
Six hard red (2137, Jagalene, Jagger, OK101, Stanton, and Thunderbolt) and six hard white (Burchett, Lakin, NuFrontier, NuHills, NuHorizon, and Trego) winter wheat (*Triticum aestivum* L.) cultivars were evaluated for forage yield and nutritive value. Forage samples were collected in December, March, and May. Red cultivars averaged greater total-season forage yield in one growing season than white cultivars, but yield differences among cultivars within a color group were greater than differences between color groups, indicating that color did not affect yield as much as cultivar did. Total growing-season forage yield was greatest among red cultivars 2137, Jagalene, Stanton, and Thunderbolt and white cultivar Trego. Color had no effect on forage nutritive value. Crude protein averaged 230 g/kg in December, 240 g/kg in March, and 140 g/kg in May. Acid detergent fiber averaged 190 g/kg in December, 240 g/kg in March, and 320 g/kg in May. Neutral detergent fiber averaged 430 g/kg in December, 410 g/kg in March, and 550 g/kg in May. Total digestible nutrients averaged 790 g/kg in December, 740 g/kg in March, and 670 g/kg in May. Nitrate-nitrogen averaged 247 mg/kg in December, 550 mg/kg in March, and 1,366 mg/kg in May. Both red and white wheat cultivars can be used in a dual-purpose system with no adverse affects on forage yield or nutritive value. Producers should select cultivars adapted to their grazing system and environment.

Winter Wheat Forage Yield
Averaged across locations in 2003–2004, of the red cultivars, 2137, Jagalene, Jagger, and Stanton had the greatest December yield, and OK101 and Thunderbolt yielded less than Jagalene but similar to 2137, Jagger, and Stanton ($P \leq 0.05$). Averaged across locations in 2003–2004, of the white cultivars, Burchett, Lakin, NuFrontier, NuHorizon, and Trego had greater December forage yield than NuHills ($P \leq 0.05$). Cultivars in this study yielded similarly to how they were previously rated with the exception of OK101 and NuHills, which were rated as producing "very good" to "excellent" but yielded "below average" in this study (Table 1).

Cultivars in this study produced greater yields at different harvest dates (Table 1). Of the red cultivars, 2137, Jagalene, Stanton, and Thunderbolt produced the most total growing-season yield ($P \leq 0.05$). Of these cultivars, 2137, Jagalene, and Stanton produced the greatest December yield, and 2137 and Thunderbolt produced the greatest May yield. Thunderbolt was one of the lowest-yielding cultivars in December. Of the white cultivars, Trego produced the most total-season and May yield ($P \leq 0.05$) and also yielded comparatively well in December and March. Winter wheat can be grazed in the fall only, grazed in the fall and spring, grazed out, or hayed in the spring. Producers need to consider the intended forage use of the winter wheat crop and select cultivars on the basis of that intended use. Few cultivar trials evaluate the forage potential of winter wheat cultivars, and those that do usually evaluate only fall forage yield. Cultivar grain

[1] Former livestock production specialist, Southwest Area Extension Office.

yield trials in regions that use winter wheat in a dual-purpose system should evaluate fall and spring forage yield.

Conclusions

In this study, nutrient composition was affected most by harvest date. Crude protein and energy (total digestible nutrients and relative feed value) decreased, and fiber concentration (acid detergent fiber and neutral detergent fiber) increased with later harvest date. Compared with other grass hay, winter wheat was of premium nutritive value when harvested in the fall or early spring and good to premium nutritive value when harvested in late spring for hay production or graze out. Compared with alfalfa, winter wheat was of good to premium nutritive value when harvested in the fall or early spring and fair to utility nutritive value when harvested in late spring for hay production or graze out. Nitrate-nitrogen concentration was often high; therefore, caution should be taken, and wheat should be tested for nitrate-nitrogen before it is fed. This study suggests winter wheat is an excellent source of forage during a time of year when forage is often limited and of poor nutritive value.

Cultivar forage yield varied across harvest dates. Certain cultivars produced more fall forage for grazing, whereas other cultivars produced more spring forage for graze out or hay production. More information is needed on cultivar forage yield across harvest dates. These results suggest producers should select cultivars on the basis of the intended forage use. Many hard white winter wheat cultivars produced forage yield and nutritive value similar to those of hard red winter wheat cultivars. These results suggest producers could grow hard white winter wheat in a dual-purpose, graze only, or hay system if they select a cultivar by using the same process that has been used to select hard red winter wheat cultivars.

Table 1. Summary of hard red and hard white winter wheat dry matter forage yield at three harvest dates (December, March, and May) and for the total growing season averaged across locations (Clark and Stanton counties, Kansas) and growing seasons (2003–2004 and 2004–2005).

		Harvest date							
		December		March		May		Total[1]	
Color	Cultivar	Yield (kg/ha)	Rank[2]	Yield (kg/ha)	Rank	Yield (kg/ha)	Rank	Yield (kg/ha)	Rank
Red	2137	2,029ab	Avg.	1,251a	Avg.	2,424a	Above avg.	4,689ab	Avg.
	Jagalene	2,300a	Above avg.	1,343a	Avg.	2,158b	Below avg.	4,651ab	Avg.
	Jagger	2,135ab	Avg.	1,334a	Avg.	1,957b	Below avg.	4,358bc	Below avg.
	OK101	1,923b	Below avg.	1,232a	Avg.	2,034b	Below avg.	4,228c	Poor
	Stanton	2,024ab	Average	1,380a	Avg.	2,187b	Below avg.	4,579abc	Avg.
	Thunderbolt	1,937b	Below avg.	1,334a	Avg.	2,520a	Above avg.	4,822a	Above avg.
White	Burchett	2,342a	Above avg.	1,234ab	Avg.	2,077b	Avg.	4,482b	Avg.
	Lakin	2,245a	Above avg.	1,259ab	Avg.	2,120b	Avg.	4,502b	Avg.
	NuFrontier	2,440a	Above avg.	1,161b	Below avg.	2,182b	Avg.	4,563b	Avg.
	NuHills	1,817b	Below avg.	1,226ab	Avg.	1,741c	Poor	3,875c	Below avg.
	NuHorizon	2,406a	Above avg.	1,316a	Above avg.	1,973bc	Below avg.	4,492b	Avg.
	Trego	2,434a	Above avg.	1,329a	Above avg.	2,477a	Above avg.	5,024a	Above avg.
SEM[3]		100		65		94		146	

Fall forage was insufficient to harvest in December 2004, so the fall yield summary is from December 2003 only.

[1] Total is the cumulative of individual harvest dates for a cultivar.

[2] Cultivars were ranked as above average, average, below average, and poor on the basis of pairwise t-tests.

[3] SEM, standard error of the mean for comparing values within a column.

Within a column, letters separate means within color group at P=0.05 by independent pairwise t-tests in Proc Mixed (pdiff option).

Evaluation of Accolade in Winter Wheat for Reducing the Amount of Nitrogen Application Required[1]

J. Holman, K. Martin, and S. Maxwell

Summary
Winter wheat grown under center-pivot irrigation produced high grain yield and test weight in 2009 at Garden City, KS. Grain yield averaged 97 bu/acre, and test weight averaged 62.5 bu across treatments. Treatment did not affect grain yield or test weight.

Procedures
This field study was conducted during the 2008–2009 winter wheat growing season at the Southwest Research-Extension Center in Garden City, KS. Soil type was a Ulysses silt loam (fine-silty, mixed, superactive, mesic Aridic Haplustolls). Winter wheat variety Danby was planted on Oct. 1, 2008, at a seeding rate of 90 lb/acre with a Fabro plot drill using a John Deere double disk opener with 8-in. row spacing. Starter fertilizer as monoammonium phosphate (11-52-0) was applied with the seed at a rate to supply 5.5 lb/acre nitrogen (N) and 26 lb/acre P_2O_5. Wheat was planted with conventional tillage following a soybean cover crop. The experiment was a split-plot randomized complete block design with four replications. Plots were 22.5 ft wide and 35 ft long. The main plot was seed treatment.

Seed treatments were Accolade dry (peat), Accolade liquid, and an untreated control (Table 1). Accolade is a biological growth enhancer marketed by INTX Microbials, LLC, that contains a guaranteed minimum of 1 billion viable *Azospirillum brasilense* per gram of product. Accolade dry was applied at a rate of 3.05 oz of product per bushel of wheat, and Accolade liquid was applied at a rate of 6 oz of product per bushel of wheat. Subplots were N top-dressed to supply 50% and 100% of the N recommend by the Kansas State University soil testing lab for a winter wheat yield goal of 70 bu/acre. Nitrogen top-dress rates were reduced to account for soil N level, soybean residue mineralization, and starter N. The soil testing lab suggested a 20 lb/acre N credit from soybean residue mineralization. Nitrogen was top-dressed as urea (46-0-0) on Mar. 20, 2009, at a rate to supply 46 lb/acre N for the 50% rate and 93 lb/acre N for the 100% rate. Supplemental irrigation was applied on Mar. 4, 2009, at 0.5 in./acre and June 10, 2009, at 0.75 in./acre. Wheat was harvested on July 1, 2009, with a Wintersteiger Delta plot combine. The harvest area was 6.5 ft wide by 35 ft long.

Data were analyzed with the PROC MIXED procedure in SAS. Replication and all interactions with replication were considered random effects in the model. Treatment effects were determined significant at $P \leq 0.05$, and when ANOVA indicated, significant effects means were separated with pairwise t-tests at $P \leq 0.05$.

[1] This research is funded in part by INTX Microbials, LLC, and the Kansas Agricultural Experiment Station.

Results and Discussion

Treatment did not affect wheat yield or test weight (Figures 1 and 2). Grain N content was not measured. We thought the 50% N top-dress rate would have resulted in lower grain yield than the 100% N top-dress rate. The 50% N top-dress rate averaged 97.6 bu/acre, and the 100% N top-dress rate averaged 96.3 bu/acre. Irrigated winter wheat yields in the crop performance test at Garden City, KS, have averaged 68 bu/acre for the past 5 years. Cool temperatures and adequate rainfall during the 2008–2009 winter wheat growing season resulted in exceptional yields. Warm temperatures during the winter, adequate rainfall, conventional tillage, and the soybean cover crop might have increased N mineralization of the soybean residue in this study, which might have contributed enough N so that N was not limiting.

Table 1. Seed and nitrogen treatments

Treatment	Seed treatment	Nitrogen top-dress rate
1	Untreated control	50%
2	Untreated control	100%
3	Accolade liquid	50%
4	Accolade liquid	100%
5	Accolade dry	50%
6	Accolade dry	100%

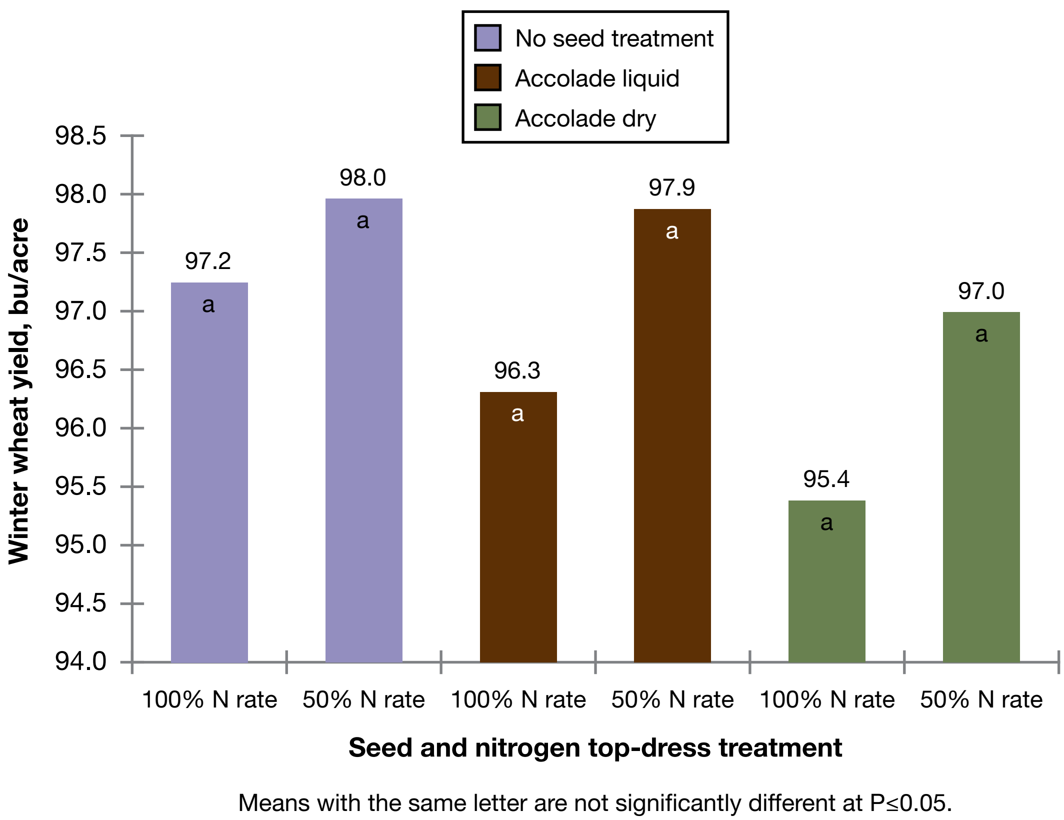

Figure 1. Wheat grain yield response to seed treatment and nitrogen top-dress in 2009.

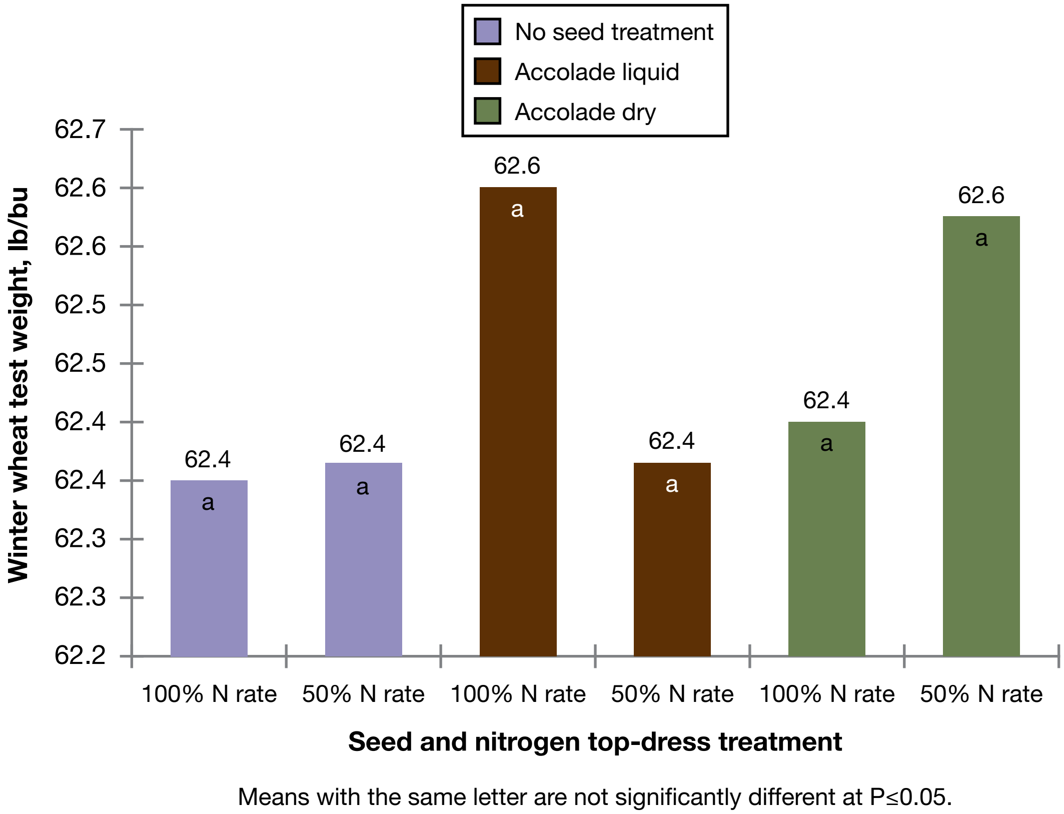

Figure 2. Wheat grain test weight response to seed treatment and nitrogen top-dress in 2009.

Effects of Planting Date on Winter Canola[1]

J. Holman, M. Stamm[2,3], S. Maxwell, C. Godsey[3], Kent Martin, and K. Roozeboom[2]

Summary

Determining the optimum planting date of canola is crucial for successful stand establishment and yield. One of the most limiting factors in Kansas canola production is identifying varieties and planting methods that result in successful stand establishment and winter survival. Once successful canola production systems are identified, it is expected that production will increase, more local grain elevators will purchase the crop, more local processing facilities will process the crop, and local feedlots will be able to use the meal (a by-product of oil crushing) as a soybean meal replacement.

In 2007, tillage had no effect on canola. In 2008, however, tillage increased fall stand establishment, winter survival, spring vigor, and spring stand. In both years of this study, fall stand establishment was successful across planting dates except the earliest planting date in mid-August. In 2007, diamondback moth (*Plutella xylostella* L.) density and damage was greatest at the earliest planting date, and in 2008, rabbits tended to selectively feed and caused greatest damage to canola planted on the earliest planting date. In 2007, fall stand density was greatest at the last planting date (October 15) and increased as planting date was delayed. In 2008, fall stand density was greatest at the fourth (September 29) planting date and lowest at the first planting date (August 22). In 2007, winter survival was greatest for the second and third planting dates (September 4 and 17), and no plants survived the last planting date (October 15). In 2008, winter survival was very poor overall but highest at the first planting date. No plants survived with no-till at the third planting date (September 11) or with either no-till or tillage at the fourth (September 29) and fifth (October 20) planting dates. In 2007, spring vigor was greatest at the first three planting dates (August 16, September 4 and 17). In 2008, spring vigor was greatest with tillage at the first (August 22) and second (September 2) planting dates. In 2007, spring stand was greatest at the second, third, and fourth (September 4, 17, and 28) planting dates. In 2008, spring stand was greatest at the first (August 22) planting date and with tillage at the second (September 2) planting date. Current information suggests planting winter canola with tillage around September 1 for the best chance of winter survival and obtaining a successful spring stand.

Conclusion

This study will be replicated during the 2009–2010 growing season. Current information suggests winter canola should be planted in tilled soil for greater winter survival and successful spring stand establishment. Canola planted with no-till tended to perform similarly to canola planted with tillage at the earliest planting dates but worse than canola planted with tillage at later planting dates. Canola, like other crops, is highly susceptible to hail damage, especially when the crop is mature and near harvest.

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[1] USDA-CSREES Supplemental and Alternative Crops Competitive Grants Program.

[2] Kansas State University Department of Agronomy.

[3] Oklahoma State University Department of Plant and Soil Sciences.

Winter canola should be planted around September 1 for successful fall stand establishment and winter survival.

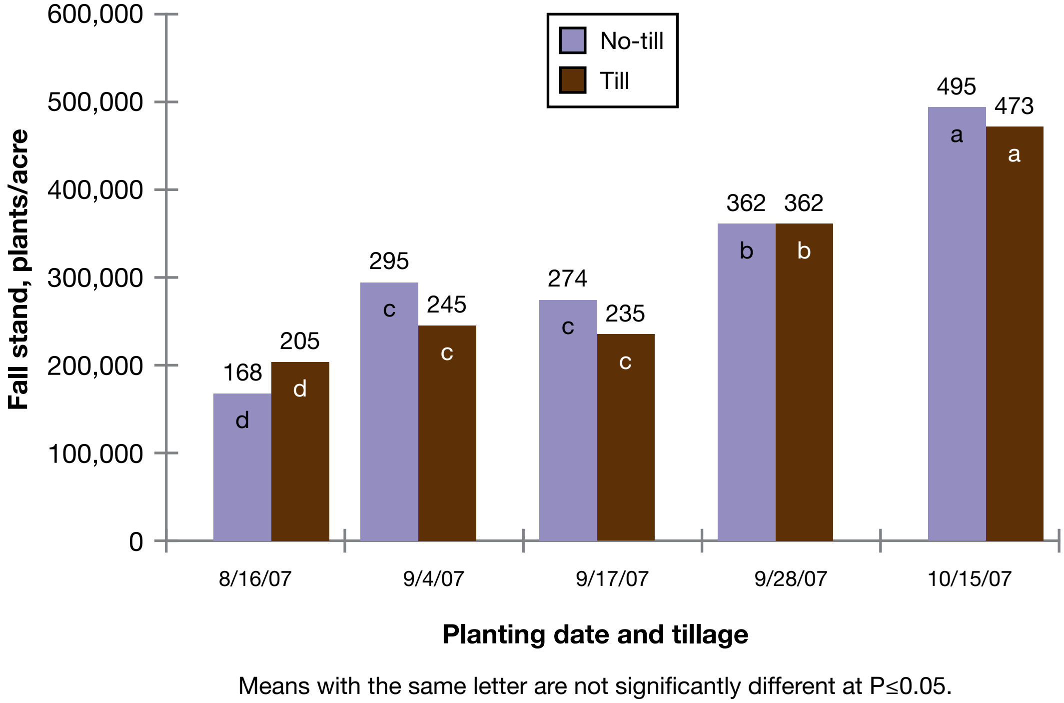

Figure 1. Winter canola fall stand establishment at five different planting dates in tillage and no-till, Garden City, 2008.

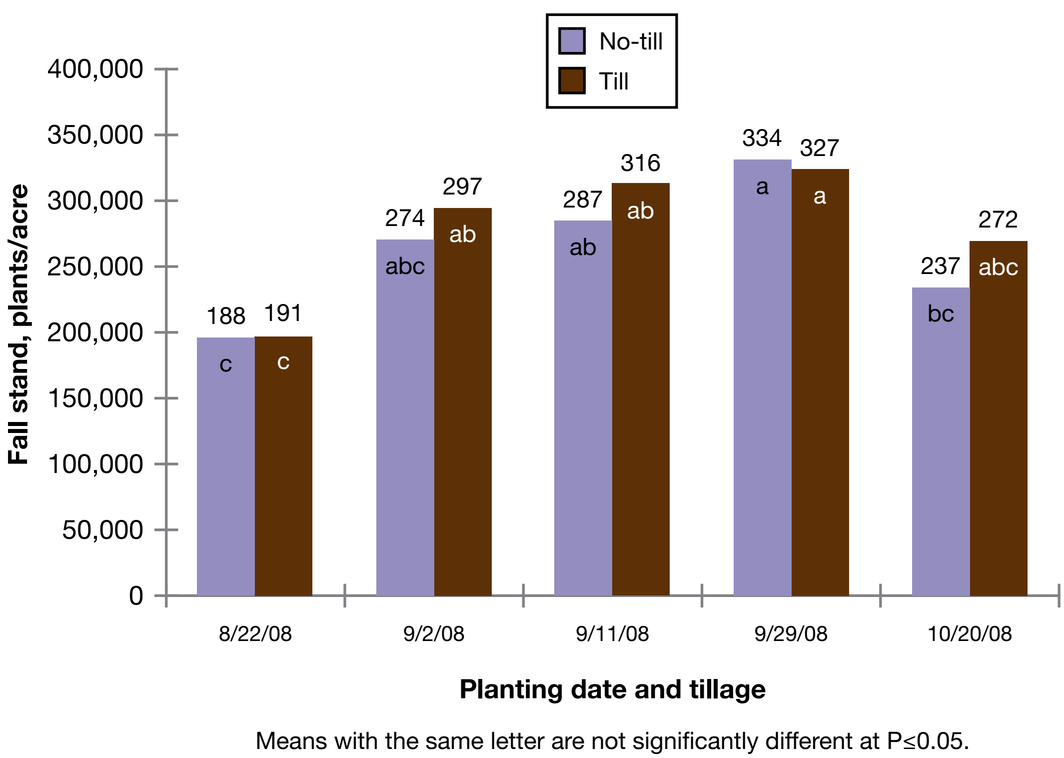

Figure 2. Winter canola fall stand establishment at five different planting dates in tillage and no-till, Garden City, 2009.

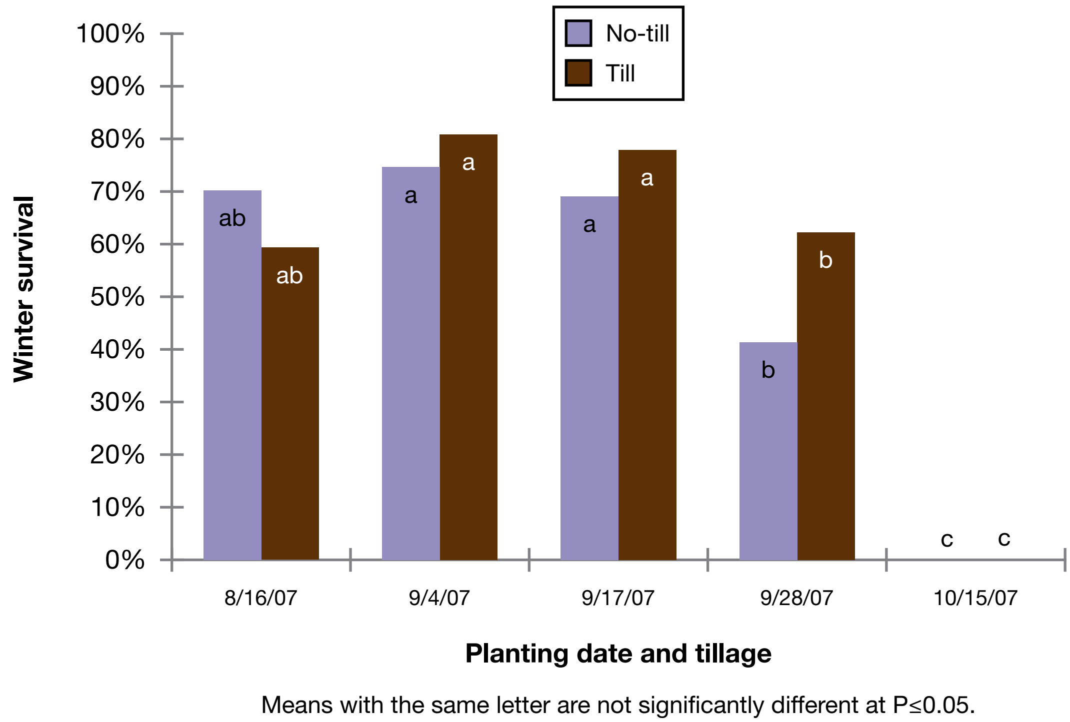

Figure 3. Winter canola winter survival at five different planting dates in tillage and no-till, Garden City, 2008.

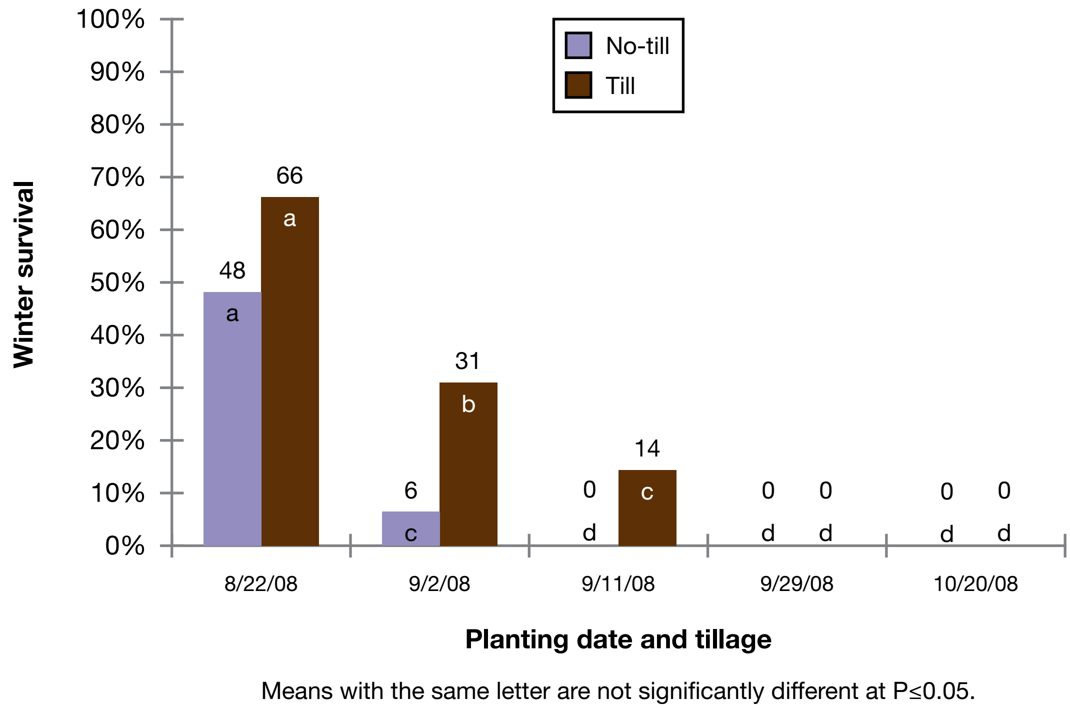

Figure 4. Winter canola winter survival at five different planting dates in tillage and no-till, Garden City, 2009.

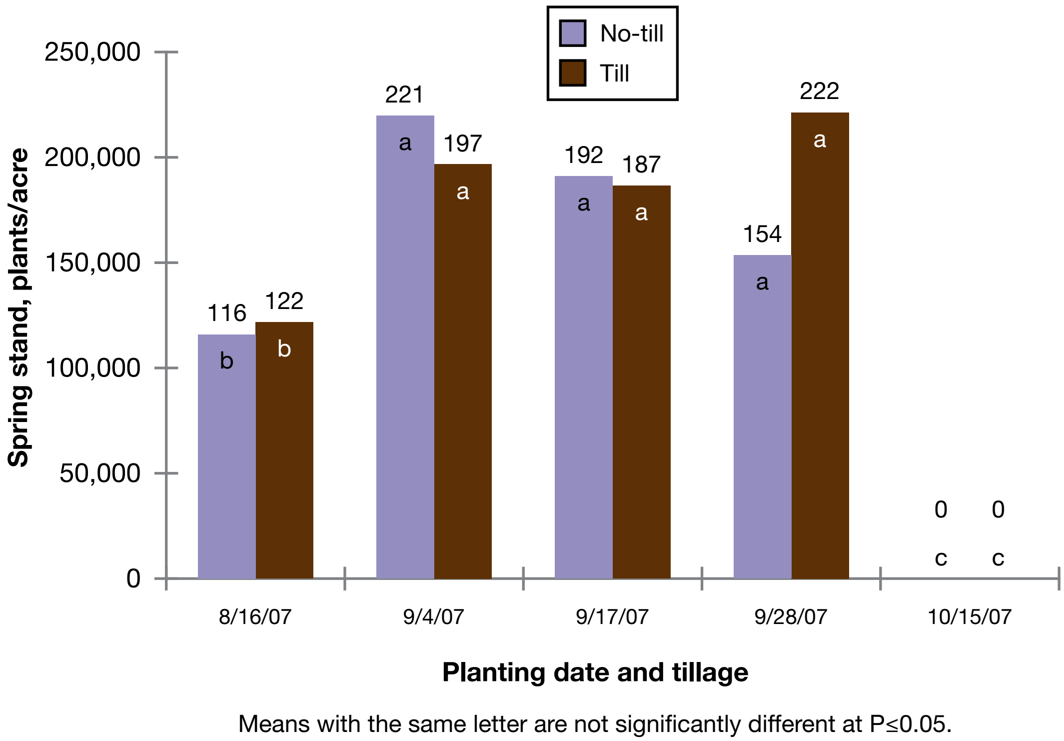

Figure 5. Winter canola spring stand establishment at five different planting dates in tillage and no-till, Garden City, 2008.

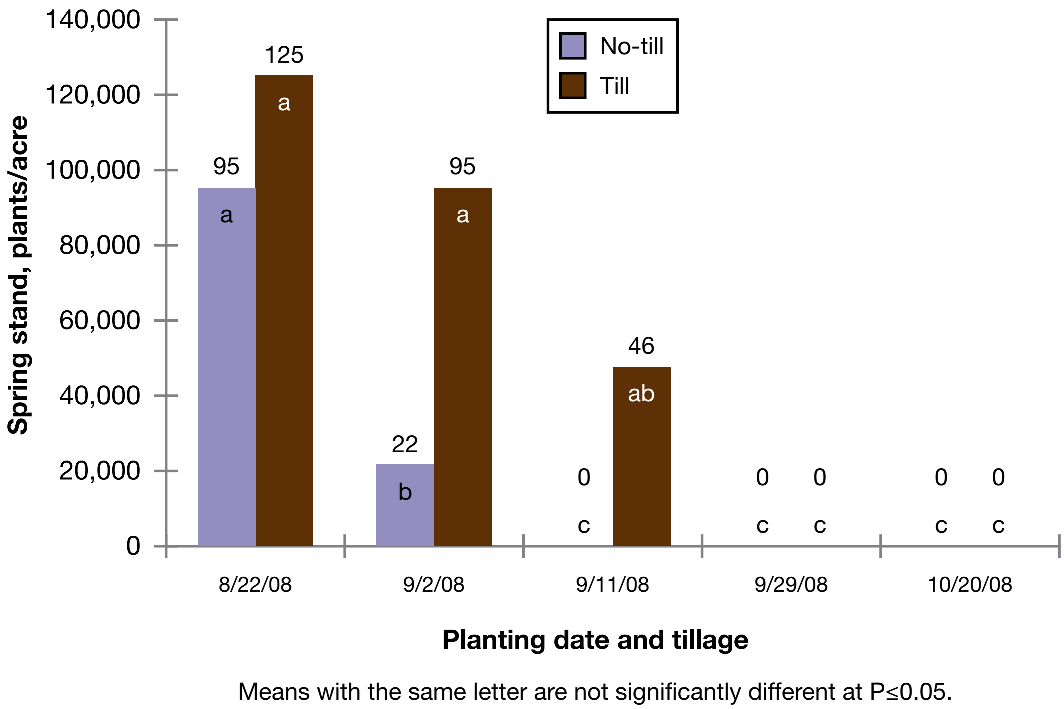

Figure 6. Winter canola spring stand establishment at five different planting dates in tillage and no-till, Garden City, 2009.

Evaluation of Annual Cover Crops for Forage Yield in a Wheat-Fallow Rotation[1]

J. Holman, S. Maxwell, A. Dille[2], K. Roozeboom[2], K. Martin[2], D. Presley[2], A. Schlegel, J. Petrosino[2], and K. Arnet[2]

Summary

Producers have expressed interest in growing a cover crop during traditional fallow periods. Western Kansas crop yields are limited by moisture and heat stress, and fallow is an important component of the system because it stores moisture for subsequent crops. Conventional tillage and no-till systems store about 20% and 30%, respectively, of the precipitation received during the traditional 14-month fallow period of a wheat-fallow rotation. Thus, there is great interest in increasing the efficiency of storing precipitation during the fallow period. This study was conducted to evaluate replacing the fallow period with either a fall or spring cover crop grown either as a green manure or forage crop (Table 1). This report presents the first 3 years of findings on cover crop forage yields. Triticale and broadleaf mixtures with triticale produced greater forage yield than broadleaf species alone. Winter crops produced more forage yield than spring crops.

Results and Discussion

Triticale and broadleaf mixtures with triticale produced greater forage yield than broadleaf species alone (Figures 1, 2, and 3). Winter pea planted in a mixture with triticale tended to yield more than triticale alone (Figures 2 and 3). Yellow sweet clover planted alone did not produce enough yield to harvest in 2008 (Figure 2) and produced very little forage yield in 2007. Thus, yellow sweet clover was replaced by winter lentil in 2009. Hairy vetch planted alone suffered from winterkill and did not produce enough yield to harvest in 2009 (Figure 3). Legumes tended to survive the winter better when planted in a mixture with triticale. When winter crops that did not survive the winter were excluded, winter crops produced more forage yield than spring crops (Figures 4, 5, and 6). Spring cover crops were harvested approximately 2 weeks later than winter cover crops each year.

[1] This research is funded in part by the USDA-CSREES North Central Region Integrated Pest Management grants program.

[2] Kansas State University Department of Agronomy.

Table 1. Cover crop treatments

Season	Cover crop	Year produced 2007	2008	2009	2010	2011
Fall	Yellow sweet clover	x	x			No
Fall	Yellow sweet clover/winter triticale		x			No
Fall	Hairy vetch	x	x	x	x	?
Fall	Hairy vetch/winter triticale		x	x	x	?
Fall	Winter lentil			x	x	x
Fall	Winter lentil/winter triticale			x	x	x
Fall	Winter pea (grain)		x	x	x	No
Fall	Winter pea (forage)	x	x	x	x	?
Fall	Winter pea/winter triticale		x	x	x	?
Fall	Winter triticale	x	x	x	x	x
Spring	Spring lentil	x	x	x	x	x
Spring	Spring lentil/spring triticale		x	x	x	x
Spring	Spring pea	x	x	x	x	x
Spring	Spring pea/spring triticale		x	x	x	x
Spring	Spring triticale		x	x	x	x

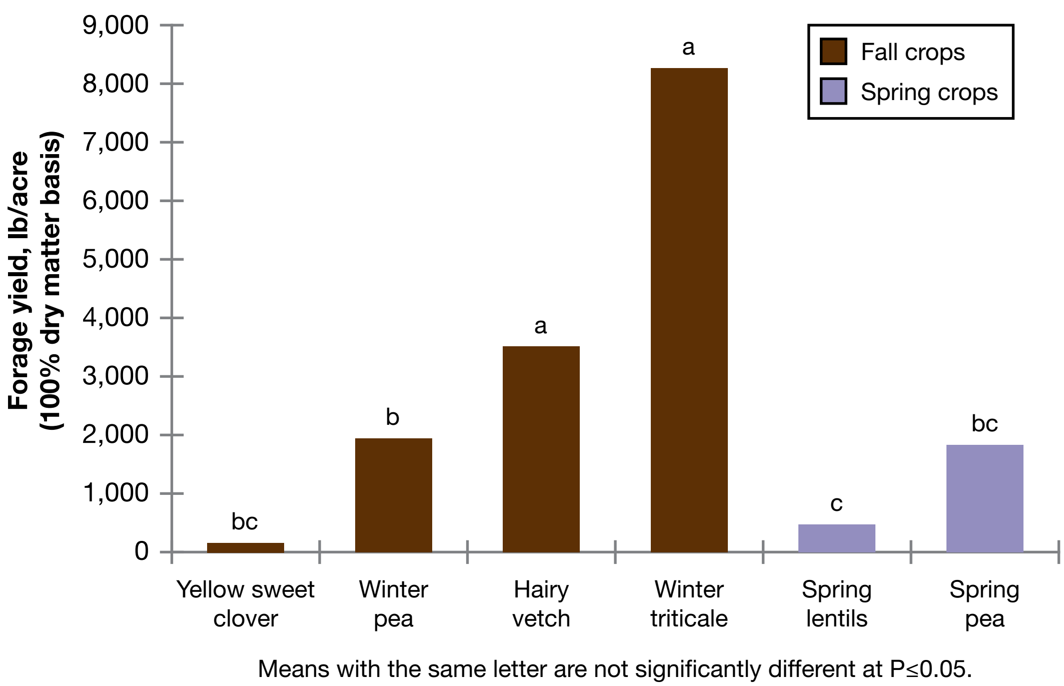

Figure 1. Cover crop forage yield in 2007.

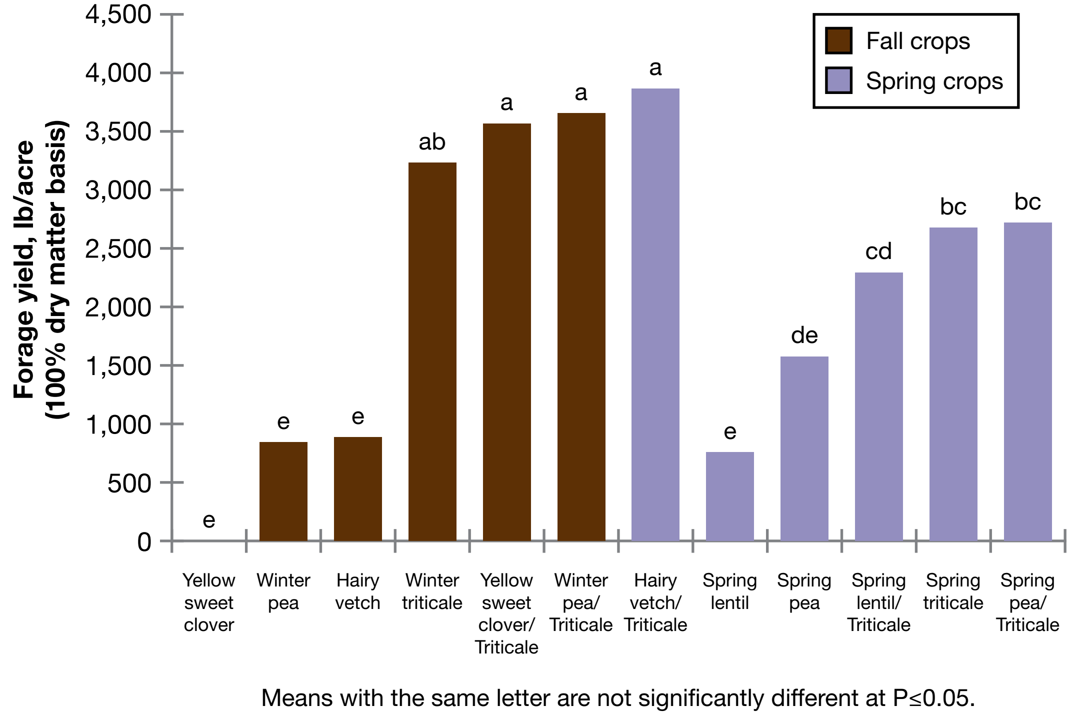

Figure 2. Cover crop forage yield in 2008.

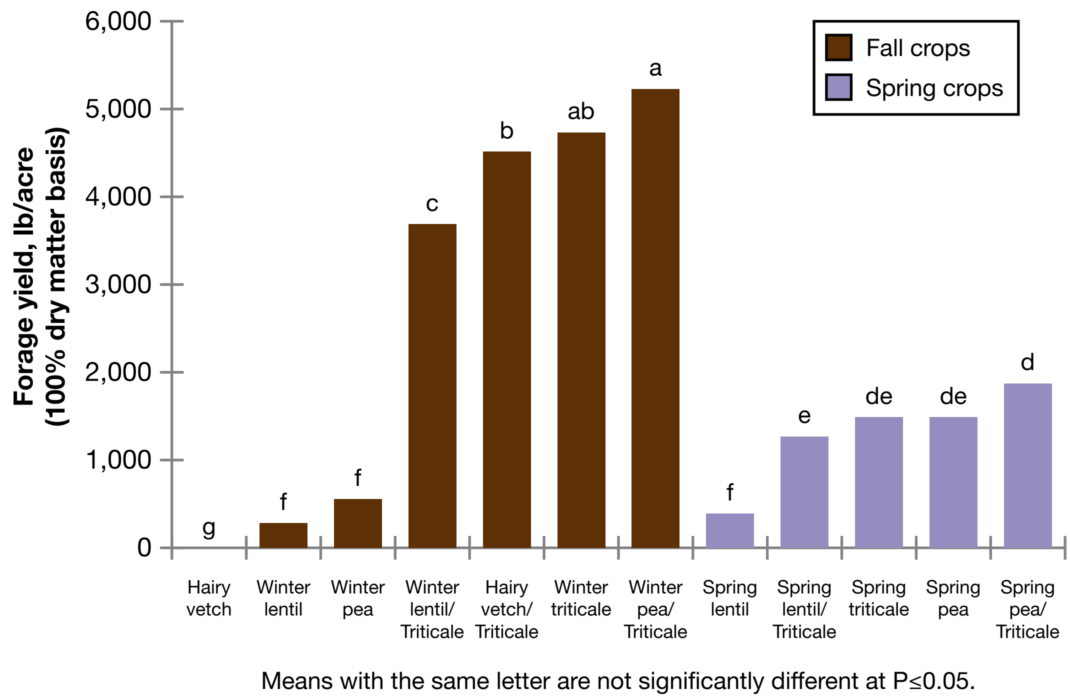

Figure 3. Cover crop forage yield in 2009.

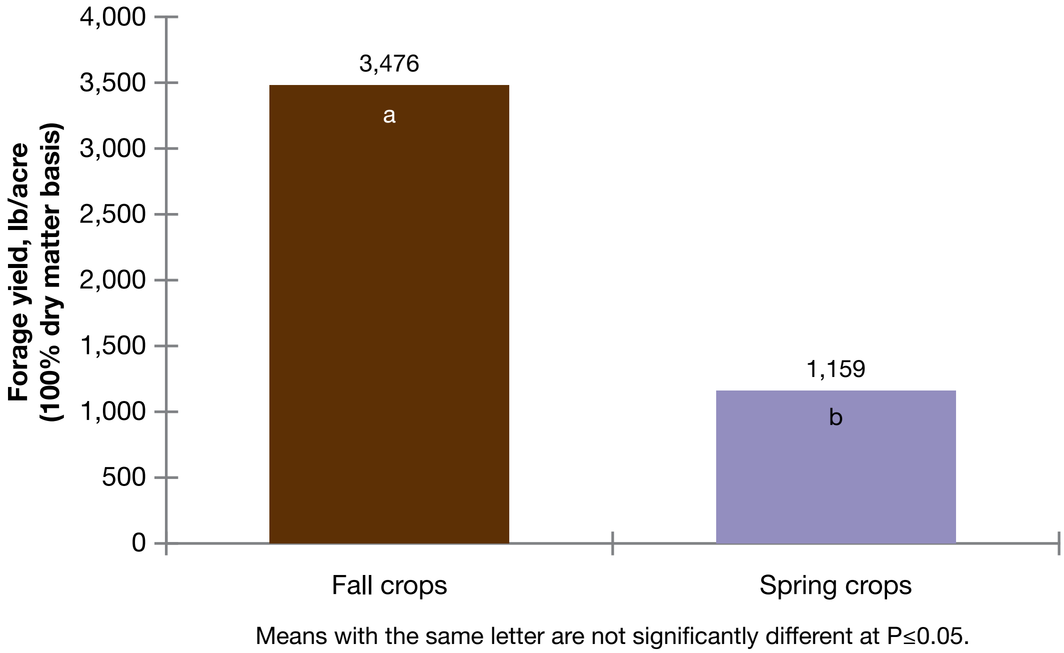

Figure 4. Fall and spring cover crop forage yield averages in 2007.

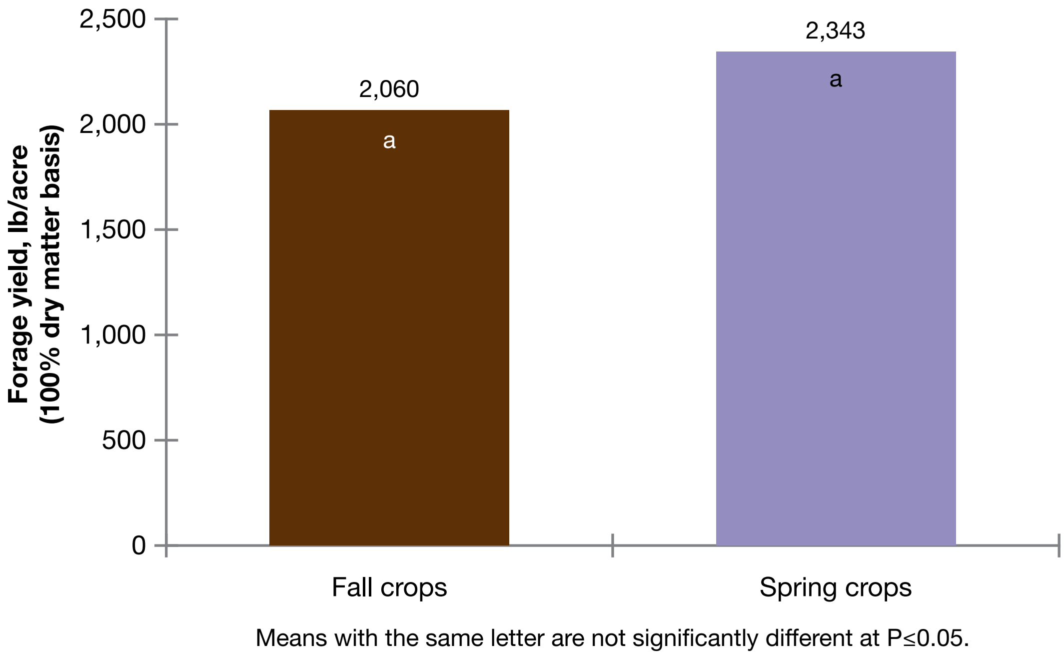

Figure 5. Fall and spring cover crop forage yield averages in 2008.

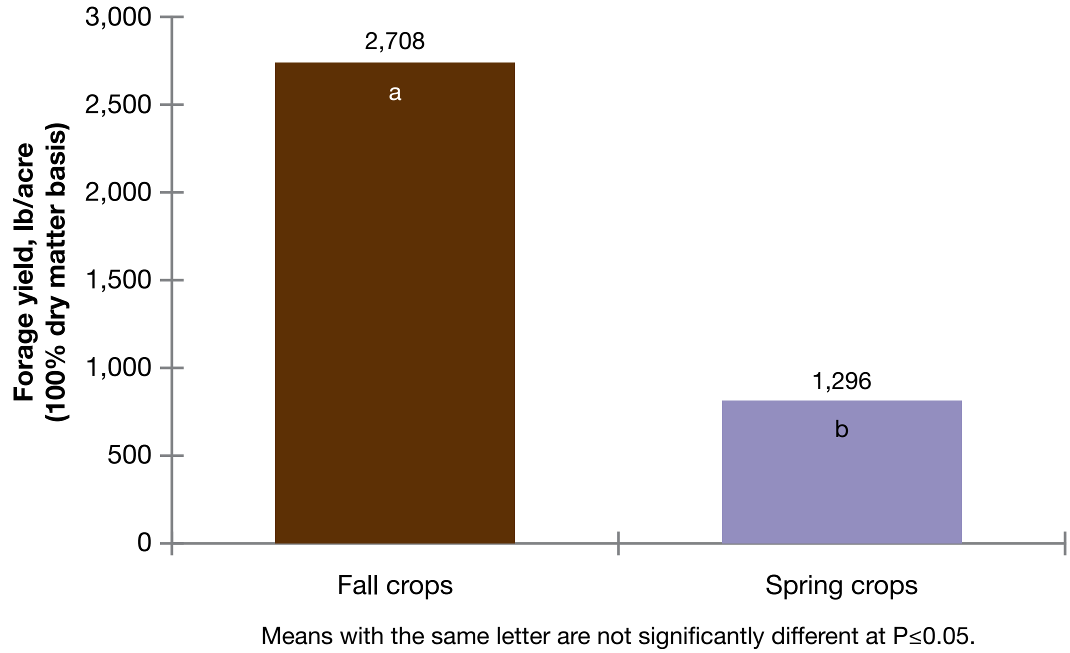

Figure 6. Fall and spring cover crop forage yield averages in 2009.

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***Jeff Elliott**, Research Farm Manager*
B.S., University of Nebraska

Jeff joined the staff as an Animal Caretaker III in 1984 and was promoted to Research Farm Manager in 1989.

***John Holman**, Cropping Systems Agronomist*
B.S., M.S., Montana State University
Ph.D., University of Idaho

John joined the staff in 2006. His research involves crop rotations, forages, and integrated weed management.

***Norman Klocke**, Water Resources Engineer*
B.S., University of Illinois
M.S., University of Kansas
Ph.D., Colorado State University

Norm joined the staff in 2001. His research emphases include limited irrigation, water conservation, and leaching.

***Kent Martin**, Crops and Soils Specialist*
B.S., M.S., Oklahoma State University
Ph.D., Kansas State University

Kent joined the staff in 2009. His extension and research work focuses on soil and crop production.

***Bertha Mendoza**, Bilingual EFNEP Program Assistant*
B.S., Kansas State University
M.S., Fort Hays State University

Bertha joined the staff in October 2009. She delivers nutrition education programs and emphasizes the importance of physical activity for a healthy lifestyle to low-income families from several cultural backgrounds in southwest Kansas.

***Alan Schlegel**, Agronomist-in-Charge, Tribune*
M.S., Ph.D., Purdue University

Alan joined the staff in 1986. His research involves fertilizer and water management in reduced tillage systems.

***Justin Waggoner**, Extension Specialist, Beef Systems*
B.S., M.S., Animal Sciences and Industry, Kansas State University
Ph.D., Ruminant Nutrition, New Mexico State University

Justin joined the staff in 2007. His extension program focuses primarily on beef cattle and livestock production.

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