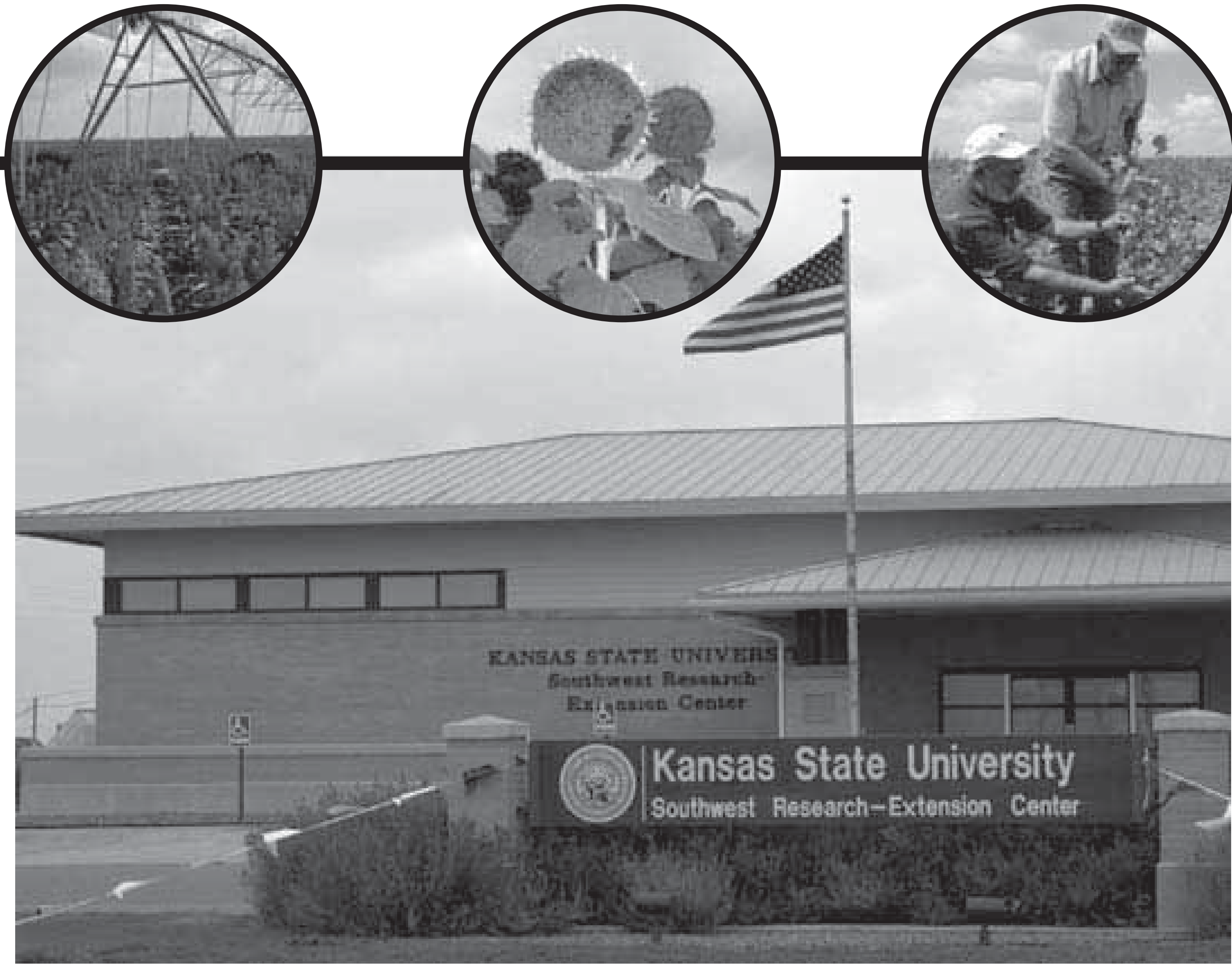
FIELD DAY 2008



K-STATE
Kansas State University

Southwest Research-Extension Center

Report of Progress 997

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

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B.S., 1978, Colorado State University
Ph.D., 1982, 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.

PAUL HARTMAN*, Southwest Area Extension Director*

B.S., 1977; M.S., 1989, Animal Sciences and Industry, Kansas State University

Paul accepted his current position in 1991. He previously served Kansas State University as County Extension Agricultural Agent in Stanton County (1977-1980) and Pratt County (1980-1991).

MAHBUB ALAM*, Extension Specialist, Irrigation and Water Management*

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Mahbub joined the staff in 1996. He previously worked for Colorado State University as an Extension Irrigation Specialist. His extension responsibilities are in the areas of irrigation and water management.

DEBRA BOLTON*, Extension Specialist, Family Consumer Sciences*

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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
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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, 1969, Iowa State University
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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
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Ph.D., Texas A&M University

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

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2008 RESEARCH-EXTENSION CENTER STAFF

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Paul Hartman	Area Extension Director
Conall Addison	Instructor Emeritus
Mahbub Ul Alam	Extension Specialist, Irrigation
Debra Bolton	Extension Specialist, Family Consumer Sciences
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Rod Buchele	Extension Specialist, 4-H Youth Development
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WEATHER INFORMATION FOR GARDEN CITY

Jeff Elliott

Precipitation for 2007 totaled 17.59 in, below the 30-year average of 18.79 in. We had good soil moisture entering the spring season because of heavy ice accumulations in December 2006. April recorded 2.90 in., the wettest April since 1985. May was drier than normal with 1.19 in. compared with 3.39 in. in an average year. December recorded 1.33 in. of moisture compared with an average of 0.41 in. Our largest daily precipitation was 1.64 in. on September 18. We received light hail on three occasions: May 24, June 10, and June 20. On December 13, we observed ¼ in. of ice on exposed surfaces.

Measurable snowfall occurred in the first 4 months and last 2 months of 2007. Annual snowfall totaled 29.7 in. for the year, 10.2 in. more than average. Our largest snowfall event was 8 in., recorded on April 14. Seasonal snowfall (2006-2007) was 25.7 in.

In 2007, August was the warmest month, and January was the coldest month. Our annual mean temperature was 53.9°F, slightly above the 30-year-average. It was the 10th consecutive year with above average temperature.

Triple-digit temperatures were recorded on 13 days in 2007; the highest (105°F) was recorded on August 12. We noted seven consecutive triple-digit days beginning August 10. Six record-high temperatures were tied or broken in 2007: 101°F on September 17, 95°F on October 6, 79°F on November 12, 79°F on November 14, 80°F on November 20, and 76°F on December 5.

We recorded sub-zero temperatures on two occasions: -9°F on February 15 and -8°F on February 16. These were record lows along with 40°F on June 8 and 48°F on June 29.

The last spring freeze (32°F) was April 29, 2 days later than normal. The first fall freeze (32°F) was October 16, 5 days later than normal. This resulted in a 170-day frost-free-period, 3 days longer than the 30-year-average.

Open pan evaporation from April through October was 73.14 in., 2.54 in. above normal. Average daily wind speed was 4.80 mph, less than the 5.25 mph average.

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

			Monthly Average Temperatures (°F)									
	Precipitation (in.)		2007 Average		Mean		2007 Extreme		Wind (MPH)		Evaporation (in.)	
Month	2007	Normal	Max	Min	2007	Average	Max	Min	2007	Normal	2007	Normal
January	0.58	0.43	33.4	11.9	22.6	28.4	48	2	4.64	4.68	---	---
February	0.62	0.48	39.0	17.7	28.4	33.7	70	-9	5.13	5.39	---	---
March	1.75	1.38	63.6	36.4	50.0	42.3	83	20	5.78	6.72	---	---
April	2.90	1.65	60.9	35.9	48.4	52.1	86	19	6.05	6.73	6.10	8.35
May	1.19	3.39	78.6	50.3	64.9	62.0	91	40	5.13	6.04	10.84	9.93
June	2.50	2.88	85.4	57.8	71.6	72.4	94	40	4.36	5.59	11.10	12.32
July	1.65	2.59	92.6	63.4	78.0	77.4	100	58	3.62	4.85	12.80	13.41
August	2.64	2.56	95.3	67.0	81.2	75.5	105	58	4.68	4.17	13.94	11.19
September	2.10	1.25	86.4	55.4	70.9	67.0	101	42	4.75	4.63	10.53	8.88
October	0.23	0.91	75.8	41.5	58.6	54.9	95	29	5.61	4.84	7.83	6.52
November	0.10	0.86	60.7	24.2	42.4	40.5	80	8	4.24	4.86	---	---
December	1.33	0.41	41.9	18.5	30.2	31.3	76	2	3.59	4.47	---	---
ANNUAL	17.59	18.79	67.8	40.0	53.9	53.1	105	-9	4.80	5.25	73.14	70.60

Normal latest spring freeze (32°F): Apr. 27. 2007: Apr. 29; Normal earliest freeze (32°F) in fall: Oct. 11. 2007: Oct. 16.
Normal frost-free (> 32°F) period: 167 days. 2007: 170 days; Normal is 30-year average (1971-2000).

WEATHER INFORMATION FOR TRIBUNE

Dewayne Bond and Dale Nolan

Total yearly precipitation was 14.52 in., 2.92 in. below normal. Seven months had below-normal precipitation.

April (3.32 in.) and August (3.31 in.) were the wettest months. The largest single amount of precipitation was 1.88 in. on August 2. November was the driest month (0.08 in.). Snowfall for the year totaled 33.8 in.: 7.8 in. in January, 5.5 in. in February, 1.0 in. in March, 8.6 in. in April, 1.0 in. in November, and 9.9 in. in December for a total of 81 days of snow cover. The year began with 66 straight days of snow cover (January 1–March 7), which was the longest consecutive period.

Record-high temperatures were recorded on 5 days: August 27 (104°F), September 17 (101°F), October 6 (95°F), November 20 (82°F), and December 5 (73°F). Record-high temperatures were tied on 4 days: July 19 (104°F), October 7 (92°F) and 21 (91°F), and November 17 (76°F). Record-low temperatures were set on 4 days: February 15 (-14°F) and 16 (-9°F) and June 8 (37°F) and 29 (47°F). August was the warmest month with a mean temperature of 79.0°F. The hottest days of the year (104°F) were July 19 and August 27. The coldest day of the year was February 15 (-14°F). January was the coldest month with a mean temperature of 19.1°F.

Mean air temperature was above normal for 7 months. March had the greatest departure above normal (6.6°F), and both January and February had the greatest departure below normal (-8.4°F). There were 12 days of 100°F or above temperatures, 2 days above normal. There were 75 days of 90°F or above temperatures, 13 days above normal. The last day of 32°F or less in the spring was April 26, 10 days earlier than the normal date; the first day of 32°F or less in the fall was October 16, 13 days later than the normal date. This produced a frost-free period of 173 days, 23 days more than the normal of 150 days.

April through September open pan evaporation totaled 70.64 in., one hundredth of an inch below normal. Wind speed for this period averaged 5.0 mph, 0.5 mph less than normal.

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

			Monthly Average Temperatures (°F)									
	Precipitation (in.)		2007 Average		Mean		2007 Extreme		Wind (MPH)		Evaporation (in.)	
Month	2007	Normal	Max	Min	2007	Average	Max	Min	2007	Normal	2007	Normal
January	0.77	0.45	30.2	8.0	42.2	12.8	45	-6	---	---	---	---
February	0.40	0.52	34.0	14.9	48.5	17.1	52	-14	---	---	---	---
March	1.46	1.22	61.4	32.1	56.2	24.2	80	16	---	---	---	---
April	3.32	1.29	59.9	33.7	65.7	33.0	85	19	5.9	6.3	6.48	8.28
May	1.09	2.76	75.9	47.2	74.5	44.1	88	37	4.9	5.8	12.02	10.88
June	1.43	2.62	85.1	55.3	86.4	54.9	95	37	4.6	5.3	13.25	13.88
July	0.50	3.10	93.0	60.6	92.1	59.8	104	53	4.3	5.4	15.49	15.50
August	3.31	2.09	93.9	64.2	89.9	58.4	104	53	4.3	5.0	12.64	12.48
September	0.73	1.31	86.8	52.7	81.9	48.4	101	40	5.7	5.2	10.76	9.63
October	0.14	1.08	73.9	39.8	70.0	35.1	95	27	---	---	---	---
November	0.08	0.63	61.3	24.3	53.3	23.1	82	6	---	---	---	---
December	1.29	0.37	41.0	15.3	44.4	15.1	73	-6	---	---	---	---
ANNUAL	14.52	17.44	66.6	37.5	67.1	35.5	104	-14	5.0	5.5	70.64	70.65

Normal latest freeze (32°F) in spring: May 6. 2007: Apr. 26; Normal earliest freeze (32°F) in fall: Oct. 3. 2007: Oct. 16.
Normal frost-free (> 32°F) period: 150 days. 2007: 173 days.
Normal for precipitation and temperature is 30-year average (1971-2000) from National Weather Service.
Normal for latest freeze, earliest freeze, wind, and evaporation is 30-year average (1971-2000) from Tribune weather data.

EFFECT OF PREVIOUS CROP ON WHEAT YIELD[1]

Alan Schlegel, Curtis Thompson, and Troy Dumler

SUMMARY

A large-scale, rain-fed cropping systems research and demonstration project evaluated the effect of previous crop on subsequent wheat yields. Previous crops were grain sorghum and sunflower grown in a no-till wheat-summer crop-fallow rotation compared with a reduced tillage wheat fallow system. Highest wheat yields were with a wheat-fallow rotation. Wheat yields were less following sunflower than sorghum in 3-year rotations. This trend was observed in most years; wheat yields averaged 10 bu/a lower following sunflower than sorghum.

INTRODUCTION

The purpose of this project is to research and demonstrate several multi-crop rotations that are feasible for the region along with several alternative systems that are more intensive than 2- or 3-year rotations. Objectives are to 1) enhance and stabilize production of rain-fed cropping systems through use of multiple crops and rotations using best management practices to optimize capture and utilization of precipitation for economic crop production and 2) enhance adoption of alternative, rain-fed cropping systems that provide optimal profitability. This report focuses on the effect of previous crop on subsequent winter wheat yields.

PROCEDURES

Crop rotations are 2-year wheat-fallow and 3-year wheat-grain sorghum-fallow and wheat-sunflower-fallow. The 3-year rotations are both no-till; the 2-year wheat-fallow system uses reduced tillage. All phases of each rotation are present each year. Plot size is a minimum of 100 ft by 450 ft. Grain yields were determined by harvesting the center 60 ft (by entire length) of each plot with a commercial combine and determining grain weight in a weigh-wagon.

RESULTS AND DISCUSSION

Grain yields of winter wheat were above average in 2007 (Table 1). Above-normal precipitation from fall of 2006 through spring of 2007 favored wheat production. Similar to past years, wheat yields were lower following sunflower than sorghum. Averaged over the past 13 years, wheat yields were 10 bu/a less following sunflower than sorghum. For the same time period, wheat yields were 3 bu/a greater in wheat-fallow than wheat-grain sorghum-fallow.

[1] This research project receives support from the Ogallala Aquifer Initiative

Table 1. Wheat yields in three rotations since 1995 in a large-scale cropping systems study, Tribune

Year	Wheat-Fallow	Wheat-Grain Sorghum-Fallow	Wheat-Sunflower-Fallow
	------------------------------wheat yield (bu/a)	------------------------------	
1995	34	31	27
1996	26	15	7
1997	47	42	28
1998	55	53	51
1999	69	68	52
2000	18	28	11
2001	60	46	30
2002	2	0	0
2003	31	22	18
2004	4	4	3
2005	43	43	19
2006	15	12	4
2007	46	46	35
Mean	35	32	22

Initial rotations used tillage prior to wheat and no-till prior to row crop but changed to complete no-till in 1998, except for wheat-fallow, which remained reduced tillage.

EFFECT OF STUBBLE HEIGHT IN A NO-TILL WHEAT-CORN/SORGHUM-FALLOW ROTATION[1]

Alan Schlegel and Lucas Haag

SUMMARY

Various studies have been conducted since 2001 to evaluate the effect of stubble height on subsequent grain yield of summer annual crops. A study started in 2006 was designed to evaluate the effect of three stubble heights on grain yields of both corn and sorghum; the 2007 fall harvest was the first collection of yield data from that study. Corn grain yields increased as stubble height increased. Grain sorghum response was less apparent. Because only 1 year of data exists, no conclusions should be drawn from the grain sorghum portion of the study. It is anticipated that seasons with less growing season water supply than 2007 will be necessary to observe yield differences among treatments for grain sorghum, a crop noted for water stress tolerance. Corn grain yields, averaged over 2005 through 2007, were 50, 55, and 60 bu/a for the short cut, tall cut, and stripped stubble treatments respectively. From 2001 through the present, neither tall cut nor stripped stubble has resulted in lower yields than short cut stubble. Data from this study and others suggest producers should increase cutting heights or adopt stripper header technology where practical.

INTRODUCTION

Seeding of summer annual row crops throughout the west-central Great Plains typically occurs 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 over-winter fallow periods. Use of stripper headers increases harvest capacity and provides taller wheat stubble than previously attainable with conventional small grains platforms. Increasing wheat cutting heights or using a stripper header should further improve the effectiveness of standing wheat stubble. The purpose of this study is to evaluate the effect of wheat stubble height on subsequent row crop yields.

PROCEDURES

Studies are ongoing at the Southwest Research-Extension Center dryland station near Tribune, KS. In 2007, corn and grain sorghum were planted into standing wheat stubble measuring 7 and 14 in. in height (platform harvest) and 22 in. in height (stripper harvest). Corn and grain sorghum were seeded at rates of 15,000 seeds/a and 33,000 seeds/a, respectively. Nitrogen was applied to all plots at a rate of 100 lb/a N. Starter fertilizer (10-34-0) was applied in-row at rates of 7 and 9 gal/a for corn and sorghum, respectively. Two rows were harvested with a plot combine for yield and yield component analysis. Soil water measurements were obtained with neutron attenuation.

RESULTS AND DISCUSSION

Good growing season conditions in 2007 resulted in above-average row crop yields. Corn grain yield (Table 1) increased from 71 to 83 bu/a as stubble height increased from 7 to 22 in. The yield increase resulted from an increase in the number of kernels/ear. Harvest moisture also increased with increasing stubble height. Two other yield components, ears/plant and kernel weight, were unaffected by stubble height. The trend in corn yields, although not statistically significant, resembles results from a similar, 2-year study at Tribune in which corn yields averaged 39, 45, and 49 bu/a for low, high, and stripped stubble treatments, respectively. Another study that spanned 6 years found average corn grain yields of 32 and 38 bu/a for low and high cut stubble treatments, respectively.

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

Grain sorghum yields showed no evident trend with regard to stubble height. The high cut treatment yielded more than the low cut treatment at the 0.10 significance level. No difference existed between the stripped and either the low or high cut treatments. No trends with respect to stubble treatment were evident in any of the yield components of the grain sorghum trial.

The 2007 corn grain yields support long-term observations of the effect stubble height on water conservation and subsequent crop yields. Acquiring long-term data sets is important for evaluating the effects of stubble height across a wide range of environments. Effects of stubble height were not apparent for grain sorghum in 2007. However, in a year with sufficient growing season water supply, such as 2007, the effects of water saving practices could be masked, especially in a crop tolerant of water stress. Additional years of data are needed to make conclusions regarding the effect of stubble height on grain sorghum.

Table 1. Corn yield and yield components as affected by stubble height, Tribune, 2007

Stubble height	Yield (bu/a)	Moisture (%)	Test weight (%)	Plant population (-------10^3/acre-------)	Ear population	Residue Amount (lb/a)	RY[a] ratio (lb/lb)	1000 Seed (oz)	Kernels no./ear	Kernels no./ft^2
Low	71	12.3	59.8	15.1	14.9	5957	1.50	10.19	422	144
High	76	12.6	59.9	15.0	14.6	6669	1.64	10.10	461	154
Strip	83	12.8	59.7	15.3	15.0	6479	1.40	10.15	491	169
LSD $_{0.05}$	13	0.3	0.4	0.6	0.5	1012	0.37	0.41	82	25
ANOVA (P >F)										
Stubble height	0.156	0.005	0.483	0.440	0.233	0.310	0.370	0.907	0.224	0.121

[a] RY ratio is residue divided by yield (lb of residue/lb of yield).

Table 2. Sorghum yield and yield components as affected by stubble height, Tribune, 2007

Stubble height	Yield (bu/a)	Moisture (%)	Test weight (%)	Plant population (-------10^3/acre-------)	Ear population	Residue Amount (lb/a)	RY[a] ratio (lb/lb)	1000 Seed (oz)	Kernels no./hd	Kernels no./ft^2
Low	111	11.5	60.6	20.8	43.5	5107	0.82	1.08	2117	2110
High	118	11.6	60.7	21.4	44.3	5662	0.86	1.11	2176	2185
Strip	112	11.6	60.8	21.5	42.9	5228	0.83	1.08	2179	2137
LSD $_{0.05}$	6	0.2	0.3	1.8	4.6	1269	0.22	0.04	291	169
ANOVA (P >F)										
Stubble height	0.102	0.267	0.552	0.683	0.788	0.607	0.908	0.362	0.868	0.622

[a] RY ratio is residue divided by yield (lb of residue/lb of yield).

REDUCING TILLAGE INTENSITY FOR IRRIGATED CORN[1]

Alan Schlegel, Loyd Stone[2], and Troy Dumler

SUMMARY

Reducing tillage reduced grain yield of irrigated corn. Averaged over the past 3 years, no-till corn yields were 12% less and strip-till corn yields were 5% less than yields with conventional tillage. The primary reason for lower yields was lower plant populations in the reduced tillage systems caused by increased surface residue cover at planting. Soil water at planting tended to be less with conventional tillage than strip-till or no-till. Increasing irrigation capacity by 50% increased yields by 12%. An N rate of 160 lb/a N was sufficient in all tillage systems.

PROCEDURES

This study was initiated at the Tribune Unit of the Southwest Research-Extension Center in 2005. The study is a factorial of tillage, irrigation level, and N rate. All treatments are replicated four times. The three tillage systems are conventional (chop stalks and disk in the fall followed by disk/field cultivate in the spring as needed), strip-till (in conjunction with injection of N fertilizer), and no-till. Sprinkler irrigation levels (two capacities) supply the equivalent of about 1 or 1.5 in./week of irrigation. Irrigation amounts were 12.14 and 16.86 in. in 2005, 14.83 and 21.59 in. in 2006, and 10.96 and 16.48 in. in 2007 for 1 and 1.5 in./week irrigation treatments, respectively. All N fertilizer (160 and 240 lb/a N) was injected to allow for direct comparisons of tillage systems. Strip tillage was done in the spring in conjunction with N application. Corn was planted in early May. Herbicides were used to control in-season weeds in all plots. All plots were machine harvested. Plant population, ear population, seed weight, and seeds/ear were determined. Harvest index was calculated as percentage of above-ground biomass that was grain. Soil water measurements (8-ft depth in 1-ft increments) were taken using neutron attenuation from planting through harvest for all tillage and water treatment combinations (placed in high-N plots only).

RESULTS AND DISCUSSION

Grain yields were affected by tillage practices and irrigation capacity (Table 1). Highest and lowest yields were obtained with conventional tillage and no-till, respectively; strip-till yields were intermediate. The primary reason for lower yields with no-till was lower plant population (Table 2). The same seeding rate was used for all tillage systems, but increased surface residue with no-till caused more non-uniformity in seed placement and depth, which reduced emergence. Seed weight and number of kernels/ear were similar for all tillage systems.

Similar to grain yield, harvest index was greater with conventional and strip-till than no-till. Water use efficiency was greatest with conventional tillage and least with no-till. Off-season capture of precipitation tended to be higher with strip-till and lower with conventional tillage (Table 3).

Grain yields were greater at the higher irrigation capacity because of increased numbers of kernels/ear. Irrigation capacity had no effect on plant population or seed weight. As expected, water use was greater with greater irrigation capacity, and off-season capture of precipitation was less.

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

[2] Kansas State University Department of Agronomy, Manhattan, KS

Table 1. Corn yield, biomass production, and N content response to tillage, irrigation, and N fertilizer, Tribune, 2005-2007

Tillage	Irrigation	N Rate (lb/a)	Grain Yield (bu/a)	Grain N (lb/a)	Grain WUE[a] (lb/in.)	Biomass	Stover[b]	Stover N	Plant N Removal
						-----lb/a-----			
Conventional	High	160	213	123	---	17050	6981	32	155
Conventional	High	240	213	130	392	17176	7000	40	170
Conventional	Low	160	177	109	---	13778	5818	32	141
Conventional	Low	240	189	118	398	15188	6366	40	158
No-Till	High	160	185	111	---	16475	7629	38	148
No-Till	High	240	173	108	320	15807	7411	42	150
No-Till	Low	160	175	103	---	14852	6771	33	136
No-Till	Low	240	163	101	329	14496	6977	44	145
Strip-Till	High	160	203	120	---	16409	6853	37	157
Strip-Till	High	240	199	124	367	16827	7154	43	166
Strip-Till	Low	160	182	109	---	14341	6107	34	142
Strip-Till	Low	240	173	110	375	14935	6472	43	153
MEANS									
Tillage									
Conventional			198	120	395	15798	6541	36	156
No-Till			174	106	324	15408	7197	39	145
Strip-Till			189	116	371	15628	6647	39	155
$LSD_{0.05}$			16	9	43	871	434	5	7
Irrigation									
High			198	119	360	16624	7171	39	158
Low			177	108	367	14598	6418	38	146
$LSD_{0.05}$			13	7	35	711	355	4	6
N Rate									
160			189	112	---	15484	6693	34	147
240			185	115	---	15738	6897	42	157
$LSD_{0.05}$			5	4	---	390	223	3	5

Total amount of biomass = stover + grain weight (does not include cob weight).
[a] WUE = water use efficiency.
[b] Stover is calculated as whole plant biomass less ears.

Table 2. Yield component response to tillage, irrigation, and N fertilizer, Tribune, 2005-2007

Tillage	Irrigation Level	N Rate (lb/a)	Plant pop. (10^3/a)	Ear pop. (10^3/a)	Ear weight (lb)	1000 seed (oz)	Kernels #/head	Kernels #/ft^2	Harvest Index (%)
Conventional	High	160	29.8	28.9	0.41	12.08	548	363	59
Conventional	High	240	29.9	29.1	0.41	12.20	542	364	59
Conventional	Low	160	29.6	27.8	0.33	11.84	455	293	57
Conventional	Low	240	29.5	28.5	0.36	12.25	479	315	58
No-Till	High	160	26.7	25.9	0.41	12.41	526	312	54
No-Till	High	240	25.7	24.9	0.40	12.25	524	299	53
No-Till	Low	160	27.4	26.3	0.36	12.29	473	287	55
No-Till	Low	240	24.5	23.3	0.38	12.55	492	263	52
Strip-Till	High	160	28.2	27.4	0.41	12.24	539	340	58
Strip-Till	High	240	28.8	27.7	0.41	12.41	532	339	57
Strip-Till	Low	160	28.9	27.3	0.35	11.91	474	301	57
Strip-Till	Low	240	29.5	27.5	0.36	12.11	474	305	56
MEANS									
Tillage									
Conv.			29.7	28.6	0.38	12.09	506	334	58
No-Till			26.1	25.1	0.39	12.37	504	290	53
Strip-Till			28.8	27.5	0.38	12.17	505	321	57
$LSD_{0.05}$			1.3	1.5	0.03	0.34	28	28	4
Irrigation									
High			28.2	27.3	0.41	12.26	535	336	57
Low			28.3	26.8	0.36	12.16	474	294	56
$LSD_{0.05}$			1.0	1.2	0.02	0.28	23	23	3
N Rate									
160			28.4	27.3	0.38	12.13	503	316	57
240			28.0	26.8	0.39	12.29	507	314	56
$LSD_{0.05}$			0.7	0.7	0.01	0.17	13	12	1

Table 3. Effect of tillage and irrigation on profile available soil water, Tribune, 2005-2007

Tillage	Irrigation Level	N Rate	Available Water: Previous Harvest	Available Water: Planting	Available Water: Harvest	Water use (in.)	Fallow Accumulation (in./8-ft profile)
			--------in./8-ft profile--------				
Conventional	High	240	9.62	12.31	9.26	30.96	2.69
Conventional	Low	240	5.90	10.14	5.68	26.70	3.82
No-Till	High	240	9.30	12.05	8.92	31.04	3.37
No-Till	Low	240	7.27	11.91	7.03	27.12	4.97
Strip-Till	High	240	8.42	11.84	8.36	31.39	3.71
Strip-Till	Low	240	7.27	11.94	7.25	26.94	4.92
MEANS							
Tillage							
Conventional			7.76	11.23	7.47	28.83	3.25
No-Till			8.29	11.98	7.98	29.08	4.17
Strip-Till			7.84	11.89	7.81	29.16	4.31
$LSD_{0.05}$			0.83	0.59	0.75	0.71	1.04
Irrigation							
High			9.11	12.07	8.85	31.13	3.25
Low			6.81	11.33	6.66	26.92	4.57
$LSD_{0.05}$			0.68	0.48	0.61	0.58	0.85

Previous harvest available water and fallow accumulation include only 2006- 2007 data.
Access tubes were set only in spring-applied 240 lb/a N treatments.

NITROGEN, PHOSPHORUS, AND POTASSIUM FERTILIZATION OF IRRIGATED GRAIN SORGHUM

Alan 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 2007, N and P applied alone increased yields about 70 and 15 bu/a, respectively; N and P applied together increased yields up to 90 bu/a. Averaged over the past 10 years, N and P fertilization increased sorghum yields up to 60 bu/a. Application of 40 lb/a N (with P) was sufficient to produce more than 85% of maximum yield, although yields continued to increase at N rates of 120 lb/a N in 2007. Application of 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 was 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

Fertilizer treatments initiated in 1961 were N rates of 0, 40, 80, 120, 160, and 200 lb/a N without P and K; with 40 lb/a P_2O_5 and zero K; and with 40 lb/a P_2O_5 and 40 lb lb/a K_2O. All fertilizers were broadcast by hand in the spring and incorporated prior to planting. The soil is a Ulysses silt loam. Sorghum (Pioneer 8500/8505 from 1998-2007) was planted in late May or early June. Irrigation was 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 were machine harvested after physiological maturity. Grain yields were adjusted to 12.5% moisture. Soil samples were taken after harvest in 2005 and analyzed for soil test P. Without P fertilization, soil test P levels were 6 to 9 ppm P (Mehlich-3) across all N rates. With P fertilization, soil test P levels were > 20 ppm P (Mehlich 3).

RESULTS AND DISCUSSION

Grain sorghum yields in 2007 were the highest of the past 10 years (Table 1). Nitrogen alone increased yields more than 70 bu/a, P alone increased yields about 15 bu/a, and N and P applied together increased yields up to 90 bu/a. Averaged over the past 10 years, N and P applied together increased yields up to 60 bu/a. In 2007, 40 lb/a N (with P) produced more than 85% of maximum yields, about 5% less than the 10-year average. Sorghum yields have not been affected by K fertilization throughout the study period.

Table 1. Effect of N, P, and K fertilizers on irrigated sorghum yields, Tribune, 1998-2007

N	P_2O_5	K_2O	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Mean
----------lb/a----------			----------bu/a----------										
0	0	0	77	74	77	76	73	80	57	58	84	80	74
0	40	0	77	85	87	81	81	93	73	53	102	97	84
0	40	40	76	84	83	83	82	93	74	54	95	94	83
40	0	0	91	83	88	92	82	92	60	63	102	123	89
40	40	0	118	117	116	124	120	140	112	84	133	146	123
40	40	40	114	114	114	119	121	140	117	84	130	145	121
80	0	0	111	94	97	110	97	108	73	76	111	138	103
80	40	0	125	113	116	138	127	139	103	81	132	159	125
80	40	40	130	123	120	134	131	149	123	92	142	166	133
120	0	0	102	76	82	98	86	97	66	77	101	138	93
120	40	0	125	102	116	134	132	135	106	95	136	164	126
120	40	40	128	105	118	135	127	132	115	98	139	165	127
160	0	0	118	100	96	118	116	122	86	77	123	146	112
160	40	0	131	116	118	141	137	146	120	106	145	170	134
160	40	40	124	107	115	136	133	135	113	91	128	167	126
200	0	0	121	113	104	132	113	131	100	86	134	154	120
200	40	0	133	110	114	139	136	132	115	108	143	168	131
200	40	40	130	120	120	142	143	145	123	101	143	170	135
ANOVA (P>F)													
Nitrogen			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic			0.001	0.227	0.001	0.001	0.001	0.001	0.018	0.005	0.004	0.001	0.001
P-K			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Zero P vs. P			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
P vs. P-K			0.649	0.741	0.803	0.619	0.920	0.694	0.121	0.803	0.578	0.992	0.829
N x P-K			0.186	0.482	0.061	0.058	0.030	0.008	0.022	0.195	0.210	0.965	0.019
MEANS													
Nitrogen, lb/a													
0			76	81	82	80	79	88	68	55	93	91	80
40			108	105	106	112	108	124	96	77	121	138	111
80			122	110	111	127	119	132	100	83	128	155	120
120			118	95	105	122	115	121	96	90	125	156	115
160			124	108	110	132	129	134	107	92	132	161	124
200			128	115	113	138	131	136	113	98	140	164	129
$LSD_{0.05}$			8	13	7	8	9	10	11	10	11	9	7
P_2O_5-K_2O, lb/a													
0			103	90	91	104	94	105	74	73	109	130	98
40- 0			118	107	111	126	122	131	105	88	132	151	120
40-40			117	109	112	125	123	132	111	87	130	151	121
$LSD_{0.05}$			6	9	5	6	6	7	7	7	7	6	5

REDUCING TILLAGE INTENSITY IN A WHEAT-SORGHUM-FALLOW ROTATION[1]

Alan Schlegel, Loyd Stone[2], Troy Dumler, and Curtis Thompson

SUMMARY

Grain yields of wheat and grain sorghum increased with decreased tillage intensity in a wheat-sorghum-fallow (WSF) rotation. Averaged over the past 17 years, no-till wheat yields were 4 bu/a greater than reduced tillage and 9 bu/acre greater than conventional tillage. In 2007, no-till wheat yields were 15 bu/a greater than reduced tillage and 25 bu/a greater than conventional tillage. Similarly, for grain sorghum in 2007, yields were 36 bu/a greater with no-till than conventional tillage. Averaged over the past 17 years, no-till sorghum yields were 14 bu/a greater than reduced tillage and 34 bu/acre greater than conventional tillage. Averaged across the past 7 years, sorghum yields were 24 bu/a greater with long-term no-till than short-term no-till.

PROCEDURES

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

RESULTS AND DISCUSSION

Conservation tillage increased wheat yields (Table 1). On average, wheat yields were 9 bu/a higher for NT (37 bu/a) than CT (28 bu/a). Wheat yields for RT were 5 bu/a greater than CT. In 2007, wheat yields for CT and RT were similar to the long-term average, and NT wheat yields were >35% greater than the long-term average.

The yield benefit from reduced tillage was greater for grain sorghum than wheat. Grain sorghum yields for RT averaged 20 bu/a more than CT, whereas NT averaged 14 bu/a more than RT (Table 2). In 2007, sorghum yields were 19 bu/a greater with NT than RT, even though sorghum is planted NT into wheat stubble in both systems. The difference between the systems is whether they have been in long-term NT (since 1991) or short-term NT (NT sorghum followed by CT wheat). This consistent yield benefit with long-term vs. short-term no-till has been observed since the RT system was changed in 2001. Averaged across the past 7 years, long-term NT has produced 24 bu/a more than short-term NT (53 vs. 29 bu/a).

An economic analysis was conducted based on grain prices and input costs from 2007 KSU Farm Management Guide crop budgets (Table 3). Averaged across the past 7 years, the long-term NT rotation had returns of $74/a more than short-term NT and $116/a more than CT. The advantage of long-term NT was particularly apparent with grain sorghum; the long-term rotation had returns of $78/a more than short-term NT and $121/a more than CT. Because yield response with conservation tillage was less for wheat than grain sorghum, the economic advantage was lower as well. Nevertheless, long-term NT wheat had returns of $33/a more than short-term CT and $54/a more than long-term CT.

[1] This research project was partially supported by the Ogallala Aquifer Initiative
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Table 1. Wheat response to tillage in a wheat-sorghum-fallow rotation, Tribune, 1991-2007

	Tillage				ANOVA (P > F)		
Year	Conventional	Reduced	No-Till	LSD $_{0.05}$	Tillage	Year	Tillage x Year
	---------------bu/a---------------						
1991	16	14	15	6	0.672		
1992	26	14	21	10	0.067		
1993	43	55	58	4	0.001		
1994	48	48	46	7	0.602		
1995	49	51	56	7	0.066		
1996	16	25	26	9	0.073		
1997	34	42	52	17	0.121		
1998	52	68	64	9	0.011		
1999	76	77	83	7	0.100		
2000	20	32	44	6	0.001		
2001	17	40	31	8	0.002		
2002	0	0	0	---	---		
2003	22	15	30	7	0.007		
2004	1	2	4	2	0.001		
2005	32	32	39	12	0.360		
2006	0	2	16	6	0.001		
2007	26	36	51	15	0.017		
Mean	28	33	37	2	0.001	0.001	0.001

Table 2. Grain sorghum response to tillage in a wheat-sorghum-fallow rotation, Tribune, 1991-2007

Year	Tillage			LSD $_{0.05}$	ANOVA (P > F)		
	Conventional	Reduced	No-Till		Tillage	Year	Tillage x Year
	---------------bu/a---------------						
1991	23	39	39	18	0.110		
1992	38	41	27	15	0.118		
1993	47	83	68	11	0.001		
1994	20	38	57	9	0.001		
1995	37	54	59	5	0.001		
1996	97	117	119	12	0.007		
1997	71	94	115	33	0.044		
1998	87	105	131	37	0.073		
1999	19	88	99	10	0.001		
2000	13	37	51	6	0.001		
2001	6	43	64	7	0.001		
2002	0	0	0	---	---		
2003	7	7	37	8	0.001		
2004	44	67	118	14	0.001		
2005	28	38	61	65	0.130		
2006	4	3	29	10	0.001		
2007	26	43	62	42	0.196		
Mean	33	53	67	4	0.001	0.001	0.001

Table 3. Net return to land and management for conventional, reduced, and no-till wheat-sorghum-fallow rotations, 2001-2007

Crop	Conventional	Reduced	No-till
	---------------------------------- $/a ----------------------------------		
Wheat	-16	5	38
Sorghum	-38	5	83
Rotation	-18	3	40

WHEAT AND GRAIN SORGHUM IN 4-YEAR ROTATIONS

Alan Schlegel, Troy Dumler, and Curtis Thompson

SUMMARY

Research on 4-year crop rotations with wheat and grain sorghum was initiated at the Kansas State University (KSU) Southwest Research-Extension Center (SWREC) near Tribune in 1996. Rotations were wheat-wheat-sorghum-fallow (WWSF) and wheat-sorghum-sorghum-fallow (WSSF) along with continuous wheat (WW). Soil water at wheat planting averages about 9 in. following sorghum, which is about 3 in. more than the second wheat crop in a WWSF rotation. Soil water at sorghum planting was approximately 1.5 in. less for the second sorghum crop compared with sorghum following wheat. Fallow efficiency prior to wheat was greater for the shorter fallow period following wheat than for the longer fallow following sorghum. Prior to sorghum, average fallow efficiency was about 40% and not affected by the previous crop. Grain yield of recrop wheat averaged about 87% of wheat following sorghum; grain yield of continuous wheat averaged about 72% of the yield of wheat grown in a 4-year rotation following sorghum. In most years, recrop wheat and continuous wheat yielded similarly, but recrop wheat yields were 22 bu/a greater than continuous wheat in 2007. Wheat yields were similar following one or two sorghum crops. Similarly, average sorghum yields were the same following one or two wheat crops. Yield of the second sorghum crop in a WSSF rotation averages 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, crop productivity, and profitability of 4-year and continuous cropping systems.

PROCEDURES

Research on 4-year crop rotations with wheat and grain sorghum was initiated at the SWREC near Tribune 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 (Fig. 1). Soil water was similar following fallow after either one or two sorghum crops and averaged, across the 11-year period, about 9 in. Water at planting of the second wheat crop in a WWSF rotation generally was less than the first wheat crop, except in 1997 and 2003. Soil water for the second wheat crop averaged more than 3 in, (or about 35%) less than the first wheat crop in the rotation. Continuous wheat averaged about 1 in, less water at planting than the second wheat crop in a WWSF rotation. Fallow efficiency (amount of water accumulated from previous harvest to planting of current crop divided by precipitation during the same period) ranged from less than 0 to more than 60%. Fallow efficiency was greater for the shorter (3 month) fallow period following wheat than for the longer (11 month) fallow period following sorghum. Fallow efficiency prior to wheat averaged less than 30% following sorghum compared with more than 40% following wheat.

Similar to wheat, the amount of available water in the soil profile at sorghum planting varied greatly from year to year (Fig. 2). Soil water was similar following fallow after either one or two wheat crops and averaged (12 years) about 8.8 in. Water at planting of the second sorghum crop in a WSSF rotation was always less than the first sorghum crop, although sometimes by very little. For instance, in 1998, there was less than 0.25 in. difference between them. Averaged across the entire study period, the first sorghum crop had about 1.5 in. more available water at planting than the second crop. Similar to wheat, fallow efficiency prior to sorghum ranged from less than 0 to more than 60%. In contrast to wheat, average fallow efficiency prior to sorghum was similar following wheat or sorghum (about 40%).

Grain yields

Wheat yields were above average in 2007 (Table 1). Averaged across 11 years, recrop wheat (the second wheat crop in a WWSF rotation) yielded about 85% of the yield of first-year wheat in either WWSF or WSSF rotations. Before 2003, recrop wheat yielded about 70% of the yield of first-year wheat. In 2003, however, recrop wheat yields were more than double the yield in all other rotations. This is possibly due to 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. Generally, there has been little difference in wheat yields following one or two sorghum crops. However, in 2007, wheat yields following two sorghum crops were 14 bu/a greater than following one sorghum crop. In most years, continuous wheat yields have been similar to recrop wheat yields; however, in 2007 and 2003, recrop wheat yields were considerably greater than continuous wheat.

Sorghum yields in 2007 were much greater than average (Table 2). This corresponds to the greater than normal amount of soil water at planting. Similarly, in 1998 and 1999, high yields corresponded to greater than normal available soil water at planting. Sorghum yields in 2007 were the same following one or two wheat crops, which is consistent with the long-term average. The second sorghum crop yield typically averages about 70% of the yield of the first sorghum crop. However, in 2007, second-year sorghum yields were 85% of the first sorghum crop yield.

An economic analysis was conducted based on grain prices and input costs from 2007 KSU Farm Management Guide crop budgets (Table 3). Using a wheat price of $5.43/bu and a sorghum price of $3.62/bu, the WWSF and WSSF rotations had identical returns ($69/a) averaged over the 11 years of the study. The WW rotation had lower average returns of $46/a. Returns for a hypothetical wheat-sorghum-fallow (WSF) rotation were also calculated using average yields of the first wheat crop in the WWSF and WSSF rotations and yields of the first sorghum crop in the WSSF rotation. The hypothetical WSF rotation had returns similar to the WWSF and WSSF rotations at $66/a. Relative differences in prices between wheat and sorghum can affect rotation returns. For example, using long-term price forecasts from the 2007 KSU Farm Management Guides, the WWSF rotation would have returns of $26/a compared with $21/a for the WSSF rotation. The higher returns are due to higher wheat prices relative to sorghum ($4.21/bu to $2.49/bu, respectively).

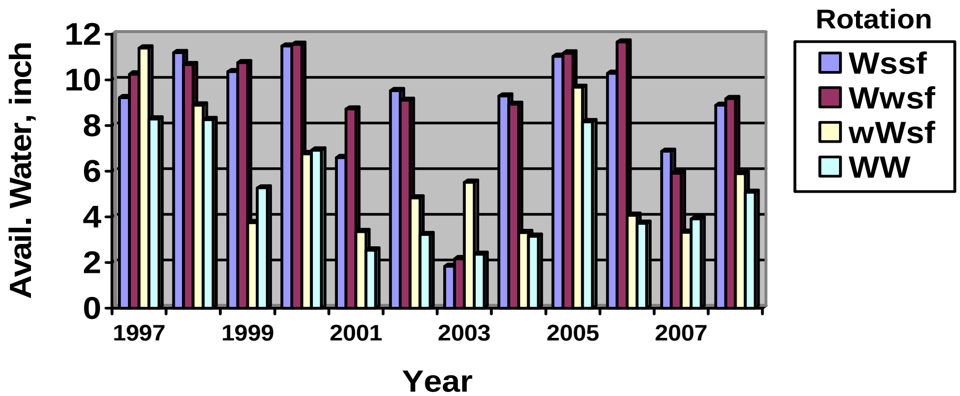

Figure 1. Available soil water at planting of wheat in several rotations, Tribune, 1997-2007
Capital letter denotes current crop in rotation. Last set of bars is average across years.

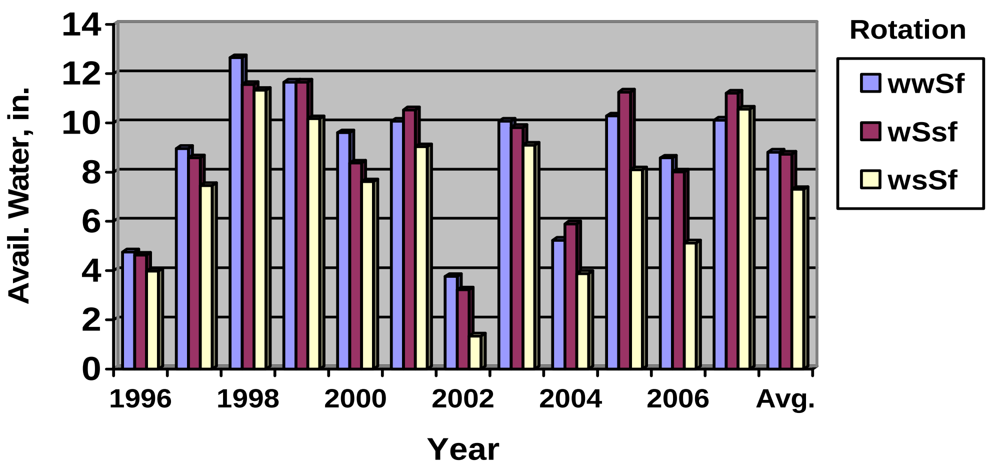

Figure 2. Available soil water at planting of sorghum in several rotations, Tribune, 1996-2007
Capital letter denotes current crop in rotation.

Table 1. Wheat response to rotation, Tribune, 1997-2007

Rotation[a]	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Mean
	--bu/a--											
Wssf	57	70	74	46	22	0	29	6	45	28	75	41
Wwsf	55	64	80	35	29	0	27	6	40	26	61	39
wWsf	48	63	41	18	27	0	66	1	41	7	63	34
WW	43	60	43	18	34	0	30	1	44	2	41	29
$LSD_{0.05}$	8	12	14	10	14	---	14	2	10	8	14	2

[a] Capital letters denote current year crop.

Table 2. Grain sorghum response to rotation, Tribune, 1996-2007

Rotation[a]	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Mean
	--bu/a--												
wSsf	58	88	117	99	63	68	0	60	91	81	55	101	73
wsSf	35	45	100	74	23	66	0	41	79	69	13	86	53
wwSf	54	80	109	90	67	73	0	76	82	85	71	101	74
$LSD_{0.05}$	24	13	12	11	16	18	---	18	17	20	15	9	4

[a] Capital letters denote current year crop.

Table 3. Net return to land and management for 4-year rotations, 1996-2007

Price Scenario	WWSF	WSSF	WW	WSF (hypothetical)
	-------------------------------Returns ($/tillable acre)---------------------------------			
Short-run prices	69	69	46	66
Long-run prices	26	21	11	23

NITROGEN AND PHOSPHORUS FERTILIZATION OF IRRIGATED CORN

Alan 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 2007, N applied alone increased yields about 110 bu/a, but P applied alone had no effect on yield. When N and P were applied together, yields were increased up to 180 bu/a. Averaged over the past 10 years, corn yields were increased up to 135 bu/a by N and P fertilization. Application of 120 lb/a N (with P) was sufficient to produce > 90% of maximum yield in 2007, which was slightly less than the 10-year average. In 2007, P increased corn yields an average of 80 bu/a when applied with at least 120 lb/a N. Application of 80 lb/a instead of 40 lb/a P_2O_5 increased yields 8 bu/a.

INTRODUCTION

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

PROCEDURES

Initial fertilizer treatments in 1961 were N rates of 0, 40, 80, 120, 160, and 200 lb/a N without P and K; with 40 lb/a P_2O_5 and zero K; and with 40 lb/a P_2O_5 and 40 lb/a K_2O. Treatments were changed in 1992; the K variable was replaced by a higher rate of P (80 lb/a P_2O_5). All fertilizers were broadcast by hand in the spring and incorporated prior to planting. The soil is a Ulysses silt loam. Corn hybrids were Pioneer 3395IR (1998), Pioneer 33A14 (2000), Pioneer 33R93 (2001 and 2002), DeKalb C60-12 (2003), Pioneer 34N45 (2004 and 2005), Pioneer 34N50 (2006), and Pioneer 33B54 (2007) planted at about 30,000 to 32,000 seeds/a in late April or early May. Hail damaged the 2005 and 2002 crop and destroyed the 1999 crop. Corn was irrigated 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 were machine harvested after physiological maturity, and grain yields were adjusted to 15.5% moisture. After harvest in 2005, soil samples were collected and analyzed for soil test P (Mehlich-3) for the 0 to 6-in. depth and for inorganic N in the 0 to 24-in. depth (Table 1).

RESULTS AND DISCUSSION

Soil test P levels, after not receiving any P fertilizer for 45 years, have decreased to less than 10 ppm (Mehlich-3). Application of 40 lb/a P_2O_5 annually have maintained soil test P at levels similar to the start of the study, but soil test P levels increased since 1992 when higher rates of fertilizer P have been applied. As expected, residual inorganic N levels are higher with increased rates of fertilizer N. Residual inorganic N levels are also higher when no fertilizer P is applied because of lower yields and less N removal in the grain.

Corn yields in 2007 were higher than the 10-year average (Table 2). Nitrogen alone increased yields 110 bu/a; P alone increased yields only 2 bu/a. However, N and P applied together increased corn yields up to 180 bu/a. Only 120 lb/a N with P was required to obtain > 90% of maximum yield. Over the past 10 years, 120 lb/a N with P has produced 95% of maximum yield. Averaged across all N rates, application of 80 lb/a instead of 40 lb/a P_2O_5 increased corn yields 8 bu/a, which is similar to the 10-year average.

Table 1. Soil chemical properties after 45 years of N and P fertilizer application, Tribune, 2005

N Rate (lb/a)	P Rate (lb/a)	Mehlich 3-P 0-6 in. (ppm)	NH_4-N 0-24 in. (ppm_	NO_3-N 0-24 in. (ppm)
0	0	7	3.0	1.7
	40	51	3.4	1.9
	80	79	3.2	1.8
40	0	7	3.6	3.6
	40	27	4.2	3.3
	80	64	3.5	2.7
80	0	10	4.0	5.7
	40	15	3.7	3.4
	80	49	3.5	3.7
120	0	6	3.6	8.5
	40	13	4.2	5.5
	80	49	3.4	4.4
160	0	7	4.6	10.5
	40	14	4.8	6.2
	80	32	3.7	5.9
200	0	6	4.1	13.3
	40	14	3.9	7.6
	80	35	3.4	9.5
ANOVA (P < F)				
Nitrogen		0.001	0.027	<0.001
Linear		0.001	0.013	<0.001
Quadratic		0.001	0.125	0.229
Phosphorus		0.001	0.054	<0.001
Linear		0.001	0.152	<0.001
Quadratic		0.001	0.050	0.026
Zero P vs. P		0.001	0.799	<0.001
40 P vs. 80 P		0.001	0.017	0.977
Nitrogen*Phosphorus		0.001	0.901	0.211
Means				
Nitrogen	0	45	3.2	1.8
	40	32	3.7	3.2
	80	25	3.8	4.2
	120	23	3.7	6.2
	160	18	4.4	7.5
	200	18	3.8	10.1
$LSD_{0.05}$		6	0.6	1.8
Phosphorus	0	7	3.8	7.2
	40	22	4.0	4.6
	80	51	3.5	4.6
$LSD_{0.05}$		4	0.5	1.3

Table 2. Effect of N and P fertilizers on irrigated corn yields, Tribune, 1998-2007[a]

N	P_2O_5	1998	2000	2001	2002	2003	2004	2005	2006	2007	Mean
lb/a		-----	-----	-----	-----	bu/a	-----	-----	-----	-----	-----
0	0	49	131	54	39	79	67	49	42	49	62
0	40	55	152	43	43	95	97	60	68	50	74
0	80	55	153	48	44	93	98	51	72	51	74
40	0	76	150	71	47	107	92	63	56	77	82
40	40	107	195	127	69	147	154	101	129	112	127
40	80	95	202	129	76	150	148	100	123	116	127
80	0	95	149	75	53	122	118	75	79	107	97
80	40	155	205	169	81	188	209	141	162	163	164
80	80	149	211	182	84	186	205	147	171	167	167
120	0	92	143	56	50	122	103	66	68	106	90
120	40	180	204	177	78	194	228	162	176	194	177
120	80	179	224	191	85	200	234	170	202	213	189
160	0	101	154	76	50	127	136	83	84	132	105
160	40	186	203	186	80	190	231	170	180	220	183
160	80	185	214	188	85	197	240	172	200	227	190
200	0	130	165	130	67	141	162	109	115	159	131
200	40	188	207	177	79	197	234	169	181	224	184
200	80	197	218	194	95	201	239	191	204	232	197
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	0.001	0.001	0.007	0.001	0.001	0.001	0.001	0.001	0.001
N x P		0.001	0.008	0.001	0.133	0.001	0.001	0.001	0.001	0.001	0.001
MEANS											
N, lb/a	0	53	145	48	42	89	87	53	61	50	70
	40	93	182	109	64	135	132	88	103	102	112
	80	133	188	142	73	165	178	121	137	146	143
	120	150	190	142	71	172	188	133	149	171	152
	160	157	190	150	71	172	203	142	155	193	159
	200	172	197	167	80	180	212	156	167	205	171
$LSD_{0.05}$		11	10	15	8	9	11	10	15	11	8
P_2O_5, lb/a	0	91	149	77	51	116	113	74	74	105	94
	40	145	194	147	72	168	192	134	149	160	151
	80	143	204	155	78	171	194	139	162	168	157
$LSD_{0.05}$		7	7	10	6	6	8	7	11	8	5

[a] No yield data for 1999 because of hail damage.

APPLICATION OF ANIMAL WASTES ON IRRIGATED CORN[1]

Alan Schlegel, Loyd Stone[2], H. Dewayne Bond, and Mahbub Alam

SUMMARY

Animal wastes are routinely applied to cropland to recycle nutrients, build soil quality, and increase crop productivity. This study evaluates established best management practices for land application of animal wastes on irrigated corn. Swine (effluent water from a lagoon) and cattle (solid manure from a beef feedlot) wastes have been applied annually since 1999 at rates to meet estimated corn P or N requirements along with a rate double the N requirement. Other treatments were N fertilizer (60, 120, and 180 lb/a N) and an untreated control. Corn yields were increased by applying animal wastes and N fertilizer. Over-application of cattle manure has not had a negative effect on corn yield. Over-application of swine effluent has not reduced corn yields, except for 2004, when the effluent had much greater salt concentration than in previous years; this caused reduced germination and poor early growth.

INTRODUCTION

This study was initiated in 1999 to determine the effect of land application of animal wastes on crop production and soil properties. The study evaluated the two most common animal wastes in western Kansas: solid cattle manure from a commercial beef feedlot and effluent water from a lagoon on a commercial swine facility.

PROCEDURES

Rate of waste application was based on amounts needed to meet the estimated crop P requirement, estimated crop N requirement, or twice the N requirement (Table 1). The Kansas Department of Agriculture Nutrient Utilization Plan Form was used to calculate animal waste application rates. Expected corn yield was 200 bu/a. Allowable P application rates for the P-based treatments were 105 lb/a P_2O_5 because soil test P levels were less than 150 ppm Mehlich-3 P. The N recommendation model uses yield goal less credits for residual soil N and previous manure applications to estimate N requirements. For the N-based swine treatment, residual soil N levels after harvest in 2001, 2002, 2004, and 2006 were great enough to eliminate the need for additional N the following year. Thus, no swine effluent was applied to the 1x N treatment in 2002, 2003, 2005, and 2007 or to the 2x N requirement treatment because it is based on the 1x treatment (Table 1). The same situation occurred for the N-based treatments using cattle manure in 2003. Nutrient values used to calculate initial applications of animal wastes were 17.5 lb available N and 25.6 lb available P_2O_5 per ton of cattle manure and 6.1 lb available N and 1.4 lb available P_2O_5 per 1,000 gal of swine effluent (actual analysis of animal wastes as applied varied somewhat from the estimated values, Table 2). Subsequent applications were based on previous analyses. Other nutrient treatments were three rates of N fertilizer (60, 120, and 180 lb/a N) along with an untreated control. The N fertilizer treatments also received a uniform application of 50 lb/a P_2O_5. The experimental design was a randomized complete block with four replications. Plot size was 12 rows wide by 45 ft long.

The study was established in border basins to facilitate effluent application and flood irrigation. Swine effluent was flood applied as part of a preplant irrigation each year. At the same time, plots not receiving swine effluent were irrigated to balance water additions. Cattle manure was hand broadcast and incorporated. The N fertilizer (granular NH_4NO_3) was applied with a 10-ft fertilizer applicator (Rogers Mfg.). The entire study area was uniformly irrigated during the growing season with flood irrigation in 1999-2000 and sprinkler irrigation in 2001-2007. The soil is a Ulysses silt loam. Corn was

[1] Project received support from the Kansas Fertilizer Research Fund, Kansas Dept. of Health and Environment, and the Ogallala Aquifer Initiative

[2] Kansas State University Department of Agronomy, Manhattan, KS

planted at about 33,000 seeds/a in late April or early May each year. Grain yields are not reported for 1999 because of severe hail damage. Hail also damaged the 2002 and 2005 crop. The center four rows of each plot were machine harvested after physiological maturity with yields adjusted to 15.5% moisture.

RESULTS AND DISCUSSION

Corn yields were increased by all animal waste and N fertilizer applications in 2007, as was the case in previous years except 2002 when yields were greatly reduced by hail damage (Table 3). Type of animal waste affected yields in 6 of the 8 years; higher yields occurred from cattle manure than swine effluent. Averaged across the 8-year period, corn yields were 15 bu/a greater following application of cattle manure than swine effluent on an N application basis. Over-application (2xN) of cattle manure had no negative effect on grain yield in any year. In 2004, over-application of swine effluent reduced corn yield. However, no adverse residual effect from the over-application has been observed.

Table 1. Application rates of animal wastes, Tribune, 1999-2007

Application basis[a]	1999	2000	2001	2002	2003	2004	2005	2006	2007
	Cattle manure (ton/a)								
P requirement	15.0	4.1	6.6	5.8	8.8	4.9	3.3	6.3	5.9
N requirement	15.0	6.6	11.3	11.7	0	9.8	6.8	6.3	9.8
2X N requirement	30.0	13.2	22.6	22.7	0	19.7	13.5	12.6	19.6
	Swine effluent (1000 gal/a)								
P requirement	28.0	75.0	61.9	63.4	66.9	74.1	73.3	66.0	70.9
N requirement	28.0	9.4	37.8	0	0	40.8	0	16.8	0
2X N requirement	56.0	18.8	75.5	0	0	81.7	0	33.7	0

[a] Animal waste applications are based on the estimated requirement of N and P for a 200 bu/a corn crop.

Table 2. Analysis of animal waste as applied, Tribune, 1999-2007

Nutrient Content	1999	2000	2001	2002	2003	2004	2005	2006	2007
	Cattle manure (lb/ton)								
Total N	27.2	36.0	33.9	25.0	28.2	29.7	31.6	38.0	18.8
Total P_2O	29.9	19.6	28.6	19.9	14.6	18.1	26.7	20.5	11.7
	Swine effluent (lb/1000 gal)								
Total N	8.65	7.33	7.83	11.62	7.58	21.42	13.19	19.64	10.09
Total P_2O	1.55	2.09	2.51	1.60	0.99	2.10	1.88	2.60	1.09

Table 3. Effect of animal waste and N fertilizer on irrigated corn, Tribune, 2000-2007

Nutrient source	Rate Basis[a]	Grain yield[b] 2000	2001	2002	2003	2004	2005	2006	2007	Mean
		-----	-----	-----	-----	bu/a	-----	-----	-----	
Cattle manure	P	197	192	91	174	241	143	236	232	188
	N	195	182	90	175	243	147	217	230	185
	2 X N	195	185	92	181	244	155	213	228	187
Swine effluent	P	189	162	74	168	173	135	189	217	163
	N	194	178	72	167	206	136	198	210	170
	2 X N	181	174	71	171	129	147	196	216	160
N fertilizer	60 N	178	149	82	161	170	96	178	112	141
	120 N	186	173	76	170	236	139	198	195	172
	180 N	184	172	78	175	235	153	200	225	178
Control	0	158	113	87	97	94	46	123	45	95
$LSD_{0.05}$		22	20	17	22	36	16	18	15	11
ANOVA										
Treatment		0.034	0.001	0.072	0.001	0.001	0.001	0.001	0.001	0.001
Selected contrasts										
Control vs. treatment		0.001	0.001	0.310	0.001	0.001	0.001	0.001	0.001	0.001
Manure vs. fertilizer		0.089	0.006	0.498	0.470	0.377	0.001	0.001	0.001	0.001
Cattle vs. swine		0.220	0.009	0.001	0.218	0.001	0.045	0.001	0.001	0.001
Cattle 1x vs. 2x		0.900	0.831	0.831	0.608	0.973	0.298	0.646	0.730	0.772
Swine 1x vs. 2x		0.237	0.633	0.875	0.730	0.001	0.159	0.821	0.399	0.080
N rate linear		0.591	0.024	0.639	0.203	0.001	0.001	0.021	0.001	0.001
N rate quadratic		0.602	0.161	0.614	0.806	0.032	0.038	0.234	0.001	0.012

[a] Rate of animal waste applications based on amount needed to meet estimated crop P requirement, N requirement, or twice the N requirement.
[b] No yields reported for 1999 because of severe hail damage. Hail reduced corn yields in 2002 and 2005.

GRAIN AND FORAGE PRODUCTION WITH LIMITED IRRIGATION CROPPING SYSTEMS

Norman Klocke, Randall Currie, Alan Schlegel, and Micheal Brouk[1]

SUMMARY

Corn grain and forage yields declined with less than full irrigation, but sorghum grain and forage yields remained nearly constant. Net economic returns increased as more irrigation was applied to corn but decreased with additional irrigation on sorghum. When irrigation was reduced in corn and sorghum production, there was less effect on grain and forage yield from the same proportional decrease in irrigation. For example, a 50% reduction in full irrigation caused a 20% reduction in corn grain yields. Sorghum grain yields were reduced by 8% with a 72% reduction in irrigation. However, net economic return from corn production increased at the same rate with additional irrigation. Additional irrigation decreased annual net returns from sorghum production. Irrigators, responding to economic returns from their irrigation practices, tend to fully irrigate corn and reduce irrigation for sorghum.

INTRODUCTION

The overall project goal was to determine grain and forage yields of deficit irrigated corn and sorghum and net economic returns from deficit irrigation practices. Objectives were:

1. Measure grain and forage production of corn and grain sorghum with deficit irrigation and no-till management.
2. Determine net economic returns of corn and grain sorghum receiving irrigation from deficit to fully irrigated management.

PROCEDURES

Cropping systems projects at the Kansas State University Southwest Research-Extension Center used deficit irrigation and no-till management strategies to test crop responses to limited water supplies. The cropping sequence was corn-corn-wheat-grain sorghum and sunflower; each crop was grown each year. Six levels of irrigation, replicated four times within each crop, ranged from 2 in. annually to irrigation to meet full crop water requirements. All crops were grown under sprinkler irrigation and no-till management; other cultural practices (hybrid selection, fertility practices, weed control, etc.) were selected to optimize production. All water levels and phases of each rotation were present each year and replicated four times.

Field measurements included soil water with neutron attenuation, irrigation and rainfall amounts, and grain and forage yields. Yield-irrigation relationships, current commodity price, and crop production costs were used to determine net economic returns from corn and sorghum crops across water allocations.

RESULTS AND DISCUSSION

Relative yields and relative irrigation were calculated for each irrigation treatment as a percentage of fully irrigated yields and irrigation amounts. Relative corn yields ranged from 98% to 60% over irrigation treatments when relative irrigation was reduced from 85% to 29% (Table 1). Likewise, relative sorghum yields ranged from 98% to 92% as relative irrigation was reduced from 86% to 28%. Corn and sorghum relative forage yields followed similar trends (Table 2). Trends in accumulation of soil water stored during the non-growing season and used during the following growing season corresponded to the applied irrigation for corn and sorghum (Table 3). More soil water was stored and used as irrigation was reduced. Soil water measurements (not shown) indicated that reduced irrigation led to soil water extraction from deeper in the soil profile. More soil water extraction during the growing season contributed to more capacity to store soil water. Deeper rooting during the following growing season led to more aggressive soil water extraction. Annual net

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economic returns from corn, defined as gross income from the crop minus production costs, increased at a constant rate with additional irrigation (Tables 4 and 5 and Fig. 1). Marginal returns were the same for all irrigation treatments. Annual net returns for sorghum decreased with additional irrigation. Relatively small decreases in grain yields and decreasing production costs with less irrigation led to decreased net returns.

Table 1. Average grain yields and relative grain yields for corn after corn and sorghum after wheat for 2004-2007

	Corn after corn 2004-2007				Sorghum after Wheat 2004-07			
Irrigation Treatment	Average Yield (bu/a)	Relative Yield (%)	Annual Irrigation (in.)	Relative Irrigation (%)	Average Yield (bu/a)	Relative Yield (%)	Annual Irrigation (in.)	Relative Irrigation (%)
High 1	201	100	12	100	119	100	7	100
2	198	98	10	85	116	98	6	86
3	183	91	9	74	114	96	5	72
4	160	80	6	52	107	90	4	48
5	139	69	5	39	109	92	3	34
Low 6	121	60	3	29	109	92	2	28

Table 2. Average forage yields (dry matter) and relative forage yields for corn after corn and sorghum after wheat for 2004-2007

	Corn after corn 2004-2007				Sorghum after Wheat 2004-07			
Irrigation Treatment	Average Yield (T/a)	Relative Yield (%)	Annual Irrigation (in.)	Relative Irrigation (%)	Average Yield (T/a)	Relative Yield (%)	Annual Irrigation (in.)	Relative Irrigation (%)
High 1	9.6	100	12	100	7.6	100	7	100
2	8.2	85	10	85	7.2	98	6	86
3	7.9	82	9	74	7.5	96	5	72
4	5.7	59	6	52	6.8	90	4	48
5	6.2	64	5	39	7.5	92	3	34
Low 6	5.7	61	3	29	6.7	92	2	28

Table 3. Stored soil water (SW) gains during the previous non-growing season and stored SW use during the growing season for corn following corn and sorghum following wheat

Irrigation Treatment	SW Gain Corn (in.)	SW Use Corn (in.)	SW Gain Sorghum (in.)	SW Use Sorghum (in.)
High 1	3.3[b]	1.8[d]	6.8[bc]	4.3[d]
2	4.9[ab]	2.3[cd]	6.4[c]	4.7[d]
3	4.9[ab]	3.2[ab]	7.5[ab]	5.5[c]
4	5.9[a]	2.9[abc]	7.8[ab]	5.8[bc]
5	5.7[a]	3.9[ab]	8.0[a]	6.3[b]
Low 6	6.0[a]	4.3[a]	7.9[a]	6.9[a]
$LSD_{0.05}$	1.7	1.1	1.1	0.5

Within columns, means without a common superscript differ (P < .05).

Table 4. Net returns (gross income – production costs) for irrigated corn

Net Irrigation (in.)	Corn Price ($/bu)	Grain Yield (bu/a)	Gross Income ($/a)	Irrigation Cost ($/a-in.)	Production Costs[a] ($/a)	Net Return ($/a)
11.5	4	205	820	9	471	349
9.8	4	199	796	9	507	289
8.5	4	185	740	9	474	266
6	4	163	652	9	427	225
4.5	4	141	564	9	380	185
3.3	4	119	476	9	344	132

[a] Includes irrigation costs.

Table 5. Net returns (gross income – production costs) for irrigated sorghum

Net Irrigation (in.)	Sorghum Price ($/bu)	Grain Yield (bu/a)	Gross Income ($/a)	Irrigation Cost ($/a-in.)	Production Costs[a] ($/a)	Net Return ($/a)
7.3	3.5	119	416	9	301	115
6.3	3.5	116	406	9	286	120
5.3	3.5	114	400	9	270	131
3.5	3.5	107	376	9	253	123
2.5	3.5	109	382	9	246	136
2.0	3.5	109	381	9	235	146

[a] Includes irrigation costs.

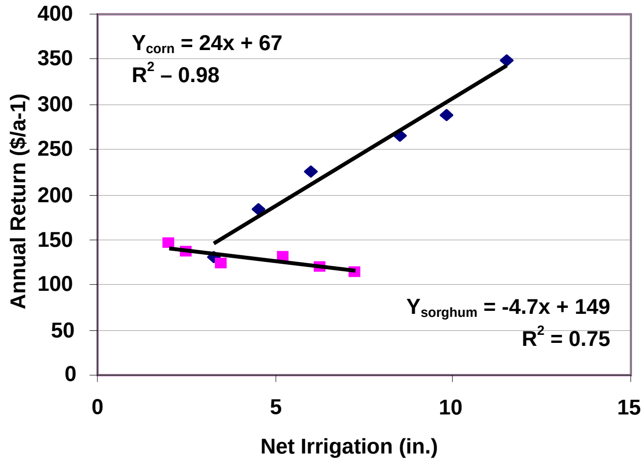

Figure 1. Net returns (gross income – production costs) for irrigated corn and grain sorghum

MANAGING IRRIGATION WITH DIMINISHED CAPACITY WELLS[1]

Alan Schlegel, Loyd Stone[2], and Troy Dumler

SUMMARY

Corn yields were increased an average of 13 bu/a by preseason irrigation. As expected, grain yields increased with increased well capacity. Grain yields (averaged across preseason irrigation and plant population) were 15% 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/a was adequate with the lowest well capacity and without preseason irrigation. When well capacity increased to 1.5 in./day, 27,500 plants/a were required to optimize yields without preseason irrigation; with preseason irrigation, a higher population was required. With a well capacity of 0.2 in./day, 32,500 plants/a provided greater yields with or without preseason irrigation. Preseason irrigation increased available soil water at planting by about 2 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 2-year field study was conducted at the Kansas State University Southwest Research-Extension Center near Tribune, KS. The study was a factorial design of preplant irrigation (0 and 3 in.), well capacities (0.1, 0.15, and 0.2 in./day capacity), and plant population (22,500, 27,500, and 32,500 plants/a). 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; 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 using 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 irrigation was 9.55, 12.61, and 19.01 in. in 2006 and 7.21, 10.10, and 15.62 in. in 2007 for the 0.1, 0.15, and 0.2 in./day well capacity treatments, respectively. In-season precipitation was 6.93 in. in 2006 and 8.08 in. in 2007. Water use efficiency was calculated by dividing grain yield (lb/a) by crop water use.

RESULTS AND DISCUSSION

Preseason irrigation increased grain yields an average of 13 bu/a (Table 1). Although not significant, the effect was greater at lower well capacities. For example, with 27,500 plants/a, preseason irrigation (3 in.) increased grain yield by 18 bu/a with a well capacity of 0.1 in./day but only 3 bu/a 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 15% greater when well capacity increased from 0.1 to 0.2 in./day. Seed weight and number of seeds/ear both increased with increased well capacity. Preseason irrigation increased the number of seeds/ear but had little effect on seed weight.

Optimum plant population varied with irrigation level. A plant population of 22,500 plants/a was adequate with the lowest well capacity and without preseason irrigation. However, if preseason irrigation was applied, a higher plant population (27,500 plants/a) increased yields even at the lowest well capacity. When well capacity increased to 1.5 in./day, 27,500 plants/a were required to optimize yields without preseason irrigation; with preseason irrigation, a higher population was required. With a well capacity of 0.2 in./day 32,500 plants/a provided greater yields with or without preseason irrigation.

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

[2] Kansas State University Department of Agronomy, Manhattan, KS

Water use efficiency was greatest at the lowest well capacity (Table 1). Preseason irrigation had little effect on water use efficiency. Similar to grain yields, the effect of plant population varied with irrigation level. At lower irrigation levels, a plant population of 27,500 plants/a tended to optimize water use efficiency. Only at the highest well capacity did higher plant population improve water use efficiency.

Crop water use increased with increased well capacity and preseason irrigation (Table 2). Soil water at harvest increased with increased well capacity, but this caused less soil water to accumulate during the winter. Preseason irrigation increased available soil water at planting by about 2 in. Seeding rate had little effect on soil water at planting or harvest, water accumulation during fallow, or crop water use.

Table 1. Crop parameters as affected by well capacity, preseason irrigation, and seeding rate, Tribune, 2006-2007

Well Capacity (in./day)	Preseason Irrigation (in.)	Seed Rate (10^3/a)	Yield (bu/a)	WUE (lb/in.)	Plant pop.	Ear pop.	Ear Weight (lb)	1000 Seed (oz)	Kernel (#/head)
					-----10^3/a-----				
0.10	0	22.5	186	481	22.5	22.5	0.47	12.81	582
		27.5	188	489	27.1	26.5	0.40	12.26	523
		32.5	185	476	31.9	31.4	0.33	11.92	448
	3	22.5	197	468	22.0	22.1	0.50	12.83	624
		27.5	206	485	27.2	26.7	0.43	12.61	549
		32.5	211	494	32.1	31.7	0.37	12.30	487
0.15	0	22.5	194	441	22.3	21.8	0.50	12.83	624
		27.5	205	475	27.2	26.9	0.43	12.34	558
		32.5	190	431	31.6	30.9	0.35	12.47	445
	3	22.5	203	443	22.3	22.3	0.51	13.16	623
		27.5	215	475	27.2	26.8	0.45	12.78	565
		32.5	223	484	31.8	31.4	0.40	12.39	519
0.20	0	22.5	208	423	22.0	21.8	0.54	13.21	648
		27.5	227	442	26.9	26.8	0.48	12.99	587
		32.5	232	461	31.8	31.2	0.42	12.61	530
	3	22.5	210	411	21.9	21.6	0.55	13.30	656
		27.5	230	443	26.9	26.6	0.48	13.02	596
		32.5	240	467	31.9	31.2	0.43	12.57	551
MEANS									
Well Capacity, in./day		0.10	195	482	27.1	26.8	0.42	12.46	536
		0.15	205	458	27.1	26.7	0.44	12.66	556
		0.20	225	441	26.9	26.5	0.48	12.95	595
$LSD_{0.05}$			12	23	0.3	0.4	0.02	0.30	19
Preseason Irrigation, in.		0	202	458	27.0	26.6	0.43	12.60	549
		3	215	463	27.0	26.7	0.46	12.77	574
$LSD_{0.05}$			10	19	0.3	0.3	0.02	0.25	15
Seed Rate, 10^3/a		22,500	200	445	22.2	22.0	0.51	13.02	626
		27,500	212	468	27.1	26.7	0.45	12.67	563
		32,500	214	469	31.9	31.3	0.38	12.38	497
$LSD_{0.05}$			5	11	0.2	0.2	0.01	0.13	12

Table 2. Soil profile available water for corn as affected by well capacity, preseason irrigation, and seeding rate, Tribune, 2006-2007

Well Capacity (in./day)	Preseason Irrigation (in.)	Seed Rate (10^3/a)	Available Water: Previous Harvest	Available Water: Planting	Available Water: Harvest	Water use (in.)	Fallow accumulation (in./8-ft profile)
			-----in./8-ft profile-----				
0.10	0	22.5	4.57	10.31	4.52	21.68	6.10
		27.5	4.28	10.11	4.39	21.60	5.84
		32.5	4.27	10.15	4.18	21.86	5.67
	3	22.5	4.72	12.67	5.00	23.56	8.74
		27.5	4.29	12.71	4.75	23.85	9.25
		32.5	4.79	13.08	5.04	23.92	8.94
0.15	0	22.5	5.20	11.32	5.46	24.71	6.78
		27.5	5.67	11.18	5.76	24.28	5.89
		32.5	5.34	11.21	5.41	24.66	6.76
	3	22.5	6.02	12.73	5.85	25.74	7.10
		27.5	5.26	11.90	5.41	25.35	7.78
		32.5	5.43	12.42	5.41	25.87	7.87
0.20	0	22.5	8.05	11.53	8.86	27.49	5.42
		27.5	6.66	11.09	7.14	28.77	6.21
		32.5	7.84	11.71	8.27	28.26	5.45
	3	22.5	10.61	14.01	10.28	28.56	4.32
		27.5	9.25	13.99	9.73	29.08	5.58
		32.5	9.35	13.72	9.73	28.81	5.56
MEANS		0.10	4.49	11.51	4.65	22.74	7.42
Well Capacity, in./day		0.15	5.49	11.79	5.55	25.10	7.03
		0.20	8.63	12.68	9.00	28.49	5.43
$LSD_{0.05}$			1.93	1.49	1.80	0.69	0.91
Preseason Irrigation, in.		0	5.76	10.96	6.00	24.81	6.01
$LSD_{0.05}$		3	6.64	13.03	6.80	26.08	7.24
			1.58	1.22	1.47	0.56	0.75
Seed Rate, 10^3/a		22.5	6.53	12.10	6.66	25.29	6.41
		27.5	5.90	11.83	6.20	25.49	6.76
		32.5	6.18	12.05	6.34	25.56	6.71
$LSD_{0.05}$			0.57	0.36	0.30	0.27	0.70

Previous harvest-available water and fallow accumulation include only 2007 data.

LIMITED IRRIGATION OF FOUR SUMMER CROPS IN WESTERN KANSAS[1]

Alan Schlegel, Loyd Stone[2], and Troy Dumler

SUMMARY

Research was initiated under sprinkler irrigation to evaluate limited irrigation with no-till for four summer crops. In 2007, crop yields generally were greater than long-term average yields. Corn responded the most to increased irrigation. The most profitable crop changes from year to year because of changes in growing conditions. Growing different crops when irrigation is limited can reduce risk and increase profitability. Averaged over the past 7 years, corn has been the most profitable crop at higher irrigation amounts. Profitability at the lowest irrigation level, was in the order of grain sorghum > corn = soybean > sunflower.

PROCEDURES

A study was initiated under sprinkler irrigation at the Kansas State University Southwest Research-Extension Center near Tribune in the spring of 2001. Objectives of this research are to determine the effect of limited irrigation on crop yield, water use, and profitability. All crops are grown no-till; other cultural practices (hybrid selection, fertility practices, weed control, etc.) are selected to optimize production. All water levels are present each year and replicated four times. Irrigations are scheduled to supply water at the most critical stress periods for the specific crops and limited to 1.5 in./week. Soil water is measured at planting, during the growing season, and at harvest in 1-ft increments to a depth of 8 ft. Grain yields are determined by machine harvest. An economic analysis determines optimal water allocations. Irrigation amounts are 5, 10, and 15 in. annually. Crops evaluated are corn, grain sorghum, soybean, and sunflower grown in a 4-year rotation (a total of 12 treatments). The crop rotation is corn-sunflower-grain sorghum-soybean (alternating grass and broadleaf crops). Irrigation amounts for a particular plot remain constant throughout the study (e.g., a plot receiving 5 in. of water when corn is grown will also receive 5 in. in other years when grain sorghum, sunflower, or soybean are grown).

RESULTS AND DISCUSSION

Precipitation from June through August of 2007 was 7.65 in. (98% of normal). Corn responded most to irrigation; corn yields were 48 bu/a greater with 10 than 5 in. of irrigation and 30 bu/a more with an additional 5 in. of irrigation (Table 1). Soybean yields were significantly increased by increased irrigation amounts, sorghum yields showed little response, and sunflower yields decreased from increased irrigation. In 2005, plots in this study were split and a ≈20% higher seeding rate was added to each crop, except the corn seeding rate was reduced by 20%. Original seeding rates were 30,000/a for corn, 80,000/a for sorghum, 150,000/a for soybean, and 23,500/a for sunflower. The same hybrids were used for each crop except sorghum; a longer-season sorghum hybrid was planted at the higher population. For corn, the lower seeding rate slightly increased corn yields at lower irrigation amounts and decreased yields at the highest irrigation amount. The increased seeding rate had little effect on sunflower yields and slightly reduced soybean yields. Sorghum yields were greater with the higher seeding rate at the higher irrigation amounts, but because this also involved a different hybrid, it is not possible to determine which factor affected yield.

Averaged across 2001-2007, corn was the most responsive to higher irrigation amounts (Table 2). Corn yields increased 76% when irrigation increased from 5 in. to 15 in.; yields of grain sorghum, soybean, and sunflower increased 28%, 53%, and 16%, respectively

[1] This research project received support from the Kansas Corn Commission, Kansas Grain Sorghum Commission, Kansas Soybean Commission, Western Kansas Groundwater Management District #1, and the Ogallala Aquifer Initiative

[2] Kansas State University Department of Agronomy, Manhattan, KS

An economic analysis (based on original seeding rates, October grain prices each year, and input costs from each year) found that average net returns (2001-2007) at the lowest irrigation level were in the order of sorghum > corn = soybean > sunflower (Table 3). At higher irrigation levels, corn was the more profitable crop. Corn was the only crop for which profitability appreciably increased with more than 10 in. of irrigation.

Table 1. Grain yield of four crops in 2007 as affected by irrigation amount and seeding rate

Irrigation amount (in.)	Corn	Sorghum	Soybean	Sunflower (lb/a)
	-----------------------bu/a-----------------------			
5	151 (154)	141 (147)	37 (35)	2620 (2730)
10	199 (193)	150 (158)	54 (48)	2300 (2320)
15	229 (206)	149 (161)	64 (59)	2480 (2550)

Values in parentheses are for about 20% different seeding rate.

Table 2. Average grain yield of four crops (at original seeding rate) from 2001-2007 as affected by irrigation amount

Irrigation amount (in.)	Corn	Sorghum	Soybean	Sunflower (lb/a)
	-----------------------bu/a-----------------------			
5	114	94	30	1820
10	173	109	41	2100
15	201	120	46	2110

Table 3. Net return to land, irrigation equipment, and management for four crops from 2001-2007 as affected by irrigation amount

Irrigation amount (in.)	Corn	Sorghum	Soybean	Sunflower
	-----------------------annual net return ($/a)-----------------------			
5	51	66	50	42
10	163	74	91	44
15	210	72	100	29

NO-TILL LIMITED IRRIGATION CROPPING SYSTEMS[1]

Alan Schlegel, Loyd Stone[2], and Troy Dumler

SUMMARY

Research was initiated under sprinkler irrigation to evaluate limited irrigation in a no-till crop rotation. With limited irrigation (10 in. annually), continuous corn has been more profitable than multi-crop rotations including wheat, sorghum, and soybean primarily because of spring freeze and hail damage to wheat in the multi-crop rotations. In multi-crop rotations, relatively poor results with one crop (in this case wheat) can reduce profitability compared with a monoculture, especially when the monoculture crop does well. However, the multi-crop rotation can reduce economic risk when the monoculture crop does not perform as well. All multi-crop rotations had net returns $40 to 50/a less than continuous corn. However, relatively small changes in prices or yields could result in any of the rotations being more profitable than continuous corn, indicating the potential for alternate crop rotations under limited irrigation.

PROCEDURES

Research was initiated under sprinkler irrigation at the Kansas State University Southwest Research-Extension Center near Tribune in the spring of 2001. Objectives of this research are to determine the effect of limited irrigation on crop yield, water use, and profitability in several crop rotations. All crops are grown no-till; other cultural practices (hybrid selection, fertility practices, weed control, etc.) are selected to optimize production. All phases of each rotation are present each year and replicated four times. All rotations have annual cropping (no fallow years). Irrigations are scheduled to supply water at the most critical stress periods for the specific crops and are limited to 1.5 in./week. Soil water is measured at planting, during the growing season, and at harvest in 1-ft increments to a depth of 8 ft. Grain yields are determined by machine harvest. An economic analysis determines optimal crop rotations. Rotations include 1-, 2-, 3-, and 4-year rotations. Crop rotations are 1) continuous corn, 2) corn-winter wheat, 3) corn-wheat-grain sorghum, and 4) corn-wheat-grain sorghum-soybean (a total of 10 treatments). All rotations are limited to 10 in. of irrigation water annually, but the amount of irrigation water applied to each crop within a rotation varies, depending on expected responsiveness to irrigation. For example, continuous corn receives the same amount of irrigation each year, but more water is applied to corn than to wheat in the corn-wheat rotation. Irrigation amounts are 15 in. to corn in 2-, 3-, and 4-yr rotations, 10 in. to grain sorghum and soybean, and 5 in. to wheat.

RESULTS AND DISCUSSION

Wheat followed corn in all rotations and received 5 in. of irrigation. All rotations were limited to 10 in. of irrigation; however, corn following wheat received 15 in. because the wheat only received 5 in. This extra 5 in. of irrigation increased corn yields 13 to 20 bu/a compared with the continuous corn (which received only 10 in. of irrigation) (Table 1). Corn yields tended to be greater with longer rotations. Grain sorghum yields were the same in the 3- and 4-year rotations.

Averaged over the past 5 years, corn yields were 36 to 41 bu/a greater in the multi-year rotations with an additional 5 in. of irrigation compared with continuous corn (Table 2). Wheat and grain sorghum yields were similar regardless of length of rotation.

An economic analysis (based on October grain prices and input costs from each year) found that the most profitable rotation was continuous corn (Table 3). All multi-year rotations had net returns of about $40 to $50/a

[1] This research project received support from the Kansas Corn Commission, Kansas Grain Sorghum Commission, Kansas Soybean Commission, Western Kansas Groundwater Management District #1, and the Ogallala Aquifer Initiative

[2] Kansas State University Department of Agronomy, Manhattan, KS

less than continuous corn. Llower returns in the rotations were largely due to low returns from wheat. In 2 of the past 4 years, wheat yields were depressed by spring freeze damage; this lowered average wheat yields and reduced net returns from the multi-year rotations.

Table 1. Grain yield in 2007 of four crops as affected by rotation

Rotation	Corn	Wheat	Sorghum	Soybean
	---------------------------------bu/a---------------------------------			
Continuous corn	204	---	---	---
Corn-wheat	217	25	---	---
Corn-wheat-sorghum	223	28	158	---
Corn-wheat-sorghum-soybean	224	28	158	55

Table 2. Average grain yields from 2003-2007 of four crops as affected by rotation

Rotation	Corn	Wheat	Sorghum	Soybean
	---------------------------------bu/a---------------------------------			
Continuous corn	173	---	---	---
Corn-wheat	209	36	---	---
Corn-wheat-sorghum	210	37	139	---
Corn-wheat-sorghum-soybean	214	39	141	47

Table 3. Net return to land, irrigation equipment, and management from four rotations, 2003-2007

	Crop Rotation[a]			
Crop	CC	C-W	C-W-GS	C-W-GS-SB
	---------------------------------$/a---------------------------------			
Corn	173	231	236	245
Wheat	---	12	12	17
Sorghum	---	---	131	135
Soybean	---	---	---	132
Net for rotation	173	122	126	132

[a] CC = continuous corn; CW = corn-wheat; C-W-GS = corn-wheat-grain sorghum; C-W-GS-SB = corn-wheat-grain sorghum-soybean.

EFFECTS OF HAIL INJURY ON PALMER AMARANTH AND IRRIGATED CORN AT DIFFERENT CORN POPULATIONS AND LEVELS OF IRRIGATION

Randall Currie and Norman Klocke

SUMMARY

Although hail reduced the return on each additional increment of irrigation, irrigation was still beneficial. Hail reduced total corn leaf area and induced Palmer Amaranth germination after the corn had tasseled. Increasing corn leaf area by increasing plant population or reducing leaf area loss decreased total Palmer amaranth biomass. Models are presented that allow prediction of Palmer amaranth increases from corn leaf area, corn yield, and level of irrigation. These models support the well-known concept that a healthy, dense corn canopy is the foundation for effective weed control.

INTRODUCTION

A crop is most vulnerable to defoliation as it approaches maximum leaf area. For corn, this growth stage often coincides with one of the seasonal peaks of hail activity throughout most corn-growing regions in North America. In 2005, while executing a long-term experiment to measure the dose response relationship of irrigation and corn grain yield, a hail storm significantly reduced the leaf area index (LAI) of corn. This occurred again in 2006 at approximately the same growth stage. Replicated studies of natural hail injury and resulting weed flushes are rare. Therefore, study objectives were redirected to examine these effects.

PROCEDURES

Corn had a preemergence application of isoxaflutole, atrazine, s-metolachlor, and 2,4-D at 0.05, 1, 1.9, and 1 lb/a followed by two or more postemergence applications of glyphosate at 0.75 lb/a to maintain weed-free conditions at canopy closure. Six irrigation treatments, replicated four times, were 100, 84, 71, 55, 42, and 30% of what locally-derived models predicted for non-rate-limited irrigation. Corn populations for each treatment were 9,500, 22,000, 24,500, 27,000, 29,500, and 32,000 plants/a, increasing as irrigation level increased. No hail injury occurred in 2004 or 2007, so these years were used for comparisons. Palmer amaranth biomass samples were taken at corn harvest.

RESULTS AND DISCUSSION

In 2005, hail injury reduced LAI to the same level in all but the highest corn population. In 2005 and 2006, all but the highest corn population had statistically significant reductions in LAI. Reductions in LAI correlated well with reductions in corn yield. In 2005, hail opened up the canopy and produced a dramatic flush of Palmer amaranth. At the lowest level of corn population and irrigation inputs, Palmer amaranth biomass (PABM) at corn harvest was twice that seen in the two highest corn populations. This was predicted by the equation: lb/a of PABM = 945 (corn yield in bu/a) - 7.76 (corn yield bu/a)^2 +.029 (corn yield in bu/a)^3 – 18,883 (LAI) + 3,249 (LAI)^2 - 184 (LAI)^3, with an R^2 of 0.87.

In 2006, regardless of irrigation level or corn population, hail-induced increases in PABM were consistently high across all levels of treatment. Hail in the previous year could have increased the amount of weed seed dropped and elevated weed pressure, which might have buffered the effects of differences in canopy damage. Although differences among treatments were difficult to measure, the relationship between corn grain yield, LAI, and PABM clearly showed a curvilinear trend at higher levels of each factor. This trend was predicted by the equation: lb/a of PABM = 3129 (LAI) - 531 (LAI)^2 -871 (in. of irrigation) + 49.6 (in. of irrigation)^2, with an R^2 of 0.78. Corn injury was severe enough to remove corn grain yield as a predictor of PABM.

In 2007, PABM was 4- to 15-fold less than in 2005 or 2006. Even under these much more competitive conditions, similar trends in PABM were seen with increasing levels of inputs. More than 4-fold reduction in PABM was seen with increasing corn populations and irrigation.

ECONOMIC THRESHOLD OF VOLUNTEER GLYPHOSATE-RESISTANT CORN IN IRRIGATED CORN

Randall Currie, Jim Lee, Phillip Westra[1], John Fenderson[2], Jeff Tichota[3], and Jeff Mueller[4]

SUMMARY

Yield losses from volunteer corn in irrigated corn were difficult to measure below 5,000 plants/a. Models are presented that predict yield losses of 10% beginning at populations of 11,000 volunteer corn plants/a. Volunteer corn plants coming from a single seed had less of an effect than clumps of corn coming from parts of whole ears. Presence of 650 clumps/a increased the effect of volunteer corn coming from single seed. We speculate that these single plants produce an ear often enough to make measurement of yield loss difficult.

INTRODUCTION

The increasing popularity of glyphosate-resistant corn hybrids has led to concern among growers about the effect of volunteer corn on subsequent irrigated corn crops. There are a limited number of options for reducing volunteer corn prior to planting (Currie et al., 2007) and very few options for removing this problem in the growing crop. To determine the economic threshold for this problem, five studies were conducted using a range of volunteer corn populations.

PROCEDURES

In the early winter of 2007, naturally dropped ears were collected from a field planted with a glyphosate-resistant corn hybrid in the 2006 growing season. A portion of these ears were shelled, and balances of these ears were broken into three pieces. In Garden City, KS, during the first week in May 2007, corn from shelled ears was scattered randomly by hand over eight plots/block to simulate volunteer corn populations ranging from 5,000 to 31,000 kernels/a in a randomized complete block design with four replicates. In an additional four plots/block, broken ears were placed on the soil surface and trod in to simulate 650 dropped ears/a. These plots were then overseeded with the shelled corn to simulate corn populations of 5,000 to 36,000 kernels per/a. The entire plot area was tilled lightly, and a glyphosate-resistant corn hybrid was planted at 32,000 kernels/a. This procedure was repeated near Pratt, KS, and Yuma, CO. Similar experiments were conducted near Gothenburg, NE (eight rates of volunteer corn populations ranging from 3,000 to 25,000 kernels/a and no simulated dropped ears), and Fort Collins, CO (four rates of volunteer corn populations ranging from 4,000 to 36,000 plants/a with and without dropped ears). At Fort Collins, volunteer corn was established with a corn planter. All locations were fertilized and irrigated for maximum yield. Plots were maintained weed free by a preemergence application of acetochlor and atrazine and postemergence applications of glyphosate as needed.

RESULTS AND DISSCUSSION

Clear yield loss trends were not observed at Gothenburg or Pratt. Data from Gothenburg suggested that volunteer corn might have elevated yield. Clear dose-response relationships were seen at the Fort Collins and Yuma sites for plots with and without simulated dropped ears. Simple linear regression equations from these locations predicted 10% yield loss from volunteer corn populations of 17,700 and 22,200 kernels/a in plots without simulated dropped ears. In plots with dropped ears, (Table 1) simple linear regression equations predicted 10% yield loss at volunteer corn populations of 11,900 and 12,300 kernels/a. Data was much more

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variable at Garden City; some plots showed an increase in yield with increasing volunteer corn population, as was seen at Gothenburg, but overall, yield decreased with increasing volunteer corn populations. Simple linear regression equations derived at Garden City predicted 10% yield loss at a volunteer corn population of 11,000 kernels/a. Yield response in plots with simulated dropped ears did not show a clear trend. Yield losses from glyphosate-resistant volunteer corn are greatly influenced by environment and difficult to measure at populations less than 11,000 kernels/a. Yield losses in plots without simulated dropped ears ranged from 7 to 28% at the highest populations tested. Therefore, future research should target volunteer corn populations ranging from 11,000 to more than 36,000 kernels/a.

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Table 1. Equations for yield loss from glyphosate-resistant corn and levels predicted for 10% yield

Location	Clumps	Slope	Intercept	R^2	10% Yield Loss
Yuma	-	0.00045*	0.027 ns	0.69	22,200
Yuma	+	0.00048*	4.12 ns	0.92	12,300
Ft. Collins	-	0.00039*	3.1 ns	0.80	17,700
Ft. Collins	+	0.00042*	5.0 ns	0.91	11,900
Garden City	-	0.00067*	16.7*	0.91	11,000

* $p < 0.05$.

EXPRESSSUN SUNFLOWER—A NEW WEED CONTROL SYSTEM

Curtis Thompson, Alan Schlegel, and John Holman

SUMMARY

The ExpressSun sunflower is a weed control system that allows use of tribenuron "Express with Total Sol" granules (Express) for postemergence control of susceptible broadleaf weeds. Express is a sulfonylurea herbicide that is an acetolactate synthase (ALS) inhibitor. Thus, ALS-resistant weeds such as Palmer amaranth in the Garden City experiment were not controlled. Express does not control grass species; therefore, it is recommended that preemergence soil-applied herbicides be applied in this system to help control grass and broadleaf weed species. Several postemergence herbicides are available for grass control in sunflower.

Express controlled common puncturevine, tumble pigweed, and Russian thistle in Tribune and Garden City experiments. When Express was tank mixed with Assure II, volunteer wheat was controlled also. The ExpressSun sunflower system is another tool available to growers for broadleaf weed control. Understanding the system's limitations is important. As of the spring of 2008, sunflower hybrid availability is very short. Higher yielding hybrids with the NuSun oil quality hopefully will be available in the near future.

INTRODUCTION

Broadleaf weed control in sunflower has been a challenge. Soil-applied herbicides Treflan, Prowl H_20, Dual Magnum, and Spartan are available and can effectively control broadleaf weeds provided adequate, timely rainfall is received. Only Beyond herbicide is available for postemergence broadleaf weed control in Clearfield sunflower. A new sunflower hybrid system developed by Pioneer and DuPont allows for use of Express, which is 50% a.i. tribenuron, a sulfonylurea herbicide. Express can be used postemergence to control broadleaf weeds in sunflower. These experiments evaluate Express in combination with other herbicides for a total weed control package in sunflower.

PROCEDURES

Two experiments were established at the Kansas State University Southwest Research-Extension Center in Tribune and Garden City during 2007 under limited irrigation applied with linear irrigation systems. An "ExpressSun" trait sunflower, Pioneer 63N81, was planted at 24,000 seed/a on June 4 near Tribune and at 18,000 seed/a into dry soil on June 7 near Garden City. A single row of Russian thistle was planted in both the Tribune and Garden City experiments, and a row of wheat was planted in the Garden City experiment. Preemergence (PRE) treatments were applied on the same day following planting with a backpack sprayer delivering 20 gal/a at 34 psi traveling 3 mph. Post-emergence (POST) treatments were applied to six-leaf sunflower with a backpack sprayer delivering 10 gal/a at 42 psi traveling 3 mph at Tribune on June 26 and July 4 at Garden City. The slight delay in sunflower development at Garden City was due to planting into dry soil. Approximately 0.60 in. of rain fell 3 days after planting in Garden City.

Weed control and crop injury were evaluated visually on dates shown in Tables 1, 2, and 3. Sunflowers were harvested with a plot combine on October 15 at Tribune. Sunflowers were not harvested at Garden City because of very poor sunflower stands and severe bird damage.

RESULTS AND DISCUSSION

Sunflower seed yield, test weight, and moisture were not affected by herbicide treatment in the Tribune experiment (Table 1). Sunflowers were very competitive with the weeds, and untreated sunflowers yielded similar to sunflowers that were weed free (Hand weeded check). Only slight visual injury from PRE herbicides was observed at the June 19 rating. Spartan at 4.5 fl oz/a injured sunflower 6% to 8%. Spartan-injured sunflowers recovered quickly, and no injury was observed at or after the July 1 rating. July 1 injury ratings reflect very slight chlorosis from some of the Express treatments; but, sunflowers returned to their natural color quickly, and no injury was observed with any treatment at the August 29 rating.

June 19 weed control ratings show the effect of PRE applied herbicides at the Tribune experiment (Table 2). Common puncturevine control ranged from 43 to 90% in the PRE herbicides treatments. Sequence (Dual II/glyphosate mixture) tank mixed with Spartan at 4 fl oz/a controlled puncturevine 90%. Regardless of rate, puncturevine treated with Express was controlled based on the ratings taken on July 1 and August 29. Russian thistle control was very good in PRE treatments containing Spartan. Alone, Prowl H_20 or Sequence gave 53% or less control of Russian thistle at the June 19 rating and 78% or less control at the August 19 rating. Although Russian thistle control was best with treatments containing Spartan, Express gave better than 90% control at the July 1 rating and 99% or better control at the August 29 rating. No ALS-resistant Russian thistle was present in the Tribune population. Tumble pigweed control was acceptable in all treatments, but Prowl H_20 alone at 3.2 pt/a provided the least control (83%). In the Tribune experiment, no grass pressure was present to rate effectiveness of the Assure II treatments.

Prowl H_20 and Spartan applied alone or tank mixed together did not injure sunflower in the Garden City Experiment (Table 3). All Express treatments caused chlorosis in the ExpressSun sunflower 8 days after POST treatments were applied, the July 12 rating. The 0.25 oz/a rate of Express injured sunflower 10% to 14%, and the 0.5 oz/a rate injured sunflower 18% to 21%. Sunflowers grew out of the chlorosis by 2 weeks after the July 12 rating (data not shown).

Russian thistle control was 90% or better with all treatments, except control with Prowl H_20 applied alone at 3 pt/a was 43% (Table 3). Express gave complete control of Russian thistle. Palmer amaranth control was best when Spartan was included in a treatment. Prowl H_20 applied alone at 3 pt/a controlled Palmer amaranth 66%. Addition of Spartan to Prowl H_20 increased control to 96%. Express without PRE herbicides controlled Palmer amaranth 45% to 61% at the July 12 rating. This suggests that the Palmer amaranth population in the Garden City experiment contained a large percentage of ALS-resistant plants. Therefore, Palmer amaranth control was acceptable only when Express followed PRE applied Spartan. Treatments containing Assure II controlled wheat 88% to 97%. Prowl H_20 and Spartan had some activity on wheat but did not provide acceptable control.

Table 1. Sunflower response to preemergence and postemergence herbicides, Tribune, 2007

			Sunflower seed			Crop Injury (%)		
Treatment	Rate	Growth Stage	Yield (lb/a)	Test weight (lb/bu)	Moisture (%)	19-Jun	1-Jul	29-Aug
Prowl $H_2$0	3.2 pt/a	PRE	1383	30	8	0		0
Sequence	2.5 pt/a	PRE	1390	30	8	0		0
Prowl $H_2$0	2.6 pt/a	PRE	1126	30	7	1		0
Spartan 4F	4 fl oz/a	PRE						
Sequence	2.5 pt/a	PRE	1308	30	7	2		0
Spartan 4F	4 fl oz/a	PRE						
Prowl $H_2$0	2 pt/a	PRE	1193	30	7	0	1	0
Express	0.25 oz/a	POST						
Assure II	8.8 fl oz/a	POST						
COC	1.5 pt/a	POST						
Prowl $H_2$0	2 pt/a	PRE	1411	31	7	0	2	0
Express	0.5 oz/a	POST						
Assure II	8.8 fl oz/a	POST						
COC	1.5 pt/a	POST						
Spartan 4F	4.5 fl oz/a	PRE	1242	30	7	8	1	0
Express	0.25 oz/a	POST						
Assure II	8.8 fl oz/a	POST						
COC	1.5 pt/a	POST						
Spartan 4F	4.5 fl oz/a	PRE	1367	30	7	6	0	0
Express	0.5 oz/a	POST						
Assure II	8.8 fl oz/a	POST						
COC	1.5 pt/a	POST						
Express	0.25 oz/a	POST	1276	31	7		0	0
Assure II	8.8 fl oz/a	POST						
COC	1.5 pt/a	POST						
Express	0.5 oz/a	POST	1922	30	7		3	0
Assure II	8.8 fl oz/a	POST						
COC	1.5 pt/a	POST						
Handweeded Check			1408	30	7			
Untreated check			1591	30	8			
LSD (P = .05)			516	1	1	3	3	0
CV			26	2	6	99	152	0
Treatment Prob(F)			0.2421	0.2067	0.1868	0.0001	0.2806	1

Yield adjusted to 10% moisture.
Express = Express Total Sol, 50% a.i. tribenuron.
Sequence = Dual II + glyphosate.

Table 2. The effect of Express SG and other herbicides on broadleaf weed control in sunflower, Tribune, 2007

Treatment	Product Rate	Growth Stage	Common puncturevine 19-Jun	Common puncturevine 1-Jul	Common puncturevine 29-Aug	Russian thistle 19-Jun	Russian thistle 1-Jul	Russian thistle 29-Aug	Tumble pigweed 19-Jun	Tumble pigweed 1-Jul	Tumble pigweed 29-Aug
			% Control								
Prowl H_20	3.2 pt/a	PRE	50		100	35		73	98		83
Sequence	2.5 pt/a	PRE	50		98	53		78	98		98
Prowl H_20	2.6 pt/a	PRE	85		98	83		100	100		100
Spartan 4F	4 fl oz/a	PRE									
Sequence	2.5 pt/a	PRE	90		100	100		100	100		100
Spartan 4F	4 fl oz/a	PRE									
Prowl H_20	2 pt/a	PRE	53	100	100	30	94	100	88	95	97
Express	0.25 oz/a	POST									
Assure II	8.8 fl oz/a	POST									
COC	1.5 pt/a	POST									
Prowl H_20	2 pt/a	PRE	43	100	100	15	93	99	98	97	100
Express	0.5 oz/a	POST									
Assure II	8.8 fl oz/a	POST									
COC	1.5 pt/a	POST									
Spartan 4F	4.5 fl oz/a	PRE	80	100	99	100	100	100	100	100	99
Express	0.25 oz/a	POST									
Assure II	8.8 fl oz/a	POST									
COC	1.5 pt/a	POST									
Spartan 4F	4.5 fl oz/a	PRE	83	100	100	100	100	100	100	100	100
Express	0.5 oz/a	POST									
Assure II	8.8 fl oz/a	POST									
COC	1.5 pt/a	POST									
Express	0.25 oz/a	POST		100	100		92	100		90	100
Assure II	8.8 fl oz/a	POST									
COC	1.5 pt/a	POST									
Express	0.5 oz/a	POST		100	100		96	99		91	99
Assure II	8.8 fl oz/a	POST									
COC	1.5 pt/a	POST									
LSD (P = .05)			26	0	3	30	5	27	9	4	11
CV			22	0	2	32	3	20	7	3	8
Treatment Prob(F)			0.004	1	0.5713	0.0001	0.007	0.2977	0.1598	.0007	0.072

Express = Express Total Sol, 50% a.i. tribenuron.
Sequence = Dual II + glyphosate.

Table 3. Crop injury and weed control with herbicides in sunflower, Garden City, 2007

Treatment	Product Rate	Growth Stage	Russian thistle 12-Jul	Russian thistle 31-Aug	Palmer amaranth 12-Jul	Palmer amaranth 31-Aug	Vo. Wheat 12-Jul	Injury 12-Jul
			% Control					%
Prowl H_20	3 pt/a	PRE	35	43	66	66	54	0
Spartan 4F	4 fl oz/a	PRE	100	90	91	83	35	0
Spartan 4F	4 fl oz/a	PRE	100	100	97	96	54	0
Prowl H_20	2.6 pt/a	PRE						
Prowl H_20	1.75 pt/a	PRE	92	100	71	63	90	10
Express	0.25 oz/a	POST						
Assure II	8.8 fl oz/a	POST						
COC	1.5 pt/a	POST						
Prowl H_20	1.75 pt/a	PRE	97	100	76	73	88	21
Express	0.5 oz/a	POST						
Assure II	8.8 fl oz/a	POST						
COC	1.5 pt/a	POST						
Spartan 4F	4.5 fl oz/a	PRE	100	100	95	92	97	14
Express	0.25 oz/a	POST						
Assure II	8.8 fl oz/a	POST						
COC	1.5 pt/a	POST						
Spartan 4F	4.5 fl oz/a	PRE	100	100	91	91	90	20
Express	0.5 oz/a	POST						
Assure II	8.8 fl oz/a	POST						
COC	1.5 pt/a	POST						
Express	0.25 oz/a	POST	91	100	45	0	89	13
Assure II	8.8 fl oz/a	POST						
COC	1.5 pt/a	POST						
Express	0.5 oz/a	POST	93	100	61	0	90	18
Assure II	8.8 fl oz/a	POST						
COC	1.5	POST						
LSD (P=.05)			13	24	11	18	15	5
CV			10	18	10	20	13	34
Treatment Prob(F)			0.0001	0.0007	0.0001	0.0001	0.0001	0.0001

Express = Express Total Sol, 50% a.i. tribenuron.
Sequence = Dual II + glyphosate.

BENEFIT OF FUNGICIDE APPLICATIONS IN THE 2007 WHEAT CROP

Curtis Thompson, Alan Schlegel, Tanner Gillum[1], Mike Deewall[2], and Andrea Burns[3]

SUMMARY

Results from the irrigated Tam 110 wheat experiment in Garden City, the dryland Jagalene experiment in Tribune, and the wheat demonstrations in Clark, Comanche, and Ford Counties show the importance of treating wheat with fungicide to preserve wheat yield and quality when leaf diseases, especially leaf rust, are infesting the wheat crop. Wheat infested with leaf rust can have 10% to 15% yield increases when treated with a properly timed fungicide application. Yield and quality in the 2007 experiments were greater than in previous years. The most important factor is not which fungicide to use but fungicide use in general. Fungicide application frequently increased test weight and seed size. Certified seed growers should plan to use fungicide on wheat that is at risk of being infested with fungal leaf diseases.

INTRODUCTION

Leaf diseases, especially leaf or stripe rust, often infest wheat grown in western Kansas. Yield reduction due to disease is affected by variety, wheat yield potential, level of disease pressure, and environmental conditions affecting disease development. Stripe rust infested wheat and reduced yields in 2001, 2003, and 2005. All disease pressure was very low during the 2006 wheat growing season because of severe drought and poor wheat development in Texas and Oklahoma in the fall of 2005 and spring of 2006. Wheat to the south was in much better condition in the fall of 2006 and spring of 2007.

PROCEDURES

Experiments were established at the Kansas State University Southwest Research-Extension Center in Garden City, KS, and Tribune, KS, during the fall of 2006. Tam 110 was planted at 90 lb/a on irrigated and 60 lb/a on dryland on October 13, 2006, at Garden City. Jagalene was planted at 75 lb/a on October 10, 2006 at Tribune. Wheat varieties were planted during October in Clark, Comanche, and Ford Counties in Kansas. All fungicide treatments were applied with a backpack sprayer delivering 20 gal/a at all timings and locations. Unless otherwise stated in the data tables, fungicides were applied to wheat at the emerged flagleaf stage and prior to head emergence. All wheat was harvested with a plot combine. Each experiment at Garden City and Tribune was a randomized complete block design with four replications. Data from each county demonstration was treated as a replication, and data were combined. In southern Clark County, two locations (grazed and not grazed) were included. In addition, a northern Clark County location at Mineola, a Comanche County location south of Cold Water, and a site in Ford County east of Dodge City were included in the analysis. Individual data from the locations are not shown.

RESULTS AND DISCUSSION

Wheat grown in Clark, Comanche, and Ford counties might have been affected by an April freeze. Disease pressure, especially leaf rust, was severe at all locations including Garden City and Tribune. Untreated wheat flag leaves of susceptible varieties were infested with leaf rust prior to wheat heading.

Irrigated Tam 110 was very responsive to fungicide applications (Table 1). Quilt-treated wheat yielded 96 bu/a, 32 bu/a (50% increase) more than untreated wheat. All fungicides applied at the F9 (flag leaf) stage increased wheat yields. Wheat treated with Tilt at 4 fl oz/a or Headline at 3 fl oz/a applied at the F9 stage yielded less than other fungicide treatments applied at the F9 stage. Headline at 3 oz/a applied at the F5-6 stage (jointing) did not increase wheat yield. Split applications of Headline at F5-6 and F9 stages did not

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increase wheat yield compared with Headline applied only at the F9 stage.

Tam 110 test weight increased 2.4 to 3.7 lb/bu when fungicides were applied to wheat at the F9 stage compared with untreated wheat. Quilt- and experimental fungicide-treated wheat had the highest test weights. No test weight increases were observed from early-applied Headline treatment. Seed size increased when fungicides were applied to wheat at the F9 stage.

Despite heavy leaf rust infestation on dryland Tam 110 at Garden City, fungicide did not affect wheat yield or quality (Table 2). Visual observations of disease level indicated fungicide reduced flagleaf destruction; however, drought resulted in premature flagleaf death. This explains the lack of yield and quality response.

Jagalene wheat yields increased 14 to 15 bu/a (21% to 23%) when treated with Headline, Quadris, or Quilt at Tribune (Table 3). Wheat yields increased 11 bu/a when treated with Tilt or Stratego. Test weights were more than 61 lb/bu even if fungicide was not applied, indicating that growing conditions were very favorable during the grain fill period. Untreated wheat tended to have the lowest test weight, the driest grain, and the smallest seed size.

Combined data from the county demonstrations are shown in Table 4. Fungicide-treated wheat yielded 8 bu/a (24%) more than untreated wheat when averaged over all varieties. Variety by fungicide interaction was not significant, indicating that wheat varieties responded to fungicide application similarly. Rust-resistant wheat varieties had increased yield when treated with fungicide, an indication that other leaf fungal diseases were reducing grain yield. Fungicide-treated wheat had 1.5 lb/bu higher test weight than untreated wheat averaged over varieties. Also, fungicide-treated wheat had large kernel size. Overley was the largest-seeded variety. Fungicide application did not affect grain moisture.

Table 1. Irrigated Tam 110 wheat response to fungicide treatments, Garden City, 2007

Treatment	Rate	Growth Stage	Yield at 13% moisture (bu/a)	Test Weight (lb/bu)	Moisture (%)	Kernel Weight (seed/lb)	Flag leaf destruction (%)
Untreated			64	56.6	11.0	17260	99
Headline	3 fl oz/a	F5-6	66	57.0	10.9	16780	100
Headline	3 fl oz/a	F5-6	85	59.0	11.2	14980	56
Headline	3 fl oz/a	F9					
Headline	3 fl oz/a	F5-6	92	59.5	11.3	13720	29
Headline	6 fl oz/a	F9					
Headline	6 fl oz/a	9	93	59.7	11.1	14370	33
Quilt	14 fl oz/a	9	96	60.3	11.1	13870	21
Tilt	4 fl oz/a	9	87	59.2	11.2	14860	70
Stratego	10 fl oz/a	9	90	59.5	11.1	14430	38
Absolute 500 SC[a]	5 fl oz/a	9	94	60.2	11.2	13600	21
Prosaro 421 SC[a]	6.5 fl oz/a	9	93	60.3	11.2	13790	23
Induce	0.125 % v/v	9					
LSD (0.05)			7	0.4	0.2	580	18
(P > F)			0.0001	0.0001	0.0869	0.0001	0.0001

[a] Not a registered treatment.

Table 2. Dryland Tam 110 wheat response to fungicide treatments, Garden City, 2007

Treatment	Rate	Growth Stage	Yield (bu/a)	Test Weight (lb/bu)	Moisture (%)	Kernel Weight (seed/lb)	Flag leaf destruction (%)
Untreated			24	54.0	11.5	18260	48
Headline	3 fl oz/a	F5-6	25	54.4	11.5	18310	43
Headline	3 fl oz/a	F5-6	25	54.6	11.6	18180	3
Headline	3 fl oz/a	F9					
Headline	3 fl oz/a	F5-6	29	55.4	11.7	17010	0
Headline	6 fl oz/a	F9					
Headline	6 fl oz/a	9	22	53.9	11.3	19750	0
Quilt	14 fl oz/a	9	21	53.6	11.5	19160	0
Tilt	4 fl oz/a	9	25	54.3	11.7	18930	0
Stratego	10 fl oz/a	9	23	53.7	11.5	18580	0
Absolute 500 SC[a]	5 fl oz/a	9	26	54.6	11.6	17630	0
Prosaro 421 SC[a]	6.5 fl oz/a	9	28	55.4	11.6	17330	0
Induce[a]	0.125 % v/v	9					
LSD (0.05)			4	1.2	0.3	1440	3
(P > F)			0.0046	0.0301	0.3827	0.013	0.0001

[a] Not a registered treatment.

Table 3. Jagalene wheat response to fungicides, Tribune, 2007

Treatment	Rate (fl oz/a)	Stage	Yield at 13% moisture (bu/a)	Test weight (lb/bu)	Moisture (%)	Kernel weight (seed/lb)
Headline	6	Boot	80	62.1	13.5	14000
Tilt	4	Boot	77	62.2	12.9	14350
Quadris	6	Boot	80	62.0	13.8	13450
Quilt	14	Boot	81	62.1	13.6	13770
Stratego	10	Boot	77	61.8	13.4	13930
Untreated			66	61.4	12.4	14740
LSD (0.05)			7	0.5	0.8	860

Table 4. Wheat variety response to Quilt: Combined data for Ford, Comanche, and three Clark County sites, 2007

	Yield at 13% moisture			Test Weight			Kernel Weight		
Variety	Quilt	No Quilt	Average	Quilt	No Quilt	Average	Quilt	No Quilt	Average
	--------(bu/a)--------			--------(lb/bu)--------			--------(seed/lb)--------		
2137	40	38	39[abcd]	55.3	54.5	54.9[efg]	16815	18381	17563[fg]
2174	42	35	39[abcd]	57.3	56.4	56.9[abcd]	17361	18052	17700[fgh]
Above	47	30	38[abcde]	54.4	52.1	53.3[ghi]	16272	19278	17631[fghi]
Cutter	37	27	32[fg]	55.3	52.2	53.8[fgh]	18418	19527	18956[hi]
Danby	40	34	37[bcde]	57.8	57.1	57.5[a]	17295	17665	17462[efg]
Endurance	41	37	39[abcd]	56.5	54.9	55.7[bcde]	16099	17665	16846[cdef]
Jagalene	37	28	33[fg]	56.2	54.8	55.5[de]	17197	19485	18270[gh]
Jagger	36	26	31[g]	53.8	52.2	53.0[hi]	19036	20359	19696[i]
Keota	42	33	37[bcde]	55.8	54.0	54.9[efg]	15548	17495	16479[bcde]
OKBullet	35	32	33[efg]	56.5	54.1	55.3[def]	17132	18052	17597[fg]
Overley	39	34	36[cdef]	56.4	55.0	55.7[cde]	14910	15958	15416[a]
PostRock	46	38	42[a]	57.6	56.8	57.2[ab]	17036	17197	17132[def]
Protection	37	27	32[fg]	52.8	50.6	51.7[i]	16157	18016	17036[def]
RonL	46	35	41[ab]	57.7	56.3	57.0[abc]	14910	16331	15575[ab]
SantaFe	42	38	40[ab]	53.7	53.3	53.5[gh]	18381	18607	18493[ghi]
Stanton	46	36	41[ab]	57.2	56.2	56.7[abcd]	15628	17036	16302[abc]
Tam112	38	33	35[def]	56.4	55.2	55.8[bcde]	15791	16972	16360[abcd]
Average	41 A	33 B		55.9 A	54.5 B		16630 A	17945 B	

Within columns, values without a common superscript differ ($P < 0.05$).
Regardless of parameter measure, Fungicide was significant, Variety was significant, but Fungicide by Variety was not significant.

EFFICACY OF FIPRONIL APPLIED AS FOLIAR AND SEED TREATMENT TO CONTROL *DECTES* STEM BORERS IN SOYBEAN, GARDEN CITY, KS, 2007 – SOUTH CIRCLE

Holly Davis[1], Larry Buschman, Phil Sloderbeck, and Ankush Joshi

SUMMARY

We tested seed and foliar fipronil insecticide treatments applied to five soybean varieties to determine the treatments' effectiveness at reducing *Dectes* stem borers (*Dectes texanus*) in soybean. The foliar treatment of fipronil significantly reduced *Dectes* stem borer infestations 61% and 76%, depending on the variable measured. These treatments increased yield 10.5%. Different soybean varieties had significantly different yields. The seed treatment was evaluated at three different rates. Seed treatments significantly reduced *Dectes* stem borer infestations 85% at the high rate, 70% at the medium rate, and 47% at the low rate. On average, treated plots yielded 1.4% less than untreated plots, but this was not statistically significant. *Dectes* stem borer infestation averaged 68% infested plants. There was a thrips (Thysanoptera: Thripidae) infestation in late June to early July. Sampling indicated that there was a significant difference in number of thrips found on different varieties. The high and medium rate fipronil seed treatment appeared to reduce thrips populations, but differences were not significant.

PROCEDURES

Seed of five commercial soybean varieties in maturity groups III through to IV was machine planted at 16 seeds/row-foot on May 23, 2007, in a half circle of irrigated soybeans on the Southwest Research and Extension Center, Garden City, KS. Plots were four rows wide and 20 ft long. There was a 3-ft-wide alley at each end of the plot. The study design was a randomized complete block with four replications. There was a treated and untreated plot of each variety in each replication. The foliar treatment of fipronil was applied on July 23 during the peak of the beetle flight (Fig. 1). This treatment targeted the first two instars developing inside the plants. The foliar treatment was applied with a backpack sprayer using a handheld boom with two nozzles (Conejet TXVS 6) directed at a single row. Nozzles were held 6 to 8 in. from the plants to maximize coverage of the upper canopy. The sprayer was calibrated to deliver 24.7 gal/a (7.5 sec/20 ft row at 35 psi). A chronometer was used to measure the time spent on each row to help maintain appropriate speed. The foliar experiment was analyzed as a two-factor ANOVA with four levels of variety and two levels of treatment. The seed treatment experiment was analyzed as an ANOVA with four treatments.

Dectes stem borer infestations were recorded at the end of the season (September 13-27) by dissecting five consecutive plants from two sections from the two outside rows in each plot for a total of 20 plants. Plants were dissected to record entry nodes, upper stem tunneling, tunneling that reached the base of the plant, and presence of live *Dectes* larvae. Percentage of girdled plants was recorded on March 14, 2008, for plants in 3 ft of row. Grain yield data were collected by machine harvesting plots October 5 and converted to bu/a at 13% moisture.

On July 6, thrips samples were taken by collecting 10 plants/plot. Samples were placed in 76-L Berlese funnels, and thrips were collected in 70% methanol. Thrips were filtered on white filter paper using a Buchner funnel. Thrips from each plot were counted using a dissecting microscope. Data were analyzed as an ANOVA with eight treatments.

RESULTS AND DISCUSSION

Dectes stem borer infested 68% of plants in 2007. Timing of the foliar application was a week later than intended (Fig. 1). The foliar fipronil treatment significantly reduced *Dectes* stem borer infestations 69%, 63%, 69%, 70%, and 76% for entry nodes, stem tunneling, base

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tunneling, live larvae, and stem girdling, respectively (Table 1; Fig. 2 and 3). Because the fipronil application was late, some larvae were able to start tunneling in the upper stems; but, fipronil still killed the larvae and gave 69% control. There were no significant differences in *Dectes* infestations across different varieties (Table 1). The foliar treatments reduced girdling (Fig. 4). Yields were significantly different between varieties and between foliar treated and untreated plots. Treated plots averaged 35.8 bu/a, and untreated plots averaged 32.4 bu/a (Table 1; Fig. 5). Variety KS4404RR consistently gave the highest yields (41.2 bu/a treated and 38.1 bu/a untreated), and Dyna-GroDB32C25 consistently gave the lowest yields (30.8 bu/a treated and 20.0 bu/a untreated; Table 1). The fipronil seed treatments significantly reduced *Dectes* stem borer infestations at all treatment rates (Table 2; Fig. 6 and 7). The high rate of treatment reduced infestations 76% to 90%, but the three treatments were not significantly different (Table 2). The seed treatments also reduced girdling 49-97% (Fig. 8). Fipronil seed treated plots had lower grain yields (1.4%), but this was not a significant decrease (Fig. 9).

Soybean varieties KS4404RR and KS4704RR had significantly lower thrips populations than Dyna-Gro DB32C45 and Pioneer 93M92 (Table 3). The fipronil seed treatments at the high and medium rates of application appeared to reduce thrips populations, but differences were not significant (Table 3).

Fig. 1. ***Dectes*** **Stem Beetles in 200 Sweeps in Soybeans 2007**

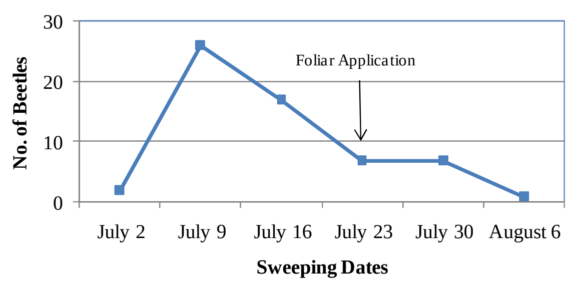


Fig. 2. ***Dectes*** **Stem Borer Entry Nodes Per 20 Plants: Foliar Treatment**

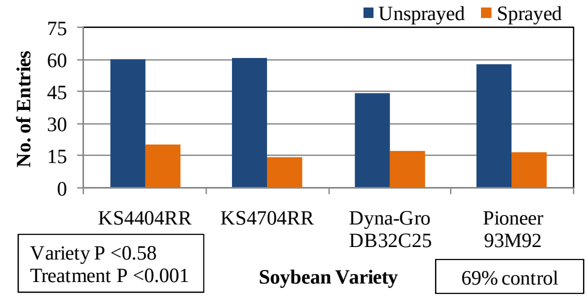


Fig. 3. ***Dectes*** **Stem Borer Larvae Per 20 Plants: Foliar Treatment**

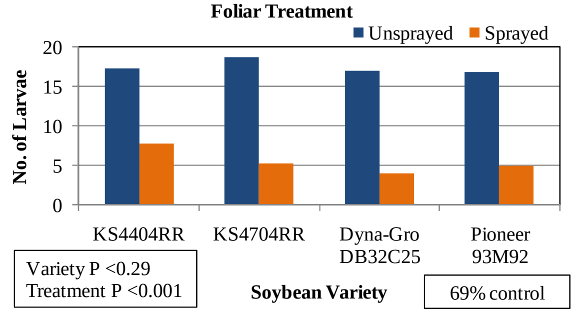
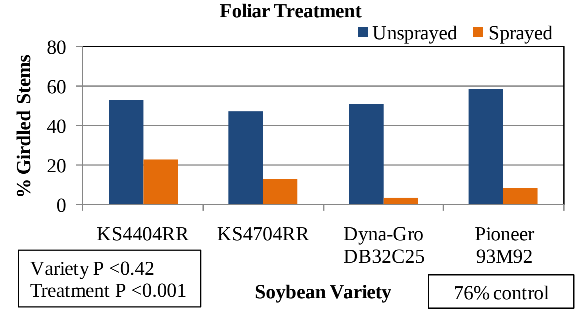


Fig. 4. % Stems Girdled by ***Dectes*** **Stem Borer in Foliar Treatment**



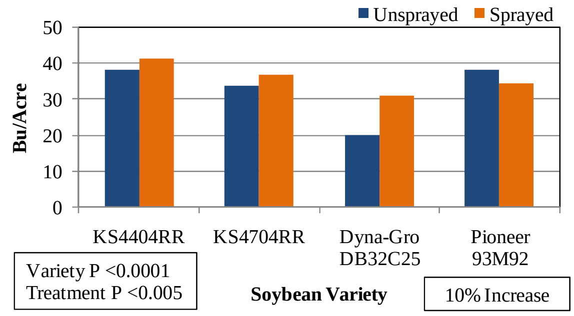


Fig. 5. Grain Yield Bu/Acre: Foliar Treatment

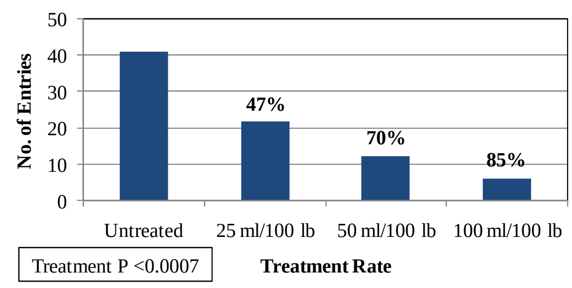


Fig. 6. *Dectes* Stem Borer Entry Nodes Per 20 Plants: Seed Treatment

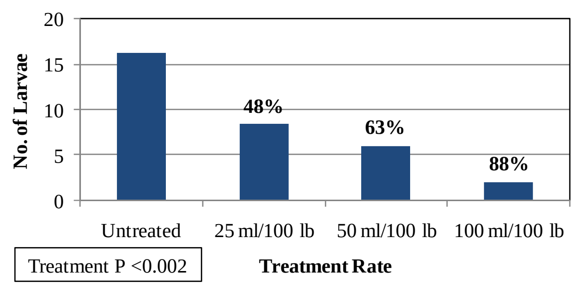


Fig. 7. *Dectes* Stem Borer Larvae Per 20 Plants: Seed Treatment

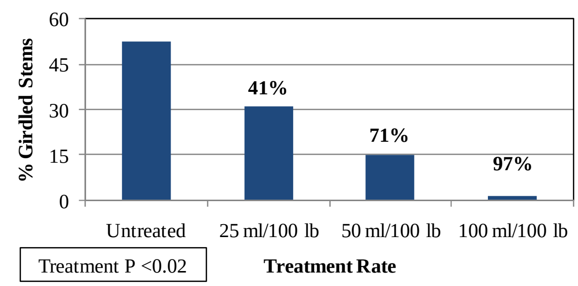


Fig. 8. % Stems Girdled by *Dectes* Stem Borer in Seed Treatment

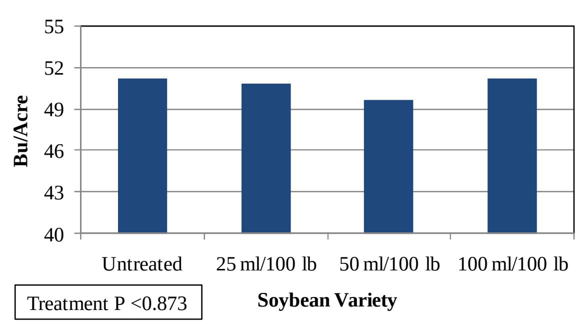


Fig. 9. Grain Yield Bu/Acre: Seed Treatment

Table 1. F-test probability values for ANOVA tests of the two main effects, variety and foliar treatment, Garden City, KS, 2007 – S. Circle

	Soybean Maturity Group	Treatment	Entry Nodes/20 plants	Stem Tunneling /20 plants	Base Tunneling /20 plants	Live Larvae/ 20 plants	Grain Yield bu/a	Girdled Stems %
		ANOVA F-Test Probability – Foliar Treatment						
Variety			0.589	0.865	0.626	0.298	<0.0001	0.42
Insecticide			<0.0001	<0.0001	<0.0001	<0.001	<0.005	<0.001
V x I Interaction			0.584	0.533	0.305	0.340	0.306	0.34
		Variety Means – Foliar Treatment						
KS4404RR	Early IV	Unsprayed	60.5	32.5	16.8	17.3	38.1	53.4
KS4404RR	Early IV	Sprayed	20.5	15.5	7.0	7.8	41.2	22.9
KS4704RR	Mid IV	Unsprayed	60.8	32.8	18.8	18.8	33.6	47.7
KS4704RR	Mid IV	Sprayed	14.8	11.8	5.3	5.3	36.8	13.4
Dyna-Gro DB32C25	Early III	Unsprayed	44.8	28.3	17.5	17.0	20.0	51.0
Dyna-Gro DB32C25	Early III	Sprayed	17.5	15.8	4.3	4.0	30.8	3.6
Pioneer 93M92	Late III	Unsprayed	58.3	29.3	17.0	16.8	38.0	58.7
Pioneer 93M92	Late III	Sprayed	17.0	14.3	5.0	5.0	34.4	9.0
		Main Effects Means for Treatment						
Mean		Unsprayed	56.0^{a}	30.7^{a}	17.5^{a}	17.5^{a}	32.4^{b}	51.5^{a}
Mean		Sprayed	17.5^{b}	14.4^{b}	5.4^{b}	5.5^{b}	35.8^{a}	12.2^{b}
% Control/ Increase			69%	63%	69%	69%	10%	76%

Fipronil treatments were applied as foliar treatments.
Within columns, means without a common superscript differ ($P < 0.05$).

Table 2. F-test probability values and main effects means for ANOVA tests of the seed treatment, Garden City, KS, 2007 – S. Circle

	Soybean Maturity Group	Entry Nodes/20 plants	Stem Tunneling /20 plants	Base Tunneling /20 plants	Live Larvae/ 20 plants	Grain Yield bu/a	Girdled Stems %
	ANOVA F-Test Probability – Seed Treatment						
Insecticide Treatment		<0.0007	<0.0009	<0.001	<0.0002	0.873	<0.02
	Variety Means – Fipronil – Seed Treatment						
Pioneer 93M50 100 ml/100 lb	Mid III	6.0^{b}	4.5^{b}	4.0^{b}	2.0^{b}	51.2	1.5^{b}
Pioneer 93M50 50 ml/100 lb	Mid III	12.3^{b}	9.5^{b}	4.8^{b}	6.0^{b}	49.6	15.4^{b}
Pioneer 93M50 25 ml/100 lb	Mid III	21.8^{b}	14.5^{b}	7.8^{b}	8.5^{b}	50.8	31.2^{ab}
Pioneer 93M50 untreated	Mid III	41.0^{a}	23.8^{a}	15.3^{a}	16.3^{a}	51.2	52.5^{a}
	% Control/Yield Increase						
Pioneer 93M50 100 ml/100 lb		85%	81%	74%	88%	0%	97%
Pioneer 93M50 50 ml/100 lb		70%	60%	69%	63%	-3%	71%
Pioneer 93M50 25 ml/100 lb		47%	39%	49%	48%	-1%	41%

Fipronil treatments were applied as seed treatments.
Within columns, means without a common superscript differ ($P < 0.05$).

Table 3. F-test probability values and main effects means for ANOVA tests of the thrips populations in soybean plant varieties and seed treatments, Garden City, KS, 2007 – S. Circle

ANOVA F-Test Probability	Soybean Maturity Group	Thrips/10 plants
Varieties		<0.006
	Variety Means - Thrips	
KS4404RR	Early IV	59.8^{b}
KS4704RR	Mid IV	59.0^{b}
Dyna-GroDB32C25	Early III	108.6^{a}
Pioneer 93M92		100.8^{a}
	Fipronil Seed Treatment Means- Thrips	
Pioneer 93M50, 100 ml/100 lb	Mid III	81.8^{a}
Pioneer 93M50, 50 ml/100 lb	Mid III	75.3^{a}
Pioneer 93M50, 25 ml/100 lb	Mid III	101.5^{a}
Pioneer 93M50, untreated	Mid III	101.3^{a}
	% Control	
Pioneer 93M50, 100 ml/100 lb		19%
Pioneer 93M50, 50 ml/100 lb		26%
Pioneer 93M50, 25 ml/100 lb		0%

Within columns, means without a common superscript differ ($P < 0.05$).

EFFICACY OF FIPRONIL APPLIED AS FOLIAR AND SEED TREATMENT TO CONTROL *DECTES* STEM BORERS IN SOYBEAN, SCANDIA, KS, 2007

Terutaka Niide[1], Larry Buschman, Barney Gordon[2], Phil Sloderbeck, Holly Davis[1], and Chitvan Khajuria[1]

SUMMARY

We tested the systemic insecticide fipronil applied as a foliar spray or as a seed treatment for effectiveness at suppressing *Dectes* stem borer (*Dectes texanus*) in commercial soybean varieties. Both foliar and seed treatments significantly reduced *Dectes* damage on soybean. There were slight differences in levels of infestation for the four tested varieties, but foliar treatment was effective in each variety. The three doses of fipronil seed treatment significantly reduced *Dectes* infestations. There was a small increase in effectiveness of the highest dose of fipronil over the lowest dose, but this difference was not statistically significant. Treated plots yielded 1.4 to 7.3 bu/a more than untreated plots, but this difference was not statistically significant.

PROCEDURES

Seed of four commercial soybean varieties in maturity groups III and IV were used for evaluating the efficacy of a systemic insecticide, fipronil, applied as foliar treatment. Seed was machine planted at 16 seeds/row-ft on May 28 at the North Central Kansas Experiment Field near Scandia, KS. Plots were four rows wide and 28 ft long. The study design was a randomized block with four replications. There was a treated and untreated plot of each variety in each replication. The foliar treatment of fipronil was applied on July 26 during the beetle flight. This treatment targeted the first two instars developing inside the leaf petioles of the plants. The foliar treatment was applied with a backpack sprayer using a handheld boom with two nozzles (Conejet TXVS 6) directed at a single row. Nozzles were held 6 to 8 in. from the plants to maximize coverage of the upper canopy. The sprayer was calibrated to deliver 4.2 oz/a Regent SC (9.4 sec/25-ft row at 30 psi). A chronometer was used to measure the time spent on each row to help maintain appropriate speed.

Dectes stem borer infestations were observed at the end of the season (September 21) by dissecting two sets of five consecutive plants from each of the two outside rows in each plot for a total of 20 plants. Entry nodes, upper stem tunneling, tunneling that reached the base of the plant, and presence of live larvae were recorded. Percentage of plants girdled was recorded on April 15, 2008. For statistical analysis, the SAS-ANOVA procedure was used to analyze the two factors, variety, and insecticide treatment. Means were compared with LSD. Soybean seed (Pioneer 93M50, maturity group III), was treated with the three rates of fipronil (Regent 500TS); 25, 50, and 100 g /100 kg (a.i.) seed. Other seed was saved to be planted as the check. Seed treatments were planted with the four varieties that were planted for foliar treatment evaluations. Grain yield data on both treatments were collected by machine harvest on November 2 and converted to bu/a at 13% moisture. The SAS-ANOVA procedure was used for statistical analysis, and means were compared with LSD.

RESULTS AND DISCUSSION

Dectes stem borer infestation averaged 61% to 76% plants infested in untreated plots of the four tested varieties. Both foliar and seed treatments of fipronil significantly suppressed *Dectes* stem borer infestations on soybean. Treated plants had significantly lower numbers of entry nodes, stem tunneling, tunneling to the base, and live larva found in 20 sample plants dissected compared with untreated plants (Table 1; Fig. 1 and 2). The percentage of plants infested was also significantly higher in untreated than in treated plants. Although 61% to 76% of

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untreated plants were infested, only 6% to 44% were girdled by the end of the season (Table 1; Fig. 3). Treated plots had virtually no girdling. Average percent control among four varieties ranged from 56% to 100%. Timing of foliar spray appeared to be effective for killing early instars of *Dectes* developing inside leaf petioles of the plants and also appeared to kill larger larvae tunneling in the stem before they reached base of the plant.

All of the seed treatments also significantly reduced all *Dectes* stem borer variables relative to untreated plants (Table 2; Fig. 5 and 6). Percentage of infested plants was reduced 86% to 98%, and the percentage of plants girdled was reduced 100%. Average percent control for the three doses ranged from 83% to 100%. Residual activity of the fipronil seed treatments remained effective even into August, when *Dectes* larvae were tunneling into plant stems. There were no statistical differences in efficacy of the three seed treatment doses. There was a small increase in effectiveness of the highest dose of fipronil over the lowest dose, but this difference was not statistically significant. Both, foliar and seed treatments reduced girdling (Tables 1 and 2; Fig. 3 and 7). Treated plots yielded 1.4 to 7.3 bu/a more than untreated plots, but this difference was not statistically significant. We were not able to show a significant physiological yield loss associated with *Dectes* stem borer infestations (Tables 1 and 2; Fig. 4 and 8).

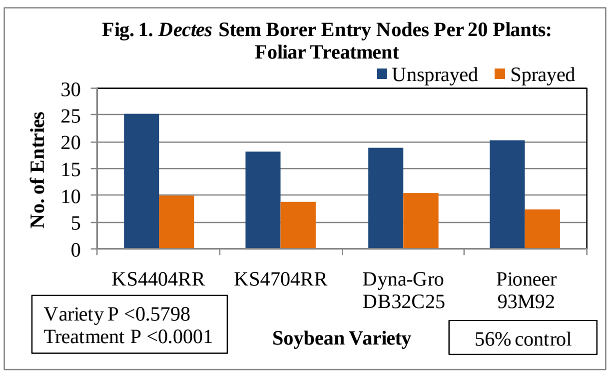

Fig. 1. ***Dectes*** **Stem Borer Entry Nodes Per 20 Plants: Foliar Treatment**

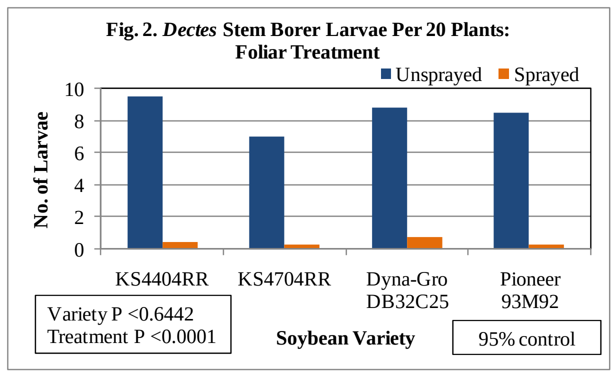

Fig. 2. ***Dectes*** **Stem Borer Larvae Per 20 Plants: Foliar Treatment**

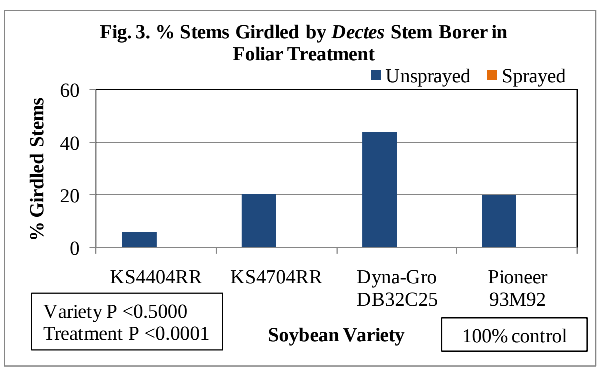

Fig. 3. % Stems Girdled by ***Dectes*** **Stem Borer in Foliar Treatment**

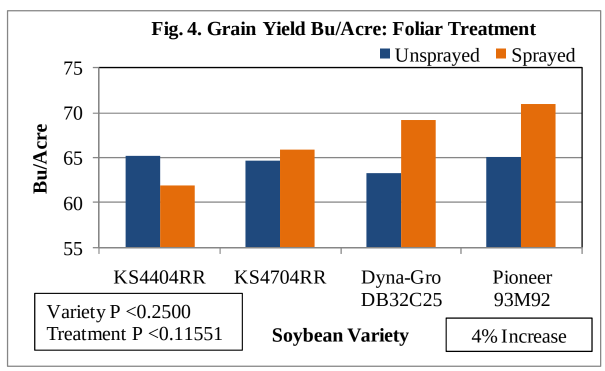

Fig. 4. Grain Yield Bu/Acre: Foliar Treatment

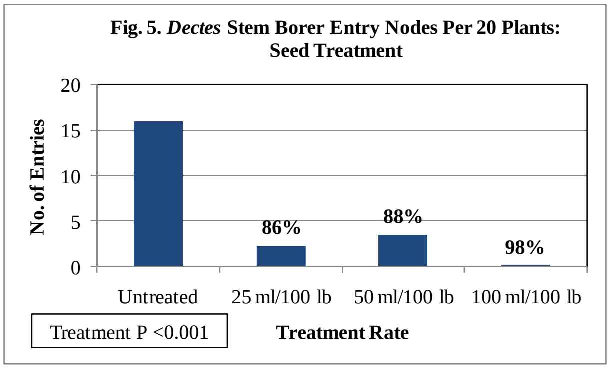
Fig. 5. *Dectes* Stem Borer Entry Nodes Per 20 Plants: Seed Treatment
No. of Entries
20
15
10
5
0
86%
88%
98%
Untreated
25 ml/100 lb
50 ml/100 lb
100 ml/100 lb
Treatment P <0.001
Treatment Rate

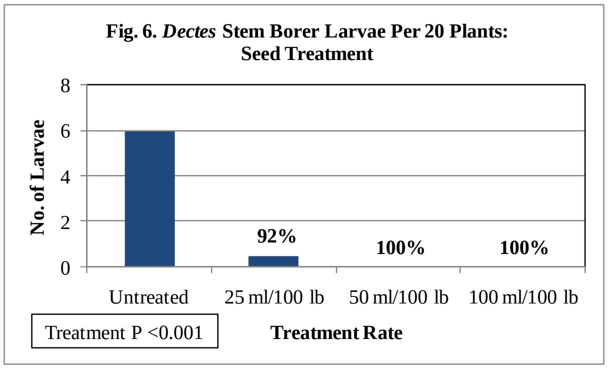
Fig. 6. *Dectes* Stem Borer Larvae Per 20 Plants: Seed Treatment
No. of Larvae
8
6
4
2
0
92%
100%
100%
Untreated
25 ml/100 lb
50 ml/100 lb
100 ml/100 lb
Treatment P <0.001
Treatment Rate

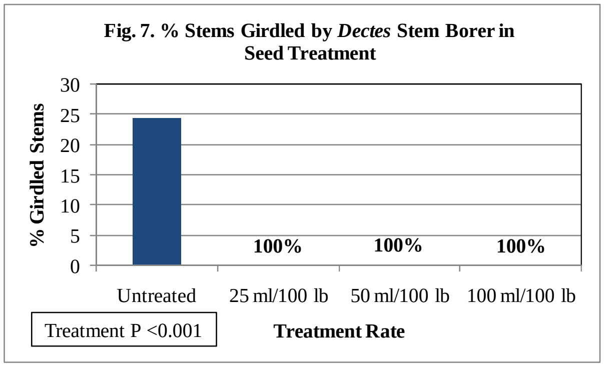
Fig. 7. % Stems Girdled by *Dectes* Stem Borer in Seed Treatment
% Girdled Stems
30
25
20
15
10
5
0
100%
100%
100%
Untreated
25 ml/100 lb
50 ml/100 lb
100 ml/100 lb
Treatment P <0.001
Treatment Rate

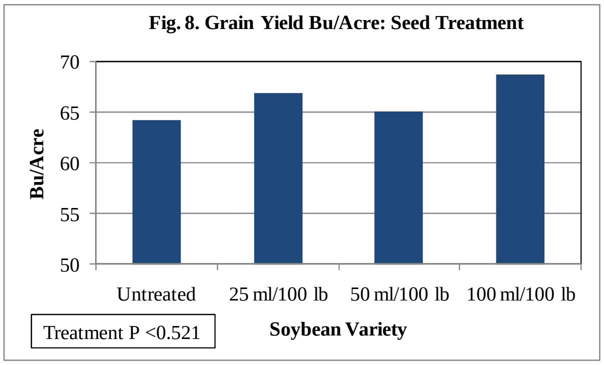
Fig. 8. Grain Yield Bu/Acre: Seed Treatment
Bu/Acre
70
65
60
55
50
Untreated
25 ml/100 lb
50 ml/100 lb
100 ml/100 lb
Treatment P <0.521
Soybean Variety

Table 1. F-test probability values for ANOVA tests of the two main effects, variety and insecticide treatment, Irrigation Experiment Field, Scandia, KS, 2007

	Soybean Maturity Group	Treatment	Entry Nodes/20 plants	Stem Tunneling /20 plants	Base Tunneling /20 plants	Live Larvae/ 20 plants	Grain Yield bu/a	Girdled Stems %
			ANOVA F-Test Probability – Foliar Treatment					
Variety			0.5798	0.3855	0.0337	0.6442	0.2500	<0.5000
Insecticide			<0.0001	<0.0001	<0.0001	<0.0001	0.1151	<0.0001
V x I Interaction			0.6988	0.372	0.0948	0.7939	0.1258	<0.5000
			Variety Means – Foliar Treatment					
KS4404RR	Early IV	Unsprayed	25.3	16.8	5.8	9.5	65.2	6.3
KS4404RR	Early IV	Sprayed	10.0	6.5	0.3	0.5	62.0	0.0
KS4704RR	Mid IV	Unsprayed	18.3	11.8	3.3	7.0	64.6	20.5
KS4704RR	Mid IV	Sprayed	8.8	5.3	0.0	0.3	65.9	0.0
Dyna-Gro DB32C25	Early III	Unsprayed	19.0	12.5	8.5	8.8	63.3	44.0
Dyna-Gro DB32C25	Early III	Sprayed	10.5	8.0	0.5	0.8	69.2	0.0
Pioneer 93M92	Late III	Unsprayed	20.5	14.3	5.0	8.5	65.0	20.3
Pioneer 93M92	Late III	Sprayed	7.5	4.8	0.3	0.3	70.9	0.0
			Main Effects Means for Treatment					
Mean		Unsprayed	20.8[a]	13.8[a]	5.6[a]	8.4[a]	64.5	22.8[a]
Mean		Sprayed	9.2[b]	6.1[b]	0.3[b]	0.4[b]	67.0	0.0[b]
% Control/ Yield Increase			55.7%	55.8%	94.6%	95.2%	+3.9%	100.0%

Fipronil treatments were applied as foliar treatments.

Within columns, means without a common superscript differ ($P < 0.05$).

Table 2. F-test probability values and main effects means for ANOVA tests of the application rates of the insecticide treatment, Irrigation Experiment Field, Scandia, KS, 2007

	Soybean Maturity Group	Entry Nodes/20 plants	Stem Tunneling /20 plants	Base Tunneling /20 plants	Live Larvae/ 20 plants	Grain Yield bu/a	Girdled Stems %
	ANOVA F-Test Probability – Seed Treatment						
Insecticide Treatment		<0.001	<0.001	<0.001	<0.001	0.521	<0.001
	Variety Means – Fipronil – Seed Treatment						
Pioneer 93M50 100 ml/100 lb	Mid III	0.3[b]	0.0[b]	0.0[b]	0.0[b]	68.7	0.0[b]
Pioneer 93M50 50 ml/100 lb	Mid III	3.5[b]	1.8[b]	0.0[b]	0.0[b]	65.0	0.0[b]
Pioneer 93M50 25 ml/100 lb	Mid III	2.3[b]	1.5[b]	0.3[b]	0.5[b]	66.9	0.0[b]
Pioneer 93M50 untreated	Mid III	16.0[a]	11.0[a]	3.5[a]	6.0[a]	64.2	24.5[a]
	% Control/Yield Increase						
Pioneer 93M50 100 ml/100 lb		98.1%	100%	100%	100%	7.0%	100%
Pioneer 93M50 50 ml/100 lb		88.2%	83.6%	100%	100%	1.2%	100%
Pioneer 93M50 25 ml/100 lb		86.3%	85.4%	91.4%	91.7%	4.2%	100%

Fipronil treatments were applied as seed treatments.
Within columns, means without a common superscript differ ($P < 0.05$).

EFFICACY OF FIPRONIL APPLIED AS FOLIAR AND SEED TREATMENT TO CONTROL *DECTES* STEM BORERS IN SOYBEAN, GARDEN CITY, KS, 2007 – RAMSEY FIELD

Holly Davis[1], Larry Buschman, Terutaka Niide[1], Ankush Joshi, and Chitvan Khajuria[1]

SUMMARY

We tested seed and foliar fipronil insecticide treatments applied to five soybean varieties to determine the treatments' effectiveness for reducing *Dectes* stem borers (*Dectes texanus*) in soybean. Foliar applications of fipronil significantly reduced *Dectes* stem borer infestations in the different varieties between 68% and 74%. These treatments increased yield only 5.4%, which was not statistically significant. The seed treatment was tested at three different rates. The seed treatment significantly reduced *Dectes* stem borer infestations 96% at the high rate, 88% at the medium rate, and 82% at the low rate. However, these treatments increased yield only 3.5%, which was not statistically significant. *Dectes* stem borer infestation averaged 19% infested plants. There was a thrips (Thysanoptera: Thripidae) infestation in mid to late June. There was no significant difference in thrips populations among different soybean varieties. However, all fipronil seed treatments significantly reduced thrips populations relative to untreated plots.

PROCEDURES

Seed of five commercial soybean varieties in maturity groups III through to IV was machine planted at 16 seeds/row-foot on June 5, 2007, in a half circle of irrigated soybeans on the Ramsey Brothers Farm 4 miles north of Garden City, KS. Plots were four rows wide and 20 ft long. There was a 3-ft-wide alley at each end of the plot. The study design was a randomized complete block with four replications. The foliar treatment of fipronil was applied on July 23 during the *Dectes* stem borer flight (Fig. 1). There was a treated and untreated plot for each variety in each replication. This treatment targeted the first two instars developing inside the plants. The foliar treatment was applied with a backpack sprayer using a handheld boom with two nozzles (Conejet TXVS 6) directed at a single row. Nozzles were held 6 to 8 in. from the plants to maximize coverage of the upper canopy. The sprayer was calibrated to deliver 24.7 gal/a (7.5 sec/20-ft row at 35 psi). A chronometer was used to measure the time spent on each row to help maintain appropriate speed. The foliar experiment was analyzed as a two-factor ANOVA with four levels of variety and two levels of treatment. The seed treatment experiment was analyzed as an ANOVA with four treatments.

Dectes stem borer infestations were recorded at the end of the season (September 28) by dissecting five consecutive plants from each of the four rows in each plot for a total of 20 plants. Plants were dissected to record entry nodes, upper stem tunneling, tunneling that reached the base of the plant, and presence of live *Dectes* larvae. Percentage of girdled plants was recorded March 19, 2008, for plants in 3 ft of row. Grain yield data were collected by machine harvest on October 19 and converted to bu/a at 13% moisture.

On June 21, thrips samples were taken by collecting 10 plants/plot. Samples were placed in 76-L Berlese funnels, and thrips were collected in 70% methanol as the preservative. Thrips were filtered onto lined white filter paper using a Buchner funnel. Thrips from each plot were counted using a dissecting microscope. Data were analyzed as an ANOVA with eight treatments.

RESULTS AND DISCUSSION

Dectes stem borer infested 19% of plants in 2007. We were able to apply the foliar fipronil treatment at the peak of beetle flight (Fig. 1). The foliar fipronil treatment significantly reduced *Dectes* stem borer infestations 65% to 94% for entry nodes, stem tunneling, base tunneling, live larvae, and stem girdling (Table 1; Fig. 2 and 3). Because

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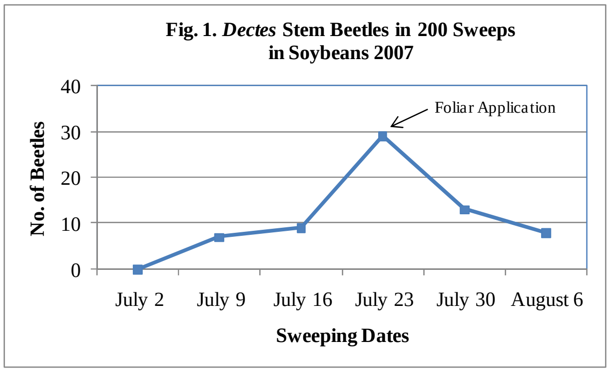
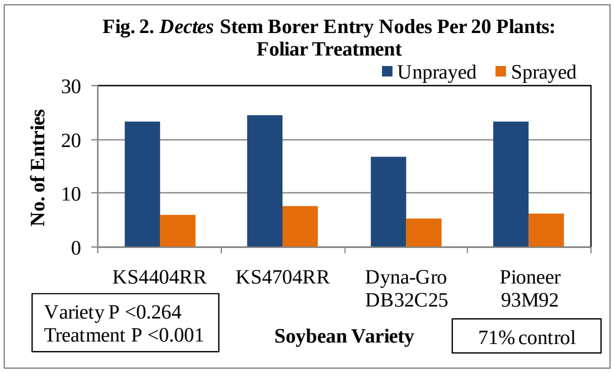
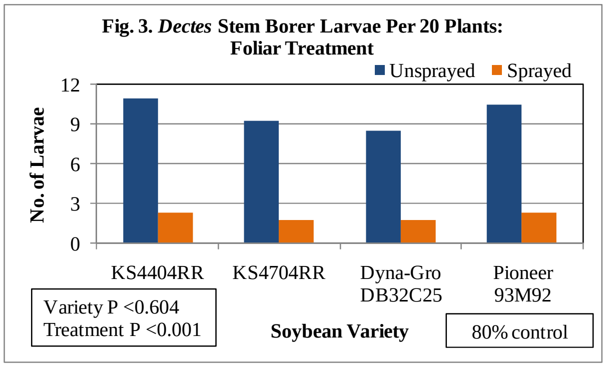
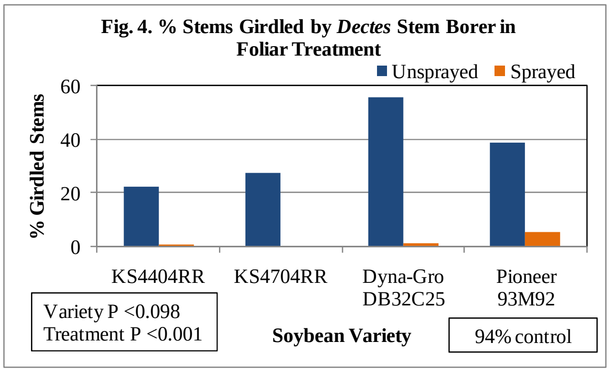
the timing of the application was better, control also was better. There were no significant differences in *Dectes* infestations across different varieties. Foliar treatments significantly reduced girdling (Fig. 4) but only increased yield 5.7%, which was not statistically significant (Table 1; Fig. 5). The fipronil seed treatments significantly reduced *Dectes* stem borer infestations at all rates of application (Table 2; Fig. 6 and 7). The seed treatments also reduced girdling 94% to 100% (Fig. 8) but only increased grain yield 3.5%, which was not statistically significant (Table 2; Fig. 9). The 2007 results suggest there was little yield loss associated with such low *Dectes* stem borer infestations.

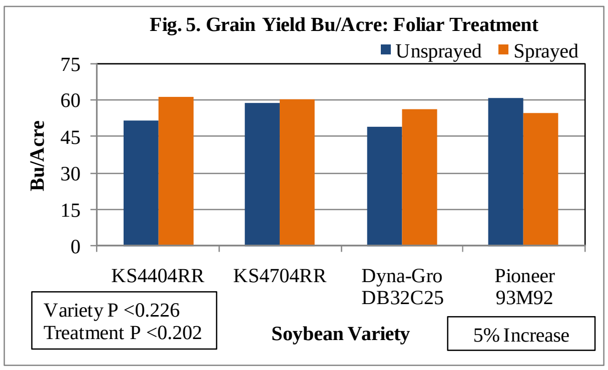
There was a thrips (Thysanoptera: Thripidae) infestation in mid to late June. There was no significant difference in thrips populations among different soybean varieties (Table 3). However, all fipronil seed treatments significantly reduced thrips populations relative to the untreated plots (Table 3).

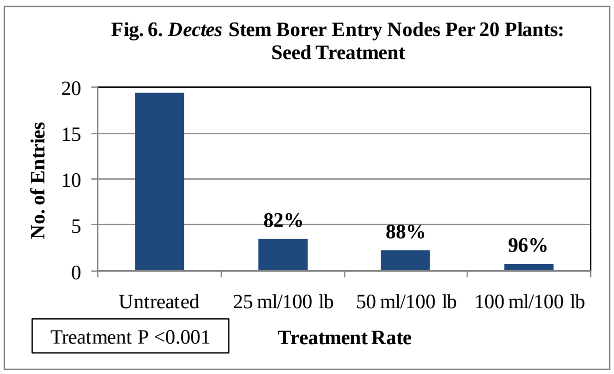












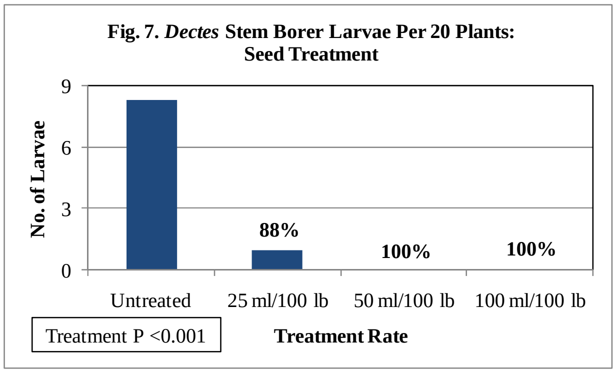


Fig. 7. *Dectes* Stem Borer Larvae Per 20 Plants: Seed Treatment
No. of Larvae
9
6
3
0
88%
100%
100%
Untreated
25 ml/100 lb
50 ml/100 lb
100 ml/100 lb
Treatment P <0.001
Treatment Rate

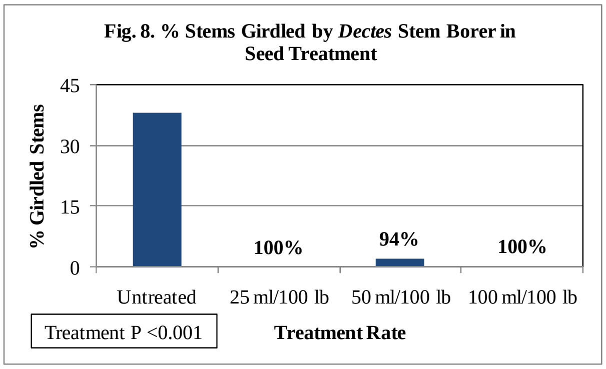


Fig. 8. % Stems Girdled by *Dectes* Stem Borer in Seed Treatment
% Girdled Stems
45
30
15
0
100%
94%
100%
Untreated
25 ml/100 lb
50 ml/100 lb
100 ml/100 lb
Treatment P <0.001
Treatment Rate

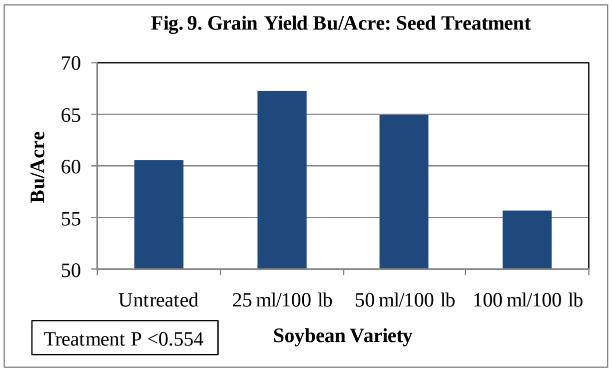


Fig. 9. Grain Yield Bu/Acre: Seed Treatment
Bu/Acre
70
65
60
55
50
Untreated
25 ml/100 lb
50 ml/100 lb
100 ml/100 lb
Treatment P <0.554
Soybean Variety

Table 1. F-test probability values for ANOVA tests of the two main effects, variety and foliar treatment, Garden City, KS, 2006 - Ramsey Field

	Soybean Maturity Group	Treatment	Entry Nodes/20 plants	Stem Tunneling /20 plants	Base Tunneling /20 plants	Live Larvae/ 20 plants	Grain Yield bu/a	Girdled Stems %
			ANOVA F-Test Probability – Foliar Treatment					
Variety			0.264	0.282	0.619	0.604	0.226	<0.098
Insecticide			<0.001	<0.001	<0.001	<0.001	0.202	<0.001
V x I Interaction			0.575	0.655	0.970	0.868	0.087	0.238
			Variety Means – Foliar Treatment					
KS4404RR	Early IV	Unsprayed	23.5	13.3	10.0	11.0	51.5	22.4
KS4404RR	Early IV	Sprayed	6.0	4.8	1.8	2.3	61.4	0.8
KS4704RR	Mid IV	Unsprayed	24.5	16.5	8.5	9.3	58.8	27.8
KS4704RR	Mid IV	Sprayed	7.8	5.5	1.0	1.8	60.0	0.0
Dyna-Gro DB32C25	Early III	Unsprayed	16.8	11.3	8.8	8.5	49.2	55.6
Dyna-Gro DB32C25	Early III	Sprayed	5.5	4.3	1.8	1.8	56.3	1.6
Pioneer 93M92	Late III	Unsprayed	23.5	16.0	10.3	10.5	60.9	39.0
Pioneer 93M92	Late III	Sprayed	6.3	5.3	2.5	2.3	54.7	5.6
			Main Effects Means for Treatment					
Mean		Unsprayed	22.1^{a}	14.3^{a}	9.4^{a}	9.8^{a}	55.1	36^{a}
Mean		Sprayed	6.4^{b}	5.0^{b}	1.8^{b}	2.0^{b}	58.1	2^{b}
% Control/ Yield Increase			71%	65%	81%	80%	5%	94%

Fipronil treatments were applied as foliar treatments.
Within columns, means without a common superscript differ ($P < 0.05$).

Table 2. F-test probability values and main effects means for ANOVA tests of the application rates of the seed treatment, Garden City, KS, 2007 - Ramsey Field

	Soybean Maturity Group	Entry Nodes/20 plants	Stem Tunneling /20 plants	Base Tunneling /20 plants	Live Larvae/ 20 plants	Grain Yield bu/a	Girdled Stems %
	ANOVA F-Test Probability – Seed Treatment						
Insecticide Treatment		<0.001	<0.001	<0.001	<0.001	0.554	<0.001
	Variety Means – Fipronil – Seed Treatment						
Pioneer 93M50 100 ml/100 lb	Mid III	0.8[b]	0.3[b]	0.0[b]	0.0[b]	55.7	0.0[b]
Pioneer 93M50 50 ml/100 lb	Mid III	2.3[b]	1.5[b]	0.0[b]	0.0[b]	64.9	2.1[b]
Pioneer 93M50 25 ml/100 lb	Mid III	3.5[b]	2.3[b]	0.8[b]	1.0[b]	67.2	0.0[b]
Pioneer 93M50 untreated	Mid III	19.5[a]	14.0[a]	8.5[a]	8.3[a]	60.5	38.1[a]
	% Control/Yield Increase						
Pioneer 93M50 100 ml/100 lb		96%	98%	100%	100%	-8%	100%
Pioneer 93M50 50 ml/100 lb		88%	89%	100%	100%	7%	94%
Pioneer 93M50 25 ml/100 lb		82%	84%	91%	88%	11%	100%

Fipronil treatments were applied as seed treatments.
Within columns, means without a common superscript differ (P < 0.05).

Table 3. F-test probability values and main effects means for ANOVA tests of the thrips populations in soybean plant varieties and seed treatments, Garden City, KS, 2007 - Ramsey Field

ANOVA F-Test Probability	Soybean Maturity Group	Thrips/10 plants
Seed Treatment and Varieties		<0.006
Variety Means - Thrips		
KS4404RR	Early IV	150.8
KS4704RR	Mid IV	236.0
Dyna-GroDB32C25	Early III	248.3
Pioneer 93M92		189.0
Fipronil Seed Treatment Means- Thrips		
Pioneer 93M50, 100 ml/100 lb	Mid III	24.3[b]
Pioneer 93M50, 50 ml/100 lb	Mid III	29.3[b]
Pioneer 93M50, 25 ml/100 lb	Mid III	27.0[b]
Pioneer 93M50, untreated	Mid III	273.3[a]
% Control		
Pioneer 93M50, 100 ml/100 lb		91%
Pioneer 93M50, 50 ml/100 lb		89%
Pioneer 93M50, 25 ml/100 lb		90%

Within columns, means without a common superscript differ (P < 0.05).

EFFICACY OF MONSANTO STACKED EVENT CORN HYBRIDS FOR CONTROL OF SOUTHWESTERN CORN BORER AND CORN EARWORM, 2007

Larry Buschman, Holly Davis[1], and Phil Sloderbeck

SUMMARY

This trial was conducted to evaluate the efficacy of corn hybrids containing events MON89034 (YGVTPRO), MON810 (YGCB) and TC1507 (HXCB) for controlling the corn earworm (CEW), *Helicoverpa zea* (Bobbie), and the southwestern corn borer (SWCB), *Diatraea grandiosella* Dyar. All three of the Bt hybrids gave excellent control of SWCB. Efficacy of the YGVTPRO event was outstanding against both SWCB and CEW. A significant proportion of kernel damage appeared to be attributable to the Dusky Sap Beetle (DSB), *Carpophilus lugubris* Murray, and none of the Bt corn hybrids had efficacy on this insect.

PROCEDURES

Experimental corn seed (supplied by Monsanto) was machine planted on May 21 at the Southwest Research-Extension Center, Garden City, KS. Plots were eight rows wide and 20 ft long. There were 10-ft-wide alleys at each end of the plots. The study design was a randomized block with four replicates. Four rows of non-Bt corn were planted around the experimental plots as a border and windbreak. On July 13, 15 plants in two designated SWCB rows were infested with ≈45 SWCB first instars. On August 10, the rest of the plants in the SWCB rows were infested with ≈15 SWCB first instars. The SWCB eggs were from a laboratory colony provided by Monsanto. A few WBCW first instars from a field-collected egg mass were used to infest two plants in the two WBCW rows in the first three replicates.

On July 24, the 15 SWCB infested plants were evaluated for feeding damage using the Guthrie Rating (1-9). Plants had tasseled at this time. On August 6 and 7, 15 ears from the outside rows in each plot were evaluated for CEW. This was done to catch the CEW before they reached maturity and left the ear. On August 9, a set of five infested plants was dissected to record SWCB damage in the stalks and CEW damage in the ears. In October, another 20 plants were dissected to record end-of-season SWCB damage; five of the plants had been infested on July 13, and 15 had been infested on August 10. There was a significant difference in damage recorded for the two groups of plants, so data are reported separately. Ears were also evaluated for CEW damage. At this stage, however, there was also significant damage from DSB so an effort was made to separate CEW damage from DSB damage. Ear tip damage was measured using the Winstrom scale (cm of feeding penetration plus 1 for silk feeding). The number of harvestable kernels removed by CEW feeding or DSB feeding was counted. Some SWCB damage in the ear base was present and was reported separately from damage at the ear tip, which was associated with CEW or DSB feeding. Tunneling in the stalk or shank was also recorded. Data were analyzed by ANOVA, and means were separated by LSD.

RESULTS AND DISCUSSION

There was considerable variability in the maturity of plants across replicates. On July 20, Treatment 2 (YGCB) had slightly fewer plants showing tassels but difference in maturity across treatments was not significant ($P = 0.1099$).

First-generation SWCB feeding damage was significantly higher in the check than in the Bt corn hybrids (Table 1, Photo 1). Guthrie ratings were lower (4.6) than in other years (up to 7 or 8) because plants were much larger when infested than in other years (Fig. 1). When plants were dissected (August 9), there were significantly more SWCB larvae and more tunneling damage in the check than in the Bt corn hybrids (Table 2, Fig. 2). Results were similar in October; there were significantly more SWCB larvae and more SWCB tunneling damage in the check than in the Bt corn hybrids (Tables 3 and 4).

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Feral CEW pressure was quite high, as usual; 93% of check ears were infested on August 6 and 7 (Tables 1 and 2), and 100% were infested later in the season. On August 6 and 7, CEW larvae were significantly larger (larger instars) in the check than in the Bt corn hybrids, and larvae in Treatment 1, (YGVTPRO) were significantly smaller than those in the Bt corn hybrids (Table 1, Fig. 3). The number of first, second, and third instars did not differ significantly across hybrids, but the number of fourth, fifth, and sixth instars was significantly higher in the check than in the Bt corn hybrids. The number of damaged kernels also was significantly higher in the check than in the Bt corn hybrids, but the number of damaged kernels in Treatment 1 (YGCB) was significantly lower than in the check hybrid (Tables 1 and 2). It is interesting that when kernel damage was assigned to CEW or DSB, the DSB appeared to be responsible for 20% to 40% of kernel damage (Tables 3 and 4, Fig. 4). The DSB damage was not suppressed by any of the Bt corn hybrids, but CEW damage was significantly suppressed by Treatment 1 (YGVTPRO). This year's Winstrom ratings were moderate, reaching 4.9 to 11.3.

Only three western been cutworms *Loxagrotis albicosta* (Smith) were recorded; they were on the control and standard Bt hybrids. A total of 13 DSB larvae were recorded, all on the Bt hybrids. The CEW larvae might have eliminated the larvae from control ears.

Because plant stand and growing conditions were variable, grain yield was variable and there were no significant differences among hybrids. The SWCB row yielded 142.95 bu/a (P = 0.4180), and the CEW row yielded 128.14 bu/a (P = 0.9313).

Efficacy of the all the Bt hybrids was outstanding on SWCB. Efficacy of YGVTPRO was outstanding on both SWCB and CEW. A significant proportion of kernel damage could be attributed to DSB; none of the Bt corn hybrids had efficacy on this insect.

Photo 1. Corn earworm damage on corn ears in the different treatments.
Photos by Larry Buschman

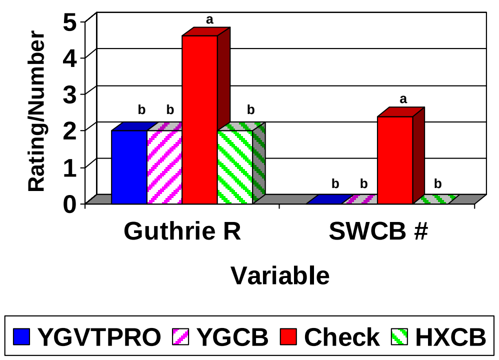

Figure 1. First generation ratings and numbers of southwestern corn borer

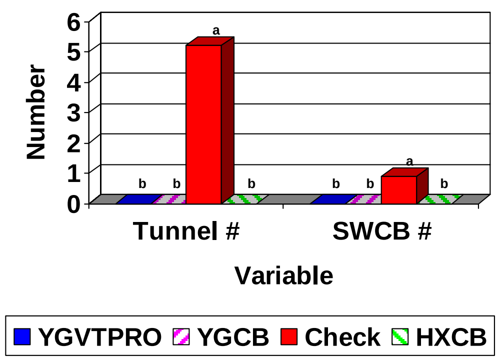

Figure 2. Second generation southwestern corn borer tunnels and numbers of larvae

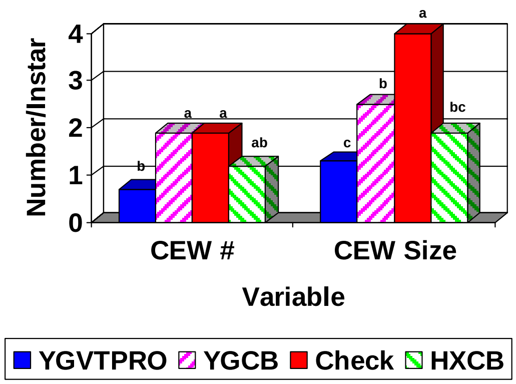

Figure 3. Corn earworms in the ear and corn earworm size

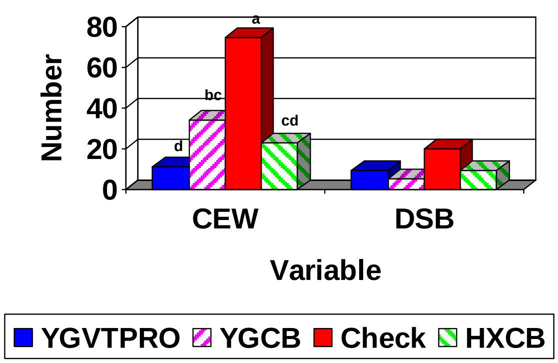

Figure 4. Kernels damaged by corn earworms and dusky sap beetles

Table 1. Southwestern corn borer (SWCB) damage ratings on July 24 and corn earworm (CEW) observations on August 6 and 7

	Means				ANOVA	
	YGVTPRO	YGCB	Check	HXCB	P-value	CV
SWCB (Guthrie Rating 1-9)	2.0[b]	2.0[a]	4.6[a]	2.0[b]	<0.0001	13
CEW (% Ears Infested)	50.5[b]	88.3[a]	93.3[a]	62.3[b]	<0.0225	25
CEW Larvae/Ear	0.7[c]	1.9[ab]	1.9[ab]	1.2[bc]	<0.0067	31
CEW Mean Instar	1.3[c]	2.5[b]	4.0[a]	1.9[bc]	<0.0001	18
Damaged Kernels/Ear	1.0[c]	8.3[b]	34.3[a]	5.8[bc]	<0.0003	27
Mean Damaged Kernels/Damaged Ear	1.5[c]	9.8[b]	38.3[a]	7.0[bc]	<0.0021	29
CEW 1st-3rd Instars/Ear	0.7	1.6	0.6	1.1	<0.1109	26
CEW 4th-6th Instars/Ear	0.0[c]	0.3[b]	1.3[a]	0.1[bc]	<0.0001	28

Within rows, means without a common superscript differ (P < 0.05).

Table 2. Corn earworm (CEW) and southwestern corn borer (SWCB) observations on August 9 from five plants infested with SWCB on July 11

	Means				ANOVA	
	YGVTPRO	YGCB	Check	HXCB	P-value	CV
CEW Larvae/Plant	0.8[b]	2.0[a]	2.3[a]	2.2[a]	0.0001	25
CEW Mean Instar	1.8[c]	3.3[b]	4.9[a]	3.0[bc]	0.0032	25
Damaged Kernels/Ear Tip	2.3[c]	16.9[bc]	88.9[a]	15.7[bc]	0.0002	57
SWCB Larvae/Plant	0.0[b]	0.0[b]	2.4[a]	0.0[b]	0.0001	24
% of Plants With Ear Tongue Feeding	0.0[b]	1.5[b]	80.5[a]	0.0[b]	0.0001	30
SWCB Stalk Tunnels, no.	0.0[b]	0.0[b]	2.6[a]	0.0[b]	0.0001	8
SWCB Stalk Tunnels, cm/plant	0.0[b]	0.0[b]	19.4[a]	0.0[b]	0.0001	12
SWCB Shank Tunnels, no.	0.0[b]	0.0[b]	0.6[a]	0.0[b]	0.0001	16
SWCB Shank Tunnels, cm/plant	0.0[b]	0.0[b]	3.7[a]	0.0[b]	0.0001	33
SWCB Damage Ear Base, cm/plant	0.0[b]	0.0[b]	12.7[a]	0.0[b]	0.0001	40
Damaged Kernels/ Plant Ear Base	0.0[b]	0.4[b]	12.7[a]	0.0[b]	0.0001	52

Within rows, means without a common superscript differ (P < 0.05).

Table 3. End-of-season observations on southwestern corn borer (SWCB), corn earworm (CEW), and dusky sap beetle (DSB) from five plants infested with SWCB on both July 11 and August 10

	Means				ANOVA	
	YGVTPRO	YGCB	Check	HXCB	P-value	CV
SWCB Larvae/Plant	0.0^{b}	0.0^{b}	0.9^{a}	0.0^{b}	<0.0001	14
SWCB Stalk Tunnels, no.	0.0^{b}	0.0^{b}	5.2^{a}	0.0^{b}	<0.0001	4
SWCB Stalk Tunnels, cm/plant	0.0^{b}	0.0^{b}	44.5^{a}	0.0^{b}	<0.0001	16
SWCB Shank Tunnels, no.	0.0^{b}	0.0^{b}	0.6^{a}	0.0^{b}	<0.0001	78
SWCB Shank Tunnels, cm/plant	0.0^{b}	0.0^{b}	1.2^{a}	0.0^{b}	<0.0001	62
SWCB Damage Ear Base, cm/plant	0.0^{b}	0.0^{b}	1.5^{a}	0.0^{b}	<0.0014	150
CEW Winstrom Rating Ear Tip cm/Plant	2.7^{c}	5.1^{bc}	11.3^{a}	4.5^{bc}	<0.0012	15
CEW Kernel Damage Ear Tip/Plant	11.3^{d}	34.2^{bc}	74.7^{a}	23.2^{cd}	<0.0034	15
DSB Kernel Damage/Plant	9.6	5.2	20.1	9.4	<0.4175	50
Total Kernel Damage/Plant	20.9^{c}	39.4^{bc}	94.9^{a}	32.6^{bc}	<0.0058	9

Within rows, means without a common superscript differ ($P < 0.05$).

Table 4. End-of-season observations on southwestern corn borer (SWCB), corn earworm (CEW), and dusky sap beetle (DSB) from 5 plants infested with SWCB on August 10

	Means				ANOVA	
	YGVTPRO	YGCB	Check	HXCB	P-value	CV
SWCB Larvae/Plant	0.0^{b}	0.0^{b}	0.9^{a}	0.0^{b}	<0.0001	31
SWCB Stalk Tunnels, no.	0.0^{b}	0.1^{b}	2.3^{a}	0.0^{b}	<0.0001	50
SWCB Stalk Tunnels, cm/plant	0.0^{b}	0.3^{b}	27.9^{a}	0.0^{b}	<0.0001	50
SWCB Shank Tunnels, no.	0.0^{b}	0.0^{b}	0.3^{a}	0.0^{b}	<0.0005	116
SWCB Shank Tunnels, cm/plant	0.0^{b}	0.0^{b}	0.5^{a}	0.0^{b}	<0.0002	108
SWCB Damage Ear Base, cm/plant	0.0^{b}	0.1^{b}	0.3^{a}	0.0^{b}	<0.0007	91
CEW Winstrom Rating Ear Tip cm/Plant	2.1^{c}	4.2^{bc}	4.9^{a}	2.8^{bc}	<0.0364	20
CEW Kernel Damage Ear Tip/Plant	6.3^{b}	26.3^{a}	33.9^{a}	10.6^{b}	<0.0246	14
DSB Kernel Damage/Plant	12.5	18.4	23.5	17.1	<0.6358	12
Total Kernel Damage/Plant	20.3^{b}	44.7^{a}	57.9^{a}	30.2^{b}	<0.0130	6

Within rows, means without a common superscript differ ($P < 0.05$).

WINTER CANOLA, SPRING CANOLA, AND SPRING CAMELINA VARIETY TRIALS

John Holman, Mike Stamm[1], Curtis Thompson, Gary Miller, and Scott Maxwell

SUMMARY

Winter hardiness is one of the most limiting factors for canola production in Kansas. Other important variety attributes are lodging and shattering resistance and high yield potential. 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 byproduct of oil crushing) as a soybean meal replacement. Winter canola is expected to yield better than spring types in the southern and central Great Plains because high temperatures occur during pod fill for spring types, which reduces the grain fill period and reduces yield. But, because winter varieties have been prone to winter kill and because of producer interest, spring types were evaluated at the Southwest Research Extension Center (SWREC) in Garden City, KS.

High winter precipitation and continuous snow cover enabled canola plants to tolerate very low temperatures during the 2006-2007 winter. Winter canola fall stand and winter survival were excellent. Winter canola yields were high enough to cause substantial lodging of some varieties. Winter canola averaged 2,811 lb/a. Spring canola averaged 734 lb/a, and spring camelina averaged 1,237 lb/a. Shattering was greater in spring canola than spring camelina. Camelina appears to have less shattering potential than canola, and other studies have indicated camelina has greater drought and heat tolerance than canola. Because southwest Kansas is prone to hot, dry, and high wind environmental conditions, camelina might be better suited than canola to this region. Results indicate that winter canola is better suited than spring canola or spring camelina in this region. Evaluation of winter canola varieties and winter camelina at the SWREC is ongoing.

INTRODUCTION

Winter canola production has increased in the southern Great Plains states of Kansas, Oklahoma, and Texas in recent years. Close to 60,000 acres were seeded in the 2005-2006 growing season, with additional acreage increases expected in 2006-2007. Winter canola is a broadleaf crop that was first introduced to the region as a rotational crop with winter wheat. Planting winter canola enables use of alternative herbicides for suppressing hard to control grass weed species and disrupts disease cycles that often plague continuous wheat production systems.

As interest in renewable energy sources gains momentum in the region, demand for canola oil as a feedstock for biodiesel is outpacing our understanding and ability to establish the crop, especially under no-till cropping systems. Establishing winter canola is a more significant undertaking than establishing winter wheat, particularly in years when soil moisture is lacking at fall planting. Stand establishment affects all other periods of the growing season, the most important of which is winter dormancy. Plants that fail to establish adequately in the fall will have limited time to attain the minimum amount of growth necessary to survive the winter in the southern Great Plains. A quality stand provides the greatest opportunity for winter survival and is crucial for harvesting a high-yielding crop.

A lack of current, regional research on stand establishment has slowed farmer acceptance of winter canola. Kansas State University initiated production research using high erucic acid winter rapeseed in the late 1980s and early 1990s at the Northwest Kansas Research-Extension Center and the South Central Kansas Experiment Field, but winter varieties available at the time were not well adapted to the region. Limited winter canola production research has been conducted in the Southeast and Pacific Northwest; however, soil and climatic

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conditions in those areas vary greatly from conditions in the southern Great Plains. Most establishment research has been completed in the primary canola growing regions of North Dakota and Canada using spring canola.

Winter canola is well suited for growing conditions of the southern Great Plains and possesses a 20 to 30% yield advantage over spring canola. Spring types flower 1 month later and are harvested approximately 2 weeks later than winter types. The late flowering of spring types occurs during a hotter period of the growing season; this reduces the grain fill period and yield potential of spring types. Until heat-tolerant spring cultivars are developed, winter canola will be the primary oilseed rape crop grown in the region.

Winter canola establishes best in moist, firm, well-drained, medium-textured soils. It is imperative that canola has appropriate seed-to-soil contact because of its small seed size and shallow planting depth. Obtaining a uniform seeding depth is a challenge but can be accomplished with properly adjusted no-till seeding equipment. No-till cropping practices are used often across the semi-arid Great Plains to conserve surface soil moisture and reduce soil erosion. A canola seedbed that is too fine or overworked will lose soil moisture rapidly, and crusting normally occurs after a heavy rain. Overly coarse seedbeds result in poor seed placement and seed-to-soil contact, and soils dry out rapidly. No-till seeding can help avoid these hindrances to establishment and could also result in fuel savings.

PROCEDURES

Two *Brassica* variety trials were implemented in the 2007 growing season. The first was a winter canola trial planted September 12, 2006, and the second was a spring canola and spring camelina trial planted March 28, 2007. The winter canola variety trial was part of the National Winter Canola Variety Trial planted at 53 locations across the United States during the 2006-2007 growing season. Winter canola was planted at a rate of 5 lb/a, spring canola was planted at a rate of 8 lb/a, and spring camelina was planted at a rate of 7 lb/a. All studies were planted under full irrigation; soil type was a Ulysses silt loam soil. Pendimethalin (Prowl H_20) was applied at a rate of 3 pt/a (product) or 1.43 lb/a (a.i.), and glyphosate (Roundup) was applied at a rate of 1 qt/a (product) or 0.75 lb/a (ae) preplant for all trials. Fall fertilizer was applied at a rate of 140 lb/a N as urea and 14 lb/a S as elemental sulfur. Each trial was a randomized complete block. The winter canola trial had three replications, and the spring canola and camelina trial had four replications. All plots were planted in twelve 7.5-in. rows that were 30 ft long and 7.5 ft wide. Yield calculations were based on plot sizes of approximately 6 ft by 25 ft (5 ft of alley) and adjusted to 9% moisture content. Table 1 provides a list of agronomic characteristics observed during the growing season. Opportunistic notes were taken if necessary. Winter canola was harvested on June 26, 2007, and spring canola and spring camelina were harvested July 16, 2007.

RESULTS AND DISCUSSION

Precipitation was high in December 2006, and snow cover throughout most of the winter enabled canola plants to tolerate very low temperatures (Fig. 1). Winter canola fall stand evaluation (8.5 out of 10) and winter survival (91%) were excellent (Table 2). Winter survival might have been increased because of snow cover that protected plant crowns. Winter canola yields were high enough to cause substantial lodging of some varieties. Plainsman had the greatest lodging (72%), and overall lodging was 13%. Winter canola varieties were harvested at an average moisture content of 11.3%. Canola should be harvested at 9%, but the trial was harvested early to prevent yield differences caused by differences in maturity. When canola is ripe, shattering can occur. Early-maturing varieties would be at a yield disadvantage compared with later-maturing varieties if the study was harvested after all varieties were mature and below 9% moisture content. Shattering averaged 6.1%, which might have been slightly less than grower field conditions because the varieties were harvested early (Table 2). Winter canola yield averaged 2,811 lb/a (Table 2).

Spring canola averaged 734 lb/a, and spring camelina averaged 1,237 lb/a (Table 3). Shattering was greater in canola than camelina (data not shown). Camelina appears to have less shattering potential than canola, and other studies have indicated camelina has greater drought and heat tolerance than canola. Thus, camelina might be better suited to southwest Kansas than canola because the region is prone to hot, dry, and high wind environmental conditions.

Results indicate that winter canola is better suited than spring canola or spring camelina in this region. A current study at the SWREC is continuing to evaluate winter canola varieties as well as winter camelina.

Table 1. Agronomic characteristics observed during the growing season

Characteristic	Description
Fall Stand	Visual growth rating based on 0 to 10 scale with 0 = no stand and 10 = excellent.
Winter Survival	Visual estimate of percent of plants that have survived the winter. Ratings are taken after danger of further winter loss has passed.
Lodging	Visual estimate of percent of plants that have lodged.
Shatter	Visual estimate of percent of seeds lost to shattering. Estimate taken immediately prior to harvest.
Seed Moisture	Percent seed moisture taken at the same time as harvest weight.
Test Weight	Pounds per bushel as determined by standard test weight equipment.
Yield	Reported as pounds per acre. All yield estimates are adjusted to 9% moisture content.
Yield % of Mean	Reported as a percent. Calculated by dividing the entry mean by the plot mean and multiplying by 100.

Table 2. Winter canola variety performance during the 2006-2007 growing season

Entry	Fall Stand (0-10)	Winter Survival (%)	Lodging (%)	Shatter (%)	Moisture (%)	Test Weight (lbs/bu)	Yield (lbs/a)	Yield (bu/a)	Yield (% of Mean)
Baldur	8.6	91	0.0	5.0	10.5	52.2	3651	73.0	130
Taurus	8.5	85	0.0	8.3	10.5	48.8	3533	70.7	126
TCI.06.M4	8.5	88	1.7	6.7	11.4	50.8	3418	68.4	122
X01W522C	8.9	86	3.3	6.7	12.0	48.1	3377	67.5	120
Viking	8.6	86	0.0	5.0	10.4	50.5	3285	65.7	117
Jetton	8.7	93	3.3	5.0	10.7	51.3	3265	65.3	116
ARC2180-1	7.8	96	1.7	5.0	11.0	50.5	3214	64.3	114
DSV06202	8.7	86	10.0	6.7	11.3	49.5	3191	63.8	114
ARC97019	7.8	88	13.3	5.0	12.1	49.0	3177	63.5	113
SLM0402	8.9	93	0.0	5.0	10.4	50.7	3166	63.3	113
NPZ0391RR	8.8	76	1.7	5.0	11.5	51.9	3162	63.2	112
KS3302	8.2	100	6.7	6.7	10.2	51.1	3155	63.1	112
NPZ0591RR	8.9	91	5.0	5.0	11.0	52.1	3140	62.8	112
X02W534C	8.7	93	1.7	5.0	11.1	51.2	3124	62.5	111
NPZ0404	8.2	100	0.0	8.3	11.0	51.2	3124	62.5	111
06UIWC.4	8.4	100	0.0	6.7	11.9	46.7	3093	61.9	110
MH 604001	9.0	78	0.0	6.7	11.0	49.2	3014	60.3	107
KS3018	8.1	83	3.3	6.7	10.8	48.1	3007	60.1	107
ARC97018	8.3	89	5.0	6.7	11.5	48.2	3000	60.0	107
Hybristar	8.5	89	3.3	5.0	10.6	52.1	2994	59.9	107
KS4085	8.4	100	30.0	5.0	11.6	51.3	2985	59.7	106
Ceres	8.3	95	1.7	16.7	11.1	49.3	2983	59.7	106
Falstaff	8.7	100	8.3	5.0	11.0	49.3	2960	59.2	105
Virginia	8.4	100	0.0	5.0	10.8	45.8	2954	59.1	105
Abilene	8.4	94	5.0	8.3	10.3	52.1	2947	58.9	105
Rasmus	8.3	90	0.0	6.7	10.9	51.1	2943	58.9	105
DKW13-62	8.5	88	16.7	5.0	10.7	50.5	2940	58.8	105
X01W692C	9.0	85	0.0	5.0	11.8	50.9	2913	58.3	104
Sumner	8.1	100	5.0	8.3	9.7	44.5	2912	58.2	104
KS3132	8.5	90	25.0	8.3	10.8	49.9	2893	57.9	103
Kronos	8.7	93	21.7	5.0	12.9	47.4	2887	57.7	103
DSV06200	8.3	100	0.0	5.0	11.3	50.4	2885	57.7	103
TCI.06.M2	8.8	82	20.0	5.0	9.8	49.7	2880	57.6	102
Kalif	8.9	68	1.7	6.7	10.4	50.8	2877	57.5	102
KS9135	8.7	100	26.7	6.7	12.4	51.3	2852	57.0	101
KS7436	8.1	93	51.7	5.0	12.3	48.6	2836	56.7	101
Satori	8.3	71	0.0	8.3	10.9	51.2	2762	55.2	98
TCI.06.M1	8.9	93	6.7	5.0	10.6	48.9	2740	54.8	98
Wichita	8.7	90	26.7	6.7	10.9	49.7	2725	54.5	97
Gospel	8.7	61	0.0	6.7	12.2	51.0	2717	54.3	97
ARC98015	8.0	96	10.0	5.0	13.2	48.8	2698	54.0	96
DSV06201	9.0	85	11.7	5.0	11.2	48.1	2686	53.7	96
EXP3269	8.3	94	10.0	6.7	10.1	51.6	2683	53.7	95
06UIWC.1	8.4	100	6.7	5.0	10.8	50.9	2680	53.6	95
DSV05102	8.4	100	15.0	3.3	11.2	47.6	2621	52.4	93

(continued)

Entry	Fall Stand (0-10)	Winter Survival (%)	Lodging (%)	Shatter (%)	Moisture (%)	Test Weight (lbs/bu)	Yield (lbs/a)	Yield (bu/a)	Yield (% of Mean)
Trabant	9.1	93	1.7	11.7	10.4	50.8	2608	52.2	93
06UIWC.5	8.3	96	25.0	5.0	12.4	49.7	2596	51.9	92
DKW13-86	8.2	84	16.7	5.0	10.7	48.1	2584	51.7	92
TCI.06.M3	8.2	100	0.0	5.0	12.9	48.6	2547	50.9	91
ARC98007	8.4	90	20.0	5.0	12.1	51.5	2524	50.5	90
06UIWH.3	8.1	93	15.0	5.0	11.8	50.7	2503	50.1	89
KS3077	8.4	93	38.3	5.0	10.6	49.3	2492	49.8	89
06UIWC.2	8.3	100	3.3	5.0	12.1	49.1	2488	49.8	89
DSV05101	9.0	94	6.7	5.0	11.8	49.2	2482	49.6	88
Ovation	8.8	76	5.0	5.0	11.8	50.9	2480	49.6	88
KS4022	8.5	96	46.7	5.0	11.6	48.7	2466	49.3	88
DSV05100	8.7	87	46.7	5.0	11.6	49.6	2446	48.9	87
Kadore	8.7	82	16.7	7.6	12.1	50.3	2432	48.6	87
Baros	8.4	91	1.7	8.3	10.6	50.9	2322	46.4	83
KS3254	8.6	86	40.0	5.0	12.8	48.7	2104	42.1	75
Plainsman	8.7	91	71.7	5.1	11.0	47.3	2065	41.3	73
06UIWH.5	8.4	94	36.7	5.0	12.9	50.6	2003	40.1	71
KS3074	8.5	82	36.7	6.7	10.8	49.1	1990	39.8	71
06UIWH.1	8.0	100	60.0	5.0	14.3	48.2	1774	35.5	63
Mean	8.5	91	13.0	6.1	11.3	49.8	2811	56.2	100
CV	4.8	5	116.9	45.0	7.9	5.5	17	17.0	17
LSD (0.05)	0.7	16	25.8	4.6	1.5	NS	851	17.0	30

Table 3. Spring canola and camelina variety performance during the 2007 growing season

Entry	Moisture (%)	Test Weight (lb/bu)	Yield (lb/a)	Yield (bu/a)
			9% moisture	
Canola	6.2	51.4	733.8	27.8
Camelina	6.9	46.0	1236.8	14.1
CV	2.0	6.8	23.4	23.6
LSD (0.05)	0.2	4.7	305.6	6.0

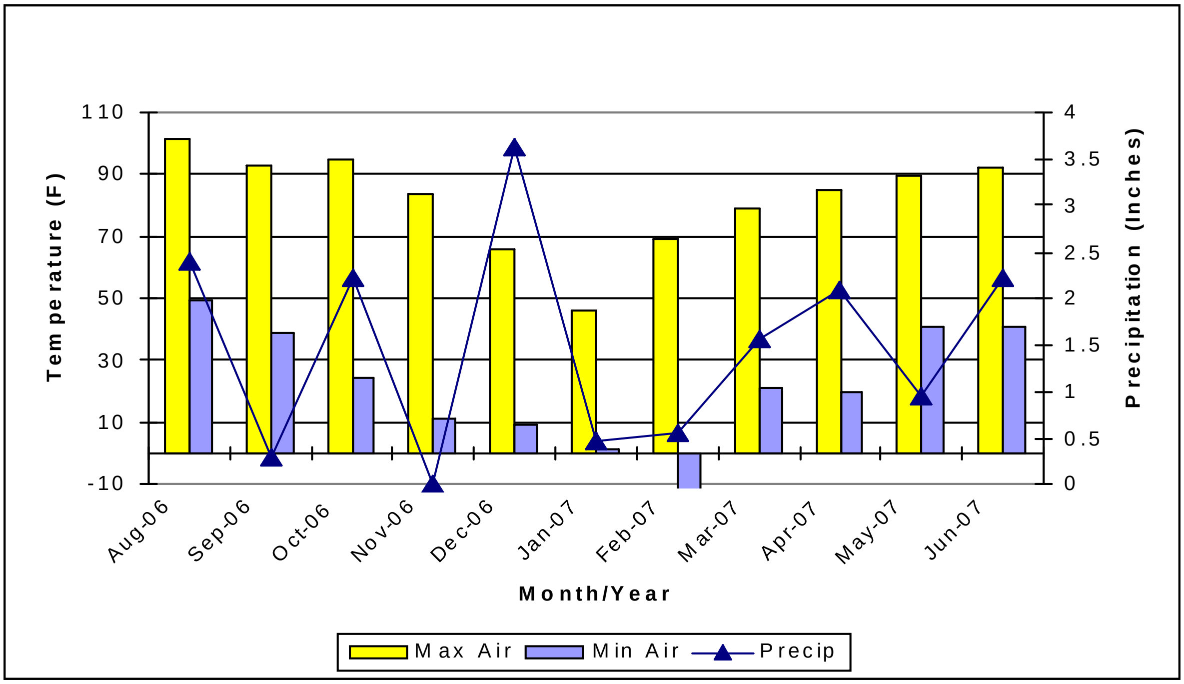

Figure 1. Temperature and precipitation during the 2006-2007 winter canola, spring canola, and camelina growing seasons

CHLORIDE RESEARCH ON CORN, SORGHUM, AND WHEAT IN SOUTHWEST KANSAS

John Holman, Alan Schlegel, Gary Miller, and Scott Maxwell

SUMMARY

Chloride (Cl) is a micronutrient important for plant growth. It is necessary for several plant physiological processes and is believed to help suppress plant diseases in many agronomic crops including wheat, corn, and sorghum. Past research has found that Cl often increases crop yields in central and eastern Kansas. A series of experiments with wheat, corn, and sorghum was conducted in southwest Kansas between 2006 and 2007. In all experiments, Cl application did not increase crop yields. One study with irrigated corn measured the effect of Cl on disease presence; in this study, Cl did not affect severity of stalk rot or grey leaf spot, although disease pressure was low.

INTRODUCTION

Chloride is one of nine micronutrients essential for crop growth, but Cl deficiencies were found in crops in Kansas and the Great Plains. Plants take up Cl in the form of chloride ion (Cl^-). Chloride has several important functions. It is a counter ion for essential cation (Ca^+, K^+, Mg^+, and NH_4^+) plant uptake and transport, maintains cell hydration and turgor, activities enzymes for water oxidation in photosystem II, and suppresses disease in many crops including stalk rot in corn and take all in wheat (Mortvedt 2000; Lamond and Leikam, 2002).

Chloride indirectly affects plant nutrition by suppressing soil nitrification, which leads to higher NH_4^+ concentrations in the plant and soil. This increases manganese uptake and might help suppress plant diseases (Brady and Weil, 2002).

Soil pH has little to no effect on Cl availability (Brady and Weil, 2002). Most chloride in the soil is in the form of chloride ion, which is highly soluble and leaches readily. In poorly drained soils or where excessive amounts of potassium chloride were applied, Cl can be present at concentrations high enough to result in osmotic stress on plants caused by excessive salts in the root zone.

In wheat, leaf spotting is a symptom of Cl deficiency, with spotting described as random chlorotic spots on leaves. Other agronomic crops such as corn and sorghum have shown positive yield responses to Cl but do not show any obvious visual deficiency symptoms. Research on low-Cl soil showed that only certain varieties were responsive to chloride.

A summary of Cl research from central and eastern Kansas found that 60, 55, and 83% of the wheat, dryland corn, and sorghum studies, respectively, showed positive yield responses to Cl application (Mengel et al., 2007). The same summary found that Cl soil tests explained 42, 15, and 2% of the variability in corn, sorghum, and wheat yields, respectively. Because of this variability, a series of Cl studies were conducted in southwest Kansas to determine the effect of chloride on corn, sorghum, and wheat yields.

PROCEDURES

A series of experiments were conducted between 2006 and 2007 at Tribune and Garden City, KS, to determine the effect of Cl application on yield, test weight, and disease suppression of corn, sorghum, and wheat. All experiments at Tribune were on a Richfield silt loam, and all experiments at Garden City were on a Ulysses-Richfield silt loam. In 2006, Cl studies on wheat and corn were implemented at Tribune; in 2007, Cl studies were implemented on wheat and sorghum in Tribune and on corn in Garden City. Soil Cl was measured prior to implementing treatments at all locations. Chloride was applied as ammonium chloride (6-0-0-16.5), and nitrogen (N) was applied to balance N across all treatments. The 2006 wheat experiment treatments were 0, 10, 20, and 30 lb/a Cl applied broadcast on February 8, 2006. The 2006 corn experiment treatments were 0, 10, 20, and 30 lb/a Cl applied with surface dribble between rows on June 30, 2006. The 2007 wheat experiment treatments were 0, 10, 20, 30 and 40 lb/a Cl applied with coulter injection on September 23, 2006 and broadcast on March 20, 2007. The 2007 sorghum experiment treatments were 0, 10, 20, 30, and 40 lb/a Cl applied pre-plant inject and post-plant broadcast. The 2007 corn experiment was furrow irrigated, and treatments were 0, 20, 40, 60, 80, and 100 lb/a Cl applied broadcast on June 30, 2006. All experiments were a randomized complete block with four to six replications. Data was analyzed using Proc GLM in SAS (SAS Institute, Cary, NC).

RESULTS AND DISCUSSION

Chloride fertilizer is recommended for soil < 6 ppm (Table 1) (Lamond and Leikam, 2002). All experiments in this study, except for the irrigated corn test in Garden City in 2007, had soil tests lower than 6 ppm. Irrigated soils typically are not low in Cl because irrigation water contains Cl. Irrigation water for the 2007 irrigated corn experiment was 186 ppm Cl^-.

In both 2006 and 2007, wheat yields, grain moisture, and test weight were not affected by Cl rate (Tables 2 and 3). In 2007, time of Cl application did not affect wheat, and neither Cl rate nor time of application affected leaf Cl content.

In both 2006 and 2007, corn yields, grain moisture, and test weight were not affected by Cl rate (Tables 4 and 5). In 2007, corn ear number, plant height, disease incidence of stalk rot and grey leaf spot, and plant Cl content were not affected by chloride rate.

In 2007, sorghum yield, grain moisture, leaf Cl content, and test weight were not affected by Cl rate or time of application (Table 6).

In this series of experiments, Cl did not affect grain yield. The irrigated corn study in 2007 also measured the effect of Cl on disease presence; Cl did not affect severity of stalk rot or grey leaf spot. Past research found that Cl had variable and inconsistent effects on grain yield. This variability might be due to only certain varieties responding to Cl and to Cl application having a positive yield benefit only when soils are very low in Cl and/or when there is disease incidence.

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Table 1. Chloride fertilizer recommendations from soil test

Profile Soil Chloride		Chloride Recommendation
ppm	lb/a	lb/a
<4	<30	20
4-6	30-45	10
>6	>45	0

Table 2. Dryland heat response to chloride (Cl) in 2006

Time of Application	Rate (lb/a)	Grain Yield (bu/a)	Moisture (%)	Test Weight (lb/bu)
2/8/2006	0	29.8	8.3	57.3
	10	30.3	8.5	57.9
	20	27.6	8.6	56.6
	30	32.9	8.5	58
$LSD_{0.10}$		5.6	0.6	1.2
ANOVA (P>F)				
Cl rate		0.44	0.455	0.192

Soil test for the top 24 in. was 4.1 ppm Cl^-.

Table 3. Dryland wheat response to chloride (Cl) in 2007

Time of Application	Rate (lb/a)	Grain Yield (bu/a)	Moisture (%)	Test Weight (lb/bu)	Leaf Cl (ppm)
None	0	65.4	12.7	58.1	3458
Fall (9/20/06)	10	64.1	12.5	58.5	3302
	20	65	12.1	58.5	3446
	30	63.1	12.7	58	3670
	40	63.7	13.6	57.4	3458
Spring (3/26/07)	10	66.6	12.4	58.2	3491
	20	65.5	13.8	57.9	3447
	30	63.4	13.6	57.1	3786
	40	65.6	14.4	57.7	4237
$LSD_{0.05}$		4	2	1.5	753
C.V. %		4.2	10.6	1.8	14.4
ANOVA (P>F)					
Cl rate		0.199	0.112	0.532	0.347

Soil test for the top 24 in. was 2.5 ppm Cl^-.

Table 4. Dryland corn response to chloride (Cl) in 2006

Cl Rate (lb/a)	Grain Yield (bu/a)	Moisture (%)	Test Weight (lb/bu)
0	23.3	14.6	60
10	21.9	14.3	60.3
20	22.9	14.6	60.1
30	20.9	14.5	59.8
$LSD_{0.10}$	2.9	0.3	0.4
ANOVA (P>F)			
Cl rate	0.471	0.486	0.28

Soil test for the top 24 in. was 3.3 ppm Cl^-.

Table 5. Irrigated corn response to chloride (Cl) in 2007

Cl rate (lb/a)	Ear count (50-ft. row)	Height (in.)	Stalk rot (cm)	Grey leaf spot (% leaf area)	Yield (bu/a)	Moisture (%)	Test Weight (lb/bu)	Ear Leaf (ppm)	Whole Plant (ppm)
0	88.3	5.9	0.5	7.2	89.9	12.2	55.3	5550.5	12846
20	89.5	5.9	0.4	3.5	89.9	12.3	55.5	5469.9	14315
40	88.3	5.9	0.7	4.1	86.7	12.1	55.6	5493.3	12405
60	91.0	5.6	0.2	3.3	82.9	12.1	54.2	5382.0	12555
80	92.3	5.7	1.2	4.8	80.1	11.5	54.9	6013.0	13798
100	92.5	5.6	0.2	4.5	85.6	12.0	55.3	5465.1	12985
$LSD_{0.05}$	7.4	0.5	1.1	5.4	16.1	0.4	1.3	546.9	2735.5

Soil test for the top 24 in. was 30 ppm Cl^-.

Table 6. Dryland grain sorghum response to chloride (Cl) rate and time of application, Tribune, 2007

Time of application	Cl Rate (lb/a)	Grain Yield (bu/a)	Moisture (%)	Test Weight (lb/bu)	Leaf Cl (ppm)
None	0	97	11.4	60.5	2575
Pre-plant inject	10	86	11.3	60.4	2091
	20	95	11.6	60.5	2297
	30	93	11.5	60.1	2193
	40	103	11.8	60.4	2330
Post-plant broadcast	10	98	11.5	60.2	2105
	20	101	11.5	60.5	2217
	30	101	11.4	60.4	2199
	40	103	11.5	60.3	2392
$LSD_{0.05}$		15	0.4	0.6	385
C.V. %		10.6	2.6	0.6	11.6
ANOVA (P>F)					
Trt		0.378	0.381	0.769	0.273
CONTRASTS					
Control vs. Cl trt		0.988	0.491	0.571	0.02
Pre vs. post		0.083	0.515	0.92	0.996

Soil test for the top 24 in. was less than 6 ppm Cl^-.

EFFECT OF GRAZING ON MILLING CHARACTERISTICS OF HARD AND WHITE WINTER WHEAT VARIETIES

John Holman, Curtis Thompson, Alan Schlegel, Ron Hale[1], Tim Herrman[2], and Leigh Murray[3]

SUMMARY

Six hard red (2137, Jagalene, Jagger, OK101, Stanton, and Thunderbolt) and six hard white (Burchett, Lakin, NuFrontier, NuHills, NuHorizon, and Trego) winter wheat varieties were evaluated for grain milling characteristics at Clark County and Stanton County, KS, during the 2003-2004 and 2004-2005 growing seasons. Study locations are in regions that commonly produce wheat in a dual-purpose system (both graze and harvest grain). The experimental design was a randomized complete block with split-plot treatment arrangement. Main plot was cattle (*Bos Taurus* L.) grazed/ungrazed, and subplots were wheat varieties. Varieties were selected based on regional popularity and not parentage. Grain milling characteristics measured were kernel diameter, hardness, and 1,000-kernel weight, which are part of the single-kernel characterization system (SKCS) used to determine milling quality. Red varieties averaged 4% greater kernel diameter than white varieties, but both were of medium seed size. Jagalene, Stanton, Burchett, and NuHills had larger kernel diameter, and 2137 and NuFrontier had smaller kernel diameter. Grazing reduced kernel diameter 3% in 2004 and had no effect in 2005. White varieties averaged 4% greater kernel hardness than red varieties, but both were classified as hard seed. Jagalene and NuHills had greater hardness, and OK101 and Lakin had lower hardness. Grazing did not affect kernel hardness in 2004 and increased hardness 3% in 2005. Red varieties averaged 5% greater 1,000-kernel weight than white varieties. Stanton and Trego had greater 1,000-kernel weight; and 2137, Jagger, Thunderbolt, and NuFrontier had lower 1,000-kernel weight. Grazing reduced kernel weight an average of 4%. Both red and white wheat can be used in a dual-purpose system with no adverse affects on milling characteristics. Certain varieties responded better to grazing and environmental conditions than others, indicating producers should select varieties based on the system and environmental conditions in which wheat will be grown.

INTRODUCTION

Wheat can be used as a forage source or in a dual forage and grain program. Using winter wheat as a source of forage for livestock allows producers to use land more effectively and profitably. Wheat provides economical, high-quality forage at a time of the year when few other comparable forages are available. Research has shown that grazing winter wheat can occur up to first hollow stem (just prior to jointing) without reducing grain yield. An estimated 6 million acres of Kansas winter wheat can be grazed during a good forage-producing year. Little is known about the effect of grazing on grain yield and quality of hard white winter wheat varieties. This experiment examined the effect of grazing on grain yield and quality of six hard red and six hard white winter wheat varieties.

PROCEDURES

Field studies were conducted during the 2003-2004 and 2004-2005 winter wheat growing seasons at two locations each growing season in southwest Kansas. In 2003-2004, the first site was in Clark County, KS (37°01´47.44´´N, 99°59´17.89´´W, elevation 599 m), and the second site was in Stanton County, KS (37°39´51.97´´N, 101°33´29.70´´W, elevation 960 m). Both sites were on a Ulysses silt loam soil (fine-silty, mixed, superactive, mesic Aridic Haplustolls). In 2004-2005, the Clark County site was located in a different field

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(37°01´36.81´´N, 100°00´55.35´´W, elevation 1,988 ft), and the Stanton County site was located adjacent to the previous year's study in the same field (37°39´51.97´´N, 101°33´29.70´´W, elevation 960 m). The 2004-2005 locations were on a similar Ulysses silt loam soil.

The previous crop at all locations was winter wheat in a continuous conventional tillage winter wheat cropping system. Locations were on producer-cooperator farms in regions that commonly graze winter wheat in the fall in a dual-purpose system. The experimental design was a randomized complete block with split-plot treatment arrangement. Main plot was stocker cattle (*Bos Taurus* L.) grazed/ungrazed, and subplots were winter wheat varieties. Each treatment was replicated four times. Winter wheat varieties were six hard white varieties (Burchett, Lakin, NuFrontier, NuHills, NuHorizon, and Trego) and six hard red varieties (2137, Jagalene, Jagger, OK101, Stanton, and Thunderbolt). Varieties were selected based on popularity among producers in the region and not parentage.

In both years, the soil was conventionally tilled prior to planting winter wheat, and 73 and 90 kg/ha N as dry urea (46-0-0) were broadcast applied at Clark and Stanton County sites, respectively. Winter wheat varieties were planted at both sites on the same date (September 16, 2003; September 5, 2004). Winter wheat was planted in 25-cm rows at a targeted seeding depth of 4.4 cm and seeding rate of 100 kg/ha at Clark County sites and 134 kg/ha at Stanton County sites. Starter fertilizer of 12 kg/ha N and 57 kg/ha P as monoammonium phosphate (11-52-0) was applied with the seed.

In 2004, heavy rainfall and subsequent crusting of the soil surface after planting prevented emergence of wheat varieties at both Clark and Stanton County. Experiments were sprayed with glyphosate to kill emerged wheat and were replanted on October 6, 2004. The same planting method and rate was used, but starter fertilizer was not reapplied.

In late March of both years, liquid urea ammonium nitrate (28-0-0) was applied at 34 kg/ha N at both locations. Stanton County received supplemental irrigation water from late April through May of a total estimated amount of 15 cm in 2004 and 10 cm in 2005. Clark County sites were located in dryland fields.

Experiments were located in producers' wheat fields, where stocker cattle were allowed to graze after winter wheat was well rooted and had sufficient tillering to withstand grazing. Wheat was grazed from late November to mid-March. In 2004, cattle were removed from sites before jointing began. In 2005, cattle were removed from the plots in Stanton County before wheat jointing began but not until after jointing in Clark County. Stocking rate was adjusted based on forage availability throughout the growing season. The area clipped for forage yield was outside of the plot area used to determine grain production.

Winter wheat grain was harvested in 2004 from Clark County on June 4 and Stanton County on July 3 and in 2005 from Clark County on June 22 and Stanton County on June 27. Grain yield was measured by harvesting each plot with a plot combine (Model SP50, Kincaid Manufacturing, Haven, KS). The harvested area was 1.5 m wide by 8.2 m long. Grain was bagged from each plot, cleaned, and weighed with an electronic scale to calculate yield. Grain yield was adjusted to 130 g/kg water content, and test weight was determined using a grain analysis computer (Dickey John GAC 2100, Auburn, IL). Grain samples were sent to the Kansas State University (KSU) grain laboratory for measurement of kernel diameter, hardness, and 1,000-kernel weight. Kernel diameter is classified as: $<$ 2.24 mm, small; $\geq$ 2.24 mm to $\leq$2.92 mm, medium; and $>$ 2.92 mm, large. Kernel hardness is classified as: 49 to 49, medium soft; 50 to 64, medium hard; 65 to 79, hard; and 80 to 89, very hard. Kernel diameter, hardness, and 1,000-kernel weight are part of the SKCS used to determine grain milling quality. Samples were also analyzed at the KSU soil laboratory for crude protein (CP) content.

Analyses of variance (ANOVA) for grain quality, yield, and milling characteristics were performed using PROC MIXED in SAS (SAS Institute, Cary, NC). Replication and all interactions with replication were considered random effects in the model. Treatment effects were determined to be significant at a probability level of 0.05, and when ANOVA indicated, significant effects means were separated using pair-wise *t* tests with a probability level of 0.05.

RESULTS AND DISCUSSION

Winter wheat grain yield and quality were different between growing seasons; therefore, data were analyzed separately by growing season (Table 1). Yield and quality differences between growing seasons were partially due to amount and timing of precipitation. Total growing season precipitation (September 1 through July 1) was similar among locations in a growing season. Precipitation was 30 cm at Clark County and 32 cm at Stanton County during the 2003-2004 growing season (Fig. 1) and 48 cm at Clark County and 40 cm at Stanton County during the 2004-2005 growing season (Fig. 2). An average of 13 cm more precipitation occurred during the 2004-2005 growing season than the 2003-2004 growing season. Although Stanton and Clark Counties had similar total growing season precipitation during the 2003-2004 growing season, most of the precipitation occurred late at Stanton County; precipitation occurred throughout the entire growing season at Clark County (Fig. 1). During September 2004, heavy rainfall soon after planting resulted in soil crusting and poor wheat emergence causing the stand to be sprayed out with glyphosate and replanted on October 6 at both locations.

Kernel diameter averaged 2.2 mm (small) in 2004 and 2.4 mm (medium) in 2005 (data not shown). Kernel diameter was affected by location, color, variety, and grazing. Kernel diameter was 11% greater at Clark County (2.4 mm) than Stanton County (2.1 mm) in 2004 and 3% greater at Stanton County (2.4 mm) than Clark County (2.3 mm) in 2005 (data not shown). Red varieties averaged 4% greater kernel diameter than white varieties, but both were classified as having medium seed size. Red varieties averaged 2.3 mm (medium), and white varieties averaged 2.2 mm (small) in 2004; red varieties averaged 2.4 mm (medium) and white varieties averaged 2.3 mm (medium) in 2005. Of the red varieties, Jagalene and Stanton had the greatest and 2137 had the lowest kernel diameter in 2004; Jagalene and Stanton had the greatest and 2137 and Jagger had the lowest kernel diameter in 2005 (Table 2).

Of the white varieties, Burchett, Lakin, NuHills, and Trego had the greatest and NuFrontier and NuHorizon had the lowest kernel diameter in 2004; Burchett and NuHills had the greatest and NuFrontier had the lowest kernel diameter in 2005 (Table 2). In 2004, all varieties had a greater kernel diameter at Clark than Stanton County; differences ranged from 5% (NuHorizon) to 18% (OK101) (data not shown). In 2005, kernel diameter of most varieties was between 0.04% (Jagalene) and 8% (OK101) greater in Stanton County than Clark County, except for Trego, which was 2% greater in Clark than Stanton County (data not shown). Grazing reduced kernel diameter 3% when grazed (2.2 mm) and not-grazed (2.3 mm) treatments were compared in 2004; grazing did not affect kernel diameter in 2005. Kernel diameter of all varieties responded similarly to grazing in 2004, but varieties responded differently in 2005. In 2005, grazing reduced the kernel diameter of NuFrontier 5%, NuHills 3%, and NuHorizon 7%, and all other varieties were within less than 1% difference between grazed and non-grazed treatments.

Kernel hardness averaged 64 (medium hard) in 2004 and 69 (hard) in 2005 (data not shown). Kernel hardness was affected by location, color, variety, and grazing. Kernel hardness was 28% greater at Clark County (74) than Stanton County (55) in 2004, and 26% greater at Stanton County (77) than Clark County (61) in 2005 (data not shown). White varieties averaged 4% greater kernel hardness than red varieties, but both were classified as hard seed (Table 2). Red varieties averaged 63 (medium hard), and white varieties averaged 65 (hard) in 2004; red varieties averaged 68 (hard), and white varieties averaged 71 (hard) in 2005. Of the red varieties, Jagalene had the greatest (hard) and OK101 had the lowest (medium hard) kernel hardness in 2004 and 2005 (Table 2). Of the white varieties, NuHills had the greatest (hard) kernel hardness in 2004 and 2005, Lakin and NuFrontier had the lowest (medium hard) in 2004, and Lakin had the lowest (medium hard) kernel hardness in 2005. In 2004, all varieties had greater kernel hardness at Clark County than Stanton County; differences ranged from 20% (Jagalene) to 50% (OK101) (data not shown). In 2005, all varieties had greater kernel hardness at Stanton County than Clark County; differences ranged from 17% (Jagalene and Stanton) to 41% (NuFrontier) (data not shown). Grazing did not affect kernel hardness in 2004. Grazing increased kernel hardness 3% in 2005 but did not change the hardness classifiation between grazed (70, hard) and not-grazed (68, hard) treatments. Kernel hardness of varieties responded differently to grazing both years. In 2004, grazing increased kernel hardness of 2137 3.5%, reduced kernel hardness of NuHorizon 5%, and all other varieties were within less than 2% difference between grazed and non-grazed treatments. In 2005, grazing increased kernel hardness of Jagalene 3%, Stanton 4%, Thunderbolt 6%, NuFrontier 5%, NuHills 5%, and NuHorizon 8%, and all other varieties were within less than 2% difference between grazed and non-grazed treatments.

Kernel weight (1,000-seed count) averaged 27 g in 2004 and 28 g in 2005 (data not shown). Kernel weight was affected by location, color, variety, and grazing (Table 1). Kernel weight was 20% greater at Clark County (29 g) than Stanton County (24 g) in 2004 and was not different between locations in 2005 (data not shown). Red varieties averaged 5% greater kernel weight than white varieties. Red varieties averaged 27 g, and white varieties averaged 26 g in 2004; red varieties averaged 29 g, and white varieties averaged 28 g in 2005. Of the red varieties, Jagalene and Stanton had greater kernel weight than 2137, Jagger, OK101, and Thunderbolt in 2004 (Table 2); in 2005, Stanton had the greatest and 2137, Jagger, and Thunderbolt had the lowest kernel weight. Of the white varieties, Lakin and Trego had the greatest and NuFrontier and NuHorizon had the lowest kernel weight in 2004; in 2005, Burchett, NuHills, and Trego had the greatest and NuFrontier had the lowest kernel weight. In 2004, all varieties had greater kernel hardness at Clark County than Stanton County; differences ranged from 12% (NuHorizon) to 27% (Stanton) (data not shown). In 2005, Jaggalene, Thunderbolt, and Trego had greater kernel weight in Clark County than Stanton County; differences ranged from 2% (Jaggalene and Thunderbolt) to 4% (Trego). Jagger, 2137, OK101, Stanton, Lakin, NuFrontier, NuHills, and NuHorizon had greater kernel weight in Stanton County than Clark County; differences ranged from 2% (2137, Lakin, NuFrontier, and NuHills) to 5% (Jagger, OK101, and NuHorizon), and the kernel weight of Burchett was not different between locations (data not shown). Grazing reduced kernel weight 5% in 2004 and 3% in 2005. Kernel weight of varieties responded similarly to grazing in 2004 but differently in 2005. In 2005, grazing increased kernel weight of Lakin 2%; reduced kernel weight of Jagalene 3%, Thunderbolt 3%, NuFrontier 8%, NuHills 6%, NuHorizon 10%, and Trego 4%; and all other varieties were within less than 1% difference between grazed and non-grazed treatments.

Table 1. Analysis of variance results for yield, test weight, protein content, and single kernel characterization system for kernel diameter, kernel hardness, and 1,000-kernel weight in 2003-2004 and 2004-2005 growing seasons, Clark and Stanton Counties

Source[a]	Yield	Test Weight	Protein	Kernel Diameter	Kernel Hardness	1,000-Kernel Weight
	2003-2004 Growing Season					
	$P > F$					
L	0.3121	<0.0001	0.0146	<0.0001	<0.0001	<0.0001
V(C)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
L*V(C)	<0.0001	<0.0001	0.0644	<0.0001	<0.0001	<0.0001
G	0.9641	0.1101	0.1233	0.0003	0.7371	<0.0001
L*G	0.2220	0.0145	0.4369	0.1430	0.0169	0.0944
G*V(C)	0.0343	0.0086	0.1153	0.2555	0.0025	0.2231
L*G*V(C)	0.0474	<0.0001	0.8053	0.0030	<0.0001	0.0411
	2004-2005 Growing Season					
	$P > F$					
L	<0.0001	<0.0001	0.0169	0.0381	<0.0001	0.3571
V(C)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
L*V(C)	<0.0001	<0.0001	<0.0001	0.0007	<0.0001	0.0190
G	0.0038	0.5432	0.1292	0.0703	0.0002	0.0116
L*G	0.0023	0.0536	0.1331	0.0840	0.0033	0.0388
G*V(C)	0.0134	0.0444	0.3045	<0.0001	<0.0001	<0.0001
L*G*V(C)	0.1505	0.3230	0.0210	0.0059	<0.0001	0.0017

[a] L = Location; V(C) = Variety(Color); G = Grazed.

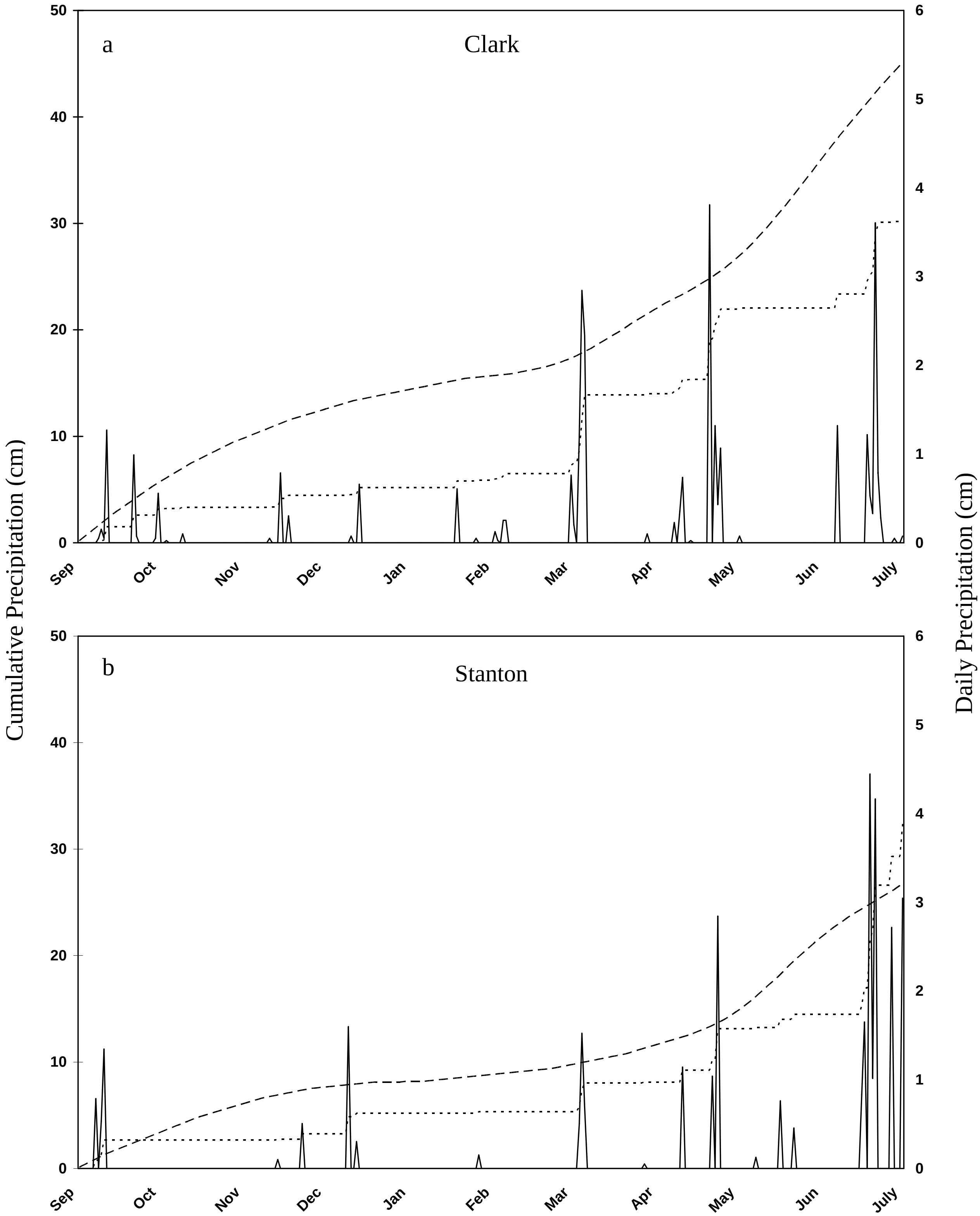

Figure 1. Cumulative (dotted line), daily (solid line), and 30-yr normal cumulative (dashed line) precipitation during the 2003-2004 winter wheat growing season at (a) Clark and (b) Stanton Counties

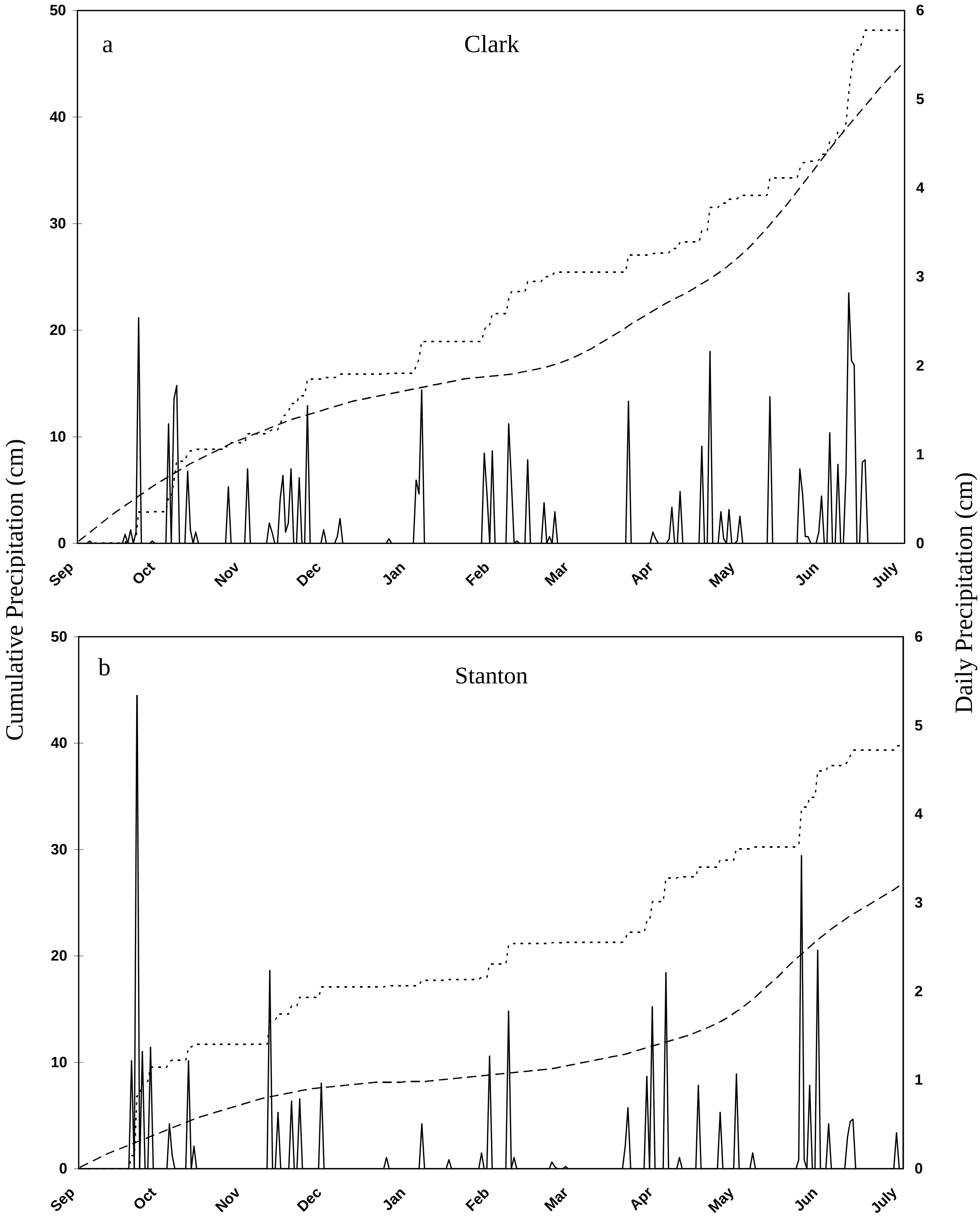

Figure 2. Cumulative (dotted line), daily (solid line), and 30-yr normal cumulative (dashed line) precipitation during the 2004-2005 winter wheat growing season at (a) Clark and (b) Stanton Counties

Table 2. Effects of fall grazing variety within a color group (hard red and white) on winter wheat single kernel characterization system kernel diameter (mm), hardness index, and 1,000-kernel weight (g) during the 2003-2004 and 2004-2005 growing seasons, Clark and Stanton Counties

	2003-2004 Growing Season					2004-2005 Growing Season				
	Clark		Stanton			Clark		Stanton		
Color Variety	Grazed	Not Grazed	Grazed	Not Grazed	Variety Mean†	Grazed	Not Grazed	Grazed	Not Grazed	Variety Mean†
	Kernel Diameter (mm)‡									
Red										
2137	2.27	2.36	2.07	2.06	2.19[c]	2.33	2.25	2.35	2.39	2.33[e]
Jagalene	2.42	2.49	2.22	2.31	2.36[a]	2.44	2.49	2.47	2.47	2.47[ab]
Jagger	2.38	2.41	2.08	2.16	2.26[b]	2.28	2.31	2.43	2.42	2.36[de]
OK101	2.37	2.47	2.04	2.08	2.24[b]	2.33	2.28	2.49	2.50	2.40[cd]
Stanton	2.50	2.53	2.12	2.25	2.35[a]	2.47	2.45	2.58	2.56	2.51[a]
Thunderbolt	2.31	2.39	2.20	2.22	2.28[b]	2.42	2.42	2.48	2.44	2.44[bc]
White										
Burchett	2.32	2.37	2.16	2.22	2.27[a]	2.33	2.39	2.43	2.39	2.38[a]
Lakin	2.35	2.42	2.13	2.15	2.26[a]	2.26	2.26	2.34	2.31	2.29[b]
NuFrontier	2.07	2.19	1.97	1.99	2.05[b]	2.09	2.31	2.25	2.26	2.23[c]
NuHills	2.37	2.44	2.12	2.22	2.29[a]	2.30	2.44	2.45	2.48	2.42[a]
NuHorizon	1.99	2.21	1.98	2.01	2.04[b]	2.10	2.35	2.35	2.42	2.30[b]
Trego	2.38	2.53	2.08	2.15	2.28[a]	2.30	2.39	2.31	2.31	2.33[b]
	Kernel Hardness Index§									
Red										
2137	67.45	64.76	50.28	48.95	57.86[e]	53.00	54.62	74.11	72.56	63.57[d]
Jagalene	80.85	78.64	66.30	66.85	73.16[a]	70.72	67.15	81.10	79.85	74.70[a]
Jagger	79.19	80.34	60.27	61.96	70.44[b]	63.73	65.78	80.47	80.48	72.62[b]
OK101	67.51	67.38	45.31	44.82	56.25[f]	51.69	50.21	71.63	70.82	61.09[e]
Stanton	67.10	64.48	52.73	53.14	59.36[d]	63.23	59.98	72.82	71.02	66.76[c]
Thunderbolt	72.07	71.82	52.75	54.28	62.73[c]	64.54	58.76	74.09	72.64	67.51[c]
White										
Burchett	76.74	75.17	56.78	58.55	66.81[b]	68.50	66.85	81.33	80.27	74.24[b]
Lakin	73.14	71.90	50.07	50.96	61.52[e]	53.11	54.65	73.28	73.85	63.72[e]
NuFrontier	72.56	73.40	49.86	50.27	61.52[e]	58.75	52.70	78.48	78.41	67.08[d]
NuHills	84.86	82.69	61.97	65.57	73.77[a]	71.82	65.86	82.81	82.16	75.66[a]
NuHorizon	73.07	80.50	52.59	51.90	64.51[c]	70.12	59.08	83.66	83.52	74.10[b]
Trego	73.01	70.27	54.58	54.47	63.08[d]	63.17	57.86	76.07	76.97	68.52[c]

(continued)

Color Variety	2003-2004 Growing Season: Clark Grazed	Clark Not Grazed	Stanton Grazed	Stanton Not Grazed	Variety Mean†	2004-2005 Growing Season: Clark Grazed	Clark Not Grazed	Stanton Grazed	Stanton Not Grazed	Variety Mean†
	1,000-Kernel Weight (g)									
Red										
2137	28.45	30.08	24.33	23.85	26.68[b]	28.25	27.33	28.03	28.73	28.08[c]
Jagalene	29.23	31.00	24.95	26.65	27.96[a]	28.93	30.18	28.75	29.48	29.33[b]
Jagger	29.08	30.18	23.13	24.33	26.68[b]	27.15	27.38	28.68	28.63	27.96[c]
OK101	29.08	31.05	23.43	24.53	27.02[b]	28.80	28.28	29.58	30.08	29.18[b]
Stanton	31.30	31.90	23.43	26.50	28.28[a]	30.23	30.20	31.15	31.08	30.66[a]
Thunderbolt	28.05	29.10	25.03	25.55	26.93[b]	28.35	29.65	28.05	28.73	28.69[bc]
White										
Burchett	27.83	28.85	24.60	25.63	26.72[b]	27.45	29.00	28.45	27.58	28.12[ab]
Lakin	29.38	30.88	25.10	25.23	27.64[a]	27.53	27.58	28.63	27.58	27.83[b]
NuFrontier	24.18	26.13	21.48	21.98	23.44[c]	23.58	27.30	25.70	25.98	25.64[d]
NuHills	28.40	30.13	23.58	24.88	26.74[b]	27.03	29.75	28.68	29.33	28.69[a]
NuHorizon	22.95	25.30	21.28	21.85	22.84[c]	23.55	28.35	26.83	27.93	26.66[c]
Trego	29.83	32.43	23.73	25.60	27.89[a]	27.60	29.93	27.58	27.50	28.15[ab]

† Different superscript letters indicate significant difference within wheat color group (red and white) and growing season (2003-2004 and 2004-2005) using pairwise *t* tests ($P < 0.05$).
§ SKCS kernel diameter: < 2.24 mm, small; ≥ 2.24 mm - ≤ 2.92 mm, medium; > 2.92 mm, large.
‡ SKCS hardness index: 40-49, medium soft; 50-64, medium hard; 65-79, hard; 80-89, very hard.

EFFECT OF GRAZING ON GRAIN QUALITY AND YIELD OF HARD AND WHITE WINTER WHEAT VARIETIES

John Holman, Curtis Thompson, Alan Schlegel, Ron Hale[1], and Leigh Murray[2]

SUMMARY

Six hard red (2137, Jagalene, Jagger, OK101, Stanton, and Thunderbolt) and six hard white (Burchett, Lakin, NuFrontier, NuHills, NuHorizon, and Trego) winter wheat varieties were evaluated for grain quality and yield at Clark County and Stanton County, KS, during the 2003-2004 and 2004-2005 growing seasons. Study locations were in regions that commonly produce wheat in a dual-purpose system (both graze and harvest grain). The experimental design was a randomized complete block with split-plot treatment arrangement. Main plot was cattle (*Bos Taurus* L.) grazed/ungrazed, and subplots were wheat varieties. Varieties were selected based on regional popularity and not parentage. Grain quality components measured were test weight, protein, and sprouting. Grain yield was not affected by color. Jagalene and NuHills consistently yielded the greatest, and Jagger consistently yielded the lowest. Grazing reduced yield when cattle grazed wheat past jointing. NuHorizon consistently yielded less when grazed, suggesting NuHorizon is not a good dual-purpose variety. Red varieties averaged 4 kg/m^3 greater test weight than white varieties. Burchett consistently had high test weight, and 2137, OK101, and NuFrontier consistently had lower test weight. Grazing did not affect test weight. Color and grazing had no effect on protein. Jagger and Burchett consistently had high protein, and 2137, OK101, Stanton, and Lakin consistently had lower protein. Sprouting occurred only at Clark County in 2005. White varieties averaged 48% sprouted, and red varieties averaged 14% sprouted. Although white varieties had greater sprouting, Burchett averaged less sprouting than Stanton. Grazing did not affect sprouting. Both red and white wheat can be used in a dual-purpose system with no adverse affects on grain quality or yield. Certain varieties responded better to grazing and environmental conditions than others, indicating producers should select varieties based on the system and environmental conditions in which wheat will be grown.

INTRODUCTION

Wheat can be used as a forage source or in a dual forage and grain program. Using winter wheat as a source of forage for livestock allows producers to use land more effectively and profitably. Wheat provides economical, high-quality forage at a time of the year when few other comparable forages are available. Research has shown that grazing winter wheat can occur up to first hollow stem (just prior to jointing) without reducing grain yield. An estimated 6 million acres of Kansas winter wheat can be grazed during a good forage-producing year. Little is known about the effect of grazing on grain yield and quality of hard white winter wheat varieties. This experiment examined the effect of grazing on grain yield and quality of six hard red and six hard white winter wheat varieties.

PROCEDURES

Field studies were conducted during the 2003-2004 and 2004-2005 winter wheat growing seasons at two locations each growing season in southwest Kansas. In 2003-2004, the first location was in Clark County, KS (37°01´47.44´´N, 99°59´17.89´´W, elevation 599 m), and the second site was in Stanton County, KS (37°39´51.97´´N, 101°33´29.70´´W, elevation 960 m). Both sites were on a Ulysses silt loam soil (fine-silty, mixed, superactive, mesic Aridic Haplustolls). In 2004-2005, the Clark County site was located in a different field (37°01´36.81´´N, 100°00´55.35´´W, elevation 1,988 ft), and the Stanton County site was located adjacent to the previous year's study in the same field (37°39´51.97´´N,

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101°33´29.70´´W, elevation 960 m). The 2004-2005 locations were on a similar Ulysses silt loam soil.

The previous crop at all locations was winter wheat in a continuous conventional tillage winter wheat cropping system. Locations were on producer-cooperator farms in regions that commonly graze winter wheat in the fall in a dual-purpose system. The experimental design was a randomized complete block with split-plot treatment arrangement. Main plot was stocker cattle (*Bos Taurus* L.) grazed/ungrazed, and subplots were winter wheat varieties. Each treatment was replicated four times. Winter wheat varieties were six hard white varieties (Burchett, Lakin, NuFrontier, NuHills, NuHorizon, and Trego) and six hard red varieties (2137, Jagalene, Jagger, OK101, Stanton, and Thunderbolt). Varieties were selected based on popularity among producers in the region and not parentage.

In both years, soil was conventionally tilled prior to planting winter wheat, and 73 and 90 kg/ha N as dry urea (46-0-0) were broadcast applied at Clark and Stanton County sites, respectively. Winter wheat varieties were planted at both sites on the same date (September 16, 2003; September 5, 2004). Winter wheat was planted in 25-cm rows at a targeted seeding depth of 4.4 cm and seeding rate of 100 kg/ha at Clark County sites and 134 kg/ha at Stanton County sites. Starter fertilizer of 12 kg/ha N and 57 kg/ha P as monoammonium phosphate (11-52-0) was applied with the seed.

In 2004, heavy rainfall and subsequent crusting of the soil surface after planting prevented emergence of wheat varieties at both Clark and Stanton County. Experiments were sprayed with glyphosate to kill emerged wheat and replanted on October 6, 2004. The same planting method and rate was used, but starter fertilizer was not reapplied.

In late March of both years, liquid urea ammonium nitrate (28-0-0) was applied at 34 kg/ha N at both locations. Stanton County received supplemental irrigation water from late April through May of a total estimated amount of 15 cm in 2004 and 10 cm in 2005. Clark County sites were located in dryland fields.

Experiments were located in producers' wheat fields, where stocker cattle were allowed to graze after winter wheat was well rooted and had sufficient tillering to withstand grazing. Wheat was grazed from late November to mid-March. In 2004, cattle were removed from sites before jointing began. In 2005, cattle were removed from the plots in Stanton County before wheat jointing began but not until after jointing in Clark County. Stocking rate was adjusted based on forage availability throughout the growing season. The area clipped for forage yield was outside of the plot area used to determine grain production.

Winter wheat grain was harvested in 2004 from Clark County on June 4 and Stanton County on July 3 and in 2005 from Clark County on June 22 and Stanton County on June 27. Grain yield was measured by harvesting each plot with a plot combine (Model SP50, Kincaid Manufacturing, Haven, KS). The harvested area was 1.5 m wide by 8.2 m long. Grain was bagged from each plot, cleaned, and weighed with an electronic scale to calculate yield. Grain yield was adjusted to 130 g/kg water content, and test weight was determined using a grain analysis computer (Dickey John GAC 2100, Auburn, IL). Grain samples were sent to the Kansas State University (KSU) grain laboratory for measurement of kernel diameter, hardness, and 1,000-kernel weight. Kernel diameter is classified as: < 2.24 mm, small; ≥ 2.24 mm to ≤ 2.92 mm, medium; and > 2.92 mm, large kernel size. Kernel hardness is classified as: 49 to 49, medium soft; 50 to 64, medium hard; 65 to 79, hard; and 80 to 89, very hard. Kernel diameter, hardness, and 1,000-kernel weight are part of the SKCS used to determine grain milling quality. Samples were also analyzed at the KSU soil laboratory for crude protein (CP) content.

Analyses of variance (ANOVA) for grain quality, yield, and milling characteristics were performed using PROC MIXED in SAS (SAS Institute, Cary, NC). Replication and all interactions with replication were considered random effects in the model. Treatment effects were determined to be significant at a probability level of 0.05, and when ANOVA indicated, significant effects means were separated using pair-wise *t* tests with a probability level of 0.05.

RESULTS AND DISCUSSION

Winter wheat grain yield and quality were different between growing seasons; therefore, data were analyzed separately by growing season (Table 1). Yield and quality differences between growing seasons were partially due to amount and timing of precipitation. Total growing season precipitation (September 1 through July 1) was similar among locations in a growing season. Precipitation was 30 cm at Clark County and 32 cm at Stanton County during the 2003-2004 growing season (Fig. 1) and 48 cm at Clark County and 40 cm at Stanton County during the 2004-2005 growing season (Fig. 2). An average of 13 cm more precipitation occurred during the 2004-2005 growing season than the 2003-2004 growing season. Although Stanton and Clark Counties had similar total growing season precipitation during the 2003-2004 growing season, most of the precipitation occurred late at Stanton County; precipitation occurred throughout the entire growing season at Clark County (Fig. 1). During September 2004, heavy rainfall soon after planting resulted in soil crusting and poor wheat emergence causing the stand to be sprayed out with glyphosate and replanted on October 6 at both locations.

Grain yield averaged 2.43 Mg/ha in 2004 and 2.94 Mg/ha in 2005. Winter wheat yield was not different between Clark County (2.48 Mg/ha) and Stanton County (2.39 Mg/ha) in 2004 and was 54% greater in Stanton County (3.56 Mg/ha) than Clark County (2.31 Mg/ha) in 2005 (data not shown). Yield was not affected by color either year. Varieties yielded differently within a color group, but the differences and ranking of varieties varied across location, graze, and year (Tables 1 and 2). Of the red varieties, Jagalene and Thunderbolt had the highest and Jagger and OK101 had the lowest yields in 2004; Jagalene, OK101, and Stanton had the highest and 2137 and Jagger had the lowest yields in 2005. Of the white varieties, Burchett, Lakin, NuHills, and Trego had the highest and NuFrontier and NuHorizon had the lowest yields in 2004; NuHills and NuHorizon had the highest and Burchett, Lakin, and Trego had the lowest yields in 2005. In 2004, most varieties had comparable yields across locations, except Thunderbolt yielded 47% greater in Clark County than Stanton County, and Jagalene yielded 23% greater in Stanton County than Clark County. In 2005, Jagger yielded 133% greater and all other varieties yielded between 37% (NuFrontier) and 66% (Stanton) greater in Stanton County than Clark County County. In 2004, grazing did not affect grain yield at either county. Averaged over locations in 2004, winter wheat yielded 2.43 Mg/ha in both grazed and non-grazed treatments (Table 2). In 2005, grazing reduced grain yield 23% in Clark County but did not affect yield in Stanton County. In 2005, Clark County yielded 2.01 Mg/ha in grazed and 2.62 Mg/ha in non-grazed treatments, and Stanton County yielded 3.58 Mg/ha in grazed and 3.55 Mg/ha in non-grazed treatments (Table 2). Averaged over locations in 2004, Jagger yielded 20% greater in grazed than non-grazed, NuFrontier yielded 12% less, and NuHorizon yielded 27% less in grazed than non-grazed, and all other varieties yielded within 10% or less between grazed and non-grazed treatments (Table 2). Averaged over locations in 2005, Jagalene yielded 14%, Jagger yielded 13%, OK101 yielded 15%, NuHills yielded 17%, and NuHorizon yielded 27% greater in non-grazed than grazed, and all other varieties yielded within 10% or less difference between grazed and non-grazed treatments.

Test weight was 21% greater in Clark County (787 kg/m^3) than Stanton County (648 kg/m^3) in 2004 and 7% greater in Stanton County (797 kg/m^3) than Clark County (747 kg/m^3) in 2005 (data not shown). Test weight was affected by color, but differences were negligible (Table 2). In 2004, red varieties averaged 719 kg/m^3 and white varieties averaged 715 kg/m^3. In 2005, red varieties averaged 770 kg/m^3 and white varieties averaged 774 kg/m^3. Variety test weight varied across location, graze, and year (Tables 1 and 2). Of the red varieties, Jagalene had the greatest and 2137 and OK101 had the lowest test weight in 2004; Thunderbolt had the greatest and 2137 and OK101 had the lowest test weight in 2005 (Table 2). Of the white varieties, Burchett had the greatest and NuFrontier and NuHorizon had the lowest test weight in 2004; Burchett and NuHills had the greatest and Lakin and NuFrontier had the lowest test weight in 2005 (Table 2). In 2004, all varieties had a greater test weight in Clark County than Stanton County; differences ranged from 17% (Jagalene) to 26% (OK101).

In 2005, all varieties had a greater test weight in Stanton County than Clark County; differences ranged from 4% (Thunderbolt) to 11% (OK101). Grazing had no effect on test weight (Table 1). Test weight of varieties varied differently with grazing treatment, but differences were negligible. In 2004, grazing reduced the test weight of NuHorizon 2%, and all other variety test weights were within less than 1% between grazed and non-grazed treatments. In 2005, grazing increased the test weight of Stanton 1% and Burchett 1%, and all other variety test weights were within less than 1% difference between grazed and non-grazed treatments.

Protein content of the seed averaged 161 g/kg in 2004 and 141 g/kg in 2005. Protein was 8% and 9% greater in Stanton County than Clark County in 2004 and 2005, respectively (data not shown). Winter wheat color did not affect protein content in 2004 but, although negligible, did in 2005. In 2005, protein content of red varieties averaged 142 g/kg and white varieties averaged 141 g/kg. Protein content of certain varieties within a color group varied across location in 2005 and year (Tables 1 and 2). Of the red varieties, Jagger had the greatest and 2137, Jagalene, OK101, and Stanton had the lowest protein content in 2004; Jagger and Thunderbolt had the greatest and 2137, OK101, and Stanton had the lowest protein content in 2005 (Table 2). Of the white varieties, Burchett, NuHills, and NuHorizon had the greatest and Lakin and Trego had the lowest protein content in 2004; Burchett had the greatest and Lakin and NuFrontier had the lowest protein content in 2005 (Table 2). In 2005, protein content of most varieties ranged from 4% (Jagger) to 18% (Lakin) greater in Stanton County than Clark County, except the variety Stanton was not different between the two locations (data not shown). Grazing had no effect on protein content.

In 2005, Stanton County received precipitation near crop maturity, which delayed harvest and resulted in grain sprouting. Sprouting did not occur in 2004 or at Clark County in 2005. Sprouting was affected by color and variety. White varieties averaged 48% sprouted seed, and red varieties averaged 14% sprouted seed. Sprouted seed was 70% less in red varieties than white varieties. Of the red varieties, Stanton (26%) had the greatest amount of sprouted seed, and 2137 (9%), Jagalene (8%), and Thunderbolt (9%) had the least amount of sprouted seed (Table 3). Of the white varieties, NuHorizon (71%) had the greatest amount of sprouted seed, and Burchett (21%) had the least amount of sprouted seed (Table 3). Grazing did not affect sprouting. Varieties varied in the amount of seed sprouted and grazing treatment. Grazing, on average, increased sprouting of 2137 24% and Jagalene 19% and reduced sprouting of Jagger 20%, OK101 3%, Stanton 15%, Thunderbolt 17%, Burchett 1%, Lakin 5%, NuFrontier 7%, NuHills 18%, NuHorizon 18%, and Trego 2%.

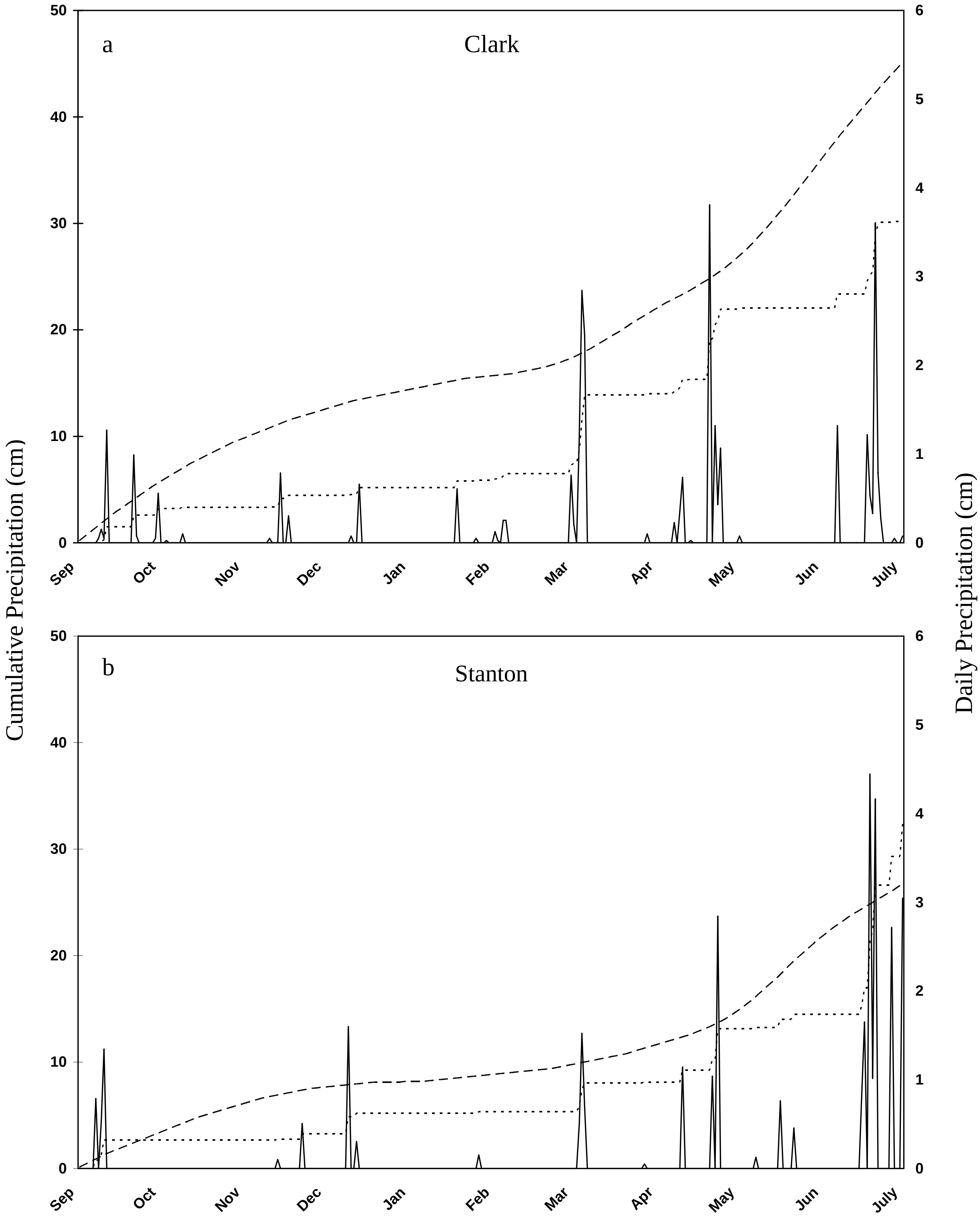

Figure 1. Cumulative (dotted line), daily (solid line), and 30-yr normal cumulative (dashed line) precipitation during the 2003-2004 winter wheat growing season at (a) Clark and (b) Stanton Counties

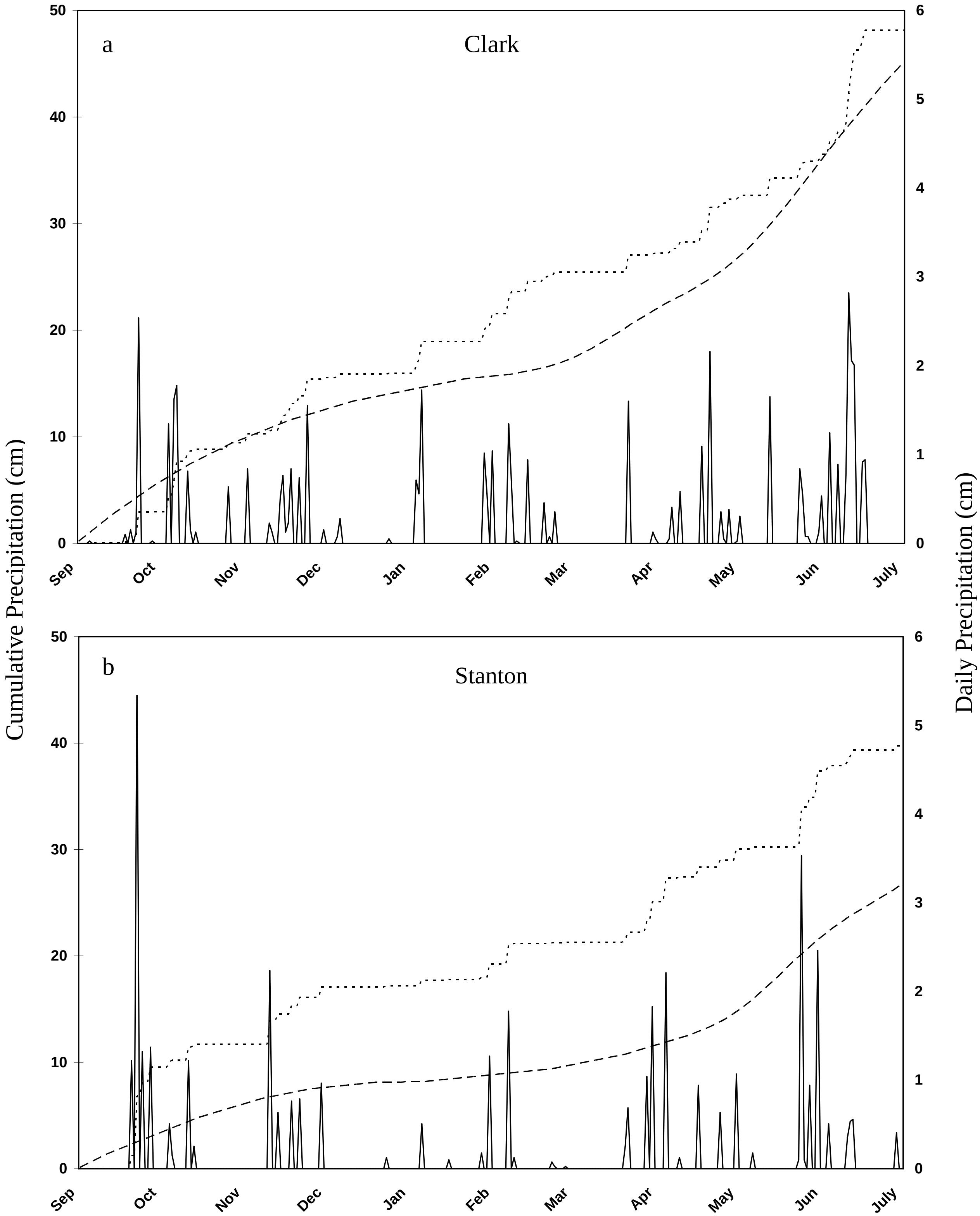

Figure 2. Cumulative (dotted line), daily (solid line), and 30-yr normal cumulative (dashed line) precipitation during the 2004-2005 winter wheat growing season at (a) Clark and (b) Stanton Counties

Table 1. Analysis of variance results for yield, test weight, protein content, and single kernel characterization system for kernel diameter, kernel hardness, and 1,000-kernel weight in 2003-2004 and 2004-2005 growing seasons, Clark and Stanton Counties

Source[a]	Yield	Test Weight	Protein	Kernel Diameter	Kernel Hardness	1,000-Kernel Weight
	2003-2004 Growing Season					
	----------*P* > *F*----------					
L	0.3121	<0.0001	0.0146	<0.0001	<0.0001	<0.0001
V(C)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
L*V(C)	<0.0001	<0.0001	0.0644	<0.0001	<0.0001	<0.0001
G	0.9641	0.1101	0.1233	0.0003	0.7371	<0.0001
L*G	0.2220	0.0145	0.4369	0.1430	0.0169	0.0944
G*V(C)	0.0343	0.0086	0.1153	0.2555	0.0025	0.2231
L*G*V(C)	0.0474	<0.0001	0.8053	0.0030	<0.0001	0.0411
	2004-2005 Growing Season					
	----------*P* > *F*----------					
L	<0.0001	<0.0001	0.0169	0.0381	<0.0001	0.3571
V(C)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
L*V(C)	<0.0001	<0.0001	<0.0001	0.0007	<0.0001	0.0190
G	0.0038	0.5432	0.1292	0.0703	0.0002	0.0116
L*G	0.0023	0.0536	0.1331	0.0840	0.0033	0.0388
G*V(C)	0.0134	0.0444	0.3045	<0.0001	<0.0001	<0.0001
L*G*V(C)	0.1505	0.3230	0.0210	0.0059	<0.0001	0.0017

[a] L = Location; V(C) = Variety(Color); G = Grazed.

Table 2. Effects of fall grazing variety within a color group (hard red and white) on winter wheat yield (kg/ha), test weight (kg/bu), and protein content (g/kg) during the 2003-2004 and 2004-2005 growing seasons, Clark and Stanton Counties

	2003-2004 Growing Season					2004-2005 Growing Season				
	Clark		Stanton			Clark		Stanton		
Color Variety	Grazed	Not Grazed	Grazed	Not Grazed	Variety Mean	Grazed	Not Grazed	Grazed	Not Grazed	Variety Mean
	----Yield (bu/a)----									
Red										
2137	39.3500	38.4000	34.5250	34.3750	36.6625	32.8750	37.1750	50.3750	49.9500	42.5938
Jagalene	37.1750	35.7750	46.1250	43.8750	40.7375	27.5000	40.0000	55.1250	54.0750	44.1750
Jagger	37.1250	27.8250	34.3500	31.5750	32.7187	20.6250	27.8250	55.2500	57.9500	40.4125
OK101	35.4500	30.8750	29.6500	32.3000	32.0687	31.1750	43.6500	52.9500	52.8500	45.1563
Stanton	37.6250	32.1250	34.9250	43.3500	37.0062	35.1500	35.2250	58.9750	58.0500	46.8500
Thunderbolt	45.5250	49.2750	33.5000	33.3750	40.4187	30.1000	40.7250	52.2250	47.3000	42.5875
White										
Burchett	35.1500	33.1000	35.3239	39.9000	35.8685	30.2000	38.0750	52.3750	50.8500	42.8750
Lakin	41.5750	35.3500	30.9570	35.4500	35.8330	28.9000	36.6750	50.6500	47.2000	40.8563
NuFrontier	32.7000	39.7250	33.2000	34.3000	34.9812	33.7500	40.2000	49.8500	51.2500	43.7625
NuHills	41.0000	34.8000	34.8587	36.4000	36.7647	29.8000	43.7500	56.8250	57.9750	47.0875
NuHorizon	27.5500	39.2250	29.3000	32.7250	32.2000	27.9250	46.7750	52.1250	55.1500	45.4938
Trego	42.2500	37.3000	38.9000	38.0250	39.1187	30.9000	37.2000	52.1250	50.3500	42.6438
	---- Test Weight (lb/bu) ----									
Red										
2137	59.6500	60.3250	50.5750	49.4750	55.0063	56.7500	56.0250	61.1250	61.5000	58.8500
Jagalene	62.1000	62.8750	53.7500	53.4500	58.0438	59.4500	59.1500	61.8750	62.0750	60.6375
Jagger	60.9500	61.6500	49.2250	49.1000	55.2313	57.3250	56.8000	61.5250	61.6500	59.3250
OK101	60.5000	61.2750	48.7500	48.2000	54.6813	56.1500	55.3500	61.6250	62.0500	58.7938
Stanton	60.2000	60.3500	49.7250	50.2500	55.1313	59.2500	57.6500	61.6500	62.0500	60.1500
Thunderbolt	61.5250	61.8250	52.9750	52.6000	57.2313	60.3000	59.5750	62.3500	62.7750	61.2500
White										
Burchett	61.9250	62.1250	52.2891	52.3750	57.1785	60.0750	58.9750	62.5250	62.1000	60.9188
Lakin	60.9000	61.2500	50.8767	50.5750	55.9004	57.0000	56.4500	62.0250	61.7500	59.3063
NuFrontier	59.5250	60.7750	48.1000	47.7000	54.0250	57.0250	57.5000	61.2500	61.6500	59.3563
NuHills	62.1500	62.1000	50.3201	50.5250	56.2738	59.0750	59.4250	62.4000	62.8750	60.9438
NuHorizon	58.3500	61.3250	48.1250	47.2250	53.7563	58.1250	57.6500	61.2000	61.9750	59.7375
Trego	61.4000	61.8250	50.5250	51.2750	56.2563	58.9250	58.8250	61.7250	62.3250	60.4500

(continued)

Color Variety	2003-2004 Growing Season Clark Grazed	Clark Not Grazed	Stanton Grazed	Stanton Not Grazed	Variety Mean	2004-2005 Growing Season Clark Grazed	Clark Not Grazed	Stanton Grazed	Stanton Not Grazed	Variety Mean
	---Protein Content (%)---									
Red										
2137	14.7625	15.6475	15.7025	16.7600	15.7181	12.4725	12.8375	14.0875	13.9650	13.3406
Jagalene	14.3925	15.2475	16.6000	17.1575	15.8494	14.5600	14.1675	15.1775	15.3600	14.8162
Jagger	16.9000	17.8975	17.6400	17.7700	17.5519	15.3250	14.8925	15.6325	15.6525	15.3756
OK101	14.4200	15.4175	16.1875	16.1175	15.5356	12.9700	12.3450	13.7850	13.7650	13.2162
Stanton	14.8350	16.2050	16.1150	16.1175	15.8181	13.2600	13.6500	13.5900	13.2100	13.4275
Thunderbolt	14.6925	16.0475	17.1550	18.2825	16.5444	14.8150	14.1450	15.8375	15.5750	15.0931
White										
Burchett	15.3775	15.8900	17.2373	16.5725	16.2693	14.9150	13.7775	15.4900	16.0325	15.0537
Lakin	14.3950	15.2900	15.7750	15.5900	15.2625	12.6425	12.0275	14.3675	14.7150	13.4381
NuFrontier	15.1350	15.0050	16.8125	16.6700	15.9056	13.3925	12.6925	14.2050	13.9300	13.5550
NuHills	15.6750	16.2175	17.2875	17.6550	16.7087	14.1150	13.2025	15.3125	15.4000	14.5075
NuHorizon	15.7325	14.9200	16.9425	16.7450	16.0850	13.9125	12.6000	14.7950	14.5800	13.9719
Trego	14.7075	15.7050	15.3350	16.4475	15.5487	13.5200	13.1100	14.4825	14.5375	13.9125

Table 3. Effects of fall grazing and variety within a color group (hard red and white) on winter wheat sprouting (number of seed sprouted out of 200 seed) during the 2004-2005 growing season, Stanton County

Color	Variety	Seed Sprouted (out of 200 seed) Grazed	Not Grazed	Variety Mean†
Red	2137	19.25	15.50	17.38[c]
	Jagalene	17.00	14.25	15.63[c]
	Jagger	29.25	36.75	33.00[b]
	OK101	35.00	36.25	35.63[b]
	Stanton	48.50	56.75	52.63[a]
	Thunderbolt	15.50	18.75	17.13[c]
White	Burchett	41.87	42.25	42.06[e]
	Lakin	99.25	104.25	101.75[c]
	NuFrontier	115.75	124.00	119.88[b]
	NuHills	62.50	76.50	69.50[d]
	NuHorizon	128.00	155.25	141.63[a]
	Trego	100.00	101.75	100.88[c]

† Different letters indicate significant difference within wheat color group (red and white) and growing season (2003-2004 and 2004-2005) using pairwise t tests ($P < 0.05$).

EFFECTS OF WINTER CANOLA PLANTING DATE ON WINTER SURVIVAL

John Holman, Kraig Roozeboom[1], Mike Stamm[1], Scott Maxwell, and Gary Miller

SUMMARY

Determining the optimum planting date of canola is crucial for fall 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. 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 byproduct of oil crushing) as a soybean meal replacement. Fall stand establishment was successful at all planting dates and ranged from 168,400 to 495,100 plants/a. Fall stand density was greatest at the last planting date and increased with later planting date. Tillage had no effect on fall stand density. The first planting date (August 16) in the fall of 2007 was heavily infested with diamondback moth. Minor diamondback moth occurred on the second planting date (September 4) Winter survival was greatest for the second and third planting dates (September 4 and 17), and no plants survived at the last planting date (October 15). Tillage had no effect on fall survival. Spring regrowth was slowest at the first planting date; but after a couple weeks of spring, vigor was greatest at the first three planting dates. Tillage had no effect on spring vigor. This study will be replicated for at least one more year, but current information suggests planting between September 4 and 17 for successful winter canola stand establishment and survival.

INTRODUCTION

Winter canola production has increased in the southern Great Plains states of Kansas, Oklahoma, and Texas in recent years. Close to 60,000 acres were seeded in the 2005-2006 growing season, with additional acreage increases expected in 2006-2007. Winter canola is a broadleaf crop that was first introduced to the region as a rotational crop with winter wheat. Planting winter canola enables use of alternative herbicides for suppressing hard to control grass weed species and disrupts disease cycles that often plague continuous wheat production systems.

As interest in renewable energy sources gains momentum in the region, the demand for canola oil as a feedstock for biodiesel is outpacing our understanding and ability to establish the crop, especially under no-till cropping systems. Establishing winter canola is a more significant undertaking than establishing winter wheat, particularly in years when soil moisture is lacking at fall planting. Stand establishment affects all other periods of the growing season, the most important of which is winter dormancy. Plants that fail to establish adequately in the fall will have limited time to attain the minimum amount of growth necessary to survive the winter in the southern Great Plains. A quality stand provides the greatest opportunity for winter survival and is cruical for harvesting a high yielding crop.

A lack of current, regional research on stand establishment has slowed farmer acceptance of winter canola. Kansas State University initiated production research using high erucic acid winter rapeseed in the late 1980s and early 1990s at the Northwest Kansas Research-Extension Center and the South Central Kansas Experiment Field, but winter varieties available at the time were not well adapted to the region. Limited winter canola production research has been conducted in the Southeast and Pacific Northwest; however, soil and climatic conditions in those areas vary greatly from conditions in the southern Great Plains. Most establishment research has been completed in the primary canola growing regions of North Dakota and Canada using spring canola.

Winter canola is well suited for growing conditions of the southern Great Plains and possesses a 20 to 30% yield advantage over

[1] Kansas State University Department of Agronomy, Manhattan, KS

spring canola. Spring types flower 1 month later and are harvested approximately 2 weeks later than winter types. The late flowering of spring types occurs during a hotter period of the growing season; this reduces the grain fill period and yield potential of spring types. Until heat-tolerant spring cultivars are developed, winter canola will be the primary oilseed rape crop grown in the region.

Winter canola establishes best in moist, firm, well-drained, medium-textured soils. It is imperative that canola has appropriate seed-to-soil contact because of its small seed size and shallow planting depth. Obtaining a uniform seeding depth is a challenge but can be accomplished with properly adjusted no-till seeding equipment. No-till cropping practices are used often across the semi-arid Great Plains to conserve surface soil moisture and reduce soil erosion. A canola seedbed that is too fine or overworked will lose soil moisture rapidly, and crusting normally occurs after a heavy rain. Overly coarse seedbeds result in poor seed placement and seed-to-soil contact, and soils dry out rapidly. No-till seeding can help avoid these hindrances to establishment and could also result in fuel savings.

PROCEDURES

Winter canola was planted in the fall of 2007 at five different planting dates: August 16, September 4, 17, 28, and October 15 into till and no-till. Soil was tilled with a rotary tiller on August 13, 2007. Pendimethalin (Prowl H_20) was applied at a rate of 3 pt/a (product) or 1.43 lb/a (a.i.), and glyphosate (Roundup) was applied at a rate of 1 qt/a (product) or 0.75 lb/a (ae) within 2 days preplant for each planting date. The variety KS3195 was planted on a fully irrigated Ulysses silt loam soil. All plots were planted in twelve 7.5-in rows, 30 ft long and 7.5 ft wide. Soil tests indicated nutrient levels were sufficient, but an additional 1.1 lb N and 5.2 lb P was applied at seeding as monoammonium phosphate (11-52-0), and 9 lb S was banded 1 in. to the side and 2 in. deep at time of planting. Seed was placed 0.5 in. deep. After each planting, 2.54 cm of irrigation was applied by sprinkler pivot irrigation to help obtain successful germination and emergence. The study design was a randomized complete block with four replications. Within each plot, four different permanently marked 3-ft row segments were quantified for fall and spring plant density to determine fall stand establishment and winter survival. Fall stand density was quantified on November 1, 2007, and spring stand density was quantified on April 8, 2008. Insect presence was quantified on November 1, 2007. Yield, test weight, and grain moisture will be determined during the 2008 growing season. Data from the four row segments were averaged and analyzed using Proc Mixed in SAS (SAS Institute, Cary, NC). Replication and all interactions with replication were considered random effects in the model. Treatment effects were determined to be significant at a probability level of 0.05, and when ANOVA indicated, significant effects means were separated using pair-wise *t* tests with a probability level of 0.05. When plant density was zero for a treatment, the analysis was done by dropping that treatment from the model.

RESULTS AND DISCUSSION

Fall stand establishment was successful at all planting dates and ranged from 168,400 plants/a planted on August 16 to 495,100 plants/a planted on October 15 (Fig. 1) Fall stand density was greatest at the October 15 planting date. Stand density increased with each later planting date, except for the second and third planting dates, which were not significantly different. Tillage had no effect on fall stand density. The first planting date during fall of 2007 (August 16) was heavily infested with diamondback moth (*Plutella xylostella* L.). Minor diamondback moth infestation was present on the second planting date (September 4).

Winter survival was greatest for the second and third planting dates (September 4 and 17), and winter survival at the first planting date was not significantly different than the second, third, or fourth planting dates (Fig. 2). No plants survived at the last planting date (October 15) (Fig. 2 and Photo 1). Winter survival of the first planting date might have been reduced by diamondback moth feeding during fall of 2007.

Spring regrowth was slowest at the first planting date; but after a couple weeks of spring, vigor (visual growth determination) was greatest at the first three planting dates (Fig. 3). Spring regrowth at the first planting date might have been delayed because of heavy diamondback moth feeding and winter injury (Fig. 2). The fourth planting date had less spring vigor, which might have been caused by winter injury (Fig. 2). The last planting date had no winter survival to rate vigor.

This study will be replicated for at least one more year, but current information suggests planting winter canola between September 4 and 17 for successful winter canola stand establishment and survival.

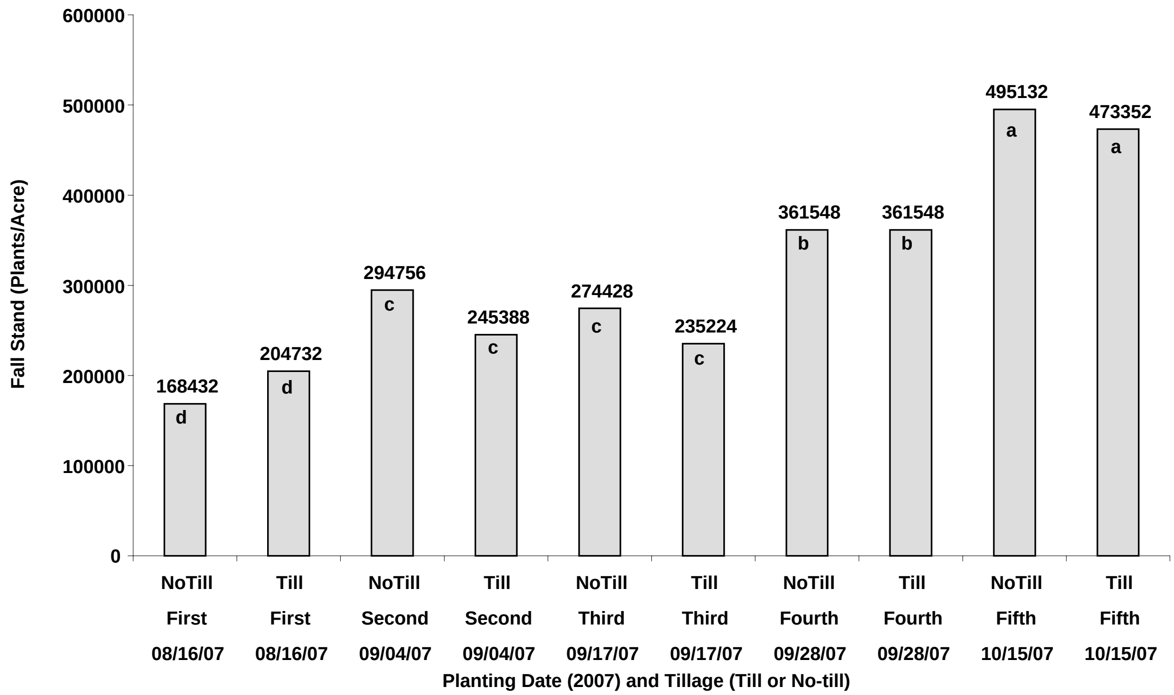

Figure 1. Winter canola fall stand establishment at five different planting dates in till and no-till, Garden City, 2007

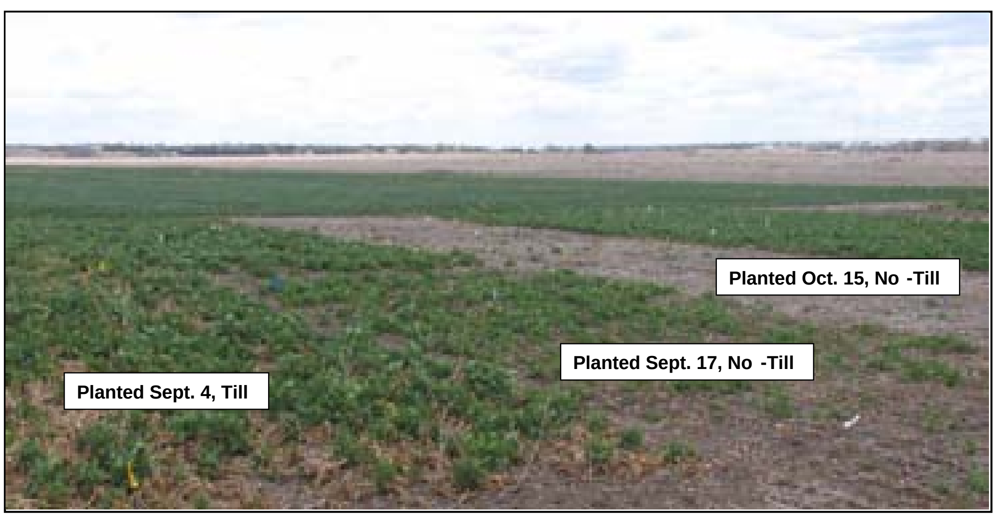

Photo 1. Winter canola on April 11, 2008
No canola planted on October 15, 2007, in till or no-till treatments survived the winter

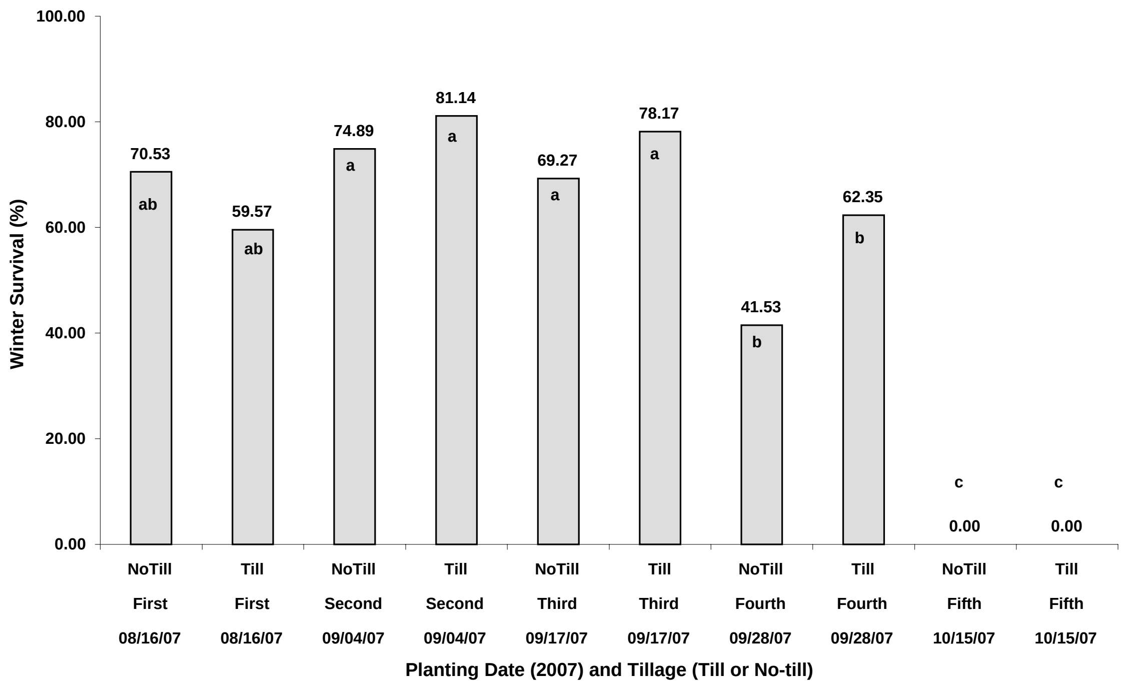

Figure 2. Winter canola winter survival at five different planting dates in till and no-till, Garden City, 2007-2008

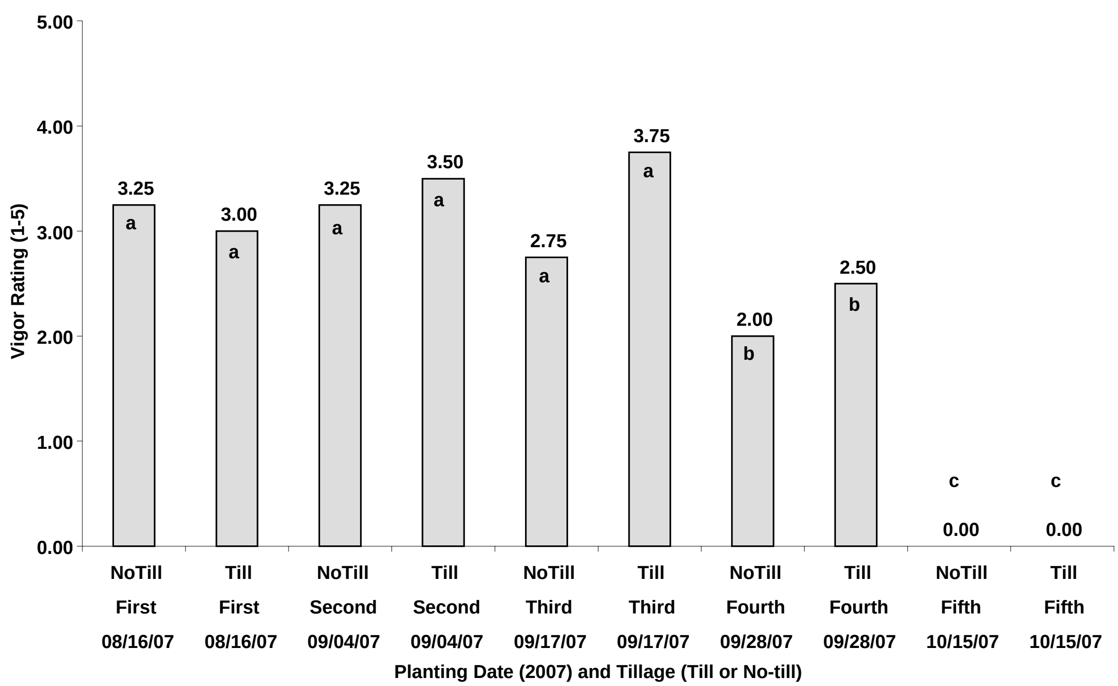

Figure 3. Winter canola spring vigor at five different planting dates in till and no-till, Garden City, 2007-2008

1 to 5 rating: 5 = excellent, 1 = poor.

UPLAND RAIN-FED ALFALFA VARIETY PERFORMANCE IN CLARK COUNTY 1999-2002

Curtis Thompson and Don Yauk[1]

SUMMARY

Rain-fed upland alfalfa near Englewood, KS, from 1999 to 2002 produced 11.7 to 14.6 ton/a of hay over seven cuttings, which averaged 1.6 to 2.1 ton/cutting. The top producing variety was an old standard, Liberty; and Enhancer, from Drussel Seeds, was the second-highest producing variety. Generally, little or no differences were observed in forage quality.

INTRODUCTION

Alfalfa variety selection is an important multi-year investment. An alfalfa variety needs to be adapted to the area, have a competitive yield potential, and have quality that meets a grower's needs. Little work has been done to evaluate rain-fed alfalfa yield performance on upland soils in southwest Kansas. Low average annual precipitation and high evaporation rates limit the area in which rain-fed alfalfa can be grown. Recently released alfalfa varieties have not been evaluated under such growing conditions. In addition, dryland alfalfa establishment can be very difficult without timely rainfall and cooperative weather conditions following planting. In this experiment, four modern varieties (from Sharp Brothers and Drussel Seeds) were compared with two old standard varieties (Cimarron VR and Liberty) on upland rain-fed soils in southern Clark County near Englewood, KS.

PROCEDURES

Alfalfa varieties listed in Table 1 were planted 0.5 in. deep at 15 lb/a in a Ulysses silt loam soil on August 25, 1998. Seed was planted into dry soil and rain fell shortly after planting, which allowed an excellent stand to establish. The alfalfa experiment, along with the remainder of the field, was managed by the grower. Fertility, weed control, and insect control were managed by the grower. Cost of management during 1999 is shown in Table 2. All varieties were replicated three times and arranged in a randomized complete block design; each plot was 10 ft by 100 ft. Forage harvest was accomplished by cutting 2 ft^2/plot. Samples were oven dried to 5% to 6% moisture and weighed to determine yield. Samples from the first three cuttings (two in 1999 and one in 2000) were sent to Servi-Tech Laboratories in Dodge City, KS, for forage analysis. Only two harvests were gathered each year because of increasing variability with later season cuttings.

RESULTS AND DISCUSSION

Alfalfa variety yields are shown in Table 1. Enhancer was the top yielding variety at the first cutting on May 17, 1999. Amerigraze, Reward, and Cimarron VR were the lowest yielding varieties in the experiment. Enhancer and Shamrock were the top two varieties when both cuttings were added together for the 1999 season. Enhancer remained the top yielding variety when cuttings were summed in 2000. Remaining data of individual cuttings showed no significant differences among alfalfa varieties. However, when all cuttings were added together, Liberty emerged as the top forage producer. Enhancer also showed trends for slightly higher yield; remaining varieties yielded 12.8 ton or less.

Table 2 shows input costs, which totaled $173/a for 1999. A $40/ton value would be required to cover these input costs for the lowest yielding variety. This value does not include a land charge.

Alfalfa quality was determined for the first three cuttings taken from the experiment (Table 3). No significant quality differences were observed from the first cutting in 1999 or the first cutting in 2000. Only acid detergent fiber (ADF) and total digestible nutrients (TDN) were affected by variety in the second cutting of 1999. Shamrock and Amerigraze had the lowest ADF and highest TDN compared with remaining varieties.

[1] Former Clark County Agricultural Extension Agent, Kansas State University, Ashland, KS

Table 1. Dryland alfalfa variety forage production, Englewood, 1999-2002

		1999			2000			2001			2002	
		Cut1	Cut2		Cut1	Cut2		Cut1	Cut2		Cut1	Grand
Comp.[a]	Variety	5/17	6/22	Total	5/3	6/12	Total	5/1	6/8	Total	5/8	total
						(ton/a at 15% moisture)						
Sharps	Amerigraze	2.40	1.94	4.33	1.74	0.83	2.57	2.24	1.56	3.65	2.16	12.34
Drussel	Enhancer	3.34	1.70	5.04	2.31	1.14	3.44	1.77	1.32	2.89	2.51	13.64
Drussel	Reward	2.34	1.89	4.24	2.11	1.04	3.15	1.95	1.56	3.27	2.01	12.39
Sharps	Shamrock	3.11	1.96	5.06	2.03	0.90	2.93	1.88	1.35	3.28	2.03	12.80
None	Cimarron VR	2.51	1.86	4.37	1.58	0.88	2.45	1.82	1.56	3.29	1.99	11.66
None	Liberty	2.86	1.97	4.83	2.13	0.95	3.09	2.25	1.51	3.61	2.56	14.59
LSD (P = .05)		0.37	NS	0.69	NS	NS	0.48	NS	NS	NS	NS	1.51
CV		7.3	16.66	8.11	14.02	18.48	8.9	15.1	18.1	15.4	12.73	6.45
Treatment Prob(F)		0.00	0.89	0.07	0.07	0.35	0.01	0.28	0.87	0.72	0.10	0.02

[a] Companies: Sharps = Sharp Brothers, Healy, KS; Drussel = Drussel Seeds, Garden City, KS.

Table 2. Input costs for 1999, Harry and Rick Walker, Englewood

Input	Cost/a
Gopher treatment	$4.00
Harrow	$3.00
Weevil treatment + application	$10.89
Weed/grass control + application	$12.00
Fertilizer + application	$17.15
Swathing	$24.50
Raking	$10.25
Baling	$27.50
Hauling (small bales)	$18.50
Hauling (round bales)	$15.00
Loading hay	$10.00
Miscellaneous expenses	$20.00
Total Expenses	$72.79

Table 3. Dryland alfalfa variety forage quality, Englewood, 1999-2000

		May 17, 1999 (Cut 1)				
Comp.[a]	Variety	Protein	ADF	NDF	TDN	RFV
				%		
Sharps	Amerigraze	19.3	36.4	44.0	62.7	128
Drussel	Enhancer	20.8	37.2	43.1	62.0	129
Drussel	Reward	19.7	34.5	40.3	64.5	144
Sharps	Shamrock	17.7	38.4	46.1	60.9	120
None	Cimarron VR	19.3	35.6	42.5	63.5	135
None	Liberty	17.5	36.7	43.9	62.4	129
LSD (P = .05)		NS	NS	NS	NS	NS
CV		9.4	6.1	8.3	3.2	11
Treatment Prob(F)		0.30	0.42	0.54	0.42	0.48
		June 22, 1999 (Cut 2)				
Comp.[a]	Variety	Protein	ADF	NDF	TDN	RFV
				%		
Sharps	Amerigraze	22.3	34.0	43.0	64.9	135
Drussel	Enhancer	21.4	37.3	45.1	61.9	125
Drussel	Reward	20.8	39.0	45.9	60.4	119
Sharps	Shamrock	22.2	34.5	42.4	64.4	136
None	Cimarron VR	22.1	37.2	44.6	62.0	125
None	Liberty	19.1	40.5	47.9	58.9	111
LSD (P = .05)		NS	3.3	NS	3.0	NS
CV		6.8	4.9	6.8	2.7	8
Treatment Prob(F)		0.13	0.01	0.33	0.01	0.09
		May 3, 2000 (Cut 1)				
Comp.[a]	Variety	Protein	ADF	NDF	TDN	RFV
				%		
Sharps	Amerigraze	22.9	27.5	33.4	70.8	190
Drussel	Enhancer	21.0	32.7	38.2	66.1	157
Drussel	Reward	22.2	31.0	36.3	67.7	167
Sharps	Shamrock	21.1	31.4	38.9	67.4	158
None	Cimarron VR	22.6	27.1	33.1	71.1	191
None	Liberty	21.4	124.0	36.6	69.0	168
LSD (P = .05)		NS	NS	NS	NS	NS
CV		8.8	148.5	10.5	4.3	14
Treatment Prob(F)		0.77	0.48	0.37	0.31	0.36

Quality reported on a dry matter basis. Quality analysis conducted by Servi-Tech Laboratories, Dodge City, KS.

ADF = acid detergent fiber; NDF = neutral detergent fiber; TDN = total digestible nutrients; RFV = relative feed value.

[a] Companies: Sharps = Sharp Brothers, Healy, KS; Drussel = Drussel Seeds, Garden City, KS.

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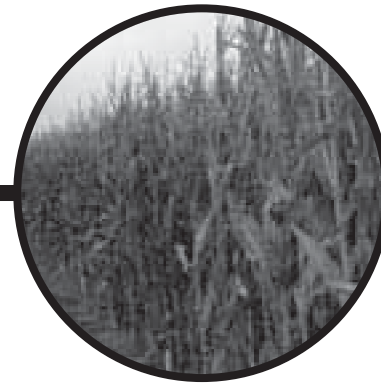

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