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Southwest Research–Extension Center

Report of Progress
961

Kansas State University
Agricultural Experiment Station
and Cooperative Extension Service

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Larry Buschman—Entomologist. Larry received his M.S. at Emporia State University and his Ph.D. at the University of Florida. He 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.

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Contribution 07-34-S from the Kansas Agricultural Experiment Station.

WEATHER INFORMATION FOR GARDEN CITY

by

Jeff Elliott

Total precipitation for 2005 was 18.15 inches. This was near our 30-year average of 18.79 inches. Seasonal distribution was relatively normal. July was our wettest month, with 3.52 inches, and November was our driest, with 0.11 inches. Dime-size hail fell on July 4, causing some crop damage. We received 2.78 inches in October, the wettest since 1984 and 1.87 inches above the average for this month.

Only the months of January, November, and December received measurable snowfall, totaling 5.6 inches. This was considerably less than our 30-year average of 19.51 inches. Our largest 24-hour snowfall event was 1 inch, occurring on January 6 and again on December 17. *Seasonal* snowfall (2004-2005) was also minimal, measuring 5.20 inches.

July was the warmest month in 2005, with an average daily mean temperature of 77.9°F and an average daily maximum of 92.9°F. December was the coolest, with an average daily mean of 31.3°F and an average low of 16.5°F. September through November temperatures were considerably above normal. The average daily mean temperature for the entire year was 55.2°F, which is 2.1°F above our 30-year average. It was our eighth consecutive year with above-average temperature.

Triple-digit temperatures were recorded on 16 days in 2005, the highest being 105°F on June 29. We recorded seven consecutive days above 100 degrees, beginning July 20. Six record-high temperatures were broken or tied in 2005: 72°F on January 25, 81°F on March 13, 102°F on May 22, 100°F on September 22, 95°F on October 3, and 80°F on November 4.

We recorded sub-zero temperatures on three occasions during 2005, with the coldest being -11°F on December 8. Record lows occurred on three consecutive days: 48°F, 49°F, and 53°F, beginning July 27.

The last spring freeze (30°F) was on May 2, which was five days later than normal. The first fall freeze (23°F) was on October 24, thirteen days later than average. This resulted in a 175-day frost-free period, which was nine days longer than the 30-year average.

Open-pan evaporation from April through October totaled 77.44 inches, 6.84 inches above normal. Average daily wind speed was 5.02 mph, compared with 5.25 mph on average.

A summary of the 2005 climate data is presented in the table below.

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

	Precipitation inches		Temperature (°F) 2005Average		Mean		2005 Extreme		Wind MPH		Evaporation inches	
Month	2005	Avg.	Max.	Min.	2005	Avg.	Max.	Min.	2005	Avg.	2005	Avg.
January	0.61	0.43	43.3	19.7	31.5	28.4	73	-1	4.23	4.68		
February	0.87	0.48	50.3	25.7	38.2	33.7	70	12	4.11	5.39		
March	0.44	1.38	59.0	28.1	43.5	42.3	81	17	5.25	6.72		
April	1.04	1.65	68.7	37.1	52.9	52.1	86	26	5.83	6.73	7.68	8.35
May	2.81	3.39	78.6	48.1	63.4	62.0	102	30	5.67	6.04	11.06	9.93
June	3.13	2.88	88.6	58.9	73.7	72.4	105	47	5.69	5.59	13.13	12.32
July	3.52	2.59	92.9	62.8	77.9	77.4	104	48	5.71	4.85	15.72	13.41
August	1.70	2.56	89.7	61.9	75.8	75.5	103	54	3.71	4.17	11.10	11.19
September	0.95	1.25	87.7	56.4	72.1	67.0	100	40	5.93	4.63	11.60	8.88
October	2.78	0.91	73.0	41.3	57.2	54.9	95	23	5.05	4.84	7.15	6.52
November	0.11	0.86	61.2	28.4	44.8	40.5	80	16	4.97	4.86		
December	0.19	0.41	46.2	16.5	31.3	31.3	68	-11	4.03	4.47		
Annual	**18.15**	**18.79**	**70.0**	**40.4**	**55.2**	**53.1**	**105**	**-11**	**5.02**	**5.25**	**77.44**	**70.60**

Average latest freeze in spring	April 27	2005	May 2
Average earliest freeze in fall	October 11	2005	October 24
Average frost-free period	167 days	2005:	175 days

All averages are for the period 1971-2000.

WEATHER INFORMATION FOR TRIBUNE

by
Dewayne Bond and Dale Nolan

Precipitation was 1.55 inches above normal, for a yearly total of 18.99 inches, with five months having above-normal precipitation. June was the wettest month, with 4.48 inches. The largest single amount of precipitation was 2.06 inches on June 11. November was the driest month, with 0.08 inches of precipitation. Snowfall for the year totaled 9.2 inches; 1.7 inches in January, 2.1 inches in February, 0.5 inches in March, 2.0 inches in April and 2.9 inches in December, for a total of twenty days snow cover. Four days was the longest consecutive period of snow cover, occurring four times: January 5 through 8, February 6 through 9, and December 7 through 10 and 17 through 20.

Record high temperatures were recorded on seven days: January 21, 74°F; May 22, 100°F; August 3, 105°F; September 25, 96°F, October 4, 94°F, November 12, 82°F, and December 26, 68°F. Record high temperatures were tied on seven days: January 25, 71°F; March 13, 78°F; July 21; 107°F; August 1, 104°F; August 2, 105°F; September 22, 98°F; and October 3, 95°F. Record low temperatures were set on July 27, 46°F, and December 8, -15°F. July 6, 53°F, tied a record low temperature. July was the warmest month, with a mean temperature of 77.5°F, and had the hottest day of the year on July 21, 107°F. The coldest day of the year was December 8, -15°F. January and December almost tied for the coldest month of the year, with mean temperatures of 31.7°F and 31.8°F, respectively.

All twelve months had mean air temperature above normal. November had the greatest departures from normal, 6.6°F above. There were 17 days of 100°F or above temperatures, seven days above normal. There were 72 days of 90°F or above temperatures, ten days above normal. The last day of 32°F or less in the spring, on May 3, was three days earlier than the normal date, and the first day of 32°F or less in the fall, on October 7, was four days later than the normal date. This produced a frost-free period of 157 days, seven days more than the normal of 150 days.

April through September open pan evaporation totaled 75.59 inches, 4.94 inches above normal. Wind speed for the same period averaged 5.4 mph, 0.1 mph less than normal.

Table 1. Weather data, Southwest Research-Extension Center, Tribune, Kansas.

	Precipitation inches		Temperature (°F) 2005 Average		Normal		2005 Extreme		Wind MPH		Evaporation inches	
Month	2005	Normal	Max.	Min.	Max.	Min.	Max.	Min.	2005	Avg.	2005	Avg.
January	0.43	0.45	43.7	19.7	42.2	12.8	74	-2				
February	0.60	0.52	50.7	24.1	48.5	17.1	71	9				
March	0.70	1.22	57.8	28.0	56.2	24.2	78	15				
April	1.83	1.29	65.5	34.8	65.7	33.0	84	21	5.9	6.3	7.73	8.28
May	1.64	2.76	75.7	45.0	74.5	44.1	100	30	5.2	5.8	12.35	10.88
June	4.48	2.62	86.2	56.2	86.4	54.9	100	44	5.4	5.3	13.76	13.88
July	1.21	3.10	94.3	60.8	92.1	59.8	107	46	6.0	5.4	18.80	15.50
August	3.85	2.09	89.3	59.2	89.9	58.4	105	52	4.0	5.0	12.09	12.48
September	0.34	1.31	85.8	54.2	81.9	48.4	98	40	5.9	5.2	10.86	9.63
October	3.59	1.08	71.4	39.5	70.0	35.1	95	22				
November	0.08	0.63	61.1	28.5	53.3	23.1	82	14				
December	0.24	0.37	46.2	17.4	44.4	15.1	69	-15				
Annual	**18.99**	**17.44**	**72.5**	**34.3**	**67.1**	**35.5**	**107**	**-15**	**5.4**	**5.5**	**75.59**	**70.65**

Average latest freeze in spring[1]	May 6	2005:	May 3
Average earliest freeze in fall	October 3	2005:	October 7
Average frost-free period	150 days	2005:	157 days

[1]Latest and earliest freezes recorded at 32 °F. Average precipitation and temperature are 30-year averages (1971-2000) calculated from National Weather Service. Average temperature, latest freeze, earliest freeze, wind, and evaporation are for the same period calculated from station data.

FOUR-YEAR CROP ROTATIONS WITH WHEAT AND GRAIN SORGHUM[1]

by
Alan Schlegel, Troy Dumler, and Curtis Thompson

SUMMARY

Research on 4-yr crop rotations with wheat and grain sorghum was initiated at the K-State Southwest Research-Extension Center near Tribune in 1996. The 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 inches following sorghum, which is about 3 inches more than at planting of the second wheat crop in a WWSF rotation. Soil water at sorghum planting is about 1.5 inches less for the second sorghum crop, compared with sorghum following wheat. Fallow efficiency was greater for the shorter fallow period following wheat than for the longer fallow following sorghum. Following sorghum, fallow efficiency before wheat averaged 25%, compared with 35% in WW and 43% for the second wheat crop in a WWSF rotation. Before sorghum, fallow efficiency was 36 to 38% and was not affected by previous crop. Grain yield of continuous wheat averages about 78% of the yield of wheat grown in a 4-yr rotation following sorghum. Except for one year, there has been no difference in yields of continuous wheat and recrop wheat grown in a WWSF rotation. Yields are similar for wheat following one or two sorghum crops. Similarly, average sorghum yields were the same when following one or two wheat crops. Yield of the second sorghum crop in a WSSF rotation averages 73% of the yield of the first 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, the question arises as to whether more intensive cropping is feasible. The objectives of this research were to quantify soil water storage, crop water use, crop productivity, and profitability of 4-yr and continuous cropping systems.

PROCEDURES

Research on 4-yr crop rotations with wheat and grain sorghum was initiated at the K-State Southwest Research-Extension Center near Tribune in 1996. The rotations were wheat-wheat-sorghum-fallow and wheat-sorghum-sorghum-fallow, along with a continuous wheat rotation. 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 8 ft) at wheat planting varied greatly from year to year (Fig. 1). Soil water was similar after fallow after either one or two sorghum crops, and averaged, across the 9-yr period, about 9 inches. Water at wheat planting of the second wheat crop in a WWSF rotation was always less than at planting of the first wheat crop, except in 2003, which had the least water content at planting of any year. Soil water for the second wheat crop averaged almost 3 inches (or about 30%) less than soil water ifor the first wheat crop in the rotation. Continuous wheat averaged about 1 inch less water at planting than did 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 fallow) 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 months) fallow following sorghum. Following sorghum, fallow efficiency averaged 25%, compared with 35% in WW and 43% for the second wheat crop in a WWSF rotation.

The amount of available water in the soil profile at sorghum planting also varied greatly from year to

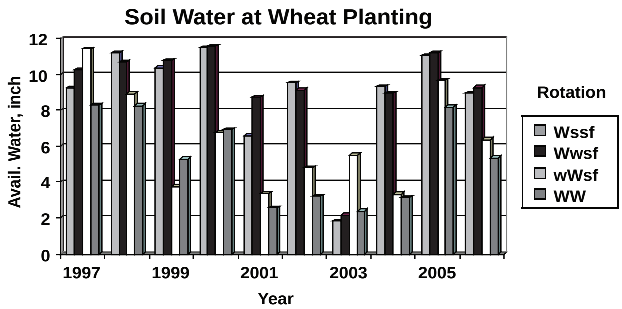

Figure 1. Available soil water at planting of wheat in several rotations, 1997-2005, Tribune, Kansas. Last bars are averages across years. Letter capitalized denotes current crop in rotation.

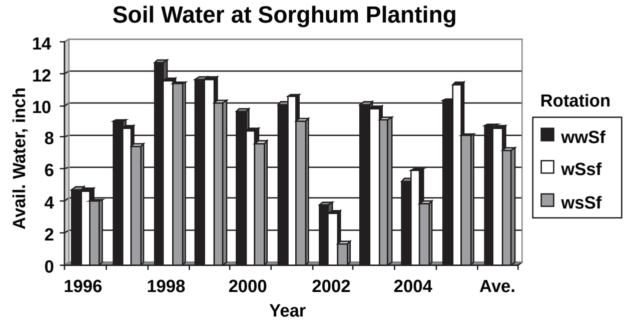

Figure 2. Available soil water at planting of sorghum in several rotations, 1996-2005, Tribune, Kansas. Letter capitalized denotes current crop in rotation.

(Fig. 2). Soil water was similar after fallow after either one or two wheat crops, and averaged (10-yr) about 8.6 inches. Water at planting of the second sorghum crop in a WSSF rotation was always less than water at planting of the first sorghum crop, although sometimes by very little. For instance, in 1998, there was less than 0.25-inch difference between them. When data were averaged across the entire study period, the first sorghum crop had 1.35 inches more available water at planting than did the second crop. Fallow efficiency before sorghum ranged from less than 0 to more than 60%. In contrast to fallow efficiency before wheat, average fallow efficiency before sorghum was similar after wheat or sorghum, at 36 to 38%.

GRAIN YIELDS

Wheat yields were above the long-term average in 2005 (Table 1). Averaged across 9 years, recrop wheat (the second wheat crop in a WWSF rotation) yielded about 90% 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, the recrop wheat yields were more than double the yield in all other rotations. This is possibly due to the failure of the first-year wheat in 2002, resulting in a period from 2000 sorghum harvest to 2003 wheat planting without a harvestable crop. There has been no difference in wheat yields following one or two sorghum crops. The continuous-wheat yields have been similar to recrop wheat yields, except in 2003.

Sorghum yields in 2005 were greater than the long-term yield average for each rotation (Table 2). The recrop sorghum yield averages about 73% of the yield of the first sorghum crop following wheat; in 2005, however, recrop yields were 85% of the first-yearsorghum yield. Although variable from year to year, average sorghum yields were the same following one or two wheat crops. An economic analysis using current costs and average annual commodity prices from 1996 through 2005 was conducted to determine which rotation had the greatest return to land and management. The estimated returns do not

Table 1. Wheat response to rotation, Southwest Research-Extension Center, Tribune, Kansas, 1997 through 2005.

Rotation*	1997	1998	1999	2000	2001	2002	2003	2004	2005	Mean
	- - - - - - - - - -	-	-	-	bu/acre	-	-	- - - - - - - - - -		
Wssf	57	70	74	46	22	0	29	6	45	39
Wwsf	55	64	80	35	29	0	27	6	40	37
wWsf	48	63	41	18	27	0	66	1	41	34
WW	43	60	43	18	34	0	30	1	44	30
LSD (0.05)	8	12	14	10	14	—	14	2	10	3

*Capital letters denote current-year crop.

Table 2. Grain sorghum response to rotation, Southwest Research-Extension Center, Tribune, Kansas, 1996 through 2005.

Rotation*	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Mean
	- bu/acre -										
wSsf	58	88	117	99	63	68	0	60	91	81	72
wsSf	35	45	100	74	23	66	0	41	79	69	53
wwSf	54	80	109	90	67	73	0	76	82	85	72
LSD (0.05)	24	13	12	11	16	18	—	18	17	20	4

* Capital letters denote current year crop.

include government payments or insurance indemnity payments. Average returns were $8.66, $6.75, and $-5.77/tillable acre (crop acres plus fallow acres) for the WWSF, WSSF, and WW rotations, respectively. Although a WSF rotation was not included in this study, if we assume that wheat yields in WSF would be the same as the yield of the first wheat crop in WWSF and that sorghum yields would be the same as the first sorghum crop in WSSF, we can make comparisons of 4-yr and 3-yr rotations. Although it is possible that actual yields in WSF would be different, calculations using the assumed yields show that the return to WSF would be $6.36/acre.

NO-TILL LIMITED IRRIGATED CROPPING SYSTEMS[1]

by
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 inches annually), continuous corn was more profitable in 2005 than were multi-crop rotations including wheat, sorghum, and soybean. Averaged across the past 3 yr, continuous corn has been the most profitable system. A hail storm in mid-August 2005 reduced summer crop yields, particularly for soybean. Wheat yields were reduced by adverse spring weather and some disease pressure, primarily stripe rust.

PROCEDURES

Research was initiated under sprinkler irrigation at the Tribune Unit, Southwest Research-Extension Center near Tribune in the spring of 2001. The objectives are to determine the impact 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 are 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 inches/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. The rotations include 1-, 2-, 3-, and 4-year rotations. The 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 inches of irrigation water annually, but the amount of irrigation water applied to each crop within a rotation varies, depending upon 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. The irrigation amounts are 15 inches to corn in 2-, 3-, and 4-yr rotations, 10 inches to grain sorghum and soybean, and 5 inches to wheat.

RESULTS AND DISCUSSION

The wheat in all rotations followed corn and received 5 inches of irrigation. Wheat yields were low and were reduced by stripe rust (Table 1). All rotations were limited to 10 inches of irrigation, but the corn in rotation with other crops received 15 inches because the wheat only received 5 inches. This extra 5 inches of irrigation increased corn yields about 50 bu/acre, compared with yields of the continuous corn. Corn yields were similar following wheat and sorghum, but about 10 bu/acre greater following soybean. Grain sorghum yields were similar in the 3- and 4-yr rotations.

Averaged across the past 3 years, wheat yields were similar for all rotations (Table 2). Sorghum yields were also similar in the 3- and 4-yr rotations. Continuous corn (with 10 inches of irrigation) yields were about 40 bu/acre less than yields of corn in rotation (with 15 inches of irrigation), with no differences among rotations.

An economic analysis was performed to determine returns to land, irrigation equipment, and management for all four rotations. Because of the poor wheat yields and good corn yields, all returns for the multi-crop rotations were less than continuous corn. Averaged across the past 3 years, continuous corn was about $40/acre more profitable than corn in rotation, primarily because of poor wheat yields.

[1]Project receives 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]Department of Agronomy, Kansas State University, Manhattan.

Table 1. Grain yield of four crops as affected by rotation, Southwest Research-Extension Center, Tribune, Kansas, 2005.

Rotation	Corn	Wheat	Sorghum	Soybean
	----------------- bu/acre -------------			
cont. corn	143	—	—	—
corn-wheat	192	20	—	—
corn-wheat-sorghum	192	18	118	—
corn-wheat-sorghum-soybean	205	18	121	29

Table 2. Average grain yield of four crops as affected by rotation, Southwest Research-Extension Center, Tribune, Kansas, 2003-2005.

Rotation	Corn	Wheat	Sorghum	Soybean
	----------------- bu/acre -------------			
cont. corn	170	—	—	—
corn-wheat	213	33	—	—
corn-wheat-sorghum	211	33	125	—
corn-wheat-sorghum-soybean	213	34	129	45

LONG-TERM NITROGEN AND PHOSPHORUS FERTILIZATION ON YIELD OF IRRIGATED CORN

by
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 2005, N and P applied alone increased yields about 60 and 11 bu/acre, respectively, but N and P applied together increased yields as much as 142 bu/acre. Averaged across the past 10 years, corn yields were increased as much as 125 bu/acre by N and P fertilization. Application of 120 lb N/acre (with P) was sufficient to produce ~90% of maximum yield in 2005, which was slightly less than the 10-year average. Phosphorus increased corn yields in 2005 from 60 to 104 bu/acre (average about 85 bu/acre) when applied with at least 120 lb N/acre. Application of 80 lb P_2O_5/acre increased yields 2 to 22 bu/acre, compared with application of 40 lb P_2O_5/acre, when applied with at least 120 lb N/acre.

INTRODUCTION

This study was initiated in 1961 to determine responses of continuous corn and grain sorghum grown under flood irrigation to N, P, and K fertilization. The study was conducted on a Ulysses silt loam soil with an inherently high K content. No yield benefit to corn from K fertilization was observed in 30 years, and soil K content did not decline, so 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 N/acre without P and K; with 40 lb P_2O_5/acre and zero K; and with 40 lb P_2O_5/acre and 40 lb K_2O/acre. In 1992, the treatments were changed, with the K variable being replaced by a higher rate of P (80 lb P_2O_5/acre). All fertilizers were broadcast by hand in the spring and incorporated before planting. The soil is a Ulysses silt loam. The corn hybrids were Pioneer 3225 (1995-97), Pioneer 3395IR (1998), Pioneer 33A14 (2000), Pioneer 33R93 (2001 and 2002), DeKalb C60-12 (2003), and Pioneer 34N45 (2004 and 2005), planted at about 30,000 to 32,000 seeds/acre in late April or early May. Hail damaged the 2005 and 2002 crop and destroyed the 1999 crop. The corn was irrigated to minimize water stress. Furrow irrigation was used through 2000, and sprinkler irrigation since 2001. The center 2 rows of each plot were machine harvested after physiological maturity. Grain yields were adjusted to 15.5% moisture.

RESULTS AND DISCUSSION

Corn yields in 2005 were slightly less than the 10-year average because of hail damage on August 19 (Table 1). Nitrogen alone increased yields up to 60 bu/acre, whereas P alone increased yields only about 11 bu/acre. But N and P applied together increased corn yields up to 142 bu/acre. Only 120 lb N/acre with P was required to obtain about 90% of maximum yields. Over the past 10 years, 120 lb N/acre with P has produced about 95% of maximum yield. Corn yields were 5 bu/acre greater with 80 than with 40 lb P_2O_5/acre in 2005, which is consistent with the 10-year average. With N rates of 120 lb N/acre or greater in 2005, the higher P rate increased yields about 10 bu/acre.

Table 1. Effect of N and P fertilizers on irrigated corn, Southwest Research-Extension Center, Tribune, Kansas, 1996-2005.

		Grain yield									
Nitrogen	P_2O_5	1996	1997	1998*	2000	2001	2002	2003	2004	2005	Mean
---- lb/acre ----		bu/acre									
0	0	58	66	49	131	54	39	79	67	49	66
0	40	64	79	55	152	43	43	95	97	60	77
0	80	73	83	55	153	48	44	93	98	51	78
40	0	87	86	76	150	71	47	107	92	63	87
40	40	111	111	107	195	127	69	147	154	101	125
40	80	106	114	95	202	129	76	150	148	100	125
80	0	95	130	95	149	75	53	122	118	75	101
80	40	164	153	155	205	169	81	188	209	141	163
80	80	159	155	149	211	182	84	186	205	147	164
120	0	97	105	92	143	56	50	122	103	66	93
120	40	185	173	180	204	177	78	194	228	162	176
120	80	183	162	179	224	191	85	200	234	170	181
160	0	103	108	101	154	76	50	127	136	83	104
160	40	185	169	186	203	186	80	190	231	170	178
160	80	195	187	185	214	188	85	197	240	172	185
200	0	110	110	130	165	130	67	141	162	109	125
200	40	180	185	188	207	177	79	197	234	169	179
200	80	190	193	197	218	194	95	201	239	191	191
ANOVA											
N		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
P_2O_5		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	0.007	0.001	0.001	0.001	0.001
N x P		0.001	0.001	0.001	0.008	0.001	0.133	0.001	0.001	0.001	0.001
MEANS											
N, lb/acre	0	65	76	53	145	48	42	89	87	53	73
	40	102	104	93	182	109	64	135	132	88	112
	80	139	146	133	188	142	73	165	178	121	143
	120	155	147	150	190	142	71	172	188	133	150
	160	161	155	157	190	150	71	172	203	142	156
	200	160	163	172	197	167	80	180	212	156	165
	$LSD_{0.05}$	10	12	11	10	15	8	9	11	10	6
P_2O_5, lb/acre	0	92	101	91	149	77	51	116	113	74	96
	40	148	145	145	194	147	72	168	192	134	149
	80	151	149	143	204	155	78	171	194	139	154
	$LSD_{0.05}$	7	9	7	7	10	6	6	8	7	4

*Note: There were no yield data for 1999 because of hail damage. Hail reduced yields in 2002 and 2005.

K-STATE

Southwest Research-Extension Center

LONG-TERM NITROGEN AND PHOSPHORUS FERTILIZATION ON YIELD OF IRRIGATED GRAIN SORGHUM

by
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 2003, N and P applied alone increased yields about 50 and 13 bu/acre, respectively, but N and P applied together increased yields more than 65 bu/acre. Averaged across the past 10 years, sorghum yields were increased more than 50 bu/acre by N and P fertilization. Application of 40 lb N/acre (with P) was sufficient to produce >90% of maximum yield in 2003 and for the 10-year average. Application of K had no effect on sorghum yield in 2003 or averaged across all years.

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 N/acre without P and K; with 40 lb P_2O_5/acre and zero K; and with 40 lb P_2O_5/acre and 40 lb K_2O/acre. All fertilizers were broadcast by hand in the spring and incorporated before planting. The soil is a Ulysses silt loam. Sorghum (Mycogen TE Y-75 from 1992-1996, Pioneer 8414 in 1997, and Pioneer 8500/8505 from 1998-2005) 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 2 rows of each plot were machine harvested after physiological maturity. Grain yields were adjusted to 12.5% moisture.

RESULTS AND DISCUSSION

Grain sorghum yields were reduced by hail in 2005, and were less than the 10-year average (Table 1). Nitrogen alone increased yields as much as 28 bu/acre, whereas P alone had no effect on yield. But N and P applied together increased sorghum yields as much as 50 bu/acre. Averaged across the past 10 years, only 40 lb N/acre has been required to obtain >90% of maximum yields. Sorghum yields were not affected by K fertilization, which has been true throughout the study period.

Table 1. Effect of N, P, and K fertilizers on irrigated sorghum yields, Southwest Research-Extension Center, Tribune, Kansas, 1996-2005.

N	P_2O_5	K_2O	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Mean
- - - - - lb/acre - - - -			- bu/acre -										
0	0	0	74	81	77	74	77	76	73	80	57	58	73
0	40	0	77	75	77	85	87	81	81	93	73	53	79
0	40	40	79	83	76	84	83	83	82	93	74	54	80
40	0	0	74	104	91	83	88	92	82	92	60	63	84
40	40	0	100	114	118	117	116	124	120	140	112	84	116
40	40	40	101	121	114	114	114	119	121	140	117	84	116
80	0	0	73	100	111	94	97	110	97	108	73	76	95
80	40	0	103	121	125	113	116	138	127	139	103	81	118
80	40	40	103	130	130	123	120	134	131	149	123	92	125
120	0	0	79	91	102	76	82	98	86	97	66	77	86
120	40	0	94	124	125	102	116	134	132	135	106	95	118
120	40	40	99	128	128	105	118	135	127	132	115	98	120
160	0	0	85	118	118	100	96	118	116	122	86	77	105
160	40	0	92	116	131	116	118	141	137	146	120	106	124
160	40	40	91	119	124	107	115	136	133	135	113	91	118
200	0	0	86	107	121	113	104	132	113	131	100	86	111
200	40	0	109	126	133	110	114	139	136	132	115	108	123
200	40	40	95	115	130	120	120	142	143	145	123	101	125
ANOVA (P>F)													
Nitrogen			0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear			0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic			0.116	0.001	0.001	0.227	0.001	0.001	0.001	0.001	0.018	0.005	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			0.727	0.436	0.649	0.741	0.803	0.619	0.920	0.694	0.121	0.803	0.688
N x P-K			0.185	0.045	0.186	0.482	0.061	0.058	0.030	0.008	0.022	0.195	0.018

(continued)

Table 1. (cont.) Effect of N, P, and K fertilizers on irrigated sorghum yields, Southwest Research-Extension Center, Tribune, Kansas, 1996-2005.

N	P_2O_5	K_2O	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Mean
- - - - - lb/acre - - - -			- bu/acre -										
MEANS													
Nitrogen	0 lb/a		77	80	76	81	82	80	79	88	68	55	78
	40		92	113	108	105	106	112	108	124	96	77	105
	80		93	117	122	110	111	127	119	132	100	83	113
	120		91	114	118	95	105	122	115	121	96	90	108
	160		89	118	124	108	110	132	129	134	107	92	116
	200		97	116	128	115	113	138	131	136	113	98	120
	$LSD_{0.05}$		9	10	8	13	7	8	9	10	11	10	7
P_2O_5-K_2O	0 lb/a		79	100	103	90	91	104	94	105	74	73	92
	40- 0		96	113	118	107	111	126	122	131	105	88	113
	40-40		95	116	117	109	112	125	123	132	111	87	114
	$LSD_{0.05}$			7	7	6	9	5	6	6	7	7	7

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

by
Alan Schlegel, Loyd Stone, and Troy Dumler

SUMMARY

Research was initiated under sprinkler irrigation to evaluate limited irrigation with no-till for four summer crops. In 2005, crop yields were reduced because of hail on August 19. Corn tended to withstand the hail better than the other crops. Because of changes in growing conditions, the most profitable crop changes from year to year, so that there is not a single best crop. Growing different crops when irrigation is limited can reduce risk and increase profitability. Averaged across the past 5 years, corn has been the most profitable crop at larger irrigation amounts, whereas soybean has been the most profitable at the least irrigation amount.

PROCEDURES

A study was initiated under sprinkler irrigation at the Tribune Unit, Southwest Research-Extension Center near Tribune in the spring of 2001. The objectives are to determine the impact of limited irrigation on crop yield, water use, and profitability. All crops are grown no-till, and other cultural practices (hybrid selection, fertility practices, weed control, etc.) are selected to optimize production. All irrigation amounts are present each year and are replicated four times. Irrigations are scheduled to supply water at the most critical stress periods for the specific crops, and are limited to 1.5 inches/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 inches annually. The crops evaluated are corn, grain sorghum, soybean, and sunflower, grown in a 4-yr rotation (a total of 12 treatments). The crop rotation is corn-sunflower-grain sorghum-soybean (alternating grass and broadleaf crops). The irrigation amounts for a particular plot remain constant throughout the study (e.g., a plot receiving 5 inches of water one year when corn is grown will also receive 5 inches in the other years when grain sorghum, sunflower, or soybean are grown).

RESULTS AND DISCUSSION

Precipitation from June through August was 10.08 inches (29% above normal), but only 0.76 inches was received in July. Hail on August 19 caused damage to all crops, particularly to soybean. Soybean yields were less than 30 bu/acre for all irrigation treatments (Table 1). Corn responded most to irrigation; corn yields were 58 bu/acre greater with 10 than with 5 inches of irrigation, and were another 17 bu/acre greater with an additional 5 inches of irrigation. Sunflower yields were not increased by increased irrigation amounts.

Table 1. Grain yield of four crops in 2005 as affected by irrigation amount, Southwest Research-Extension Center, Tribune, Kansas.

Irrigation amount	Corn	Sorghum	Soybean	Sunflower
inches	------------ bu/acre	------------	-	lb/acre
5	136	60	23	1880
10	194	76	23	1890
15	211	86	28	1580

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

Table 2. Net return to land, irrigation equipment, and management for four crops from 2001-2005 as affected by irrigation amount, Southwest Research-Extension Center, Tribune, Kansas.

Irrigation amount	Corn	Sorghum	Soybean	Sunflower
inches	- - - - - - - - - - - - - - - - annual net return, $/acre - - - - - - - - - - - - - -			
5	27	12	31	-12
10	130	28	56	-3
15	146	27	52	-26

An economic analysis found that, with the least irrigationl, average net returns (2001-2005) were best for soybean (Table 2), followed closely by corn. With the larger amounts of irrigation, corn was the more profitable crop. Corn was the only crop for which profitability increased with more than 10 inches of irrigation.

In 2005, the plots were split, and a ~20% higher seeding rate was added to each crop except corn, for which the seeding rate was reduced by 20%. The original seeding rates were 30,000 for corn, 80,000 for sorghum, 150,000 for soybean, and 23,500 for sunflower. The same hybrids were used for each crop, except for sorghum, for which a longer-season hybrid was planted at the higher population. For soybean, the higher seeding rate tended to have little impact on grain yield (Table 3). Similarly, for corn, the lower seeding rate tended to have little effect on yield. Sorghum yields were greater with the higher seeding rate, but because this also involved a different hybrid, it is not possible to determine which factor affected yield. With sunflower, results were mixed, with slightly lower yields at the smaller irrigation amounts.

Table 3. Grain yield of four crops in 2005 as affected by irrigation amount and seeding rate, Southwest Research-Extension Center, Tribune, Kansas.

Irrigation amount	Corn	Sorghum	Soybean	Sunflower
inches	- - - - - - - - - - - - - - - - bu/acre - - - -- - - - - - - -			lb/acre
5	136 (131)	60 (92)	23 (25)	1880 (1670)
10	194 (194)	76 (106)	23 (27)	1890 (1620)
15	211 (207)	86 (126)	28 (28)	1580 (1640)

The values in parentheses are for 20% different seeding rate.

LAND APPLICATION OF ANIMAL WASTES ON YIELD OF IRRIGATED CORN[1]

by
Alan Schlegel, Loyd Stone, 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, and at a rate double the N requirement. Other treatments were N fertilizer (60, 120, and 180 lb N/acre) and an untreated control. Corn yields were increased by application of animal wastes and N fertilizer. Over-application of cattle manure has not had a negative effect on corn yield. For swine effluent, over-application has not reduced corn yields, except in 2004, when the effluent had much greater salt concentration than in previous years, which 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 two most common animal wastes in western Kansas were evaluated; solid cattle manure from a commercial beef feedlot and effluent water from a lagoon on a commercial swine facility.

PROCEDURES

The rate of waste application was based on the amount needed to meet the estimated crop P requirement, crop N requirement, or double the N requirement (Table 1). The Kansas Dept. of Agriculture Nutrient Utilization Plan Form was used to calculate animal waste application rates. Expected corn yield was 200 bu/acre. The allowable P application rates for the P-based treatments were 105 lb P_2O_5/acre because soil test P content was 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, the residual soil N content after harvest in 2001, 2002, and 2004 were sufficient to eliminate the need for additional N the following year. So no swine effluent was applied to the 1xN treatment in 2002, 2003, or 2005, or to the 2xN requirement treatment because it is based on 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 1000 gallon of swine effluent (actual analysis of animal wastes as applied differed 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 N/acre) and an untreated control. The N fertilizer treatments also received a uniform application of 50 lb/acre of 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. The swine effluent was flood-applied as part of a pre-plant irrigation each year. Plots not receiving swine effluent were also irrigated at the same time to balance water additions. The 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 through 2005. The

[1]Project supported in part by Kansas Fertilizer Research Fund and Kansas Dept. of Health and Environment.

soil is a Ulysses silt loam. Corn was planted at about 33,000 seeds/acre 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.

Table 1. Application rates of animal wastes, Southwest Research-Extension Center, Tribune, Kansas, 1999 to 2005.

Application basis *	Cattle manure						
	ton/acre						
	1999	2000	2001	2002	2003	2004	2005
P req.	15.0	4.1	6.6	5.8	8.8	4.9	3.3
N req.	15.0	6.6	11.3	11.7	0	9.8	6.8
2XN req.	30.0	13.2	22.6	22.7	0	19.7	13.5
	Swine effluent						
	1000 gal/acre						
	1999	2000	2001	2002	2003	2004	2005
P req.	28.0	75.0	61.9	63.4	66.9	74.1	73.3
N req.	28.0	9.4	37.8	0	0	40.8	0
2XN req.	56.0	18.8	75.5	0	0	81.7	0

* The animal waste applications are based on the estimated requirement of N and P for a 200 bu/acre corn crop.

Table 2. Analysis of animal waste as applied, Southwest Research-Extension Center, Tribune, Kansas, 1999 to 2005.

Nutrient content	Cattle manure						
	lb/ton						
	1999	2000	2001	2002	2003	2004	2005
Total N	27.2	36.0	33.9	25.0	28.2	29.7	31.6
Total P_2O_5	29.9	19.6	28.6	19.9	14.6	18.1	26.7
	Swine effluent						
	lb/1000 gal						
	1999	2000	2001	2002	2003	2004	2005
Total N	8.65	7.33	7.83	11.62	7.58	21.42	13.19
Total P_2O_5	1.55	2.09	2.51	1.60	0.99	2.10	1.88

RESULTS AND DISCUSSION

Corn yields were increased by all animal waste and N fertilizer applications in 2005, as has been true for all years except in 2002, in which yields were greatly reduced by hail damage (Table 3). The type of animal waste affected yields in 4 of the 6 years, with higher yields from cattle manure than from swine effluent. Averaged across the 6 years, corn yields were 13 bu/acre greater after application of cattle manure than after swine effluent on an N-application basis. Over-application (2xN) of cattle manure has had no negative impact on grain yield in any year, but over-application of swine effluent reduced yields in 2004 because of considerably greater salt content (2 to 3 times greater electrical conductivity than any previous year), causing germination damage and poor stands. No adverse residual effect from the over-application was observed in 2005.

Table 3. Effect of animal waste and N fertilizer on irrigated corn, Southwest Research-Extension Center, Tribune, Kansas, 2000-2005.

		Grain yield						
Nutrient source	Rate basis†	2000	2001	2002	2003	2004	2005	Mean
		bu/acre						
Cattle manure	P	197	192	91	174	241	143	173
	N	195	182	90	175	243	147	172
	2 X N	195	185	92	181	244	155	175
Swine effluent	P	189	162	74	168	173	135	150
	N	194	178	72	167	206	136	159
	2 X N	181	174	71	171	129	147	145
N fertilizer	60 N	178	149	82	161	170	96	139
	120 N	186	173	76	170	236	139	163
	180 N	184	172	78	175	235	153	166
Control	0	158	113	87	97	94	46	99
$LSD_{0.05}$		22	20	17	22	36	16	12
ANOVA								
Treatment		0.034	0.001	0.072	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
Manure vs. fertilizer		0.089	0.006	0.498	0.470	0.377	0.001	0.049
Cattle vs. swine		0.220	0.009	0.001	0.218	0.001	0.045	0.001
Cattle 1x vs. 2x		0.900	0.831	0.831	0.608	0.973	0.298	0.597
Swine 1x vs. 2x		0.237	0.633	0.875	0.730	0.001	0.159	0.031
N rate linear		0.591	0.024	0.639	0.203	0.001	0.001	0.001
N rate quadratic	0.602	0.161	0.614	0.806	0.032	0.038	0.051	

†Rate of animal waste applications based on amount needed to meet estimated crop P requirement, N requirement, or twice the N requirement.

No yields reported for 1999 because of severe hail damage. Hail reduced corn yields in 2002 and 2005.

LARGE-SCALE DRYLAND CROPPING SYSTEMS[1]

by
Alan Schlegel, Curtis Thompson, and Troy Dumler

SUMMARY

A large-scale rain-fed cropping systems research and demonstration project evaluated four summer crops (corn, grain sorghum, sunflower, and soybean), along with winter wheat, in crop rotations varying in length from 2 to 4 years. The objective of the study is to identify cropping systems that enhance and stabilize production in rain-fed cropping systems to optimize economic crop production. Wheat yields in 2005 were lower following sunflower than following any other crop. This trend has been seen in most years, with an average of 10 bu/acre lower wheat yields following sunflower than following sorghum. In 2005, grain sorghum and sunflower yields were 24 to 34% higher following wheat than following corn. In 2005, corn yields were reduced by below-normal precipitation during July, whereas sorghum benefited from above-average precipitation during August. Averaged across the past 11 yr, sorghum has yielded 15 bu/acre more than corn.

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. The objectives are a) to enhance and stabilize production of rain-fed cropping systems through the use of multiple crops and rotations, using best management practices to optimize capture and utilization of precipitation for economic crop production and b) to enhance adoption of alternative rain-fed cropping systems that provide optimal profitability.

PROCEDURES

The crop rotations are 2-yr (wheat-fallow [WF]), 3-yr (wheat-grain sorghum-fallow [WSF] and wheat-sunflower-fallow), and 4-yr rotations (wheat-corn-sunflower-fallow, wheat-corn-sorghum-fallow, and wheat-corn-soybean-fallow). All rotations are grown by using no-till (NT) practices, except for wheat-fallow, which is grown by using reduced tillage (RT). All phases of each rotation are present each year. Plot size is a minimum of 100 by 450 ft. In most instances, grain yields were determined by harvesting the center 60 ft (by entire length) of each plot with a commercial combine, and determining grain weight in a weigh-wagon. If harvesting the entire plot was not feasible, then smaller sections of each plot were harvested with a plot combine.

RESULTS AND DISCUSSION

Grain yield of winter wheat in 2005 was 43 bu/acre in WF and WSF rotations (Table 1). Wheat following either soybean or sorghum in 4-yr rotations yielded 10 to 12 bu/acre less than in WF or WSF. Wheat following sunflower, whether in a 3- or 4-yr rotation, yielded less than half of yield in WF or WSF. Above-average temperatures and below-average (39% of normal) rainfall in July severely reduced corn yields. Grain sorghum was better able to withstand the dry July and benefited from above-average (184% of normal) precipitation in August. Sorghum yields were 15 bu/acre higher following wheat than following corn. Similarly, sunflower yields were 30% higher following wheat than following corn. Soybean yields were severely restricted by rodent damage, primarily rabbits.

In most years, wheat yields are lower following sunflower than following sorghum (Table 2). Averaged across the past 11 years, wheat yields are 10 bu/acre higher following sorghum than following sunflower. For the same time period, wheat yields have been 3 bu/acre higher in WF than in WSF. In 7 of the past 11 years, grain sorghum has yielded more than corn when both were planted no-till into wheat stubble (Table 3).

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

Table 1. Grain yield response to crop rotation, Southwest Research-Extension Center, Tribune, Kansas, 2005.

Crop Rotation	Wheat	Corn	Sorghum	Soybean*	Sunflower
	- - - - - - - - - - - - - -	bu/acre	- - - - - - - - - - - -		lb/acre
Wheat – fallow	43	- - -	- - -	- - -	- - -
Wheat - sorghum – fallow	43	- - -	77	- - -	- - -
Wheat - sunflower – fallow	19	- - -	- - -	- - -	1115
Wheat - corn - sunflower - fallow	18	7	- - -	- - -	835
Wheat - corn – sorghum - fallow	33	17	62	- - -	- - -
Wheat - corn – soybean - fallow	31	15	- - -	7	- - -
$LSD_{0.05}$	13	13	9	- - -	598

* Nearly destroyed by rabbits.

Table 2. Wheat yields in three rotations, Southwest Research-Extension Center, Tribune, Kansas.

Wheat yields	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Mean
	- - - - - - - -					bu/a					- - - - - - - -	
W -F (RT)	34	26	47	55	69	18	60	2	31	4	43	35
W -GS - F (RT/NT)	31	15	42	53	68	28	46	0	22	4	43	32
W – SF - F (RT/NT)	27	7	28	51	52	11	30	0	18	3	19	22

The 3-yr rotations initially used tillage before wheat, but since 1998 these rotations were changed to complete NT.
W=wheat, F=fallow, GS=grain sorghum, and SF=sunflower. NT=no-till and RT=reduced tillage.

Table 3. Grain yield of corn, grain sorghum, and sunflower in wheat-row crop-fallow rotations, Southwest Research-Extension Center, Tribune, Kansas.

Row crop yields	1995	1996	1997	1998	1999	2000	2001*	2002	2003	2004	2005	Mean
	- - - - - - - -					bu/a					- - - - - - - -	
W-C-F (RT/NT)	20	80	33	78	70	11	4	0	5	116	13	39
W -GS F (RT/NT)	38	65	21	94	96	48	19	0	28	112	77	54
W - SF - F (RT/NT)	634	61	603	59	1025	312	217	0	223	1272	1115	502

* Corn yields since 2001 are from 4-yr rotations.

The wheat-row crop rotations initially used tillage before wheat, but since 1998 these rotations were changed to complete NT.
Sunflower yields are in lb/acre.
W=wheat, F=fallow, GS=grain sorghum, and SF=sunflower. NT=no-till and RT=reduced tillage.

IMPACT OF LONG-TERM NO-TILL ON CROP YIELD AND ECONOMICS[1]

by
Alan Schlegel, Troy Dumler, and Loyd Stone

SUMMARY

A study was initiated in west-central Kansas near Tribune to evaluate the long-term effects of tillage intensity on soil properties and grain yield in a wheat-sorghum-fallow (WSF) rotation. Grain yields of wheat and grain sorghum increased with decreased tillage intensity. Averaged across 15 yr, yield of no-till (NT) wheat was 4 bu/acre greater than yield with reduced tillage (RT) and 8 bu/acre greater than yield with conventional tillage (CT). Average NT sorghum yields were 13 bu/acre greater than for RT and 34 bu/acre greater than for CT. For grain sorghum, in particular, the advantage of reducing tillage intensity has increased with time. Also for grain sorghum, there is a yield benefit from long-term no-till, compared with short-term no-till. An economic analysis showed that CT was the least profitable system. Profitability was similar for both RT and NT, at about $15/a/yr greater than CT.

INTRODUCTION

In recent years, tillage intensity has decreased in dryland systems in the Great Plains in an attempt to improve precipitation capture and reduce evaporation losses. The objectives of this study were to quantify the impact of reduced-tillage practices on precipitation capture, soil properties, crop production, and profitability in a WSF rotation.

PROCEDURES

Research on different tillage intensities in a WSF rotation at the K-State Southwest Research-Extension Center at Tribune was initiated in 1991 on land just removed from native sod. The three tillage intensities are CT, RT, and NT. The CT system was tilled as needed to control weed growth during the fallow period. On average, this resulted in 4 to 5 tillage operations per year, usually with a blade plow. The NT system used herbicides (primarily glyphosate) to control weed growth during the fallow period, usually requiring 3 to 4 applications during each fallow period. The RT system initially used a combination of herbicides (1 to 2 applications) and tillage (2 to 3 tillage operations) to control weed growth during the fallow period before each crop. In 2001, the RT system was changed to a combination of NT from wheat harvest through sorghum planting and CT from sorghum harvest to wheat planting. This did not change the overall number of tillage and herbicide applications for the rotation, but did change when they were performed. All tillage systems used herbicides for in-crop weed control. Plot size was 50 by 100 ft, with four replications. All phases of the rotation were present each year.

Grain yield was determined by machine harvesting the center of each plot after crop physiological maturity. Profile soil water was measured to a depth of 8 ft near planting time and after harvest of each crop. Economic returns to land and management were calculated for each tillage system by using enterprise budget techniques. Crop input costs for each tillage system were based on typical practices during the study and input prices from 2004, which are more representative of long-term average costs. Machinery costs were based on values reported in *Kansas Custom Rates* from Kansas Agricultural Statistics Service. Crop prices reflect average prices in southwest Kansas during the month of harvest.

RESULTS AND DISCUSSION

SOIL WATER

The amount of soil water accumulation during fallow (from harvest of previous crop to planting of current crop) varied widely among years for both crops (Fig. 1 and 2). In some years, there was a loss of stored soil water from harvest to planting whereas, in other years, fallow accumulation exceeded 10 inches. On average, CT was the least effective in accumulating soil water for both crops. Before wheat,

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

fallow accumulation averaged 4.82 inches for CT, compared with 5.66 inches for RT and 5.24 inches for NT. Somewhat surprising was that the NT system did not accumulate more water than RT. Fallow efficiency (amount of water accumulated during fallow, divided by precipitation during fallow) ranged from less than 0 to more than 50%, and averaged 26% for CT, compared with 31% for RT and 28% for NT.

For sorghum, soil water accumulation from wheat harvest to sorghum planting averaged 3.92 inches for CT, compared with 5.34 inches for RT and 4.93 inches for NT. Fallow efficiency was 22% for CT, compared with 33% for RT and 29% for NT.

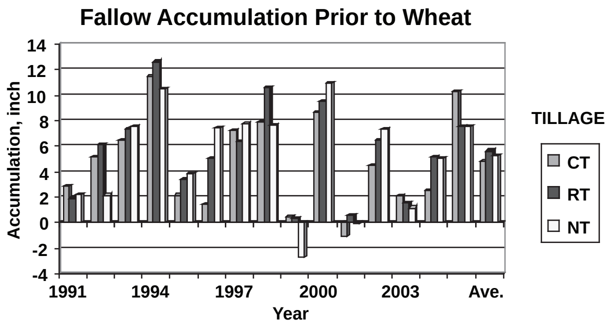

Figure 1. Soil water accumulation during fallow before wheat in a WSF rotation, 1991-2005, Tribune, Kan.

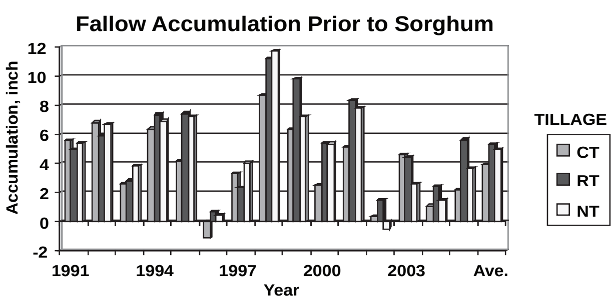

Figure 2. Soil water accumulation during fallow before sorghum in a WSF rotation, 1991-2005, Tribune, Kan.

GRAIN YIELD OF WHEAT AND GRAIN SORGHUM

Wheat yields increased when tillage intensity decreased. On average (1991-2005), wheat yields were 8 bu/acre higher for NT (38 bu/acre) than for CT (30 bu/acre). Wheat yields for RT (34 bu/acre) were 4 bu/acre greater than for CT. During the first 5 yr of the study, wheat yields were similar for CT and RT, with NT yields 3 bu/acre greater (Fig. 3). During the late1990s (1996-2000), NT yields were 5 bu/acre greater than yields for RT and 14 bu/acre greater than yields for CT. The two years with the lowest wheat yields (less than 5 bu/acre) of the entire study occurred in the past 5 yr (2002 because of drought and 2004 because of mid-May freeze). Although average yields during this 5-yr period were very low, NT produced 6 bu/acre more wheat than CT did.

The yield benefit from reduced tillage was greater for grain sorghum than for wheat (Fig. 4). Grain sorghum yields for CT averaged 36 bu/acre for the entire study period, compared with 57 bu/acre for RT and 70 bu/acre for NT. The yield benefit from reduction in tillage has increased during the study. During the first 5 yr, sorghum yields were about 17 bu/acre greater with RT or NT than with CT. During the late 1990s, with generally good growing conditions, CT sorghum averaged 57 bu/acre, compared with 88 bu/acre for RT and 103 bu/acre for NT. Similar to results for wheat, there have been two poor sorghum years since 2000 (2002 and 2003), but the relative advantage to reduced tillage has increased. Averaged across the past 5 yr, sorghum yields were 56 bu/acre for NT, compared with 31 bu/acre for RT and only 17 bu/acre for CT. In 2004, NT sorghum yields were 118 bu/acre, compared with 67 bu/acre for RT and 44 bu/acre for CT.

In the past 5 yr, the RT system used a combination of no-till before sorghum and conventional tillage before wheat, so it is interesting that sorghum yields were 25 bu/acre greater with NT than with RT, even though both were no-till planted. There evidently is a yield benefit from long-term vs. short-term no-till.

ECONOMICS

Reflecting increased yields with reduced tillage, economic returns were higher for RT and NT rotations compared with CT. With 28% higher costs associated with NT wheat versus CT wheat and 54% higher costs for NT sorghum versus CT sorghum, returns for the NT rotation were only slightly higher than RT (Table 1). Considering individual crop returns, RT wheat had average returns of $24.12/ac, compared with $12.60/ac for CT wheat and $13.54/ac for NT wheat. NT sorghum had the highest average returns at $10.42/ac, compared with -$12.28/ac for CT sorghum and -$0.89 for RT sorghum.

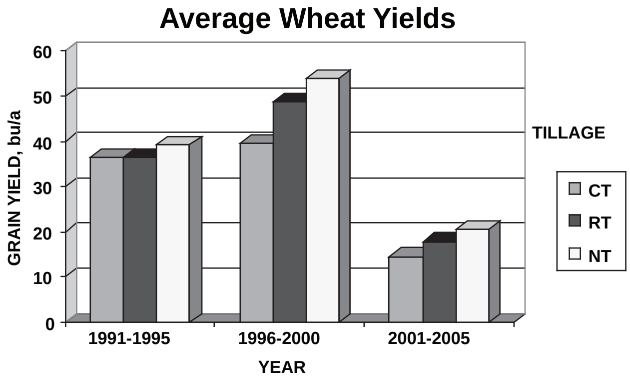

Figure 3. Average wheat yields, as affected by tillage in a WSF rotation, Tribune, Kansas.

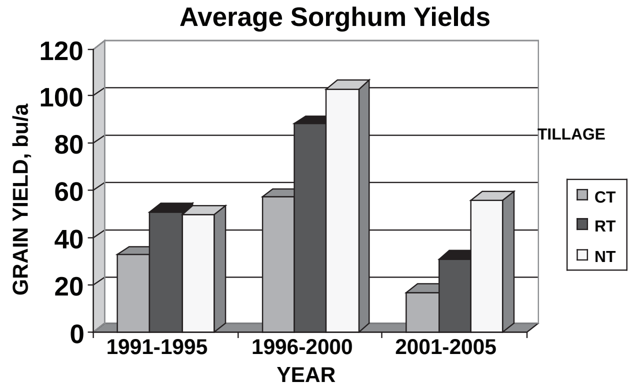

Figure 4. Average grain sorghum yields, as affected by tillage in a WSF rotation, Tribune, Kansas.

Table 1. Average costs and returns per planted acre and average returns for a WSF rotation with different tillage intensities, Southwest Research-Extension Center, Tribune, Kansas.

Tillage	CT	RT	NT
		Average costs per planted acre	
Wheat	$79.82	$80.84	$102.43
Grain sorghum	$87.46	$119.96	$134.49
		Average returns per planted acre	
Wheat	$12.60	$24.12	$13.54
Grain sorghum	-$12.28	-$0.89	$10.42
		Average returns per tillable acre	
WSF rotation	$0.21	$15.48	$15.97

K-STATE
Southwest Research-Extension Center

SOIL WATER EVAPORATION AS INFLUENCED BY CROP-RESIDUE MANAGEMENT IN SPRINKLER IRRIGATION

by
Norman Klocke, Rob Aiken[1], Randall Currie, and Loyd Stone

SUMMARY

Soil water evaporation beneath sprinkler irrigated no-till corn and soybean crops was measured with mini-lysimeters. The frequency and wetting patterns of sprinkler irrigation keep the soil surface vulnerable to evaporation controlled by radiant and convective energy. This study documented the role of irrigation frequency and crop residues in soil water evaporation. Reducing soil water evaporation with the adoption of crop-residue management can lead to reduced pumping and energy costs for irrigators, while providing adequate water and increased crop production for irrigators with limited water supplies.

INTRODUCTION

Evapotranspiration from crops (ETc) is a two-part process. The transpiration process, or water consumed principally by evaporation near leaf and stem surfaces, is essential for plant growth and relates directly to grain yield. The soil water evaporation process (E), or water directly vaporizing into the air from the soil, is not productive and can be reduced without sacrificing crop yield. The proportion of soil water evaporation relative to ETc indicates the potential for reducing non-effective water use.

Wet soil surfaces from sprinkler irrigation account for most of energy-limited evaporation during the growing season. Crop residues left in place insulate the soil surface from this energy and reduce evaporation. The objectives of this study were: (1) to measure soil water evaporation under full and limited sprinkler irrigation in corn and soybean crops that have both no-till wheat and corn residue and (2) to determine the proportions of soil water evaporation to crop evapotranspiration (E/ETc).

PROCEDURES

Soil water evaporation was measured during the summers of 2003, 2004, and 2005 at Kansas State University's Research and Extension Center near Garden City, Kansas. Mini-lysimeters were used for evaporation measurement. They were undisturbed soil cores, 12 inches in diameter and 5.5 inches deep, encased in PVC tubing. The bottoms of the cores were sealed with galvanized discs and caulking. Because water could only escape from the soil surface, evaporation could be measured from daily weight changes in the mini-lysimeters.

Two lysimeters within the same surface treatment were placed in a diagonal pattern across 30-inch rows under the crop canopy to record east-west effects of row orientation. There were four replications of corn stover, wheat stubble, and a bare-soil control each year of the study. High- and low-frequency irrigation treatments were applied to corn and soybean crops with mini-lysimeters in 2004 and to just a corn crop with mini-lysimeters in 2005. Only soybeans were grown with high-frequency irrigation in 2003. High-frequency irrigation was managed to meet full atmospheric demand for water (full ETc). The low-frequency irrigation treatment received approximately half the amount of water as the high-frequency treatment.

Crop evapotranspiration (ETc) was calculated from a bi-weekly water balance of field measurements of rainfall, net irrigation, and change in soil water from the surface to a depth of 8 feet. The volumetric soil water content was measured with neutron attenuation techniques.

A second experiment was conducted with soil surfaces partly covered with crop residues. The objectives were to (1) quantify the relationships

[1]Northwest Research-Extension Center, Colby.

between surface cover dry matter and soil water evaporation and (2) quantify the relationship between percentage of surface cover and soil water evaporation. This experiment was conducted in a controlled area surrounded by irrigated clipped grass. The mini-lysimeters were slipped into PVC sleeves that were buried at ground level. All of the mini-lysimeters were arranged adjacent to each other in two rectangular arrays. To determine evaporative loss, the mini-lysimeters were weighed daily. The two irrigation treatments were low and high frequency, which corresponded to watering once and twice per week. Partial-cover treatments had 25%, 50%, and 65% of the surface covered. The percentages of surface covered were confirmed with the NRCS line transect method. The 100% corn and 89% wheat treatments were field-prepared mini-lysimeters

RESULTS AND DISCUSSION

UNDER CROP CANOPY FIELD RESULTS

During 2003, the more frequent irrigation treatment (8 irrigation events) for soybean was conducted to meet full ET demand of the crop. Corn and wheat residues reduced evaporation by 50%, or 0.03 inch/day. This quantity is impressive on a daily basis because extrapolated over 100 days of a growing season, the water savings totals 3 inches. With ample rainfall during 2004 (17 inches from May 1 through Sept. 30), the high- and low-irrigation treatments received 3 and 7 applications on the soybean and 4 and 9 applications on the corn.

For 2003 and 2005, only the irrigation events were reported in Table 1 because rain events did not have influence on data collection periods. Because 2004 rain was a factor during data collection, rainfall events are reported to indicate the impact on evaporation. Because 2004 was a wet year and 2005 was drier, with a hail storm (July 4, 2005) that destroyed the soybeans and damaged the corn, comparisons of the years are risky. Total rainfall from May 1 through September 30, 2005, was 13 inches, 4 inches less than the same period in 2004.

Soil water evaporation rates for high-frequency irrigation treatments in soybeans were similar in 3003 and 2004, except for bare soil. The 2004 observation period started a month earlier, with less canopy development. This could bring more days with higher evaporation rates into the data set. Residue-covered soil would not be influenced as much as the bare soil by the lack of crop canopy. Soil water evaporation daily rates for corn were more in 2005 than in 2004, possibly due to the more open canopy after the 2005 hail storm (Table 1). The crop residues cut evaporation in half during both observation periods. Differences in evaporation between irrigation treatments with crop residues were not evident. If both irrigation treatments had similar durations of energy-limited evaporation, losses would be similar under the crop residue.

Table 1. Soil water evaporation results beneath corn and soybean canopies, Southwest Research-Extension Center, Garden City, Kansas, 2003 to 2005.

Surface cover	E rate —in/day—	E savings[1] —in/day—	E/ETc[2] %	Watering events[3]
2003 Soybean		July 18 - Sept 6 (51 days)		
Bare 2[4]	0.06		25	8
Corn 2	0.03	0.03	14	8
Wheat 2	0.03	0.03	12	8
2004 Soybean		Jun 9 - Sept 20 (104 days)		
Bare 1	0.06		33	12
Bare 2	0.08		32	19
Corn 1	0.04	0.02	19	12
Corn 2	0.03	0.05	15	19
Wheat 1	0.03	0.03	17	12
Wheat 2	0.04	0.04	17	19
2004 Corn		Jun 2 - Sept 20 (111 days)		
Bare 1	0.05		32	14
Bare 2	0.06		35	22
Corn 1	0.03	0.02	17	14
Corn 2	0.03	0.03	19	22
Wheat 1	0.02	0.03	15	14
Wheat 2	0.03	0.03	19	22
2005 Corn		Jun 21-Aug 11 (52 days)		
Bare 1	0.07		29	5
Bare 2	0.07		23	9
Corn 1	0.04	0.03	16	5
Corn 2	0.04	0.03	13	9
Wheat 1	0.05	0.02	20	5
Wheat 2	0.04	0.03	15	9

[1]Evaporation savings as the difference between total soil evaporation from bare soil and corn or wheat covered.
[2]Evaporation as a percentage of calculated ETc from water balance.
[3]Includes rainfall events in 2004.
[4]Numbers indicate weekly watering frequency (1 = Low, 2 = High).

CONTROL AREA PARTIAL-COVER RESULTS

The partial-cover treatments were intended to simulate corn residue left after tillage operations. From past research, these crop residue amounts might represent these tillage operations: 25% cover—double disk; 50% cover—single disk; 75% cover—chisel. These partial-cover corn stover treatments were compared with the 100% corn stover and wheat stubble treatments from the field study. The mass in tons per acre of residue cover remaining on the mini-lysimeters at the end of the control study was: 0.5(25%), 2.3(50%), 1.6(65%), 8.3(100%), and 7.1(90% wheat). Percentage cover and total cover mass did not always correlate because the leaf and stem densities were not necessarily consistent among treatments. For example, average residue mass for the 25% corn stover actually exceeded the mass for the 50% corn stover treatment.

Figure 1 shows the average daily rate of soil water evaporation for all surface cover-water frequency combinations from September 6 to October 7. Twice weekly irrigation resulted in 0.01 inch/day more evaporation than the once weekly irrigation in the bare and partial-cover treatments. The 100% corn stover and wheat stubble treatments had the same evaporation with irrigation frequency. Reducing soil surface energy with full cover slowed evaporation rates so that soil limitations to surface drying did not become a factor.

Treatments with less than 65% of soil surface cover and 2.5 tons/acre of dry matter had daily E rates equal

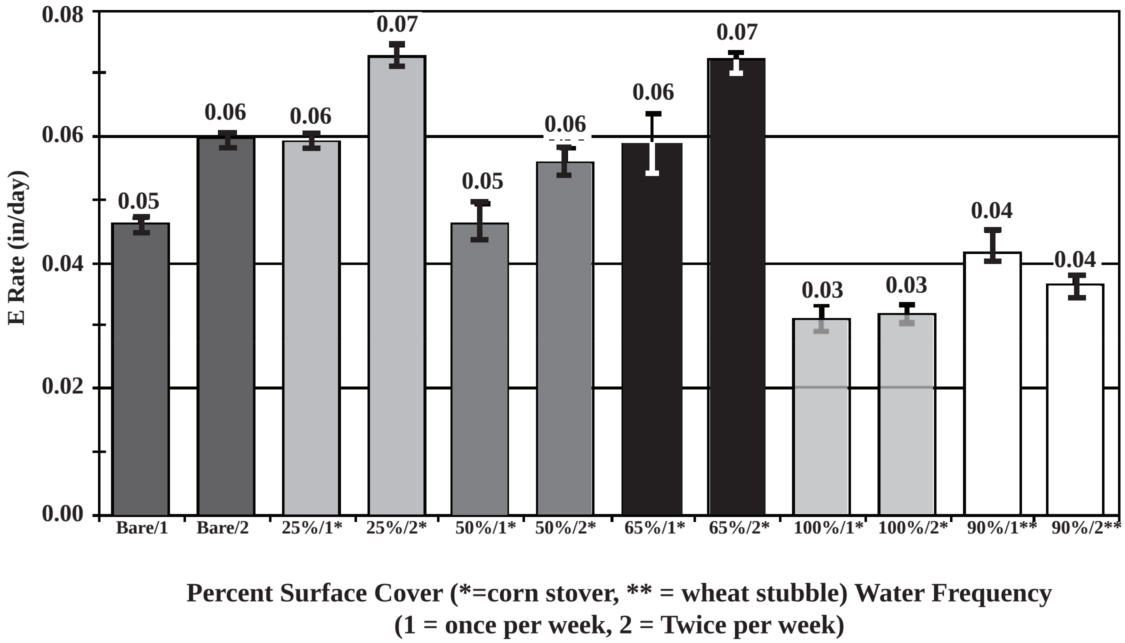

Figure 1. Total soil water evaporation from September 6 to October 7, 2005, for bare, partly covered, and fully covered treatments. Error bars represent ± one standard deviation from the mean.

to or 0.01 inch/day greater than bare soil rates. Only treatments with 90% of cover and 7.1 tons/acre of dry matter had daily E rates of 0.02-0.03 inch/day less than bare soil rates. We speculate that a combination of residue cover and mass were needed to reduce evaporation

The 50% corn stover treatment, results were similar to the bare treatment, whereas the 25% and 65% results were similar. This trend may have been related to the mass of cover on the soil surface. Even though the 50% cover treatment shaded some of the surface, it had less mass to absorb energy. The 100% corn stover and 90% wheat stubble treatments had both surface cover and residue mass to reduce evaporation.

No matter how efficient sprinkler irrigation applications become, the soil is left wet and subject to evaporation. Frequent irrigations and shading by the crop leave the soil surface in the state of energy-limited evaporation for a large part of the growing season. This research found that evaporation from the soil surface (E) is a substantial portion of total consumptive use (ET). As much as 30% of ET was E for bare soil conditions during the irrigation season under corn and soybean canopies with silt loam soils. Under a variety of climatic conditions, crop residues reduced the evaporation from soil by half, even beneath an irrigated crop canopy.

OPTIMIZATION OF WATER AMONG CROPS FOR LIMITED IRRIGATION

by

Norman Klocke, Loyd Stone[1], Troy Dumler, and Gary Clark[2]

SUMMARY

Software has been completed for a computer software tool (Crop Water Allocator) that irrigators and water policy makers can use to allocate limited water to a selection of crops. Because irrigation well capacities are dwindling and water allocations are more restrictive, irrigators need to consider different crop combinations. Optimum economic returns are calculated from all possible combinations of crops, irrigation patterns, and land allocations proposed by a user's input scenario. This tool guides irrigators and water professionals to cropping strategies that return the best value from the limited water used in irrigation, from individual fields to a regional analysis.

INTRODUCTION

To make reductions in water and energy use, irrigators are considering shifts in cropping patterns. Irrigators who have shrinking water supplies need to make decisions on the most profitable cropping systems. Furthermore, they need to allocate both land and water resources to multiple crops. Irrigation scheduling decisions for irrigation managers with limited water resources are not made on a daily basis, as is true for managers of fully irrigated systems. Managers of limited-capacity irrigation systems need to schedule their applications with a fixed amount of cropping-season water, due to limited well capacity or water allocation, and need to plan a cropping system strategy. The objective was to develop and implement an irrigation decision model that will allow irrigators to optimize water and land resources for the best mix of crops and associated water allocations.

PROCEDURES

A crop water allocator (CWA) has been developed to assist in planning cropping patterns and targeting irrigation to those crops. It is an economic model that will predict the net returns of possible cropping options. Net returns are to land, management, and irrigation equipment inasmuch as only operating costs are subtracted from gross income. The model uses crop-yield and irrigation relationships that were generated from the Kansas Water Budget, a water balance simulation model for western Kansas. The Kansas Water Budget used yield-evapotranspiration relationships for each crop. Through simulations with rainfall patterns across western Kansas and irrigation-management assumptions, yield-irrigation relationships were formulated. Example output yield-irrigation relationships for grain sorghum are in Figure 1. Each broken line represents annual rainfall for an area across the region. Diminishing-return relationships of yield with irrigation applied were typical for all crops used in CWA (corn, grain sorghum, wheat, soybean, sunflower, and alfalfa). Crop production and irrigation costs can be completely controlled by the user with inputs to CWA, or the user can rely on default values from K-State surveys of typical farming operations in western Kansas.

The user first selects possible proportions of land considered for potential rotation of crops and/or fallow. The percentages of land splits could be: 50-50, 75-25, 33-33-33, 50-25-25, and 25-25-25-25. The user can select more crops than the selected number of land splits for consideration by the program. The program will consider all possible combinations of crops and water allocations. The crop species, maximum crop

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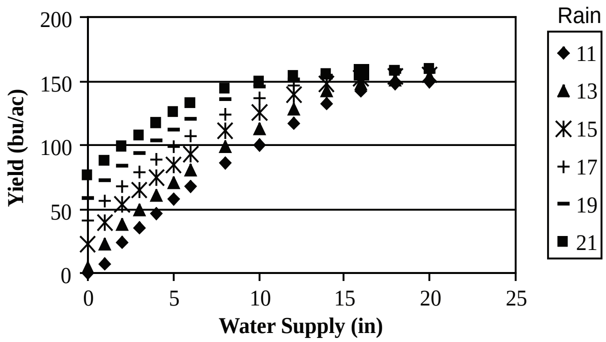

Figure 1. Yield-irrigation relationship for grain sorghum, with annual rainfall from 11 to 21 inches.

yields, irrigation water costs, crop-production costs, and water allocation for the season (gross irrigation) are then entered. The program then iterates, by 10% increments of the water allocation, all possible net income solutions. By changing one input value at a time, subsequent runs of the model can give the user indications of the sensitivities of net returns to commodity prices, production-cost inputs, crop selections, and land allocations.

RESULTS AND DISCUSSION

Crop Water Allocator (CWA) was released on the World Wide Web during December 2004 at www.oznet.ksu.edu/mil. It is available to users to download to their individual computers. Individual farmers as users of the program can guide outcomes by their own preferences and strengths. The program is sensitive to commodity prices and maximum yields, which can influence results, based on user inputs. Water-policy agencies are reviewing CWA for application in risk-management programs. The crop insurance industry is considering more options for limited-irrigation cropping sequences under insured programs. Colorado is considering the feasibility of rotation of fallowed water rights in cropping sequences._

Output from CWA gives irrigators who are planning strategies for their limited water, and those working in water professions, the opportunity to examine trends. For example, multiple runs of the model allow the user to examine combined effects of water allocation, commodity prices, maximum yields, irrigation costs, and production costs. Figure 2 shows the results of series of CWA outputs of net returns over a range of water allocations. The first line generated for Figure 2 was the "reference" scenario. The inputs for the reference scenario were typical for no-till management in western Kansas during 2006. The water costs were based on $7.00/acre-inch, and the commodity prices and maximum expected crop yields with no water restrictions are in Table 1. The annual rainfall was 17 inches and the land split was 33-33-33. The CWA could choose among row crops (corn, soybean, sunflower, grain sorghum, and wheat) for crop rotations. Alfalfa was excluded until later.

First, the reference inputs were used to execute the CWA at each water supply amount to construct the points for the reference line in Figure 2. When the water supply was from 12 to 20 inches, CWA selected continuous corn, but CWA selected a corn-wheat rotation when the water supply was from 6 to 10 inches. Second, the soybean price was increased from $4.50 to $5.50/bu. All other reference inputs remained constant. The result was the "high" soybean line in Figure 2. The CWA did not select soybeans for the reference scenario, but exclusively selected soybeans for water supplies from 8 to 22 inches. Third, the soybean price returned to $4.50/bu and the irrigation cost was

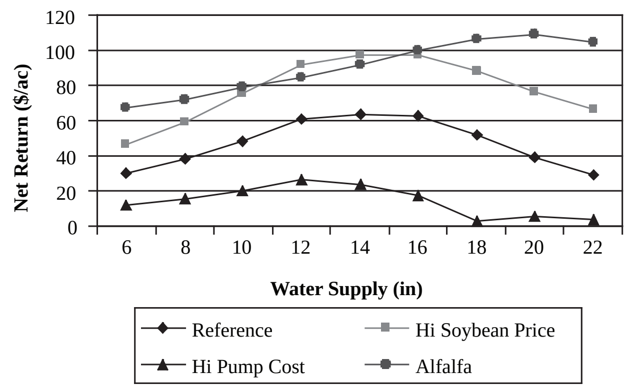

Figure 2. Trends in net return to land, management, and irrigation equipment predicted by CWA for a 2006 reference (row crop) scenario, for a "high" soybean price ($5.50 vs. $4.50/bu for reference), for a "high" pumping cost ($10 vs. $7/acre-inch for reference), and for an alfalfa scenario.

Table 1. Input values for CWA reference example.

Crop	Commodity price	Maximum yield
Corn	$2.38 $/bu	200 bu/ac
Sorghum	$2.14 $/bu	120 bu/ac
Soybean	$4.50 $/bu	65 bu/ac
Wheat	$3.20 $/bu	75 bu/ac
Sunflower	$11.00/cwt	2700 lb/ac
Alfalfa	$75.00/ton	7 t/ac

increased from $7.00 to $10.00/acre-inch. This is a typical range of pumping costs reported for natural gas and diesel during 2005. The CWA selected corn and wheat rotations for 6- to 10-inch water supplies, continuous corn for 12 to 16 inches of water, and corn-fallow rotations for 18- to 22-inch water supplies. The increased energy costs penalized high water use to the point of reducing irrigated acres. If pumping costs were to increase to $12/acre-inch, CWA would predict no net return from this scenario. Fourth, the pumping cost was returned to $7.00/acre-inch, and alfalfa was considered for selection, along with the row crops and fallow. In this selection, alfalfa was chosen exclusively over the row crops and fallow, even at the lowest water supply. When water was very limited, water was applied at full irrigation to part of the field and at nearly dryland rates on the rest of the field.

The CWA model allows irrigators, county agents, consultants, or water planners to evaluate combinations of land allocations, cropping systems, and water allocations for optimum economic return. The CWA model is user friendly and can be executed with a few basic inputs, but more experienced users can modify default input and production costs to match field-specific scenarios. As water resources become more limited, programs such as the CWA model can be used to help plan for future farming operations, or to assess potential impacts of changes in water policy.

CROP WATER
ALLOCATOR

LIMITED IRRIGATION CROPPING SYSTEMS

by
Norman Klocke and Randall Currie

SUMMARY

Total soil water management during the growing and non-growing season can be enhanced with crop-residue management. Capture and retention of soil water, plus supplemental irrigation at critical growth stages, can maximize limited irrigation resources. This research quantifies the water use and irrigation requirements of corn, winter wheat, grain sorghum, and sunflower crops grown with optimum water management by using all water conservation techniques available. The outcome is the potential to reduce irrigation requirements for more fully irrigated crops and to increase grain yields for limited irrigated crops.

INTRODUCTION

Past irrigation management research has demonstrated that annual grain crops respond best to water applications during flowering and seed-fill growth periods. No-till management systems, which leave crop residues on the surface, have been beneficial in increasing off-season capture and retention of precipitation, reducing soil water evaporation, and reducing runoff in sprinkler irrigation. This project is designed to combine the best irrigation and crop-residue management techniques into one management system. The products of this project are grain yield-water use and grain yield-irrigation relationships. By harvesting the plots for both grain and forage, the issue of the value of forages for water conservation is also examined.

The objective of this study was to measure the grain yield-irrigation and grain yield-water use relationships for corn, soybean, grain sorghum, winter wheat, and sunflower crops in no-till management with irrigation inputs from 3 inches to full irrigation.

PROCEDURES

The experimental field was subdivided into six 3-acre cropped strips that were irrigated by a 4-span linear-move sprinkler irrigation system. The cropping sequence was corn-corn-soybean-winter wheat-grain sorghum-sunflower. The soil was a silt loam with pH 8.3 and slope of less than 1%. The six irrigation treatments, replicated four times, ranged in water application from a season total of 3 inches to full atmospheric demand. Irrigation frequency was limited to no more than 2 inches per week. If rainfall was sufficient to fill the soil profile to field capacity, irrigation was not applied. The extra irrigation allocation was rolled over to the next growth stage. If there was extra allocation at the end of the year, it was not carried over to the next year. The study area was not pre-irrigated, and the same irrigation treatments followed one another from year to year. (Dry plots followed dry plots and wet plots followed wet plots.)

Soil water was measured once every two weeks with the neutron attenuation method in increments of 1 ft to a depth of 8 ft. There was one sampling site per plot. These measurements were used to calculate evapotranspiration for each 2-week period from a water balance of soil water, net irrigation, and rainfall.

RESULTS AND DISCUSSION

Grain yield response to irrigation for 2004 and 2005 is shown in Figures 1 and 2. Grain sorghum and sunflower yields were the same for all irrigation treatments. The lowest application rate (3 inches) was sufficient both years. Grain yields were less in 2005 than 2004 because of hail damage (July 4, 2005). Wheat yields responded slightly to irrigation in 2005, but not at all in 2004. Favorable spring rain in 2004 assisted the drier wheat plots. Corn yields responded to additional irrigation in both years. Favorable growing conditions and rainfall in 2004 (17 inches from May 1 to September 30, 2004) produced maximum yields with 10 inches of irrigation. Again in 2005, maximum corn yields were produced with 10 to 11 inches of irrigation, even though hail affected the crop and rainfall was less (13 inches from May 1 to September 30, 2005).

The grain yield responses to irrigation in Figures 1 and 2 are based on how the water was managed on a year-round basis. Irrigation was reduced from conventional practices (normally 16 to 18 inches) because there was soil water available from the off-season, and irrigation was managed according to atmospheric demand and soil water availability. Extra water came from snow trapped and retained by standing crop residue. Precipitation infiltrated where it fell. Soil water evaporation was reduced, starting from harvest of the previous crop through the entire growing season, by untilled crop residue. Water application on fully irrigated plots was managed to meet, and not exceed, atmospheric demand for water. Soil water status was measured bi-weekly, and was monitored for management decisions. All of these factors worked together to reduce crop irrigation needs.

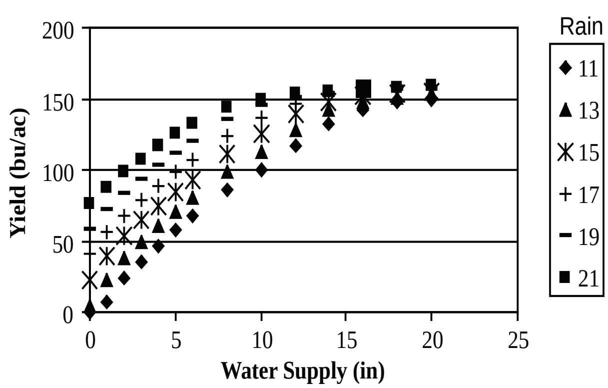

Figure 1. Yield-irrigation relationship for grain sorghum, with annual rainfall from 11 to 21 inches.

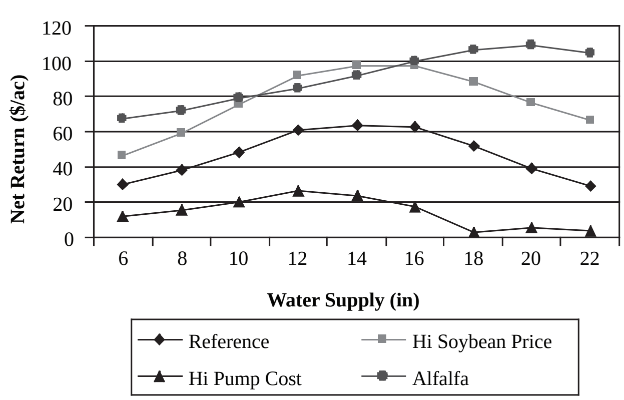

Figure 2. 2005 crop yield-irrigation relationships for crops grown at Garden City, Kansas, Southwest Research-Extension Center, Kansas State University.

Differences in grain yield among crops opens possibilities for strategies for crop selection when well capacity is limited. Corn returned more grain with added water until it became over-watered. Economic returns follow this same trend (see paper on “Optimization of Water among Crops for Limited Irrigation” in this publication). Wheat, sunflower, and grain sorghum yielded well with small amounts of irrigation. Results are needed for dry years, but previous research at this research center has indicated that these traditional dryland crops can be sustained at optimum yields with little irrigation. The two characteristics of economic response to irrigation from corn and sustainable yields with small irrigation investments can be used for limited-capacity wells. Planting two crops, one with lower water demand than the other, on one field increases the per-acre capacity of the well. This option is also enhanced with crop-residue management possibilities that take advantage of the stubble that crops like wheat produce for water savings in the next crop (see paper on “Soil Water Evaporation as Influenced by Crop-residue Management in Sprinkler Irrigation” in this publication). Systems management, including crop residues and irrigation timing, for limited water resources has the potential to reduce water applications and/or increasing crop yields.

ECONOMICS OF IRRIGATION ENDING DATE FOR CORN: USING FIELD DEMONSTRATION RESULTS[1]

by

Mahbub Alam, Troy J. Dumler, Danny H. Rogers[2], and Kent Shaw[3]

SUMMARY

The results from a field study indicate that corn growers of western Kansas may cut back the last one or two irrigation events of the season without appreciable loss in production. This will improve the economic return by reducing input cost from water. Recent increases in energy costs for pumping water necessitated this study to compare the benefits of continuing irrigation until black layer formation. With the decline of Ogallala aquifer groundwater level and rising fuel costs, any reduction of pumping makes economic sense. Ending irrigation around August 10 to 15, corresponding to denting at 1/4 to 1/2 of starch-layer formation toward the germ layer, resulted in a yield reduction of 17 bushels per acre, compared with ending irrigation around August 21 or 22, corresponding to 1/2 to 3/4 of starch-layer formation toward the germ layer. Whereas, continuing irrigation until September 1, corresponding to the start of black layer formation, improved yield by only 2.5 bushels per acre. Economic sensitivity tests show that irrigating until the formation of starch layer at 1/2 to 3/4 towards germ layer is feasible with a corn price of $2 per bushel and $8 per inch pumping costs. Irrigating past this stage of grain development is not economical, even with $2.75 / bushel of corn and pumping costs as low as $4 / inch.

INTRODUCTION

Crop production in western Kansas is dependent on irrigation. The irrigation water source is groundwater from the Ogallala aquifer. The water level of the Ogallala aquifer is declining, causing the depth of pumping to increase. The additional fuel consumption required for greater pumping depths and higher energy costs have resulted in increased pumping costs in recent years. Because of declining water levels and higher pumping costs, it is necessary to conserve water by adopting efficient water-management practices. Irrigation scheduling is an important management tool. Farmers are interested in information on optimum timing for ending the irrigation season. There are some misconceptions regarding the optimum irrigation ending dates. Some farmers believe that the corn crop must continue to have water to avoid eardrop. Over-application at the end of season, based on this perception, causes waste of water, increases cost of production, and may even cause degradation of the quality of the grain due to high humidity or disease. Most of all, the excess use of water may reduce the useful life of the Ogallala aquifer, which is a confined aquifer with little or no recharge. Depletion of the Ogallala aquifer will impact irrigated agriculture and the present economy of the area. The objective of the study was to determine the effect that irrigation ending date had on corn yield and economic return.

PROCEDURES

A producer's field with center-pivot sprinkler irrigation was selected for the study. A Ulysses silty loam soil was selected, and the study was conducted for four years (2000-2003). Two sets of six nozzles were shut progressively after the formation of the starch layer in the corn grain. The first closure was done when the starch layer was 1/4 to 1/2 to the germ. This corresponded to August 10 to 15, depending on growing degree units. The second closure was done

[1]This research project recieves support from the Kansas Corn Commission, Kansas Water Authority and the producers at Rome Farms in Stevens County.
[2]Department of Biological and Agricultural Engineering, Kansas State University, Manhattan.
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when the starch layer was 1/2 to 3/4 to the corn germ. This corresponded to August 21 to 24. The third closure occurred when the producer ended irrigation for the year. This happened during the first week of September.

Four random plots of 30 ft by 30 ft were identified within the center-pivot sprinkler circle, over which the selected nozzles would pass during an irrigation event. Ridges were built around the plots to prevent entry of water from the adjacent areas. Gypsum block soil water sensors were buried in the plots at 1, 2, and 3 ft below the soil surface. The soil of the test field is relatively dark, with a deep profile and good water-holding capacity, but the soil surface cracks when dry.

Corn ears were hand harvested. Four contiguous rows, measuring 10 ft each, were harvested at the middle of each plot to remove any border effect. Grain yields were adjusted to 15.5% moisture content.

In 2005, the study was moved to a field with loamy fine sand soil (Vona loamy fine sand) to evaluate irrigation ending date for a light textured soil with less water-holding capacity. The hypothesis is that the sandy soil may require continuation of irrigation, and irrigation ending date may be delayed, compared with a silty loam soil having greater water-holding capacity. The procedure followed was similar to the earlier study, in which two sets of six nozzles were closed progressively as the grain formed its starch layer.

RESULTS AND DISCUSSION

Continuation of irrigation from the first ending date in early August (August 10 to 15) to the second ending date in the beginning of the fourth week (August 21 to 22) gave an increase averaging 17 bushels of grain per acre. The additional irrigation application amounted to 2.1 inches. The yield difference from the August 22 ending date to the ending date in the first week of September, as normally practiced, was only 2.5 bushels per acre, on average, over four years. The additional irrigation quantity for the period from the first ending to last irrigation date was 4.6 inches (additional 2.5 inches from second ending date), on average, over four years. The yearly yields are shown in Figure 1.

The tool used to determine the optimum irrigation ending date was the marginal value vs. marginal cost analysis. In this analysis, corn prices ranged from $2.00 to $2.75 per bushel, and pumping costs ranged from $3.00 to $8.00 per inch. Positive returns indicate that the marginal benefit of continuing irrigation was greater than the cost of applying water.

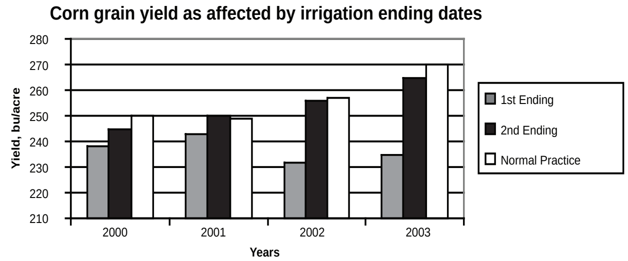

Figure 1. Yield of corn grain as affected by irrigation ending date at different growth stage on a silty loam soil, Stevens County, Kansas, 2000 to 2003.

Figure 2 shows that, under nearly all scenarios, irrigation remains profitable until the second ending date. Irrigation past this growth stage may not be profitable (Figure 3). Return becomes negative for corn at a pumping cost of $4.00 per inch, even at a corn price of $2.75 per bushel.

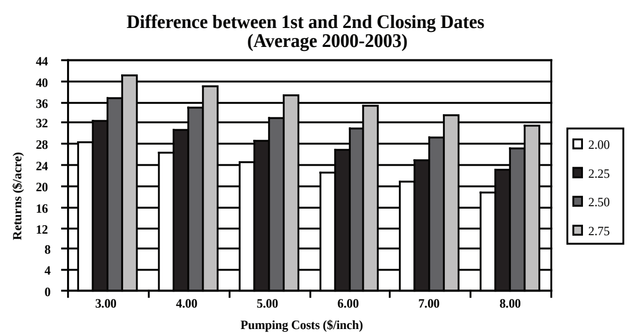

Figure 2. Returns at different levels of input cost and price of corn for difference between first and second ending dates .

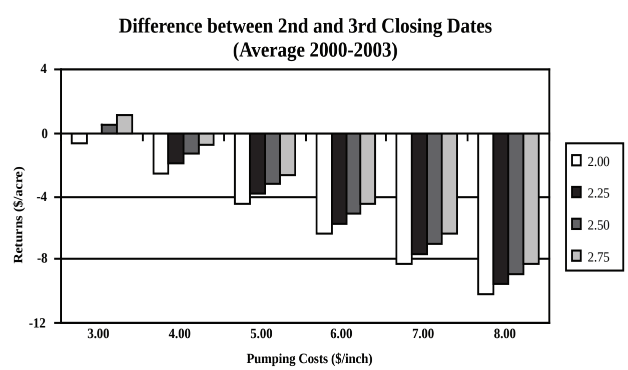

Figure 3. Returns at different levels of input cost and price of corn for difference between second and third ending dates.

Kansas State University water management bulletin No. MF-2174 presents a table showing normal water requirements for corn between stages of growth and maturity. Corn grain, at full dent, will use 2.5 inches of water for the remaining 13 days before reaching physiological maturity.

The available water-holding capacity of the soil in the study field is estimated to be approximately six inches or more per 3 feet of root zone. It is expected that at a 50% management allowable depletion level, this soil will provide about 3 inches of water. This may be why there was no appreciable benefit from continuing irrigation past August 21 or after the starch layer has moved past 1/2 to 3/4 toward the germ layer. The soil water sensors indicated that the soil water condition was adequate to carry the crop to full maturity. Soil water status monitored by gypsum block sensors is presented in Figures 4 through 6.

Figure 4 shows that the soil water at 1 and 3-ft depths were falling below Management Allowable Depletion (MAD) level for the first ending date, which caused a reduction in yield. Figure 5 shows that soil water in the top 1 ft started to decrease in the plots of the second ending date, but there was enough water at the 2- and 3-ft depths to carry the crop to maturity. At this site for some reason, the moisture level at 1 to 2 ft was at MAD levels at the beginning of the season. This changed as irrigation started.

Figure 6 shows soil water readings taken until September 11 at the area where irrigation continued until September 1 under producers' practices; the readings indicate that soil water was almost at Field Capacity, except for the first foot of the profile. The crop was already mature, and there was no more water use. The profile was left with high water content over the winter. Most of the irrigated cornfields in western Kansas reflect this situation, and have little room to store winter and early spring precipitation. This causes double loss, from not taking advantage of natural precipitation and from leaching of nutrients with the deep percolation of excess water. A three-year study by Rogers and Lamm (1994) also indicated that the irrigation practices of corn producers of western Kansas leave approximately 1.4 inches of available soil water per foot of soil profile at harvest.

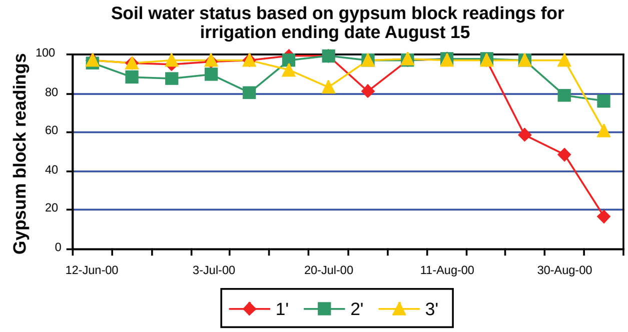

Figure 4. Soil water status for first irrigation ending date. (FC=field capacity, 100% available water holding capacity or AWHC, MAD=management allowable depletion, 50% AWHC, PWP=permanent wilting point, 0% AWHC).

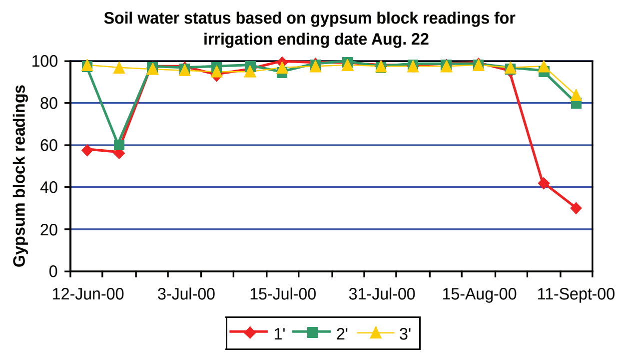

Figure 5. Soil water status for second irrigation ending date. (FC = Field Capacity, MAD = Management Allowable Depletion, and PWP = Permanent Wilting Point).

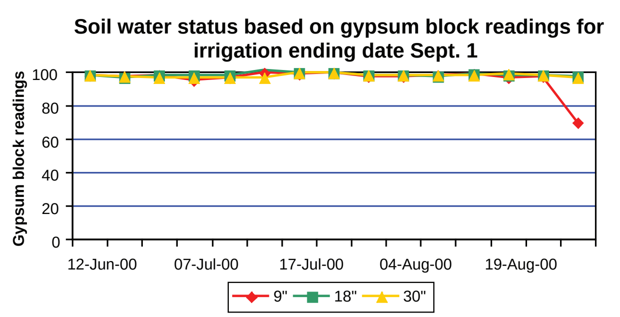

Figure 6. Soil water status on third irrigation ending date. (FC = Field Capacity, MAD = Management Allowable Depletion, and PWP = Permanent Wilting Point).

Producers using irrigated agriculture are continuously being educated on irrigation scheduling. Kansas State University Biological and Agricultural Engineering developed computer software called KanSched to provide the producers with an easy to use tool for irrigation scheduling. The irrigation events, rainfall, and crop water use (Evapotranspiration) data were entered to track the soil water depletion pattern, which is presented in Figure 7. Tracking of crop water use and irrigation applications show that the soil profile was pretty full at the end of the season when irrigation was continued until September 1.

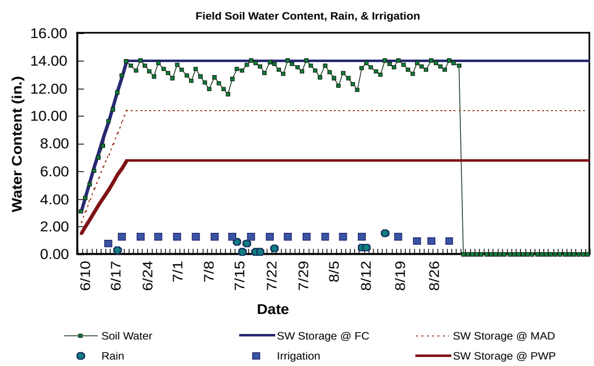

Figure 7. Chart showing water balance between soil water storage at field capacity and permanent wilting point. The dashed line in the middle represents management allowable depletion.

It would be worthwhile to mention that there was no appreciable eardrop observed in the field within the circular area having the first irrigation ending date, but the plants were dryer than plants in the rest of the field at the time of harvest.

The 2005 trial on Vona loamy fine sand needs to be continued to establish a trend, but the first-year results do indicate that the return remains positive at a pumping cost of $5.00 per inch, although the rate of return has been greatly reduced, Figures 8 and 9.

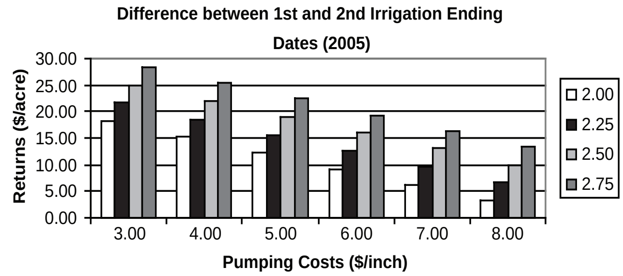

Figure 8. Returns at different levels of input cost and price of corn for difference between first and second ending dates.

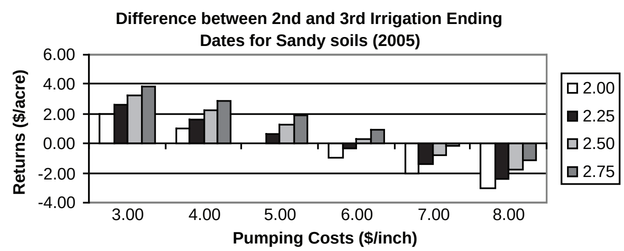

Figure 9. Returns at different levels of input cost and price of corn for difference between second and third ending dates.

The four-year field study indicates that the present practice of irrigating until the formation of black layer in corn grain may not be economical. An earlier ending date for irrigation corresponding to the starch layer at 1/2 to 3/4 of the grain may help improve the economic return and best utilize the soil profile water in a silt loam soil. Using KanSched or Soil water monitoring by other means may help in the decision process. Earlier ending dates may require more cautious evaluation for a sandy soil because of its poor water-holding capacity.

IS CHEAT (*BROMUS TECTORUM L.*) A NOXIOUS WEED OR VALUED COVER CROP IN IRRIGATED CORN?

by
Randall Currie and Norman Klocke

INTRODUCTION

Previous work has shown that a wheat cover crop can improve water-use efficiency (WUE), weed control, and yield of irrigated corn. (Weed Science 53:709-716). Therefore, to reduce the expense of planting the wheat cover crop, we hypothesized that a downy brome (cheat) cover crop could provide the same benefits.

PROCEDURES

To study the masking of cover-crop effects by herbicide treatments, and to study the benefits of WUE, a split-plot experiment was established, with irrigation as the main plot, and a random factorial four-way split consisting of two levels of downy brome cover crop and two rates of herbicide in 4 blocks. A natural stand of downy brome was allowed to naturally reseed in the fall 2003. In March 2004, two of four 49- by 60-ft subplots from within a 120- by 98-ft main plot were treated with 0.75 lb ae/ acre of glyphosate. Corn was planted no-till, with 26,000 kernels per acre, across the whole plot area in May. Two rates of preemergence herbicide, Isoxaflutole+atrazine+S-metolachlor, at .05 +1.5+2 lbs/acre or at half of this rate, were applied on each of the two levels of downy brome cover crop within the larger main plot. Shortly after corn emergence, 8-ft access tubes were installed for bi-weekly soil water monitoring with a neutron attenuation method, as described previously (Weed Science 53:709-716). Irrigation was begun when total available water in the top 4 ft of the soil of the high-water treatment was depleted by 25 to 40%. The high-water treatment simulated a medium-capacity 700 gal/min well, and consisted of two 1-inch irrigations per week. The low-water treatment simulated the lower end of currently economical well capacity of 300 gal/min. This treatment consisted of a single 1-inch irrigation per week. End-of-season Palmer amaranth biomass was measured. Corn was harvested when grain moisture dropped below 15.5%. Water-use efficiencies were calculated by dividing total corn grain mass by total water used, based on water balance calculated from biweekly soil water measurements, irrigation, and rainfall, as described previously (Weed Science 53:709-716). The experiment was repeated in 2005 at a separate location. At this location, Johnsongrass was present; therefore, a 0.031 lb ai/acre application of nicosulfuron, or of half this rate, was applied to the high- and low-input herbicide plots, respectively.

RESULTS AND DISCUSSION

Summer annual weeds did not differ between treatments in 2004 (data not shown). In 2005, end-of-season Palmer amaranth biomass was 3-fold more in the high-water treatments, compared with the low-water treatments (Figure 1). Further, end-of-season Palmer amaranth biomass was 30% less in the higher-herbicide treatments, compared with the lower-water treatments. The open canopy produced by a severe hail storm in the V-12 growth stage may have increased weed pressure. The downy brome cover-crop treatment reduced corn yield 12.6% in 2004 (Figure 2), but caused no significant yield loss in 2005 (Figure 3). Despite the yield depression seen in 2004, WUE was not depressed by the downy brome cover crop (Figure 4). In contrast, under the more challenging conditions in 2005, WUE was increased by the presence of a brome cover crop (Figure 5). We conclude that a downy brome cover crop might be an asset under conditions of high rainfall, or with appropriately valued irrigation resources. Under certain conditions, however, it should be considered a weed due to its ability to compete for water resources.

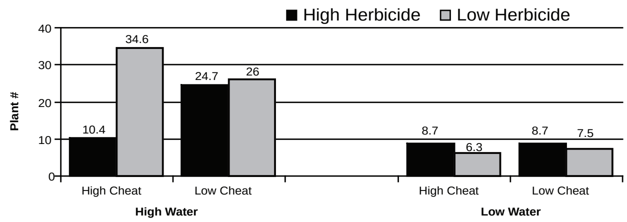

Figure 1. Effect of a downy brome (cheat) cover on Palmer amaranth, with high and low herbicide input and with high and low irrigation inputs, in 2005.

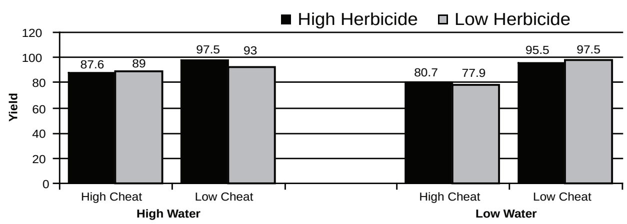

Figure 2. Effects of a downy brome (cheat) cover crop on corn yield, with high and low herbicide inputs and with high and low irrigation inputs, in 2004.

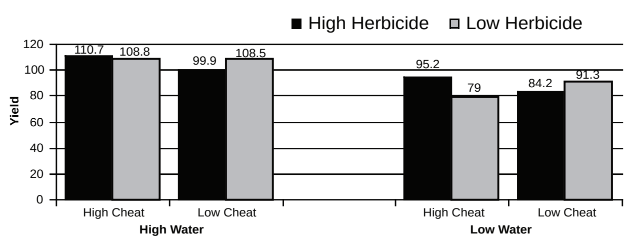

Figure3. Effects of downy brome (cheat) cover crop on corn yield, with high and low herbicide inputs and with high and low irrigation inputs, in 2005.

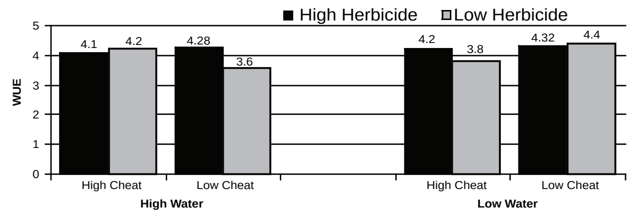

Figure 4. Effects of a downy brome (cheat) cover crop on corn water use efficiency (WUE), with high and low herbicide inputs and with high and low irrigation inputs, in 2004.

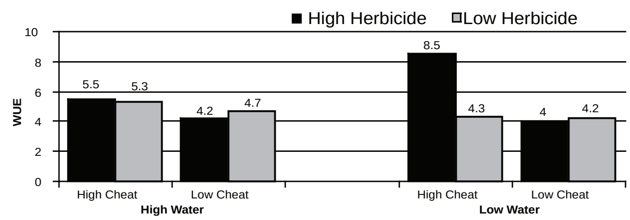

Figure 5. Effects of a downy brome (cheat) cover crop on corn water use efficiency (WUE), with high and low herbicide inputs and with high and low irrigation inputs, in 2005.

COMPARISON OF 22 HERBICIDE TANK MIXES FOR WEED CONTROL IN GLYPHOSATE-RESISTANT CORN

by
Randall Currie

SUMMARY

The best tank mixes reduced crabgrass from 522 to less than 35 plants per 30 foot of row. Perfect control was provided by four tank mixes. Palmer amaranth control changed more than that for the other weed species as the season progressed, as crop canopy was added by later emerging corn and then subtracted by the July 4 hail storm. Early-season control was excellent 16 of the 22 tank mixes, reducing Palmer amaranth numbers to less than 3 plants per 30 foot of row. These treatments tended to maintain control thru July 21.

INTRODUCTION

Although it is possible to achieve 100% weed control with continuous applications of glyphosate to glyphosate-tolerant corn, as the average farm size increases this can be logistically difficult. Further, as genes for glyphosate tolerance begin to appear in weed populations, it is prudent to expose these populations to several different types of herbicides to reduce the rate at which these weeds spread. Therefore, it is desirable to discover a broad range of combinations of pre-emergence and post-emergence tank mixes for weed control in corn. This experiment allows producers to compare weed control and cost of these combinations to allow them to balance the various inputs of capital and labor.

PROCEDURES

Palmer amaranth, yellow foxtail, crabgrass, sunflower, barnyard grass, and shattercane were seeded at 700,000; 344,124; 9,800,000; 40,000; 817,000; and 119,000 seeds/acre, respectively, into prepared fields on May 4, before corn was planted. All weeds except shattercane were planted with a carrier mixture of cracked corn at a rate of 40 lb/acre by using a 14-foot Great Plains Drill with tubes removed to allow weed seed to be dropped on the soil surface. Shattercane was drilled separately, with every third hole set at 1 inch deep, at 2 inches deep, or with the tube pulled for seed to be dropped on the soil surface. Weed seed was planted in 10-inch rows and soil moisture was poor.

The field was conventionally tilled and bedded in the fall. Dekalb DK-6019 RR corn was planted 1.5 inches deep in 30-inch rows at a rate of 34,300 seeds/acre with a John Deere Max Emerge II 6-row planter. Soil moisture at planting was almost adequate for emergence, and the threat of rain in the forecast compelled us to plant. Although the forecast was correct, only 0.19 inches fell, which was not enough to produce an even stand. It was 21 days until sufficient rain fell to ensure emergence of all corn kernels. This produced an uneven stand, with two separate emergence timings. Unevenness in canopy light interception was further aggravated by a July 4 hail storm that removed 30 to 40% of the corn leaf surface just before tasseling.

Irrigation was begun before tasseling, and locally derived irrigation models were used to supply enough water to carry the crop to physiological maturity. Corn was combine harvested, and yields were adjusted to 15% moisture.

RESULTS AND DISCUSSION

Early-season crabgrass control was very similar among most of the tank mixes. Tank mixes that reduced crabgrass plants to less than 38 plants per 30 foot of row were not statistically different from perfect control. Tank mixes with greater than 99 plants per 30 foot of row often did not contain any or contained insufficient pre-emergence activity, or were not applied at the time of the rating and were not statistically different from no herbicide application (Table 1). Later in the season, all treatments provided statistically significant crabgrass control, compared with no treatment. Tank mixes that did not reduce crabgrass numbers to less than 121 plants per 30 foot of row were inferior to the best treatments.

Tank mixes that reduced shattercane to less than 12 plants per 30 foot of row were statistically equal to the best treatments (Table 2). Those tank mixes that did not produce reductions below 21 plants per 30 foot of row did not provide statistically significant reductions in shattercane numbers, compared with no treatment.

Tank mixes that reduced sunflower to less than 5 plants per 30 foot of row were statistically equal to the best treatments. Those tank mixes that did not produce reductions below 7 plants per 30 foot of row did not provide statistically significant reductions in sunflower numbers, compared with no treatment.

Palmer amaranth control changed more than the other weed species as the season progressed, as crop canopy was added by later emerging corn and then subtracted by the July 4 hail storm. Early-season control was excellent with tank mixes that reduced Palmer amaranth control to less than 3 plants per 30 foot of row. These treatments tended to maintain control through July 21. All treatments improved as the season progressed and, by July 21, all treatments provided some, albeit, poor control, compared with the untreated control.

Although all yields were low due to hail injury, all treatments significantly increased corn yield (Table 4). All treatments followed by the letter T were not statistically different from the top-yielding herbicide tank mix. With the exception of treatments 3 and 14, which were total pre-emergence treatments, and treatment 16, which consisted of two well timed post-emergence applications of glyposate, all other top-yielding treatments contained a pre-emergence treatment followed by a post-emergence treatment.

Table 1. Effect of corn herbicide tank mixes on crabgrass, Southwest Research-Extension Center, Garden City, Kansas, 2005.

	Treatment	Rate	Unit	Application timing*	6/16	7/7
					weeds/30 ft of corn	
1	Define SC +Aatrex 90	0.56 + 1.35	lb ai/a + lb ai/a	PREPRE +PREPRE	0	49
2	Radius + Aatrex 90	0.344 + 1.35	lb ai/a + lb ai/a	PREPRE +PREPRE	2	23
3	Balance Pro + Define SC + Aatrex 90	0.0375 + 0.5 + 1.35	lb ai/a + lb ai/a + lb ai/a	PREPRE +PREPRE + PREPRE	0	35
4	Guardsman Max + Balance Pro	2.13 +0.0375	lb ai/a + lb ai/a	PREPRE +PREPRE	16	156
5	Define SC + Aatrex 90 + Option + Distinct +	0.25 + 1 + 0.0328 + 0.0955 +	lb ai/a + lb ai/a + lb ai/a + lb ai/a +	PREPRE + PREPRE +POSPOS + POSPOS +		
	Methylated Seed Oil +UAN 28%	1.57 + 1.5	lb ai/a + lb ai/a	POSPOS + POSPOS	5	10
6	Option + Lexar + Methylated Seed Oil	0.0219 +1.5 +1.57	lb ai/a + lb ai/a +lb ai/a	POSPOS + POSPOS +POSPOS		
	UAN 28%	+ 1.5	lb ai/a	POSPOS	130	189
7	Option + Callisto + Aatrex 90 +	0.0328 +0.0625 +1	lb ai/a + lb ai/a + lb ai/a +	POSPOS + POSPOS +POSPOS +		
	Methylated Seed Oil + UAN 28%	+ 1.57 + 1.5	lb ai/a + lb ai/a	POSPOS + POSPOS	96	112
8	Option + Distinct + Methylated Seed Oil +	0.0328 + 0.191 + 1.57 +	lb ai/a + lb ai/a + lb ai/a	POSPOS + POSPOS + POSPOS		
	UAN 28%	1.5	lb ai/a	POSPOS	97	227
9	Balance Pro + Aatrex 90 +	0.0313 + 0.9 +	lb ai/a + lb ai/a +	PREPRE + PREPRE +		
	Roundup Ultra Max + Ammonium Sulfate	1.02 + 3.4	lb ai/a + lb ai/a	POSPOS + POSPOS	32	2
10	Keystone + Starane + Aatrex 90 +COC	3.4 + 0.127 +0.5 + 1	lb ai/a + lb ai/a + lb ai/a + % v/v	PREPLA + corn<V6 + EAPOWE + EAPOWE	0	14
11	Keystone + Hornet + Balance Pro	3.4 + 0.086 + 0.0156	lb ai/a + lb ai/a + lb ai/a	PREPLA + PREPLA + PREPLA	11	139
12	Keystone + Hornet + Callisto +	3.4 + 0.103 + 0.0313 +	lb ai/a + lb ai/a + lb ai/a +	PREPLA + corn<V7 + POSPOS +		
	Aatrex 90 + COC	0.225 + 1	lb ai/a + % v/v	POSPOS + POSPOS	19	95
13	Python WDG + Balance Pro +	0.05 + 0.0313 +	lb ai/a + lb ai/a +	PREPLA + PREPLA +		
	Glyphomax XRT + Ammonium Sulfate	1.01 + 3.4	lb ai/a + lb ai/a	POSPOS + POSPOS	18	10
14	Lumax + Aatrex 4L	2.47 + 0.375	lb ai/a + lb ai/a	PREPLA + PREPLA	0	69
15	Lexar	2.78	lb ai/a	PREPLA	9	71
16	Touchdown Hitech 5 SL + NIS +	0.75 + 0.25 +	lb ai/a + % v/v +	3"weed + 3"weed +		
	Ammonium Sulfate + Touchdown Hitech 5 SL +	3.4 + 0.75 +	lb ai/a + lb ai/a +	3"weed + corn<18" +		
	NIS + Ammonium Sulfate	0.25 + 3.4	% v/v + lb ai/a	corn>6" + corn=V6	142	3
17	Bicep Lite II Magnum +	2.25 +	lb ai/a +	PREPLA +		
	Touchdown Hitech 5 SL + NIS +	0.75 + 0.25 +	lb ai/a + % v/v +	POSPOS + POSPOS +		
	Ammonium Sulfate	3.4	lb ai/a	POSPOS	4	3
18	Camix + Aatrex 4L + Touchdown Hitech 5 SL +	1.15 + 1 + 0.75 +	lb ai/a + lb ai/a +lb ai/a +	PREPLA + PREPLA + POSPOS +		
	NIS + Ammonium Sulfate	0.25 + 3.4	% v/v + lb ai/a	POSPOS + POSPOS	8	3

(continued)

Table 1. (cont.) Effect of corn herbicide tank mixes on crabgrass, Southwest Research-Extension Center, Garden City, Kansas, 2005.

					6/16	7/7
Treatment		Rate	Unit	Application timing*	weeds/30 ft of corn	
19	Lumax + Touchdown Hitech 5 SL + NIS +	1.98 + 0.75 + 0.25 +	lb ai/a + lb ai/a + % v/v +	EAPOWE + EAPOWE + EAPOWE +		
	Ammonium Sulfate	3.4	lb ai/a	EAPOWE	0	0
20	Expert 4.9 SC + Touchdown Hitech 5 SL +	2.45 + 0.195 +	lb ai/a + lb ai/a +	EAPOWE + EAPOWE +		
	Ammonium Sulfate + Touchdown Hitech 5 SL +	3.4 +0.75 +	lb ai/a + lb ai/a +	EAPOWE + POSPOS +		
	NIS + Ammonium Sulfate	0.25 + 3.4	% v/v + lb ai/a	POSPOS + POSPOS	0	0
21	Camix + Touchdown Hitech 5 SL + NIS +	1.84 + 0.75 +0.25 +	lb ai/a + lb ai/a + % v/v +	EAPOWE + EAPOWE + EAPOWE		
	Ammonium Sulfate + Touchdown Hitech 5 SL +	3.4 + 0.75 +	lb ai/a + lb ai/a +	EAPOWE + POSPOS		
	NIS + Ammonium Sulfate	0.25 + 3.4	% v/v + lb ai/a	POSPOS + POSPOS	0	0
22	Bicep II Magnum + Aatrex 4L + Callisto	2.06 + 0.25 + 0.094	lb ai/a + lb ai/a +lb ai/a	PREPLA + POSPOS +POSPOS	9	82
23	Untreated Check				137	522
LSD (P=.10)					38	121

* PREPRE = pre-emergence; POSPOS = post-emergence; EAPOWE = early post-emergence, PREPLA = Preplant.

Table 2. Effect of corn herbicide tank mixes on shattercane and sunflower, Southwest Research-Exension Center, Garden City, Kansas, 2005.

	Treatment	Rate	Unit	Application timing*	Shattercane 6/16	Sunflower 7/7
					weed/30 ft of corn	
1	Define SC + Aatrex 90	0.56 + 1.35	lb ai/a + lb ai/a	PREPRE + PREPRE	5	2
2	Radius + Aatrex 90	0.344 + 1.35	lb ai/a + lb ai/a	PREPRE + PREPRE	4	0
3	Balance Pro + Define SC + Aatrex 90	0.0375 +0.5 + 1.35	lb ai/a + lb ai/a + lb ai/a	PREPRE + PREPRE + PREPRE	6	5
4	Guardsman Max + Balance Pro	2.13 + 0.0375	lb ai/a + lb ai/a	PREPRE + PREPRE	13	1
5	Define SC + Aatrex 90 + Option + Distinct + Methylated Seed Oil + UAN 28%	0.25 +1 + 0.0328 + 0.0955 + 1.57 + 1.5	lb ai/a + lb ai/a + lb ai/a + lb ai/a + lb ai/a + lb ai/a	PREPRE + PREPRE + POSPOS + POSPOS + POSPOS + POSPOS	21	1
6	Option + Lexar + Methylated Seed Oil + UAN 28%	0.0219 + 1.5 + 1.57 + 1.5	lb ai/a + lb ai/a + lb ai/a + lb ai/a	POSPOS + POSPOS + POSPOS + POSPOS	34	12
7	Option + Callisto + Aatrex 90 + Methylated Seed Oil + UAN 28%	0.0328 + 0.0625 + 1 + 1.57 + 1.5	lb ai/a + lb ai/a + lb ai/a + lb ai/a + lb ai/a	POSPOS + POSPOS + POSPOS + POSPOS + POSPOS	44	19
8	Option + Distinct + Methylated Seed Oil + UAN 28%	0.0328 + 0.191 + 1.57 + 1.5	lb ai/a + lb ai/a + lb ai/a + lb ai/a	POSPOS + POSPOS + POSPOS + POSPOS	40	16
9	Balance Pro + Aatrex 90 + Roundup Ultra Max + Ammonium Sulfate	0.0313 + 0.9 + 1.02 + 3.4	lb ai/a + lb ai/a + lb ai/a + lb ai/a	PREPRE + PREPRE + POSPOS + POSPOS	12	1
10	Keystone + Starane + Aatrex 90 + COC	3.4 + 0.127 + 0.5 + 1	lb ai/a + lb ai/a + lb ai/a + % v/v	PREPLA + corn<V6 + EAPOWE + EAPOWE	20	1
11	Keystone + Hornet + Balance Pro	3.4 + 0.086 + 0.0156	lb ai/a + lb ai/a + lb ai/a	PREPLA + PREPLA + PREPLA	23	1
12	Keystone + Hornet + Callisto + Aatrex 90 + COC	3.4 + 0.103 + 0.0313 + 0.225 + 1	lb ai/a + lb ai/a + lb ai/a + lb ai/a + % v/v	PREPLA + corn<V7 + POSPOS + POSPOS + POSPOS	21	1
13	Python WDG + Balance Pro + Glyphomax XRT + Ammonium Sulfate	0.05 + 0.0313 + 1.01 + 3.4	lb ai/a + lb ai/a + lb ai/a + lb ai/a	PREPLA + PREPLA + POSPOS + POSPOS	35	2
14	Lumax + Aatrex 4L	2.47 + 0.375	lb ai/a + lb ai/a	PREPLA + PREPLA	22	1
15	Lexar	2.78	lb ai/a	PREPLA	31	1
16	Touchdown Hitech 5 SL + NIS + Ammonium Sulfate + Touchdown Hitech 5 SL + NIS + Ammonium Sulfate	0.75 + 0.25 + 3.4 + 0.75 + 0.25 + 3.4	lb ai/a + % v/v + lb ai/a + lb ai/a + % v/v + lb ai/a	3"weed + 3"weed + 3"weed + corn<18" + corn>6" + corn=V6	35	0
17	Bicep Lite II Magnum + Touchdown Hitech 5 SL NIS + Ammonium Sulfate	+2.25 + 0.75 + 0.25 + 3.4	lb ai/a + lb ai/a + % v/v + lb ai/a	PREPLA +POSPOS + POSPOS + POSPOS	38	3
18	Camix + Aatrex 4L + Touchdown Hitech 5 SL + NIS + Ammonium Sulfate	1.15 + 1+ 0.75 + 0.25 + 3.4	lb ai/a + lb ai/a + lb ai/a + % v/v + lb ai/a	PREPLA + PREPLA + POSPOS + POSPOS + POSPOS	28	2

(continued)

Table 2. (cont.) Effect of corn herbicide tank mixes on shattercane and sunflower, Southwest Research-Exension Center, Garden City, Kansas, 2005.

					Shattercane	Sunflower
					6/16	7/7
	Treatment	Rate	Unit	Application timing*	weed/30 ft of corn	
19	Lumax + Touchdown Hitech 5 SL +	1.98 + 0.75 +	lb ai/a + lb ai/a +	EAPOWE + EAPOWE +		
	NIS + Ammonium Sulfate +	0.25 + 3.4	% v/v + lb ai/a	EAPOWE + EAPOWE	0	0
20	Expert 4.9 SC + Touchdown Hitech 5 SL +	2.45 + 0.195 +	lb ai/a + lb ai/a +	EAPOWE + EAPOWE +		
	Ammonium Sulfate + Touchdown Hitech 5 SL +	3.4 + 0.75 +	lb ai/a + lb ai/a +	EAPOWE + POSPOS +		
	NIS + Ammonium Sulfate	0.25 + 3.4	% v/v + lb ai/a	POSPOS + POSPOS	1	0
21	Camix + Touchdown Hitech 5 SL +	1.84 + 0.75 +	lb ai/a + lb ai/a +	EAPOWE + EAPOWE +		
	NIS + Ammonium Sulfate + Touchdown Hitech 5 SL +	0.25 + 3.4 + 0.75 +	% v/v + lb ai/a + lb ai/a	EAPOWE + EAPOWE + POSPOS +		
	NIS + Ammonium Sulfate	0.25 + 3.4	% v/v + lb ai/a	POSPOS + POSPOS	0	0
22	Bicep II Magnum + Aatrex 4L + Callisto	2.06 + 0.25 + 0.094	lb ai/a + lb ai/a + lb ai/a	PREPLA + POSPOS + POSPOS	28	1
23	Untreated Check				33	12
	LSD (P=.10)				12	5

* PREPRE = pre-emergence; POSPOS = post-emergence; EAPOWE = early post-emergence, PREPLA = Preplant.

Table 3. Effect of herbicide tank mixes on Palmer amaranth, Southwest Research-Extension Center, Garden City, Kansas, 2005.

				Rating date			
				6/16	6/20	7/7	7/21
Treatment	Rate	Unit	Application timing*	weeds/30 ft of corn			
1 Define SC + Aatrex 90	0.56 + 1.35	lb ai/a + lb ai/a	PREPRE +PREPRE	0	1	5	6
2 Radius + Aatrex 90	0.344 + 1.35	lb ai/a +lb ai/a	PREPRE + PREPRE	0	0	1	1
3 Balance Pro + Define SC + Aatrex 90	0.0375 + 0.5 + 1.35	lb ai/a + lb ai/a + lb ai/a	PREPRE+ PREPRE + PREPRE	0	0	1	3
4 Guardsman Max + Balance Pro	2.13 + 0.0375	lb ai/a + lb ai/a	PREPRE + PREPRE	0	1	2	5
6 Option + Lexar + Methylated Seed Oil +	0.0219 + 1.5 + 1.57 +	lb ai/a + lb ai/a + lb ai/a +	POSPOS + POSPOS + POSPOS +				
UAN 28%	1.5	lb ai/a	POSPOS	140	116	47	88
7 Option + Callisto + Aatrex 90 +	0.0328 + 0.0625 + 1 +	lb ai/a + lb ai/a + lb ai/a +	POSPOS + POSPOS + POSPOS +				
Methylated Seed Oil + UAN 28%	1.57 + 1.5	lb ai/a + lb ai/a	POSPOS + POSPOS	143	73	12	28
8 Option + Distinct + Methylated Seed Oil +	0.0328 + 0.191+ 1.57 +	lb ai/a + lb ai/a +lb ai/a +	POSPOS + POSPOS +				
UAN 28%	1.5	lb ai/a	POSPOS + POSPOS	116	66	8	7
9 Balance Pro + Aatrex 90 +	0.0313 + 0.9 +	lb ai/a + lb ai/a +	PREPRE +PREPRE +				
Roundup Ultra Max + Ammonium Sulfate	1.02 + 3.4	lb ai/a + lb ai/a	POSPOS + POSPOS	3	2	0	2
10 Keystone + Starane + Aatrex 90 +	3.4 + 0.127 + 0.5 +	lb ai/a + lb ai/a + lb ai/a +	PREPLA + corn<V6 + EAPOWE +				
COC	1	% v/v	EAPOWE	0	0	1	1
11 Keystone + Hornet + Balance Pro	3.4 + 0.086 + 0.0156	lb ai/a + lb ai/a +lb ai/a	PREPLA + PREPLA + PREPLA	0	0	2	4
12 Keystone + Hornet + Callisto +	3.4 + 0.103 + 0.0313 +	lb ai/a + lb ai/a + lb ai/a +	PREPLA + corn<V7 + POSPOS +				
Aatrex 90 + COC	0.225 + 1	lb ai/a + % v/v	POSPOS + POSPOS	0	0	0	0
13 Python WDG + Balance Pro +	0.05 + 0.0313 +	lb ai/a + lb ai/a +	PREPLA + PREPLA +				
Glyphomax XRT + Ammonium Sulfate	1.01 + 3.4	lb ai/a + lb ai/a	POSPOS + POSPOS	43	29	1	2
14 Lumax + Aatrex 4L	2.47 + 0.375	lb ai/a + lb ai/a	PREPLA + PREPLA	0	1	1	4
15 Lexar	2.78	lb ai/a	PREPLA	0	0	1	3
16 Touchdown Hitech 5 SL + NIS +	0.75 + 0.25 +	lb ai/a + % v/v +	3"weed + 3"weed +				
Ammonium Sulfate +	3.4 +	lb ai/a +	3"weed +				
Touchdown Hitech 5 SL + NIS +	0.75 + 0.25 +	lb ai/a + % v/v	corn<18" + corn>6"				
Ammonium Sulfate	3.4	lb ai/a	corn=V6	161	0	0	9
17 Bicep Lite II Magnum +	2.25 +	lb ai/a +	PREPLA +				
Touchdown Hitech 5 SL + NIS	0.75 + 0.25+	lb ai/a + % v/v +	POSPOS + POSPOS +				
Ammonium Sulfate	3.4	lb ai/a	POSPOS	2	5	0	2
18 Camix + Aatrex 4L	1.15 + 1 +	lb ai/a + lb ai/a +	PREPLA + PREPLA +				
Touchdown Hitech 5 SL + NIS	0.75 + 0.25 +	lb ai/a + % v/v +	POSPOS + POSPOS				
Ammonium Sulfate	3.4	lb ai/a	POSPOS	1	3	0	4

(continued)

Table 3. (cont.) Effect of herbicide tank mixes on Palmer amaranth, Southwest Research-Extension Center, Garden City, Kansas, 2005.

Treatment	Rate	Unit	Application timing*	Rating date 6/16	6/20	7/7	7/21
				weeds/30 ft of corn			
19 Lumax + Touchdown Hitech 5 SL +	1.98 + 0.75 +	lb ai/a + lb ai/a +	EAPOWE + EAPOWE				
NIS + Ammonium Sulfate	0.25 +3.4	% v/v + lb ai/a	EAPOWE +EAPOWE	0	0	0	1
20 Expert 4.9 SC + Touchdown Hitech 5 SL +	2.45 + 0.195 +	lb ai/a + lb ai/a +	EAPOWE + EAPOWE +				
Ammonium Sulfate +	3.4 +	lb ai/a +	EAPOWE +				
Touchdown Hitech 5 SL +	0.75 + 0.25 +	lb ai/a + % v/v +	POSPOS + POSPOS +				
NIS + Ammonium Sulfate	3.4	lb ai/a	POSPOS	0	0	0	1
21 Camix + Touchdown Hitech 5 SL +	1.84 + 0.75 +	lb ai/a + lb ai/a +	EAPOWE + EAPOWE +				
NIS + Ammonium Sulfate +	0.25 + 3.4 +	% v/v + lb ai/a +	EAPOWE + EAPOWE +				
Touchdown Hitech 5 SL + NIS +	0.75 + 0.25 +	lb ai/a + % v/v	POSPOS + POSPOS +				
Ammonium Sulfate	3.4	lb ai/a	POSPOS	0	0	0	1
22 Bicep II Magnum + Aatrex 4L + Callisto	2.06 + 0.25 + 0.094	lb ai/a + lb ai/a + lb ai/a	PREPLA + POSPOS + POSPOS	1	2	1	5
23 Untreated Check				115	78	231	273
LSD (P=.10)				33	23	42	63

* PREPRE = pre-emergence; POSPOS = post-emergence; EAPOWE = early post-emergence, PREPLA = Preplant.

Table 4. Effect of corn herbicide tank mixes on corn yield, Southwest Research-Extension Center, Garden City, Kansas, 2005.

	Treatment	Rate	Unit	Application timing*	Bu/a
1	Define SC + Aatrex 90	0.56 + 1.35	lb ai/a + lb ai/a	PREPRE + PREPRE	90
2	Radius + Aatrex 90	0.344 + 1.35	lb ai/a + lb ai/a	PREPRE + PREPRE	88
3	Balance Pro + Define SC + Aatrex 90	0.0375 +0.5 + 1.35	lb ai/a + lb ai/a + lb ai/a	PREPRE + PREPRE + PREPRE	94 T
4	Guardsman Max + Balance Pro	2.13 + 0.0375	lb ai/a + lb ai/a	PREPRE + PREPRE	86
5	Define SC + Aatrex 90 + Option +	0.25 +1 + 0.0328 +	lb ai/a + lb ai/a + lb ai/a +	PREPRE + PREPRE + POSPOS +	
	Distinct + Methylated Seed Oil + UAN 28%	0.0955 + 1.57 + 1.5	lb ai/a + lb ai/a + lb ai/a	POSPOS + POSPOS + POSPOS	96
6	Option + Lexar +	0.0219 + 1.5 +	lb ai/a + lb ai/a +	POSPOS + POSPOS +	
	Methylated Seed Oil + UAN 28%	1.57 + 1.5	lb ai/a + lb ai/a	POSPOS + POSPOS	51
7	Option + Callisto + Aatrex 90 +	0.0328 + 0.0625 + 1 +	lb ai/a + lb ai/a + lb ai/a +	POSPOS + POSPOS + POSPOS +	
	Methylated Seed Oil + UAN 28%	1.57 + 1.5	lb ai/a + lb ai/a	POSPOS + POSPOS	76
8	Option + Distinct + Methylated Seed Oil +	0.0328 + 0.191 + 1.57 +	lb ai/a + lb ai/a + lb ai/a +	POSPOS + POSPOS + POSPOS +	
	UAN 28%	1.5	lb ai/a	POSPOS	63
9	Balance Pro + Aatrex 90 +	0.0313 + 0.9 +	lb ai/a + lb ai/a +	PREPRE + PREPRE +	
	Roundup Ultra Max + Ammonium Sulfate	1.02 + 3.4	lb ai/a + lb ai/a	POSPOS + POSPOS	107 T
10	Keystone + Starane +	3.4 + 0.127 +	lb ai/a + lb ai/a +	PREPLA + corn<V6 +	
	Aatrex 90 + COC	0.5 + 1	lb ai/a + % v/v	EAPOWE + EAPOWE	92 T
11	Keystone + Hornet + Balance Pro	3.4 + 0.086 + 0.0156	lb ai/a + lb ai/a + lb ai/a	PREPLA + PREPLA + PREPLA	90
12	Keystone + Hornet + Callisto +	3.4 + 0.103 + 0.0313 +	lb ai/a + lb ai/a + lb ai/a +	PREPLA + corn<V7 + POSPOS +	
	Aatrex 90 + COC	0.225 + 1	lb ai/a + % v/v	POSPOS + POSPOS	79
13	Python WDG + Balance Pro +	0.05 + 0.0313 +	lb ai/a + lb ai/a +	PREPLA + PREPLA +	
	Glyphomax XRT + Ammonium Sulfate	1.01 + 3.4	lb ai/a + lb ai/a	POSPOS + POSPOS	95 T
14	Lumax + Aatrex 4L	2.47 + 0.375	lb ai/a + lb ai/a	PREPLA + PREPLA	94 T
15	Lexar	2.78	lb ai/a	PREPLA	83
16	Touchdown Hitech 5 SL + NIS +	0.75 + 0.25 +	lb ai/a + % v/v +	3"weed + 3"weed +	
	Ammonium Sulfate + Touchdown Hitech 5 SL +	3.4 + 0.75 +	lb ai/a + lb ai/a +	3"weed + corn<18" +	
	NIS + Ammonium Sulfate	0.25 + 3.4	% v/v + lb ai/a	corn>6" + corn=V6	95 T
17	Bicep Lite II Magnum + Touchdown Hitech 5 SL +	2.25 + 0.75 +	lb ai/a + lb ai/a +	PREPLA + POSPOS +	
	NIS + Ammonium Sulfate	0.25 + 3.4	% v/v + lb ai/a	POSPOS + POSPOS	98 T
18	Camix + Aatrex 4L + Touchdown Hitech 5 SL +	1.15 + 1+ 0.75 +	lb ai/a + lb ai/a + lb ai/a +	PREPLA + PREPLA + POSPOS +	
	NIS + Ammonium Sulfate	0.25 + 3.4	% v/v + lb ai/a	POSPOS + POSPOS	102 T
19	Lumax + Touchdown Hitech 5 SL +	1.98 + 0.75 +	lb ai/a + lb ai/a +	EAPOWE + EAPOWE +	
	NIS + Ammonium Sulfate +	0.25 + 3.4	% v/v + lb ai/a	EAPOWE + EAPOWE	97 T

(continued)

Table 4. (cont.) Effect of corn herbicide tank mixes on corn yield, Southwest Research-Extension Center, Garden City, Kansas, 2005.

	Treatment	Rate	Unit	Application timing*	Bu/a
20	Expert 4.9 SC + Touchdown Hitech 5 SL +	2.45 + 0.195 +	lb ai/a + lb ai/a +	EAPOWE + EAPOWE +	
	Ammonium Sulfate + Touchdown Hitech 5 SL +	3.4 + 0.75 +	lb ai/a + lb ai/a +	EAPOWE + POSPOS +	
	NIS + Ammonium Sulfate	0.25 + 3.4	% v/v + lb ai/a	POSPOS + POSPOS	99 T
21	Camix + Touchdown Hitech 5 SL +	1.84 + 0.75 +	lb ai/a + lb ai/a +	EAPOWE + EAPOWE +	
	NIS + Ammonium Sulfate + Touchdown Hitech 5 SL	+0.25 + 3.4 + 0.75 +	% v/v + lb ai/a + lb ai/a +	EAPOWE + EAPOWE + POSPOS +	
	NIS + Ammonium Sulfate	0.25 + 3.4	% v/v + lb ai/a	POSPOS + POSPOS	104 T
22	Bicep II Magnum + Aatrex 4L + Callisto	2.06 + 0.25 + 0.094	lb ai/a + lb ai/a + lb ai/a	PREPLA + POSPOS + POSPOS	83
23	Untreated Check				34
	LSD (P=.10)				15

* PREPRE = pre-emergence; POSPOS = post-emergence; EAPOWE = early post-emergence, PREPLA = Preplant.

COMPARISON OF PREEMERGENCE HERBICIDE TANK MIXES AUGMENTED WITH GLYPHOSATE FOR WEED CONTROL IN GLYPHOSATE-RESISTANT CORN

by
Randall Currie

SUMMARY

Early-season crabgrass control, which reduced numbers from 247 to less than 52 plants per 30 ft of row, was very good (Table 1). Due in part to some removal of crop canopy by hail, however, control of all but 2 of the 8 treatments declined to no better than the untreated control by August 5.

Early-season Palmer amaranth control was excellent in most treatments. With the application of glyphosate by July 21, all treatments provided good control. By the time corn tasseled, all treatments provided control.

INTRODUCTION

Although it is possible to achieve 100% weed control with continuous applications of glyphosate to glyphosate-tolerant corn, as the average farm size increases, this can be logistically difficult. Therefore, some pre-emergence herbicide is often applied increase the application flexibility and control of glyphosate applications. Further, the presence of glyphosate-resistant Palmer amaranth populations have been confirmed outside Kansas, so the urgency has increased to prudently expose these populations to several different types of herbicides to reduce the rate as this potential problem spreads. It is very desirable to discover a range of combinations of pre-emergence and post-emergence tank mixes for weed control in corn. This experiment allows producers to compare weed control and cost of these combinations to allow them to balance the various inputs of capital and labor.

PROCEDURES

Palmer amaranth, yellow foxtail, crabgrass, sunflower, barnyard grass, and shattercane were seeded at 700,000; 344,124; 9,800,000; 40,000; 817,000; and 119,000 seeds/acre, respectively, into prepared fields on May 9, before corn was planted. All weeds except shattercane were planted with a carrier mixture of cracked corn at a rate of 40 lb/acre by using a 14-foot Great Plains Drill with tubes removed to allow weed seed to be dropped on the soil surface. Shattercane was drilled separately, with every third hole set at 1 inch deep, at 2 inches deep, or with the tube pulled for seed to be dropped on the soil surface. Weed seed was planted in 10-inch rows.

The field was conventionally tilled in the fall. Dekalb DK-6019 RR corn was planted 1.5 inches deep in 30-inch rows at a rate of 34,300 seeds/acre with a John Deere Max Emerge II 6-row planter. Although soil moisture at planting was not adequate for emergence, rain was forecast, which emboldened us to plant. The forecast was not correct, and 9 days passed before one rain fell sufficient to ensure emergence of all corn kernels. Canopy light interception was aggravated less by a July 4 hail storm described in previous article because corn was only in 5- to 7-collar stage and had more potential to set leaf area.

RESULTS AND DISCUSSION

Early-season crabgrass control, which reduced numbers from 247 to less than 52 plants per 30 foot of row, was very good (Table 1). Most of the poorer treatments were substantially improved by July 21 by the application of glyphosate. Due in part to some removal of crop canopy by hail, however, control of all treatments except 4 and 7 declined to no better than the untreated control by Aug. 5.

Early-season Palmer amaranth control was excellent in most treatments (Table 2). With the application of glyphosate by July 21, all treatments provided good control. By the time corn tasseled, all treatments provided control, compared with the untreated control .

Corn yields were low due to hail injury; all treatments caused a 3-fold or more increase in yield, compared with untreated control (Table 3). All treatments followed by the letter T were not statistically different from the top-yielding herbicide tank mix. With the exception of Treatment 1, all other top-yielding treatments contained a pre-emergence treatment, followed by a second post-emergence glyphosate treatment.

Table 1. Herbicide control of crabgrass in corn, Southwest Research-Extension Center, Garden City, Kansas, 2005.

Treatment	Rate	Unit	Application Timing*	Crabgrass 6/3	6/21	8/5
				weed/30 ft of corn		
1 Lumax	2.46	lb ai/a	PREPLA	7	18	150
2 Balance Pro + Define SC	1 + 0.53	oz ai/a + lb ai/a	PREPLA + PREPLA	4	7	77
3 Harness Xtra + Roundup Original Max	1.8 + 0.75	lb ai/a + lb ae/a	PREPLA + MIPOWE	52	158	135
4 Degree Extra + Roundup Original Max	2.02 + 0.75	lb ai/a + lb ae/a	PREPLA + MIPOWE	32	12	35
5 Degree Extra + Roundup Original Max	2.02 + 0.75	lb ai/a + lb ae/a	corn<5" + corn<5"	267	0	102
6 Lumax + Touchdown Total	1.97 + 0.78	lb ai/a + lb ae/a	corn<5" + corn<5"	261	0	17
7 Untreated Check				247	192	242
LSD (P=.10)				123	62	114

* PREPLA = Preplant; MIPOWE = Midpost.

Table 2. Herbicide control of Palmer amaranth, Southwest Research-Extension Center, Garden City, Kansas, 2005.

Treatment	Rate	Unit	Application timing*	Palmer amaranth 6/30	6/21	8/5
				weeds/30 ft of corn		
1 Lumax	2.46	lb ai/a	PREPLA	0	0	0
2 Balance Pro + Define SC	1 + 0.53	oz ai/a + lb ai/a	PREPLA + PREPLA	0	11	56
3 Harness Xtra + Roundup Original Max	1.8 +0.75	lb ai/a + lb ae/a	PREPLA + MIPOWE	0	2	5
4 Degree Extra + Roundup Original Max	2.02 + 0.75	lb ai/a + lb ae/a	PREPLA + MIPOWE	0	0	3
5 Degree Extra + Roundup Original Max	2.02 + 0.75	lb ai/a + lb ae/a	corn<5" + corn<5"	99	0	9
6 Lumax + Touchdown Total	1.97 + 0.78	lb ai/a + lb ae/a	corn<5" + corn<5"	71	0	0
7 Untreated Check				56	210	280
LSD (P=.10)				62	17	57

* PREPLA = Preplant; MIPOWE = midpost.

Table 3. Effects of herbicide tank mixes on corn, Southwest Research-Extension Center, Garden City, Kansas, 2005.

	Treatment	Rate	Unit	Application Timing*	Bu/a
1	Lumax	2.46	lb ai/a	PREPLA	109 T
2	Balance Pro + Define SC	1 + 0.53	oz ai/a + lb ai/a	PREPLA + PREPLA	75
3	Harness Xtra + Roundup Original Max	1.8 + 0.75	lb ai/a + lb ae/a	PREPLA + MIPOWE	99
4	Degree Extra + Roundup Original Max	2.02 + 0.75	lb ai/a + lb ae/a	PREPLA + MIPOWE	108 T
5	Degree Extra + Roundup Original Max	2.02 + 0.75	lb ai/a + lb ae/a	corn<5" + corn<5"	104
6	Lumax + Touchdown Total	1.97 + 0.78	lb ai/a + lb ae/a	corn<5" + corn<5"	118 T
7	Untreated Check				23
	LSD (P=.10)				13

* PREPLA = Preplant; MIPOWE = Midpost.

LUMAX® AND CAMIX®: (EXPERIMENTAL) POTENTIAL FOR WEED CONTROL IN GRAIN SORGHUM

by
Curtis Thompson and Alan Schlegel

SUMMARY

Lumax® and Camix® are currently not registered for use in grain sorghum, and should not be used until a registration is approved. In the following experiments, these herbicides are being evaluated for potential weed-control products to be used in grain sorghum. In 2005, the greatest amount of sorghum injury was observed, but had little effect on final sorghum yield. Sorghum yields in 2003 increased as herbicide rate increased and with treatment applied pre-emergence (PRE), compared with 10 or 20 days before planting, indicating that herbicide injury did not affect sorghum yield. Excellent weed control was observed with Lumax® and Camix® Lumax® provided control similar to that with Bicepâ Lite II Magnum. Lumax® could have an advantage over Bicep® Lite II when velvet leaf and triazine-resistant kochia and pigweed are present, but these were not evaluated in these experiments.

INTRODUCTION

Fewer herbicides are available for weed control in grain sorghum than in corn. Herbicide-resistant pigweeds and kochia are becoming more difficult to control with the current herbicides registered for grain sorghum. Previous work with corn suggests that Lumax® could enhance the control of pigweeds, kochia, and velvet leaf in grain sorghum. The objectives of this experiment were to evaluate the effect of soil-applied Lumax® and Camix® on grain sorghum and for weed control.

PROCEDURES

Three experiments were conducted during 2003 through 2005 on the SWREC irrigation field near Tribune, Kansas. Callisto®+Dual® II Magnum (Camix®) and Callisto®+Dual® II Magnum+atrazine (Lumax®) and Bicep® Lite II were applied at field use (1X) and 2X rates. The 1X rate of Lumax® was 2.5 quarts, Camix 2.0 quarts, and Bicep® Lite II 1.5 quarts. Camix® and Lumax® contain the identical amounts of Dual® II Magnum and Callisto®, but Lumax® also contains atrazine. The Lumax® and Bicep®Lite II Magnum contain the same amount of atrazine, whereas Lumax® contains slightly more Dual® II Magnum. Herbicides were applied with a backpack sprayer set at 24 psi, equipped with 11003 turbo tee nozzles delivering 20 gpa. Herbicide treatments were applied to the soil surface 20 days early pre-plant (20DEPP), 10 days early pre-plant (10DEPP) and immediately after planting (PRE). Pioneer 8699 was planted at 33,000 seeds/a (spa) on June 10, 2003. Pioneer 8505 was planted at 80,000 spa on May 27, 2004. Triumph TRX44631 was planted at 80,000 spa on June 2, 2005. Glyphosate was used to burn down weeds in the entire experiments, after planting but before sorghum emergence. Experiments in 2004 and 2005 each received 13 inches of irrigation, plus rainfall; the 2003 experiment was rainfed only. Experimental units were 10 by 30 ft and arranged as a factorial in a randomized complete-block design with four replications. Weed control and crop injury were rated visually 3 to 4 weeks after planting. A 5 by 20 ft area was combine harvested from the center of each plot to determine grain yield.

RESULTS AND DISCUSSION

Very little crop injury was observed in 2003 from any treatment (Table 1). The only treatment causing visible sorghum injury in 2004 was the 2X rate of Lumax® applied PRE. Sorghum grew out of the injury later in the season (data not provided). The most sorghum injury was observed during 2005, but all three herbicides responded similarly. The 2X herbicide rate caused 5% more injury than the 1X rate, when averaged over timing and herbicide in 2005. More injury occurred with the PRE treatments than with those applied 10 or 20 days before planting, averaged over rate and herbicide. The most severe injury (12%) occurred with the 2X rate of herbicide applied at the PRE timing, averaged over herbicides.

Grain sorghum yield in 2003 was lower with Camix® than with Bicep® Lite II treatments, when averaged over time and rate (Table 1). This was likely due to poor late-season weed control with Camix® (data not shown). Yield increased with the 2X herbicide rate, averaged over herbicide and time and with the PRE timing, compared with earlier timings, averaged over herbicide and rate, indicating that crop injury was not a factor in the 2003 experiment. Grain sorghum yield data from 2004 were similar, regardless of treatment. In 2005, the only significant yield difference found (5 bu/a) was the 2X and 1X rates comparison, averaged over time and herbicide.

Excellent control of redroot pigweed, tumble pigweed, kochia, Russian thistle, and green foxtail was observed with all treatments 3 to 4 weeks after planting (Table 2). More variable control of puncturevine and sandbur, compared with the other weeds evaluated in these experiments, is expected, but Lumax® should provide as good control of these weeds as Bicep® Lite II Magnum did. This may not be true for Camix® because it does not contain atrazine. The Callisto®component in Lumax® could enhance the control of velvet leaf, triazine-resistant kochia, and pigweed species.

A Section 18 label for emergency use of Lumax® on grain sorghum has been submitted for the 2006 season. To date it has not been approved. A full Section 3 registration could be possible for the 2008 season. These proposed labels are under review by EPA, and Lumax® and Camix® herbicides SHOULD NOT BE USED until the registrations are granted. Postemergence use of these herbicides could be very detrimental to grain sorghum.

Table 1. Camix® and Lumax® effect on grain sorghum yield, SWREC, Tribune, Kansas, 2003 through 2005.

			Grain sorghum yield				Grain sorghum injury			
Herbicide	Rate*	Time	2003	2004	2005	Avg.	2003	2004	2005	Avg.
			(bu/a)				(%)			
Camix	X	20DEPP	23	112	88	74	0	0	0	0
Camix	2X	20DEPP	32	121	86	80	0	0	9	3
Lumax	X	20DEPP	31	134	98	88	0	0	3	1
Lumax	2X	20DEPP	37	120	86	81	0	0	5	2
Bicep Lite II	X	20DEPP	30	121	95	82	0	0	1	0
Bicep Lite II	2X	20DEPP	41	119	89	83	0	0	1	0
Camix	X	10DEPP	25	130	93	83	0	0	1	0
Camix	2X	10DEPP	31	124	78	78	0	1	8	3
Lumax	X	10DEPP	27	130	81	79	0	0	2	1
Lumax	2X	10DEPP	44	129	86	86	0	0	5	2
Bicep Lite II	X	10DEPP	25	125	85	78	0	0	5	2
Bicep Lite II	2X	10DEPP	37	129	84	83	0	0	6	2
Camix	X	PRE	37	127	86	83	0	0	4	1
Camix	2X	PRE	40	130	76	82	1	0	14	5
Lumax	X	PRE	42	130	95	89	0	0	8	3
Lumax	2X	PRE	31	122	87	80	3	9	11	8
Bicep Lite II	X	PRE	52	133	93	93	0	0	1	0
Bicep Lite II	2X	PRE	37	130	91	86	0	3	10	4
LSD (0.05) Herbicide*Rate*Time			NS	NS	NS		NS	NS	NS	
Camix	avg		31	124	85	80	0	0	6	2
Lumax	avg		35	128	89	84	1	2	6	3
Bicep Lite II	avg		37	126	90	84	0	1	4	2
LSD (0.05) Herbicide			5	NS	NS		NS	NS	NS	
avg	X		32	127	90	83	0	0	3	1
avg	2X		37	125	85	82	0	1	8	3
LSD (0.05) Rate			4	NS	5		NS	NS	3	
avg	avg	20DEPP	32	121	90	81	0	0	3	1
avg	avg	10EPP	32	128	85	81	0	0	5	2
avg	avg	PRE	40	129	88	86	1	2	8	4
LSD (0.05) Time			5	NS	NS		NS	2	3	
avg	X	20DEPP	28	122	94	81	0	0	1	0
avg	2X	20DEPP	37	120	87	81	0	0	5	2
avg	X	10DEPP	26	128	86	80	0	0	3	1
avg	2X	10DEPP	37	127	83	82	0	0	6	2
avg	X	PRE	44	130	91	88	0	0	4	1
avg	2X	PRE	36	127	85	83	1	4	12	6
LSD (0.05) Rate*Time			7	NS	NS		NS	2	4	
Weedy check			6	45	73	41				
Weed free check					101					

* Camix X = 2 qts, Lumax X = 2.5 qts, Bicep Lite II X = 1.5 qts
Weedy and weed-free checks were not included in the analysis. Several interaction means are not shown because the interaction was not significant in any of the 3 years.

Table 2. Camix and Lumax for weed control in grain sorghum, Southwest Research - Extension Center, Tribune, Kansas, 2003-05.

Herbicide	Rate	Time	Redroot pigweed			Tumble pigweed			Puncturevine			Kochia		Russian thistle		GrFt	SaBr
			2003	2004	2005	2003	2004	2005	2003	2004	2005	2003	2004	2003	2004	2004	2005
	(qt/a)	(% visual control of the weed species, 0 = no control and 100 = complete control)															
Camix	2	20DEPP	98	93	100	97	92	100	90	78	69	99	97	99	98	96	95
Camix	4	20DEPP	100	100	100	99	100	100	92	89	92	100	100	100	100	100	98
Lumax	2.5	20DEPP	98	100	100	96	100	100	92	95	81	100	100	99	100	100	99
Lumax	5	20DEPP	97	100	100	97	100	100	89	88	81	100	100	100	100	100	100
Bicep Lite II	1.5	20DEPP	96	100	100	96	100	100	78	85	64	100	100	100	100	100	88
Bicep Lite II	3	20DEPP	100	100	100	99	100	100	88	93	84	100	100	100	100	100	100
Camix	2	10DEPP	96	98	100	95	96	100	84	85	83	100	99	98	100	100	98
Camix	4	10DEPP	100	100	100	98	100	100	88	90	92	100	100	96	100	100	100
Lumax	2.5	10DEPP	100	100	100	99	96	100	93	88	88	100	100	100	100	100	100
Lumax	5	10DEPP	100	100	100	99	100	100	87	100	95	100	100	100	100	100	100
Bicep Lite II	1.5	10DEP	100	100	100	96	100	100	81	89	80	100	100	100	100	100	100
Bicep Lite II	3	10DEPP	100	100	100	100	100	100	85	96	93	100	100	100	100	100	100
Camix	2	PRE	99	100	100	100	100	100	93	91	89	100	100	98	99	99	98
Camix	4	PRE	100	100	100	100	100	100	96	71	98	100	100	100	100	100	100
Lumax	2.5	PRE	100	100	100	100	100	100	92	75	93	100	100	100	100	100	100
Lumax	5	PRE	100	100	100	99	100	100	97	99	96	100	100	100	100	100	99
Bicep Lite II	1.5	PRE	100	100	100	100	100	100	94	96	88	100	100	100	100	100	100
Bicep Lite II	3	PRE	100	100	100	100	100	100	99	99	96	100	100	100	100	100	98
LSD (0.05)			3	6	NS	4	5	NS	12	22	14	1	1	2	1	2	10

GrFt = green foxtail, SaBr = Longspine sandbur, 20DEPP = 20 days before planting, 10DEPP = 10 days before planting, PRE = after planting
All visual weed control evaluations were conducted 3 to 4 weeks following planting and PRE applications.

EFFECT OF STRIPE RUST ON WINTER WHEAT

by
Curtis Thompson, Alan Schlegel, Paul Rickabaugh[1], and Gary Gold[2]

SUMMARY

Since 2001, wheat stripe rust has been infesting Kansas wheat at an increasing frequency and intensity, compared with previous years. Fungicide applications can be costly, but may be required to maintain wheat yield, quality, and profitability. These experiments evaluate wheat variety response to various fungicide treatments. Experiments were conducted near Wright in Ford County, Garden City-SWREC, Hugoton in Stevens County, Ashland in Clark County, and Coldwater in Comanche County, Kansas. Tilt® at 4 oz/a increased wheat yield by 20 bu/acre and increased test weight by 4 lb/bu in the Ford County experiment, which was heavily infested with stripe rust during spring of 2001. Fungicide-treated wheat yielded 9 bu/acre more than untreated wheat when averaged over varieties at the Comanche, Clark, and Stevens County sites during 2005, but only a 0.6 lb/bu increase in test weight was observed. A stripe rust-resistant variety, Tam 111, was the highest yielding variety, and had excellent test weight. In experiments at SWREC near Garden City in 2005, fungicide application reduced stripe rust infestation on Jagger, Stanton, and Thunderbolt, but had little or no effect on grain yield or test weight. Jagger and Stanton seed size increased slightly with some of the fungicide treatments. Stripe rust can be devastating to a wheat crop, making properly applied fungicides very valuable to maintain wheat yield and quality. Wheat variety selection remains one of the most important management decisions to manage stripe rust on wheat.

INTRODUCTION

Leaf, stem, and stripe rusts infest wheat, and potentially can reduce grain yields. Leaf rust has been the most prevalent rust attacking our wheat crop, and has continued to overcome new wheat varieties initially developed to resist leaf rust. Very little stem rust has been observed over the last several years due to good wheat variety resistance. The newest rust adversely affecting wheat quality and yield is stripe rust. The first significant stripe rust infestation in many years occurred during the spring of 2001, followed by infestations in 2003 and 2005. These infestations have affected wheat in western Kansas during each of these three years.

Stripe rust is a different rust organism than leaf rust, and is considered a cool-season rust. Stripe rust has been most prevalent and a common problem in the Pacific Northwest. This cool-season rust, best adapted to temperatures less than 65 °F, will attack the wheat crop much earlier in the season than leaf rust does. Because of the early infection, stripe rust potentially could be more devastating to wheat than leaf rust. It is currently believed that stripe rust spores are blown into the area from the south each year and do not over-winter in Kansas.

Fungicide applications on wheat do not assure increased grain yields and profits, even when rust is present. Timing of the rust infection relative to wheat development (earlier the infestation, the greater the impact), environmental conditions during the rust spore showers and infection (moist and cool is best for stripe rust, moist and warm is best for leaf rust), and timing of the fungicide application (it is most important to protect the flag leaf) all interact, affecting the impact of the rust on wheat yield. The objectives of the following experiments were to evaluate the impact of fungicide applications on wheat variety yield and test weight.

PROCEDURES

Several wheat varieties were planted in Ford County in fall of 2000. On May 9, 2001, Tilt® at 4 fl oz/acre was applied on heading, to just headed, wheat varieties in an attempt to protect the flag leaf from a

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[2] Former Stevens County Agricultural Extension Agent, Kansas State University, Hugoton.

severe stripe rust infestation. Wheat was harvested with a small plot combine in mid-June to determine grain yield and test weight. Varieties were not replicated. Tilt® and no-Tilt® treatments can be compared statistically, and varieties averaged over fungicide treatment can be compared.

Several wheat varieties were planted in Comanche County, in Stevens County, and in Clark County during fall of 2004. Tilt® at 4 fl oz/acre was applied at the flag leaf stage in Comanche County and Quilt® at 14 fl oz/acre was applied at the flag leaf stage in Clark County on April 27, 2005. Quadris® at 6.2 fl oz/acre and Tilt® at 4 fl oz/acre were applied at the flag leaf stage in Stevens County during the first week of May 2005. All treatments were applied with a backpack sprayer equipped with 11003 Turbo Tee nozzles set at 34 psi, delivering 20 gpa. Wheat at each of the locations was harvested with a small plot combine in June 2005 to determine grain yield and test weight. Varieties were not replicated. Each location was treated as a replication; thus, only fungicide, treated vs. not treated. averaged over varieties, can be compared statistically, and varieties averaged over fungicide treatments can be compared.

An experiment was established at the SWREC – Garden City in fall 2004 to compare the effects of various fungicides and timing of spring application on Jagger wheat. Jagger has been considered resistant to stripe rust but susceptible to leaf rust. Fungicides were applied at three stages of development, early jointing on March 18, flag leaf emerged on April 20, and headed but not flowering on May 9. All treatments were applied as previously described. An evaluation of rust infestation on the flag leaf was made on June 1, 2005. Wheat was harvested with a small plot combine on June 18 to determine grain yield, test weight, and moisture. Two hundred kernels were counted from each plot and weighed to determine kernel weight (KWT).

An experiment was established at the SWREC – Garden City in fall 2004 to compare the effect of various fungicides on Stanton wheat. Stanton has been considered intermediately resistant to stripe rust. All fungicide treatments were applied to flag leaf wheat, collar just visible, on May 2. All treatments were applied as previously described. An evaluation of rust infestation on the flag leaf was made on June 1, 2005. Wheat was harvested with a small plot combine on June 21 to determine grain yield, test weight, and moisture. Two hundred kernels were counted from each plot and weighed to determine KWT.

An experiment was established in Comanche County in fall 2004 to compare the effects of various fungicides on Thunderbolt wheat. Thunderbolt has been considered intermediately resistant to stripe rust. All treatments were applied to boot-stage wheat on April 27. Fungicides were applied as previously described. An evaluation of rust infestation on the flag leaf was made on May 11, 2005. Wheat was harvested with a small plot combine on June 15, and grain yield, test weight, moisture, and KWT were determined.

RESULTS AND DISCUSSION

During the spring of 2001, the first significant stripe rust epidemic occurred in parts of southwestern Kansas. The 4 fl oz of Tilt® protected wheat flag leaves, resulting in a longer fill period, especially for the varieties susceptible to stripe rust. Jagger, the most stripe rust-resistant variety, and which did not carry stripe rust in the 1991 Ford County wheat demonstration, was infected with leaf rust, especially where no Tilt® had been applied. Because of the stripe rust resistance and excellent yield potential, Jagger was the highest yielding variety at 49 bu/acre (Table 1). 2137, Lakin, and Oro Blanco yielded significantly less than Jagger. These three varieties were the most susceptible to stripe rust. Tilt® treatment increased the test weight of these three varieties by 5 to 9 lb/bu. Averaged over all varieties, results showed that Tiltâ increased wheat yield by 20 bu/acre and increased test weight by 4 lb/bu. In this situation, fungicide application obviously was profitable.

At the Clark, Comanche, and Stevens County locations, all varieties carried some amount of stripe rust during the spring of 2005, unlike what was observed in 2001. Stripe rust resistance bred into our wheat varieties currently is temperature sensitive and is expressed at warmer temperatures. It is most likely that the cold temperatures in April led to the stripe rust infestation, even on the stripe rust-resistant wheat varieties. With the warming temperatures in May, stripe rust did not advance on these resistant varieties. Averaged over wheat varieties, results showed that fungicide application increased wheat yield 9 bu/acre and increased test weight by 0.6 lb/bu (Table 2). This response was much less than was observed in 2001, but this still more than paid for the fungicide applications. Tam 111, which has stripe rust resistance, was the top-yielding variety, and had one of the highest test weights of the varieties evaluated,but Tam 111 is very susceptible to leaf rust. Lakin, 2137, and Above, all susceptible to stripe rust, were among the lowest-yielding varieties. Fungicide application on these three varieties increased test weight by about 1.4 lb/bu. Return to fungicide application would be greatest on susceptible wheat varieties.

Table 1. Wheat variety response to Tilt treatment in Ford County, 2001.

Variety	Grain yield Tilt	Grain yield No Tilt	Grain yield Average	Test weight Tilt	Test weight No Tilt	Test weight Average
	— (bu/a @ 13% H_2O) —			— (lb/bu) —		
2137	44	22	33	59.1	54.2	56.7
Agseco 7853	55	27	41	58.8	54.7	56.8
Ike	47	35	41	57.7	55.7	56.7
Jagger	51	47	49	59.2	58.1	58.6
Lakin	46	16	31	57.8	50.5	54.2
NuFrontier	44	34	39	47.3	46.5	46.9
Ogallala	48	39	44	58.7	57.3	58.0
Oro Blanco	48	17	33	58.5	49.3	53.9
Prairie Red	48	25	37	58.0	51.2	54.6
Smokey	51	24	38	57.4	50.6	54.0
Stanton	54	35	45	56.9	53.1	55.0
Tam 110	50	30	40	58.4	52.6	55.5
Thunderbolt	45	36	41	58.0	56.6	57.3
Trego	55	25	40	57.9	53.7	55.8
Trego&Lakin	54	24	39	59.4	52.1	55.8
Venango	47	26	36	57.5	56.1	56.8
Average	49	29		57.5	53.3	
LSD (0.05)	Variety = 14	Fungicide = 5		Variety = 4.1	Fungicide = 1.4	

Variety * Fungicide can not be tested   Variety * Fungicide can not be tested

Table 2. Wheat variety response to fungicide treatment in Clark, Comanche, and Stevens County, 2005.

Variety	Grain yield Fung	Grain yield No fung.	Grain yield Average	Test weight Fung	Test weight No fung.	Test weight Average
	— (bu/a @ 13% H_2O) —			— (lb/bu) —		
2137	44	27	36 f,g	56.9	55.3	56.1 c,d,e
2145	45	40	43 c,d,e	56.3	57.0	56.5 b,c
2174	43	35	39 e,f,g	57.0	56.2	56.6 b,c
Above	39	30	35 g	55.8	54.4	55.1 e
Cutter	47	43	45 b,c,d	56.2	56.4	56.3 b,c,d
Jagalene	50	40	45 c,d	57.7	57.6	57.6 a
Jagger	46	38	42 c,d,e	55.5	55.2	55.4 d,e
Lakin	34	21	27 h	53.7	52.3	53.0 f
OK 102	51	42	46 b,c	57.4	56.9	57.2 a,b
Overley	54	49	51 a,b	56.5	55.8	56.2 b,c,d,e
Stanton	49	36	42 c,d,e	56.6	54.8	55.7 c,d,e
T 81	47	41	44 c,d	57.4	56.9	57.1 a,b
Tam 111	58	54	56 a	57.8	57.9	57.8 a
Thunderbolt	45	37	41 c,d,e	58.0	57.7	57.9 a
Trego	47	34	40 d,e,f	56.9	55.9	56.4 b,
Average	47A	38B		56.6A	56B	

Numbers in the same column followed by the same letter are not significantly different (0.05).
Data has been combined over all locations, Tilt-Clark Co., Quilt-Comanche Co., Tilt or Quadris - Stevens Co.
Variety by fungicide interaction was not significant.

Table 3. Jagger wheat response to fungicide applications and timings, Southwest Research - Extension Center, Garden City, Kansas.

				Jagger wheat				
Fungicide treatment	RateUnit		Wheat stage[1]	Yield	Test weight	200 KWT	Strip rust	Leaf rust
			(bu/a)	(lb/bu)		(g)	(% of flag leaf covered)	
Untreated				57	59.5	5.3	4	9
Headline	3	fl oz/a	Early joint	58	59.6	5.4	2	6
Headline+	6	fl oz/a	FLE	54	59.8	5.6	2	3
NIS	0.125	% v/v	FLE					
Headline+	6	fl oz/a	Headed	55	60.2	5.6	2	2
NIS	0.125	% v/v	Headed					
Caramba	13.5	fl oz/a	Headed	53	59.6	5.6	2	1
Tilt	2	fl oz/a	FLE	55	59.8	5.6	2	2
Tilt	4	fl oz/a	FLE	57	59.5	5.5	2	1
Headline+	6	fl oz/a	FLE	54	60.0	5.8	1	1
NIS+	0.125	% v/v	FLE					
Caramba	13.5	fl oz/a	Headed					
LSD (0.05)				NS	0.3	0.2	1	3

[1] FLE = flag leaf emerged, Feeks 9.0, Headed = headed but not flowering, Feeks 10.5

Fungicide application on Jagger wheat did not affect grain yield, moisture, or test weight (Table 3). Jagger 200 KWT increased when fungicide applications were made at flag leaf emergence or later, regardless of fungicide applied. A very small amount of stripe rust was present on Jagger, with only 4% of the flag leaf being affected when not treated with a fungicide. All fungicide treatments performed similarly on stripe rust. Leaf rust destroyed about 9% of the flag leaf when left untreated. An early application of Headline® did not provide the same level of protection as the fungicide treatments applied at flag leaf emergence or after. Fungicide application was not profitable in this experiment with Jagger.

Stanton wheat has an intermediate response to stripe rust, but initial infestation on the lower leaves was very heavy, likely because of the very cool weather in April. Fungicide application on Stanton wheat did not statistically increase grain yield or test weight (Table 4). Wheat treated with Headline®, Tilt®, or

Table 4. Stanton wheat response to fungicides, Southwest Research - Extension Center, Garden City, Kansas.

Fungicide treatment	Rate	Unit	Wheat stage[1]	Yield	Test weight	200 KWT	Strip rust
				(bu/a)	(lb/bu)	(g)	(% flg leaf)
Untreated				39	62.6	6.4	33
Headline+	6	fl oz/a	FLE	45	62.3	6.6	13
NIS	0.125	% v/v	FLE				
Caramba	13.5	fl oz/a	FLE	40	62.4	6.8	13
Tilt	4	fl oz/a	FLE	44	62.3	6.6	19
Quadris	6.2	fl oz/a	FLE	36	62.9	6.6	19
Quilt	14	fl oz/a	FLE	43	62.8	6.6	16
LSD (0.05)				NS	NS	0.3	8

[1] FLE = flag leaf emerged, Feeks 9.0

Quilt® tended to have higher yield. All test weights were excellent, regardless of treatment. Stanton treated with Caramba®, an experimental fungicide, had heavier 200 KWT than untreated Stanton, and all fungicide treatments tended to result in heavier 200 KWT. When left untreated, stripe rust destroyed approximately 33% of the Stanton flag leaf. Fungicide-treated Stanton had less stripe rust infestation,but no differences were observed among the fungicides evaluated. As temperatures warmed up in May, the progression or spread of stripe rust on Stanton stopped, but some of the flag leaf tissue was destroyed (rating in Table 4). Fungicide application, depending on treatment, only returned the cost of the fungicide and application (data not provided). If weather had remained cooler, allowing stripe rust to progress and completely destroy the flag leaf, results could have been much different.

Thunderbolt wheat has an intermediate response to stripe rust and, like the Stanton wheat, Thunderbolt was heavily infested during April when temperatures were very cool. Stripe rust did not move onto the flag leaf as expected, with only 6% of the flag leaf being destroyed on the untreated Thunderbolt (Table 5). Wheat response to fungicide was similar, regardless of fungicide used. Fungicide application was not profitable in this experiment.

Wheat yield potential and wheat variety susceptibility to stripe rust must be considered before fungicide applications are made. The value of the wheat crop will also impact whether or not fungicides should be applied. For instances in which quality is essential to maintain high value, such as wheat produced for seed, fungicide applications may be especially beneficial. The experiments display the variable response to fungicides that wheat has when infested with stripe rust. There are no guarantees that fungicide applications will be profitable, but the 2001 experiment suggests that stripe rust can be devastating, andworse than leaf rust. Stripe rust has to be taken very seriously. Wheat variety selection remains one of the most important management decisions to manage stripe rust.

Table 5. Thunderbolt wheat response to fungicides, Comanche Co., Kansas.

Fungicide treatment	Rate	Unit	Wheat stage[1]	Yield	Test weight	200 KWT	Strip rust
				(bu/a)	(lb/bu)	(g)	(% flg leaf)
Untreated			Boot	45	61.6	6.4	6
Headline+	6	fl oz/a	Boot	44	62.0	6.8	4
NIS	0.125	% v/v	Boot				
Tilt	4	fl oz/a	Boot	41	62.1	6.7	4
Quadris	6.2	fl oz/a	Boot	44	62.1	6.6	4
Quilt	14	fl oz/a	Boot	44	61.9	6.6	4
LSD (0.05)				NS	NS	NS	1

[1]Boot = Wheat in the boot stage, occassional beards showing

EFFICACY OF VIP & CRY1AB EVENT CORN HYBRIDS FOR THE CONTROL OF SOUTHWESTERN CORN BORER AND CORN EARWORM

by
Larry Buschman and Phil Sloderbeck

SUMMARY

This trial was conducted to evaluate the efficacy of corn hybrids containing Cry1Ab, for controlling the southwestern corn borer (SWCB), *Diatraea grandiosella* Dyar, stacked with a VIP event for controlling the corn earworm (CEW), *Helicoverpa zea* (Bobbie). The experimental stacked hybrid with both Bt11 and MIR162V gave outstanding efficacy against both the corn earworm and the southwestern corn borer.

PROCEDURES

Experimental corn seed (supplied by Syngenta) was machine-planted June 3 at the Southwest Research-Extension Center Garden City, Kansas. The plots were 4 rows wide and 20 ft long. The experimental seed was planted in a single row (row 2), and the other rows were planted to a commercial Bt corn seed. There were 10-ft-wide alleys at each end of the plots. The design was a randomized block design with four replicates. Four to 12 rows of Bt and non-Bt corn were planted around the experimental plots as a border and windbreak. One isoline was treated for second-generation SWCB and CEW with Warrior T at 3.84 oz/acre, applied with a 2-gallon hand sprayer on August 5. The spray was directed at the plants, while the nozzle was moved up and down to treat the whole plant. The plots were infested by free flying feral moths. There was no first-generation data.

Two sets of SWCB and CEW observations were made. The first observations were made in 5 plants per plot on August 16 and 17 to catch the CEW in the ears. At this time, the SWCB had not started tunneling in the stalks. The second observations were made on up to 15 plants (when available) on September 12 through 14 to record the total CEW damage in the ear and SWCB tunneling in the stalk. The ears from both sets of dissected plants were examined for corn earworm damage. Ear tip damage was measured according to the Winstrom scale (cm of feeding penetration plus 1 for silk feeding). We also counted (or estimated) the number of harvestable kernels removed by CEW feeding on both sets of ears. We estimated the number of CEW traces (tunnels) and the cm of tunneling in the kernels. Some SWCB damage in the ear base was present, but it was minor and is not reported separately. Tunneling in the rest of the plant was also recorded. The data were analyzed by ANOVA, and means were separated by LSD.

RESULTS AND DISCUSSION

Because the plants were not artificially infested with SWCB larvae, there was no first-generation damage to evaluate. There was considerable variability in the maturity of plants within plots and across the plots. The percentage of plants that had reached brown silk on August 16 was analyzed, and there were no significant differences across the treatments (P=0.3049), but there were differences across replication (P=0.0542)

Corn earworm damage was moderate, reaching 3.0 to 4.3 on the Winstrom scale (Table 1). In the August observations, which were made before any of the CEW had left the ears, the number of CEW larvae, the CEW instar, length of CEW feeding tunnels, and Windstrum ratings were significantly less in the two treatments with the MIR162V events (#2 & 3) (Table 1). The Bt 11 event and the Warrior treatments did not significantly reduce the CEW variables. In the September observations, which were made after the CEW damage was complete, the number of CEW is not recorded because they had left the ears. The length of CEW feeding tunnels, number of CEW tunnels, number of kernels destroyed, and Windstrum ratings were significantly less in the two treatments with the MIR162V events (#2 & 3) (Table 1). The Bt 11 hybrid and the Warrior treatments reduced all of the CEW variables, but the reduction was statistically significant for some of the variables.

The second-generation SWCB population averaged only 0.45 and 0.5 larvae per plant in the untreated non-Bt hybrid (#4) (Table 2). During the August observations, most of the SWCB were found in the ear around the shank, but in September all SWCB were found in the stalk; most of these were down in the base of the plant, and plant girdling had started. All the treatments significantly reduced SWCB variables, except the husk-feeding observations, which record the first feeding attempts of the SWCB (Table 2). There was an average of 0.77 tunnels and 4.2 cm of tunneling per untreated non-Bt plant (#4) (Table 2).

The efficacy of the experimental hybrids was outstanding against both the CEW and the SWCB. The efficacy of the MIR162V (VIP3a) event stacked with a Cry1Ab event was outstanding against both the corn earworm and the southwestern corn borer.

Table 1. Observations on corn earworm feeding taken on the primary corn ears in the different treatments. Corn ear feeding damage recorded August 16 and 17 and September 12 through 14, 2005, Southwest Research-Extension Center, Garden City, Finney Co., Kansas.

		August 16 & 17				September 12 through 14			
Treat. No.	Hybrid Code Event/treatment	Number per plant	Instar	Feeding (cm/ear)	Windstrum rating	Feeding (cm/ear)	Feeding tunnels	Kernels destroyed	Windstrum rating
1.	MG051311 (Bt11)	3.0 ab	2.1 ab	1.5 bc	1.8 b	3.8 b	1.9 ab	27.4 ab	3.1 b
2.	MG033058 (MIR162V)	0.3 c	1.3 c	0.3 c	0.4 c	0.7 c	0.5 c	6.6 c	0.7 c
3.	MG051540 (Bt11 & MIR162V)	0.4 c	1.7 bc	0.0 c	0.1 c	0.4 c	0.4 c	3.3 c	0.5 c
4.	MG032765 Isoline	4.6 a	3.5 ab	3.8 a	3.0 a	5.7 a	2.4 a	41.9 a	4.3 a
5.	MG032765 Isoline & Warrior	1.9 b	3.7 a	2.8 ab	2.5 ab	4.2 ab	1.8 b	25.9 b	3.3 ab
	P-value	0.0001	0.0664	0.0024	0.0001	>0.0001	>0.0001	0.0005	>0.0001
	LSD-value	1.315	1.926	1.7886	0.932	1.5000	0.636	14.587	1.154

Means followed by the same letter are not significantly different (P ≤ 0.05, LSD).

Table 2. Observations on second-generation southwestern corn borer feeding on corn plants of different treatments. Plants dissected August 16 and 17 and September 12 through 14, 2005, Southwest Research-Extension Center, Garden City, Finney Co., Kansas.

		August 16 & 17			September 12 through 14			
Treat. No.	Hybrid Code Event/treatment	Number per plant	Husk feeding	number per plant	Husk feeding	Stalk tunneling	Shank tunneling	Tunnels per plant
			(Pos/15 plt.)		(Pos/5 plt)	(cm/plant)	(cm/plant)	
1.	MG051311 (Bt11)	0.0 b	0.16	0.0 b	0.06 b	0.0 b	0.0	0.00 b
2.	MG033058 (MIR162V)	0.0 b	0.14	0.0 b	0.03 b	0.2 b	0.0	0.03 b
3.	MG051540 (Bt11 & MIR162V)	0.0 b	0.14	0.0 b	0.09 b	0.0 b	0.0	0.00 b
4.	MG032765 Isoline	0.45 a	0.29	0.5 a	0.31 a	4.2 a	0.2	0.77 a
5.	MG032765 Isoline & Warrior	0.0 b	0.33	0.0 b	0.11 b	0.0 b	0.0	0.00 b
	P-value	0.0013	0.2577	0.0004	0.0012	0.0039	0.1262	0.0016
	LSD-value	0.207	—	0.1949	0.113	2.154	—	0.355

Means followed by the same letter are not significantly different ($P \leq 0.05$, LSD).

EFFICACY OF IN-SEASON APPLICATIONS OF SYSTEMIC INSECTICIDE TO CONTROL DECTES STEM BORERS IN SOYBEAN

by
Larry Buschman, Holly Davis[2], and Phil Sloderbeck

SUMMARY

We tested six systemic insecticides applied to the soil and nine systemic insecticides applied to the foliage for their effectiveness in reducing Dectes stem borers (*Dectes texanus*) in soybean. The insecticides were applied during the beetle flight to target the first two instars of the insect developing inside the plants. Of the soil insecticides tested, only fipronil significantly reduced Dectes stem borer infestations with both applications. The late application of imidacloprid and acetamiprid also seemed to reduce Dectes stem borer infestations. Of the soil insecticides tested, only fipronil significantly reduced Dectes stem borer infestations with both applications. The late application of thiacloprid also seemed to reduce Dectes stem borer infestations. Dectes stem borer infestation was 20 to 25% of plants infested.

PROCEDURES

This trial was conducted in soybeans, Pioneer 93B85 (maturity group 3.8), planted May 20, 2005, on the Ramsey Brothers Farm 3 miles north of Garden City, Kansas. Three sets of plots were set up, one for soil-applied insecticides and two for foliar-applied insecticides. In two experiments, 20 treatments were assigned in a randomized complete-block design with five replications. In the third experiment, four treatments were assigned in a randomized complete-block design with five replications. Plots were four rows (10 ft) wide and 20 ft long, with a 5-ft alley across the ends of the plots. We tested six systemic insecticides applied to the soil and nine systemic insecticides applied to the foliage. The insecticides were applied during the beetle flight to target the first two instars of the insect developing inside the plants. The soil-applied treatments were applied July 20 and August 8, when the soybeans were 12 and 24 inches high, respectively. The liquid soil treatments were applied with a back-pack, hand-held sprayer with a single nozzle (fan LF3 80^{o}) that was held close to the ground to apply a 6-inch band 6 inches from the base of the plants. The insecticides were incorporated by hand raking the soil and by irrigation several days later. The foliar treatments were applied July 22 and August 19 with the back–pack sprayer, with a hand-held boom with two nozzles (Conejet TXVS 6) directed at a single row. The nozzles were held 12 inches from the row and to each side. In both methods, the sprayer was calibrated to deliver 20 gal/acre (7.5 sec per 20 ft row at 30 psi). A chronometer was used to measure the time spent on each row to help maintain appropriate speed.

Dectes stem borers infestations were recorded at the end of the season (September 15 to October 20) by dissecting 30 plants in each plot, taken from six locations in the two center rows. The plants were dissected to record any tunneling, tunneling that reached the base of the plant, and presence of live Dectes larvae. Grain yield data was not collected because infestations were very low, and the plants had been heavily damaged by hail.

RESULTS AND DISCUSSION

Dectes stem borer populations were much higher in 2005 than in 2004, but on July 4 there was a serious hail storm that seriously defoliated the soybeans. It also broke or bruised the stems. Although the plants recovered from buds, the resulting plants were smaller, later maturing, and more branched than normal. They were almost a month later than usual in reaching the stage at which Dectes beetles could oviposit in them. This meant that most of the plants escaped the main flight of Dectes beetles. A few of the plants were

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tunneling in the stem, inasmuch as the number of larvae was much fewer than the number of tunnels in the stems. The second application was applied later than intended, due to an interruption from irrigation and rainy weather.

In 2004, we were able to show a significant difference in yield (4.6 to 6.6 bu/acre) between the fipronil and the untreated check treatments. This implies a 7 to 11% physiological yield loss due to Dectes stem borer infestations. We did not take yield data in 2005.

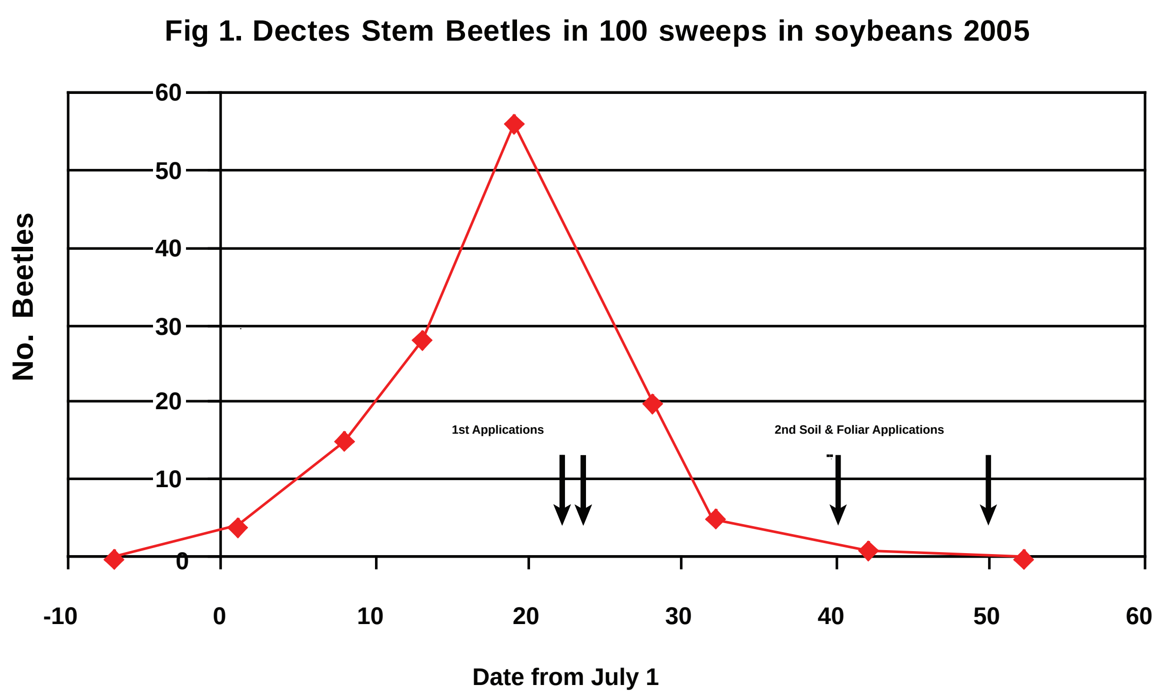


Figure 1. Dectes stem beetles in 100 sweeps in soybeans, 2005.

Table 1. Efficacy of soil-applied systemic insecticides against Dectes stem borers in soybean. Southwest Research-Extension Center, Garden City, Kansas, 2005.

Treat. No.	Chemical name	Product name[1]	Rates-product */1000ft	Treatment time July 20	Treatment time Both	Treatment time Aug 8	Tunneling present /30 plant	Tunneling to base /30 plants	Larva present /30 plants
1.	Check		___				6.3 ab	4.9 a	3.4 abc
2.	Fipronil	Regent 4SC	0.24oz	6.2 ml			1.2 d	0.4 d	0.3 d
3.	Imidacloprid	Provado 1.6 F	1.72 oz	44.3 ml			5.5 abc	3.1 abc	3.7 ab
4.	Imidacloprid	Provado 1.6 F	1.72 oz		44.3 ml		5.2 abc	3.0 abc	3.6 abc
5.	Imidacloprid	Provado 1.6 F	3.44 oz	88.6 ml			4.2 abc	2.4 abcd	2.5 abc
6.	Thiamethoxam	Platinum	0.46 oz	11.8 ml			6.8 a	3.5 abc	5.2 a
7.	Thiamethoxam	Platinum	0.46 oz		11.8 ml		4.4 abc	2.4 abcd	3.6 abc
8.	Acetamiprid	Intruder WSP	0.132 oz	3.26 gm			6.9 a	5.1 a	4.6 a
9.	Acetamiprid	Intruder WSP	0.132 oz		3.26 gm		6.9 a	3.3 abc	4.0 ab
10.	Dinotefuran	V-10112	16.4 gm	14.28			6.1 ab	3.5 abc	4.0 ab
11.	Dinotefuran	V-10112	16.4 gm		14.28 gm		6.3 ab	4.1 ab	4.1 ab
12.	Acephate	Orthene 90 S	1.01 oz	24.9 gm			5.9 abc	3.8 abc	4.4 a
13.	Acephate	Orthene 90 S	1.01 oz		24.9 gm		7.2 a	4.1 ab	5.1 a
14.	Fipronil	Regent 4SC	0.24 oz			6.2 ml	3.3 bcd	**1.4 cd**	**1.3 cd**
15.	Imidacloprid	Provado 1.6 F	1.72 oz			44.3 ml	**2.7 cd**	**1.9 bcd**	**1.7 bcd**
16.	Imidacloprid	Provado 1.6 F	3.44 oz			88.6 ml	5.6 abc	3.9 abc	3.8 ab
17.	Thiamethoxam	Platinum	0.46 oz			11.8 ml	5.7 abc	3.7 abc	4.6 a
18.	Acetamiprid	Intruder WSP	0.132 oz			3.26 gm	5.2 abc	**1.6 bcd**	3.9 ab
19	Dinotefuran	V-10112	16.4 gm			14.28 gm	4.4 abc	2.1 abcd	2.8 abc
20.	Acephate	Orthene 90 S	1.01 oz			24.9 gm	6.1 ab	2.8 abc	4.3 a
	F-test Prob.						0.0393	0.0914	0.0009
	CV						23 %	28 %	37 %

[1]Reference to specific products is provided solely for informational purposes. Experiments with pesticides on non-labeled crops or pests are part of the insecticide registration process; it does not imply endorsement or recommendation of non-labeled uses of pesticides by Kansas State University. All pesticide use must be consistent with current labels.

Table 2. Efficacy against the Dectes stem borers in soybean of systemic insecticides applied to foliage. Southwest Research-Extension Center, Garden City, Kansas, 2005.

Treat. No.	Chemical name	Product name[1]	Rates-product */acre	Treatment time			Tunneling present /30 plant	Tunneling to base /30 plants	Larva present /30 plants
				July 22	Both	Aug 19.			
1.	Check		—				6.5 abcde	6.0 abc	5.0 ab
2.	Fipronil	Regent 4SC 0.13 lb ai/A	4.2 oz	6.2 ml			**1.1 g**	**1.0 efg**	**1.0 ef**
3.	Thiacloprid	Calypso 4F 0.125 lb ai/A	4 oz	5.9 ml			4.0 cdef	**3.2 bcdef**	**2.1 def**
4.	Thiacloprid	Calypso 4F 0.125 lb ai/A	4 oz		2X		**3.4 defg**	**2.6 efg**	2.5 bcdef
5.	Clothianidin	TM-44401 50WP 1.6 oz ai/A/COC	0.24 oz&1%	4.4 gm			7.1 abc	6.3 ab	4.6 abc
6.	Clothianidin	TM-44401 50WP 1.6 oz ai/A/COC	0.24 oz&1%		2X		4.1 cdef	3.9 abcde	2.8 bcde
7.	Thiamethoxam	Centric 40 WG 0.05 lb ai/A	2 oz	2.84 gm			8.6 a	7.2 a	6.0 a
8.	Thiamethoxam	Centric 40 WG 0.05 lb ai/A	2 oz		2X		3.6 bef	2.0 defg	2.4 cdef
9.	Acetamiprid	Intruder WSP 70%	2.3 oz	3.26 gm			4.8 bcdef	3.4 bcdef	2.9 bcde
10.	Acetamiprid	Intruder WSP 70%	2.3 oz		2X		3.8 def	3.0 cdefg	2.4 cdef
11.	Dinotefuran	V-10112 70SG 0.176 lb ai/A	4.0 oz	5.7 gm			7.8 ab	5.4 abcde	3.4 abcd
12.	Dinotefuran	V-10112 70SG 0.176 lb ai/A	4.0 oz		2X		6.3 abcde	5.0 abcde	3.5 abcd
13.	Acephate	Orthene 90S 1 lb ai/A	1.1 lb	25 gm			7.4 abc	5.5 abcde	4.5 abcd
14	Fipronil	Regent 4SC 0,13 lb ai/A	4.2 oz			6.2 ml	**2.3 fg**	**0.7 g**	**0.7 f**
15.	Thiacloprid	Calypso 4F 0.125 lb ai/A	4 oz			5.9 ml	5.6 abcde	5.1 abcde	4.7 abc
16.	Clothianidin	TM-44401 50WP 1.6 oz ai/A/COC	0.24 oz&1%			4.4 gm	4.8 bcdef	3.6 bcde	2.4 cdef
17.	Thiamethoxam	Centric 40 WG 0.05 lb ai/A	2.0 oz			2.84 gm	6.8 abcd	6.0 abc	4.5 abcd
18.	Acetamiprid	Intruder WSP 70%	2.3 oz			3.26 gm	7.2 abc	5.8 abcd	4.6 abc
19	Dinotefuran	V-10112 70SG 0.176 lb ai/A	4.0 oz			5.7 gm	3.4 efg	3.2 bcdef	2.7 bcde
20.	Acephate	Orthene 90S 1 lb ai/A	1.1 lb			25 gm	5.3 abcde	5.4 abcde	3.7 abcd
	F-test Prob.						0.0003	0.0005	0.0009
	CV						22 %	24 %	23 %

[1]Reference to specific products is provided solely for informational purposes. Experiments with pesticides on non-labeled crops or pests are part of the insecticide registration process; it does not imply endorsement or recommendation of non-labeled uses of pesticides by Kansas State University. All pesticide use must be consistent with current labels.

Table 3. Efficacy against the Dectes stem borers in soybean of systemic insecticides applied to foliage August 19, Southwest Research-Extension, Center, Garden City, Kansas, 2005

Treat. No.	Chemical name	Product name[1]	Rates-product */acre	Tunneling present /30 plant	Tunneling to base /30 plants	Larva present /30 plants
1.	Check		—	6.2	5.2	4.2
2.	Thiamethoxam &	Centric 40 WG	2 oz			
	Lambda cyhalothrin	Warrior 1CS	3.8 oz	8.0	7.2	5.4
3.	Lambda cyhalothrin	Warrior 1CS	3.8 oz	8.2	7.2	5.0
4.	Emamectin Benzoate	Proclaim 5SG	4.8 oz	5.6	5.6	3.8
	F-test Prob.			0.4662	0.6945	0.6957
	CV			18 %	20 %	20%

[1]Reference to specific products is provided solely for informational purposes. Experiments with pesticides on non-labeled crops or pests are part of the insecticide registration process; it does not imply endorsement or recommendation of non-labeled uses of pesticides by Kansas State University. All pesticide use must be consistent with current labels.

Dectes entry hole.

Dectes tunnel with 3 entry holes.

EFFICACY OF MITICIDES APPLIED AT TASSEL STAGE FOR CONTROL OF SPIDER MITES IN CORN, 2005

by
Larry Buschman, Holly Davis, Randall Currie, and Phil Sloderbeck

SUMMARY

Spider mite populations started out low, but reached 785 mites per 2 plants by 30 Aug. (46 days post treatment). The populations were mostly Banks grass mites (BGM) in July, but by the end of the season, nearly 90 percent of the population was twospotted spider mites (TSM). The standard treatment, Comite®, gave some early control, but had little impact on the late-season TSM populations.. The Oberon®, Onager®, and Zeal® treatments seemed to give early-season control of BGM, but had limited impact on TSM populations late in the season. The Agri-Mek® treatment was applied late, due to equipment problems, and gave inconsistent control of the BGM populations, but did seem to provide some control of TSM later in the season. Predator numbers were very low for most of the season, but predator mite populations increased late in the season, when spider mite populations were high. No differences in predator mite populations were observed among treatments. Grain yields were highest in some of the Onager® and Oberon® treatments, but they were not significantly different from the Check, probably as a result of soil variability in the field.

PROCEDURES

Field corn, N73-F7 (GT/LL/YGCB) (112-day maturity), was planted April 26 with a John Deere MaxEmerge 6 row planter at a rate of 35,000 seeds/acre in wheat stubble under a center-pivot irrigation system (Field N34) at the Southwest Research- Extension Center, Finney County, Kansas. A test with 10 treatments was set up in a randomized complete-block design with four replications. Plots were four rows (10 ft) wide and 50 ft long, with a 4-row (10 ft) border of untreated corn on each side and a 10-ft alley at each end. The field received 170 lb of N as anhydrous ammonia and was irrigated 16 times, receiving 14.5 inches of water. The plots were manually infested with Banks grass mites (BGM) July 12 by tying on mite-infested leaves collected from a cornfield in Stevens County. We infested 6 plants in each plot, 3 for each of the two center rows. Treatments (except #6) were applied July 15, when the corn was late whorl stage to tassel stage (6 ft). The sprayer broke down, so treatment #6 could not be applied with the other treatments. Treatment #6 was applied August 1, when the corn was in the soft dough stage, with other post-tassel treatments in the adjacent plots (see companion report). The treatments were applied with a high-clearance sprayer using a 10-ft boom with two nozzles directed at each row (one on each side of the row on an 18-inch drop hose). The nozzles were directed up into the plant. The sprayer was calibrated to deliver 14 gal/acre at 2 mph and 40 psi.

Spider mites were sampled by collecting half the leaves from 4 plants (4 half plants = 2 plants) from the two center rows in each plot. Early in the season, we sampled plants next to the infested plants. The plant material from each plot was placed in separate large paper bags and transported to the laboratory, where the plant materialwas placed in separate, large 76-liter Berlese funnels. A 100-watt light bulb was used to dry the vegetation and drive arthropods down into a collecting jar containing 70% methanol. The alcohol samples were filtered on ruled white filter paper, and spider mites, predator mites, and thrips were counted under a binocular microscope. A subsample of spider mites (about 20) was mounted on a microscope slide. The slides were examined to determine the proportion of BGM and TSM in the populations from each plot. Pre-treatment spider mite samples were collected July 14, and post-treatment samples were collected July 18, 22, 29, and August 5, 12, and 30. Spider mite counts were transformed with Taylor's power transformation for statistical analysis, and were back-transformed to mites per 4 half-plants for presentation. Grain yield was collected by machine harvesting two rows from each plot. There was considerable variation in the plant height and a gradient in the yield going down the field, so we calculated the "field yield trend" by calculating the average yield across 6 rows of plots going down the field. The position means were smoothed by using rolling averages. Then this "field yield trend" was used as the covariate in the ANOVA of grain yield. The F-value for the covariate was 3.5717; that for treatment was 2.3672.

RESULTS AND DISCUSSION

Banks grass mite and TSM populations averaged 12 mites per 2 plants on July 14. The Banks grass mite populations in the untreated control increased to 126 mites per 2 plants by August 5, and then declined to 38 mites per 2 plants by August 12 (Table 1). The TSM populations in the untreated control were present at very low numbers during July, but they increased rapidly in August, from 6% on August 5 to 89% on August 30. By this time, the TSM population averaged 694 mites per 2 plants in the untreated plots (Tables 3 and 4). There was a period of wet weather in early August that seemed to be associated with the collapse of the BGM populations was followed by increasing TSM populations. This confirms previous observations in this region that the species composition often shifts from mostly BGM early in the season to TSM later in the season.

The standard early-season miticide, Comite®, gave good early control (up to 100%) of BGM (Table 2), but it did not seem to affect the late-season populations of tTSM (Table 3 and 4). The season-total control of both spider mites was only 20% (Table 5). The percentage of TSM in the population did not differ meaningfully between the Comite® treatment and the control (Table 4).

The three rates of Onager® gave excellent BGM control, 72 to 98% from 7 to 21 days after treatment (DAT) (Table 2). The season-total BGM control was 41 to 78% (Table 2). These treatments seemed to have little impact on the late-season TSM, season-total control of TSM was 1 to 28% (Table 4). The season-total control for both spider mites was only 32 to 57% (Table 5). There seemed to be a significant increase in the percentage of TSM in the Onager® plots 21 DAT (Table 4), probably as a result of the significant impact of these treatments on the BGM during this period. There was no clear indication of a rate response among the three rates of Onager® tested, and the highest rate was the treatment that seemed to break down first.

The two formulations of Oberon® also gave excellent BGM control, 50 to 97% out to 21 DAT (Table 2). The season-total BGM control was 61 to 64% (Table 2). The impact of these treatments on the

Table 1. Banks grass mites per 4 half plants (=2 plants) in plots treated with miticides*. Southwest Research -Extension Center, Garden City, Kansas, 2005.

			BGM/4 half-plants [a]						
No.	Treatment	Rate	July 14 Pre-treat.	July 18 3 days	July 22 7 days	July 29 14 days	Aug. 5 21 days	Aug. 12 28 days	Aug. 30 46 days
1	Check	—	19	29	79 a	14 ab	126 a	38	81
2	Comite II 6EC	2.25 pt	8	11	0 d	8 bc	41 ab	20	141
3	Onager 1E	6 oz	9	16	8 bc	2 c	4 c	30	11
4	Onager 1E	8 oz	7	18	8 bc	1 c	2 d	4	7
5	Onager 1E	12 oz	3	11	15 bc	1 c	5 cd	9	84
6 [b]	AgriMek 0.15 EC	8 oz	3	12	19 ab	47 a	43 ab	38	5
7	Oberon 240EC	8.5 oz	9	5	3 bcd	2 c	3 cd	37	21
8	Oberon 480EC	4.25 oz	9	12	2 cd	3 bc	15 bcd	20	60
9	Zeal	0.66 oz	14	11	9 bc	3 bc	22 bcd	25	65
10	Zeal	1.0 oz	2	27	9 bc	6 bc	23 bcd	10	24
	F-test P value		0.7394	0.3248	0.0023	0.0016	0.0024	0.3382	0.2496

*Treatments made July 15, 2005, when the corn was just starting to tassel.
[a] Means followed by the same letter are not significantly different (P < 0.05, LSD)
[b] Treatment 6 was not applied until August 1, so it was a Check until the August 5 sample.

Table 2. Percentage of control of Banks grass mites in plots treated with miticides*, Southwest Research -Extension Center, Garden City, Kansas, 2005.

			Percentage control for BGM						
		Rate	July 18	July 22	July 29	Aug. 5	Aug. 12	Aug. 30	Season
No.	Treatment		3 days	7 days	14 days	21 days	28 days	46 days	Total
1	Check	—	—	—	—	—	—	—	—
2	Comite II 6EC	2.25 pt	56	**100**	33	**60**	35	0	16
3	Onager 1E	6 oz	34	**88**	**86**	**96**	6	**84**	**68**
4	Onager 1E	8 oz	21	**88**	**88**	**98**	**86**	**90**	**78**
5	Onager 1E	12 oz	43	**72**	**90**	**94**	**63**	0	41
6 [a]	AgriMek 0.15 EC	8 oz				49	0	**91**	21
7	Oberon 240EC	8.5 oz	**81**	**96**	**84**	**97**	0	**69**	**64**
8	Oberon 480EC	4.25 oz	50	**98**	**78**	**86**	37	13	**61**
9	Zeal	0.66 oz	**60**	**88**	**81**	**81**	30	14	51
10	Zeal	1.0 oz	0	**80**	28	**70**	55	52	46

*Treatments made July 15, 2005, when the corn was just starting to tassel.
[a] Treatment 6 was not applied until August 1, so it was a Check until the August 5 sample.

Table 3. Twospotted spider mites per 4 half plants (=2 plants) in plots treated with miticides*, Southwest Research-Extension Center, Garden City, Kansas, 2005.

			TSM/4 half-plants [a]						
			July 14	July 18	July 22	July 29	Aug. 5	Aug. 12	Aug. 30
No.	Treatment	Rate	Pre-treat.	3 days	7 days	14 days	21 days	28 days	46 days
1	Check	—	0.0	0.0	0.0	4	4	34	694
2	Comite II 6EC	2.25 pt	0.0	0.0	0.0	1	7	11	673
3	Onager 1E	6 oz	0.0	0.0	0.0	0	1	25	696
4	Onager 1E	8 oz	0.0	0.0	0.0	1	3	9	511
5	Onager 1E	12 oz	0.0	0.0	0.0	0	5	15	587
6 [b]	AgriMek 0.15 EC	8 oz	0.0	0.0	0.0	7	2	15	403
7	Oberon 240EC	8.5 oz	0.0	0.0	0.0	0	2	16	726
8	Oberon 480EC	4.25 oz	0.0	0.0	0.0	2	4	15	424
9	Zeal	0.66 oz	0.0	0.0	0.0	1	4	19	613
10	Zeal	1.0 oz	0.0	0.0	0.0	2	5	11	496
	F-test P value		—	—	—	0.1729	0.8792	0.9452	0.8824

*Treatments made July 15, 2005, when the corn was just starting to tassel.
[a] Means followed by the same letter are not significantly different ($P < 0.05$, LSD)
[b] Treatment 6 was not applied until August 1, so it was a Check until the August 5 sample.

late-season TSM varied from 0 to 59% on the samples 21 to 46 DAT (Table 4). The season-total control for both spider mites was only 31 to 60% (Table 5). There was no clear indication of a difference in performance of the two Oberon® formulations.

The BGM populations in the Agri-Mek® treatment were similar to the untreated check until August 5, 4 days after the treatment. The Agri-Mek® treatment gave inconsistent control of BGM populations (49 and 91% control on August 5 and 30, respectively, but control was 0% on August 12 (Table 2)). The season-total BGM control was only 21% (Table 2), but this treatment seemed to impact the late-season TSM populations (42 to 55% control 21 to 46 days after treatment (Table 4)). The season-total control for both spider mites was 52% (Table 5). The 8-oz rate of Agri-Mek® used here did not work as well as the 16-oz rate used in 2003, but the 16-oz rate is estimated to cost $64 an acre.

The two rates of Zeal® gave fair to excellent BGM control, 28 to 88% 7 to 21 DAT (Table 2). The season total BGM control was 46 to 51% (Table 2),

Table 4. Percentage of control of twospotted spider mites in plots treated with miticides*, Southwest Research-Extension Center, Garden City, Kansas, 2005.

			Percentage population TSM [a]			Percentage control for TSM			
No.	Treatment	Rate	Aug. 5 21 days	Aug. 12 28 days	Aug. 30 46 days	Aug. 5 21 days	Aug. 12 28 days	Aug. 30 46 days	Season total
1	Check	—	6 b	48	89	—	—	—	—
2	Comite II 6EC	2.25 pt	18 ab	37	79	0	**69**	3	8
3	Onager 1E	6 oz	**43 a**	46	97	**68**	27	0	1
4	Onager 1E	8 oz	**48 a**	64	95	30	**72**	26	28
5	Onager 1E	12 oz	**45 a**	57	87	0	56	15	19
6	AgriMek 0.15 EC	8 oz	6 b	32	88	53	55	42	41
7	Oberon 240EC	8.5 oz	31 ab	35	93	59	52	0	1
8	Oberon 480EC	4.25 oz	23 ab	32	85	7	56	39	40
9	Zeal	0.66 oz	21 ab	42	90	10	44	12	12
10	Zeal	1.0 oz	23 ab	52	89	0	**68**	29	31
	F-test P value		0.0832	0.5697	0.4082	—	—	—	—

*Treatments made July 15, 2005, when the corn was just starting to tassel.
[a] Means followed by the same letter are not significantly different (P < 0.05, LSD)

but these treatments seemed to have less impact on the late-season TSM, with season-total control of 12 to 31% (Table 4). The season-total control for both spider mites was only 33 to 53% (Table 5). There was no clear indication of a rate response among the two rates of Zeal® tested.

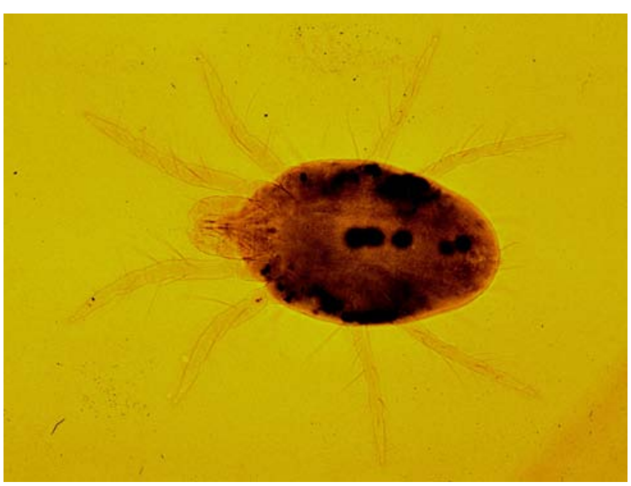
During the early part of the season, July 14 and August 5, predator mite populations were low, 0.35 to 0.9 per 2 plants, because spider mite populations were also low, <50 mites per plant (Tables 1 and 3). In late August, however, when the mite populations increased from <50 to >1190 mites per 2 plants, the predator mite populations increased from 0.9 to 116.3 mites per 2 plants. (Table 5). This was the only predator population that seemed to increase as spider mite populations increased. The late-season predator mite numbers were not significantly different across the miticide treatments (Table 5). Thrips populations, *Frankliniella* spp., decreased from 3.0 to 0.9 per 2 plants during the sampling period. They were sampled during the post-tassel period, when thrips numbers are usually smaller than they are during the early to mid-whorl stages. In the past, these thrips seemed to be important early-season facultative predators of spider mites. The spider mite populations generally increase rapidly during the corn reproductive stage, when the thrips populations are low. Sixspotted thrips, *Scolothrip* spp., were present, but populations were low during the sampling period, 0.06 to 0.25 thrips per 2 plants. These thrips are reported to be important predators of the spider mites, but we have recorded them only infrequently. Predator populations were too low early in the season, when treatments were applied, to determine if there were differences in their responses to the miticide treatments.

Although there were some significant differences in yields among treatments, and the coefficient of variation (CV) was only 7.9%, interpretation is difficult. The highest yields were in the Oberon® 480EC and 8 oz. Onager® 1E treatments, which had the highest season-total percentage of control, but they were not significantly different from the untreated check. The treatments were good enough to protect enough yield to be clearly identified in this trial.

Table 5. Numbers of predator mites, season-total numbers of spider mites, and grain yield for plots treated with miticides*, Southwest Research-Extension Center, Garden City, Kansas, 2005.

			Predator mites/4 half-plants [a]			Spider mites /4 half-plants [a]				Grain
			Aug. 5	Aug. 12	Aug. 30	Season totals				yield [a]
No.	Treatment	Rate	21 days	28 days	46 days	BGM	TSM	Sum	% Control	bu/acre
1	Check	—	1.5	9.8	109	434 a	756	1190		162.2 ab
2	Comite II 6EC	2.25 pt	2.0	9.3	152	295 ab	699	994	20	166.2 ab
3	Onager 1E	6 oz	0.5	20.5	158	118 cd	749	867	32	155.8 b
4	Onager 1E	8 oz	1.5	2.3	159	77 d	542	619	57	174.6 a
5	Onager 1E	12 oz	0.8	13.0	119	172 bcd	615	787	41	169.8 ab
6 [b]	AgriMek 0.15 EC	8 oz	0.3	6.3	67	232 abc	444	674	52	154.5 b
7	Oberon 240EC	8.5 oz	0.0	18.3	119	130 cd	749	880	31	164.8 ab
8	Oberon 480EC	4.25 oz	1.5	2.8	107	146 bcd	452	597	60	178.6 a
9	Zeal	0.66 oz	0.5	4.8	75	199 bc	663	862	33	175.2 a
10	Zeal	1.0 oz	0.5	6.0	100	142 bcd	519	661	53	155.6 b
	F-test P value		0.0787	0.1102	0.6397	0.0139	0.8682	—	—	0.0430

[a] Means followed by the same letter are not significantly different (P < 0.05, LSD)
[b] Treatment 6 was not applied until August 1, so it was a Check until the August 5 sample.



BGM female.

BGM male.

EFFICACY OF MITICIDES APPLIED POST-TASSEL FOR CONTROL OF SPIDER MITES IN CORN, 2005

by

Larry Buschman, Holly Davis, Randall Currie, and Phil Sloderbeck

SUMMARY

The Banks grass mite (BGM) populations increased from 26 to 240 mites per 2 plants by August 8 and then declined to 12 mites per 2 plants on August 23. The twospotted spider mite (TSM) populations increased rapidly in August, from 13 per 2 plants on August 8 to 628 per 2 plants on September 8. The percentage of the population that was TSM increased from 5% to 97% during the season. The two rates of the standard miticide, Capture® 2EC (bifenthrin active ingredient), gave some early control (up to 40%) of BGM. The combination of Capture® plus Dimethoate also seemed to give some early control of both mites. The two rates of Fanfare® (bifenthrin active ingredient) gave some early control of BGM (up to 65%). The two Onager® combinations gave reasonable BGM control, 38 to 85% from 7 to 21 days after treatment (DAT). The Onager® plus Capture® treatment seemed to have some impact (24 to 39%) on the TSM populations. The two formulations of Oberon® gave excellent BGM control, 53 to 89% out to 14 DAT, but the Oberon® 480EC treatment seemed to fade at 22 DAT. These treatments seemed to have some impact on the twospotted spider mites, on the samples through 22 DAT (3 to 76%). Predator numbers were very small for most of the season, but predator mite populations increased late in the season, when spider mite populations were high. No differences in predator mite populations were observed among treatments. There were no significant differences in yields among the treatments, even though the coefficient of variance (CV) was only 8%.

PROCEDURES

Field corn, N73-F7 (GT/LL/YGCB) (112-day maturity), was planted April 26 with a John Deere MaxEmerge 6-row planter at a rate of 35,000 seeds/acre in wheat stubble under a center-pivot irrigation system (Field N34) at the Southwest Research-Extension Center, Finney County, Kansas. A test with 10 treatments was set up in a randomized complete-block design with four replications. Plots were four rows (10 ft) wide and 50 ft long, with a 4-row (10 ft) border of untreated corn on each side and a 10-ft alley at each end. The field received 170 lb of N as anhydrous ammonia and was irrigated 16 times, receiving 14.5 inches of water. The plots were manually infested with BGM July 12 by tying on mite-infested leaves collected from a cornfield in Stevens County. We infested 6 plants in each plot, 3 for each of the two center rows. Treatments were applied August 1, when the corn was soft dough stage, 2 wk post-tassel. The treatments were applied with a high-clearance sprayer using a 10-ft boom with two nozzles directed at each row (one on each side of the row on a 18-in drop hose). The nozzles were directed to the ear zone of the plants. The sprayer was calibrated to deliver 14 gal/acre at 2 mph and 40 psi.

Spider mites were sampled by collecting half the leaves from 4 plants (4 half plants = 2 plants) from the two center rows in each plot. Early in the season, we sampled plants next to the infested plants. The plant material from each plot was placed in separate large paper bags and transported to the laboratory, where the plant material was placed in separate, large 76-liter Berlese funnels. A 100-watt light bulb was used to dry the vegetation and drive arthropods down into a collecting jar containing 70% methanol. The alcohol samples were filtered on ruled white filter paper, and spider mites, predator mites, and thrips were counted under a binocular microscope. A subsample of spider mites (about 20) was mounted on a microscope slide. The slides were examined to determine the proportion of BGM and TSM in the populations from each plot. Pre-treatment spider mite samples were collected July 25 and post-treatment samples were collected August 8, 15, and 23 and September 8. Spider mite counts were transformed with Taylor's power transformation for statistical analysis, and were back-transformed to mites per 4 half-plants for presentation. Grain yield was collected by machine harvesting two rows from each plot. There was considerable variation in the plant height and a gradient in the yield going down the field, so we calculated the “field yield trend” by calculating the average yield across 6 rows of plots going down the field. The position means were smoothed by using rolling averages. Then this “field yield trend” was used as the covariate in the ANOVA of grain yield. The F-value for the covariate was 4.9596; that for treatment was 0.8069.

RESULTS AND DISCUSSION

The BGM and TSM populations averaged 50 mites per 2 plants on July 25. The BGM populations in the untreated control increased from 26 to 240 mites per 2 plants by August 8 and then declined to 12 mites per 2 plants on August 23 (Table 1). In the untreated control, the TSM populations were present in very small numbers during July, but they increased rapidly in August, from 13 per 2 plants on August 8 to 628 per 2 plants on September 8 (Table 4). The percentage of the population that was TSM increased from 6% on July 25 to 95% by September 8. There was a period of wet weather in early August that seemed to be associated with the collapse of the BGM populations, followed by increasing TSM populations. This confirms previous observations in this region that the species composition often shifts from mostly BGM early in the season to TSM later in the season).

The two rates of the standard miticide, Capture® 2EC (bifenthrin active ingredient), gave some early control (up to 40%) of BGM (Table 2), and the high rate also seemed to give some control of TSM (Table 4). The combination of Capture® plus Dimethoate also seemed to give some early control of both mites (Tables 2 and 4). The season-total percentage control was low for both spider mites (Table 2 and 4). The percentage of the population that was TSM did not differ meaningfully between the Capture® and control treatments (Table 5).

The two rates of Fanfare® (bifenthrin active ingredient) gave some early control of BSM (up to 40%) (Table 2), but little control of TSM (Table 4). The season-total percentage control was a little higher than it was for Capture® (Table 2 and 4), but there was too much variation in the performance of the two bifenthrin treatments to determine if there were any meaningful differences among them.

The two Onager® combinations gave reasonable BGM control, 38 to 85% from 7 to 21 DAT (Table 2). The season total BGM control was 47 to 51% (Table 2). The Onager® plus Capture® treatment seemed to have some impact (24 to 39%) on the TSM populations (Table 4). But these treatments seemed to have little impact on season-total control, (3 to 47%) (Table 2 and 4), and the control for the season total for both spider mites was 14 to 20% (Table 6). It was not clear if there was a meaningful increase in the percentage of TSM in the Onager®-treated plots (Table 5).

The two formulations of Oberon® gave excellent BGM control, 53 to 89% out to 14 DAT (Table 2). The season-total BGM control was 50 to74% (Table 2). For some odd reason, the Oberon® 480EC treatment seemed to fade at 22 DAT. These treatments seemed to have some impact on the TSM, on the samples through 22 DAT (3 to 76%) (Table 4), and the season-total control for both spider mites was 20 to 23% (Table 6). There was no clear indication of a difference in performance of the two Oberon® formulations.

Predator mite populations increased from 0.3 to 35.0 per 2 plants during the growing season (Table 6). During this time, the spider mite populations increased from 34 to 1215 mites per 2 plants (Table 6). This was the only predator population that seemed to increase as spider mite populations increased. The predator mite numbers were significantly smaller for all the treatments at 14 DAT (Table 6). Thrips populations, *Frankliniella* spp., decreased from 2.1 to 0.6 per 2 plants during the sampling period. They were sampled during the post-tassel period, when thrips numbers are usually smaller than they are during the early to mid-whorl stages. In the past, these thrips seemed to be important early-season facultative predators of spider mites. The spider mite populations generally increase rapidly during the corn reproductive stage, when the thrips populations are low. Sixspotted thrips, *Scolothrip* spp., were present, but populations decreased from 0.17 to 0.00 per 2 plants during the sampling period. These thrips are reported to be important predators of the spider mites, but we have recorded them only infrequently. Both thrips populations were too low to determine if there were differences in their responses to the miticide treatments.

There were no significant differences in yields among the treatments, even though the CV was only 8%. None of the treatments were good enough to protect enough yield to be detected in this trial.

Table 1. Banks grass mites per 4 half plants (=2 plants) in plots treated with miticides* Southwest Research - Extension Center, Garden City, Kansas, 2005.

			BGM/4 half-plants [a]					
No.	Treatment	Rate	July 25 Pre-treat.	Aug. 8 7 days	Aug. 15 14 days	Aug. 23 22 days	Sept. 8 38 days	Season total
1	Check	—	*26*	240	44	12 b-e	22 ab	417
2	Capture 2EC	0.08 lb	*13*	123	40	40 a-d	96 a	439
3	Capture 2EC	0.1 lb	*36*	157	32	61 ab	21 ab	373
4	Capture 2EC	0.08 lb						
	Dimethoate 400EC	0.5 lb	*55*	137	57	101 a	3 b	419
5	Onager 1E	6 oz						
	Capture 2EC	0.08 lb	*63*	104	20	5 de	15 ab	248
6	Onager 1E	6 oz						
	Dimethoate 400EC	0.5 lb	*38*	57	7	8 cde	95 a	239
7	Fanfare 2EC	0.08 lb	*22*	81	61	25 a-e	0 b	207
8	Fanfare 2EC	0.1 lb	*20*	110	41	49 abc	0 b	229
9	Oberon 240EC	8.5 oz						
	COC	1%	*22*	26	14	3 e	2 b	106
10	Oberon 480EC	4.25 oz						
	COC	1%	*21*	35	20	13 b-e	88 a	199
	F-test P value		0.0413	0.1347	0.2950	0.0190	0.0244	0.1236

*Treatments made August 1, 2005, when the corn was soft dough stage.
[a] Means followed by the same letter are not significantly different (P < 0.05, LSD)

Table 2. Percentage control of Banks grass mites in plots treated with miticides*, Southwest Research - Extension Center, Garden City, Kansas, 2005.

			Percentage control for BGM					
No.	Treatment	Rate	July 25 Pre-treat.	Aug. 8 7 days	Aug. 15 14 days	Aug. 23 22 days	Sept. 8 38 days	Season total
1	Check	—	—	—	—	—	—	—
2	Capture 2EC	0.08 lb	—	40	0	0	0	0
3	Capture 2EC	0.1 lb	—	39	33	0	11	17
4	Capture 2EC	0.08 lb						
	Dimethoate 400EC	0.5 lb	—	52	0	0	87	15
5	Onager 1E	6 oz						
	Capture 2EC	0.08 lb	—	65	64	67	46	51
6	Onager 1E	6 oz						
	Dimethoate 400EC	0.5 lb	—	78	85	38	0	47
7	Fanfare 2EC	0.08 lb	—	65	0	0	100	48
8	Fanfare 2EC	0.1 lb	—	51	0	0	99	42
9	Oberon 240EC	8.5 oz						
	COC	1%	—	89	67	73	90	74
10	Oberon 480EC	4.25 oz						
	COC	1%	—	85	53	0	0	50

*Treatments made Aug. 1, 2005, when the corn was soft dough stage.

Table 3. Twospotted spider mites per 4 half plants (=2 plants) in plots treated with miticides*, Southwest Research - Extension Center, Garden City, Kansas, 2005.

			TSM/4 half-plants [a]					
No.	Treatment	Rate	July 25 Pre-treat.	Aug. 8 7 days	Aug. 15 14 days	Aug. 23 22 days	Sept. 8 38 days	Season total
1	Check	—	2	13	21	97	628	798
2	Capture 2EC	0.08 lb	1	12	30	130	740	953
3	Capture 2EC	0.1 lb	2	0	25	27	682	759
4	Capture 2EC	0.08 lb						
	Dimethoate 400EC	0.5 lb	4	13	27	51	707	828
5	Onager 1E	6 oz						
	Capture 2EC	0.08 lb	2	9	12	56	612	721
6	Onager 1E	6 oz						
	Dimethoate 400EC	0.5 lb	4	19	36	101	619	803
7	Fanfare 2EC	0.08 lb	1	20	33	65	713	882
8	Fanfare 2EC	0.1 lb	1	14	20	49	757	851
9	Oberon 240EC	8.5 oz						
	COC	1%	1	4	15	66	731	823
10	Oberon 480EC	4.25 oz						
	COC	1%	2	3	13	73	657	774
	F-test P value		0.9544	0.2728	0.6861	0.2501	0.9847	0.9817

*Treatments made Auguest 1, 2005, when the corn was soft dough stage.
[a] Means followed by the same letter are not significantly different (P < 0.05, LSD)

Table 4. Percentage control of twospotted spider mites in plots treated with miticides*, Southwest Research - Extension Center, Garden City, Kansas, 2005.

			Percentage control for TSM [a]					
No.	Treatment	Rate	July 25 Pre-treat.	Aug. 8 7 days	Aug. 15 14 days	Aug. 23 22 days	Sept. 8 38 days	Season total
1	Check	—	—	—	—	—	—	—
2	Capture 2EC	0.08 lb	—	0	0	0	0	0
3	Capture 2EC	0.1 lb	—	97	0	71	0	0
4	Capture 2EC	0.08 lb						
	Dimethoate 400EC	0.5 lb	—	10	0	54	0	8
5	Onager 1E	6 oz						
	Capture 2EC	0.08 lb	—	24	39	37	0	3
6	Onager 1E	6 oz						
	Dimethoate 400EC	0.5 lb	—	0	0	10	15	13
7	Fanfare 2EC	0.08 lb	—	0	0	25	0	0
8	Fanfare 2EC	0.1 lb	—	0	0	34	0	0
9	Oberon 240EC	8.5 oz						
	COC	1%	—	61	3	10	0	0
10	Oberon 480EC	4.25 oz						
	COC	1%	—	76	38	25	0	3

*Treatments made August 1, 2005, when the corn was soft dough stage.

Table 5. Percentage of spider mites, in plots treated with miticides*, that are twospotted spider mites, Southwest Research - Extension Center, Garden City, Kansas, 2005.

			Percent population TSM					
No.	Treatment	Rate	July 25 Pre-treat.	Aug. 8 7 days	Aug. 15 14 days	Aug. 23 22 days	Sept. 8 38 days	Season total
1	Check	—	7	5	32	89	97	66
2	Capture 2EC	0.08 lb	7	9	43	76	89	68
3	Capture 2EC	0.1 lb	4	0	44	30	97	67
4	Capture 2EC	0.08 lb						
	Dimethoate 400EC	0.5 lb	6	9	32	33	100	66
5	Onager 1E	6 oz						
	Capture 2EC	0.08 lb	2	8	37	92	98	74
6	Onager 1E	6 oz						
	Dimethoate 400EC	0.5 lb	9	25	83	92	87	77
7	Fanfare 2EC	0.08 lb	5	20	35	72	100	81
8	Fanfare 2EC	0.1 lb	3	11	32	50	100	79
9	Oberon 240EC	8.5 oz						
	COC	1%	3	13	52	95	100	89
10	Oberon 480EC	4.25 oz						
	COC	1%	9	8	40	84	88	80
	Mean		6	11	43	72	95	75

*Treatments made August 1, 2005, when the corn was soft dough stage.

Table 6. Numbers of predator mites, season total numbers of spider mites, and grain yield for plots treated with miticides*, SWREC, Garden City, Kansas, 2005.

			Predator mites/4 half-plants [a]			Spider mites /4 half-plants [a] Season Totals				Grain yield [a]
No.	Treatment	Rate	July 25 Pretreat	Aug. 15 14 days	Sept. 8 38 days	BGM	TSM	Sum	% Control	Bu/acre
1	Check	—	0.3	35.0 a	20.5	417	798	1215	—	162.6
2	Capture 2EC	0.08 lb	0.0	11.8 bc	22.5	439	953	1392	0	171.5
3	Capture 2EC	0.1 lb	0.3	11.3 bc	14.0	373	759	1132	7	165.8
4	Capture 2EC	0.08 lb								
	Dimethoate 400EC	0.5 lb	0.0	15.5 bc	26.3	419	828	1247	0	180.4
5	Onager 1E	6 oz								
	Capture 2EC	0.08 lb	0.5	8.8 bc	17.3	248	721	969	20	167.4
6	Onager 1E	6 oz								
	Dimethoate 400EC	0.5 lb	0.5	10.5 bc	37.8	239	803	1042	14	173.9
7	Fanfare 2EC	0.08 lb	1.0	23.3 ab	13.0	207	882	1089	10	163.0
8	Fanfare 2EC	0.1 lb	1.3	6.8 c	36.8	229	851	1080	11	172.2
9	Oberon 240EC	8.5 oz								
	COC	1%	0.0	6.8 c	12.3	106	823	929	23	160.7
10	Oberon 480EC	4.25 oz								
	COC	1%	0.3	7.3 c	19.0	199	774	973	20	164.1
	F-test P value		—	0.0227	0.4326	0.1236	0.9817	—	—	<0.5000

*Treatments made August 1, 2005, when the corn was soft dough stage.
[a] Means followed by the same letter are not significantly different ($P < 0.05$, LSD)

ACKNOWLEDGEMENTS

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

Donations:
BASF Corp.
Bayer Chemical
Cropland Coop, Inc.
DeKalb Genetics Corp.
Farm Co, Inc.
Monsanto Co.
Mycogen Seeds
Nelson Irrigation
Northrup King
Pioneer Hi-Bred Intl.
Shelboure Reynolds Inc
Syngenta
Triumph Seed
United Prairie Ag

Grant Support:
Aventis CropScience
BASF Corp.
Bayer CropScience
Dow AgroSciences
DuPont Ag Products
Fluid Fertilizer Foundation
FMC Corp.
Gowan
Helena Chemical Company
Kansas Dept. of Wildlife & Parks
Kansas Livestock Association
Kumiai Chemical Industry Co., Ltd.
Monsanto Co.
National Crop Insurance Services
RSA Microtech
Syngenta
Potash & Phosphate Institute
Kansas Corn Commission
Kansas Fertilizer Research Fund
Kansas Grain Sorghum Commission
Kansas Soybean Commission
Kansas Water Resources Institute
Sipcam Agro USA Inc.
USDA/ARS
USDA/Ogallala Initiative
US Department of Interior
Western Kansas Groundwater Management District # 1

Cooperators:
Garden City Farm Equipment
Mark Ramsey
Teeter Irrigation
United Prairie Ag

Performance Tests:
ABI Garst/Agripro
Agripro/Garst
AgriPro Seeds, Inc.
AGSECO Inc.
Asgrow Seed Co.
Arrow
Cal/West
Croplan Genetics
Dairyland Seeds
DeKalb
Drussel Seed & Supply
Dyna-Gro
Ehmke Seed
Farmer Direct
Fielder's Choice
Fontanelle
Forage Genetics
Frontier
Garst Seed Co.
General Mills
Golden Acres
Golden Harvest
Golden World
Great Plains Research Co.
HPH
Hytest
LG Seeds
Midland Seeds
Midwest Seed Genetics, Inc.
Mycogen Seeds
NC+ Hybrids
Northrup King
Ottilie
PGI
Phillips
Pioneer Hi-Bred Intl.
Producers
Rinck
Sharp Bros. Seed Company
Simplot
Sorghum Partners
Star Seed
Stine Seed Farms
Trical
Triumph Seed Co., Inc.
Watley
WestBred
W-L Research
Z-Public

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Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Manhattan 66506

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