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Southwest Research–Extension Center

Report of Progress
927

Kansas State University
Agricultural Experiment Station
and Cooperative Extension Service

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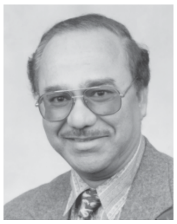
Paul Hartman—Area Extension Director, Paul received his B.S. and M.S. in Animal Sciences and Industry from Kansas State University. Prior to that, he served as County Extension Agricultural Agent in Stanton and Pratt counties.



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Jeff Elliott—Research Farm Manager. Jeff received his B.S. from the University of Nebraska. In 1984, Jeff began work as an Animal Caretaker III and was promoted to Research Farm Manager in 1989.

IN MEMORIAM
ANDREW B. ERHART

Andrew B. Erhart, 93, passed to a better life January 5th, 2004, after a long battle with Parkinson's and Alzheimer's diseases. Born November 14, 1910, in Adrian, Mo., he moved with his parents, Andrew James Erhart and Lillie Conard Erhart, to Ness City, Kansas, when he was two years old. He graduated as the honor graduate from Lansing High School and then from Kansas State College (now University) in 1933 with a bachelor's degree in Agronomy. He was a member of several honor fraternities, including Phi Kappa Phi, Gamma Sigma Delta, and Alpha Zeta.

After graduation he worked for the State of Kansas as a Research Assistant at the Tribune Experiment Station for two years, and in 1934 was assigned to Syracuse as the Hamilton County Agricultural Agent. It was during his time at Syracuse that he met Bessie Evelyn Bray where he rented a room in her parents' house. She was also hired by his office to do part-time secretarial work while she was a senior in high school. They were married September 15, 1934. After about two years in Syracuse, he was transferred to Meade, where he was Superintendent of the Southwest Kansas Experimental Fields. Following a ten-year tenure at Meade, he was transferred to the Hays Experiment Station, where he spent two years as a Soils Scientist.

In 1948, the family was transferred one last time, to Garden City, when he was appointed Superintendent of the Garden City Agricultural Experiment Station. In 1976, he reached the mandatory retirement age for State of Kansas employees and left the Experiment Station to work for Henkle Drilling and Supply Company until 1998 as an agricultural advisor. During his time at Henkle Drilling, he was able to add a Helicopter Pilot rating to his FAA Airplane Pilot license. He was provided a helicopter by Henkle that he used to assist farmers in observing their farm land and in obtaining repair parts and necessary items for Henkle drilling crews in a quick and efficient manner.

While in Garden City, he had a daily radio program in which he gave updates on agricultural items of interest. These programs lasted for forty years until the Parkinson's disease finally affected his voice and ability to get around. Each year for 17 years he wrote a small booklet, "A Thought For Each Day", using some of the short comments he gathered for use during his radio broadcasts. These booklets were sponsored by Henkle Drilling and were used as gifts to their friends and customers. He also consolidated many of these "thoughts" into a hardback book that was published and sold in book stores. During his lifetime, he was a member of Kiwanis Club, Rotary Club, Western Dairy Herd Improvement Association, Kansas Brown Swiss Breeders Association, the Garden City Board of Education, the Garden City Community College Trustees, Kansas State University Alumni Association, the First United Methodist Church Board of Trustees, and was an Honorary FFA State Farmer.

He is survived by his wife of 69 years, Bessie, of Garden City, three sons; Ron and wife Ann of Duncanville, Texas; Dennis and wife Vicki of Santa Fe, New Mexico; and Dana of Terrebonne, Oregon. He was blessed with eight grandchildren and seven great-grandchildren. He is also survived by a brother, Delbert and wife June of Lawrence, Kansas; a sister, Juanita of Oklahoma City, and several nephews and nieces. He was preceded in death by his parents, three brothers and two sisters.

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Contribution 04-330-S from the Kansas Agricultural Experiment Station.

WEATHER INFORMATION FOR GARDEN CITY

by
Jeff Elliott

Precipitation in 2003 totaled 17.72 inches, about an inch below the 30-year average. No precipitation was recorded in January or October. Combined precipitation for the months October and November totaled only 0.03 inches. Snowfall measured 20.2 inches, 2.5 inches above normal. Notable snowfall events included 6 inches on February 23 and 5 inches on March 1.

As expected, July was the warmest month, with a mean temperature of 81.7 ºF. This was 4.3 degrees above the 30-year average. February was the coldest month, with an average mean temperature of 30.7 ºF compared with 33.7 ºF on average. The annual mean temperature for 2003 was 54.5 ºF, above the 30-year average for the sixth consecutive year.

The only day with a below-zero temperature was February 24th, at minus 5 ºF. No record lows were set or tied in 2003. Triple-digit temperatures were recorded on 26 days in 2003, sixteen of which occurred in July. The highest temperature recorded in 2003 was 108 ºF on July 15. Record highs were set or tied on January 28 (72 ºF); March 15 (85 ºF); April 3 (89ºF), 14 (91ºF), and 15 (93 ºF); May 30 (101 ºF); August 19 (103 ºF); and six consecutive days starting October 19, recording 94, 95, 93, 93, 88, and 92 degrees, respectively.

The all-time temperature extremes recorded at the Research Center are -22 ºF, recorded in January of 1984, and 111 ºF in July of 1913 and 1934. It is interesting to note that, during the four years since January 1, 2000, we have seen 33 new record high temperatures, but only 6 new record lows were recorded during the same period.

The last spring freeze (24 degrees) was on April 10, sixteen days earlier than normal. The first fall freeze (32 degrees) was on October 17, six days later than normal. This resulted in a frost-free-period of 190 days, 23 days longer than normal and the longest since 1962.

Open-pan evaporation for the months of April through October totaled 74.3 inches, compared with 70.6 inches in an average year. Mean wind speed was 4.55 mph, which is below the 30-year average of 5.25 mph.

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

	Precipitation inches		Temperature (ºF) 2003 Average		Mean		2003 Extreme		Wind MPH		Evaporation inches	
Month	2003	Avg.	Max.	Min.	2003	Avg.	Max.	Min.	2003	Avg.	2003	Avg.
January	0.00	0.43	49.0	18.7	33.9	28.4	76	9	3.53	4.68		
February	1.20	0.48	45.4	16.0	30.7	33.7	80	-5	4.05	5.39		
March	1.68	1.38	55.9	29.1	42.5	42.3	85	9	5.30	6.72		
April	2.49	1.65	70.2	38.5	54.3	52.1	93	23	6.13	6.73	9.04	8.35
May	2.96	3.39	76.8	49.0	62.9	62.0	101	36	4.93	6.04	9.51	9.93
June	3.90	2.88	82.9	57.6	70.2	72.4	100	43	4.10	5.59	10.25	12.32
July	0.59	2.59	98.4	65.1	81.7	77.4	108	58	4.79	4.85	16.11	13.41
August3.11	2.56	93.8	64.6	79.2	75.5	106	57	4.53	4.17	13.36	11.19	
September	1.32	1.25	80.6	49.6	65.1	67.0	95	34	4.70	4.63	9.07	8.88
October	0.00	0.91	76.1	41.8	59.0	54.9	95	22	3.99	4.84	6.95	6.52
November	0.03	0.86	52.5	26.6	39.6	40.5	75	6	4.23	4.86		
December	0.44	0.41	50.5	19.2	34.9	31.3	72	3	4.28	4.47		
Annual	**17.72**	**18.79**	**69.3**	**39.7**	**54.5**	**53.1**	**108**	**-5**	**4.55**	**5.25**	**74.29**	**70.60**

Average latest freeze in spring	April 26	2003:	April 10
Average earliest freeze in fall	October 11	2003:	October 17
Average frost-free period	167 days	2003:	190 days

All averages are for the period 1971-2000.

WEATHER INFORMATION FOR TRIBUNE

by
Dewayne Bond and Dale Nolan

Precipitation in 2003 was 1.35" below normal, for a yearly total of 16.09", with 8 months having below-normal precipitation. June was the wettest month, with 6.25". The largest single amount of precipitation was 2.07" on May 16. October was the driest month, with 0.03" of precipitation. Snowfall for the year totaled 15.1"; 1.4" in January, 8.1" in February, 0.2" in March, 2.3" in April, 0.3" in November and 2.8" in December, for a total of fourteen days snow cover. The longest consecutive period of snow cover, seven days, occurred from February 23 to March 1.

Record high temperatures were recorded on nine days: February 2 (77 °F); March 15 (84 °F); October 19 (92 °F); 20 (94 °F); 22 (91 °F); 23 (88 °F); 24 90 °F and 30, 91 °F; and November 21, 76 °F. January 9, (75 °F); August 8 (105°); and September 24 (94°); all tied records set in previous years. No record low temperatures were set this year. The hottest days of the year were July 26 and August 8, both 105 °F. July was the warmest month, with a mean temperature of 80.1 °F and an average high of 97.3 °F. The coldest days of the year were February 24 and 25, both 0 °F. February was the coldest month of the year, with a mean temperature of 30.8 °F and an average low of 16.7 °F.

For nine months, the air temperature was above normal. January and June had the greatest departures from normal, 6.5 °F above and 2.5 °F below, respectively. There were 18 days of 100 °F or above temperatures, eight days more than normal. There were 71 days of 90 °F or above temperatures, nine days more than normal. The last day of 32 °F or less in the spring on April 21 was fifteen days earlier than the normal date, and the first day of 32 ° F or less in the fall on October 1 was two days earlier than the normal date. This produced a frost-free period of 163 days, thirteen days more than the normal of 150 days.

April through September open-pan evaporation totaled 71.75 inches, 1.10 inches more than normal. Wind speed for the same period averaged 5.2 mph, 0.3 mph less than normal.

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

	Precipitation inches		Temperature (°F) 2003 Average		Normal		2003 Extreme		Wind MPH		Evaporation inches	
Month	2003	Normal	Max.	Min.	Max.	Min.	Max.	Min.	2003	Avg.	2003	Avg.
January	0.07	0.45	49.2	18.7	42.2	12.8	75	7				
February	0.73	0.52	44.9	16.7	48.5	17.1	77	0				
March	1.19	1.22	57.2	27.5	56.2	24.2	84	9				
April	1.44	1.29	68.3	37.5	65.7	33.0	90	24	6.3	6.3	8.99	8.28
May	3.35	2.76	74.8	47.5	74.5	44.1	101	36	4.9	5.8	9.46	10.88
June	6.25	2.62	80.8	55.5	86.4	54.9	97	42	4.7	5.3	10.44	13.88
July	0.60	3.10	97.3	62.9	92.1	59.8	105	56	5.7	5.4	18.43	15.50
August	1.08	2.09	94.1	60.9	89.9	58.4	105	50	4.6	5.0	14.74	12.48
September	0.92	1.31	80.7	48.4	81.9	48.4	97	33	4.9	5.2	9.69	9.63
October	0.03	1.08	76.1	39.0	70.0	35.1	94	16				
November	0.22	0.63	52.3	25.1	53.3	23.1	76	4				
December	0.21	0.37	51.1	18.1	44.4	15.1	69	9				
Annual	**16.09**	**17.44**	**69.1**	**38.3**	**67.1**	**35.5**	**105**	**0**	**5.2**	**5.5**	**71.75**	**70.65**

Average latest freeze in spring[1]	May 6	2002:	April 21
Average earliest freeze in fall	October 3	2002:	October 1
Average frost-free period	150 days	2002:	163 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.

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HISTORICAL WEATHER HIGHLIGHT OF GARDEN CITY, KANSAS

by
Merle Witt

SUMMARY

Features of the weather commonly initiate conversation. This brief historical review of Garden City's weather during the past century will remind us of some of the climatic variety we've come to expect.

INTRODUCTION

Probably no event was more suddenly devastating than the tornado on June 23, 1967. Long-term droughts of the 1930s and 1950s remain grim benchmarks of unmatched comparison. The 1957 blizzard in late March will long be recalled for its massive destruction. Yet, each year, we continue to challenge previous records for heat, cold, droughts, snow, downpours, evaporation, or wind.

Weather data for Garden City from 1898 to current are available from the KSU Weather Data Library by contacting Mary Knapp. Some of the frequently requested features are noted here.

PRECIPITATION

Our annual precipitation each year during 1898-2003 is shown in Figure 1. During the period shown, the wettest year was 1923, with 36.19". This was more than 5 times as much precipitation as occurred during the driest year recorded, 1956, with 5.68" of moisture. Note that the 10-year average dropped to a mere 14" in 1939 at the end of the extremely dry "dirty thirties". Rainfall was favorable during the period from 1898 through 1923, and this no doubt attracted many people to the area. A great number of dry years from 1924 through 1939, and again from 1952 through 1961, highlighted the advantage of irrigation, which was readily available in some parts of the area.

The average annual precipitation has been 18.90 during this 106-year period. Fortunately, 75% of a year's total precipitation typically falls during the summer months when moisture is most needed by crops. But moisture remains sporadic and unpredictable. The driest 6-month period ever was during 1956, with less than a half inch. Twice we have gone 3 months with absolutely zero moisture. (Table 1).

The wettest month ever, June, 1951, provided 9.65". There have been 4 entire years (1934, 1935, 1937, 1956) that had less rainfall than this one record-setting month. The six-month growing-season precipitation, April-September, averages 13.9".

Table 1. Wettest and driest periods, Garden City, Kan.

Record Wet Periods		Inches
Wettest year	1923	36.19
Wettest 6 months	May – Oct., 1923	30.94
Wettest Month	June, 1951	9.65
Record Dry Periods		
Driest year	1956	5.68
Driest 6 months	Sept. 1956 – Feb. 1957	0.49
Driest 3 months	Dec. 1922 – Feb. 1923	0.00
	Jan. 1951 – June 1951	0.00

We often think of August as hot and dry. We sometimes suppose that it is our driest month. But August is the fourth-highest rainfall month, with 2.36", and the highest monthly minimum precipitation occurs in August. Note in Table 2 that all months except three have recorded zero moisture: May (0.13" minimum), July (0.06" minimum), and August (0.30" minimum). The driest month of the year, on average, is January, with only 0.41". The wettest month, on average, is June, with 3.01".

Snow, in an average year, provides nearly 18" in depth, and contributes about 2.5" of moisture to each year's total precipitation. The greatest amount of snow to fall in any one month was 34" in February of 1903.

Figure 1. Annual Precipation, Garden City, Kansas.

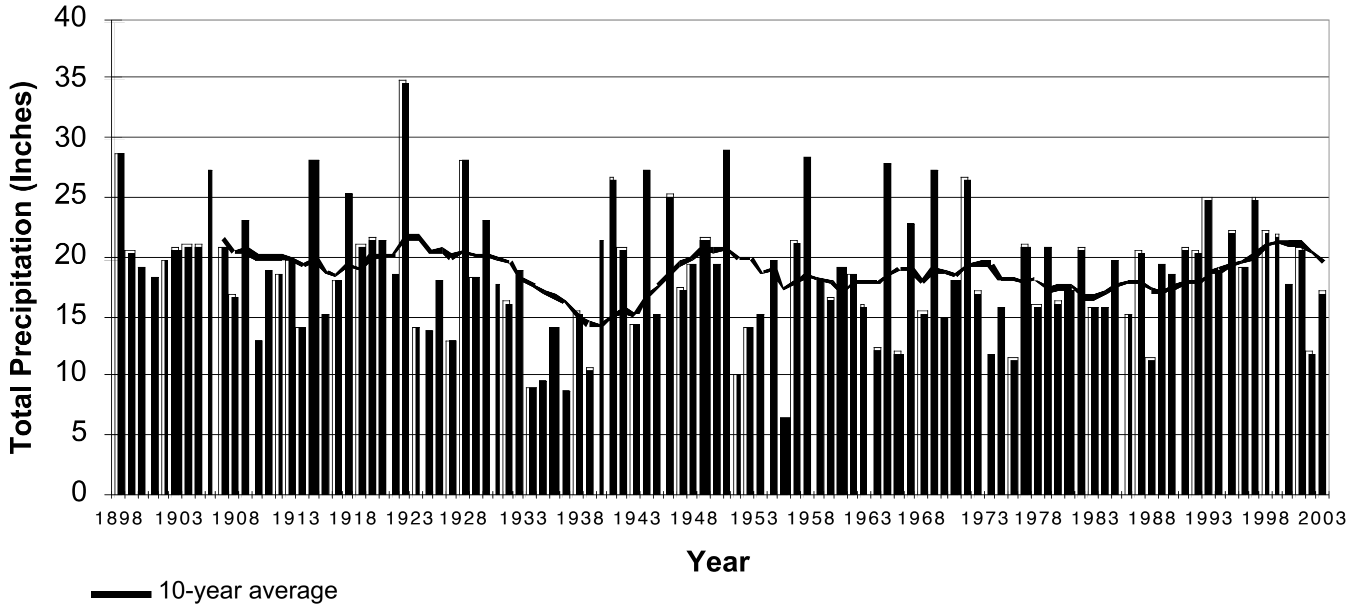

Table 2. Weather summary, 1898-2003, Garden City, Kansas.

Month	Precipitation (inches) Avg.	Wettest Ever	Driest Ever	Air Temperature (°F) Avg.	Hottest Ever	Coldest Ever	Range
January	0.41	2.18	0	30.0	77	-22	99
February	0.66	4.45	0	34.2	88	-17	105
March	1.13	5.35	0	42.2	93	-6	99
April	1.76	6.03	0	52.7	100	13	87
May	2.92	8.49	0.13	63.1	106	25	76
June	3.01	9.65	0	73.1	110	40	70
July	2.64	8.12	0.06	78.5	111	46	65
August	2.36	7.68	0.30	77.0	109	46	63
September	1.63	5.63	0	68.4	105	26	79
October	1.18	6.49	0	56.0	97	13	84
November	0.74	3.93	0	41.8	91	-5	96
December	0.51	4.60	0	32.2	83	-17	100
Annual	18.90	36.19 (1923)	5.68 (1956)	54.1	59.1 (1934)	51.0 (1993)	8.1

TEMPERATURE

In no month has the average minimum daily temperature been below zero, but the lowest average on record was 4.4 degrees during February 1899. January, 1912, had the greatest number of days when the temperature was zero or below. It had a total of 13 such days; January, 1930, and February, 1899, were next, with 12 days each.

On only 3 very cold days has the temperature failed to rise above zero. These were January 6, 1912, when the high was -2 degrees, and February 11, 1899, and January 7, 1912, when the temperature only climbed to zero. As noted in Table 2, the coldest month of the year is January, with a 30-degree average. The record coldest temperature is shown in Table 3 as -22 degrees on January 19, 1984.

The warmest month of the year is July, with a 78.5-degree average. The all time highest average daily maximum temperature for any month was 102 degrees in July of 1934.

Temperatures during the winter are more extreme than those during the summer (see Table 2). The widest temperature range month is February, with a spread of 105 degrees (-17 to 88). August has the least range of any month, with a spread of merely 63 degrees (46 to 109).

OTHER

We can be thankful that Garden City did not host the raging thunderstorm that pounded southeastern Kansas in 1970. It left a monster trophy for folks there – and the meteorological record books. The largest hailstone ever recorded in the United States fell in Kansas on Coffeyville on September 3, 1970. It weighed 1.7 pounds, had a diameter of 5.7 inches, with a circumference of 17.5 inches, and a model of it resides here at the Southwest Research – Extension Center. It seems fortunate to have missed out on this fame, upon realizing that western Kansas gets hailed on 10 times more often than does eastern Kansas.

Discussion of the weather is likely to continue, due to its untamed nature.

Table 3. Hottest and coldest periods, Garden City, Kansas.

Record Hot Periods		Record
Hottest Year	1934	59.1 degrees
Hottest Day	July 13, 1934	111 degrees
Year with most 100-degree days	1934	47 days
Record Cold Periods		
Coldest Year	1993	51.0 degrees
Coldest Day	January 14, 1984	-22 degrees
Year with most below zero days	1917-1918	19 days
Frost-Free Average Period = 169 Days		
Average last spring freeze	April 16	
Record earliest final spring freeze	April 2, 1930	
Record latest spring freeze	May 26, 1950	
Average first fall freeze	October 12	
Record earliest fall freeze	September 20, 1934	
Record latest fall freeze	November 2, 1950	

LAND APPLICATIONS OF ANIMAL WASTE FOR IRRIGATED CORN[1]

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

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 wastes (effluent water from a lagoon) and cattle wastes (solid manure from a beef feedlot) have been applied annually since 1999 at rates to meet corn P or N requirements, and at a rate double the N requirement. Other treatments were N fertilizer (60, 120, or 180 lb N/a) and an untreated control. Corn yields were increased by application of animal wastes and N fertilizer. Grain yields were 12 bu/a greater after application of cattle manure than after swine effluent. Over-application of animal wastes did not adversely affect corn yield.

INTRODUCTION

This study was initiated in 1999 to determine the effects 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/a. The allowable P application rates for the P-based treatments were 105 lb P_2O_5/a 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 contents after harvest in 2001 and 2002 were sufficient to eliminate the need for additional N. So no swine effluent was applied to the 1xN treatment in 2002 or 2003 or to the 2xN 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 gallons 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/a), along with an untreated control. 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 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 and 2000 and sprinkler irrigation in 2001 through 2003. The soil is a Ulysses silt loam. Corn was planted at about 33,000 seeds/a in late April or early May each year. Grain yields are not reported for 1999 because of severe hail damage. Hail also damaged the 2002 crop. The center four rows of each plot were machine harvested after physiological maturity, and yields were adjusted to 15.5% moisture.

[1] Project supported in part by Kansas Fertilizer Research Fund and Kansas Dept. of Health and Environment.
[2]Department of Agronomy, Kansas State University, Manhattan.

Table 1. Application rates of animal wastes, Tribune, Kansas, 1999 to 2003.

Application basis*	Cattle manure					Swine effluent				
	ton/a					1000 gal/a				
	1999	2000	2001	2002	2003	1999	2000	2001	2002	2003
P requirement	15.0	4.1	6.6	5.8	8.8	28.0	75.0	62.0	63.4	66.9
N requirement	15.0	6.6	11.3	11.4	0	28.0	9.4	38.0	0	0
2XN requirement	30.0	13.2	22.6	22.8	0	56.0	18.8	76.0	0	0

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

The N and P content of the animal wastes are shown in Table 2. The animal wastes have been collected from the same swine facility and cattle feedlot each year. The nutrient concentrations differed from year to year; reduced P concentrations were notable in 2003.

RESULTS AND DISCUSSION

Corn yields were increased by animal waste and N fertilizer applications, except in 2002, in which yields were greatly reduced by hail damage (Table 3). The type of animal waste affected yields in 2 of the 4 years, with better yields from cattle manure than from swine effluent. Averaged across the 4 years and all application rates, corn yields were 12 bu/a greater after application of cattle manure than after swine effluent. Over-application (2xN) of animal wastes did not reduce grain yields, and yields were similar for all rates of application.

Table 2. Analysis of animal waste as applied, Tribune, Kansas, 1999 to 2003.

Nutrient content	Cattle manure					Swine effluent				
	lb/ton					lb/1000 gal				
	1999	2000	2001	2002	2003	1999	2000	2001	2002	2003
Total N	27.2	36.0	33.9	25.0	28.2	8.65	7.33	7.83	11.62	7.58
Total P_2O_5	29.9	19.6	28.6	19.9	14.6	1.55	2.09	2.51	1.60	0.99

Table 3. Effect of animal waste and N fertilizer on irrigated corn, Tribune, Kansas, 2000-2003.

		Grain yield				
Nutrient source	Rate†	2000	2001	2002	2003	Mean
		bu/acre				
Cattle manure	P	197	192	91	174	164
	N	195	182	90	175	160
	2 X N	195	185	92	181	163
Swine effluent	P	189	162	74	168	148
	N	194	178	72	167	153
	2 X N	181	174	71	171	149
N fertilizer	60 N	178	149	82	161	142
	120 N	186	173	76	170	151
	180 N	184	172	78	175	152
Control	0	158	113	87	97	114
$LSD_{0.05}$		22	20	17	22	13
ANOVA						
Treatment		0.034	0.001	0.072	0.001	0.001
Selected contrasts						
Control vs. treatment		0.001	0.001	0.310	0.001	0.001
Manure vs. fertilizer		0.089	0.006	0.498	0.470	0.019
Cattle vs. swine		0.220	0.009	0.001	0.218	0.002
Cattle 1x vs. 2x		0.900	0.831	0.831	0.608	0.669
Swine 1x vs. 2x		0.237	0.633	0.875	0.730	0.535
N rate linear		0.591	0.024	0.639	0.203	0.122
N rate quadratic		0.602	0.161	0.614	0.806	0.469

†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.

FOUR-YEAR CROP ROTATIONS WITH WHEAT AND GRAIN SORGHUM

by
Alan Schlegel, Troy Dumler, and Curtis Thompson

SUMMARY

Grain yield of continuous wheat averaged 78% of the yield of wheat grown in a four-year rotation following sorghum. Except for 2003, there has been no difference in yield of continuous wheat and the second wheat crop 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. Recrop sorghum in a WSSF rotation averaged 70% yield of the first crop.

PROCEDURES

Research on four-year 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.

RESULTS AND DISCUSSION

Wheat yields in 2003 were similar for all rotations except for the second wheat crop in the WWSF rotation, which yielded twice as much as the other rotations (Table 1). This was surprising; in the previous years of the study, the yield of the recrop wheat never exceeded the first wheat crop in the WWSF rotation. Possibly, this occurred because the previous crop in the rotation (wheat 2002) never produced grain, whereas the wheat in the other 4-year rotations was following sorghum (2001), which did produce grain. In essence, the second wheat crop in the WWSF rotation in 2003 was following a longer fallow period than usual, even though it was very dry for most of the fallow. The continuous-wheat yields may have been limited by competition from winter annual grasses. Averaged across the 7 years of the study, continuous wheat yielded 78% of the first wheat crop in the four-year rotations.

Sorghum yields in 2003 were near the long-term average for each rotation (Table 2). The recrop sorghum averages about 70% of the yield of the first sorghum crop following wheat. Although variable from year to year, there was no difference in average yield of sorghum that followed one or two wheat crops.

Table 1. Wheat response to rotation, Tribune, Kansas, 1997 through 2003.

Rotation	1997	1998	1999	2000	2001	2002	2003	Mean
	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - - bu/acre	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - -
WHEAT-sorghum-sorghum-fallow	57	70	74	46	22	0	29	43
WHEAT-wheat-sorghum-fallow	55	64	80	35	29	0	27	42
wheat-WHEAT-sorghum-fallow	48	63	41	18	27	0	66	38
Continuous WHEAT	43	60	43	18	34	0	30	33
LSD $_{0.05}$	8	12	14	10	14	—	14	4

Note: Capital letters denote current-year crop.

Table 2. Grain sorghum response to rotation, Tribune, Kansas, 1996 through 2003.

Rotation	1996	1997	1998	1999	2000	2001	2002	2003	Mean
	- bu/acre -								
wheat-SORGHUM-sorghum-fallow	58	88	117	99	63	68	0	60	69
wheat-sorghum-SORGHUM-fallow	35	45	100	74	23	66	0	41	48
wheat-wheat-SORGHUM-fallow	54	80	109	90	67	73	0	76	69
$LSD_{0.05}$	24	13	12	11	16	18	—	18	4

Note: Capital letters denote current-year crop.

NITROGEN AND PHOSPHORUS FERTILIZATION 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 or P applied alone increased yields about 50 or 13 bu/a, respectively; when N and P were applied together, however, yields increased more than 65 bu/a. Averaged across the past 10 years, sorghum yields were increased more than 50 bu/a by N and P fertilization. Application of 40 lb N/a (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/a without P and K; with 40 lb P_2O_5/a and zero K; and with 40 lb P_2O_5/a and 40 lb K_2O/a. All fertilizers were broadcast by hand in the spring and incorporated before planting. Sorghum (Mycogen TE Y-75 from 1992 through 1996, Pioneer 8414 in 1997, and Pioneer 8500/8505 from 1998 through 2003) 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 in 2003 were higher than the 10-year average (Table 1). Nitrogen alone increased yields up to 51 bu/a; P alone increased yields 13 bu/a. Nitrogen and P applied together increased sorghum yields more than 65 bu/a. Only 40 lb N/a was required to obtain >90% of maximum yields, which was consistent with the 10-year average. Sorghum yields were not affected by K fertilization, which has been true throughout the study period.

Table 1. Irrigated Sorghum Fertility. Effect of N, P, and K fertilizers on yields of irrigated sorghum, Tribune, Kansas, 1994-2003*.

N	P_2O_5	K_2O	1994*	1996	1997	1998	1999	2000	2001	2002	2003	Mean
- - - - - lb/acre - - - - -			- bu/acre -									
0	0	0	64	74	81	77	74	77	76	73	80	75
0	40	0	82	77	75	77	85	87	81	81	93	82
0	40	40	78	79	83	76	84	83	83	82	93	82
40	0	0	76	74	104	91	83	88	92	82	92	87
40	40	0	113	100	114	118	117	116	124	120	140	119
40	40	40	112	101	121	114	114	114	119	121	140	118
80	0	0	96	73	100	111	94	97	110	97	108	99
80	40	0	123	103	121	125	113	116	138	127	139	123
80	40	40	131	103	130	130	123	120	134	131	149	128
120	0	0	91	79	91	102	76	82	98	86	97	89
120	40	0	131	94	124	125	102	116	134	132	135	122
120	40	40	133	99	128	128	105	118	135	127	132	123
160	0	0	105	85	118	118	100	96	118	116	122	109
160	40	0	137	92	116	131	116	118	141	137	146	127
160	40	40	125	91	119	124	107	115	136	133	135	121
200	0	0	114	86	107	121	113	104	132	113	131	114
200	40	0	133	109	126	133	110	114	139	136	132	126
200	40	40	130	95	115	130	120	120	142	143	145	127
ANOVA (P>F)												
Nitrogen			0.001	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear			0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic			0.001	0.116	0.001	0.001	0.227	0.001	0.001	0.001	0.001	0.001
P-K			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Zero P vs. P			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
P vs. P-K			0.734	0.727	0.436	0.649	0.741	0.803	0.619	0.920	0.694	0.955
N x P-K			0.797	0.185	0.045	0.186	0.482	0.061	0.058	0.030	0.008	0.029
MEANS												
Nitrogen	0 lb/a		75	77	80	76	81	82	80	79	88	80
	40		100	92	113	108	105	106	112	108	124	108
	80		117	93	117	122	110	111	127	119	132	117
	120		118	91	114	118	95	105	122	115	121	112
	160		122	89	118	124	108	110	132	129	134	119
	200		126	97	116	128	115	113	138	131	136	123
	$LSD_{0.05}$		14	9	10	8	13	7	8	9	10	7
P_2O_5-K_2O	0 lb/a		91	79	100	103	90	91	104	94	105	96
	40- 0		120	96	113	118	107	111	126	122	131	117
	40-40		118	95	116	117	109	112	125	123	132	117
	$LSD_{0.05}$		10	7	7	6	9	5	6	6	7	5

* Note: There was no yield data for 1995 due to early freeze damage.

IRRIGATED CORN RESPONSE TO N AND P FERTILIZATION

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 2003, N or P applied alone increased yields about 60 or 15 bu/a, respectively; when N and P were applied together, however, yields increased by as much as 120 bu/a. Averaged across the past 10 years, corn yields were increased more than 100 bu/a by N and P fertilization. Application of 80 lb N/a (with P) was sufficient to produce >90% of maximum yield in 2003; this was less than the 10-year average of 120 lb N/a. Phosphorus increased corn yields by as much as 70 bu/a when applied with at least 120 lb N/a. Increasing P application from 40 to 80 lb P_2O_5/a increased yields by 4 to 7 bu/a when applied with at least 120 lb N/a.

INTRODUCTION

This study was initiated in 1961 to determine responses of continuous corn and grain sorghum grown under flood irrigation to N, P, and K fertilization. The study was conducted on a Ulysses silt loam soil with an inherently high K content. 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 was 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/a without P and K; with 40 lb P_2O_5/a and zero K; and with 40 lb P_2O_5/a and 40 lb K_2O/a. In 1992, the treatments were changed, with the K variable being replaced by a higher rate of P (80 lb P_2O_5/a). All fertilizers were broadcast by hand in the spring and incorporated before planting. The corn hybrids were Pioneer 3379 (1992 through 1994), Pioneer 3225 (1995 through 1997), Pioneer 3395IR (1998), Pioneer 33A14 (2000), Pioneer 33R93 (2001 and 2002), and Dekalb C60-12 (2003), planted at about 32,000 seeds/a in late April or early May. Hail damaged the 2002 crop and destroyed the 1999 crop. The corn was irrigated 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 15.5% moisture.

RESULTS AND DISCUSSION

Corn yields in 2003 were higher than the 10-year average (Table 1). Nitrogen alone increased yields up to 62 bu/a; P alone increased yields about 15 bu/a. But N and P applied together increased corn yields by as much as 120 bu/a. Only 80 lb N/a was required to obtain >90% of maximum yields, compared with the 10-year average of 120 lb N/a. Because the 2002 crop was damaged by hail, residual N may have contributed to the higher yields at lower N rates in 2003. Corn yields were 3 bu/a greater with 80 than with 40 lb P_2O_5/a, compared with the 10-year average of 5 bu/a.

Table 1. Effect of N and P fertilizers on irrigated corn. Tribune, Kansas, 1994 through 2003.

Nitrogen	P_2O_5	Grain Yield* 1994	1995	1996	1997	1998	2000	2001	2002	2003	Mean
- - - - - lb/a - - - -		- -bu/acre -									
0	0	47	22	58	66	49	131	54	39	79	60
0	40	43	27	64	79	55	152	43	43	95	67
0	80	48	26	73	83	55	153	48	44	93	69
40	0	66	34	87	86	76	150	71	47	107	80
40	40	104	68	111	111	107	195	127	69	147	115
40	80	105	65	106	114	95	202	129	76	150	116
80	0	66	34	95	130	95	149	75	53	122	91
80	40	129	94	164	153	155	205	169	81	188	149
80	80	127	93	159	155	149	211	182	84	186	150
120	0	70	39	97	105	92	143	56	50	122	86
120	40	147	100	185	173	180	204	177	78	194	160
120	80	154	111	183	162	179	224	191	85	200	165
160	0	78	44	103	108	101	154	76	50	127	93
160	40	162	103	185	169	186	203	186	80	190	163
160	80	167	100	195	187	185	214	188	85	197	169
200	0	80	62	110	110	130	165	130	67	141	110
200	40	171	106	180	185	188	207	177	79	197	166
200	80	174	109	190	193	197	218	194	95	201	174
ANOVA											
Nitrogen		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
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	0.001	0.001	0.007	0.001	0.001
N x P		0.001	0.001	0.001	0.001	0.001	0.008	0.001	0.133	0.001	0.001
MEANS											
Nitrogen	0 lb/a	46	25	65	76	53	145	48	42	89	66
	40	92	56	102	104	93	182	109	64	135	104
	80	107	74	139	146	133	188	142	73	165	130
	120	124	83	155	147	150	190	142	71	172	137
	160	136	82	161	155	157	190	150	71	172	142
	200	142	92	160	163	172	197	167	80	180	150
	$LSD_{0.05}$	13	7	10	12	11	10	15	8	9	6
P_2O_5	0 lb/a	68	39	92	101	91	149	77	51	116	87
	40	126	83	148	145	145	194	147	72	168	136
	80	129	84	151	149	143	204	155	78	171	141
	$LSD_{0.05}$	9	5	7	9	7	7	10	6	6	4

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

NO-TILL LIMITED-IRRIGATION CROPPING SYSTEMS[1]

by

Alan Schlegel, Troy Dumler, and Loyd Stone

SUMMARY

Research was initiated under sprinkler irrigation to evaluate limited irrigation in a no-till crop rotation. In comparing rotations with limited irrigation (10 inches annually), continuous corn was slightly more profitable than multi-year rotations including wheat, sorghum, and soybean.

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 while 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 crop and are limited to 1.5 inches/week. Soil water is measured at planting, during the growing season, and at harvest, in one-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, whereas more water is applied to corn than wheat in the corn-wheat rotation. The irrigation amounts are 15 inches for corn in 2, 3, and 4-yr rotations, 10 inches for grain sorghum and soybean, and 5 inches for wheat.

RESULTS AND DISCUSSION

Soil water at sorghum harvest in 2002 was much less than for soybean or corn (Table 1). Soil-water recharge over the winter before corn planting in 2003 was 3 inches or less for all crops.

Table 1. Soil water at previous harvest and at corn planting in 2003.

Rotation	Previous harvest 2002	Corn planting 2003
	inches of water in 8-ft profile	
continuous corn	9.70	11.79
corn-wheat	6.12	9.13
corn-wheat-sorghum	3.73	5.28
corn-wheat-sorghum-soybean	8.45	9.70

The wheat in all rotations received 5 inches of irrigation and followed corn. Wheat yields tended to be greater as the length of the rotation increased, but the differences were not significant (Table 2). All rotations were limited to 10 inches of annual irrigation, but the corn following wheat received 15 inches inasmuch as the wheat only received 5 inches. This extra 5 inches of irrigation increased corn yields about 45 bu/a compared with the continuous corn (which only received 10 inches of irrigation). Results of a companion study with several irrigation amounts indicated that additional irrigation would not have been beneficial for sorghum or soybeans in 2003.

[1]This research project has received support from the Kansas Corn Commission, Kansas Grain Sorghum Commission, and Kansas Soybean Commission.

Table 2. Grain yield of four crops as affected by rotation in 2003.

Rotation	Corn	Wheat	Sorghum	Soybean
	- - - - - - - - - - - - - - - - -	bu/acre	- - - - - - - - - - - - - - -	
continuous corn	157	—	—	—
corn-wheat	205	50	—	—
corn-wheat-sorghum	202	52	119	—
corn-wheat-sorghum-soybean	195	55	120	47

An economic analysis was performed to determine returns to land, irrigation equipment, and management for all four rotations. The difference in returns from the four rotations was only $35/a. The most profitable rotation in 2003 was continuous corn, with a return of $154/a. The least profitable rotation was a 3-yr rotation of corn/wheat/sorghum, with a return of $119/a. The 2- and 4-yr rotations had similar returns of $131 to 135/a.

EFFECT OF TILLAGE INTENSITY IN A WHEAT-SORGHUM-FALLOW ROTATION

by
Alan Schlegel, Curtis Thompson, and Troy Dumler

SUMMARY

Grain yields of wheat and grain sorghum increased with decreased tillage intensity in a wheat-sorghum-fallow (WSF) rotation. In 2003, yield of no-till (NT) wheat was 8 bu/acre greater than conventional-till (CT) wheat and 15 bu/acre greater than reduced-till (RT) wheat. Averaged across the past 13 years, NT wheat yields were 3 bu/acre greater than RT and 8 bu/acre greater than CT wheat. Grain sorghum yields in 2003 were 30 bu/acre greater for NT than for either RT or CT. Averaged across the past 13 years, NT sorghum yields were 10 bu/acre greater than RT sorghum and 31 bu/acre greater than CT sorghum.

PROCEDURES

Research on different tillage intensities in a WSF rotation at the K-State Southwest Research-Extension Center at Tribune was initiated in 1991. The three tillage intensities are CT, RT, and NT. The CT treatment 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 or field cultivator. The RT treatment used a combination of herbicides (1 to 2 spray operations) and tillage (2 to 3 tillage operations) to control weed growth during the fallow period. In 2001, the RT treatment was a combination of NT from wheat harvest through sorghum planting and CT from sorghum harvest to wheat planting. The NT treatment used only herbicides to control weed growth during the fallow period. All tillage systems used herbicides for in-crop weed control.

RESULTS AND DISCUSSION

Conservation tillage increased wheat yields (Table 1). On average across the 13 years since 1991, wheat yields were 8 bu/a greater for NT (40 bu/acre) than for CT (32 bu/acre). Wheat yields for RT were 5 bu/a greater than CT. In contrast, wheat yields were less for RT than CT in 2003 (15 vs. 22 bu/acre).

The yield benefit from reduced tillage was greater for grain sorghum than for wheat. Grain sorghum yields for RT averaged 21 bu/acre more than CT, while NT averaged 10 bu/acre more than RT (Table 2). In 2003, sorghum yields were 30 bu/acre greater for NT than for either RT or CT.

Table 1. Wheat response to tillage in a wheat-sorghum-fallow rotation, Tribune, Kansas, 1991-2003.

Tillage	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Mean
							bu/acre							
Conventional	16	26	43	48	49	16	34	52	76	20	17	0	22	32
Reduced	14	14	55	48	51	25	42	68	77	32	40	0	15	37
No-till	15	21	58	46	56	26	52	64	83	44	31	0	30	40
LSD $_{0.05}$	6	10	4	7	7	9	17	9	7	6	8	—	7	2

Table 2. Grain sorghum response to tillage in a wheat-sorghum-fallow rotation, Tribune, Kansas, 1991-2003.

Tillage	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Mean
	- - - - - - - - -	- - - - - - - - - - - - - - bu/acre -												
Conventional	23	38	47	20	37	97	71	87	19	13	6	0	7	36
Reduced	39	41	83	38	54	117	94	105	88	37	43	0	7	57
No-till	39	27	68	57	59	119	115	131	99	51	64	0	37	67
LSD $_{0.05}$	18	15	11	9	5	12	33	37	10	6	7	—	8	4

EFFECT OF NITROGEN ON EARLY-SEASON GROWTH AND N UPTAKE BY DRYLAND CORN[1]

by
Alan Schlegel, Curtis Thompson, Troy Dumler, Roger Stockton[2], Dale Leikam[3], and Brian Olson[4]

SUMMARY

Dryland corn acreage in western Kansas rapidly increased during the past decade. The majority of dryland corn is grown by using no-tillage practices to optimize water conservation. But there is limited information available on N management for no-till dryland corn. The objectives of this research are to determine the impact of N fertilizer placement and time of application on N utilization by no-till dryland corn in western Kansas. The N treatments were a factorial of application methods, time of application, and N rates. The methods of application were surface broadcast, surface dribble, and sub-surface injection. The times of application were early pre-plant and pre-emergence after planting. The N rates were 0, 30, 60, 90, and 120 lb N/acre from a 28% urea ammonium nitrate (UAN) solution. Increasing N rates increased early season growth and N uptake. Early pre-plant application of N produced greater early growth at 50% of the sites, with a trend toward greater growth at the other sites. Time of N application had little effect on N uptake. Broadcast N applications produced greater early-season growth than injected N at two sites; at the other sites there was no difference in plant growth attributable to application method. Placement of UAN had no consistent effect on N uptake.

INTRODUCTION

Dryland corn acreage in western Kansas rapidly increased during the past decade. The majority of dryland corn is grown by using no-tillage practices to optimize water conservation. But there is limited information available on N management for no-till crop production in western Kansas, with no current information for dryland corn. Increased surface-residue cover in no-till systems has been shown to impact N utilization from surface N fertilizer applications. Therefore, N fertilizer recommendations may need to be adjusted to optimize no-till dryland corn production. Injection of N fertilizer below the residue layer is one means for avoiding the problems caused by plant residue reducing N utilization. But this requires a separate operation and precludes applying fluid N fertilizer with herbicides in a surface broadcast application. A one-pass application reduces application costs and labor requirements, but may also reduce N fertilizer effectiveness. The overall objectives of this project are to determine the impact of N fertilizer placement and time of application on N utilization by no-till dryland corn in western Kansas.

PROCEDURES

Study sites were established in the spring of 2003 at five locations (data shown from four sites) in west-central and northwestern Kansas (Figure 1). The Greeley-county site is at the Tribune Unit, SWREC, and the Thomas-county location is at the NWREC near Colby. The other three sites are on farmer cooperator fields in Wallace, Rawlins, and Norton counties. At all sites, dryland corn was no-till planted into standing wheat stubble. The N treatments were a factorial of applications methods, time of application, and N rates, with four replications at each site.

The three methods of application were surface broadcast, surface dribble, and sub-surface injection. The times of application were early pre-plant (March 31 to April 3) and pre-emergence after planting (May 8 to May 27). The N rates were 0, 30, 60, 90, and 120 lb N/acre. Fluid N [28% N as UAN solution] was the N source. A coulter injection fertilizer unit was used

[1]Project supported by Kansas Fertilizer Research Fund and Fluid Fertilizer Foundation.
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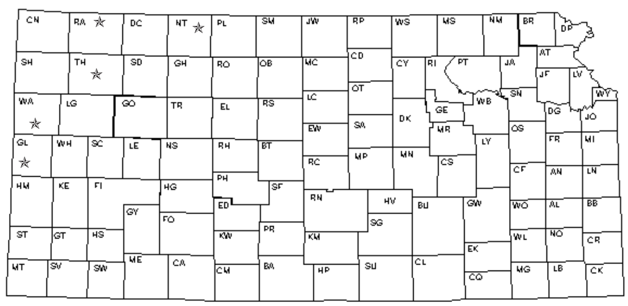
[3]Department of Agronomy, Kansas State University, Manhattan.
[4]Multicounty Extension Agronomist.

to place the N fertilizer below the soil surface on 15-inch centers for the injection treatments. The dribble applications were made using the same coulter applicator operated with the coulters about 11 inches above the soil surface. A 10-ft spray boom with 4 spray tips at 30-inch spacing was mounted on the back of the coulter injection unit to apply the broadcast treatments. Plot size was 10 (4-30” rows) by 40 ft (35 ft at the Thomas County location because of space limitations).

Figure 1. Sites for N management of dryland corn in 2003.



Site selection was based on cooperator interest and residual soil N amounts. Sites with the potential for yield response from N fertilizer were selected. At all sites, soil samples in one-ft increments to six ft were taken after corn planting and were analyzed for inorganic N, soil water, and bulk density. Surface soil samples (0 to 6 in.) were taken after planting and were analyzed for pH, soil test P, and organic-matter content. Surface residue amounts were also determined after planting. Whole-plant samples at about the 6-leaf stage were collected, dried, weighed, and analyzed for N content. Dry conditions during July and August severely reduced grain production, and there were no yield differences among treatments (data not shown).

RESULTS

Early-season growth of no-till dryland corn was increased 18 to 41% by increasing N rates, compared with the control (Table 2). Nitrogen uptake was increased by 40 to 133% by increased N rates.

Table 1. Selected soil chemical properties and surface residue at planting at 5 sites in western Kansas.

	Soil (0-6”)		Soil P (0-6”)			Soil N (0-24”)			Residue
Site (County)	pH	OM	Bray -1	Olsen P	Mehlich P	NO_3	NH_4	Total	at planting
		%	- - - - ppm -		- - -	- - - - - - ppm - - - - - -			lb/acre
Atwood (Rawlins)	6.5	2.3	36	36	19	3.90	4.35	8.25	3376
Colby (Thomas)	7.1	1.8	28	54	24	5.70	4.25	9.95	2287
Norcatur (Norton)	6.7	1.9	24	22	14	1.70	4.25	5.95	4356
Sharon Springs (Wallace)	8.3	1.8	3	9	13	4.40	3.95	8.35	4465
Tribune (Greeley)	7.8	1.5	30	36	16	7.90	5.55	13.45	2940

Table 2. Effect of N rate on early growth and N uptake of dryland corn in western Kansas, 2003.

	Biomass @ 6-leaf stage				N uptake			
N rate	Greeley	Norton	Thomas	Wallace	Greeley	Norton	Thomas	Wallace
Lb/a	- - - - - - - - - -lb/a - - - - - - - - -				- - - - - - - - - - lb/a - - - - - - - - - -			
0	338	698	341	131	10	13	11	3
30	349	864	374	159	11	18	14	5
60	381	873	431	183	13	22	17	6
90	369	911	427	178	13	27	17	6
120	400	980	435	182	14	31	17	6
$LSD_{0.05}$	51	147	38	21	2	4	2	1

Early pre-plant application of N produced greater early growth than pre-emergence applications at 50% of the sites, with a trend toward greater growth at the other sites (Table 3). Time of N application had little effect on N uptake, with only one site showing greater uptake (~13%) from early preplant application versus at planting.

Broadcast N applications produced greater early-season growth than injected N at two sites; at the other sites there was no difference in plant growth attributable to application method. The effect of placement on N uptake was inconsistent, with one site showing greater uptake from inject than broadcast and two sites showing better uptake from broadcast than injection. In all instances, the difference in N uptake between application methods was less than 20%.

Table 3. Effect of time of application on early growth and N uptake of dryland corn in western Kansas, 2003.

Time of	Biomass @ 6-leaf stage				N uptake			
Application	Greeley	Norton	Thomas	Wallace	Greeley	Norton	Thomas	Wallace
	- - - - - - - - - -lb/a - - - - - - - - -				- - - - - - - - - - lb/a - - - - - - - - - -			
Early preplant	387	982	439	180	13	26	17	6
Pre-emergence	363	832	394	170	13	23	15	6
$LSD_{0.05}$	36	104	27	15	2	3	1	1

Table 4. Effect of method of application on early growth and N uptake of dryland corn in western Kansas, 2003.

Method of	Biomass @ 6-leaf stage				N uptake			
Application	Greeley	Norton	Thomas	Wallace	Greeley	Norton	Thomas	Wallace
	- - - - - - - - - - - -lb/a - - - - - - - - - - -				- - - - - - - - - - - lb/a - - - - - - - - - -			
Broadcast	383	907	441	190	13	24	17	6
Dribble	388	863	418	181	13	23	16	6
Injection	355	951	391	156	12	27	15	5
$LSD_{0.05}$	44	127	33	18	2	4	1	1

LIMITED IRRIGATION WITH NO-TILL CROPPING SYSTEMS[1]

by
Alan Schlegel, Troy Dumler, and Loyd Stone

SUMMARY

Research was initiated under sprinkler irrigation to evaluate limited irrigation in a no-till crop rotation. In 2003, corn yields were doubled when irrigation was increased from 5 to 10 inches, sunflower yields increased 75%, soybean yields increased 56%, and sorghum yields increased 15%. Further increasing irrigation amounts to 15 inches increased corn yields another 11% but had essentially no effect on yields of the other crops. With 5 inches of irrigation, soybean and sorghum were the more profitable crops. When irrigation was increased to 10 inches, corn and soybean were the more profitable crops, and corn was the most profitable crop at 15 inches, the highest 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 while other cultural practices (hybrid selection, fertility practices, weed control, etc.) are selected to optimize production. All water treatments are present each year and are replicated four times. Irrigations are scheduled to supply water at the most critical stress periods for the specific crop and are limited to 1.5 inches/week. Soil water is measured at planting, during the growing season, and at harvest in one-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

Planting dates in 2003 were corn on April 30, soybean on May 12, sorghum on May 29, and sunflower on June 10. Soil water at planting (Table 1) was greater for sorghum and sunflower, which corresponded to the greater amounts of water at 2002 harvest of sunflower and corn (previous crops in the rotation). Except for sorghum, soil water at planting was similar for the 10- and 15-inch irrigation treatments, which again corresponded to the previous harvest amounts.

Table 1. Soil water at planting of four crops in 2003 as affected by irrigation amount.

Irrigation amount	Corn	Sorghum	Soybean	Sunflower
inches	- - - - - - - inches of water in 8-ft profile - - - - - -			
5	6.59	7.66	4.07	6.63
10	7.44	9.95	6.15	11.78
15	7.56	12.40	5.96	11.28

[1]This research project has received support from the Kansas Corn Commission, Kansas Grain Sorghum Commission, and Kansas Soybean Commission.

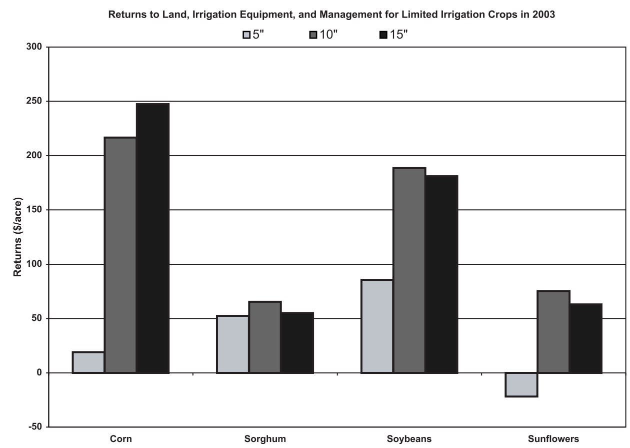
Crop production was much better in 2003 than in 2002. There was some hail damage in nod-June, but the crops recovered fairly well. Precipitation from May through August was 14.19 inches (34% above normal). Irrigation was started on June 26 for the 15-inch irrigation amounts for all crops. Grain yields of all crops were greater with 10 inches than with 5 inches of irrigation (Table 2). But there was little further increase in yields of soybean, sorghum, or sunflower with additional irrigation, although corn yields were 20 bu/a greater with 15 inches than with 10 inches of irrigation.

Table 2. Grain yield of four crops in 2003 as affected by irrigation amount.

Irrigation amount	Corn	Sorghum	Soybean	Sunflower
inches	----------bu/acre		-----------	lb/acre
5	91	104	32	1545
10	186	120	50	2704
15	206	122	51	2723

An economic analysis using current prices and costs showed that corn in 2003 was the most profitable (return to land, irrigation equipment, and management) crop with 15 inches of irrigation (Figure 1). With 10 inches of irrigation, corn was slightly more profitable than soybean. Sorghum and soybean were the more profitable crops with 5 inches of irrigation. For all crops, profitability increased when irrigation was increased from 5 to 10 inches. But only corn responded positively to more than 10 inches of irrigation.

Figure 1. Economic returns to four limited-irrigation crops in 2003.



EFFECT OF TILLAGE ON SOIL WATER RECHARGE AND CROP PRODUCTION[1]

by

Alan Schlegel, Rob Aiken[2], and Loyd Stone

SUMMARY

The impact of deep tillage (chisel plow or paratill) on soil water recharge during fallow (wheat harvest to sunflower planting) was compared with shallow tillage (sweep plow) or no tillage. Averaged across 6 site-years, soil water recharge tended to be slightly less with deep tillage than with surface tillage or no-till, but the differences were less than an inch (4.1, 4.5, 5.0, and 4.9 inches for chisel plow, paratill, sweep plow, and no-till, respectively). Sunflower yields were adversely affected by dry growing conditions and differed widely among site-years. Averaged across 4 site-years, sunflower yields were highest with no-till (922 lb/a), followed by paratill (841 lb/a), sweep plow (810 lb/a), and chisel plow (796 lb/a). Similarly, crop water use tended to be greater with no-till (11.7 inches) than after tillage (9.6, 9.7, and 10.2 inches for chisel plow, paratill, and sweep plow, respectively).

INTRODUCTION

Soil compaction is a topic of renewed interest for producers in Kansas. Compacted zones in soil can be caused by heavy equipment traffic on wet soils (e.g., combine or grain cart) and extend below normal tillage depths. Compaction in the surface soil, commonly called a tillage pan, can be caused by repeated tillage operations. Deep tillage is often recommended to alleviate compaction. But there is little information on the impact of deep tillage on soil water storage and subsequent crop production. The objectives of this research were to evaluate the effect of several tillage tools on soil water storage and crop production.

PROCEDURES

The study was initiated after wheat harvest in 2001. Four tillage practices (chisel, paratill, sweep plow, and no-till) were initiated after wheat harvest at three locations (Northern Sun, Inc. site west of Goodland and at the K-State Research-Extension Centers near Colby and Tribune). At Tribune, tillage depth was about 4 inches for sweep plow, 8 inches for chisel, and 12 inches for paratill. At Colby and Goodland, tillage depth was about 14 inches for chisel and paratill and 4 inches for sweep plow. Soil water was measured after tillage in the spring, at sunflower emergence, and in the fall at harvest. Crop water use was calculated as the total of precipitation and the change in soil water during the growing season. Yields for 2002 are reported for the Colby site only; drought resulted in crop failure at Tribune, and drought, aggravated by poor stands, resulted in crop failure at Goodland. Sunflower yields for 2003 are reported for all sites.

RESULTS AND DISCUSSION

2002 CROP SEASON

Soil water recharge was less for the chisel-plow treatment at both Colby (4-ft profile) and Goodland (10-ft profile), whereas paratill had the least recharge at Tribune. Recharge was greatest for paratill at the Goodland and Colby sites, whereas recharge was greater with sweep plow at Tribune (8-ft profile). Recharge efficiency at Colby (water stored divided by accumulated precipitation) ranged from 29% to 37%, as 12.16 inches of precipitation were recorded from July 13, 2001, through June 10, 2002. In contrast, recharge efficiency at Tribune ranged from 22% for paratill to 46% for sweep plow, but precipitation during fallow was only 3.28 inches (August 21, 2001, to May 31, 2002). At Colby, available water in the 10-ft profile was 3 inches greater for no-till than for paratill at crop emergence. Soil water at harvest was similar for all tillage treatments at Colby.

Crop water use (WU) was greatest for no-till at Colby. The greater water use occurred during

[1]Project supported by High Plains Committee, National Sunflower Association.

[2]Northwest Research-Extension Center, Colby.

vegetative growth—54% greater than vegetative water use for paratill. These tillage treatments also had greatest leaf area (LAI) at flowering. Greatest yield occurred for paratill. Oil contents were similar for all tillage treatments. Low yield for chisel plow may be due to impaired root development and limited soil water depletion (0.84 inches) during seed fill, compared with paratill (1.34 inches), sweep plow (1.60 inches), and no-till (2.25 inches).

2003 CROP SEASON

Soil water recharge was greater for no-till and sweep plow at Colby (10-ft profile), but greatest for chisel plow treatment at Goodland (10-ft profile); paratill had the least recharge at Colby and Goodland. Recharge efficiency at Colby ranged from 23% to 40%, as 19.79 inches of precipitation were recorded from July 26, 2002, through July 1, 2003. Recharge efficiency at Goodland ranged from 39% to 53% as an average of 14.91 inches of precipitation was recorded at the Goodland WSO and Goodland 19SW stations from July 29, 2002, through June 11, 2003. At Colby, available water in the 10-ft profile was 2.5 inches greater for no-till than for paratill at crop emergence. Soil water at harvest was similar for all tillage treatments at Colby.

At Tribune, soil water recharge was about 1 inch greater with sweep plow or paratill than with no-till or chisel. But soil water in the profile at planting was 8.0 inches for no-till, compared with 7.0 inches for sweep plow, 6.4 inches for paratill, and 5.3 inches for chisel, reflecting the difference in previous-harvest soil water content. Recharge efficiency ranged from 25 to 31% with no differences between tillage treatments. Precipitation from July 15, 2002, to July 8, 2003, was 19.93 inches, but rainfall from July 8, 2003, to sunflower harvest (October 17, 2003) was only 2.27 inches. The abnormally dry summer increased variability while reducing sunflower yield. At harvest, there was essentially no available water left in the profile (<1 inch in 8-ft profile) for any tillage treatment.

Crop water use was greatest for no-till, at Colby. This tillage treatment also had the greatest leaf area at flowering, biomass productivity, and seed yield. Oil contents were similar for all tillage treatments at Colby. At Goodland, crop water use, biomass productivity and seed yield were greatest for chisel plow. Oil content and leaf area were similar for all tillage treatments at Goodland. At Tribune, water use was greatest for no-till and least for chisel plow. Sunflower seed yield and water use efficiency (WUE) were less with paratill than with other tillage treatments at Tribune. Full expression of tillage effects will likely require more favorable growing conditions.

Table 1. Soil water recharge, water use, and sunflower productivity in 2002.

	Soil Water Recharge (in)			Results at NWREC, Colby				
Implement	Colby	Goodland	Tribune	WU (in)	Yield (lb/a)	Oil (%)	LAI @ R 5.5	% Straight Taproots
No-Till	4.20	3.55	1.20	15.72	1340	41.0	2.15	90
Sweep plow	4.40	3.92	1.50	12.24	1292	41.6	1.99	65
Chisel plow	3.46	2.56	0.99	10.88	897	42.5	1.79	25
Paratill	4.43	4.36	0.73	11.72	1521	41.9	2.33	60

Table 2. Soil water recharge, water use, and sunflower productivity in 2003.

	Soil Water Recharge (in)			Results at NWREC, Colby			
Implement	Colby	Goodland	Tribune	WU (in)	Yield (lb/a)	Oil (%)	LAI @ R 5.5
No-Till				7.96	7.19	5.01	13.29
1247				32.8	2.38		
Sweep plow	7.27	6.48	6.16	11.41	815	32.5	1.29
Chisel plow	4.55	7.91	5.02	10.33	1028	32.4	1.85
Paratill	5.39	5.76	6.10	10.83	917	31.2	1.84

	Results at SWREC, Tribune			Results at Goodland			
Implement	WU (in)	Yield (lb/a)	WUE (lb/inch)	WU (in)	Yield (lb/a)	Oil (%)	LAI @ R 5.5
No-Till	9.58	851	91	8.25	248	35.2	0.55
Sweep plow	8.88	881	100	8.16	250	35.0	0.66
Chisel plow	7.80	812	102	9.23	448	34.7	0.74
Paratill	8.41	560	67	7.85	366	35.2	0.70

USE OF A TERMINATED WHEAT COVER CROP IN IRRIGATED CORN TO INCREASE WATER USE EFFICIENCY

by
Randall Currie and Norman Klocke

SUMMARY

A study was conducted at the Southwest Research-Extension Center near Garden City, Kansas, to determine the effects of a terminated winter wheat cover crop, when retained as a crop residue on the ground surface, on water use efficiencies (WUE) of irrigated corn. Increases in WUE ranged from 1.1 to 1.8 bu/ac-in, which were attributed to reductions in soil-water evaporation losses during the summer growing season. The advantages of terminated winter wheat during this time period offset the net loss of water required to grow the wheat from September to May, which ranged from 2.7 to 5.7 inches.

INTRODUCTION

Wheat has been used as a fall cover crop following irrigated corn for wind-erosion control and spring grazing. Multiple secondary tillage operations in the spring normally prepare the seedbed for planting and reduce the crop residue cover to low levels. This study was conducted to determine if winter wheat could be planted as a cover crop and be terminated with herbicides to carry it forward as continuing surface mulch.

The terminated wheat residue provided shading for the soil surface. Light striking a bare soil surface in most agricultural ecosystems has negative impacts. It increases non-productive energy-limited evaporation at the expense of the productive transpiration of soil water through the crop. Cover crops can limit this non-productive evaporation, but there is an opportunity cost associated with the water used to grow the cover crop. This study was initiated to help understand the impact of cover crops on winter water storage and WUE.

PROCEDURES

In October of 1997, the first location-year, 1-98 (Table 1), was established by planting the winter wheat variety Tam 107 at 90 lbs/ac in 3 of 6 plots per block. Each plot was 30 by 45 feet, and a total of 5 blocks were established. The entire plot area was irrigated with one inch of water to ensure uniform wheat emergence.

Table 1. Descriptions of locations by year of repeated treatment combinations.

Season	Location	Location-Year Index
97-98	1	1-98
98-99	1	1-99
99-00	1	1-00
98-99	2	2-99
99-00	2	2-00
00-01	2	2-01
99-00	3	3-00
00-01	3	3-01
01-02	3	3-02

The opportunity cost of growing this wheat cover crop was determined by gravimetrically measuring soil moisture to a depth of 5 feet within 7 to 18 days of wheat emergence. This procedure was repeated within 7 to 10 days of corn emergence. The water cost of growing the cover crop was determined by taking the difference between the soil water contents of the two measurement periods.

When the wheat reached boot stage, or approximately the first week in May, a 2 lb/ac application of glyphosate was applied to the entire plot area to kill the wheat and any weeds that might be present in the non-cover-crop plots.

A sethoxydim-resistant corn was planted at a density of 36,000 kernels/ac with a no-till planter. Atrazine was then applied at 0, 0.75, or 1.5 lbs/ac to produce a balanced factorial arrangement of treatments with two rates of cover and three rates of atrazine on a total of six plots in each of five blocks. A 1-inch blanket irrigation was then applied to ensure uniform corn emergence and atrazine incorporation. As was expected, based on observations during the fallow period before initiation of the experiment, no weed species other than Palmer amaranth were present in the control plots in all blocks. Therefore, the entire plot area was treated with a 0.25-lb/ac application of sethoxydim as needed to remove light and non-uniform infestations of grassy weeds. To further increase uniformity, all weeds other than Palmer amaranth were manually removed.

When the corn was approximately at the 2-to 4-leaf stage, volumetric soil water-content measurement was begun with the neutron attenuation method. Soil water was measured to a depth of 5 feet approximately every 14 days. Irrigation of corn began in the late vegetative stage, when soil moisture reached 50% of field capacity. This often occurred within 7 to 10 days of corn tasseling, which would approximate when a producer with a limited well size would begin irrigation to allow completion on a typical 160-ac field before tasseling. After that point, 1 inch of water was applied with a center-pivot sprinkler system every 6 days to simulate what a producer in this area could apply with a modest size 600-gallon-per-min well serving a 160-ac field.

Irrigation was terminated when the corn was at approximately the late dent stage. Corn was harvested, and yield was adjusted to 15.5% moisture in mid September when corn grain moisture dropped below 18%. Evapotranspiration (ET) was calculated from a water balance of irrigation applied, rainfall collected, and soil water change in the 5-ft profile during the measurement periods. Summer-season ET was summed from the bi-weekly measurement periods. WUE was calculated by dividing corn grain yields by seasonal ET of the corn crop.

To measure the impact of repeated use of these systems, the entire plot area was disked twice shortly after corn harvest, and the treatments were reapplied on the same plots for two more seasons at each of the three locations. This produced a total of 9 location-year combinations (Table 1). Location 1 began in the fall of 1997 and was repeated in fall of 1998 and 1999, producing location-years 1-98, 1-99, and 1-00, designated for the following summer seasons. Location 2 began in the fall of 1998 and was repeated in the fall of 1999 and 2000, producing location-years 2-99, 2-00, and 2-01. Location 3 began in the fall of 1999 and was repeated in fall of 2000 and 2001, producing location-years 3-00, 3-01, and 3-02.

RESULTS AND DISCUSSION

The effects of this experiment on weed control have been previously presented (see 2003 Fall Field Day, KSU Report of Progress SRP 910). In general, the cover crop reduced weed mass per acre by more than two-thirds, but this was not enough to produce economically acceptable control. The addition of atrazine masked this effect and was necessary to produce a viable crop.

Data for annual precipitation received at the official weather station nearest to the field site during the study period were used to calculate precipitation totals for the winter and summer growing seasons corresponding to the growing seasons of the winter wheat (September-April) and the corn crop (May-August), respectively. Departures from normal precipitation recorded from 1908 through 2002 were also calculated (Table 2).

Rainfall information was collected at the field site during the summer growing season and recorded as total irrigation for the growing season (Table 3). Totals of irrigation and rainfall give a partial indication of evapotranspiration or the consumptive use by crops.

Although the presence of the cover crop caused early-season crop stunting in some location-years, this stunting was highly variable and had either no effect or seemed inversely proportional to corn grain yield (Data not shown). Corn height at tassel was the most most reproducible index of injury, producing no

Table 2. Winter precipitation, summer rainfall, and annual precipitation and departures from normal from the nearest official weather station.

Year	—Sep - Apr——		— May - Aug ——		——Annual ——	
	Total	Departure	Total	Departure	Total	Departure
97-98	8.06	0.63	13.28	2.43	21.34	3.09
98-99	10.56	3.13	13.77	2.92	24.33	6.08
99-00	9.49	2.06	7.86	-2.99	17.35	-0.90
00-01	7.69	0.26	14.88	4.03	22.57	4.32
01-02	3.35	-4.08	6.67	-4.18	10.02	-8.23
Normal (1908-2002)	7.43		10.85		18.25	

Table 3. Summer growing season rainfall and irrigation at the field site.

Year	Irrigation	Rainfall	Total
1998	10.0	11.6	21.6
1999	12.0	14.6	26.6
2000	13.0	8.0	21.0
2001	11.0	16.0	27.0
2002	8.5	7.0	15.5

significant interaction across all factors. Therefore, it was possible from a statistical standpoint to average all 30 observations at all 9 locations together. Only presence of cover had any significant effect on corn height at tassel, reducing height 2.7 inches ($\pm$ 1.9 inches at a 95% confidence level). This agrees with the work of other researchers who have shown that water stress during vegetative growth of corn was not necessarily detrimental to crop yield. These researchers suggested that early water stress might result in some later conditioning of the plant to water stress.

The gain or loss in soil water during the winter growing season of the wheat crop represented the investment in water for growing the terminated cover crop that may, or may not, be recouped later through more efficient water use in the corn crop. In 4 of the 9 location-years, there was no difference in soil water accumulation in the 5-foot soil profile between the cover and no-cover plots. In 5 of the 9 location-years, the difference ranged from 2.7 to 5.7 inches (Table 4).

No-cover plots depleted soil water more than plots with terminated wheat cover during the summer growing season in 7 of 9 location-years (Table 5). The difference ranged from 1 to 3.9 inches in the 5-foot soil profile. In the single location-year (3-02) in which the trend was reversed, the crop and weeds were severely water stressed by the second-driest year in 95 years of recorded weather. The no-cover treatment consistently accumulated more soil water than the cover treatment during the winter (Table 4) and depleted it more during the summer (Table 5), except in the driest location-year, 3-02.

The cover-crop treatment never increased ET, and reduced it in 5 of 9 location-years (Table 6). The WUE in the cover crop treatments was greater than in the no-cover treatments in 6 of 9 location-years. The location-years that favored the no-cover crop treatments for WUE also favored similar trends in ET and yield (Table 7).

The gain or loss of soil water during the fall and winter months, as well as during spring crop growth, had profound effects on WUE. Growing a wheat cover crop used water that would have otherwise been available for corn growth in slightly more than half of location-years, with an opportunity cost of 2.7 to 5.7 inches. However, these winter season losses were offset by gains in summer growing season WUE produced by the cover. Cover-crop treatments lost less water to non-productive evaporation and channeled more of it through productive crop transpiration in 7 of 9 location-years. The single location-year in which the trend was reversed was 3-02, with severe water stress, as previously noted.

Less soil water at the end of the corn growing season, along with less ET, in the no-cover treatment indicated that more soil evaporation was taking place. As reported by other researchers with normal wheat stubble, the terminated cover crop residue reduced soil water evaporation and made the saved water available for transpiration, which improved WUE. The terminated wheat produced stubble that became valuable as a water savings tool to produce more grain.

Table 4. Difference in stored soil water from fall to spring in cover (+cover) and no-cover treatments (-cover).

	Location-Year								
	1-98	1-99	1-00	2-99	2-00	2-01	3-00	3-02	3-03
	in. of soil water—5 ft. of soil profile								
+ Cover	-0.19	-3.00	2.30	-0.18	0.73	2.70	-2.20	2.60	-1.90
- Cover	3.20	2.60	6.90	0.90	3.40	3.10	0.72	2.40	-2.00
LSD @ 10%	1.60	0.79	1.10	ns	1.14	ns	1.25	ns	ns

*Positive numbers indicate an accumulation of water and negative numbers indicate usage of water.

Table 5. Difference in stored soil water from spring to fall in cover (+cover) and no-cover treatments (-cover).

	Location-Year								
	1-98	1-99	1-00	2-99	2-00	2-01	3-00	3-02	3-03
	in. of soil water—5 ft. of soil profile								
+ Cover	0.12	0.04	-0.19	0.38	0.19	-2.60	-1.80	-2.60	1.30
- Cover	-2.39	-2.80	-2.53	-3.40	-0.93	-3.60	-2.40	-4.80	0.03
LSD @ 10%	0.59	0.47	0.53	1.79	0.51	0.75	ns	1.78	0.78

*Positive numbers indicate an accumulation of water and negative numbers indicate usage of water.

Table 6. Evapotranspiration for cover and no-cover treatments during the summer growing season.

	Location-Year								
	1-98	1-99	1-00	2-99	2-00	2-01	3-00	3-02	3-03
	in. during growing season								
+ Cover	20.5	21.0	17.4	24.6	17.5	19.6	18.3	16.2	24.6
- Cover	23.0	21.3	16.2	22.3	16.8	16.2	19.5	19.6	23.2
LSD @ 10%	0.71	ns	ns	1.5	0.8	1.5	ns	1.5	ns

Table 7. Water use efficiency (WUE) for cover and no-cover treatments during summer growing season.

	Location-Year								
	1-98	1-99	1-00	2-99	2-00	2-01	3-00	3-02	3-03
	bu/ac-in								
+ Cover	5.60	4.40	4.40	4.60	3.60	3.10	5.90	4.00	0.40
- Cover	4.20	5.80	3.50	3.30	2.60	1.40	8.00	2.20	0.24
LSD @ 10%	0.49	0.86	ns	0.70	0.81	0.94	0.68	1.00	ns

COMPARISON OF 40 HERBICIDE TANK MIXES FOR WEED CONTROL IN ROUND-UP READY CORN

by
Randall Currie

SUMMARY

With few exceptions, most treatments provided good control of most weeds. Notable exceptions were treatments with only single applications of glyphosate. No one treatment provided significantly better control than any other, but the amount of time and money required to apply them differed greatly. The best choice in a given situation is dependent on the opportunity cost for an individual producer.

INTRODUCTION

With the advent of glyphosate-resistant corn, the ability of a producer to remove all weeds is no longer an issue. In response to competition, most crop-protection companies deliver an excellent package of compounds to provide control equal to or better than multiple glyphosate applications. Therefore, the more critical questions are how often and when the field needs to be sprayed or how much can be spent.

PROCEDURES

Palmer amaranth, yellow foxtail, crabgrass, sunflower, barnyard grass, and shattercane were seeded at rates of 700,000; 344,124; 9,800,000; 40,000; 817,000; and 119,0000 seeds/acre, respectively, into prepared fields on May 14, 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, soil temperature was 82F, and soil moisture was good.

The field was conventionally tilled and bedded for furrow irrigation in the fall. Dekalb DK-6019 RR corn was planted 1.5 inches deep in 30-inch rows at a rate of 36,000 seeds/acre with a John Deere Max Emerge II, 6-row planter. Soil temperature at planting was 73F. Corn was combine-harvested, and yields were adjusted to 15.5%.

RESULTS AND DISCUSSION

Although weed control was rated by individual species, and subtle differences were detected among them, information has been consolidated across all broadleaf weeds and all grassy weeds so the data is further averaged across all multiple-rating dates for the whole season to give an index of the number and duration of weeds present. Any treatment with a rating of less than 8.4 did not provide grass control superior to the best treatment. Treatments rated from 8.4 to 10.34 were superior to no treatment (Table 1).

All treatments provided significant broadleaf weed control compared with the untreated plots. No significant difference was seen between the best broadleaf treatment and any other treatment, with the exception of a single application of Touchdown. Although few statistical differences were seen, the reader is advised to also use judgment in interpretation of this data.

All treatments except a single application of Weather Max provided statistically superior yield to the untreated control. There was no statistical difference between the best yielding treatment and any other treatment, with the exception of treatments 8, 16, and 27.

No one treatment provided significantly better control than any other treatment, but the amount of time and money required to apply the treatments differed greatly. The most suitable choice of treatment in a given situation is, therefore, dependent on the opportunity cost for an individual producer.

Table1. Season-long index of grass and broadleaf weed control and their impact on corn grain yield.

	Treatment	Rate(lbs ai/a)	Application Timing	Weed Index* Grass	Weed Index* Broadleaf	Yield bu/a
1	Touchdown	0.75	Epost	7	31	172
2	Touchdown + AMS / Touchdown + AMS	0.75, 1.67 / 0.562, 1.67	Epost/Lpost	6	15	171
3	Dual II Magnum / Touchdown + AMS	0.943 / 0.75, 1.67	Pre/Post	5	25	183
4	Bicep II Magnum / Touchdown + AMS	2.25 / 0.75, 1.67	Pre/Post	4	1	175
5	Bicep Lite II Magnum / Touchdown + AMS	2.25 / 0.75, 1.67%	Pre/Post	3	1	189
6	Lumax	2.46	Pre	6	5	182
7	Bicep Lite II Magnum	2.25	Pre	7	14	182
8	Camix	1.84	Pre	5	37	154
9	Camix + Princep 4L	1.84, 1.0	Pre	8	31	190
10	Dual II Magnum / Callisto + Aatrex 4L + COC + UAN 28%	1.59 / 0.094, 0.50, 1%, 2.5%	Pre/Post	6	17	174
11	Bicep Lite II Magnum / Callisto + Aatrex 4L + COC + UAN 28%	2.25 / 0.094, 0.25, 1%, 2.5%	Pre/Post	7	6	181
12	Bicep II Magnum / Callisto + Aatrex 4L + COC + UAN 28%	2.89 / 0.094, 0.25, 1%, 2.5%	Pre/Post	3	0	179
13	A12453-F Syngenta + AMS	3.66, 2.5	Pre	12	28	165
14	A12453-Syngenta + AMS	4.56, 2.5	Pre	10	4	194
15	Fieldmaster + AMS	4.25, 2.5	Pre	8	4	167
16	Roundup Weathermax + AMS	0.75, 2.5	Pre	14	45	99
17	A12453-Syngenta	3.03	Epost	10	25	194
18	A12453-Syngenta	3.66	Epost	11	31	178
19	Fieldmaster	4.25	Epost	11	51	175
20	Roundup Weathermax + AMS	0.75, 2.5	Epost	8	31	179
21	Roundup Weathermax + AMS / Roundup Weathermax + AMS	0.75, 2.5 / 0.563, 2.5	Pre/Epost	11	13	178
22	Outlook / Glyphos + Clarity +AMS	0.84 / 0.50, 0.25, 2.5	Pre/Post	4	14	174
23	AE F130360 01 + Distinct + MSO +UAN 28%	0.066, 0.069, 0.937%, 2.5%	Epost	16	23	187
24	AE F130360 01 + Callisto + MSO + UAN 28%	0.066, 0.047, 0.937%, 2.5%	Epost	10	29	169
25	AE F130360 01 +Aatrex 4L + MSO +UAN 28%	0.066, 0.047, 0.937%, 2.5%	Epost	19	24	191
26	AE F130360 01 + Aatrex 4L +Callisto +MSO + UAN 28%	0.066, 1.0, 0.047, 0.937, 2.5%	Epost	11	22	177
27	Steadfast + Callisto + COC + UAN 28%	0.035, 0.047, 1.25%, 2.5%	Epost	7	55	162
28	Guardsman Max / Distinct + NIS +AMS	0.035 / 0.047, 1.25%, 2.5%	Pre/Post	8	2	184
29	Harness Xtra + Balance Pro	2.8, .0375	Pre	9	6	178
30	Define + Aatrex 4L	0.525, 1.5	Pre	3	8	184
31	Define SC + Aatrex 4L	0.525, 1.5	Pre	13	9	177

(continued)

Table 1. (cont.) Season-long index of grass and broadleaf weed control and their impact on corn grain yield.

	Treatment	Rate(lbs ai/a)	Application Timing	Weed Index*		Yield
				Grass	Broadleaf	bu/a
32	Balance Pro + Define + Aatrex 4L	0.0375, 0.45, 1.25	Pre	4	10	146
33	Balance Pro + Define SC + Aatrex 4L	0.0375, 0.45, 1.25	Pre	5	3	173
34	Bicep II Magnum	2.89	Pre	7	5	180
35	Outlook / Distinct + NIS + AMS	0.84 / 0.191, 0.25%, 1.0	Pre/Post	5	6	187
36	Guardsman Max / Glyphos + Clarity + AMS	2.19 / 0.5, 0.25, 2.5	Pre/Post	4	2	181
37	Guardsman Max + Balance Pro	2.5, 0.031	Pre	6	2	187
38	Outlook + Aatrex 4L / Marksman + AMS	0.84, 1.0 / 0.8, 2.5	Pre/Epost	8	1	173
39	Prowl H2O + Aatrex 4L / Guardsman Max Lite	1.19, 1.25 / 1.56	Pre/Epost	3	2	171
40	Guardsman Max Lite / Prowl H2O + Aatrex 4L	1.56 / 1.19, 1.25	Pre/Epost	11	2	201
41	Check			16	80.3	79.2
	LSD (0.05)			6	19	38

* Number of broadleaf weed present averaged over species and rating date for the whole season .

WATER SAVINGS FROM CROP RESIDUES IN IRRIGATED SOYBEANS[1]

by
Norman Klocke and Troy Dumler

SUMMARY

Soybean producers who use irrigation in western Kansas continue to plant in 30-inch rows. This practice allows for the use of row-crop headers at harvest and reduces shattering losses from the lack of humidity in the area. The wide row spacing and later ground coverage, compared with crop management practices in drilled beans, reduces the advantages of evaporation suppression by crop canopy. Crop residues resulting from no-till management in wide spaced rows could overcome this disadvantage.

Soybean growers who irrigate face restrictions in available water, either from smaller well capacities or from water allocations. Water savings, even a few inches, can convert into yield increases. Research has shown that each inch of water captured or saved in the root zone can potentially be transformed through evapotranspiration into soybean yield, at a rate of 4 bushels for each acre-inch of water saved.

Evapotranspiration is a two-part process. Transpiration, or water consumed by the crop, is the positive part of the process that relates directly to grain yield. Evaporation, or water directly vaporizing into the air from the soil, can be reduced without reducing crop yield.

Reducing evaporation from the soil is the goal of this project. Past projects have demonstrated that reducing soil evaporation under irrigated corn canopies is possible by using flat wheat stubbles. Irrigators need to know the value of stubbles, including corn stalks and standing wheat stubble.

The first year of this project has demonstrated that no-till corn stover and wheat stubble have the potential of saving 1.3 and 1.8 inches of soil water evaporation, respectively, compared with bare soil, during the last 2/3 of the soybean growing season. The potential for water savings may increase to totals of 3.0 and 3.5 inches for corn stover and wheat stubble, respectively, when the rest of the growing season is factored in. Future research will address this issue.

PROJECT OBJECTIVES

Determine the water savings value of crop residues in irrigated soybean production. 1. Measure evaporation beneath crop canopy of fully irrigated and limited irrigated soybean production by measuring evaporation from bare soil, from soil with no-till corn residue, and from soil with standing wheat residue, 2. Calculate the relative contribution of evaporation and transpiration to evapotranspiration for each treatment, and 3. Convert any potential savings in evaporation due to crop residues into equivalent grain yield gains and calculate economic impacts in water-limited areas in western Kansas.

PROCEDURES

Evaporation from the soil surface was measured beneath the canopy of replicated fully irrigated soybean plots during the 2003 growing season. No-till corn and standing wheat residues were compared with bare soil surfaces for the evaporation measurements. The evaporation measurements were taken daily by using "mini" lysimeters, small cylinders of undisturbed soil enclosed on the bottom and sides. The difference in daily weights of the mini-lysimeters constitutes the soil-water evaporation loss. The lysimeters were 12 inches in diameter and 5 inches deep. They were either covered with crop residue or left bare, but did not contain a growing crop. Two lysimeters were inserted into buried sleeves between adjacent rows of soybeans. Twenty-four lysimeters were placed within the crop canopy consisting of four replications of bare, corn stover, and wheat stubble surface treatments. The crop was planted on June 11. The crop was 6 inches tall on July 18 when measurements were initiated, and the canopy closed on August 1.

[1]The project was partly supported by funds from the Kansas Soybean Commission.

The treatments were reproduced with another 24 mini-lysimeters in a simulated canopy arrangement consisting of simple wooden "sideboard" shades which were erected at the same height as the crop. No crop grew around the mini-lysimeters in the simulated area. The simulation was to extend the potential measurement period into the non-growing season. The evaporation measurements from the simulated area started on September 15, and were taken as a guide for further comparison of irrigation frequency after the growing season. Early-season canopy effects were simulated with once per week, versus twice per week, irrigation frequency, which could not be imposed as an irrigation variable during the growing season.

Because the soil in the "mini" lysimeters did not contain active roots, soil slowly became wetter than the surrounding soil. To keep the "mini" lysimeters representative of the surrounding soil, lysimeters were replaced after each irrigation event with lysimeters matched to the field water content after the irrigation event. The lysimeters removed were dried in the greenhouse, and were able to replace those in the field by the next irrigation event.

Evapotranspiration (ET) was calculated from a soil water balance including soil water measurements (with the neutron attenuation method) and measurements of rainfall and irrigation. Crop transpiration could be calculated as the residual of ET and our evaporation measurements.

RESULTS AND DISCUSSION

Table 1 and Figure 1 summarize the results from the soil water evaporation from beneath the natural canopy. The simulated results tended to match the field results early in the growing season; there was some divergence as the season progressed and the canopy closed. The data in Table 1 show the implications for water management in irrigated soybean production. These measurements were taken in wide-row (30-inch) management, but frequent irrigation is probably the reason that the corn stover and wheat stubble made an impact on evaporation. Sprinkler irrigation occurred twice each week, which is common practice. Water on or near the surface of wet soil is most readily available for evaporation. Solar radiation and wind drive the evaporation process. Surface mulch reduced the energy available for driving evaporation, even after the canopy closed, although this effect was diminished.

Residue cover had a strong effect on soil water evaporation. The strongest effect was from wheat straw and was less from corn stover, but corn stover effects resembled those of wheat straw more than we initially might have predicted. The corn stover ended the season with 87% ground cover, which may help explain its effect. This relatively large amount of surface cover for corn stover is equivalent to very good no-till management, which is the maximum reduction in evaporation that could be expected from corn stover. Crop canopy seemed to reduce soil water evaporation as the season progressed. This would be predicted, and our measuring technique confirmed this trend. There were differences in soil water evaporation between weekly and twice-weekly irrigation, even after the growing season, when evaporative demands were less (Table 2).

Table 1. Soil water evaporation as a percentage of evapotranspiration (ET) for segments of the 2003 growing season in an irrigated soybean crop.

	Jul 18-Aug 1	Aug 1-Aug 15	Aug 26-Sep 6
Surface Treatment	% of ET	% of ET	% of ET
a. Simulation Area			
Bare Soil	39%	36%	7%
Corn Stover	24%	21%	3%
Wheat Straw	22%	17%	3%
b. Field Area			
Bare Soil	40%	29%	4%
Corn Stover	23%	17%	2%
Wheat Straw	20%	14%	2%

Field measurements were taken from July 18 until September 6. These data are summarized in Table 3. Projections of soil water evaporation from planting until July 17 were made to estimate full growing season savings from crop residues (Table 3). Future research will be carried out to confirm these projections.

In addition to soil water evaporation, growing season benefits of crop residues are infiltration enhancement and runoff reduction. Non-growing-season benefits include infiltration enhancement, runoff reduction, and snow entrapment. Dryland research has indicated that these non-growing-season benefits may be worth at least 2 inches annually in water conservation in the central plains states.

These data indicate that there may be a 3- to 4-inch savings in water from evaporation if data were extended over the growing season. There are also benefits outside the growing season and benefits due to erosion control, enhancement of infiltration, and runoff control. However, the 3- to 4-inch water savings alone could have a significant impact on the soybean industry in Kansas if crop-residue

Figure 1. Mini lysimeter total evaporation within soybean canopy.

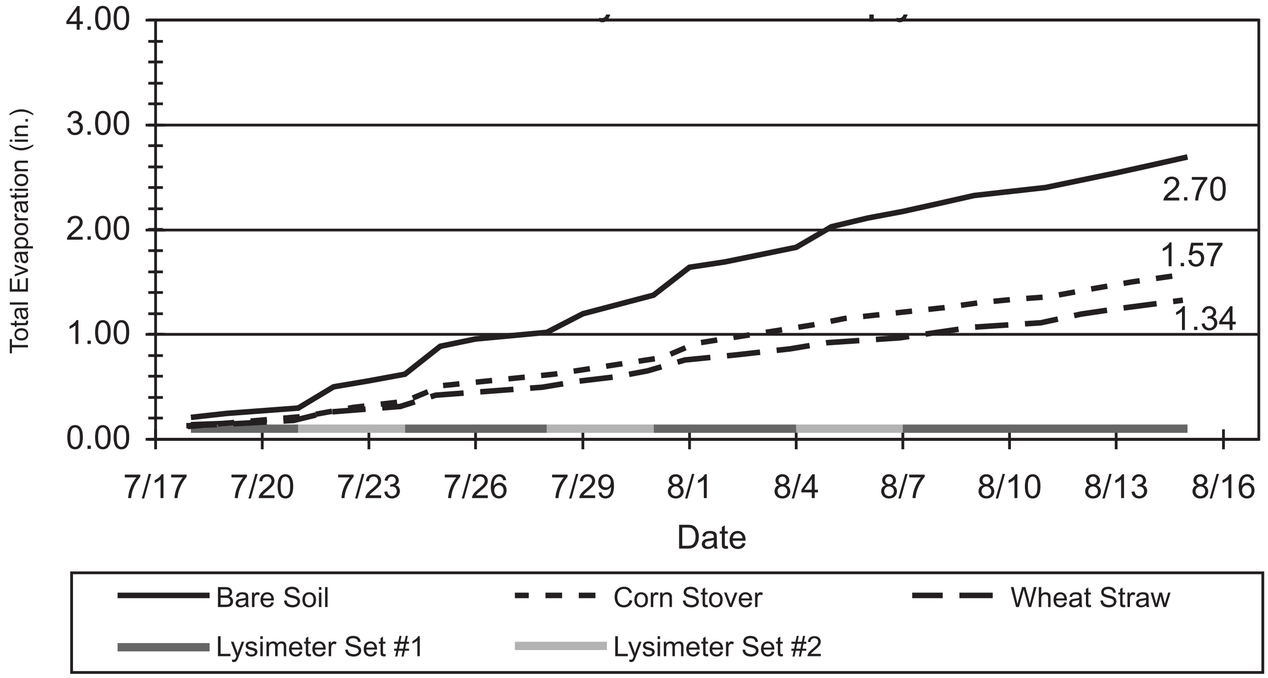


Table 2. Evaporation in simulation area for once weekly and twice-weekly watering frequencies.

Surface Treatment	September 15 to October 13, 2003 29 Total days Evaporation Total, in	In/day
Weekly Watering Frequency		
Bare Soil	1.27	0.04
Corn Stover	0.75	0.03
Wheat Straw	0.58	0.02
Twice Weekly Watering Frequency		
Bare Soil	2.14	0.07
Corn Stover	1.05	0.04
Wheat Straw	0.75	0.03

Table 3. Total evaporation and water savings by crop residues in soybean.

	7/18 – 9/6		(projected estimates)* 6/11 – 7/17		Season
Surface Cover	Total in	Savings in	Total in	Savings in	Savings in
Bare Soil	3.1		4.1*		
Corn Stover	1.8	1.3	2.4*	1.7*	3*
Wheat Straw	1.5	1.6	2.1*	2*	3.5*

* Projections from planting until measurement began on 7/18 are provided to estimate full growing-season savings.

management techniques were further adopted. There were 126,500 acres of irrigated soybeans in the western third of Kansas and 180,800 acres in the central third, for a total of 307,300 acres, reported in 2002. If 80% were irrigated with center pivots, then 246,000 ac of soybeans in the western 2/3 of Kansas could apply this research. (Statistics on the narrow-row and wide-row acreages were not available for this analysis).

Water savings would impact the soybean industry in two ways. Irrigation pumping costs have risen to $3-$5/ac-in recently, so the operating cost of the evaporation savings would be $9-$20/ac. For irrigators with limited water supplies. the water savings translate into crop production because the water becomes available to the crop. For top producers, an inch of water could be translated into 4 bushels of soybeans if water is the limiting factor. An extra 12-16 bushels of production per acre could result from the management of crop residues for evaporation suppression.

Assuming that soybean production in western Kansas is predominately in 30-inch rows, the overall economic impact, if adopted, could be significant. The impact on pumping costs would be between $1,156,500 and $2,570,000 over 128,500 acres. The impact on production would be between $7,710,000 and $10,280,000 for soybeans at $5.00/bu over the same acreage.

SOYBEAN STEM BORER MANAGEMENT TRIALS 2001-2003

by

Phil Sloderbeck, Larry Buschman, and Randy Higgins[1]

SUMMARY

Data from large-scale field plots during a three-year period indicate that properly timed insecticide treatments may be useful in managing the soybean stem borer. Aerial applications of lambda-cyhalothirn were found to control adult beetles for several days, but more than one application may be needed to reduce larval infestations to acceptable levels. Further studies are needed to determine the best methods for sampling beetles, to establish treatment thresholds, and to determine the best timing for treatments. In addition, although lambda-cyhalothrin is labeled for use on soybeans, it is not labeled for this pest. Thus, this remains an experimental practice, and growers and consultants will need to move cautiously when adapting these results into a stem-borer management plan.

INTRODUCTION

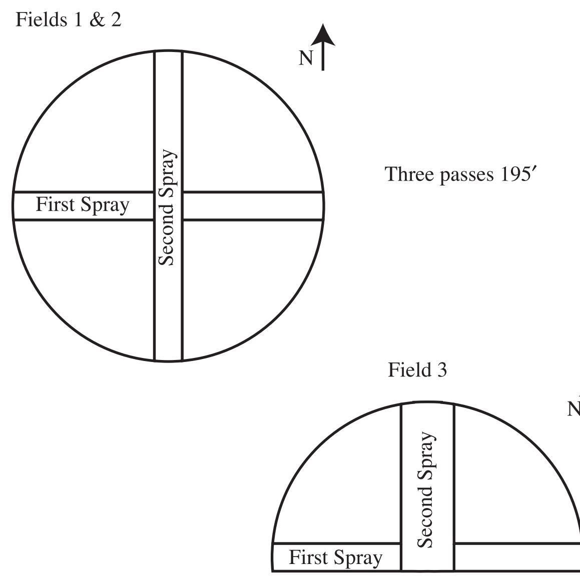
The soybean stem borer (Dectes texanus texanus) is a stem-boring insect pest of soybeans. Although the adults inflict minimal damage, larvae girdle soybean stems internally, causing plants to lodge as physiological maturity is reached.

A series of trials was conducted to determine whether targeting soybean stem-borer adults with an insecticide treatment could reduce soybean stem- borer larval infestations in soybean stems.

PROCEDURES

In 2001, three irrigated circles of soybeans in Pawnee and Edwards counties were identified has having noticeable populations of soybean stem borer adults. Lambda-cyhalothirn at 0.025 lb. ai/a in 3 gpa was applied to strips across these fields by air on 6 and 20 July. Treated strips were three passes wide (195 ft.), with the second treatment applied at 90 degrees to the first treatment, so there was an area of each field that was treated twice and large areas of the fields that were untreated. (Note: one field consisted of only a half of a circle so the second treated strip was six passes wide (390 ft.) (Fig. 1).

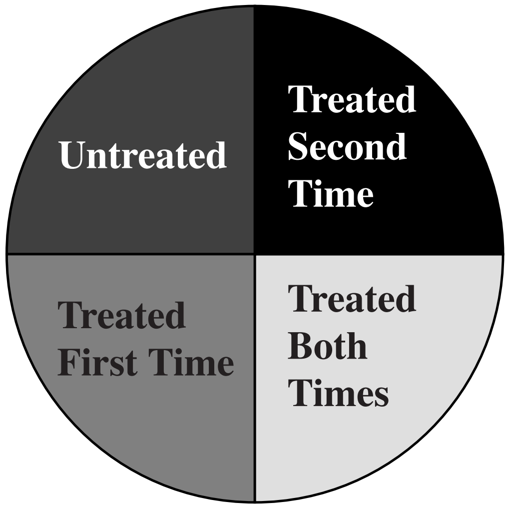
Figure 1. Diagram of treatment design for 2001.



In 2002 and 2003, plots were again established in three center-pivot-irrigated soybean fields in Pawnee County. In these trials, half of each field was treated on each treatment date, with the direction of treatment rotated 90 degrees so that 1/4 of each field was treated twice, 1/4 was treated with the first application, 1/4 was treated with the second application and 1/4 was left untreated (Fig. 2). In 2002, the first treatments were applied on July 12 (except on one field not treated until July 17) and the second treatments were applied on July 24. In 2003, the treatments were made on July 1 and 15. Treatments consisted of 0.023 and 0.025 lb ai/a of lambda-cyhalothirn in 2002 and 2003, respectively, applied in 3 gpa of water by air.

[1]Department of Entomology, Kansas State University.

Figure 2. Diagram of treatment design for 2002 and 2003.

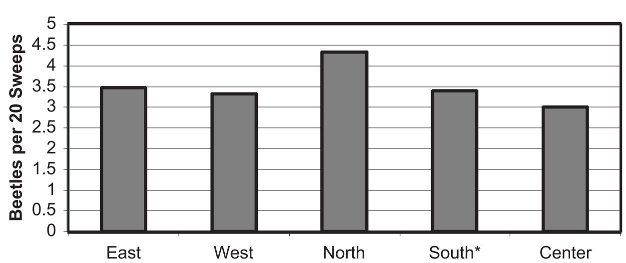


During all three years of the study, beetle populations were sampled before and after treatments by using a sweep net. In addition, at the end of the season, plants were dissected to determine the percentage of plants infested with soybean stem-borer larvae.

RESULTS AND DISCUSSION

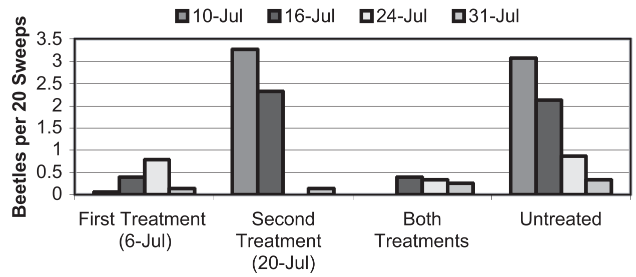
In 2001, pretreatment samples showed fairly uniform distributions of beetles across the fields (Fig. 3) (5 sets of 20 sweeps per location in each field; data from all three fields pooled for presentation in these graphs).

Figure 3. Soybean stem borer efficacy trial, pre-treatment counts, July 2, 2001.



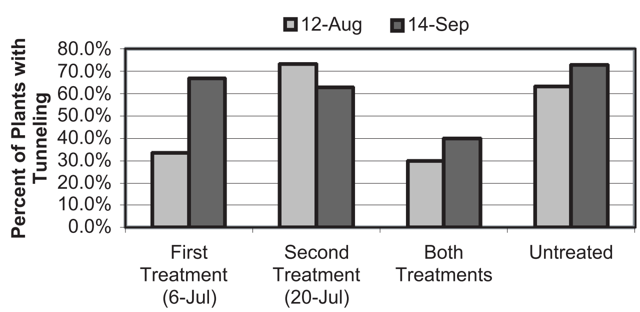
* In field 3, the sample for the south was taken in the middle of the North-South strip.

Figure 4. Soybean stem borer efficacy trial post-treatment samples, 2001.



Treatments showed good initial knockdown, lasting about 2 weeks (Fig. 4). On July 10 (4 days after the first treatment), 5 sets of 20 sweeps were taken in four different areas of each field. In the 600 sweeps from the untreated sections of the fields, a total of 95 beetles were collected, whereas only one bettle was collected in the 600 sweeps from the treated areas. Note that the populations seem to be declining in the untreated soybeans over time. But some of this decline can probably be attributed to the sweep net becoming less efficient over time because the soybeans were growing rapidly. Note; that on July 24, 18 days after the first treatment, beetle numbers in the area that received only the first treatment were nearing the level found in the untreated area.

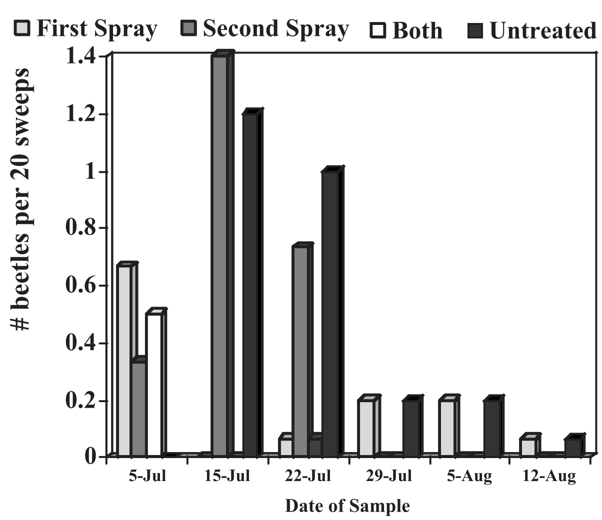
Figure 5. Soybean stem borer efficacy trial, 2001.



Plants were sampled twice for evidence of tunneling from stem-borer larvae (Fig. 5). On August 12, 2 plants at 5 locations in the 4 areas of each field were dissected; on September14, 4 plants were sampled at each location. In the August 12 sample, it seemed that the areas receiving the first treatment and the areas receiving both treatments reduced tunneling by about 50%, but in the September 14 sample, only the areas receiving both treatments showed a noticeable decrease in tunneling. Evidently the August 12 sample missed many larvae that were still tunneling in the leaf petioles.Even with two applications, however, tunneling was reduced by less than 50%. Evidence suggests that the plot size was not large enough to keep beetles from re-infesting the plots. The areas treated with two applications were actually only 195-ft squares in the middle of a 130-acre field. Thus, it was decided redo the trial and use larger treated areas to determine whether that would reduce the chance of the treatments being re-infested with beetles and, thus, increase the chance of showing differences among the treatments.

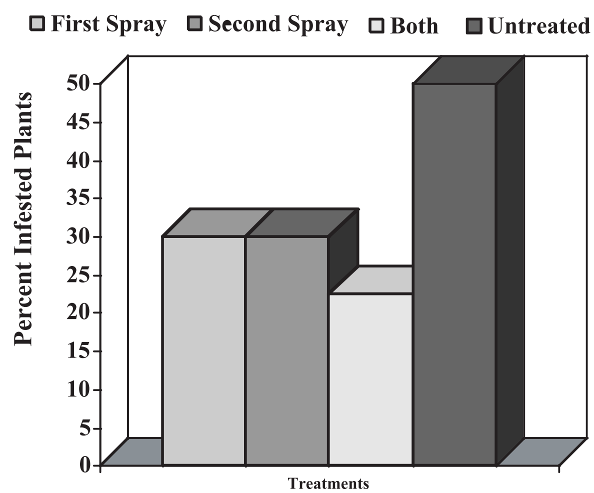
In 2002, there were only two fields in the trial because one of the fields missed being treated on the first spray date. Pretreatment samples (consisting of 3 sets of 20 sweeps per quarter of field) indicated small numbers of beetles across the fields (Fig. 6). After the first treatment (5 sets of 20 sweeps per quarter of field), the numbers of beetles in the treated plots were zero, whereas numbers in the untreated plots, and in the plots that were to receive only the second application (which had not yet been treated), averaged more than 1 beetle per 20 sweeps. Note that in the samples on July 29 and August 5, the number of beetles found in the quarters that were only treated with the first application had rebounded and were the same or greater than in the untreated quarters.

Figure 6. Soybean stem borer efficacy trial, 2002.



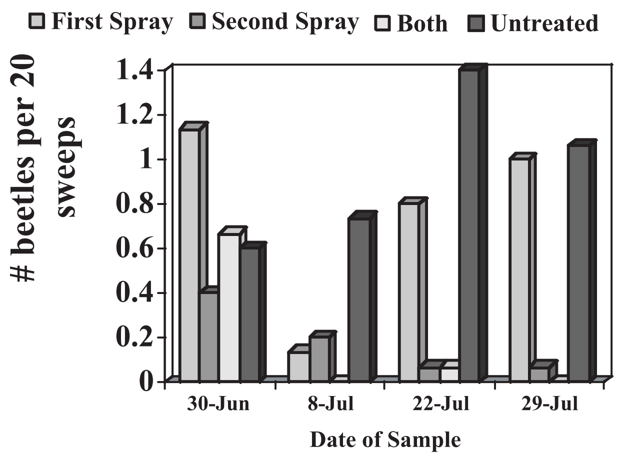
In 2002, samples taken of the larvae in the stems at the end of the season from two fields showed a reduction in larval numbers in the sprayed plots, but not as muchof a reduction in beetle numbers as we would have liked (only about a 50% reduction in larval numbers where the fields were treated twice (Fig. 7). The reason for the limited success of the treatments may have been that the initial treatment was applied later than optimal. Beetles were actually present in samples take on June 28, but numbers were thought to be too small to be meaningful, so treatment was delayed two weeks.. This means that beetles were active in the fields for at least two weeks beforetreatment, which may have allowed for significant egg laying before treatment.

Figure 7. Soybean stem borer efficacy trial, 2002.



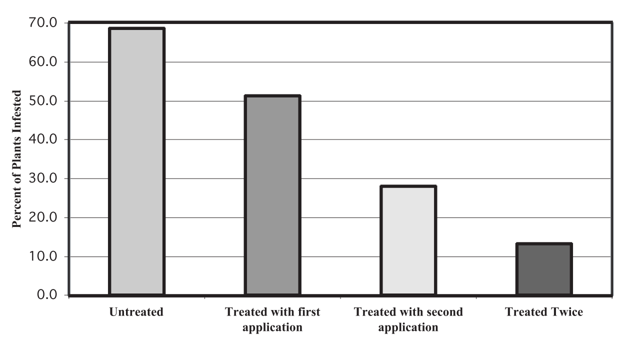
In 2003, samples of beetles were taken by using a sweep net on four different dates. Five sets of 20 sweeps were taken at random in each quarter of each field. Data from all three fields were pooled for presentation (Fig. 8). Pretreatment samples showed small numbers of beetles fairly evenly distributed across the fields, and differences between the different areas of the fields were not significant. On July 8, 7 days after the first treatment, the numbers in the treated plots were less than 0.2 beetles per 20 sweeps, whereas numbers in the untreated portions of the fields averaged more than 0.7 beetles per 20 sweeps, except that the plots that were to be treated with the second application averaged only 0.2 beetles per 20 sweeps, which was fewer than what would have been expected. By July 22, the number of beetles found in the early-treated portions of the fields was starting to rebound. But the populations in the portions of the field treated on July 15 remained very small through the end of July.

Figure 8. Soybean stem borer efficacy trial, 2003.



In September of 2003, five plants at each of 10 locations in each section of each field were dissected to determine if larvae were present. These samples showed a 25% reduction from the July 1 treatment, a 60% reduction with the July 15 treatment, and an 80%
reduction in the percentage of plants infested where the fields were treated twice (Fig. 9).

Figure 9. Soybean stem borer efficacy trial 2003, September 16th, sample (50 plants).



These data indicate that properly timed sprays may be useful in managing the soybean stem borer. But the timing, economics, and treatment thresholds for such applications are not fully understood. Timing of sprays seems to be critical, but sampling for the beetles is labor intensive, and even small populations of beetles (1 beetle per 20 sweeps) seem to result in significant larval infestations. In addition, because well timed multiple applications seem to be needed to reduce larval infestations by more than 50%, the cost of such treatments may be cost prohibitive, especially inasmuch as losses are associated with girdling and lodging, which may not take place if plants can be harvested in a timely manor.

Special thanks to: the Kansas Soybean Commission who provided partial funding for support of this project, and to Syngenta, for providing the insecticide used in this trial. We also thank all of the people who cooperated to make this study possible, including Mike Barton, Tom Threewitt, Doug and Cathy Nord, Eric Fox, Steve Gross, Becky Stubbs, Mark Ploger, and all of the producers who allowed us to sample their fields.

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

by

Larry Buschman, Phil Sloderbeck, and Merle Witt

SUMMARY

This trial was conducted to evaluate the efficacy of nine corn hybrids containing three Cry1Ab events, and two Cry1Ab events stacked with a VIP event, for controlling southwestern corn borer (SWCB), *Diatraea grandiosella* Dyar, and corn earworm (CEW), *Helicoverpa zea* (Bobbie). Syngenta supplied the seed. The efficacy of the Cry1Ab experimental events against SWCB was outstanding and seemed equal to that of current commercial Bt11 hybrids. The efficacy of the VIP event stacked with Cry1Ab against the corn earworm was also outstanding.

PROCEDURES

The plots were machine-planted on 10 June at the Southwest Research-Extension Center near Garden City, Kansas, with seed supplied by Syngenta. The plots were single rows, 20 ft long, separated from each other by four border rows of Bt corn and 10-ft-wide alleys. The plot design was a randomized block design with 4 replicates. Four to 12 rows of Bt and non-Bt corn were planted around the experimental plots as a border/windbreak. Nine treatments were evaluated, including 4 experimental hybrids expressing VIP and CRY toxins, a commercial Bt corn hybrid, NK58-D1 (Bt11), the non-Bt isoline hybrid, and two insecticide treated plots. The first 10 plants in each plot were infested with southwestern corn borer (SWCB) neonates between July 9 and 13, when the plants were in the 8- to10-leaf stage. Availability of neonates was limited, so the plants in different replicates were not equally infested. The first 5 plants received 5 to 10 neonates per plant, but the second 5 plants received only 2 to 5 neonates per plant. The insecticide-treated plots were planted to the non-Bt isoline or to the commercial Bt corn hybrid, NK58-D1. These plots were treated for second-generation SWCB with a standard insecticide, Warrior T, at 3 oz/acre per pass by using a 2-gallon hand sprayer. The spray was directed at the plants while the nozzle was moved up and down to treat the whole plant. On August 1, the plots were treated from one side (3 oz/acre). On August 12, the plots were treated from both sides (6 oz/acre).

First-generation SWCB leaf-feeding damage was evaluated on July 28 by using a modified Guthrie scale (0-no damage, 1-some pinholes and 10-dead-heart). The modified Guthrie means can be changed to standard Guthrie means by adding one to each mean. Plants were not dissected for first-generation tunneling because there were limited plant numbers. The second-generation SWCB infestation resulted from free flying feral moths and moths emerging from the manually infested first generation. On September 18 through 24, 15 plants were dissected to make observations on second-generation SWCB and their damage. The ten plants that had been infested with first-generation neonates were included in the 15 plants, so tunneling that was produced by first-generation SWCB (before the insecticide treatment was applied) was excluded. First-generation tunneling typically had pupal case remains or very dark tissues around the tunnels. This was particularly important for treatment #7, which was susceptible during the first generation, but was treated with insecticide during the second generation. In some instances, the second-generation larvae reused the first generation tunnels, so these tunnels were counted as second-generation tunnels.

The ears from the 15 dissected plants were also examined for corn earworm (CEW) damage. Ear tip damage was measured by using the Winstrom scale, the number of cm of feeding penetration plus 1 for silk feeding. We also counted (estimated) the number of harvestable kernels removed by ear feeding CEW. Southwestern corn borer damage in the ear was also present as kernel damage at the ear base and as feeding in the husk around the shank (seldom into the shank), but this damage was minor compared with the CEW damage and was not rated separately.

RESULTS AND DISCUSSION

The artificial infestation of first-generation SWCB was successful and allowed the evaluation the plant resistance to first-generation SWCB. Some 80 - 85% of "infested" susceptible plants had SWCB feeding damage. Infested susceptible plants had extensive SWCB feeding damage and some dead-heart (killed meristem). Modified Guthrie ratings averaged 4.1 and 5.0 (averaging across all "infested" plants) in the non-Bt isoline plants. Only a few pinhole-feeding scars were found on the transgenic hybrids, and the Guthrie ratings averaged less than 1.0 (Table 1). Only the non-transgenic plants had Guthrie ratings of higher than 4.0, and there were no significant differences among the transgenic hybrids.

By September 18 to 24, only 1 to 8.75 CEW were still present per 15 corn ears (CEW leave the ear at larval maturity). CEW damage on the ear tips was extensive, reaching 7.4 on the Widstrom scale in the untreated non-Bt hybrid (Table 2). The insecticide treatment did not significantly reduce CEW feeding damage in the ears. The three Cry1Ab event hybrids significantly reduced CEW feeding damage, compared with the non-Bt isoline. The VIP-event hybrids further reduced CEW damage scores to levels that were usually significantly lower even than those of the Cry1Ab event hybrids. Compared with controls, the Cry1Ab event hybrids reduced damage from 72 to between 21 and 44 kernels, but the VIP-event hybrids reduced CEW feeding to between 4 and 10 kernels per ear (Table 2).

The second-generation SWCB population averaged 0.8 larvae per plant in the non-Bt hybrid. A total of 43 SWCB and one european corn borer were recorded in the 60 untreated non-Bt plants (treatment #6). Two SWCB were found in the shank; the rest were in the stalk at the base of the plant. A total of 6 untreated non-Bt plants were girdled by SWCB (treatment #6). All the Bt hybrids and the insecticide treatment significantly reduced the number of SWCB larvae to low levels (Table 3). There was an average of 1.2 tunnels and 9.1 cm of tunneling per untreated non-Bt plant (Table 3 & 4). All treatments significantly reduced the number of SWCB larvae and tunneling. One SWCB was found in a treatment-#8 plant that had significant first-generation feeding damage, suggesting that the plant was susceptible (non-expressing plant). Three infested plants were found in plots along the south border, 3 rows away from non-Bt plants in the border planting, in treatments #2, #2,

Table 1. Early-season observations for first-generation southwestern corn borers feeding on plants of different treatments, SWREC, Garden City, Kansas.

Treatment No.	Hybrid Code	Cry1Ab Event	VIP3a Event	1st Gen. Infested / 10 Plants [1,2]	Modified Guthrie 0-10 scale [2,3]	Plants ≥4 Guthrie [2]
1	SPS1001LM	Bt11	MIR152V	3.00 c	0.28 b	0.0 b
2	SPS1002LM	3243M	MIR152V	5.75 b	0.60 b	0.0 b
3	SPS1005LM	3243M	—	4.00 bc	0.40 b	0.0 b
4	SPS1006LM	3210M	—	4.75 bc	0.40 b	0.0 b
5	SPS1007LM	Bt11	—	3.50 bc	0.35 b	0.0 b
6	SPS1008LM	—	—	8.50 a	4.10 a	6.8 a
7	SPS1008LM	—	—	8.00 a	5.00 a	6.3 a
8	N58-D1	Bt11	—	4.50 bc	0.38 b	0.0 b
9	N58-D1	Bt11	—	3.50 bc	0.35 b	0.0 b
	P-value			0.0003	>0.0001	>0.0001
	LSD			2.359	1.299	0.907

[1] Plants showing any leaf feeding.
[2] Means within a column that are followed by different letters are significantly different ($P < 0.05$)
[3] Modified Guthrie Ratings taken on July 28, 2003.

#4. One of these larvae was found in a plant with so little tunneling that the larva must have migrated from another plant. Another mature SWCB larva was found in the base of a treatment-#1 plant that was on the east border, evidently 8 rows from non-Bt plants in the border planting.

The efficacy of the experimental Cry1Ab hybrids against SWCB was outstanding and seemed equal to that of the current commercial Bt11 corn hybrid. The VIP event and a Cry1Ab event also significantly increased the efficacy of the hybrids against the CEW.

Table 2. Observations on corn earworm feeding on corn ears of different treatments, SWREC, Garden City, Kansas.

Treat-ment No.	Hybrid Code	Cry1Ab Event	VIP3a Event	Warrior Treatment[1]	Maturity July 28[2]	CEW Larvae	Winstrom Ratings[3]		Kernels Damaged[3]
						/ 15 ears	Mean / ear	3+ / 15 ears	Mean / ear
1	SPS1001LM	Bt11	MIR152V	—	2.25	1.00	1.35 c	1.25 g	4.38 d
2	SPS1002LM	3243M	MIR152V	—	1.75	2.50	1.83 c	3.50 fg	10.15 cd
3	SPS1005LM	3243M	—	—	1.25	3.00	3.28 b	7.75 de	32.15 bc
4	SPS1006LM	3210M	—	—	1.75	5.00	3.38 b	8.75 cd	44.83 b
5	SPS1007LM	Bt11	—	—	2.25	8.75	4.45 b	10.75 bc	37.58 b
6	SPS1008LM	—	—	—	2.0	7.50	7.40 a	15.00 a	72.20 a
7	SPS1008LM	—	—	Warrior	2.25	3.25	6.95 a	13.00 ab	69.10 a
8	N58-D1	Bt11	—	—	2.0	4.25	3.55 b	8.50 cd	31.90 b
9	N58-D1	Bt11	—	Warrior	1.75	2.50	2.93 bc	5.50 ef	21.83 b
	P-value				0.447	0.0763	>0.0001	>0.0001	>0.0001
	LSD				—	—	1.905	2.755	23.425

[1] Warrior T treatments were made August 1 and 12, during the SWCB flight.
[2] Plant maturity ratings, 1 = tassel, 2 = silk and 3 = brown silk taken July 28 and ear feeding damage recorded September 18 to 24, 2003
[3] Means within a column that are followed by different letters are significantly different ($P < 0.05$)

Table 3. Observations on second-generation southwestern corn borer feeding on corn plants of different treatments, SWREC, Garden City, Kansas.

Treat-ment No.	Hybrid Code	Cry1Ab Event	VIP3a Event	Warrior Treatment[1]	2nd Gen. Infested[2] /15 plants	SWCB Larvae[2] /15 plants	Tunnels / 15 plants[2,3] Stalk	Shank	Total
1	SPS1001LM	Bt11	MIR152V	—	0.25 b	0.25 b	0.25 b	0.25 b	0.50 b
2	SPS1002LM	3243M	MIR152V	—	0.50 b	0.25 b	0.50 b	0.00 b	0.50 b
3	SPS1005LM	3243M	—	—	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b
4	SPS1006LM	3210M	—	—	0.50 b	0.25 b	0.25 b	0.00 b	0.25 b
5	SPS1007LM	Bt11	—	—	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b
6	SPS1008LM	—	—	—	12.00 a	10.75 a	15.75 a	2.00 a	17.75 a
7	SPS1008LM	—	—	Warrior	0.02 b	0.00 b	0.00 b	0.25 b	0.25 b
8	N58-D1	Bt11	—	—	0.25 b	0.25 b	0.00 b	0.25 b	0.25 b
9	N58-D1	Bt11	—	Warrior	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b
	P-value				0.0035	>0.0001	>0.0001	>0.0001	>0.0001
	LSD				1.25	0.894	2.505	0.539	2.683

[1] Warrior T treatments were made August 1 and 12, during the SWCB flight.
[2] Means within a column that are followed by different letters are significantly different ($P < 0.05$).
[3] Plants dissected September 18 to 24, 2003.

Table 4. Observations on second-generation southwestern corn borers feeding on corn plants of different treatments, SWREC, Garden City, Kansas.

Treat-ment No.	Hybrid Code	Cry1Ab Event	VIP3a Event	Warrior Treatment[1]	Tunnels—cm/plant[2,3] Stalk	Shank	Total	Tunnels—cm/tunnel[2,3] Stalk	Shank
1	SPS1001LM			—	0.15 b	0.03 b	0.18 b	2.25 bc	0.25 b
2	SPS1002LM			—	0.23 b	0.00 b	0.23 b	3.50 b	0.00 b
3	SPS1005LM			—	0.00 b	0.00 b	0.00 b	0.00 c	0.00 b
4	SPS1006LM			—	0.03 b	0.00 b	0.03 b	0.50 bc	0.00 b
5	SPS1007LM			—	0.00 b	0.00 b	0.00 b	0.00 c	0.00 b
6	SPS1008LM	Isoline		—	8.68 a	0.43 a	9.13 a	8.40 a	3.20 a
7	SPS1008LM	Isoline		Warrior	0.00 b	0.00 b	0.00 b	0.00 c	0.25 b
8	N58-D1	Bt11		—	0.00 b	0.00 b	0.00 b	0.00 c	0.75 b
9	N58-D1	Bt11		Warrior	0.00 b	0.00 b	0.00 b	0.00 c	0.00 b
	P-value				>0.0001	0.0001	>0.0001	0.0003	0.0001
	LSD				1.573	0.160	1.655	3.359	1.171

[1] Warrior T treatments were made August 1 and 12, during the SWCB flight.
[2] Means within a column that are followed by different letters are significantly different ($P < 0.05$).
[3] Plants dissected September 18 to 24, 2003.

EFFICACY OF INSECTICIDES FOR THE CONTROL OF SOUTHWESTERN CORN BORER

by
Larry Buschman and Phil Sloderbeck

SUMMARY

This trial was conducted to evaluate the efficacy of insecticides for controlling southwestern corn borer (SWCB), *Diatraea grandiosella* Dyar. The second-generation SWCB infestation was light, and was not very uniform in distribution. Only the number of girdled plants per plot produced a statistically significant result (Table 2). The standard insecticides, Warrior, Baythroid, and Capture, gave 78 to 100% control. The new insecticides, Proaxis and the higher rates of Intrepid, gave equivalent levels of control. The efficacy of the lower rates of Intrepid and Tracer were not demonstrated.

PROCEDURES

The plots were machine-planted to a non-Bt corn hybrid at the Southwest Research-Extension Center near Garden City, KS. The plots were 4 rows wide (10 ft), 50 ft long, and separated by four border rows of corn and 10-ft-wide alleys. The plot design was a randomized block design with 4 replicates. Treatments were applied on 4 August with a high-clearance sprayer using a 10-ft boom with three nozzles directed at each row (one nozzle on each side of the row on 16-in drop hoses directed at the ear zone and a third nozzle directed at the top of the plant). The sprayer was calibrated to deliver 20 gal/acre at 2 mph and 40 psi. The second-generation SWCB infestation resulted from free-flying feral moths. Ten plants from the two middle rows were dissected on Sept. 25. to make observations on second-generation corn borers.

RESULTS AND DISCUSSION

The corn borer flight was so light that it was difficult to judge when to make the treatments. At the time of insecticide application, we found 4 egg masses on 9 plants. Three of the egg masses were hatched, and one was in the red bar stage, suggesting that the timing was about right for many of the standard chemicals, but may have been a little later than intended for the growth-regulator treatment, Intrepid. The second-generation SWCB infestation averaged only 0.16 larvae per plant in the untreated check (Table 1). The corn borer infestation was so light that only the number of girdled plants per plot produced a statistically significant result (Table 2). The standard insecticides, Warrior, Baythroid, and Capture, gave 78 to 100% control. The new insecticides, Proaxis and the higher rates of Intrepid, gave similar levels of control. The efficacy of the lower rates of Intrepid and Tracer were not demonstrated. The applications may have been too late to take advantage of the low rates of Intrepid and Tracer. Stalk rot was severe, and averaged 2.2 nodes across the experiment. There were many plot-to-plot differences in the field, but they were not associated with corn borer treatment. Many plants were broken over from stalk rot.

Table 1. 2003 Corn borer observations taken Sept. 25 on plots treated with different corn borer insecticides to control second-generation southwestern corn borer (SWCB). Garden City, Kan.

Treat. No.	Hybrid Code	Rate: Product per acre	2nd Gen. SWCB / 10 plant	No. 2nd Gen. Tunnels/10 plants			Total cm/plant
				Stalk	Shank	Total	
1	Check	—	1.5	2.25	0.25	2.75	3.13
2	Intrepid 2SC	2 oz	1.25	2.00	0.50	2.75	2.65
	Latron CS-7	0.25%					
3	Intrepid 2SC	4 oz	0.75	1.25	0.75	2.00	1.75
	Latron CS-7	0.25%					
4	Intrepid 2SC	6 oz	0.00	0.00	0.00	0.00	0.00
	Latron SC-7	0.25%					
5	Intrepid 2SC	8 oz	0.00	0.25	0.00	0.25	0.75
	Latron SC-7	0.25%					
6	Tracer 4 SC	2 oz	0.50	0.75	0.75	1.50	1.55
7	Tracer 4 SC	3 oz	0.75	1.00	0.50	1.50	1.50
8	Warrior Zeon	2.56 oz	0.25	0.75	0.00	0.75	0.20
9	Warrior Zeon	3.84 oz	0.75	1.25	0.00	1.25	1.45
10	Proaxis GF-317)	2.56 oz	0.75	1.50	0.50	2.25	1.35
11	Proaxis GF-317)	3.84 oz	0.00	0.75	0.00	0.75	0.70
12	Baythroid 2	1.6 oz	0.50	0.75	0.00	0.75	0.50
13	Baythroid 2	2.8 oz	0.50	0.75	0.00	1.00	0.53
14	Capture 2EC	5.12 oz	0.00	0.75	0.25	1.25	0.83
	P-value		0.198	0.799	0.203	0.722	0.397
	LSD		—	—	—	—	—

Treatments applied August 4.

Table 2. 2003 Corn borer and stalk rot observations taken Sept. 25 on plots treated with different corn borer insecticides to control second-generation southwestern corn borer (SWCB). Garden City, Kan.

Treat. No.	Hybrid Code	Rate: Product per acre	% Plants Borer Infested	No. Borer Girdled Plants/plot	% Control Girdled Plants/plot	Stalk Rot Nodes
1	Check	—	20	9.0 a	—	2.3
2	Intrepid 2SC	2 oz	18	7.75 ab	14	3.0
	Latron CS-7	0.25%				
3	Intrepid 2SC	4 oz	18	3.50 bcd	61	2.2
	Latron CS-7	0.25%				
4	Intrepid 2SC	6 oz	0	1.00 d	89	1.8
	Latron SC-7	0.25%				
5	Intrepid 2SC	8 oz	3	2.25 cd	75	1.8
	Latron SC-7	0.25%				
6	Tracer 4 SC	2 oz	13	6.75 abc	25	1.2
7	Tracer 4 SC	3 oz	13	3.25 bcd	64	1.3
8	Warrior Zeon	2.56 oz	8	0.00 d	100	2.2
9	Warrior Zeon	3.84 oz	10	1.00 d	89	1.1
10	Proaxis GF-317)	2.56 oz	8	1.00 d	89	2.5
11	Proaxis GF-317)	3.84 oz	8	2.25 cd	75	3.0
12	Baythroid 2	1.6 oz	8	2.00 cd	78	2.8
13	Baythroid 2	2.8 oz	10	0.00 d	100	2.6
14	Capture 2EC	5.12 oz	8	2.00 cd	78	2.4
	P-value		0.700	0.0005		0.598
	LSD		—	5.089		—

Treatments applied August 4.
Means in the same column followed by the same letter do not differ significantly (LSD P=0.05).

EFFICACY OF EARLY MITICIDES APPLIED EARLY TO CONTROL SPIDER MITES IN CORN, TRIAL #1, 2003

by
Larry Buschman, Randall Currie, and Phil Sloderbeck

SUMMARY

Spider mite populations increased to 1,385 mites per 2 plants at 37 days post treatment and caused severe leaf damage by the middle of September, killing an average 7 leaves per plant. Comite treatments gave some early control, but little season total control. Corn treated with Comite suffered leaf damage similar to that of the untreated control, and Comite treatments at late-whorl and tassel added only 11.3 and 13.0 Bu/A, respectively, to grain yield. The three late-whorl Onager treatments gave excellent control, 90 to 91% season-total spider mite control, but the tassel-stage treatments failed to give good control. Corn treated with Onager suffered little leaf damage, and Onager treatments added 44.5 to 63 Bu/A grain yield. The high rate of the experimental miticide, GWN1187, gave excellent, 86 to 90%, season-total, spider mite control, even when applied at tassel or dough stage. Corn receiving these treatments suffered little leaf damage and the treatments added 54.0 to 85.6 Bu/A grain yield. Predator mite populations increased during the trial, but did not seem to affect spider mite populations until August. Thrip populations were high during the whorl stage, and mite populations seemed to increase as thrip populations declined. Predator mite and thrip populations were not affected by the miticide treatments.

PROCEDURES

Field corn, DKC60-10 (RR/YGCB) (110-day maturity), was planted May 5 with a John Deere MaxEmerge 6 row planter at a rate of 36,000 seeds/acre in a furrow-irrigated field (Finnup #8) 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. Treatments #2 through 5 were applied July 5, when the corn was in late-whorl stage (4 ft). Treatments #6 through 9 were applied July 16, when the corn was just starting to tassel. The last treatment, #10, was applied July 28, when the corn was in the soft-dough stage. The treatments were applied with a high-clearance sprayer using a 10-ft boom with two nozzles directed at each row (one nozzle on each side of the row on a 16-inch drop hose). The nozzles were directed up into the plant for the first treatment and at the ear zone for the other applications. The sprayer was calibrated to deliver 14 gal/acre at 2 mph and 40 psi.

Banks grass mites infested the plots naturally from an adjacent wheat field to the west. In May, spider mites were sampled by collecting 3 row-ft of wheat from 6 locations around the experimental field. Then spider mites were sampled in corn during the summer by collecting half the leaves from 4 plants (4 half plants = 2 plants) from the two center rows in each plot. The plant material was placed in large paper bags and transported to the laboratory, where it was placed in 76-liter Berlese funnels. A light bulb was used to dry the vegetation and to 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 for each plot. The slides were examined to determine the proportion of Banks grass mites and twospotted spider mites in the population from each plot. Pre-treatment spider mite samples were collected June 27 from 20 areas across the field (before the plots were established), and post-treatment samples were collected July 7, 14, 21, and 28, and August 4 and 11. Spider-mite counts were transformed according to Taylor's power transformation for statistical analysis and were converted to mites per 4 half-plants for presentation. On September 12. the plots were rated for number of green leaves still present. Corn receiving the best treatments still had green leaves down to the ear or lower (10 or more leaves), whereas the check plots had very few green leaves. Grain yield was collected by machine harvesting two rows from each plot. Because the field was furrow irrigated from one end of the field, there was a significant gradient in the yield going down the field. Therefore, we calculated the "field yield trend" by calculating the average yield across 6 plots at each position 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 and number of green leaves.

RESULTS AND DISCUSSION

In May, spider-mite populations averaged 0.4 mites per square foot. Spider-mite populations averaged 2.7 mites per 2 plants on June 27. The mite populations increased to an average of 1,385 mites per 2 plants by August 11, and some individual samples were as high as 3,819 per 2 plants. The spider mite populations were 100% Banks grass mites during the pretreatment samples, but by August 11, the twospotted spider-mite populations had increased to 26.4% in some treatments (Table 3). The weather changed in mid-August, and seemed to cause a further shift toward twospotted spider mites. In this region, the species complex is often observed to shift from Banks grass mites early in the season to twospotted spider mites later in the season (Sloderbeck et al. 1987). We were unable to take further samples after August 11 to verify that this shift continued, but it can be inferred from the leaf damage recorded in September and from the grain yields recorded at harvest. By September 12, the mites had killed an average of 7 leaves more per plant in the untreated control, compared with the best treatment (Table 3). There was also 85.6 Bu/A of grain yield lost in the untreated control relative to the best treatment (Table 3).

The standard early-season miticide, Comite, applied at the whorl stage, gave as much as 79% control at 9 days post-treatment, but averaged only 38% season-total spider-mite control (Tables 1 & 2). Corn treated with Comite had one of the highest percentages of twospotted spider mites (Table 3). This may explain the lack of control later in the season. Comite applied at the tassel stage gave as much as 85% control early, but averaged only 57% season-total spider-mite control because of the large early mite populations. Leaf damage at the end of the season was severe for corn from both treatments, however, and the number of green leaves did not differ from the control (Table 1). This damage seemed to be caused by the late-season twospotted spider mites. Comite treatments increased grain yield only 13.0 and 11.3 Bu/A relative to the untreated control. These treatments did not seem to suppress the late-season twospotted spider mite populations.

The three rates of Onager applied at whorl stage gave remarkably good, 90 to 91%, season-total control (Tables 1 & 2). In addition, leaf damage for corn from these treatments was minimal at the end of the season, 9.5 weeks later, and the number of green leaves was not significantly different from the best treatment, but significantly different from the control (Table 3). Onager applied at the tassel stage took 4 weeks to give 61% control. But leaf damage for corn from these treatments was minimal at the end of the season, 8 weeks later, and the number of green leaves was not significantly different from the best treatment, but was significantly different from the untreated control (Table 3). Onager treatments increased grain yield 44.5 to 63 Bu/A relative to the untreated control (Table 3). These treatments seemed to suppress the late season twospotted spider-mite populations (Table 3).

The high rate of the experimental miticide, GWN1187, applied at the whorl stage or at the tassel stage, gave excellent, 90 to 96%, control soon after application, and averaged 86 to 90% season-total control (Tables 1 & 2). Corn receiving the whorl-stage treatment had one of the highest percentages of twospotted spider mites, but this was probably because of the effectiveness of this treatment, and only small numbers of mites remained, mostly twospotted spider mites (or the late-season twospotted spider-mite populations may have reinvaded the plots) (Table 2). Leaf damage at the end of the season was minimal for corn receiving the three GWN1187 treatments, and the number of green leaves remaining was the best of any treatment in the experiment (Table 3). The GWN1187 treatments seemed to give good knock-down, and also good season-total, twospotted spider-mite control.

Predator mite populations in wheat in May averaged 0.47 mites per row foot. On June 27, they averaged 0.05 mites per 2 plants, and remained at these small populations until August 11, when numbers increased to 8.5 mites per 2 plants (Table 4). It was not clear that the miticide treatments affected the predator mite populations except in reducing their food supply. The predator mite numbers were too small to suppress spider-mite populations until mid-August. Predator mite numbers were less in most of the miticide treatments, but this was probably correlated with availability of spider mite prey populations (Table 1 & 4).

Thrip populations averaged 23 thrips per 2 plants at pretreatment. Populations increased to 24 to 59 thrips per 2 plants on July 7, and then decreased rapidly as the plants reached tassel stage (Table 4). It was not clear that the miticide treatments affected the predator mite populations. The thrips seemed to be important early-season facultative predators of the spider mites. The spider-mite populations increased rapidly when the thrip populations declined during the corn reproductive stage.

Henderson, C.F., and W. Tilton. 1955. Tests with Acaricides against the Brown Wheat Mite. Journal of Economic Entomology 48: 157-161.

Sloderbeck, P.E., W.P. Morrison, C.D. Patrick, and L.L. Buschman. 1988. Seasonal shift in species composition of spider mites (Tetranychidae) in corn. Southwestern Entomologist 13: 63-68.

Table 1. Spider mites per 4 half plants (=2 plants) and late-season green leaves on plants in plots treated with miticides, SWREC, Garden City, Kansas. Miticide Trial # 1, 2003.

	Treatment Chemical	Rate per acre	Timing	Spider Mites per 2 plants [1] 6/27 Pre-treat	7/7 2 d PT	7/14 9 d PT	7/21 16 d PT	7/28 23 d PT	8/4 30 d PT	8/11 37 d PT	Season Total
1	Check	—	—	**2.7**	**8**	**48 a**	**43 a**	**154 ab**	**544 a**	**1385 a**	**2618 a**
2	Comite II 6EC	2.0 pt	Whorl		**11**	**10 ab**	**47 a**	**195 a**	**195 ab**	**775 a**	**1442 ab**
3	Onager 1E	10 oz	Whorl		**16**	**0 c**	**0 cd**	**7 c**	**22 cd**	**143 b**	**215 d**
4	Onager 1E	12 oz	Whorl		**3**	**0 c**	**7 bcd**	**8 c**	**5 d**	**189 b**	**232 cd**
5	Onager 1E	16 oz	Whorl		**3**	**1 bc**	**0 d**	**10 c**	**37 bcd**	**150 b**	**226 d**
6	GWN1187	1.5 pt	Tassel		10	15 ab	**7 abc**	**11 c**	**55 bcd**	**181 b**	**315 cd**
7	GWN1187	2.0 pt	Tassel		34	68 a	**5 abcd**	**21 c**	**28 bcd**	**140 b**	**329 cd**
8	Comite II 6EC	2.0 pt	Tassel		11	61 a	**26 a**	**160 ab**	**103 bc**	**692 a**	**1208 ab**
9	Onager 1E	16 oz	Tassel		34	14 ab	**21 ab**	**38 bc**	**82 bc**	**152 b**	**528 bcd**
10	GWN1187	2.0 pt	Dough		13	16 ab	48 a	371 a	**113 bc**	**160 b**	**801 bc**
	F-test-Prob.				0.354	0.0007	0.0036	0.0001	0.0111	0.0004	0.0005
	CV %				36	38	47	27	33	19	18

[1] Means within a column that are followed by the same letter are not significantly different (P ≤ 0.05, LSD)
Treatments 2 through 5 were applied July 5, when corn was in late-whorl (4-ft) stage. Treatments 6 through 9 were applied July 16, when corn was beginning to tassel. Treatment 9 was applied July 28, when the corn was in the soft dough stage. Post-treatment counts are in bold. Leaf ratings were made September 12.

Table 2. Spider mite percentage control in plots treated with miticides, SWREC, Garden City, Kansas. Miticide Trial #1, 2003.

	Treatment Chemical	Rate per acre	Timing	Spider Mite Percentage Control [1] 6/27 Pre-Treat	7/7 2 d PT	7/14 9 d PT	7/21 16 d PT	7/28 23 d PT	8/4 30 d PT	8/11 37 d PT	Season Total
1	Check	—	—	—	—	—	—	—	—	—	—
2	Comite II 6EC	2 pt	Whorl	—	**-50**	**79**	**-8**	**-27**	**64**	**44**	**38**
3	Onager 1E	10 oz	Whorl	—	**-115**	**100**	**99**	**95**	**96**	**90**	**91**
4	Onager 1E	12 oz	Whorl	—	**60**	**100**	**98**	**95**	**99**	**86**	**90**
5	Onager 1E	16 oz	Whorl	—	**65**	**97**	**100**	**93**	**93**	**89**	**90**
6	GWN1187	1.5 pt	Tassel			—	**50**	**77**	**68**	**59**	**57**
7	GWN1187	2.0 pt	Tassel			—	**93**	**90**	**96**	**93**	**90**
8	Comite II 6EC	2.0 pt	Tassel			—	**53**	**-17**	**85**	**60**	**57**
9	Onager 1E	16 oz	Tassel			—	**-75**	**-13**	**47**	**61**	**19**
10	GWN1187	2.0 pt	Dough					—	**91**	**95**	**86**

[1] Percentage control calculated according to the method of Henderson & Tilton (1955).

Table 3. Summary of spider mite data in plots treated with miticides during the season together with end-of-season observations on the plants, SWREC, Garden City, Kansas. Miticide Trial #1, 2003.

	Treatment Chemical	Rate per acre	Timing	Season Total Spider Mites per 2 plants	% Control [1] season total	% TSM [2] 8/11	No. Green [3] Leaves/plant 9/12	Yield [3] bu/acre
1	Check	—	—	**2618 a**	**—**	**1.1**	**1.7 b**	**98.3 c**
2	Comite II 6EC	2.0 pt	Whorl	**1442 ab**	**38**	**26.0**	**1.5 b**	**111.3 c**
3	Onager 1E	10 oz	Whorl	**215 d**	**91**	**6.3**	**6.3 a**	**161.3 ab**
4	Onager 1E	12 oz	Whorl	**232 cd**	**90**	**14.7**	**6.3 a**	**142.8 b**
5	Onager 1E	16 oz	Whorl	**226 d**	**90**	**9.9**	**7.0 a**	**157.0 ab**
6	GWN1187	1.5 pt	Tassel	**315 cd**	**57**	**7.0**	**7.1 a**	**183.9 a**
7	GWN1187	2.0 pt	Tassel	**329 cd**	**90**	**26.4**	**6.7 a**	**157.2 ab**
8	Comite II 6EC	2.0 pt	Tassel	**1208 ab**	**57**	**6.8**	**2.4 b**	**109.6 b**
9	Onager 1E	16 oz	Tassel	**528 bcd**	**19**	**10.4**	**7.7 a**	**149.6 b**
10	GWN1187	2.0 pt	Dough	**801 bc**	**86**	**11.4**	**8.4 a**	**152.3 b**
	F-test-Prob.			0.0005	—	0.1124	<0.0001	0.0001
	CV %			18%	—	5%	26%	14%

[1] Percentage control calculated according to the method of Henderson & Tilton (1955).
[2] Percentage twospotted spider mites.
[3] Means within a column that are followed by the same letter are not significantly different ($P \leq 0.05$, LSD)

Table 4. Numbers of thrips and predator mites per 4 half plants (=2 plants) in plots treated with miticides, SWREC, Garden City, Kansas. Miticide Trial #1, 2003.

	Treatment Chemical	Rate per acre	Timing	Thrips per 2 plants: 6/27 Pre-Treat	7/7 2 d PT	7/14 9 d PT	7/21 16 d PT	7/28 23 d PT	8/4 30 d PT	8/11 37 d PT	Predator Mites/2 pl 8/11
1	Check	—	—	**23**	**29**	**15**	**3**	**3**	**4**	**1**	**8.5**
2	Comite II 6EC	2.0 pt	Whorl		**31**	**12**	**7**	**3**	**4**	**0**	**2.0**
3	Onager 1E	10 oz	Whorl		**56**	**13**	**3**	**2**	**4**	**1**	**0.0**
4	Onager 1E	12 oz	Whorl		**20**	**7**	**5**	**2**	**4**	**1**	**0.0**
5	Onager 1E	16 oz	Whorl		**55**	**13**	**4**	**2**	**2**	**1**	**0.5**
6	GWN1187	1.5 pt	Tassel		51	18	**2**	**2**	**2**	**1**	**0.5**
7	GWN1187	2.0 pt	Tassel		59	12	**3**	**2**	**2**	**1**	**0.8**
8	Comite II 6EC	2.0 pt	Tassel		52	19	**5**	**3**	**2**	**5**	**2.0**
9	Onager 1E	16 oz	Tassel		28	8	**7**	**3**	**3**	**0**	**1.3**
10	GWN1187	2.0 pt	Dough		24	10	3	2	**2**	**2**	**3.3**
	F-test-Prob.				0.0116	0.285	0.384	0.913	0.607	0.376	0.427
	CV %				43	55	93	84	88	201	265

Treatments 2 through 5 were applied July 5,when corn was in late-whorl (4-ft) stage. Treatments 6 through 9 were applied July 16, when corn was beginning to tassel. Treatment 9 was applied July 28, when the corn was in the soft dough stage. Post-treatment counts are in bold.

EFFICACY OF MITICIDES APPLIED EARLY TO CONTROL SPIDER MITES IN CORN, TRIAL #2, 2003

by
Larry Buschman, Randall Currie, and Phil Sloderbeck

SUMMARY

Spider mite populations increased to 1,496 mites per 2 plants at 32 days post treatment and caused sever leaf damage by the middle of September, killing an average 8 leaves per plant. Comite treatments gave some early control, but little season-total spider mite control. Corn treated with Comite suffered leaf damage similar to that of the untreated control and Comite treatment at late-whorl and tassel added only 2.5 and 12.2 Bu/A grain yield, respectively. The higher rate of Oberon applied at late-whorl and tassel seemed to give excellent, 72 and 92%, season-total spider mite control, but leaf damage at the end of the season on corn treated with Oberon was moderate, and there were about the same number of green leaves as on the control. The higher rate of Oberon applied at late-whorl and tassel,increased grain yield 38.4 and 40.7 Bu/A, respectively, relative to the untreated control. Oberon plus Capture and Capture alone applied at dough stage gave good, 66 to 70%, spider mite control, but leaf damage on corn from these treatments was severe at the end of the season, and there were about the same number of green leaves as in the control. The Capture treatments increased grain yield 17.7 and 25.7 Bu/A, respectively, relative to the untreated control. The Agri-Mek plus Oberon treatment applied at dough stage gave excellent, 84%, spider mite control, and corn treated with Agri-Mek had the least amount of leaf damage at the end of the season. The Oberon plus Agri-Mek treatment increased grain yield 75.1 Bu/A relative to the untreated control. Predator mite populations increased during the trial, but did not seem to affect spider mite populations until August. Thrip populations were large during the whorl stage, and mite populations seemed to increase as thrip populations declined. Predator-mite and thrip populations did not seem to be affected by the miticide treatments.

PROCEDURES

Field corn, DKC60-10 (RR/YGCB) (110-day maturity), was planted May 5with a John Deere MaxEmerge 6 row planter at a rate of 36,000 seeds/acre in a furrow-irrigated field (Finnup #8) 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. Treatments #2 through 5 were applied July 5, when the corn was in late-whorl stage (4 ft). Treatments #6 through 9 were applied July 16, when the corn was just starting to tassel. The last treatment #10 was applied July 28, when the corn was in the soft-dough stage. The treatments were applied with a high-clearance sprayer using a 10-ft boom with two nozzles directed at each row (one nozzleon each side of the row on a 16-inch drop hose). The nozzles were directed up into the plant for the first treatment and at the ear zone for the other applications. The sprayer was calibrated to deliver 14 gal/acre at 2 mph and 40 psi.

Banks grass mites infested the plots naturally from an adjacent wheat field to the west. In May, spider mites were sampled by collecting 3 row-ft of wheat from 6 locations around the experimental field. Then spider mites were sampled during the summer in corn by collecting half the leaves from 4 plants (4 half plants = 2 plants) from the two center rows in each plot. The plant material was placed in large paper bags and transported to the laboratory, where it was placed in 76-liter Berlese funnels. A light bulb was used to dry the vegetation and to 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 Banks grass mites and spider mites in the populations from each plot. Pre-treatment spider-mite samples were collected June 27 from 20 areas across the field (before the plots were established) and post-treatment samples were collected July 9, 16, 23, 30 and August 6. Spider-mite counts were transformed according to Taylor's power transformation for statistical analysis and were converted to mites per 4 half-plants for presentation. On September 12, the plots were rated for number of green leaves still present. The best treatments still had green leaves down to the ear or lower (10 or more leaves), whereas the check plots had very few green leaves. Grain yield was collected by machine-harvesting two rows from each plot. Because the field was furrow irrigated from one end of the field, there was a significant gradient in the yield going down the field. Therefore, we calculated the "field yield trend" by calculating the average yield across 6 plots at each position 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 and number of green leaves.

RESULTS AND DISCUSSION

In May, spider mite populations in wheat averaged 0.4 mites per square foot. Spider mite populations averaged 2.7 mites per 2 plants on June 27. The mite populations increased to an average of 1,496 mites per 2 plants by August 4. The spider mite populations were 100% Banks grass mites during the pretreatment samples, but the twospotted spider mite populations had increased to 12.6 % in some treatments by August 6 (Table 3). The weather changed in mid-August and seemed to cause a further shift toward twospotted spider mites. In this region, the species complex is often observed to shift from Banks grass mites early in the season to twospotted spider mites later in the season (Sloderbeck et al. 1987). We were unable to take further samples after August 6 to verify that this shift continued, but it can be inferred from the leaf damage recorded in September and from the grain yields recorded at harvest. By September 12, the mites had killed an average of 8 more leaves per plant in the untreated control than in the best treatment (Table 3). There was also 75.1 Bu/A of grain yield lost in the untreated control, compared with the best treatment (Table 3).

The standard early-season miticide, Comite, applied at the whorl stage, averaged only 37% season-total spider mite control (Tables 1 & 2). The highest percentages of twospotted spider mites in the populations did not differ much across treatments (Table 3). Comite applied at the tassel stage gave as much as 82 % control early, but averaged only 28% season-total spider mite control because of the large early mite populations. Leaf damage at the end of the season on corn treated with Comite was severe, however, about 6 leaves killed, and the number of green leaves did not differ from the control (Table 3). This damage seemed to be caused by the late-season twospotted spider mites. Comite treatments at whorl and tassel increased grain yield only 2.5 and 12.2 Bu/A, respectively, relative to the untreated control. These treatments did not seem to suppress the late-season twospotted spider mite populations.

The two rates of Oberon applied at whorl stage gave good, 57 and 92%, season-total spider mite control (Table 2). But leaf damage at the end of the season, 9.5 weeks later, on corn treated with Oberon was moderate to severe, about 6 leaves killed, and the number of green leaves was significantly less than the best treatment, and only the higher rate was significantly better than the control (Table 3). The two rates of Oberon applied at the tassel stage took 4 weeks gave 6 and 77% season-total spider mite control, respectively (Table 2). But leaf damage at the end of the season, 8 weeks later, was moderate to severe on corn treated at tassel with Oberon, about 4 to 6 leaves killed, the number of green leaves was significantly fewer than the best treatment, and only the higher rate was significantly better than the control (Table 3). The higher rate of Oberon (both timings) seemed to give excellent, 72 and 92%, season-total spider mite control. Applying this rate of Oberon increased grain yield 38.4 and 40.7 Bu/A, respectively, relative to the untreated control (Table 3). The higher rate of Oberon seemed to suppress the late-season twospotted spider mite populations (Table 3). (See Post-Tassel Oberon treatments reported in the Post Tassel Trial.)

When applied at the dough stage, the Oberon plus Agri-Mek, Oberon plus Capture, and the Capture-alone treatments gave 84, 66, and 70% season-total spider mite control, respectively (Table 2). Leaf damage at the end of the season, 4 weeks later, in corn from these treatments was lowest (most green leaves) for the Oberon plus Agri-Mek treatment, and it was significantly higher (fewer green leaves) than in corn from many of the other treatments (Table 3). The two

Capture treatments had 6 or 7 dead leaves. The Oberon plus Agri-Mek treatment increased grain yield 75.1 Bu/A relative to the untreated control (Table 3). The Capture treatments increased grain yield 17.7 and 25.7 Bu/A relative to the untreated control. The Oberon plus Agri-Mek treatment seemed to be the best treatment in suppressing the late-season twospotted spider mite populations.

Predator mite populations in wheat in May averaged 0.47 mites per row-foot. On June 27, predator mite populations averaged 0.05 mites per 2 plants, and populations remained small until August 4, when their numbers had increased to 2.5 mites per 2 plants in some plots (Table 3). The predator mite numbers were too small to suppress spider mite populations until mid-August. Predator mite numbers were fewer in most of the miticide treatments, but this was probably correlated with availability of spider mite prey populations (Table 3).

Thrip populations averaged 23 thrips per 2 plants on June 27, and were still high on July 7. They decreased rapidly as the plants reached tassel stage (Table 3). The thrips seemed to be important early-season facultative predators of the spider mites. The spider mite populations increased rapidly when the thrip populations declined during the corn reproductive stage.

Henderson, C.F., and W. Tilton. 1955. Tests with Acaricides against the Brown Wheat Mite. Journal of Economic Entomology 48: 157-161.

Sloderbeck, P.E., W.P. Morrison, C.D. Patrick, and L.L. Buschman. 1988. Seasonal shift in species composition of spider mites (Tetranychidae) in corn. Southwestern Entomologist 13: 63-68.

Table 1. Spider mites per 4 half plants (=2 plants) and late-season green leaves on plants in plots treated with miticides, SWREC, Garden City, Kansas. Miticide Trial #2, 2003.

	Treatment Chemical	Rate lb/acre	Timing	Spider Mites per 2 plants[1] 6/27 Pre-treat	7/9 4 d PT	7/16 11 d PT	7/23 18 d PT	7/30 25 d PT	8/6 32 d PT	Season-total
1	Check	—	—	**2.7**	**5**	**34 ab**	**158**	**365 a**	**1496 a**	**2173 a**
2	Comite II 6EC	1.5	Whorl		**8**	**47 ab**	**128**	**349 a**	**692 ab**	**1360 ab**
3	Oberon 240 EC	0.089	Whorl		**2**	**5 bc**	**79**	**207 ab**	**562 abc**	**944 ab**
4	Oberon 240 EC	0.133	Whorl		**1**	**1 c**	**33**	**15 c**	**104 d**	**176 c**
5	Comite II 6EC	1.5	Tassel		24	58 a	**29**	**326 ab**	**808 ab**	**1560 ab**
6	Oberon 240 EC	0.089	Tassel		11	31 ab	**115**	**236 ab**	**616 ab**	**1088 ab**
7	Oberon 240 EC	0.133	Tassel		11	94 a	**114**	**199 ab**	**349 bcd**	**813 b**
8	Oberon 240 EC +Capture 2EC	0.089 0.08	Dough		19	45 ab	205	**189 ab**	**388 bcd**	**964 ab**
9	Oberon 240 EC +Agri-Mek 0.15EC	0.089 0.089	Dough		19	63 a	270	**126 b**	**126 cd**	**636 bc**
10	Capture 2EC	0.08	Dough		12	66 a	201	**282 ab**	**621 ab**	**1268 ab**
	F-test-Prob.				0.245	0.0357	0.186	0.0009	0.0186	0.0105
	CV %				37	33	26	16	21	16

[1] Means within a column that are followed by the same letter are not significantly different ($P < 0.05$, LSD). Treatments 2 through 4 were applied July 5, when corn was in late-whorl (4-ft) stage. Treatments 5 through 7 were applied July 16, when corn was beginning to tassel. Treatments 9 and 10 were applied July 28, when the corn was in the soft-dough stage. Post-treatment counts are in bold. Leaf ratings were made September 12.

Table 2. Spider mite percentage of control in plots treated with miticides, SWREC, Garden City, Kansas. Miticide Trial #2, 2003.

	Treatment Chemical	Rate per acre	Timing	Spider Mite Percentage Control[1] 6/27 Pre-Treat	7/9 4 d PT	7/16 11 d PT	7/23 18 d PT	7/30 25 d PT	8/6 32 d PT	Season-total
1	Check	—	—	—	—	—	—	—	—	—
2	Comite II 6EC	1.5	Whorl	—	**-60**	**-38**	**19**	**4**	**54**	**37**
3	Oberon 240 EC	0.089	Whorl	—	**60**	**85**	**50**	**43**	**62**	**57**
4	Oberon 240 EC	0.133	Whorl	—	**80**	**97**	**79**	**96**	**93**	**92**
5	Comite II 6EC	1.5	Tassel	—			**82**	**11**	**46**	**28**
6	Oberon 240 EC	0.089	Tassel				**-36**	**-21**	**23**	**6**
7	Oberon 240 EC	0.133	Tassel				**55**	**66**	**86**	**77**
8	Oberon 240 EC	0.089	Dough					**61**	**80**	**66**
	+Capture 2EC	0.08								
9	Oberon 240 EC	0.089	Doug					**81**	**95**	**84**
	+Agri-Mek 0.15EC	0.089								
10	Capture 2EC	0.08	Dough					**60**	**79**	**70**

[1] Percentage of control calculated according to the method of Henderson & Tilton (1955).

Table 3. Summary of spider mite data in plots treated with miticides during the season, together with end of season observations on the plants, SWREC, Garden City, Kansas. Miticide Trial #2, 2003.

	Treatment Chemical	Rate lb/acre	Timing	Season-total Spider Mites per 2 plants	% Control[1] season-total	% TSM[2,3] 8/4	No. Green Leaves/plant 9/12[2]	Yield bu/acre
1	Check	—	—	**2173 a**	**—**	**0.0 c**	**1.8 d**	**100.5 e**
2	Comite II 6EC	1.5	Whorl	**1360 ab**	**37**	**2.3 bc**	**2.4 cd**	**112.7 de**
3	Oberon 240 EC	0.089	Whorl	**944 ab**	**57**	**6.8 ab**	**2.4 cd**	**117.7 de**
4	Oberon 240 EC	0.133	Whorl	**176 c**	**92**	**11.5 a**	**3.9 bc**	**138.9 bc**
5	Comite II 6EC	1.5	Tassel	**1560 ab**	**28**	**6.3 abc**	**3.1 cd**	**103.0 e**
6	Oberon 240 EC	0.089	Tassel	**1088 ab**	**6**	**0.0 c**	**2.1 d**	**120.4 cde**
7	Oberon 240 EC	0.133	Tassel	**813 b**	**77**	**0.0 c**	**5.6 b**	**141.2 b**
8	Oberon 240 EC	0.089	Dough	**964 ab**	**66**	**12.6 a**	**3.3 cd**	**126.3 bcd**
	+Capture 2EC	0.08						
9	Oberon 240 EC	0.089	Dough	**636 bc**	**84**	**6.3 ab**	**9.5 a**	**175.6 a**
	+Agri-Mek 0.15EC	0.089						
10	Capture 2EC	0.08	Dough	**1268 ab**	**70**	**4.4 abc**	**2.5 cd**	**118.2 de**
	F-test-Prob.			0.0105	—	0.0266	≤0.0001	≤0.0001
	CV %			16%	—	33%	33%	11%

[1] Percentage of control calculated according to the method of Henderson & Tilton (1955).
[2] Means within a column that are followed by the same letter are not significantly different ($P < 0.05$, LSD).
[3] Data for two replicates only.

Table 4. Numbers of thrips and predator mites per 4 half plants (=2 plants) in plots treated with miticides, SWREC, Garden City, Kansas. Miticide Trial #2, 2003.

	Treatment Chemical	Rate lb/acre	Timing	Thrips per 2 plants						Predator Mites/2 pl
				6/27 Pre-Treat	7/7 2 d PT	7/14 9 d PT	7/21 16 d PT	7/28 23 d PT	8/4 30 d PT	8/4
1	Check	—	—	**23**	**27**	**8**	**5**	**4**	**1**	**0.75**
2	Comite II 6EC	1.5	Whorl		**29**	**8**	**4**	**3**	**1**	**0.25**
3	Oberon 240 EC	0.089	Whorl		**17**	**4**	**5**	**5**	**1**	**2.5**
4	Oberon 240 EC	0.133	Whorl		**10**	**3**	**3**	**0**	**1**	**0.5**
5	Comite II 6EC	1.5	Tassel		16	10	**2**	**5**	**0**	**0.0**
6	Oberon 240 EC	0.089	Tassel		26	8	**3**	**4**	**1**	**0.0**
7	Oberon 240 EC	0.133	Tassel		14	8	**5**	**4**	**1**	**0.5**
8	Oberon 240 EC +Capture 2EC	0.089 0.08	Dough		21	6	7	**1**	**0**	**0.0**
9	Oberon 240 EC +Agri-Mek 0.15EC	0.089 0.089	Dough		18	9	6	**2**	**0**	**0.0**
10	Capture 2EC	0.08	Dough		10	8	5	**3**	**1**	**0.75**
	F-test-Prob.				0.553	0.557	0.306	0.361	0.877	0.6414
	CV %				76		60	99	153	328

Treatments 2 through 5 were applied July 5, when corn was in late-whorl (4-ft) stage. Treatments 6 through 9 were applied July 16, when corn was beginning to tassel. Treatment 9 was applied July 28, when the corn was in the soft-dough stage. Post-treatment counts are in bold.

EFFICACY OF MITICIDES APPLIED POST-TASSEL TO CONTROL SPIDER MITES IN CORN, POST-TASSEL TRIAL, 2003

by
Larry Buschman, Randall Currie, and Phil Sloderbeck

SUMMARY

Spider mite populations increased to 1,141 mites per 2 plants at 11 to13 days post treatment, and caused severe leaf damage by the middle of September. There was a 60.3 Bu/A grain yield loss in the untreated control relative to the best treatment. The standard miticide, Capture alone at each of two rates, and the experimentalmiticide, Koromite, applied alone, gave 72, 77, and 80% control, respectively, at 6 days post-treatment, but averaged only 42, 65, and 50% season-total spider-mite control. They seemed to knock down mite populations, but they did not seem to hold them down. These treatments increased grain yield 14.2, 3.0, and 1.2 Bu/A, respectively, relative to the untreated control. Capture plus Dimethoate or Capture plus Koromite gave 80 and 78% control, respectively, at 6 days post-treatment, but averaged 76 and 73% season-total spider mite control. These treatments increased grain yield of treated corn by 12.4 and 3.7 Bu/A relative to the untreated control. The Oberon and the Oberon plus Capture treatments averaged only 51 and 50% control, respectively, over the first 11 days, but the leaf damage at the end of the season to treated corn was only about 4 leaves killed. These treatments did not seem to knock down mite populations, but they seemed to hold down the late-season twospotted spider mite populations. These treatments increased grain yield of treated corn by 29.6 and 29.9 Bu/A, respectively, relative to the untreated control. The Agri-Mek and Agri-Mek plus Capture treatments averaged 83 to 95% control, respectively, during the first 11 days, and leaf damage to treated corn was minimal at the end of the season. These treatments increased grain yield of treated corn by 59.6 and 60.3 Bu/A, respectively, relative to the untreated control. The two Agri-Mek treatments gave excellent knockdown, as well as excellent late-season twospotted spider mite control. Predator mite populations increased during the trial, but did not seem to affect spider mite populations until August. Thrip populations were large during the whorl stage, and mite populations seemed to increase as thrip populations declined. Predator mite and thrip populations did not seem to be affected by the miticide treatments.

PROCEDURES

Field corn, DKC60-10 (RR/YGCB) (110-day maturity), was planted May 5 with a John Deere MaxEmerge 6 row planter at a rate of 36,000 seeds/acre in a furrow-irrigated field (Finnup #8) 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. Treatments 2 through 4 were applied July 26, and treatments 5 through 10 were applied July 28. The corn was in the soft-dough stage. The treatments were applied with a high-clearance sprayer using a 10-ft boom with two nozzles directed at each row (one nozzle on each side of the row on 16-in drop hoses). The nozzles were directed at the ear zone. The sprayer was calibrated to deliver 14 gal/acre at 2 mph and 40 psi.

Banks grass mites infested the plots naturally from an adjacent wheat field to the west. In May, spider mites were sampled by collecting 3 row-ft of wheat from 6 locations around the experimental field. Then spider mites were sampled in corn during the summer by collecting half the leaves from 4 plants (4 half plants = 2 plants) from the two center rows in each plot. The plant material was placed in large paper bags and transported to the laboratory, where it was placed in 76-liter Berlese funnels. A light bulb was used to dry the vegetation and to 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 Banks grass mites and twospotted spider mites in the population from each plot. Pre-treatment spider-mite samples were collected July 25, and post-treatment samples were collected August 1 and 8. Spider mite counts were transformed according toTaylor's power transformation for statistical analysis and were converted to mites per 4 half-plants for presentation. On September 12, the plots were rated for number of green leaves still present. Corn receiving the best treatments still had green leaves down to the ear or lower (10 or more leaves), whereas the check plots had very few green leaves. Grain yield was collected by machine harvesting two rows from each plot. Because the field was furrow irrigated from one end of the field, there was a significant gradient in the yield going down the field. Therefore, we calculated the "field yield trend" by calculating the average yield across 6 plots at each position 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 and number of green leaves.

RESULTS AND DISCUSSION

In May, spider-mite populations in wheat averaged 0.4 mites per row-foot. Spider mite populations averaged 2.7 mites per 2 plants on June 27. On July 25, just before treatments were applied, spider mite populations averaged 50 to 193 mites per 2 plants. The mite populations increased to an average of 1,141 mites per 2 plants by August 8. The spider mite populations were 100% Banks grass mites during the pretreatment samples, but by August 8,. the twospotted spider mite populations had increased to 36.9 % in some treatments (Table 2). The percentage of twospotted spider mites did not differ significantly across treatments because of the variability in the data. The weather changed in mid-August, and seemed to cause a further shift toward twospotted spider mites. In this region, the species complex is often observed to shift from Banks grass mites early in the season to twospotted spider mites later in the season (Sloderbeck et al. 1987). We were unable to take further samples after August 8. to verify that this shift continued, but it can be inferred from the leaf damage recorded in September and in the grain yields recorded at harvest. By September 12, the mites had killed an average of 7 more leaves per plant in the untreated control relative to the best treatment (Table 3). There was also a 60.3 Bu/A grain yield loss in the untreated control relative to the best treatment (Table 3).

The standard miticide, Capture, alone at two rates, and the experimental miticide, Koromite, applied alone, gave 72, 77, and 80% control, repectively, at 6 days post-treatment, but averaged only 42, 65, and 50% season-total spider mite control (Table 1). The Capture treatments seemed to have some of the highest twospotted spider mite percentages, (although these differences were not statistically significant) (Table 2). These treatments also did not seem to give late-season twospotted spider-mite control, because leaf damage to treated corn averaged about 6 leaves killed, and the number of green leaves was only slightly better than for the untreated control. These treatments seemed to knock down the Banks grass mite populations, but they did not seem to hold down the late-season twospotted spider mite populations. These treatments increased grain yield of treated corn by 14.2, 3.0, and 1.2 Bu/A, respectively, relative to the untreated control.

Capture plus Dimethoate or Capture plus Koromite gave 80 and 78% control, respectively, at 6 days post-treatment, but averaged 76 and 73% season-total spider mite control (Table 1). These treatments provided slightly better spider mite control than did Capture alone. These treatments also seemed to have some large twospotted spider mite percentages (Table 2). These treatments did not seem to give late-season twospotted spider mite control, because leaf damage to treated corn averaged about 6 leaves killed, and the number of green leaves was only slightly better than for the untreated control. These Capture treatments seemed to knock down the Banks grass mite populations, but they did not seem to hold down the late-season twospotted spider mite populations. These treatments increased grain yield of treated corn by 12.4 and 3.7 Bu/A, respectively, relative to the untreated control.

The Oberon and the Oberon plus Capture treatments averaged only 51 and 50% control, respectively, over the first 11 days (Table 1). But the leaf damage to treated corn at the end of the season, 4 weeks later, was moderate, with only about 4 leaves killed, and there were significantly more green leaves on these treatments than on control plants (Table 2). The Oberon and the Oberon plus Capture treatments did not seem to knock down the mite populations very well, but they seemed to hold down the late-season twospotted spider mite populations better than did Capture alone. These treatments increased grain yield of treated corn by 29.6 and 29.9 Bu/A, respectively, relative to the untreated control.

The Agri-Mek and Agri-Mek plus Capture treatments averaged 83 to 95% control, respectively, during the first 11 days (Table 1). The leaf damage to treated corn at the end of the season was minimal, and the number of green leaves was significantly greater than any other treatment (Table 2). These treatments increased grain yield of treated corn by 59.6 and 60.3 Bu/A, respectively, relative to the untreated control. Agri-Mek treatments seemed to give excellent early-season knockdown, as well as excellent late-season twospotted spider mite control.

Predator mite populations in wheat in May averaged 0.47 mites per row-foot. Throughout July, predator mite populations remained small (data from adjacent plots). Populations increased in August and averaged as much as to 3.5 mites per 2 plants in some of these plots (Table 2). The predator mite numbers were too small to suppress spider mite populations until mid-August. Predator mite numbers were fewer in some of the best miticide treatments, but this was probably correlated with availability of spider mite prey populations (Table 1).

Thrip populations averaged 23 thrips per 2 plants on June 27 and increased to between 24 and 59 thrips per 2 plants on July 7 (data from adjacent plots). They decreased rapidly as the plants reached tassel stage, and averaged only 1 to 4 thrips per 2 plants in August (Table 2). The thrips seemed to be important early-season facultative predators of the spider mites. The spider mite populations increased rapidly when the thrip populations declined during the corn reproductive stage (Table 1).

Henderson, C.F., and W. Tilton. 1955. Tests with Acaricides against the Brown Wheat Mite. Journal of Economic Entomology. 48: 157-161.

Sloderbeck, P.E., W.P. Morrison, C.D. Patrick, and L.L. Buschman. 1988. Seasonal shift in species composition of spider mites (Tetranychidae) in corn. Southwestern Entomologist 13: 63-68.

Table 1. Spider mites per 4 half plants (=2 plants) and late-season green leaves remaining on plants in plots treated with miticides. SWREC, Garden City, Kansas. Post-Tassel Miticide Trial, 2003.

			Spider Mites[1]				% Control [2]		
	Treatment Chemical	Rate per acre	7/25 Pre-T	8/1 P-T	8/8 P-T	Total	8/1 P-T	8/8 P-T	Season Total
1	Check	—	95	**167 a**	**1141 a**	**1438 a**	**—**	**—**	**—**
2	Capture 2E	0.08 lb	130	**65 ab**	**872 abc**	**1138 ab**	**72**	**44**	**42**
3	Capture2E	0.1 lb	97	**40 b**	**365 bcde**	**516 a-d**	**77**	**69**	**65**
4	Capture 2E	0.08 lb	55	**31 b**	**133 de**	**196 d**	**68**	**80**	**76**
	+Dimethoate 400EC	0.5 lb							
5	Oberon 240EC	0.089 lb	86	**192 a**	**318 cde**	**643 a-d**	**-27**	**69**	**51**
6	Oberon 240EC	0.089 lb	50	**55 ab**	**259 de**	**376 b-d**	**37**	**57**	**50**
	+Capture 2EC	0.08 lb							
7	Koromite 1%EC	16 oz	177	**82 ab**	**1052 ab**	**1335 a**	**74**	**51**	**50**
8	Koromite 1%EC	16 oz	193	**68 ab**	**510 abcd**	**775 a-c**	**80**	**78**	**73**
	+Capture 2EC	0.08 lb							
9	Agri-Mek 0.15EC	0.089 lb	129	**38 b**	**152 de**	**285 cd**	**83**	**90**	**85**
10	Agri-Mek 0.15EC	0.089 lb	185	**19 b**	**106 e**	**320 cd**	**94**	**95**	**89**
	+Capture 2EC	0.08 lb							
	F-test-Prob.		0.227	0.0633	0.011	0.011			
	CV %		25	23	18	18			

[1] Means within a column that are followed by the same letter are not significantly different (P < 0.05, LSD).
2 Percentage of control calculated according to the method of Henderson and Tilton (1955).
Treatments 2 through 4 were applied July 26 and treatments 5 through 10 were applied July 28. The corn was in the soft- dough stage. Post-treatment counts are in bold. Leaf ratings were made September 12.

Table 2. End-of-season observations on corn, percentage of two-spotted spider mites, and numbers of predator mites and thrips per 4-half plants (=2 plants) in plots treated with miticides. SWREC, Garden City, Kansas. Post-Tassel Miticide Trial, 2003.

	Treatment Chemical	Rate per acre	No. Green Leaves/plant[1] 9/12	Grain Yield[1] Bu/A	% TSM [2] 8/8	Predator Mites 8/8	Thrips 7/25 Pre-T	Thrips 8/1 P-T	Thrips 8/8 P-T
1	Check	—	**2.6 e**	**144.7 c**	**29.6**	**0.5**	2	**2**	**2**
2	Capture 2E	0.08 lb	**3.8 de**	**158.9 bc**	**27.5**	**0.8**	2	**1**	**2**
3	Capture2E	0.1 lb	**4.2 cd**	**147.7 c**	**6.8**	**1.5**	5	**3**	**3**
4	Capture 2E	0.08 lb	**4.7 bcd**	**157.1 bc**	**36.9**	**0.5**	4	2	1
	+Dimethoate 400EC	0.5 lb							
5	Oberon 240EC	0.089 lb	**6.2 b**	**174.3 b**	**4.4**	**3.5**	3	**3**	**2**
6	Oberon 240EC	0.089 lb	**5.4 bc**	**174.6 b**	**22.8**	**0.8**	1	**3**	**1**
	+Capture 2EC	0.08 lb							
7	Koromite 1%EC	16 oz	**4.1 cde**	**145.9 c**	**3.9**	**0.0**	3	**2**	**1**
8	Koromite 1%EC	16 oz	**3.4 de**	**148.4 c**	**16.3**	**0.0**	4	**1**	**1**
	+Capture 2EC	0.08 lb							
9	Agri-Mek 0.15EC	0.089 lb	**9.8 a**	**204.3 a**	**19.4**	**0.5**	5	**4**	**0**
10	Agri-Mek 0.15EC	0.089 lb	**9.9 a**	**205.0 a**	**4.4**	**0.3**	4	**1**	**1**
	+Capture 2EC	0.08 lb							
	F-test-Prob.		>0.0001	>0.0001	>0.500	0.567	0.493	0.081	0.456
	CV %		19%	9%	69%	270	71	64	123

[1] Means within a column that are followed by the same letter are not significantly different (P < 0.05, LSD).
[2] Percentage of two-spotted spider mites.
Treatments were applied July 26 and 28, when the corn was in the soft-dough stage. Post-treatment counts are in bold. Leaf ratings were made September 12.

HEAD DAMAGE SIMULATION IN WINTER WHEAT

by
Merle Witt

SUMMARY

Research to evaluate the response of winter wheat to the loss of variable percentages of primary heads at 3 growth stages in the spring of 2003 was sponsored by grant funding from the National Crop Insurance Services.

INTRODUCTION

Hailstorm and/or freeze damage occur nearly every year in some portion of Western Kansas, where turbulent weather influences wheat in its more vulnerable stages of spring growth. This study simulated this type of damage to evaluate resulting losses.

PROCEDURES

A wheat variety common to the area, "TAM 110", was planted in alternately bordered drill strips on October 8, 2002. Plots were established by seeding 42 pounds per acre in 3 replicate fashion by using 100-square-foot plots with 10 inch row spacing and 20-ft row length in a dryland, fallowed field.

Head/leaf defoliation of 0%, 33%, 66%, or 100% was manually accomplished at 3 growth stages with a vertically held, gas-powered string trimmer. The first head-removal stage (Before Flag Leaf) was accomplished April 22, 2003. The second treatment stage (After Flag Leaf) was completed May 2, 2003. The final growth-stage treatment (Flowering) was performed on May 15, 2003.

Table 1. Effect of primary head removal at 3 growth stages on winter wheat production at Garden City, Kansas, 2003.

Growth Stage	Treatment % Heads Removed	Height inches	Heads per 10' row	Grain Bu/a	Grain lb/bu
Before Flag Leaf	0	30.5	507	64.4	60
	33	29.3	615	61.5	60
	66	26.7	560	49.7	58
	100	26.7	429	37.0	57
After Flag Leaf	0	30.5	507	64.4	60
	33	28.7	600	61.5	59
	66	27.3	551	50.0	57
	100	25.3	422	33.4	55
Flowering	0	30.5	507	64.4	60
	33	28.7	416	47.7	58
	66	27.3	289	30.5	55
	100	24.0	115	12.3	51
LSD (5%)					
- Growth Stage		2.8	62	7.2	—
- Head Loss Trt.		1.3	54	4.7	—
- G.S. X H.L. Trt.		2.2	93	8.1	—
CV		4.6%	11.9%	10.5%	—

As noted in Table 1, increasing amounts of primary head removal caused increasing reduction in plant height and increasing delay, particularly with the latest (flowering) stage of application when temperatures were highest. Triggering of spring tiller development to compensate for primary head removal at flowering stage caused reduction percentages as shown in Table 2.

The year 2003 provided a cool, extended grain-filling period such that later replacement tillers compensated for primary head loss more effectively than usual. But the negative effects of tiller substitution/delay became most obvious with the final flowering-stage treatment, in which complete head removal allowed only 23% head replacement by late tillers, which produced only 19% of check-treatment grain yield.

The nemesis of spring tiller compensation and the accompanying later heading is commonly the higher temperatures that increasingly accompany delayed heading and grain filling. Wheat persists as a cool-season crop and routinely truncates seed set and seed size with elevated temperatures.

Delayed crop maturity indirectly causes yield losses because of increasing respiratory rates without parallel photosynthetic enhancement, notably at night.

Table 2. Effects of percentage of head removal in wheat, Garden City, Kansas in 2003.

% Head Removal Trt.	Head # Reduction	Height Reduction	Grain Reduction	Test Wt. Reduction
0	0	0	0	0
33	18	6	26	3
66	43	7	53	8
100	77	21	81	15

TRITICALE VARIETY PRODUCTION TRIAL

by
Merle Witt

SUMMARY

Seven triticale entries produced higher forage yields and higher grain yields than a wheat check. As a group, the triticales out-produced wheat and provided an average of 15% more winter forage and 36% more harvested grain.

INTRODUCTION

Producers at times consider small grain crops for livestock forage. Additionally, triticale grain provides an efficient source of livestock feed, with particularly desirable qualities for swine feeding. This trial was conducted to compare same triticale variety possibilities for their production potential relative to wheat.

PROCEDURES

A dryland triticale variety trial was planted September 30, 2002, at 60 lbs/a with 4 replications of plots. Forage yields were taken during the winter on February 18, 2003, by hand clipping 10' of row length per plot at 1" above the ground. Grain yields were harvested June 26, 2003, on 250 sq. ft. plots. A wheat variety, TAM 107, served as the check entry for comparison.

RESULTS AND DISCUSSION

Although late maturing varieties of the cereal crops often have smaller grain yields and reduced test weights due to hot winds in June, little heat stress occurred during the grain filling period in 2003. Thus, delayed maturity was not detrimental in this year. Because of its durability, great production potential, and feeding characteristics, triticale remains a viable forage crop for grazing ruminants, and a desirable ingredient in grain feeding rations.

Table 1. Triticale variety trial, SWREC, Garden City, 2003.

Entry	Forage lbs/acre (February)	Date Headed	Height Inches	Grain	
				Test Wt.	lbs/acre
Kitaro	600	5/10	35.5	55.3	3923
Lamberto	642	5/11	35.5	52.2	3637
Sorento	624	5/13	32.5	51.0	3228
Thundercale P	659	5/7	35.0	54.2	3461
Thundercale V	573	5/10	37.5	53.0	3360
RSI 1439-960	851	5/9	34.5	53.7	3483
RSI Trical 336	679	5/9	35.0	53.9	3274
Wheat-TAM 107	572	5/6	27.5	60.0	2561
C.V.%	15.4	1	5.8	0.8	10.5
L.S.D. (5%)	49	1	1	0.2	171
Mean	650	5/10	34.1	54.1	3366

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Ron Hale—Extension Animal Scientist. Ron received his M.S. from Brigham Young University and his Ph.D. from Texas A&M. He joined the staff in 2001. His extension responsibilities include all aspects of animal production.

Norman Klocke—Water resources engineer. Norm received B.S. from the University of Illinois, his M.S. from the University of Kansas, and his Ph.D. from Colorado State University. He joined the staff in 2001. His research emphasis includes limited irrigation, water conservation, and leaching.

Alan Schlegel—Agronomist-in-Charge, Tribune. Alan received his M.S. and Ph.D. degrees at Purdue University. He joined the staff in 1986. His research involves fertilizer and water management in reduced tillage systems.

Phil Sloderbeck—Extension Entomologist. Phil received his M.S. from Purdue University and his Ph.D. from the University of Kentucky. He joined the staff in 1981. His extension emphasis is on insect pests of field crops.

Curtis Thompson—Extension Agronomist. Curtis received his M.S. from North Dakota State University and his Ph.D. from the University of Idaho. He joined the staff in 1993. His extension responsibilities include all aspects of soils and field crop production.

Tom Willson—Environmental Scientist. Tom received a B.A. in Biology and Environmental Studies from the University of California, Santa Cruz and studied Soil Science at Colorado State University before receiving his PhD in Soil Ecology and Sustainable Agriculture from Michigan State University. Tom's current research activities include integrating manure and irrigation water management in grain and forage production, water quality projects, and resource conserving/odor reducing technologies. He joined the staff in October 2000.

Merle Witt—Agronomist –Crop Specialist. Merle received his M.S. at Kansas State University and joined the staff in 1969. He received his Ph.D. from the University of Nebraska in 1981. Merle's research has included varietal and cultural testing of established crops and potential crops for southwest Kansas.

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