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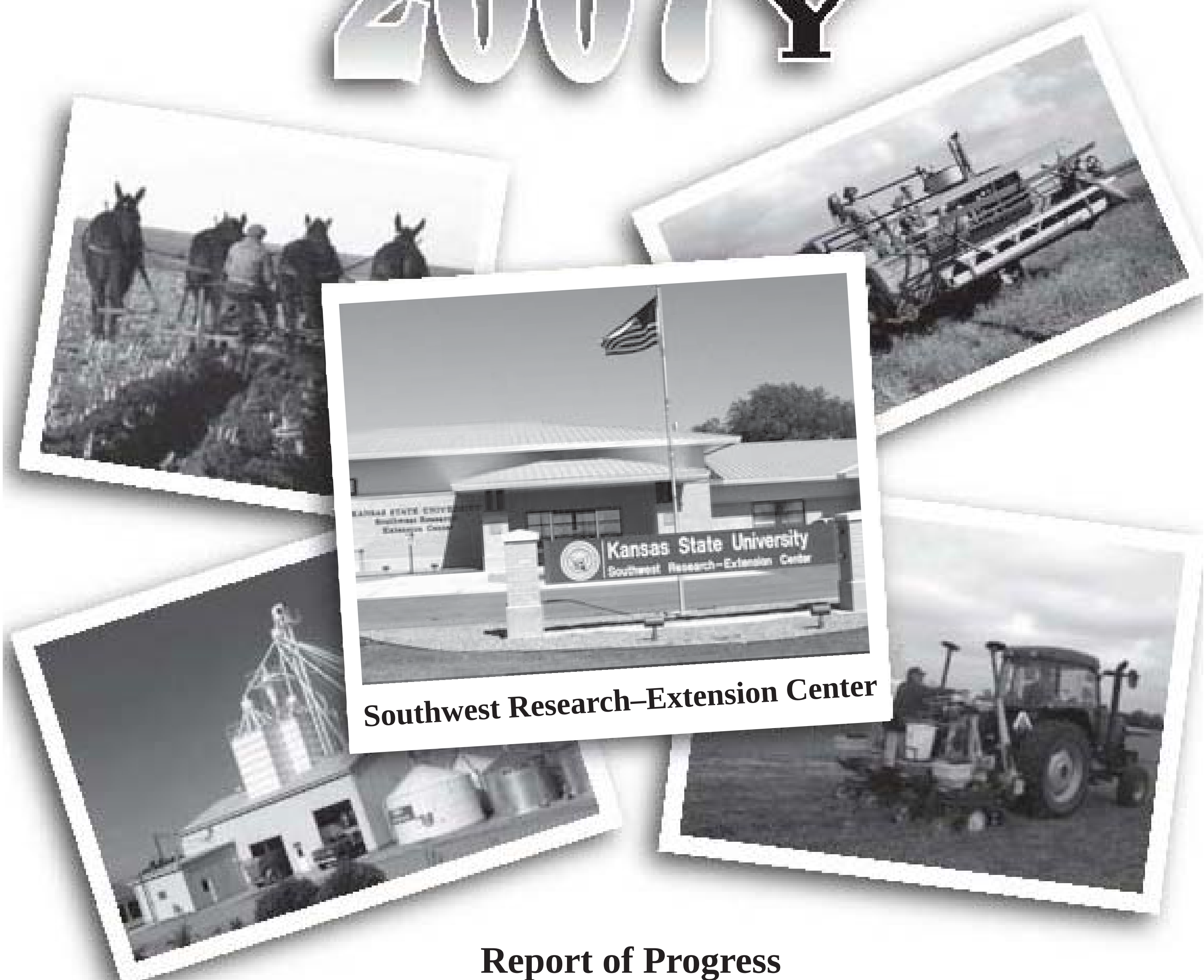

Southwest Research–Extension Center

Report of Progress
980

Kansas State University
Agricultural Experiment Station
and Cooperative Extension Service

Robert (Bob) Gillen—Center Head. Earned a B.S. degree, Colorado State University, 1978; Ph.D., Oregon State University, 1982. He was appointed head of the Western Kansas Ag Research Centers (Colby, Garden City, Hays, and Tribune) in 2006. Dr. Gillen's research interests include grazing management systems, grassland ecology, and forage establishment.

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.

Mahbub Alam—Extension Specialist, Irrigation and Water Management. Mahbub received his M.S. from the American University of Beirut, Lebanon, and a Ph.D. from Colorado State University. He joined the staff in 1996. Mahbub previously worked for Colorado State University as an Extension Irrigation Specialist. His extension responsibilities are in the area of irrigation and water management.

Debra Bolton—Extension Specialist, Family Consumer Sciences. Debra received her Bachelor's degree in English from St. Mary of the Plains College and her Master's degree from Fort Hays State University. She works with county agents on various grant projects, in program development, and training. Her research focuses on families in their environments and community development processes.

Larry Buschman—Entomologist. Larry received his M.S. at Emporia State University and his Ph.D. at the University of Florida. He joined the staff in 1981. His research includes studies of the biology, ecology, and management of insect pests, with emphasis on pests of corn, including spider mites.

Rod Buchele—Extension Specialist, 4-H Youth Development. Rod received his BS from Iowa State University in Economics in 1969 and his MS in Guidance and Counseling from the University of Wisconsin - Platteville in 1978. He joined the staff in fall of 2003, coming from Colorado State University Cooperative Extension. He previously held positions with the University of Florida Cooperative Extension and the University of Wisconsin University Extension, all in the 4-H Development program area.

Randall Currie—Weed Scientist. Randall began his agriculture studies at Kansas State University, where he received his B.S. degree. He then went on to receive his M.S. from Oklahoma State University and his Ph.D. from Texas A & M University. His research emphasizes weed control in corn.

Troy Dumler—Extension Agricultural Economist. Troy received his B.S. and M.S. from Kansas State University. He joined the staff in 1998. His extension program primarily focuses on crop production and machinery economics.

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2006 RESEARCH-EXTENSION CENTER STAFF

Robert Gillen	Head
Paul Hartman	Area Extension Director
Conall Addison	Instructor Emeritus
Mahbub Ul Alam	Extension Specialist, Irrigation
Debra Bolton	Extension Specialist, Family Consumer Sciences
Dewayne Bond	Assistant Scientist
Rod Buchele	Extension Specialist, 4-H Youth Development
Larry Buschman	Corn Entomologist
Randall Currie	Weed Scientist
Les DePew	Professor Emeritus
Troy Dumler	Extension Agricultural Economist
Jeff Elliott	Research Farm Manager
Gerald Greene	Professor Emeritus
Vacant	Extension Specialist, Animal Production
George Herron	Professor Emeritus
Johnathon Holman	Assistant Professor
Norman Klocke	Irrigation Engineer
James Lee	Assistant Scientist
Ray Mann	Professor Emeritus
Gary Miller	Assistant Scientist
Charles Norwood	Professor Emeritus
Alan Schlegel	Agronomist-in-Charge, Tribune
Phil Sloderbeck	Extension Specialist, Entomology
Curtis Thompson	Extension Specialist, Crops and Soils
Carol Young	Associate Professor Emeritus

2007 SUPPORT PERSONNEL

Jovita Baier, Administrative Specialist
Rita Dome, Senior Administrative Assistant
Manuel Garcia, Gen. Maintenance & Repair Tech. II
Ramona Hinde, Senior Administrative Assistant
William Irsik, Equipment Mechanic Senior
Jaylen Koehn, Plant Science Technician II
Scott Maxwell, Plant Science Technician II
Joanna Meier, Accountant I
Henry Melgosa, Plant Science Technician II
Dale Nolan, Plant Science Technician II - Tribune
David Romero, Jr., Equipment Mechanic
Eva Rosas, Administrative Specialist
Tim Sanko, Plant Science Technician II
Ramon Servantez, Plant Science Technician II
Jeff Slattery, Plant Science Technician II - Tribune
Monty Spangler, Agricultural Technician
Dennis Tomsicek, Plant Science Technician II
Vacant, Plant Science Technician II,
Vacant, Laboratory Technician III

Southwest Research-Extension Center
4500 East Mary, Bldg. 947
Garden City, KS 67846
620-276-8286
Fax No. 620-276-6028

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WEATHER INFORMATION FOR GARDEN CITY

by
Jeff Elliot

Total 2006 precipitation was 22.79 inches, or 4 inches above the 30-year annual average. Seasonal distribution was relatively normal until December, when the area received rain, freezing rain, sleet, and snow in two separate events totaling 4.97 inches. This made December, normally Garden City's driest month, the wettest of 2006, as well as the wettest December since moisture records began in 1908. The December ice storm was very hard on trees and power lines. The driest month, February, had no measurable precipitation.Pea-sized hail was recorded on May 8, nickel-sized on May 9, and dime-sized on July 12.

Snowfall for 2006 totaled 16.7inches, slightly less than the 19.51" average. The largest snowfall (8) occurred March 20-21. Seasonal snowfall (2005-2006) measured 15.9"

July was the warmest month, with an average daily mean temperature of 80.9°F (3.5°F above the 30-year norm). January was extremely warm, with an average daily mean temperature of 39.3°F (30-year average: 28.4°). December was the coolest month, with an average daily mean temperature of 32.9°F, or 1.6° above normal. The average daily mean temperature for the entire year was 55.8°F (2.7°F above our 30-year average). It was our ninth consecutive year with above-normal temperatures.

Nine record-high temperatures were broken or tied in 2006: 76°F on January 8, 84°F on March 1, 89°F on April 11, 94°F on April 14, 100°F on May 20, 105°F on June 21, 106°F on July 26, 96°F on October 3, and 96°F on October 4. Triple-digit temperatures were recorded on 19 days in 2006 (including eight consecutive beginning July 14), with the highest being 106°F on July 21 and July 26. A sub-zero temperature was recorded once in 2006 (-2°F on February 18). Only six days in 2006 recorded single-digit low temperatures. No record lows were observed in 2006.

The last spring freeze (30°F) was on April 27, which was normal. The first fall freeze (26°F) was on October 19, eight days later than normal. This resulted in a 175-day frost-free period, which was eight days longer than the 30-year average. Open-pan evaporation from April through October totaled 79.12 inches, substantially higher than the 70.6 inches average. Average daily wind speed was 4.99 mph, compared to 5.25 mph on average.

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

	Precipitation inches		Monthly Average Temperature (°F)						Wind MPH		Evaporation inches	
			2006 Average		Mean		2006 Extreme					
Month	2006	Normal	Max	Min	2006	Avg.	Max	Min	2006	Normal	2006	Normal
January	0.27	0.43	56.8	21.8	39.3	28.4	76	13	4.43	4.68	n/a	n/a
February	0.00	0.48	51.3	15.6	33.5	33.7	76	-2	5.01	5.39	n/a	n/a
March	1.45	1.38	59.6	29.2	44.4	42.3	76	10	7.19	6.72	n/a	n/a
April	0.76	1.65	75.6	40.2	57.9	52.1	94	21	6.44	6.73	10.71	8.35
May	2.52	3.39	80.8	51.4	66.1	62.0	100	34	4.85	6.04	12.22	9.93
June	2.33	2.88	91.4	60.5	76.0	72.4	105	50	5.84	5.59	15.68	12.32
July	4.67	2.59	95.4	66.4	80.9	77.4	106	59	3.88	4.85	14.67	13.41
August	2.57	2.56	90.0	63.9	77.0	75.5	104	50	4.33	4.17	11.15	11.19
September	0.89	1.25	79.3	48.8	64.1	67.0	97	38	4.87	4.63	8.89	8.88
October	2.30	0.91	69.9	39.9	54.9	54.9	96	24	5.02	4.84	5.80	6.52
November	0.06	0.86	59.5	25.4	42.4	40.5	85	11	4.77	4.86	n/a	n/a
December	4.97	0.41	46.3	19.5	32.9	31.3	65	9	3.28	4.47	n/a	n/a
Annual	22.79	18.79	71.3	40.2	55.8	53.1	106	-2	4.99	5.25	79.12	70.60

Normal latest freeze (32 °F) in spring: April 27. 2006: April 27.
Normal earliest freeze (32 °F) in fall: October 11. 2006: October 19.
Normal frost-free (> 32 °F) period: 167 days. 2006: 175 days.
Normal is 30-year average (1971-2000).

WEATHER INFORMATION FOR TRIBUNE

by
Dewayne Bond and Dale Nolan

December received a record-shattering monthly total of 3.82” of precipitation, breaking the previous monthly record of 2.08” set in 1913. This gave a yearly total of 19.02”, which was 1.58” above normal, even though only three months had above-normal precipitation. October was the wettest month, with 4.05”. The largest single amount of precipitation was 2.56” on October 27. February was the driest month, with 0.01” of precipitation. Snowfall for the year totaled 37.6”: 2.8” in January, 0.1” in February, 7.1” in March, 2.3” in November, and 25.3” in December, for a total of twenty-three days of snow cover. The year ended with twelve days of snow cover on December 20-31, which was the longest consecutive period.

Record high temperatures were recorded on ten days: January 8 (73°), March 1 (80°), March 8 (80°), April 14 (91°), May 27 (100°), May 28 (100°), May 29 (98°), July 18 (107°), November 9 (83°), and November 22 (75°). Record high temperatures were tied on six days: April 24 (93°), April 28 (86°), May 23 (95°), July 20 (106°), October 2 (93°), and October 3 (95°). Record low temperatures were set on February 19 (-3°) and April 26 (20°). July was the warmest month, with a mean temperature of 79.4° and the hottest day of the year (July 18, 107°). The coldest day of the year was February 18 (-4°). December was the coldest month, with a mean temperature of 31.5°.

The mean air temperature was above normal for 10 months. February was normal, January had the greatest departure above normal (11.1°), and September was below normal (-3.3°). There were 22 days of 100° temperatures or above (twelve more than normal). There were 75 days of 90° or above temperatures (13 more than normal). The last day of 32° or less in the spring (April 26) was 10 days earlier than normal, and the first day of 32° or less in the fall (October 13) was 10 days later than normal. This produced a frost-free period of 170 days, or 20 days more than normal.

Open-pan evaporation for the period April through September totaled 78.63 inches, which was 7.98 inches above normal. The average wind speed for the same period was 4.8 mph, which was 0.7 mph less than normal.

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

	Precipitation inches		Temperature (°F)						Wind MPH		Evaporation inches	
			2006 Average		Normal		2006 Extreme					
Month	2006	Normal	Max	Min	Max	Min.	Max	Min	2006	Normal	2006	Normal
January	0.37	0.45	54.9	22.2	42.2	12.8	73	11				
February	0.01	0.52	50.4	15.3	48.5	17.1	76	-4				
March	1.12	1.22	57.7	26.6	56.2	24.2	80	12				
April	0.18	1.29	73.5	37.2	65.7	33.0	93	20	5.4	6.3	10.31	8.28
May	1.60	2.76	80.3	46.9	74.5	44.1	100	33	4.6	5.8	14.98	10.88
June	3.05	2.62	90.0	58.4	86.4	54.9	102	49	5.5	5.3	15.96	13.88
July	2.11	3.10	94.8	63.9	92.1	59.8	107	55	4.6	5.4	16.96	15.50
August	1.56	2.09	90.7	60.9	89.9	58.4	104	46	4.5	5.0	12.29	12.48
September	1.00	1.31	77.5	46.3	81.9	48.4	94	34	4.0	5.2	8.13	9.63
October	4.05	1.08	68.1	37.3	70.0	35.1	95	20				
November	0.15	0.63	59.3	25.7	53.3	23.1	83	4				
December	3.82	0.37	44.2	18.6	44.4	15.1	69	3				
Annual	19.02	17.44	70.2	38.4	67.1	35.5	107	-4	4.8	5.5	78.63	70.65

Normal latest freeze (32 °F) in spring: May 6. 2006: April 26.

Normal earliest freeze (32 °F) in fall: October 3. 2006: October 13.

Normal frost-free (> 32 °F) period: 150 days. 2006: 170 days.

Normal is 30-year average (1971-2000) from National Weather Service.

Normal for latest freeze, earliest freeze, wind and evaporation is 30-year average (1971-2000) calculated from Tribune weather data.

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

by
Alan Schlegel

SUMMARY

Long-term research shows that phosphorus (P) and nitrogen (N) fertilizer must be applied to optimize production of irrigated grain sorghum in western Kansas. In 2006, N and P applied alone increased yields about 50 and 18 bu/a, respectively, while N and P applied together increased yields more than 60 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 more than 90% of maximum yield in 2006 and for the 10-year average. Application of K has had no effect on sorghum yield throughout the study period.

INTRODUCTION

This study was initiated in 1961 to determine responses of continuous grain sorghum grown under flood irrigation to N, P, and K fertilization. The study was conducted on a Ulysses silt loam soil with an inherently high K content. The irrigation system was changed from flood to sprinkler in 2001.

PROCEDURES

Fertilizer treatments initiated in 1961 were N rates of 0, 40, 80, 120, 160, and 200 lb 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 prior to planting. The soil is a Ulysses silt loam. Sorghum (Pioneer 8414 in 1997 and Pioneer 8500/8505 from 1998-2006) was planted in late May or early June. Irrigation was used to minimize water stress. Furrow irrigation was used through 2000 and sprinkler irrigation since 2001. The center two rows of each plot were machine harvested after physiological maturity. Grain yields were adjusted to 12.5% moisture.

RESULTS AND DISCUSSION

Grain sorghum yields were very good in 2006 and greater than the 10-year average (Table 1). Nitrogen alone increased yields up to 50 bu/a while P alone increased yields up to 18 bu/a, while N and P applied together increased yields up to 60 bu/a. Averaged across the past 10 years, N and P applied together have increased yields up to 55 bu/a. In 2006, 40 lb N/a (with P) produced more than 90% of maximum yields, which is similar to the 10-year average. Sorghum yields were not affected by K fertilization, which has been the case throughout the study period.

Table 1. Effect of N, P, and K fertilizers on irrigated sorghum yields, Tribune, KS, 1997-2006.

N	P_2O_5	K_2O	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Mean
lb/acre			bu/acre										
0	0	0	81	77	74	77	76	73	80	57	58	84	74
0	40	0	75	77	85	87	81	81	93	73	53	102	82
0	40	40	83	76	84	83	83	82	93	74	54	95	82
40	0	0	104	91	83	88	92	82	92	60	63	102	87
40	40	0	114	118	117	116	124	120	140	112	84	133	119
40	40	40	121	114	114	114	119	121	140	117	84	130	119
80	0	0	100	111	94	97	110	97	108	73	76	111	99
80	40	0	121	125	113	116	138	127	139	103	81	132	121
80	40	40	130	130	123	120	134	131	149	123	92	142	129
120	0	0	91	102	76	82	98	86	97	66	77	101	88
120	40	0	124	125	102	116	134	132	135	106	95	136	122
120	40	40	128	128	105	118	135	127	132	115	98	139	124
160	0	0	118	118	100	96	118	116	122	86	77	123	109
160	40	0	116	131	116	118	141	137	146	120	106	145	129
160	40	40	119	124	107	115	136	133	135	113	91	128	121
200	0	0	107	121	113	104	132	113	131	100	86	134	115
200	40	0	126	133	110	114	139	136	132	115	108	143	126
200	40	40	115	130	120	120	142	143	145	123	101	143	129

ANOVA (P>F)	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Mean
Nitrogen	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic	0.001	0.001	0.227	0.001	0.001	0.001	0.001	0.018	0.005	0.004	0.001
P-K	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Zero P vs P	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
P vs P-K	0.436	0.649	0.741	0.803	0.619	0.920	0.694	0.121	0.803	0.578	0.742
N x P-K	0.045	0.186	0.482	0.061	0.058	0.030	0.008	0.022	0.195	0.210	0.016

MEANS		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Mean
Nitrogen lb/a	0	80	76	81	82	80	79	88	68	55	93	79
	40	113	108	105	106	112	108	124	96	77	121	108
	80	117	122	110	111	127	119	132	100	83	128	116
	120	114	118	95	105	122	115	121	96	90	125	111
	160	118	124	108	110	132	129	134	107	92	132	120
	200	116	128	115	113	138	131	136	113	98	140	124
	$LSD_{0.05}$	10	8	13	7	8	9	10	11	10	11	7
P_2O_5-K_2O lb/a	0	100	103	90	91	104	94	105	74	73	109	95
	40- 0	113	118	107	111	126	122	131	105	88	132	116
	40-40	116	117	109	112	125	123	132	111	87	130	117
	$LSD_{0.05}$	7	6	9	5	6	6	7	7	7	7	5

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

by
Alan Schlegel

SUMMARY

Long-term research shows that phosphorus (P) and nitrogen (N) fertilizer must be applied to optimize production of irrigated corn in western Kansas. In 2006, N and P applied alone increased yields about 70 and 30 bu/a, respectively; however, N and P applied together increased yields up to 160 bu/a. Averaged across the past 10 years, corn yields were increased up to 125 bu/a by N and P fertilization. Application of 120 lb N/a (with P) was sufficient to produce maximum yields in 2006, which was slightly more than the 10-year average. Phosphorus increased corn yields in 2006 an average of more than 100 bu/a when applied with at least 120 lb N/a. Application of 80 lb P_2O_5/a instead of 40 lb/a increased yields 20 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 levels remained high, so the K treatment was discontinued in 1992 and replaced with a higher P rate.

PROCEDURES

Initial fertilizer treatments in 1961 were N rates of 0, 40, 80, 120, 160, and 200 lb N/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 prior to planting. The soil is a Ulysses silt loam. The corn hybrids were Pioneer 3225 (1997), Pioneer 3395IR (1998), Pioneer 33A14 (2000), Pioneer 33R93 (2001 and 2002), DeKalb C60-12 (2003), Pioneer 34N45 (2004 and 2005), and Pioneer 34N50 (2006) planted at approximately 30-32,000 seeds/a in late April or early May. Hail damaged the 2005 and 2002 crops and destroyed the 1999 crop. The corn was irrigated to minimize water stress. Furrow irrigation was used through 2000 and sprinkler irrigation since 2001. The center two rows of each plot were machine harvested after physiological maturity. Grain yields were adjusted to 15.5% moisture.

RESULTS

Corn yields in 2006 were similar to the 10-year average (Table 1). Nitrogen alone increased yields up to 70 bu/a, while P alone increased yields only 30 bu/a. However, N and P applied together increased corn yields up to 160 bu/a. Only 120 lb N/a with P was required to obtain maximum yields. Over the past 10 years, 120 lb N/a with P has produced 95% of maximum yield. Corn yields (averaged across all N rates) were 13 bu/a greater with 80 P_2O_5/a than with 40 lb/a in 2006, which is considerably greater than the 10-year average. Also, with N rates of 120 lb N/a or greater in 2006 the higher P rate increased yields more than 20 bu/a.

Table 1. Effect of N and P fertilizers on irrigated corn yields, Tribune, KS, 1997-2006.

N	P_2O_5	1997	1998	2000	2001	2002	2003	2004	2005	2006	Mean
- - - - - lb/acre	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	bu/a	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -
0	0	66	49	131	54	39	79	67	49	42	84
0	40	79	55	152	43	43	95	97	60	68	77
0	80	83	55	153	48	44	93	98	51	72	78
40	0	86	76	150	71	47	107	92	63	56	83
40	40	111	107	195	127	69	147	154	101	129	127
40	80	114	95	202	129	76	150	148	100	123	126
80	0	130	95	149	75	53	122	118	75	79	100
80	40	153	155	205	169	81	188	209	141	162	163
80	80	155	149	211	182	84	186	205	147	171	166
120	0	105	92	143	56	50	122	103	66	68	89
120	40	173	180	204	177	78	194	228	162	176	175
120	80	162	179	224	191	85	200	234	170	202	183
160	0	108	101	154	76	50	127	136	83	84	102
160	40	169	186	203	186	80	190	231	170	180	177
160	80	187	185	214	188	85	197	240	172	200	185
200	0	110	130	165	130	67	141	162	109	115	125
200	40	185	188	207	177	79	197	234	169	181	180
200	80	193	197	218	194	95	201	239	191	204	192
ANOVA (P>F)											
Nitrogen		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
P_20_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	0.007	0.001	0.001	0.001	0.001	0.001
N x P		0.001	0.001	0.008	0.001	0.133	0.001	0.001	0.001	0.001	0.001
MEANS											
N lb/a	0	76	53	145	48	42	89	87	53	61	73
	40	104	93	182	109	64	135	132	88	103	112
	80	146	133	188	142	73	165	178	121	137	143
	120	147	150	190	142	71	172	188	133	149	149
	160	155	157	190	150	71	172	203	142	155	155
	200	163	172	197	167	80	180	212	156	167	166
	$LSD_{0.05}$	12	11	10	15	8	9	11	10	15	7
P_2O_5 lb/a	0	101	91	149	77	51	116	113	74	74	94
	40	145	145	194	147	72	168	192	134	149	150
	80	149	143	204	155	78	171	194	139	162	155
	$LSD_{0.05}$	9	7	7	10	6	6	8	7	11	5

LAND APPLICATION OF ANIMAL WASTES ON IRRIGATED CORN

by

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

SUMMARY

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

INTRODUCTION

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

PROCEDURES

The rate of waste application was based on the amount needed to meet the estimated crop P requirement, crop N requirement, or twice the N requirement (Table 1). The Kansas Department of Agriculture Nutrient Utilization Plan form was used to calculate animal waste application rates. Expected corn yield was 200 bu/a. The allowable P application rates for the P-based treatments were 105 lb P2O5/a because soil test P levels were less than 150 ppm Mehlich-3 P. The N recommendation model uses yield goal less credits for residual soil N and previous manure applications to estimate N requirements. For the N-based swine treatment, the residual soil N levels after harvest in 2001, 2002, and 2004 were great enough to eliminate the need for additional N the following year. Therefore, no swine effluent was applied to the 1xN treatment in 2002, 2003, or 2005 or to the 2xN requirement treatment, because it is based on 1x treatment (Table 1). The same situation occurred for the N-based treatments using cattle manure in 2003. Nutrient values used to calculate initial applications of animal wastes were 17.5 lb available N and 25.6 lb available P_2O_5 per ton of cattle manure and 6.1 lb available N and 1.4 lb available P_2O_5 per 1000 gallons of swine effluent (actual analysis of animal wastes as applied varied somewhat from the estimated values, Table 2). Subsequent applications were based on previous analyses. Other nutrient treatments were three rates of N fertilizer (60, 120, and 180 lb N/a) along with an untreated control. The N fertilizer treatments also received a uniform application of 50 lb/a of P_2O_5. The experimental design was a randomized complete block with four replications. Plot size was 12 rows wide by 45 ft long.

The study was established in border basins to facilitate effluent application and flood irrigation. The swine effluent was flood-applied as part of a pre-plant irrigation each year. Plots not receiving swine effluent were also irrigated at the same time to balance water additions. The cattle manure was hand-broadcast and incorporated. The N fertilizer (granular NH_4NO_3) was applied with a 10-foot fertilizer applicator (Rogers Mfg.). The entire study area was uniformly irrigated during the growing season, with flood irrigation in 1999-2000 and sprinkler irrigation in 2001-2006. 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 and 2005 crop. The center four rows of each plot were machine harvested after physiological maturity with yields adjusted to 15.5% moisture.

RESULTS

Corn yields were increased by all animal waste and N fertilizer applications in 2006, as has been the case for all years except in 2002, when yields were greatly reduced by hail damage (Table 3). The type of animal waste affected yields in five of the seven years with higher yields from cattle manure than from swine effluent. Averaged across the seven years, corn yields were 14 bu/a greater follow-

ing application of cattle manure than swine effluent on an N application basis. Over-application (2xN) of cattle manure has had no negative impact on grain yield in any year. However, over-application of swine effluent reduced yields in 2004 because of considerably greater salt content (two to three times greater electrical conductivity than any previous year) causing germination damage and poor stands. No adverse residual effect from the over-application has been observed.

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

Table 1. Application rates of animal wastes, Tribune, KS, 1999 to 2006.

Application basis*	Cattle manure (ton/a)							
	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
P req.	15.0	4.1	6.6	5.8	8.8	4.9	3.3	6.3
N req.	15.0	6.6	11.3	11.7	0	9.8	6.8	6.3
2XN req.	30.0	13.2	22.6	22.7	0	19.7	13.5	12.6
	Swine effluent (1,000 gal/a)							
	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
P req.	28.0	75.0	61.9	63.4	66.9	74.1	73.3	66.0
N req.	28.0	9.4	37.8	0	0	40.8	0	16.8
2XN req.	56.0	18.8	75.5	0	0	81.7	0	33.7

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

Table 2. Analysis of animal waste as applied, Tribune, KS, 1999 to 2006.

Nutrient content	Cattle manure (lb/ton)							
	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Total N	27.2	36.0	33.9	25.0	28.2	29.7	31.6	38.0
Total P_2O_5	29.9	19.6	28.6	19.9	14.6	18.1	26.7	20.5
	Swine effluent (lb/1,000 gal)							
	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Total N	8.65	7.33	7.83	11.62	7.58	21.42	13.19	19.64
Total P_2O_5	1.55	2.09	2.51	1.60	0.99	2.10	1.88	2.60

Table 3. Effect of animal waste and N fertilizer on irrigated corn, Tribune, KS, 2000-2006.

Nutrient source	Rate basis[†]	Grain yield							
		2000	2001	2002	2003	2004	2005	2006	Mean
		- bu/acre -							
Cattle manure	P	197	192	91	174	241	143	236	182
	N	195	182	90	175	243	147	217	178
	2 X N	195	185	92	181	244	155	213	181
Swine effluent	P	189	162	74	168	173	135	189	155
	N	194	178	72	167	206	136	198	164
	2 X N	181	174	71	171	129	147	196	152
N fertilizer	60 N	178	149	82	161	170	96	178	145
	120 N	186	173	76	170	236	139	198	168
	180 N	184	172	78	175	235	153	200	171
Control	0	158	113	87	97	94	46	123	103
$LSD_{0.05}$		22	20	17	22	36	16	18	12
ANOVA									
Treatment		0.034	0.001	0.072	0.001	0.001	0.001	0.001	0.001
Selected contrasts									
Control vs. treatment		0.001	0.001	0.310	0.001	0.001	0.001	0.001	0.001
Manure vs. fertilizer		0.089	0.006	0.498	0.470	0.377	0.001	0.001	0.013
Cattle vs. swine		0.220	0.009	0.001	0.218	0.001	0.045	0.001	0.001
Cattle 1x vs. 2x		0.900	0.831	0.831	0.608	0.973	0.298	0.646	0.705
Swine 1x vs. 2x		0.237	0.633	0.875	0.730	0.001	0.159	0.821	0.043
N rate linear		0.591	0.024	0.639	0.203	0.001	0.001	0.021	0.001
N rate quadratic		0.602	0.161	0.614	0.806	0.032	0.038	0.234	0.042

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

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

LARGE-SCALE DRYLAND CROPPING SYSTEMS

by
Alan Schlegel, Curtis Thompson, and Troy Dumler

SUMMARY

A large-scale rain-fed cropping systems research and demonstration project evaluated four summer crops (corn, grain sorghum, sunflower, and soybean) along with winter wheat in crop rotations varying in length from two to four years. The objective of the study is to identify cropping systems that enhance and stabilize production in rain-fed cropping systems to optimize economic crop production. Lack of precipitation during the winter and spring depressed wheat yields in 2006. Wheat yields were less smaller following sunflower than as opposed to sorghum in three-year rotations. This trend has been seen in most years, with an average of 9 bu/a lower wheat yields following sunflower than as opposed to sorghum. In 2006, grain sorghum yields were 41 bu/a greater following wheat than they were following corn. In 2006, corn yields were reduced by below normal precipitation during pollination. Averaged across the past 12 years, sorghum has yielded 18 bu/a more than corn when both planted no-till into wheat stubble.

INTRODUCTION

The purpose of this project is to research and demonstrate several multi-crop rotations that are feasible for the region, along with several alternative systems that are more intensive than two- or three-year rotations. There are two objectives. The first is to enhance and stabilize production of rain-fed cropping systems through the use of multiple crops and rotations using best management practices to optimize capture and utilization of precipitation for economic crop production. The second is to enhance adoption of alternative rain-fed cropping systems that provide optimal profitability.

PROCEDURES

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

RESULTS AND DISCUSSION

Grain yields of winter wheat in 2006 were below average in 2006 (Table 1). Corn yields were also poor. Precipitation was below normal each month from January through May (3.28 inches compared to normal of 6.24 inches). June precipitation was slightly above average (3.05 inches compared to the average of 2.62 inches), while July and August rainfall were below average. Sorghum yields in the WSF rotation were about near-average at 50 bu/a while sorghum following corn yielded less than 10 bu/a. Soybeans were severely damaged by rabbits and yielded only 2 bu/a. Sunflower yields were greater following corn than wheat.

In most years, wheat yields are lower following sunflower than sorghum (Table 2). Averaged across the past 12 years, wheat yields were 9 bu/a greater following sorghum than sunflower. For the same time period, wheat yields were 4 bu/a greater in WF than WSF.

In eight of the past 12 years, grain sorghum has yielded more than corn when both were planted no-till into wheat stubble (Table 3). Averaged across the 12 years, grain sorghum yields have been 18 bu/a, or 50% greater than corn yields. In seven of the past nine years, grain sorghum yields have been greater following wheat than corn (averaged averaging 16 bu/a, or 50% greater yields).

This research project receives support from the Ogallala Aquifer Initiative.

Table 1. Grain yield response to crop rotation in large-scale cropping-systems study, Tribune, KS, 2006.

Crop Rotation	Wheat	Corn	Sorghum	Soybeans	Sunflower
	- - - - - - - -	- - - - bu/acre	- - - - - - - -		lb/acre
Wheat - fallow	15	- - -	- - -	- - -	- - -
Wheat - sorghum - fallow	12	- - -	50	- - -	- - -
Wheat - sunflower - fallow	4	- - -	- - -	- - -	358
Wheat - corn - sunflower - fallow	4	6	- - -	- - -	729
Wheat - corn - sorghum - fallow	4	7	9	- - -	- - -
Wheat - corn - soybean - fallow	9	4	- - -	2	- - -
$LSD_{0.05}$	6	3	39	- - -	103

Table 2. Wheat yields in three rotations since 1995 in large-scale cropping-systems study, Tribune, KS.

Rotation	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Mean
	- wheat yield, bu/a -												
W –F	34	26	47	55	69	18	60	2	31	4	43	15	34
W -GS – F	31	15	42	53	68	28	46	0	22	4	43	12	30
W – SF – F	27	7	28	51	52	11	30	0	18	3	19	4	21

Initial rotations used tillage prior to wheat and no-till prior to row crop but changed to complete NT in1998, except for WF, which remained reduced tillage.

Table 3. Grain yield of corn, grain sorghum, and sunflower since 1995 in wheat-row crop-fallow rotations in large-scale cropping-systems study, Tribune, KS.

Crop	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Mean
Corn, bu/a	20	80	33	78	70	11	(4)*	(0)	(5)	(116)	(13)	(6)	36
Sorghum, bu/a	38	65	21	94	96	48	19	0	28	112	77	50	54
Sunflower, lb/a	634	2	603	59	1025	312	217	0	223	1272	1115	358	440
Rotation													
W-Corn-S-F				54	80	11	5	0	5	121	17	7	[33]
W-C-Sorghum-F				53	67	11	24	0	8	47	62	9	[31]

*Corn yields since 2001 are average yields from 4-yr rotations (W-C-GS-F, W-C-SB-F, W-C-SF-F).
Initial rotations used tillage prior to wheat but all rotations have been complete no-till since 1998.

Last 2 rows are yields for corn and grain sorghum in a wheat-corn-grain sorghum-fallow rotation.

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

by
Alan Schlegel, Loyd Stone, Troy Dumler, and Curtis Thompson

SUMMARY

Grain yields of wheat and grain sorghum increased with decreased tillage intensity in a wheat-sorghum-fallow (WSF) rotation. Averaged across the past 16 years, no-till wheat yields were 4 bu/a greater than with reduced tillage and 8 bu/acre greater than with conventional tillage. In 2006, wheat yields were very low but no-till produced 16 bu/a while reduced or conventional tillage resulted in almost complete failure. Grain sorghum yields were also low in 2006; like no-till wheat, no-till sorghum yielded more (29 bu/a) while conventional or reduced tillage sorghum yielded less than 5 bu/a. Averaged across the past 16 years, no-till sorghum yields were 14 bu/a greater than with reduced tillage and 33 bu/acre greater than with conventional tillage. Averaged across the past six years, sorghum yields were 25 bu/a greater with long-term no-till compared to short-term no-till.

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 conventional (CT), reduced (RT), and no-till (NT). The CT system was tilled as needed to control weed growth during the fallow period. On average, this resulted in 4 to 5 tillage operations per year, usually with a blade plow or field cultivator. The RT system originally used a combination of herbicides (one or two spray operations) and tillage (two to three tillage operations) to control weed growth during the fallow period. However, in 2001, the RT system was changed to using no-till from wheat harvest through sorghum planting and conventional tillage from sorghum harvest to wheat planting. The NT system exclusively used herbicides to control weed growth during the fallow period. All tillage systems used herbicides for in-crop weed control.

RESULTS AND DISCUSSION

Conservation tillage increased wheat yields (Table 1). On average, wheat yields were 8 bu/a higher for NT (36 bu/a) than for CT (28 bu/a). Wheat yields for RT were 4 bu/a greater than CT. In 2006, wheat yields were severely reduced by dry conditions during the spring.

The yield benefit from reduced tillage was greater for grain sorghum than for wheat. Grain sorghum yields for RT averaged 21 bu/a more than CT, while NT averaged 14 bu/a more than RT (Table 2). In 2006, sorghum yields were 25 bu/a greater with NT than either RT or CT. Since the RT sorghum was no-till from wheat harvest to sorghum planting there evidently is a yield benefit from long-term no-till. Since 2001 (when the RT system was changed), sorghum yields in long-term no-till averaged 25 bu/a greater than with short term no-till (the RT system), an increase of 95%.

Acknowledgement. This research project was partially supported by the Ogallala Aquifer Initiative.

Table 1. Wheat response to tillage in a wheat-sorghum-fallow rotation, Tribune, KS, 1991-2006.

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

Table 2. Grain sorghum response to tillage in a wheat-sorghum-fallow rotation, Tribune, KS, 1991-2006.

Tillage	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Mean
	bu/acre																
Conventional	23	38	47	20	37	97	71	87	19	13	6	0	7	44	28	4	34
Reduced	39	41	83	38	54	117	94	105	88	37	43	0	7	67	38	3	53
No-till	39	27	68	57	59	119	115	131	99	51	64	0	37	118	61	29	67
$LSD_{0.05}$	18	15	11	9	5	12	33	37	10	6	7	- - -	8	14	35	10	4
<u>ANOVA (P>F)</u>																	
Tillage	0.110	0.118	0.001	0.001	0.001	0.007	0.044	0.073	0.001	0.001	0.001	- - -	0.001	0.001	0.130	0.001	0.001
Year																	0.001
Tillage x year																	0.001

SKIP ROW CORN FOR IMPROVED DROUGHT TOLERANCE

by
Alan Schlegel

SUMMARY

Research on skip row planting of dryland corn was initiated at the near Tribune in 2004. The objective was to determine whether some pattern of skipping rows would improve drought tolerance of dryland corn. The planting arrangements were to plant one row and skip one (P1S1); plant two rows and skip one (P2S1); plant two rows and skip two (P2S2); and plant every row (P-All). Target plant populations were 10,000, 15,000, and 20,000 plants per acre. Corn was no-till planted into standing wheat stubble in early May of each year from 2004 to 2006. Corn yields were above average in 2004 and 2005, with yields above 90 bu/a in both years. In these high-yielding years, corn planted every row at a plant population of 15,000 acre-1 produced the highest yields; however, the P1S1 arrangement produced similar yields. The other two planting arrangements (P2S1 and P2S2) tended to reduce yield. In 2006, yields were less than 50 bu/a and corn planted every row at 15,000 plants/a again produced the best yields, although similar yields were obtained with all other planting arrangements. Plant population had more impact on yield that skip row planting. In 2004, with yields in excess of 100 bu/a, yields increased with plant population, while in 2006, with much lower yield potential, yields were generally better with lower plant populations. Overall, yields similar to those of every-row planting could be obtained with skip-row planting in low- and high-yielding years; however, skip-row planting did not result in higher yields than every-row planting in any year.

INTRODUCTION

Skip-row planting of dryland corn may offer producers a strategy for managing risk of drought. With limited water availability, corn during drought years may exhaust available soil water during vegetative growth, creating severe water stress during reproductive stages and grain fill. With skip row planting, soil water may be available later in the growing season in the skipped rows, because corn roots would require additional time to extend into these areas. This would reserve water for reproductive stages of growth. The objective of this study was to determine whether some pattern of skip row planting would improve drought tolerance of dryland corn.

MATERIALS AND METHODS

Research on skip row dryland corn was initiated at the K-State Southwest Research-Extension Center near Tribune in 2004. The planting arrangements were plant 1 row and skip 1 row, plant 2 rows and skip 1 row, plant 2 rows and skip 2 rows, along with plant every row (30 inch rows). Target plant populations were 10,000, 15,000, and 20,000 plants/a. Corn was no-till planted into standing wheat stubble in early May of 2004 to 2006. Roundup-Ready corn was used to facilitate late season weed control. The center of each plot was machine harvested after physiological maturity and yields adjusted to 15.5% moisture.

RESULTS AND DISCUSSION

Corn yields were above average in 2004 and 2005 with some treatment yields above 100 bu/a in 2004 (Table 1) and above 90 bu/a in 2005 (Table 2). In both years, no treatment produced yields greater than corn planted every row at a population of 15,000 plants/a. However, the P1S1 row arrangement produced similar yields. The other two planting arrangements (P2S1 and P2S2) tended to reduce yield potential. Plant population had more impact on yield that skip row planting. In 2004, with yields in excess of 100 bu/a, yields increased with plant population. With overall lower yields in 2005, a plant population of 15,000 plants/a produced the best yields.

In 2006, yields were much lower than in previous years with no yields above 50 bu/a (Table 3). With every row planting, the highest yields were obtained with a plant population of 15,000 plants/a while with skip row planting the highest yields were obtained with 10,000 plants/a. Averaged across plant populations, yields were similar for all row spacings.

In 2005 and 2006, increasing plant population tended to increase the percentage of barren plants. Averaged across planting arrangements in 2005, 25% of the plants were barren at the highest plant population compared to only 10% at the middle population. In 2006, with lower yields and more water stress, more than 60% of the plants were barren at the high population compared to less than 20% at the lowest population. Skip row planting had no effect on the percent of barren plants.

Table 1. Skip-row dryland corn. SWREC-Tribune, KS 2004.

Row spacing	Target Population	Yield	Moist	Test wt.	Plant population
		bu/a	%	lb/bu	1000/a
Every row	10,000	72	21.5	54.8	9.5
	15,000	116	20.6	55.9	15.0
	20,000	117	19.1	56.5	18.5
Plant 1/Skip 1	10,000	75	22.0	54.9	9.4
	15,000	97	20.1	56.7	14.5
	20,000	118	19.1	56.6	18.8
Plant 2/Skip 1	10,000	64	20.1	56.1	9.1
	15,000	98	20.1	55.8	14.5
	20,000	105	19.9	56.7	19.5
Plant 2/Skip 2	10,000	68	20.6	55.5	9.3
	15,000	86	20.3	55.9	13.5
	20,000	90	19.3	56.8	19.6
ANOVA (P>F)					
Row spacing		0.001	0.850	0.846	0.954
Population		0.001	0.006	0.029	0.001
Row space x pop		0.178	0.519	0.792	0.362
MEANS					
Row spacing					
Every row		102	20.4	55.7	14.3
Plant 1/Skip 1		97	20.4	56.0	14.2
Plant 2/Skip1		89	20.0	56.2	14.4
Plant 2/Skip 2		81	20.1	56.0	14.1
$LSD_{0.05}$		10	1.1	1.1	0.9
Target population					
10,000		70	21.0	55.3	9.3
15,000		99	20.3	56.1	14.4
20,000		108	19.4	56.6	19.1
$LSD_{0.05}$		8	1.0	0.9	0.8

Table 2. Skip-row dryland corn. SWREC-Tribune, KS 2005.

Row spacing	Target Population	Yield bu/a	Moist %	Test wt. lb/bu	Plant population 1000/a	Ear population 1000/a	Barren plants %
Every row	10,000	87	27.9	51.1	10.9	11.7	-7
	15,000	94	27.5	51.1	15.9	14.2	11
	20,000	74	29.6	51.2	20.7	15.1	27
Plant 1/Skip 1	10,000	83	26.4	52.0	10.5	10.8	-2
	15,000	91	25.9	51.9	14.5	13.4	8
	20,000	78	28.0	51.7	20.6	17.3	16
Plant 2/Skip 1	10,000	83	27.0	51.8	10.5	10.8	-2
	15,000	89	26.6	51.9	14.7	13.3	10
	20,000	70	28.7	51.3	19.0	14.1	26
Plant 2/Skip 2	10,000	79	26.9	51.7	10.6	10.8	-3
	15,000	81	27.9	49.7	14.2	12.6	11
	20,000	82	27.6	51.8	20.6	14.6	29
ANOVA (P>F)							
Row spacing		0.733	0.026	0.296	0.013	0.340	0.626
Population		0.027	0.002	0.485	0.001	0.001	0.001
Row space x pop		0.676	0.407	0.312	0.069	0.596	0.795
MEANS							
Row spacing							
Every row		85	28.3	51.1	15.8	13.7	10
Plant 1/Skip 1		84	26.8	51.8	15.2	13.8	7
Plant 2/Skip1		80	27.4	51.7	14.8	12.7	11
Plant 2/Skip 2		81	27.5	50.1	15.1	12.7	13
LSD $_{0.05}$		10	1.0	1.0	0.6	1.6	9
Target population							
10,000		83	27.1	51.6	10.6	11.0	-4
15,000		89	27.0	51.2	14.8	13.3	10
20,000		76	28.4	51.5	20.2	15.3	25
LSD $_{0.05}$		9	0.9	0.8	0.5	1.4	8

Table 3. Skip-row dryland corn. SWREC-Tribune, KS 2006.

Row spacing	Target Population	Yield bu/a	Moist %	Test wt. lb/bu	Plant population 1000/a	Ear population 1000/a	Barren %
Every row	10,000	37	17.1	58.8	11.1	7.6	29
	15,000	48	17.2	59.5	14.5	8.2	41
	20,000	29	17.3	58.6	19.9	7.4	62
Plant 1/Skip 1	10,000	46	16.8	59.7	10.0	9.1	9
	15,000	40	17.1	59.1	14.6	8.5	40
	20,000	23	17.9	57.9	22.4	6.1	73
Plant 2/Skip 1	10,000	48	17.0	59.0	9.9	8.1	18
	15,000	22	17.0	59.0	14.7	5.4	60
	20,000	46	17.3	59.1	18.7	9.9	47
Plant 2/Skip 2	10,000	48	16.8	59.9	10.1	8.5	14
	15,000	43	17.4	58.7	15.6	8.5	45
	20,000	41	17.5	58.3	17.8	5.9	61
ANOVA (P>F)							
Row spacing		0.904	0.991	0.985	0.441	0.996	0.943
Population		0.070	0.380	0.115	0.001	0.575	0.001
Row space x pop		0.066	0.984	0.502	0.184	0.183	0.138
MEANS							
Row spacing							
Every row		38	17.2	59.0	15.1	7.7	44
Plant 1/Skip 1		36	17.3	58.9	15.7	7.9	41
Plant 2/Skip1		39	17.1	59.0	14.4	7.8	42
Plant 2/Skip 2		41	17.2	59.0	14.5	7.6	40
$LSD_{0.05}$		12	1.0	1.0	1.8	2.2	14
Plant population							
10,000		45	16.9	59.3	10.3	8.3	18
15,000		38	17.2	59.0	14.8	7.6	46
20,000		32	17.5	58.5	19.7	7.3	61
$LSD_{0.05}$		11	0.8	0.8	1.5	1.9	12

WINTER CANOLA VARIETY TRIAL

by
John Holman, Scott Maxwell, Gary Miller, and Monty Spangler

INTRODUCTION

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

Winter canola is well suited for the growing conditions of the southern plains and possesses a 20 to 30 percent yield advantage over spring canola. Spring types flower a month later and are harvested approximately two weeks later than winter types. Flowering during a hotter period of the growing season and reducing the grain fill period decreases the yield potential of spring types. Until heat-tolerant spring cultivars are developed, winter canola will be the primary oilseed rape crop grown in the region.

Winter canola establishes best in firm, well-drained, medium-textured soils. It is imperative that canola has appropriate seed-to-soil contact because of its small seed size and shallow planting depth. Obtaining a uniform seeding depth provides a challenge but can be accomplished with properly adjusted no-till seeding equipment. No-till cropping practices are well accepted and utilized across the semiarid Great Plains, allowing for the conservation of surface soil moisture and reducing the potential for soil erosion. A canola seedbed that is too fine or overworked will lose soil moisture rapidly and crusting normally occurs after a heavy rain. Overly coarse seedbeds result in poor seed placement, poor seed-to-soil contact, and soils dry out rapidly. These hindrances to establishment may be avoided with no-till seeding. In addition, fuel savings exist with no-till cropping systems.

As regional interest in renewable energy sources grows, demand for canola oil as a feedstock for biodiesel is outpacing our understanding and ability to establish the crop, especially under no-till cropping systems. Establishing winter canola is a more significant undertaking than establishing winter wheat, particularly in years when soil moisture is lacking at fall planting. Stand establishment impacts all other periods of the growing season; the most important being winter dormancy. Plants that fail to establish adequately in the fall will have limited time to attain the minimum amount of growth necessary to survive the winter in the southern Great Plains. Obtaining a quality stand provides the greatest opportunity for winter survival and is critical for harvesting a high yielding crop. The objective of this study is to identify varieties with good winter hardiness and best suited to the environmental conditions in southwest Kansas.

PURPOSE

The purpose of this project was to evaluate winter canola variety lines from the National Canola Variety Trial and the University of Idaho for fall stand, winter survival, bloom date, harvest maturity, height, lodging, shatter resistance, yield, and test weight.

PROCEDURES

Winter canola was planted September 12, 2006, at 8 lb/a in 9-inch row spacings in plots 8 feet wide by 30 feet long, replicated three times in a randomized complete block design. Two days after planting, the site was fully irrigated through flood irrigation. Fifty percent emergence occurred on September 20, 2006. Granular fertilizer was applied at 140 lbs N and 15 lbs S/a on October 20, 2006. The winter canola variety trial was evaluated for fall stand establishment on November 20, 2006. The number of dead and emerged plants per 3 feet of row was counted on March 26, 2007. The percentage of alive plants was used to predict winter stand survival.

RESULTS and DISCUSSION

Canola plants averaged 8 leaves per plant at the time of measuring fall stand establishment. Data on spring stand evaluation, including final yield, will be collected and reported in 2007. Wichita, which is currently one of the most commonly planted varieties in south-central Kansas, averaged a visual rating of 87.3% fall stand establishment and 90% winter survival. The variety lines from the University of Idaho averaged 80-84% stand fall stand establishment and 94-100% winter survival. Variety fall stand establishment ranged from 80-91% and averaged 85% across all varieties (Table 1). Winter survival was from 61-100% and averaged 90%. Producers have reported having poor winter

survival in southwestern Kansas; this experiment shows varieties vary in their winter hardiness in the region and that tests like this are important for identifying varieties best adapted to the region.

It is important to note that irrigation was provided after planting, which improved fall stand establishment. In a separate dryland study, winter canola failed to establish even after a second re-seeding attempt. Due to the small seed size of canola and the commonly dry surface soil layer during the fall in western Kansas, winter canola production might be restricted to full and limited irrigation production systems only.

Table 1. Fall stand establishment, plant emergence, and winter survival of winter canola variety lines planted, fall 2006. Stand establishment based on a visual estimation, and winter survival based on the percentage of plants that survived winter.

Variety	**Fall Stand (%)**	**Plants Emerged/3ft row**	**Winter Survival (%)**
06UIWH.1	80	5	100
Sumner	81	6	100
NPZ0404	82	6	100
KS3302	82	6	100
TCI.06.M3	82	5	100
DSV06200	83	4	100
06UIWC.2	83	5	100
DSV05102	84	5	100
06UIWC.1	84	5	100
06UIWC.4	84	5	100
Virginia	84	5	100
KS4085	84	8	100
KS9135	87	6	100
Falstaff	87	9	100
ARC2180-1	78	6	96
ARC98015	80	6	96
06UIWC.5	83	7	96
KS4022	85	10	96
Ceres	83	6	95
EXP3269	83	7	94
06UIWH.5	84	6	94
Abilene	84	6	94
DSV05101	90	9	94
06UIWH.3	81	5	93
KS7436	81	5	93
Kronos	87	7	93
X02W534C	87	8	93
Jetton	87	8	93
SLM0402	89	6	93
TCI.06.M1	89	8	93
KS3077	84	9	93
Trabant	91	9	93
Baros	84	7	91
Baldur	86	7	91
Plainsman	87	8	91
NPZ0591RR	89	7	91
Rasmus	83	6	90
ARC98007	84	5	90

Table 1 (cont.). Fall stand establishment, plant emergence, and winter survival of winter canola variety lines planted, fall 2006. Stand establishment based on a visual estimation, and winter survival based on the percentage of plants that survived winter.

Variety	**Fall Stand (%)**	**Plants Emerged/3ft row**	**Winter Survival (%)**
KS3132	85	7	90
Wichita	87	7	90
Hybristar	85	8	89
ARC97018	83	6	89
TCI.06.M4	85	8	88
DKW13-62	85	7	88
ARC97019	78	7	88
DSV05100	87	9	87
DSV06202	87	8	86
Viking	86	8	86
X01W522C	89	9	86
KS3254	86	9	86
DSV06201	90	8	85
X01W692C	90	7	85
Taurus	85	9	85
DKW13-86	82	7	84
KS3018	81	5	83
Kadore	87	9	82
KS3074	85	6	82
TCI.06.M2	88	7	82
MH 604001	90	8	78
NPZ0391RR	88	8	76
Ovation	88	11	76
Satori	83	9	71
Kalif	89	9	68
Gospel	87	11	61
LSD	**6.55**	**3.28**	**15.91**

ANNUAL FORAGE CROP PRODUCTION IN ROTATION WITH WINTER WHEAT

by
John Holman, Norman Klocke, Alan Schlegel, Dennis Tomsicek, Gary Miller, and Scott Maxwell

BACKGROUND

The central Great Plains region is prone to low and variable precipitation patterns and early terminal crop growth due to low plant-available water. This semi-arid production region has relied on fallow periods to increase plant-available water and reduce production risk. In western Kansas, the primary dryland crop rotation was winter wheat-fallow (WF), but when producers switch to no-tillage systems, the cropping system can be intensified because of increased stored available water. Summer annual crops such as grain sorghum, corn, or sunflower have been successfully produced in rotation with winter wheat in a winter wheat-summer crop-fallow (WSF) rotation and often result in greater economic net returns than WF. Producers, however, have been slow to adopt WSF despite reduced economic risk compared to WF. Producing an annual forage crop in rotation with winter wheat might reduce economic risk comparable to WSF and have greater producer acceptance than WSF due to more flexibility in the cropping system.

Critical elements of Kansas cropping systems include increased costs and reduced availability of irrigation water, higher nitrogen fertilizer costs, and stagnant commodity prices. These factors have increased decision-making complexity for all crop production inputs (water, nutrients, and weed control) and presented challenges for designing sustainable cropping systems that minimize economic risk.

Integrating cover crops into the crop rotation has been promoted as a weed IPM tool capable of reducing weed population density while reducing nitrogen fertilizer requirements and increasing cropping system profitability and sustainability. Other semi-arid locations have shown that planting a cover crop in place of fallow in a WF rotation often does not reduce subsequent wheat yield and that soil nitrogen can be increased when a legume cover crop is planted. Cover crop harvest is flexible because it can be harvested as a forage or grain crop or left unharvested as a green manure crop, and harvest can be determined based on plant-available soil-water status and anticipated precipitation. Harvesting the cover crop as forage requires less soil moisture than growing a grain crop and can result in moisture savings for the following crop.

Many producers are interested in including a legume cover crop in their rotation as a way of increasing soil nitrogen and reducing fertilizer expense. This is often accomplished in organic systems by including a biennial or perennial legume such as yellow sweet clover or alfalfa. Although biennial and perennial forages can fix more nitrogen, they also generally require more water than annual legumes. This is particularly significant in the central Great Plains, where crop yields are often limited by water. Winter or spring annual legumes might provide a better trade-off between water use and nitrogen contribution.

Green manure cover crops can reduce herbicide and fertilizer expenses, but do not generate economic returns. Harvesting a cover crop as an annual forage might generate an economic return as well as reduce herbicide and fertilizer expense. Research is needed to identify appropriate crop rotations, environments, and crop species to successfully integrate annual forage crops in rotation with winter wheat.

Our goal is to integrate an annual forage crop into the fallow phase of our cropping systems directly after a winter wheat crop is harvested. Studies around the state and the central Great Plains have indicated that yellow sweet clover, hairy vetch, and winter peas demonstrate potential adaptation to the region. Previous research found that cover crop growth in the central Great Plains needs to be terminated by May 1 to reduce adverse affects on the subsequent winter wheat yield. Planting a mixed species of canola or triticale with a legume as compared to planting a legume might result only in greater crop competition with weeds and increased forage biomass production, resulting in greater economic return.

PROJECT OBJECTIVES

1. Conduct research to quantify the benefits and impacts of annual forage crops in a no-tillage winter wheat rotation:

a. determine the influence on weed population dynamics

At the initiation of the study, two quadrats of 1 square

meter will be geo-referenced within each sub-plot to measure the baseline weed community and changes over time. Weed species and density will be measured within each quadrat during the winter wheat phase of the rotation in the spring prior to herbicide application. Throughout the study, the naturally occurring weed community will be observed and documented within the established quadrats to document any changes in the weed community. Changes may not be observed initially, but are desired outcomes for a long-term rotation study.

b. determine crop water use efficiency (WUE) and fallow use efficiency (FUE) of several different crop rotations

Data on environmental conditions (air temperature, soil temperature, solar radiation, and precipitation) will be measured throughout the experiment. Volumetric water content will be determined using a calibrated soil neutron probe with measurements taken every 30 cm to a 3 m soil depth at the time of planting winter wheat and cover crops in the fall, the beginning of December to quantify fall water use, in the spring at the beginning of active plant growth, April 1, at time of harvesting forage cover crops on May 1, and at time of harvesting winter wheat and cover crops for grain. In addition, soil water will be measured at the beginning and ending of each fallow period.

All soil water measurements will be taken from the same area throughout the duration of the study. The decrease in volumetric water content plus precipitation received during the growing period will be converted to plant available water and used to calculate crop water use efficiency (WUE) for cover crop grain and forage production. Additionally, volumetric water content within the top 8 cm of soil depth will be measured at planting winter wheat using time-domain reflectance (TDR) to determine soil moisture status within the seed zone at planting. The efficiency of fallow in the different rotations will be evaluated by measuring the increase in plant available soil water compared to amount of precipitation received during the fallow period. The percent of precipitation stored in the soil profile during the fallow period will be used to calculate fallow use efficiency (FUE).

c. optimize the economic returns of the cropping system by integrating grain and forage production based on interactions among water and weed populations

Winter pea, winter wheat, and winter canola grain yield will be measured each year in every crop rotation. A subsample of the harvested grain will be evaluated for protein and test weight. Inorganic (plant-available) N ($NH4+$ and $NO3-$) will be measured from the top 61 cm at winter wheat planting by extraction with 1 N KCl. The effect of cover crops on winter wheat yield and grain quality, soil nitrogen, and weed density will be used to derive economic crop enterprise budgets for each rotation, and the economic return of each rotation will be compared to the traditional WF rotation in western KS. A break-even economic analysis will evaluate each rotation under alternative forage and grain price scenarios. The value of including a forage crop in the rotation will be determined by measuring forage biomass and nutrient composition. Forage biomass will be calculated by harvesting three quadrats of 0.25 square meters per plot prior to harvesting the full plot area. Forage biomass wet and dry weight will be measured to determine the percentage of dry matter (DM) at harvest. Forage will be dried in a forced-air oven at 60°C for 48 hours and weighed. Harvested forage will be composited by plot and ground using a 2-mm screen, followed by a 1-mm screen. A sub-sample of the ground forage will be analyzed for forage nutrient composition. Nutrient components measured will include DM, crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), relative feed value (RFV), calculated total digestible nutrients (TDN), net energy for milk production (NE1), net energy for gain (NEg), and net energy for maintenance (NEm). Crop enterprise budgets that include grain and forage cover crops in place of fallow in a WF rotation will be evaluated to determine the most profitable crop rotations. A breakeven economic analysis will evaluate each rotation under alternative forage and grain price scenarios.

2. Provide extension education programs to disseminate results and knowledge about integrating cover crops to clientele throughout Kansas:

a. field days highlighting the research plots as demonstrations of integrating cover crops into traditional crop rotations and increase adoption of weed IPM

Annual field tours will be provided to farmers, crop advisors, and other interested parties to provide first-hand exposure to the alternative cover crop rotations and their influence on typical KS cropping systems in a field setting. Annual field days already held in the spring dealing with wheat production attract a good portion of county extension agents from the surrounding counties, agronomy professionals, and influential farmers. These field days provide an excellent opportunity to discuss and demonstrate the impacts of the various cover crops on wheat production to a group of individuals with influence far beyond the land they may control. Ideas and input from these sessions can help adjust specific rotations or cover crop combinations as the research and demonstration plots are moved forward into succeeding cycles. The field days will provide opportunities to showcase and describe the various cropping systems, explain the underlying ecological principles, and facilitate opportunities for input and feedback.

Rotations

No.	Year 1	Year 2
1	Winter pea (harvested as grain)	Winter wheat
2	Winter pea (harvested as forage)	Winter wheat
3	Yellow sweet clover (forage)	Winter wheat
4	Hairy vetch (forage)	Winter wheat
5	Winter canola (harvested as grain)	Winter wheat
6	Winter pea/winter canola (forage)	Winter wheat
7	Winter pea/winter cereal (forage)	Winter wheat
8	Yellow sweet clover/winter canola (forage)	Winter wheat
9	Yellow sweet clover/winter cereal (forage)	Winter wheat
10	Hairy vetch/winter canola (forage)	Winter wheat
11	Hairy vetch/winter cereal (forage)	Winter wheat
12	Winter wheat (grain)	Winter wheat
13	Fallow	Winter wheat

PROCEDURES

A cropping systems study was initiated in 2006 at Garden City that includes 13 two-year, no-till, winter wheat-based crop rotations with both years of the rotation present each year.

The experimental design is a randomized complete block with four replications. Each block is split by crop phase with each phase of the crop rotation present every year. Rotational crop is randomized within crop phase. Each split-block (crop phase) is 60 m wide by 50 m long, and the rotational-crop plot is 4.6 m wide by 50 m long. No fertilizer is applied to the winter forage cover crops and 80 kg/ha N is applied to winter canola and winter wheat during year 1 of the rotation. Winter cover crops will be seeded the end of August and winter wheat will be seeded in mid-September. Crops grown for forage will be terminated May 1 with an application of glyphosate plus 2,4-D prior to harvest to stop water uptake and control any weeds present. Seeding rates and methods for grain and cover crops will follow local recommendations.

RESULTS AND DISCUSSION

Current research in western Kansas indicates that winter pea might have greater stand establishment than yellow sweet clover, hairy vetch, or winter canola. The greater stand establishment of winter peas is due to a large seed size and placing the seed deeper in the soil profile into wetter soil. Soils in western Kansas are commonly dry in the fall and seeding deeper allows for improved stand establishment. If winter pea can be successfully grown in the dryland regions of western Kansas, it might provide a key annual legume growth cycle that optimizes water use efficiency while reducing the amount of nitrogen fertilizer required and the weed density during the subsequent winter wheat crop.

FOUR-YEAR CROP ROTATIONS WITH WHEAT AND GRAIN SORGHUM

by
Alan Schlegel, Troy Dumler, and Curtis Thompson

SUMMARY

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 (WWSF) and wheat-sorghum-sorghum-fallow (WSSF), along with continuous wheat (WW). Soil water at wheat planting averages about 9 inches following sorghum, which is about 3 inches more than the second wheat crop in a WWSF rotation. Soil water at sorghum planting is approximately 1.5 inches less for the second sorghum crop compared to sorghum following wheat. Fallow efficiency prior to wheat was greater for the shorter fallow period following wheat than for the longer fallow following sorghum. Prior to sorghum, average fallow efficiency was 38-40% and not affected by the previous crop. Grain yield of continuous wheat averages about 75% of the yield of wheat grown in a four-year rotation following sorghum. Except for one year, there has been no difference in yield of continuous wheat and recrop wheat grown in a WWSF rotation. Yields are similar for wheat following one or two sorghum crops. Similarly, average sorghum yields were the same when following one or two wheat crops. Yield of the second sorghum crop in a WSSF rotation averages about 70% of the yield of the first sorghum crop.

INTRODUCTION

In recent years, cropping intensity has increased in dryland systems in western Kansas. The traditional wheat-fallow system is being replaced by wheat-summer crop-fallow rotations. With concurrent increases in no-tillage, the question arises as to whether more intensive cropping is feasible. The objectives of this research were to quantify soil water storage, crop water use, crop productivity, and profitability of four-year and continuous cropping systems.

MATERIALS AND METHODS

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. Available water was measure in the soil profile (0 to 8 ft) at planting and harvest of each crop. The center of each plot was machine harvested after physiological maturity and yields adjusted to 12.5% moisture.

RESULTS AND DISCUSSION

Soil water: The amount of available water in the soil profile (0 to 8 ft) at wheat planting varied greatly from year to year (Fig. 1). Soil water was similar following fallow after either one or two sorghum crops and averaged, across the 10-year period, (about 9 inches). Water at wheat planting of the second wheat crop in a WWSF rotation was always less than the first wheat crop except in 2003, which had the lowest water content at planting of any year. Soil water for the second wheat crop averaged more than 3 inches (or about 35%) less than the first wheat crop in the rotation. Continuous wheat averaged about 1 inch less water at planting than the second wheat crop in a WWSF rotation. Fallow efficiency (amount of water accumulated from previous harvest to planting of current crop divided by precipitation during fallow) ranged from less than 0 to more than 60%. Fallow

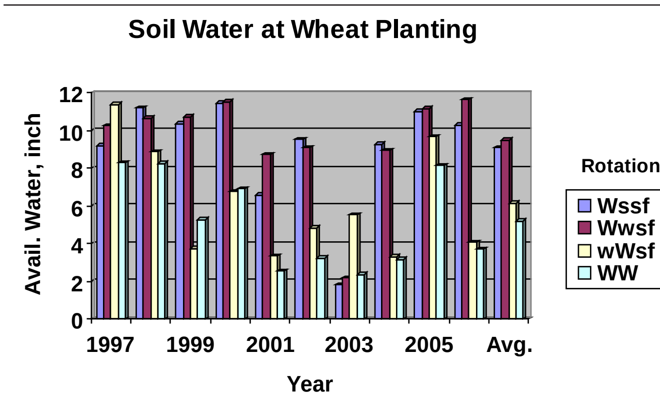


Figure 1. Available soil water at planting of wheat in several rotations, 1997-2006, Tribune, KS. Letter capitalized denotes current crop in rotation.

efficiency was greater for the shorter (3 month) fallow period following wheat than for the longer (11 month) fallow following sorghum. Following sorghum, fallow efficiency prior to wheat averaged less than 30% compared to more than 40% for wheat following wheat.

Similar to wheat, the amount of available water in the soil profile at sorghum planting varied greatly from year to year (Fig. 2). Soil water was similar following fallow after either one or two wheat crops and averaged (11 years) about 8.6 inches. Water at planting of the second sorghum crop in a WSSF rotation was always less than the first sorghum crop although sometimes by very little. For instance, in 1998, there was less than 0.25 inch difference between them. When averaged across the entire study period, the first sorghum crop had about 1.5 inches more available water at planting than did the second crop. Similar to wheat, fallow efficiency prior to sorghum ranged from less than 0 to more than 60%. In contrast, to wheat, average fallow efficiency prior to sorghum was similar following wheat or sorghum at 38 to 40%.

Grain yields: Wheat yields were below the long-term average in 2006 (Table 1). Averaged across 10 years, recrop wheat (the second wheat crop in a WWSF rotation) yielded about 86% of the yield of first-year wheat in either WWSF or WSSF rotations. Before 2003, recrop wheat yielded about 70% of the yield of first-year wheat. In 2003, however, the recrop wheat yields were more than double the yield in all other rotations. This is possibly due to the failure of the first-year wheat in 2002, resulting in a period from 2000 sorghum harvest to 2003 wheat planting without a harvestable crop. There has been no difference in wheat yields following one or two sorghum crops. The continuous-wheat yields have been similar to recrop wheat yields, except in 2003.

Sorghum yields in 2006 were more varied than the long-term yield average (Table 2). Sorghum yield following wheat was about the same or somewhat less than the long-term average while sorghum following sorghum was much less than the long-term average. The second sorghum crop yield averages about 70% of the yield of the first sorghum crop; however, in 2006, second year sorghum yields were less than 25% of the first-year sorghum yield. Averaged across years, sorghum yields were the same following one or two wheat crops.

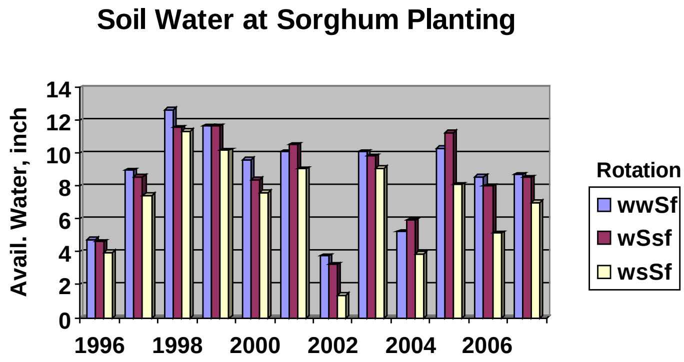


Figure 2. Available soil water at planting of sorghum in several rotations, 1996-2006, Tribune. Letter capitalized denotes current crop in rotation. Last set of bars is average from 1996-2006.

Table 1. Wheat response to rotation, Tribune, Kansas, 1997 through 2006.

Rotation*	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Mean
	bu/a										
Wssf	57	70	74	46	22	0	29	6	45	28	38
Wwsf	55	64	80	35	29	0	27	6	40	26	36
wWsf	48	63	41	18	27	0	66	1	41	7	31
WW	43	60	43	18	34	0	30	1	44	2	28
LSD (0.05)	8	12	14	10	14	--	14	2	10	8	3

* Capital letters denote current-year crop.

Table 2. Grain sorghum response to rotation, Tribune, Kansas, 1996 through 2006.

Rotation*	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Mean
	bu/a											
wSsf	58	88	117	99	63	68	0	60	91	81	55	71
wsSf	35	45	100	74	23	66	0	41	79	69	13	50
wwSf	54	80	109	90	67	73	0	76	82	85	71	72
LSD (0.05)	24	13	12	11	16	18	--	18	17	20	15	4

* Capital letters denote current year crop.

NO-TILL LIMITED IRRIGATED CROPPING SYSTEMS

by
Alan Schlegel, Loyd Stone, and Troy Dumler

SUMMARY

Research was initiated under sprinkler irrigation to evaluate limited irrigation in a no-till crop rotation. With limited irrigation (10 inches annually), continuous corn was more profitable in 2006 than multi-crop rotations, including wheat, sorghum, and soybean. Averaged across the past four years, continuous corn has been the most profitable system primarily because of spring freeze and hail damage to the wheat in the multi-crop rotations. In multi-crop rotations, relatively poor results with one crop (in this case wheat) can reduce profitability compared to a monoculture, especially when the monoculture crop does well. However, the multi-crop rotation may reduce economic risk when the monoculture crop does not perform so well. All of the multi-crop rotations had net returns of only $20 per acre less than continuous corn, so only relatively small changes in prices or yields would be needed for any of the rotations to be more profitable than continuous corn, indicating the potential for alternate crop rotations under limited irrigation.

PROCEDURES

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

RESULTS AND DISCUSSION

The wheat in all rotations followed corn and received 5 inches of irrigation. All rotations were limited to 10 inches of irrigation, however the corn following wheat received 15” since the wheat only received 5 inches. This extra 5 inches of irrigation increased corn yields about 50 bu/a compared to the continuous corn (which only received 10 inches of irrigation) (Table 1). Corn yields tended to be greater with the longer rotations. Grain sorghum yields were the same in the three- and four-year rotations.

Averaged across the past four years, corn yields were 42 to 47 bu/a greater in the multi-year rotations with an additional 5 inches of irrigation compared to continuous corn (Table 2). Wheat and grain sorghum yields were similar regardless of length of rotation.

An economic analysis (based on October grain prices and input costs from each year) found that the most profitable rotation was continuous corn (Table 3). All of the multi-year rotations had similar net returns of about $20/acre less than continuous corn. The reason for the lower returns in the rotations was the low returns from wheat. In two of the past four years, wheat yields were depressed by spring freeze damage, which lowered the average wheat yields reducing the net returns from the multi-year rotations.

Table 1. Grain yield of four crops as affected by rotation in 2006.

Rotation	Corn	Wheat	Sorghum	Soybean
	bu/acre			
continuous corn	151	--	--	--
corn-wheat	190	59	--	--
corn-wheat-sorghum	197	61	162	--
corn-wheat-sorghum-soybean	209	64	162	46

Table 2. Average grain yields from 2003-2006 of four crops as affected by rotation.

Rotation	Corn	Wheat	Sorghum	Soybean
	bu/acre			
continuous corn	165	--	--	--
corn-wheat	207	39	--	--
corn-wheat-sorghum	207	40	134	--
corn-wheat-sorghum-soybean	212	41	137	45

Table 3. Net return to land, irrigation equipment, and management from four rotations from 2003-2006.

	Crop Rotation			
Crop	CC	C-W	C-W-GS	C-W-GS-SB
	bu/acre			
corn	122	190	191	202
wheat	--	13	10	17
sorghum	--	--	95	99
soybean	--	--	--	88
net for rotation	122	102	99	101

CC=continuous corn, CW= corn-wheat, C-W-GS=corn-wheat-grain sorghum,
C-W-GS-SB=corn-wheat-grain sorghum-soybean.

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

LIMITED IRRIGATION OF FOUR SUMMER CROPS IN WESTERN KANSAS

by
Alan Schlegel, Loyd Stone, and Troy Dumler

SUMMARY

Research was initiated under sprinkler irrigation to evaluate limited irrigation with no-till for four summer crops. In 2006, crop yields were generally greater than the long-term average yields. Corn responded the most to increased irrigation. Because of changes in growing conditions, the most profitable crop may be a different one from year to year. Growing different crops when irrigation is limited can reduce risk and increase profitability. Averaged across the past six years, corn has been the most profitable crop at higher irrigation amounts, while grain sorghum and soybean have been the more profitable crops at the lowest irrigation amount.

PROCEDURES

A study was initiated under sprinkler irrigation at the Tribune Unit of the Southwest Research-Extension Center in the spring of 2001. The objectives are to determine the impact of limited irrigation on crop yield, water use, and profitability. All crops are grown no-till and other cultural practices (hybrid selection, fertility practices, weed control, etc.) are selected to optimize production. All water levels are present each year and replicated four times. Irrigations are scheduled to supply water at the most critical stress periods for the specific crops and limited to 1.5 inches per week. Soil water is measured at planting, during the growing season, and at harvest in one-foot increments to a depth of 8 feet. 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 four-year rotation (a total of 12 treatments). The crop rotation is corn-sunflower-grain sorghum-soybean (alternating grass and broadleaf crops). The irrigation amounts for a particular plot remain constant throughout the study; e.g., a plot receiving 5 inches of water one year when corn is grown will also receive 5 inches in the other years when grain sorghum, sunflower, or soybean are grown.

RESULTS AND DISCUSSION

Precipitation from June through August 2006 was 4.45 inches (57% of normal). Corn responded most to irrigation, with yields of 67 bu/a greater when receiving 10 inches rather than 5 inches of irrigation. It yielded 78 bu/a more with an additional 5 inches of irrigation (Table 1). Sorghum yields were improved least by increased irrigation. In 2006, the original plots in the limited irrigation study were split, as they were in 2005, and a seeding rate approximately 20% higher was added to each crop except corn, where the seeding rate was reduced by 20%. The original seeding rates were 30,000 for corn, 80,000 for sorghum, 150,000 for soybean, and 23,500 for sunflower. The same hybrids were used for each crop except for sorghum, where a longer-season hybrid was planted at the higher population. For corn, the lower seeding rate increased corn yields at the lower irrigation amounts and slightly decreased yields at the high-

Table 1. Grain yield of four crops in 2006 as affected by irrigation amount and seeding rate.

Irrigation amount	Corn	Sorghum	Soybean	Sunflower
inches	- - - - - - - - - - - -	bu/acre	- - - - - - - - - -	lb/acre
5	78 (107)	107 (90)	25 (21)	2340(2010)
10	145 (182)	109 (136)	40 (41)	3000 (3020)
15	223 (211)	123 (165)	49 (48)	3160 (3010)

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

est irrigation amount. The increased seeding rate had little effect on soybean and sunflower. Sorghum yields were greater with the higher seeding rate at the higher irrigation amounts, but since this also involved a different hybrid, it is not possible to determine which factor affected yield.

Averaged across 2001-2006, corn was the most responsive to higher irrigation amounts (Table 2). Corn yields increased 81% when irrigation was increased from 5 inches up to 15 inches while grain sorghum increased 34%, soybean by 48%, and sunflower by 21%.

An economic analysis (based on original seeding rates, October grain prices each year, and input costs from each year) found that, at the lowest irrigation level, average net returns (2001-2006) were similar for soybean and sorghum (Table 3) followed by corn. At the higher irrigation levels,

Table 2. Average grain yield of four crops (at original seeding rate) from 2001-2006 as affected by irrigation amount.

Irrigation amount	Corn	Sorghum	Soybean	Sunflower
inches	- - - - - - - - - - - -	bu/acre	- - - - - - - - - - -	lb/acre
5	108	86	29	1,680
10	169	102	39	2,070
15	196	115	43	2,040

Table 3. Net return to land, irrigation equipment, and management for four crops from 2001-2006 as affected by irrigation amount.

Irrigation amount	Corn	Sorghum	Soybean	Sunflower
inches	- - - - - - - - - -	annual net return, $/acre	- - - - - - - - -	
5	22	35	30	6
10	131	45	59	22
15	173	47	60	2

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

CROPPING SYSTEMS FOR LIMITED IRRIGATION

by
Norman Klocke, Randall Currie, Mike Brouk, and Loyd Stone

SUMMARY

Total soil water management during the growing and non-growing season can be enhanced with crop residue management. Capture and retention of soil water plus supplemental irrigation at critical growth stages can maximize limited irrigation resources. This research quantifies the water use and irrigation requirements of corn, winter wheat, grain sorghum and sunflower crops grown with optimum water management using all water conservation techniques available. Differences in grain yields between conventionally tilled and no-till management tended to increase as irrigation decreased. Crops in no-till practices utilized water better unless both systems were fully irrigated. The outcome is the potential reduction of irrigation requirements for more fully irrigated crops and increased grain yields for limited-irrigation crops.

INTRODUCTION

Past irrigation management research has demonstrated that annual grain crops respond best to water applications during flowering and seed-fill growth periods. No-till management systems, which leave crop residues on the surface, have been beneficial in reducing soil water evaporation in sprinkler irrigation. At the same time, there are pressures from the livestock industry to use these same crop residues for livestock forages. This project is designed to combine the best irrigation and crop residue management techniques into one management system. The products of this project are relationships between grain yield and water use, as well as grain yield and irrigation. By harvesting the plots for both grain and forage, the value of crop residues either for water conservation or livestock rations can be estimated. The objectives of this study were: (1) to measure the grain yield-irrigation and grain yield-water use relationships for corn, grain sorghum, winter wheat, and sunflower crops in no-till management with irrigation inputs from 3 inches to full irrigation, and (2) to compare the relationships between whole plant forage yield, quality, and estimated feed value for limited and fully irrigated corn and grain sorghum in a livestock system to the value of the same material as surface residue for water conservation and soil water evaporation suppression in a total grain production system.

PROCEDURES

The experimental field (18 ac) was subdivided into six cropped strips that were irrigated by a four-span linear move sprinkler irrigation system. The cropping sequence was corn-corn-soybean-winter wheat-sunflower-grain sorghum. The soil was a silt loam with pH 8.3 and a slope of less than 1%. Irrigation amounts varied in this experiment. The six irrigation treatments, replicated four times, received from 3 to 15 inches of water during the growing season, if needed. If rainfall was sufficient to fill the soil profile to field capacity, irrigation was not applied. The extra irrigation allocation was rolled over to the next growth stage. If there was extra allocation at the end of the year, it was not carried over to the next year.

Soil water was measured once every two weeks with the neutron attenuation method in increments of 12 inches to a depth of 8 feet. There was one sampling site per plot. These measurements were used to calculate crop evapotranspiration (ETc) for each two-week period during the season.

RESULTS AND DISCUSSION

This study was based on no-till crop and irrigation management from soil water data. Each crop responded differently to irrigation (figure 1). Average crop yield responses from irrigation for 2004, 2004, and 2005 were compared with yields from conventional till practices. The yield-irrigation relationships for conventional tillage management were derived from 20 years of field plot research in western Kansas. These three years provided a range of growing conditions. In 2004, weather provided desirable crop growing conditions which produced above- average yields of 230 bu ac-1 for corn. An early July hail storm in 2005 reduced corn's peak leaf area index (LAI) by 33% from 2004. The result was maximum corn yields of 165 bu ac-1 in 2005. Although less hail damage was measured in from a storm in mid-July 2006, corn's peak LAI was reduced by 14% from 2004. The maximum 2006 corn yield was 185 bu ac-1.

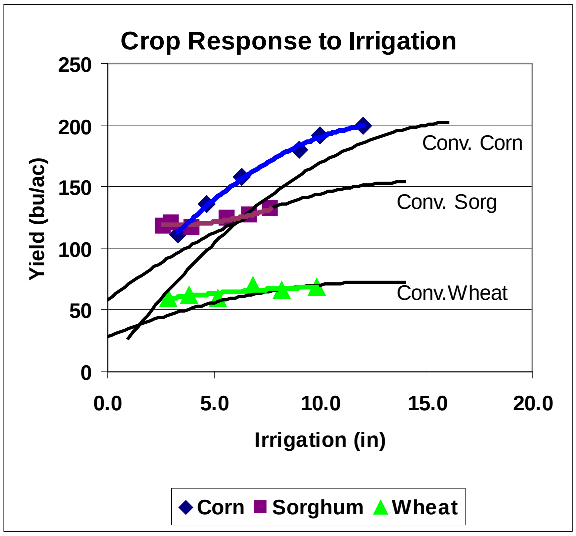
Corn yields increased the most with added irrigation, but no-till sorghum, wheat, and sunflower had little response to irrigation. Conventional tillage research indicated that all crops would increase yields with added water, but by different amounts. Generally, conventional and no-till management had the same yields when irrigation did not limit production. No-till management provided more yields for the same irrigation when water was limited.

The common result among all crops is the tendency for no-till management to produce more grain from the same water applied than conventional management. This result could be produced by several factors. Crop residue coverage on the soil surface could positively impact precipitation capture (runoff control and enhanced infiltration) and storage in the root zone. The same residue could reduce soil water evaporation from the root zone. The results clearly reinforce the long-known ability of corn to increase production per unit of water applied more than other common annual crops do.

Crop residues provide surface coverage that has positive benefits for water conservation, as this study's results indicate. However, competing pressures for other uses of stubbles and forages are becoming more common. They can provide livestock roughages and cellulose for fuel generation. For example, the dairy industry can compete for alternative use of crop residues. Forage samples from the study's plots were harvested and analyzed for quality factors important in dairy rations (table 1). Potential mild production from corn and sorghum forage was estimated utilizing the Milk2000 program, which converted forage quality factors into milk production. The program predicted that corn forage would produce more milk than would grain sorghum forage. Decreasing amounts of irrigation caused reduced forage yields, which led to less milk production. This result could be correlated with less biomass produced with less applied water.

Forage quality did not change greatly with increasing amounts of irrigation. It appears from these data that dry matter yield was more important than changes in forage quality. Increasing irrigation on corn increased estimated milk revenue by 38%; however, increasing irrigation on grain sorghum only increased estimated milk revenue by 17%. These data indicate that corn was more responsive to irrigation than grain sorghum in terms of dry matter produced. Corn also had better forage quality as measured by TDN than did grain sorghum over all irrigation treatments.

Systems management, including crop residues and irrigation timing, for limited water resources has the potential for reducing water applications and/or increasing crop yields. Competition for uses of crop forages will need careful scrutiny with respect to impacts on water resources. These forage harvest results will help understand the trade-offs between using forage for livestock feed or for water conservation.



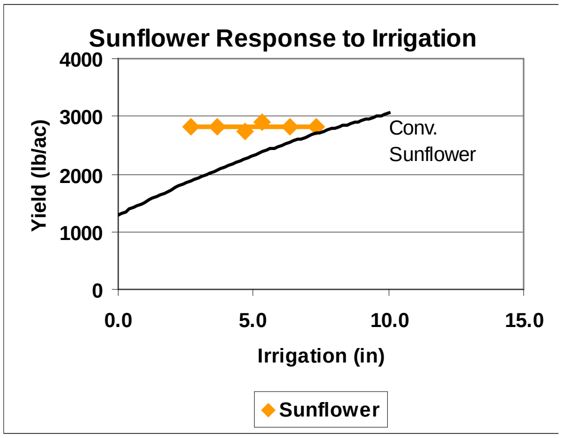


Figure 1. Grain yield response to irrigation for corn, sorghum, wheat, and sunflower. Lines without data points represent conventional tillage management from 20 years of research in western Kansas (for 19 inches of annual precipitation). Lines with data points represent regressions of irrigation vs. average yields for 2004, 2005, and 2006 crops in no-till management at Garden City, Kansas.

Table 1. Forage quality resulting from corn and grain sorghum treated with differing amounts of irrigation.

Crop	Dry Matter	Water Applied	TDN	Est. Milk	Milk Value
	ton/ac	inches	% of DM	lb/ac	$/ac
Corn	15.7	11	71.1	5,340	3,889
Corn	12.9	8	71.6	4,238	3,087
Corn	11.6	5	71.5	3,856	2,807
Sorghum	10.4	8	70.1	3,806	2,770
Sorghum	10.5	6	69.1	3,824	2,785
Sorghum	8.7	3	68.2	3,255	2,369

This research has been supported in part by the Ogallala Initiative, the USDA Water Conservation project, the US Department of Interior, and the Kansas Water Resources Institute.

SOIL WATER EVAPORATION AS INFLUENCED BY CROP RESIDUE MANAGEMENT

by
Norman Klocke, Rob Aiken, Loyd Stone, and Randall Currie

SUMMARY

Soil water evaporation was measured beneath sprinkler irrigated no-till corn and soybean crops with mini-lysimeters. The frequency and wetting patterns of sprinkler irrigation keep the soil surface vulnerable to evaporation controlled by radiant and convective energy. This study documented the role of irrigation frequency and crop residues on the soil surface in reducing this evaporation. Soil water evaporation from bare soils can be reduced by half with nearly 100% surface coverage of crop residues during the growing season in sprinkler irrigation management. Reducing soil water evaporation with adoption of crop residue management techniques can lead to reduced pumping and energy costs for irrigators with adequate water and increased crop production for irrigators with limited water supplies.

INTRODUCTION

High-frequency sprinkler irrigation leads to a preponderance of energy-limited evaporation during the growing season. Crop residues left in place on the surface can have an impact on reducing evaporation. Shifts in tillage systems may influence evaporation (E) and transpiration (T) partitioning so that yield-ET (evapotranspiration) relationships evolve and threshold ET values change. A better understanding of the energy balance components of crop canopies, surface residue, and soil surface is needed. The objectives of the study were:

1. To measure soil water evaporation in a corn canopy with wheat stubble or corn stover surface cover simulating no-till residue management.
2. To find the fraction of ET credited to E for three soil surface conditions.
3. To measure E from partially covered soil surfaces.

PROCEDURES

A field study was conducted in Garden City during 2003-2006 to test the effectiveness of corn stover and wheat stubble for evaporation suppression in soybean and corn grown in 30-inch rows. Two 12 inch diameter PVC cylinders that held 6 inches deep soil cores were placed between adjacent soybean or corn rows. These “mini-lysimeters” were pressed into undisturbed soil. The soil was bare or covered with no-till corn stover or standing wheat stubble to test the maximum effectiveness of various residues for evaporation suppression. Crop and mini-lysimeter treatments were replicated four times. Mini-lysimeters were irrigated once or twice weekly when rainfall did not satisfy crop needs. The mini-lysimeters were weighed daily, and the weight differences were translated into the evaporation amounts. Corn plant populations in the surrounding plot area were reduced to match irrigation management in the once per week frequency treatment.

A second set of replicated mini-lysimeters was established in a controlled outdoor, non-cropped setting. Irrigated mowed grass surrounded the control area. The mini-lysimeters were buried in the ground until flush with the surface. The 12 experimental treatments included six possible surface cover treatments (bare soil; 25%, 50%, 75%, or 100% coverage with corn stover; or 89% coverage with wheat stubble) with one of two irrigation frequency treatments (once per week or twice per week). Partial-cover corn stover treatments were established by evaluating the residue application with line-transect methods using mesh grids over the mini-lysimeters. The 100% corn stover and wheat stubble treatment lysimeters were similar to the field plot study treatments. The partial cover treatments were intended to simulate tillage practices equivalent to one-pass chisel, one-pass tandem disc, and two-pass tandem disc for approximately 75%, 50%, and 25% of corn stover cover remaining, respectively.

RESULTS AND DISCUSSION

Data in figure 1 are averaged over irrigation frequency (full or limited irrigation) and lysimeter placement position (to the east or west of the centerline between two adjacent crop rows). Crop evapotranspiration (ETc) was the same across surface cover treatments, when considering the average irrigation results. Average daily evaporation (E) was significantly different among the three surface treatments. Corn stover surface cover and dry matter were somewhat more than wheat stubble (see below), which contributed to more E from the wheat stubble mulch. Variations in E were

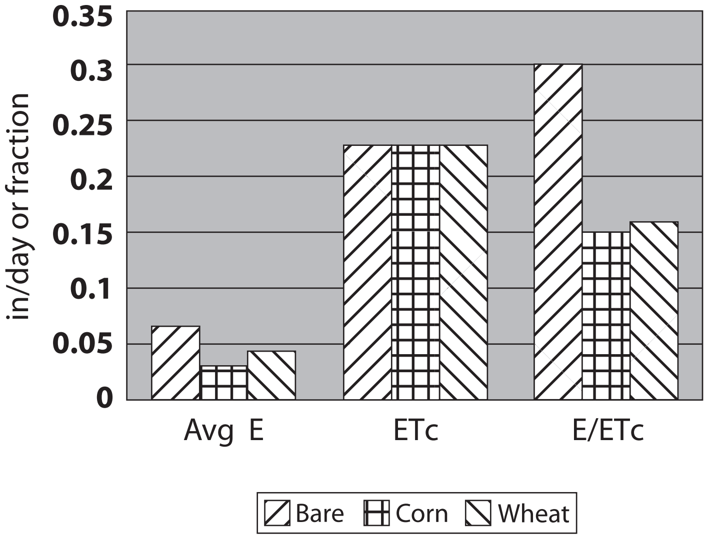


Figure 1. Average daily evaporation (Avg E), crop evapotranspiration (ETc) and the ratio of E and ETc for bare, corn stover, or wheat stubble soil surface treatments.

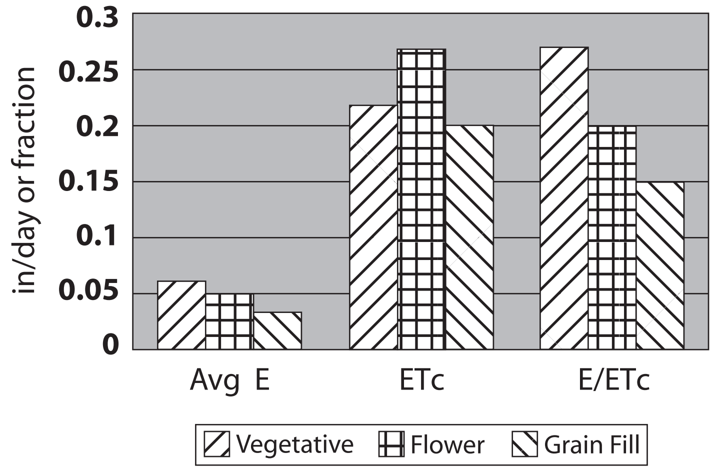


Figure 2. Average daily evaporation (Avg E), crop evapotranspiration (ETc) and the ratio of E and ETc for crop growth stages.

similar to variations in E/ETc because ETc was constant when averaged over surface treatments.

Average E decreased as the crop grew and matured (figure 2). ETc increased from the vegetative to reproductive growth stages. Then ETc decreased during grain fill. These trends are typical for corn.

The mass of corn residue remaining on the mini-lysimeters at the end of the no-canopy study was 0.68, 2.9, 2.0, and 11.1 tons/ac for respective surface cover values of 25%, 55%, 75%, and 100%. One wheat stubble treatment was covered with 8.9 tons/ac which corresponded to 89% coverage. Average daily E data were correlated with surface coverage (SC) by crop residue or dry matter (DM) of the crop residue (figure 3). Average daily E remained fairly constant over the range of 0 to 60% surface cover. From 60 to 100% coverage, average daily E decreased until the E rate for complete surface cover was half that of the no-cover treatment. Daily E rates decreased steadily with increasing dry matter. The maximum crop residue dry matter also yielded half of the daily E rate compared with bare soil.

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

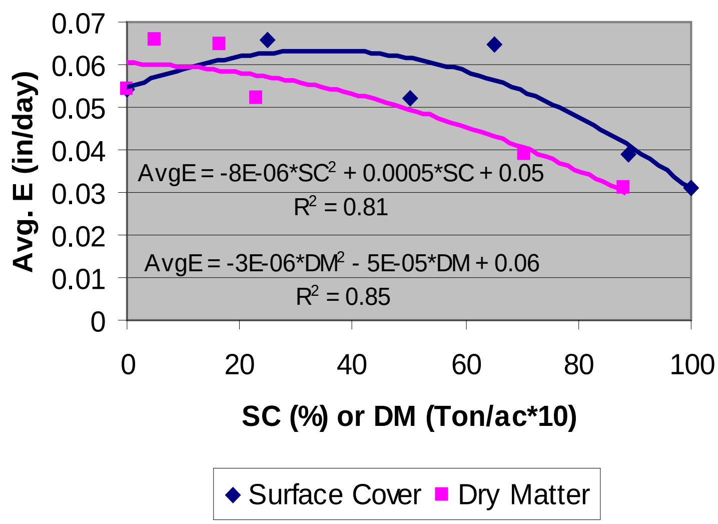


Figure 3. Correlation of average daily evaporation (Avg E) with either percent of surface coverage (SC) or crop residue dry matter (DM).

Acknowledgment: This research has been supported in part by the Ogallala Initiative, the USDA Water Conservation project, the US Department of Interior, and the Kansas Water Resources Institute.

TRENDS IN INCOME FROM LIMITED IRRIGATION USING THE CROP WATER ALLOCATOR

by
Norman Klocke, Troy Dumler, Loyd Stone, and Jeff Peterson

SUMMARY

Reducing income risk is often an irrigator's motivation for switching crops as water availability declines. The Crop Water Allocator (CWA), in its present form, ranks alternative planting patterns based on mean income alone, without considering outcomes associated with changes in input variables. This risk arises from a variety of factors that are uncertain at the time of planting; the most important of these is weather conditions during the growing season. For example, although corn often generates the highest mean income, it is also likely to have a highly uncertain yield because its growth is very sensitive to water stress during critical stages of the growing season. Adding trend analysis to CWA can project net returns over a range of input variables. Wet, dry, and median rainfall years can be simultaneously examined to find trends in net returns. The same methods can be used to project income trends from commodity prices, maximum yields, production costs, irrigation costs, and irrigation efficiency. Trend processing capabilities were added to the CWA. Ranges of user input variables can be entered with ranges of net economic returns as the output. These results indicate the income risks when rainfall, irrigation costs, crop production costs, irrigation efficiencies, commodity prices, or crop maximum yields vary. The CWA is available to download to an individual's computer from the following world wide web site: oznet.ksu.edu/mil.

INTRODUCTION

Income risk analysis has been added as a feature in existing CWA software. This option allows users to account for net-income shifts in response to trends in program inputs that vary from year to year. These input variables are: rainfall, irrigation efficiency, commodity prices, maximum crop yields, irrigation costs, and crop production costs. The trends of net-income or net-return are the basis for user decisions about the most appropriate cropping system.

Trend analysis allows the user to find net returns over a range of possible inputs: rainfall, irrigation efficiency, commodity prices, maximum crop yields, irrigation costs, and crop production costs. Fixed trend and variable trend processing are available. Fixed trend analysis starts with the user's execution of CWA and selection of one resulting cropping system. Two input ranges can be simultaneously processed in fixed trend analysis to find the influence of both inputs on net return. The results from fixed trend analysis are the changes in net return from a range of one or two inputs for a selected cropping system. The variable trend analysis is derived from the range of one of the possible inputs. The CWA is not executed in the normal fashion by the user. Crop choices, irrigation allocations and land allocations vary as part of the analysis. The outcome from variable trend analysis is the response of cropping patterns, land allocations, and water allocations to the range of the input. Variable trend analysis may be used by policy makers to forecast shifts in regional cropping systems from changes in an input variable

The original CWA has been preserved. If a user wants to ignore trend analysis, the choice can be made at the initial program screen. Output from trend processing is captured in EXCEL spreadsheets. This feature gives the user the ability to process output into table or graphical formats.

RESULTS AND DISCUSSION

Trend processing is an extension of CWA that permits entry of a range of values or the variables commodity price, maximum yield, production costs, irrigation system efficiency, and irrigation costs. For example, the program user may be interested in the response of net returns if irrigation costs vary from $5 to $15 per acre-inch. CWA executes a series of calculations over the range of irrigation costs, producing the corresponding range of net returns. Trend processing should be attempted only after the user becomes familiar with execution of CWA for one scenario at a time. Trend processing is initiated as an added feature of CWA with the "Trend Processing Start" on the entry page. Trend processing can be discontinued or enabled with the "Tools" option on the main input page.

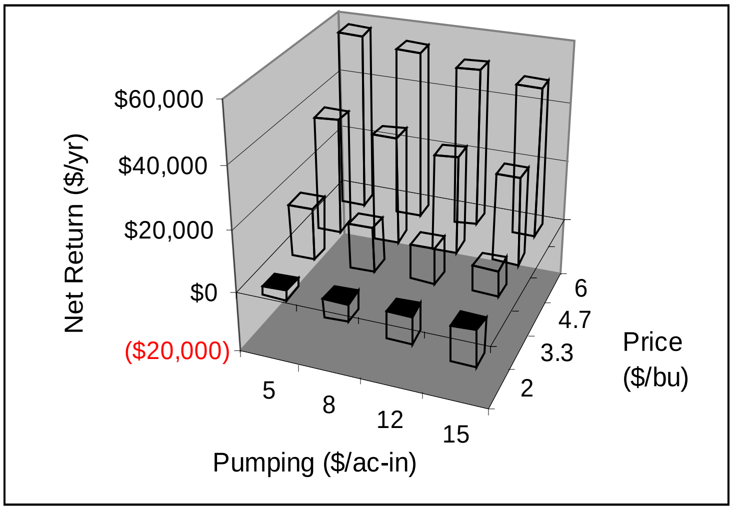


Figure 1. Annual net return for a field (100 ac) over ranges of irrigation cost and corn price from fixed trend processing in the Crop Water Allocator. For this example, corn planted on 100 acres, annual rainfall – 18 inches, irrigation – 10 inches, and irrigation efficiency – 90%.

Fixed trend processing is one of two option of trend processing, available after CWA normally executes the user's scenario. All basic inputs for the scenario must be entered (land area, irrigation costs, land split, irrigation efficiency, available water, rainfall, and production costs, prices, and maximum yields for each crop selected). The "generate output" key will initiate calculations of net returns for over all possible combinations of land and irrigation allocations. The user must select one of the options for fixed trend processing. The fixed trend feature processes only the one selected option. Activating the "Run Fixed Trend" on the selected option" will take the user to a page for the input variable range selection. For example, the range of commodity prices will lead to a corresponding range of net returns. An added option for fixed trend processing is the ability for CWA to consider two input ranges simultaneously. "Add a trend variable" switches the input entries to the second variable. For example, ranges of a commodity price and irrigation costs may be considered and results are presented in a two-way table of net returns in EXCEL. Users can further represent these results in three dimensional graphs (figure 1).

Variable trend processing is the second option for trend processing in CWA. In variable trend processing, crop selections, water allocation, and land applications can change to find optimum solutions for each value in the range of input specified. All input values must be entered before executing variable processing (land area, irrigation costs, land split, irrigation efficiency, irrigation amount, rainfall, production costs, prices, and maximum yields for each crop selected). However, the "generate output" button is not used to initiate variable trend procession. Variable trend processing is initiated from the TOOLS option on the main input page only after all input values have been entered. The range of the chosen input variable is entered before execution. Only one input variable can be examined with variable processing. Execution of the variable processing will precede any normal execution of CWA results. The limitation of variable trend processing is that options one to four of each solution will be examined and reported in the EXCEL output. Applications of variable trend solutions are predictions of trends in crop selections and land and water allocations over a range of an input variable. For example, if annual precipitation varied from 11 to 21inches, how would cropping patterns change (Table 1)?

The trend analysis feature of CWA opens the door for users to examine the risks in net returns when input values vary over a specified range. Volatile commodity prices, escalating production and irrigation costs, uncertain rainfall and possible water allocations cause producers and policy makers to project micro and macro economic effects. CWA has been a model that predicts crop selections, land allocations, and water allocation from one set of inputs. The trend analysis extends CWA's capability for results from a range of inputs.

Acknowledgement: This project was funded in part by the Ogallala Initiative, the USDA Water Conservation Project, the US Department of Interior, and the Kansas Water Resources Institute.

Table 1. Variable trend analysis example from the Crop Water Allocator. Net returns were calculated from inputs of: corn price - $4.05/bu; grain sorghum price - $3.65/bu; annual irrigation – 10 inches; irrigation efficiency – 10 inches.

Annual Precip. (in)	Crop	Acres	Net Irrigation (in)	Irrigation Cost/year	Production Cost per year	Net Return per year
11	Sorghum	50	3.6"	$653	$6,523	$14,015
	Corn	50	14.4"	$1,863	$16,527	
14.33	Sorghum	50	3.6"	$653	$7,125	$19,624
	Corn	50	14.4"	$1,863	$17,364	
17.67	Corn	100	9.0"	$2,516	$31,367	$30,216
21	Corn	100	9.0"	$2,516	$33,043	$37,020

MOBILE IRRIGATION LAB PROJECT: KANSCHED2[1]

by
Mahbub Alam, Danny H. Rogers[2], Gary A. Clark[2], and Kent Shaw[3]

SUMMARY

KanSched2, an ET-based irrigation scheduling program, was developed and released for public distribution for use by farmers, crop consultants, researchers, government agency personnel, and others in the Ogallala Aquifer region. Evapotranspiration (ET)-based irrigation scheduling can help conserve water and energy resources. KanSched-2 has many new features and options, including an expansion of pre-programmed summer crops, an alfalfa/summer forage crop module, a fuel use and cost module, a crop water use forecast tool, improved data input/output options, and a storage module for well and water meter records. KanSched2 retains the layout and control button format of the original version, allowing KanSched1 users to make an easy transition to KanSched2 use. New users will find that KanSched2 to be user-friendly.

INTRODUCTION

As farmers and crop consultants face rising fuel costs and limited water supplies, sound irrigation water management decisions are needed. With current computer technology and readily available weather data, computer-based irrigation scheduling models can be used by almost anyone. However, the model needs to be user-friendly and must meet consumer needs. While computer-based irrigation scheduling models have been in existence for some years, most were not adopted and used because they required extensive training and/or were difficult to use. The KanSched model was designed to be very user friendly and easily adopted through minimal training. The success of that model has been demonstrated through the Kansas Mobile Irrigation Lab (MIL) water conservation project (www.oznet.ksu.edu/mil/). However, the original KanSched model was developed for irrigated corn in southwestern and south-central Kansas. While successful patches have been developed to include other crops and soil conditions, it became necessary to redesign and code the original model to meet the needs of a larger customer base and to include other cropping systems common to the entire High Plains region. The objective was to redesign and rewrite the KanSched irrigation scheduling program for use with common High Plains irrigated crop production systems.

PROCEDURES

The general functionality of the new KanSched2 program is similar to the general format of the existing KanSched program. KanSched2 has been built in an object-oriented programming language using Microsoft's Visual Basic. During 2005, KanSched2 was designed and developed using the following elements in addition to the functions of the existing KanSched program:

1. additional summer crop modules include corn, cotton, dry beans, sorghum, soybean, and sunflower;
2. wheat (winter and spring) crop modules and an alfalfa/summer forage crop module;
3. an initial soil profile moisture content that is now user-defined;
4. a data input/output structure was incorporated to use and store data in an ASCII comma- delimited mode;
5. a crop water-use forecast tool (this tool uses current ET data and a crop coefficient curve to predict future crop water requirements for the next 5 days, and it also uses current soil water storage to estimate the next irrigation date); and
6. a fuel cost input page (similar to FuelCost Online, www.oznet.ksu.edu/mil/) that can be used to track and display fuel use and cost on each system (required user inputs will include: system capacity [gpm], depth to pumping water level in feet, wellhead operating pressure in psi, pumping plant energy type [diesel, natural gas, electricity, propane] and unit cost of fuel, as well as the option to input actual energy costs to estimate future costs).

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[1] Supported in part by State Water Plan Funds through Kansas Water Office.
[2] Department of Biological and Agricultural Engineering, Kansas State University, Manhattan, KS
[3] Mobile Irrigation Lab Project coordinator, K-State Research-Extension, Garden City, KS

RESULTS

KanSched2 was released for distribution in late 2006 after testing by developers and selected agency and KanSched1 users during the summer growing season of 2006. While KanSched2 is similar to the general format of the existing KanSched, it includes a number of new features and options. Former KanSched users will find the KanSched2 familiar which should allow an easy transition in use. Many of the inputs can be entered by using drop down menus, simplifying field setup.

KanSched2 allows for easier sharing of field information. Fields can be grouped together into field collections. Individuals using KanSched2 will most likely have only one field collection that would contain all irrigated fields being scheduled. Agency personnel and crop consultants would likely make a collection for each producer client.

KanSched2 also allows import of ET and rainfall data in the formats noted in Figure 1. Data from the daily budget page can also be exported (as noted in item 4 on previous page).

Activation of the "Field Setup" control button results in five input pages being revealed to the user. The general information page, shown in Figure 2, allows input of the crop type. The selection of crop type automatically triggers the proper selection of crop coefficient information. Eighteen crop options are pre-programmed into KanSched2. A new feature that can be utilized on this page is the ability to customize existing crop coefficients or add new crops to the selection list. This makes KanSched2 more versatile and adaptable to other climatic regions.

The initial soil water content at the start of the water budget date is easily entered on the "Soil and Roots" page during field setup shown in Figure 3. Notice also that associated with most input boxes is text that describes the input needed, making on-screen help instantly available, but with minimal or no distraction for the user.

"Forecast" is a new feature of KanSched2 shown in Figure 4. The estimated ET demand can be adjusted by using the sliding marker on the ET demand bar. Predicted crop ET and the associated soil water level for the prediction period are shown in the text at the lower section of the page.

"Irrigation System," shown in Figure 5, is also a new feature of KanSched2. If activated, the cost of application for each irrigation will be tracked and displayed on the budget page (not shown).

KanSched2 also has a feature, called "Water Information," that allows a producer to store well and water meter information for a field. This feature may be useful to any user of KanSched2, but could be particularly useful to Kansas producers when preparing irrigation water use reports required by the State of Kansas.

CONCLUSION

KanSched 2's official release was publicized via radio interviews and news releases, as well as e-mail notices to county extension agents and Kansas NRCS personnel. KanSched2 also has been submitted for approval by the NRCS computer software review committee. Survey information gathered after multiple hands-on training sessions with various groups indicate that KanSched2 and the training format is being well received. The quality assessment by participants ranked the quality and organization of presentation very close to excellent (4.22 on a scale of 5). The depth of the material was ranked in the median (3.37, where 1 was "too difficult" and 5 "too easy"). For usefulness or applicability of KanSched2, the ranking was again close to excellent (4.22 on a scale of 5).

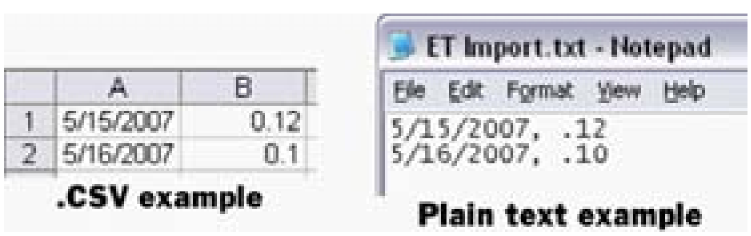

Figure 1: Examples of file format for the Import ET function.

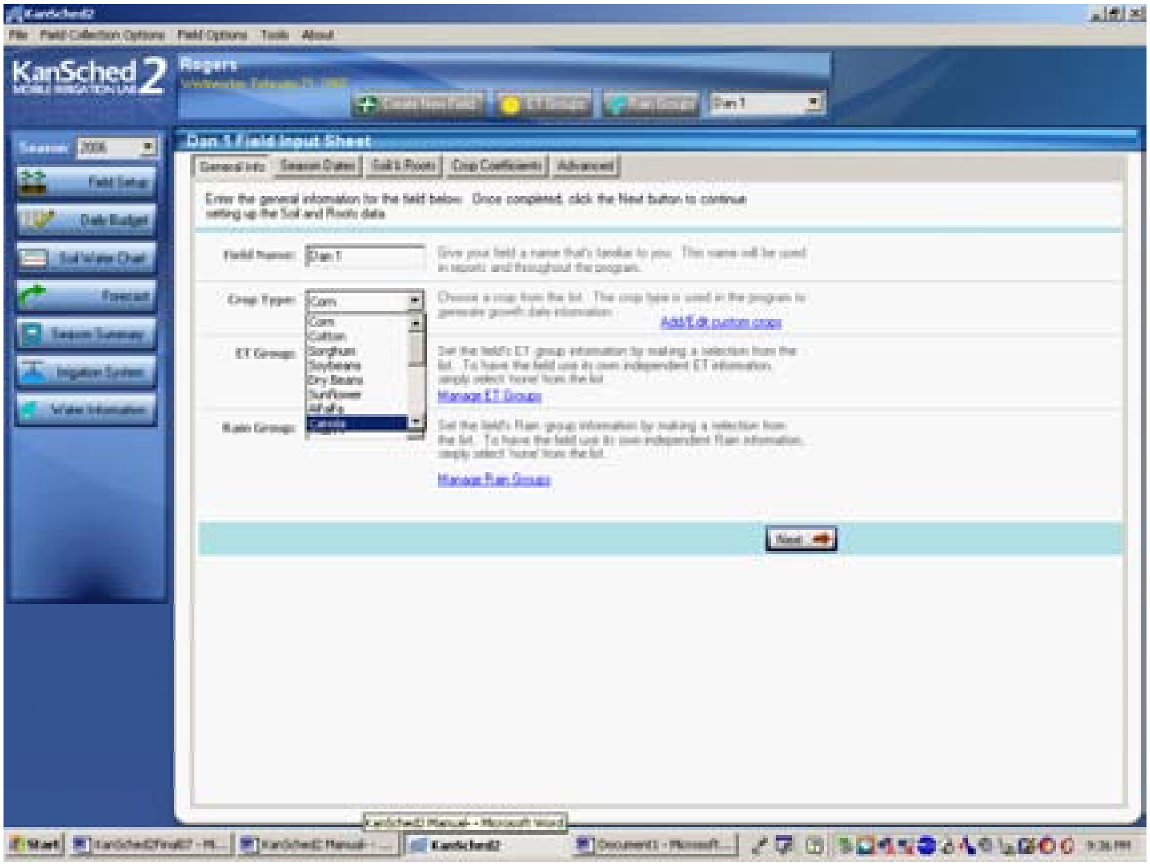

Figure 2: "Field Setup" section of KanSched2, showing the "General Information" input page with the drop down menu of crop options.

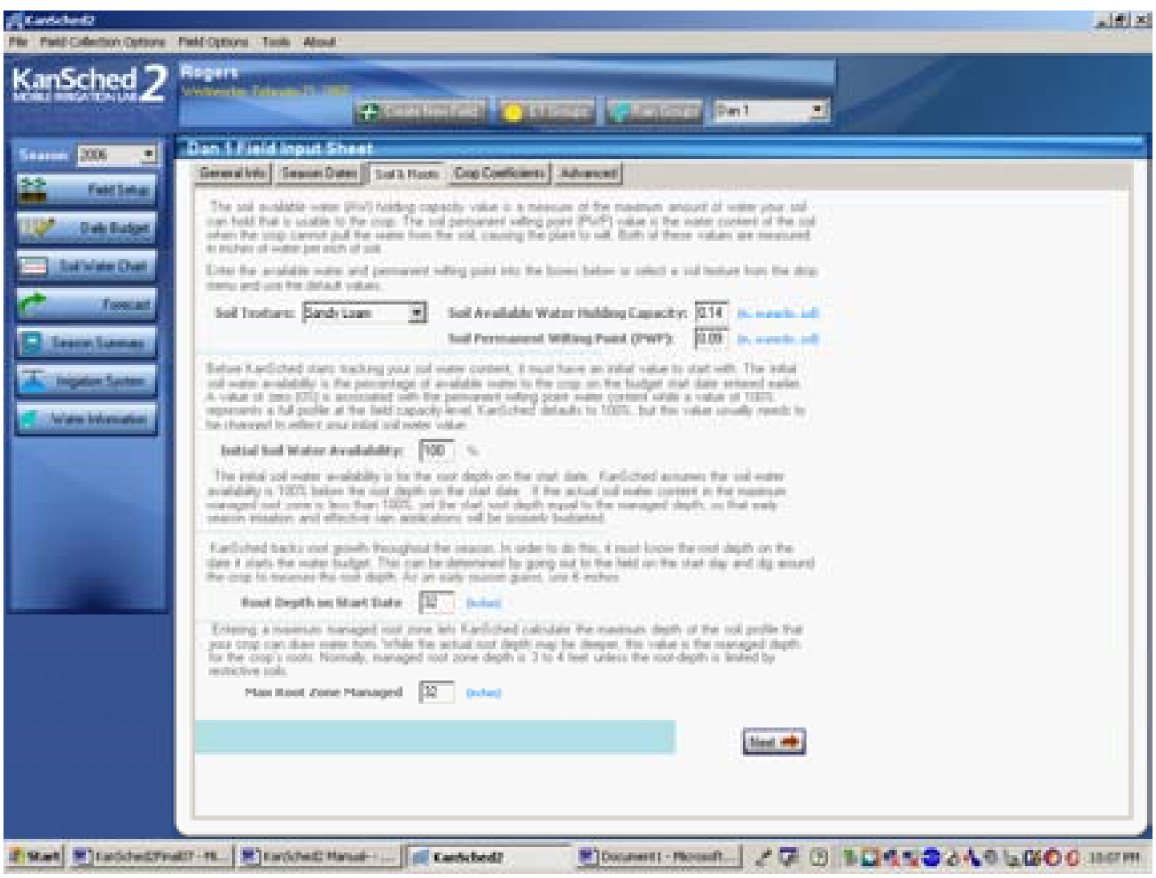

Figure 3: "Field Setup" section of KanSched2, showing the "Soil and Roots" input page.

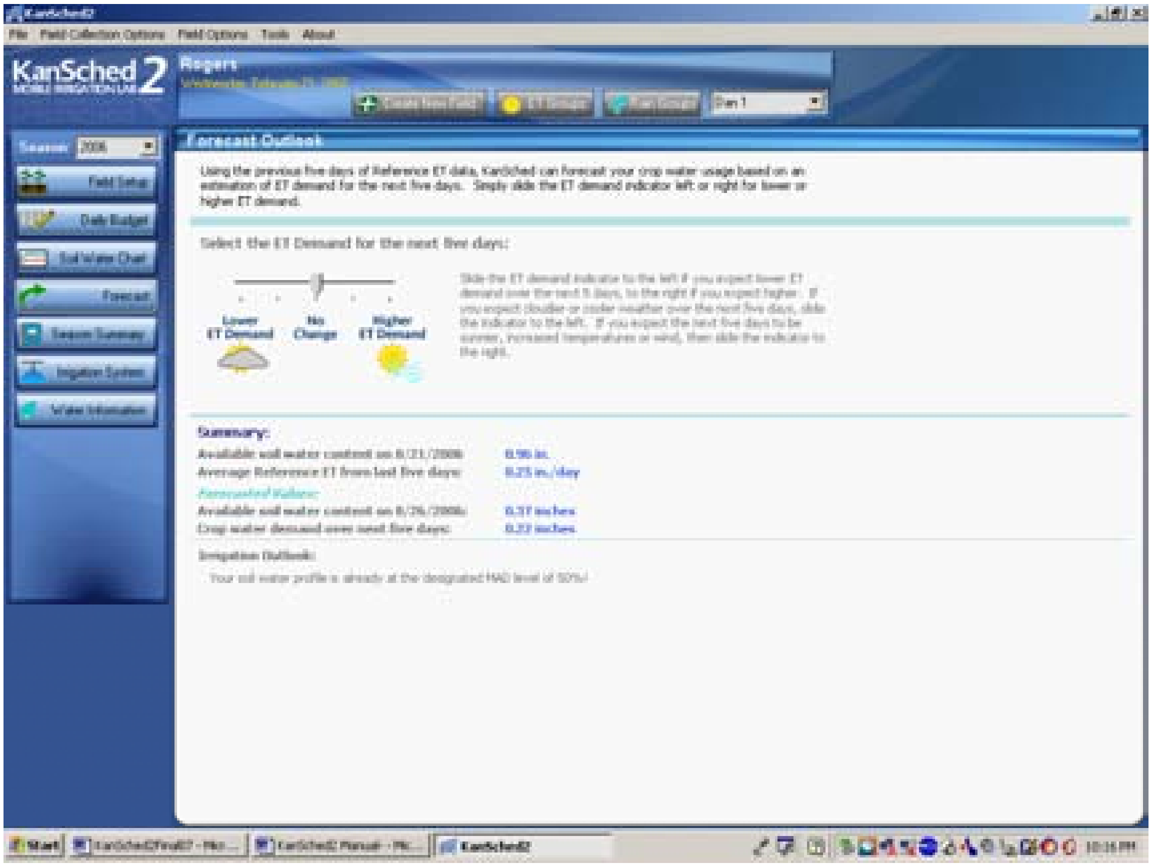

Figure 4: "Forecast" section of KanSched2.

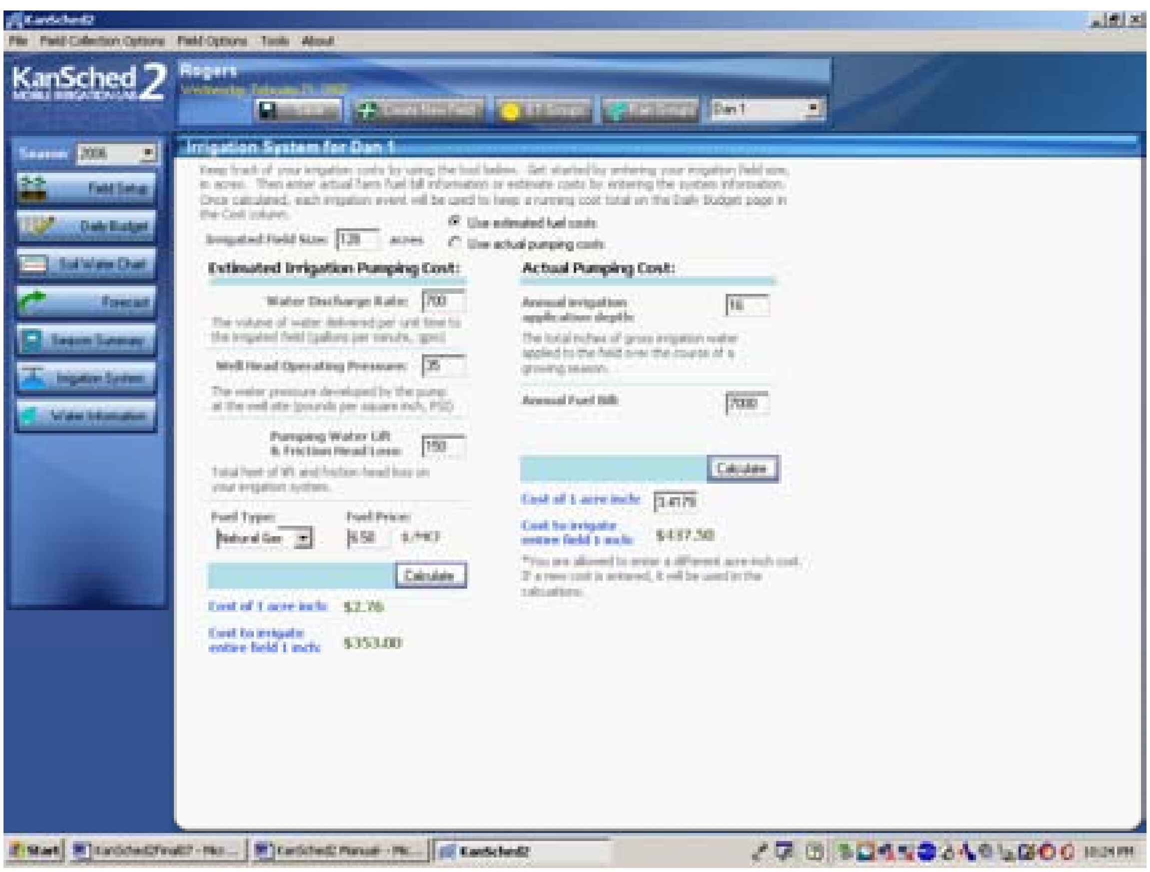

Figure 5: Irrigation System Section of KanSched2.

FIELD PERFORMANCE OF SUBSURFACE DRIP IRRIGATION IN KANSAS[1]

by
Mahbub Alam, Danny H. Rogers[2], and Kent Shaw[3]

SUMMARY

Subsurface drip irrigation (SDI) survey was mailed to a list of 297 individuals thought to be owner/operators of SDI systems. The survey return rate was 31% (92 responses), of which 53% (49 responses) were from actual SDI users. Respondents had SDI acreage totaling 8,022 of the 323,260 acres they irrigated (about 2.5%). Survey results indicated that producers were generally satisfied with their SDI systems and that the majority of the SDI systems were installed by the joint efforts of producers and contractors (54%). Contractor-installed systems accounted for 19% and the remainder (27%) was self-installed by producers. The major concerns were rodent damage, filtration, clogging due to iron bacteria, initial system costs, and wetting of topsoil during germination in dry years.

INTRODUCTION

Drip irrigation has proven to be an effective irrigation method for saving water and improving returns for high-dollar cash crops. However, surface drip systems are not as suitable to the field cropping system practiced in the Central Great Plains. Kansas State University's research on suitability of using subsurface drip irrigation (SDI) has shown that it is a feasible technology for irrigating field crops like corn. More than 2 million acres out of 3 million irrigated in Kansas depend on groundwater from the Ogallala Aquifer. Producers are experiencing water-level declines and rising pumping costs because of greater depth of pumping and increasing fuel costs. Economic comparison of systems indicates that a well managed SDI system with a promise of fifteen or more years of life is economically competitive, although it requires a high investment initially. Extension demonstrations have encouraged a steady increase in acreage irrigated by SDI; initially, many of these systems were installed in small farms with limited water where a part of the water supply was diverted from existing flood or center pivot sprinkler irrigation systems. Lately, producers with large acreage under flood irrigation have started switching to SDI. Statewide SDI acreage is estimated at 20,000 acres, most of which is in western Kansas and represents about 1% of irrigated crop land. Although no major concern regarding system failure has surfaced, the present operational condition of these systems was evaluated to provide field-performance information to farmers intending to adopt SDI. The study objective was to assess the operational condition of the existing SDI systems and the level of producer satisfaction. Information could help address clientele needs and keep service providers informed.

PROCEDURES

A questionnaire was sent out to 297 producers. The sample questionnaire may be viewed at http:www.oznet.ksu.edu/SWAO/Irrigation/sdi.htm under the link"Field Performance of SDI." The mailing list of producers was prepared from sign-up lists of farmers attending extension educational meetings on SDI and a list obtained from the Kansas State Division of Water Resources of producers reporting use of microirrigation. Recipients of survey forms were asked to return the survey form even if they were not SDI users. The survey requested information regarding acreage, installation, and performance satisfaction.

RESULTS AND DISCUSSION

Results indicated that producers were generally satisfied with their SDI systems. The majority of SDI systems were installed by the joint efforts of producers and contractors (54%). Contractor-installed systems account for 19% and the remainder (27%) were self-installed by the producers.

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[1] This project receives support from the Ogallala Aquifer Project of the USDA-ARS Research Initiative.
[2] Department of Biological and Agricultural Engineering, Kansas State University, Manhattan, KS
[3] Mobile Irrigation Lab Project coordinator, K-State Research-Extension, Garden City, KS

When asked if the producers had received an "as-built" drawing or diagram of the system from the contractors, 34 positive responses were received and 14 were negative. The response on receiving operational and maintenance instructions or operating procedures for the SDI system was similar; 33 received instructions and 15 did not receive instructions on operational procedures.

Crops irrigated by SDI systems were corn (43 responses), soybeans (24 responses), cotton and alfalfa (5 responses each), and sorghum (3 responses). Other crops included wheat, oats, and sorghum silage.

The survey asked about the level of satisfaction with the SDI system, using a level of satisfaction scale of 1 ("very satisfied") to 5 ("unsatisfied"). The majority rated their level of satisfaction as "very satisfied" (17) or "satisfied" (19); other response options were "almost satisfied" (4), "somewhat satisfied" (4), and "unsatisfied" (2).

Most respondents (30) planned to expand acreage under SDI; however, 19 indicated they did not plan to expand their SDI acreage at that time.

The survey asked producers to list their own concerns regarding the SDI systems. The major concerns were:

- Rodent, gopher, and other vermin damage requiring many hours of repair; this was the most-cited concern (37 responses).
- Filtration is a concern, but with a good system and maintenance there was no problem. Some asked if there were better filtration systems available or should one oversize to avoid frequent cleaning. (15)
- Clogging due to iron bacteria and calcium precipitation is a concern. Some reported clogging from pump-oil drips. Clogging from drip oil is more evident in pumps with low capacity or fluctuating water levels. (15)
- Cost of the system, especially the life of the system. (8)
- Wetting of the top soil for germination. (3)
- Hard to visualize soil water condition and thus monitor soil water situation.

Finally, the survey asked producers to list information needs that Kansas State Research and Extension might be able to address. The responses from the producers were as follows:

- Rodent control – how and what to use.
- Fertilizer use through SDI, including micronutrients.
- More educational meetings, seminars on management (both pre and post season). Arrange field tour to visit systems and exchange information with other operators.
- Drip tape spacing for crops other than corn. More research for alternative crops under SDI.
- More information about planting alfalfa under SDI.
- How to germinate seed in dry soil or conserving moisture in surface soil for planting.
- How to unclog drip lines. How one may keep systems clean with different water supplies.
- System capacity, how much water to use, and limited water issues.
- Comparisons of crop yield advantage from SDI over sprinkler.
- Any changes to cut costs, improve filtration, and decrease maintenance requirements.
- Property taxation classification for SDI needs to be developed to avoid over-taxation where producers currently are being penalized for conserving water.
- Why assistance is unavailable to conservation-conscious farmers who want to install SDI, whereas it is available to circle irrigators

FOLLOW-UP

Producers were asked if they would like an in-field analysis of their SDI systems. Approximately 30 responded that they would be willing to participate. Eight individuals were selected for the site visit based on criteria of system age and location. Three systems have been visited and two of those appear to be performing near their original design specifications. The other was suffering from extensive rodent damage, with many large leaks. Leakage was so extensive that no flow was occurring in flush lines. Rodent infestation and lack of timely maintenance has brought the system to the point that abandonment is being considered. The system is still in operation and was installed 10 years ago.

EFFECT OF AMMONIUM SULFATE (AMS) AND AMS REPLACEMENTS ON GLYPHOSATE EFFICACY

by
Curtis Thompson, Dallas Peterson, and Alan Schlegel

SUMMARY

Most glyphosate labels recommend that ammonium sulfate should be added to a spray solution to counteract effects of hard water and improve weed control. Recommended ammonium sulfate (AMS) rates with glyphosate are relatively high and generally inconvenient to use. Several low-rate water conditioner products are available as alternatives to AMS with glyphosate. Pesticide applicator testimonials suggest performance with those products is inconsistent. Glyphosate control of crop and weed species was enhanced consistently by adding 17 lbs AMS per 100 gallons – in some cases by 40%. Adding 8.5 lbs AMS per 100 gallons to glyphosate generally provided control similar to or slightly less than treatment with 17 lbs AMS. Commercial products with an ammonium sulfate component at the equivalent rate of 8.5 lbs controlled equally to or slightly better than glyphosate plus 8.5 lbs AMS. Commercial water conditioners without AMS or applied at a much lower rate of AMS gave less control than glyphosate with 8.5 lbs or 17 lbs AMS and often were no better than glyphosate alone. Glyphosate tank mixed with low-rate water conditioners did not provide the same level of control compared to the recommended AMS rate.

PROCEDURES

Field experiments were conducted at Manhattan, Garden City, and Tribune in 2005 and 2006. Roundup WeatherMax at below-labeled rates (8-11 fl oz) was applied to various assay species in combination with the recommended label rates of AMS and various commercial water conditioners. Sprayer application information and stage of plant growth at the time of application are shown below in Table 1. All control evaluations were made visually on a scale of 0 to 100, with 100 being complete control of the species being rated and 0 being no effect on the species. The rates of the additives are shown at % v/v or as lbs/100G. The % v/v indicates a liquid formulation of the product and refers to gallons of product/100 gallons of spray solution. The lbs/100G indicates a dry formulation and refers to pounds of the dry product/100 gallons of spray solution.

RESULTS AND DISCUSSION

Volunteer wheat was controlled by all Roundup WeatherMax (glyphosate) treatments regardless of the tank mix partner in the 2005 Garden City experiment two weeks after treatment (Table 2). Roundup WeatherMax (11 fl oz/a) controlled 4-leaf wheat regardless of additive. Palmer amaranth control was 97% when glyphosate was applied with the full load of N PAK AMS at 5% v/v (5 gallon/100 gallon spray solution). This AMS rate is equivalent to 17 lbs dry AMS per 100 gallons of spray solution. Class Act NG enhanced glyphosate efficacy similarly to Alliance, but slightly less than 17 lbs of AMS. Choice, Request, and Guardian

Table 1. Application information for field experiments conducted at Manhattan, Garden City, and Tribune, 2005 and 2006.

	2005		2006	
	Manhattan	**Garden City**	**Manhattan**	**Tribune**
Spray Volume:	15 gpa	10 gpa	15 gpa	
Water Hardness:	103 mg/L	140 mg/L	452 mg/L	
Application:				
Date:	7-1-05	7-18-05	6-28-06	9-12-06
Temperature:	83 F	70 F	82 F	78F
Rel. Humidity	46%	78%	31%	45%
Weed Sizes:				
Crabgrass	2-4”		1”	
Velvetleaf	6-10”		6-8”	
Sorghum	18”		12-15”	10-12”
Corn	24”		12-16”	12-15”
Sunflower	12-18”		7-10”	10”
Wheat		4-leaf		
P. Amaranth		2-6”		

gave less activity with glyphosate than all other products and controlled Palmer amaranth similarly to glyphosate applied alone.

Roundup WeatherMax at 8 fl. oz/a applied alone generally gave the lowest control of species evaluated in the 2005 Manhattan experiment (Table 3). Clearly, velvetleaf is the most difficult species to control ,as glyphosate alone gave 40% control. The addition of NPAK AMS at 5% v/v enhanced control of all species with glyphosate compared to glyphosate alone. Class Act NG, Alliance, and N-Tank also enhanced efficacy with glyphosate. The remaining products did not consistently improve control of species evaluated, especially velvetleaf.

Roundup WeatherMax at 8 fl oz/a alone controlled sorghum 56%, corn 74%, and sunflower 84% in the Tribune 2006 experiment (Table 4). NPAK AMS increased the level of control compared to glyphosate alone; however, the full AMS rate of 5% v/v was required to maximize control. All products applied at 1% v/v or more enhanced control with glyphosate compared to glyphosate alone. N-Tank was the most effective product with a use rate of 0.5% v/v.

Roundup WeatherMax at 8 fl oz/a alone was ineffective on the species evaluated in Manhattan in 2006 (Table 5). The 450 ppm water hardness apparently deactivated the glyphosate. NPAK AMS at 5% v/v enhanced glyphosate dramatically, but control still ranged from only 40% for velvetleaf to 85% for sunflower. All products applied at 0.5% v/v provided little to no enhancement of glyphosate, with the exception of N-Tank, which enhanced glyphosate efficacy slightly, but not equal to NPAK AMS.

In summary, the efficacy of glyphosate consistently was enhanced most by addition of NPAK AMS at 5% v/v (equal to 17 lbs dry AMS / 100 gallon) at all locations in all years. The addition of AMS at 2.5% v/v generally provided similar or slightly less control than with 5% v/v AMS. Commercial products that provided comparable rates of AMS provided a similar enhancement of glyphosate efficacy.

Most commercial water conditioners added at low use rates generally gave much lower weed control than recommended rates of AMS and often were no better than glyphosate alone. The most effective low-rate water conditioner with glyphosate tended to be N-Tank. Under ideal conditions and higher rates of glyphosate, differences in weed control due to adjuvant may be less or even negligible at high levels of weed control.

Table 2. Weed control two weeks after treatment with Roundup Weathermax glyphosate at 11 fl oz/A (0.38 lb ae/A) as influenced by adjuvants at Garden City, 2005.

Treatment	Rate	Volunteer wheat	Palmer amaranth
Roundup WM+:		--------------------(% control)	------------------
None	-	100	74
N PAK AMS	5% v/v	100	97
Class Act NG	2.5% v/v	100	90
Alliance	1.25% v/v	100	89
Choice	0.5% v/v	100	60
Request	0.5% v/v	100	74
Guardian	0.25% v/v	100	72
LSD (5%)		**NS**	**7**

Table 3. Weed control four weeks after treatment with Roundup Weathermax glyphosate at 8 fl oz/A (0.28 lb ae/A) as influenced by adjuvants at Manhattan, KS, in 2005.

Treatment	Rate	Large Crabgrass	Velvetleaf	Sorghum	Corn	Common Sunflower
Roundup WM+:		------------------------	------------(% control)	------------	------------	------------
None	-	63	40	70	67	90
N PAK AMS	5% v/v	77	78	95	98	97
Class Act NG	2.5% v/v	83	65	95	98	97
Alliance	1.25% v/v	85	60	93	93	97
Alliance	0.75% v/v	80	55	93	95	95
Choice	0.5% v/v	60	40	75	67	92
Request	0.5% v/v	63	47	67	78	97
Speedway	0.5% v/v	70	52	75	73	97
Blenmaster	1% v/v	82	53	82	85	98
US500	0.25% v/v	63	43	72	77	92
Citron	2.2 lbs/100G	60	47	77	75	95
N-Tank	0.5% v/v	88	75	95	98	100
LSD (5%)		**8**	**8**	**7**	**8**	**5**

Table 4. Weed control nine days after treatment with Roundup Weathermax glyphosate at 8 fl oz/A (0.28 lb ae/A) as influenced by adjuvants at Tribune, KS, in 2006.

Treatment	Rate	Sorghum	Corn	Common Sunflower
Roundup WM+:		---------------------------	(% control)	-------------------------
None	-	56	74	84
N PAK AMS	2.5% v/v	69	84	90
N PAK AMS	5% v/v	83	90	89
Class Act NG	2.5% v/v	80	87	90
Alliance	1.25% v/v	83	78	90
Alliance	0.75% v/v	74	86	90
Level 7	0.5% v/v	70	76	88
Level 7	1.0% v/v	73	79	86
Dispatch AMS	2.5% v/v	78	84	91
Choice WM	0.5% v/v	63	69	85
Flame	0.5% v/v	69	84	86
Interactive	1.0% v/v	80	81	90
Accuquest	0.5% v/v	66	74	83
Request	0.5% v/v	60	73	85
Bronc Plus EDT	10 lbs/100G	81	88	90
Cut Rate	4 lbs/100G	75	86	89
Cayuse Plus	0.5% v/v	69	86	86
Bronc Max	0.5% v/v	70	84	89
Array	9 lbs/100G	79	90	89
Zenith	2.25 lbs/100G	85	90	92
Power House	1.25% v/v	81	85	90
Enact	0.5% v/v	75	80	88
Load Out	0.5% v/v	68	78	86
Citron	2.2 lbs/100G	69	80	86
N-Tank	0.5% v/v	83	86	87
LSD (5%)		**16**	**11**	**5**

No Adjuvant | N PAK AMS at 5% v/v | Low rate product at 0.5% v/v

Adjuvant Effect on Glyphosate Efficacy at Manhattan, KS in 2005.

Table 5. Weed control four weeks after treatment with Roundup Weathermax glyphosate at 8 fl oz/A (0.28 lb ae/A) as influenced by adjuvants at Manhattan, KS, in 2006.

Treatment	Rate	Large Crabgrass	Velvetleaf	Sorghum	Corn	Common Sunflower
Roundup WM+:		(% control)				
None	-	13	0	0	0	3
N PAK AMS	2.5% v/v	34	23	53	57	63
N PAK AMS	5% v/v	40	50	67	70	85
Class Act NG	2.5% v/v	57	30	73	68	78
Alliance	1.25% v/v	37	17	57	57	43
Alliance	0.75% v/v	30	13	17	33	27
Level 7	0.5% v/v	10	10	5	10	7
Level 7	1% v/v	20	10	12	23	17
Dispatch AMS	2.5% v/v	30	23	50	57	53
Choice WM	0.5% v/v	10	3	0	0	5
Flame	0.5% v/v	20	5	2	3	10
Interactive	1% v/v	20	13	7	7	10
Accuquest	0.5% v/v	10	10	7	10	10
Request	0.5% v/v	10	8	0	7	7
Bronc Plus EDT	10 lbs/100G	37	30	38	50	57
Cut Rate	4 lbs/100G	13	12	13	17	15
Cayuse Plus	0.5% v/v	7	10	5	3	7
Bronc Max	0.5% v/v	10	7	0	3	10
Array	9 lbs/100G	20	33	37	50	53
Zenith	2.25 lbs/100G	20	27	27	33	40
Power House	1.25% v/v	20	18	17	23	23
Enact	0.5% v/v	10	7	5	3	10
Load Out	0.5% v/v	8	3	3	3	7
Citron	2.2 lbs/100G	17	3	3	5	3
N-Tank	0.5% v/v	23	30	22	7	23
LSD (5%)		**12**	**10**	**9**	**10**	**11**

CLETHODIM, GLUFOSINATE OR PARAQUAT TANK MIXES FOR CONTROL OF VOLUNTEER CORN

by
Randall Currie, James Lee, Brandon Fast[1] and Don Murray[1]

SUMMARY

Clethodim provided the best and most consistent control of volunteer corn. Although it could be killed with low rates of clethodim at the two-leaf and three-leaf stage, as the size of the corn increased the rate of clethodim needed to be increased. Although small corn was killed by non-clethodim tank mixes at a single location, as the corn size increased these treatments were not effective on larger corn at the other locations.

INTRODUCTION

With increasing use of glyphosate-resistant corn hybrids, volunteer corn has become a difficult weed to control. Therefore, the objective of these studies was to determine a non-glyphosate tank mix to control this emerging weed problem.

PROCEDURES

Volunteer corn was simulated by planting standard glyphosate-resistant corn hybrids in conventionally randomized complete-block experiments, with four or more replications, conducted near Stillwater, Oklahoma, and Garden City, Kansas. The plot area was kept weed-free with applications of glyphosate as needed. In the first experiment conducted near Stillwater, two-leaf or three-leaf corn was sprayed with 0.015 lbs or 0.03 lbs of clethodim. In a second study three-leaf or six-leaf corn was sprayed with glufosinate, At 0.42 lbs/a or clethodim at 0.06 lbs/a, or paraquat at 0.56 or 0.64 lbs/a or these rates of paraquat tank mixed with 0.5 lbs of atrazine or 0.14 lbs/a metribuzin. The first study at Garden City applied 0, 0.15, 0.03 or 0.06 lbs/a clethodim to four-leaf or eight-leaf corn. In a second study, glufosinate at 0.42 lbs/a or paraquat at 0.28, or 0.56 or 0.64 lbs/a or these rates of paraquat tank mixed with 0.014 lbs/a metribuzin or 0.5 lbs/a linuron were applied to four-leaf or eight-leaf corn.

RESULTS AND DISCUSSION

In Stillwater, two-leaf corn control was 100% at all rates of clethodim. At the three-leaf stage, control declined to 90% with 0.015 lbs/a clethodim. Twice as much clethodim was needed to kill 100% of the three-leaf corn. In a second study, 0.06 lb/a of clethodim was needed to get 100% control of three-leaf or six-leaf corn. In Garden City, as seen in Stillwater, 0.06 lbs ai/a of clethodim controlled more than 90% of the corn 21 DAT, regardless of timing. In contrast, regardless of treatment or timing, all corn recovered to various degrees and was harvested for grain as an index of injury. Although the lowest clethodim rate yielded 6 bu/a more than the control (no clethodim), this was not statistically significant. When 0.015-lb/a of clethodim was applied to eight-leaf corn, yield was reduced from 52 bu/a to 23 bu/a. Clethodim applied at 0.03 lbs/a to four-leaf corn resulted in a yield of 22 bu/a. In contrast, when application of the 0.03-lb/a was delayed to the eight-leaf stage, yield dropped to 3.9 bu/a. Regardless of timing of application, corn treated with 0.06 lb/a yielded less than 1.7 bu/a. Depending on the objectives of a producer, these treatments would have been commercially acceptable.

Although corn was completely defoliated at Garden City by paraquat at rates from 0.28 to 0.64 lb/a by itself or tank-mixed with 0.5 lbs/a linuron or 0.14 lb/a or metribuzin, in all instances, the corn recovered and produced a crop that ranged from 23 to 39 bu/a, which was not a statistically significant difference from no treatment. Glufosinate at 0.42 lb/a also produce similar levels of control. Delaying application of these tank-mixes until the eight-leaf stage reduced corn yield from 36 to 21 bu/a. None of these tank-mixes produced a level of control that would be considered commercially viable. At Stillwater, 100% control of three-leaf corn was achieved with Paraquat at 0.57 lb/a tank mixed with 0.14 lb/a or metribuzin or 0.5/a atrazine. Only 44% control of six-leaf corn was seen with any paraquat tank mix. These studies suggest that clethodim, when applied early at lower rates or applied late at the higher rates, might provide the best control of volunteer glyphosate-resistant corn.

[1] Oklahoma State University, Stillwater, OK.

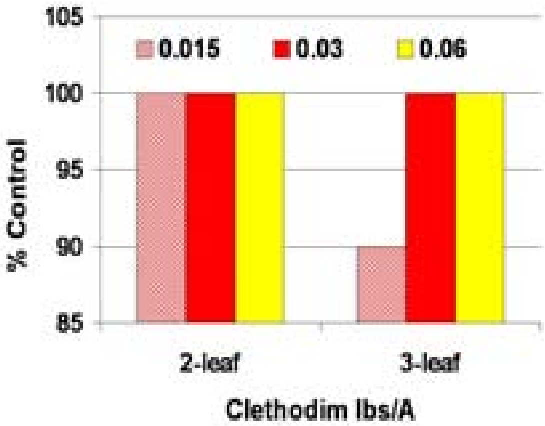


Fig. 1. Response of glyphosate-resistant corn to clethodim in Stillwater, OK.

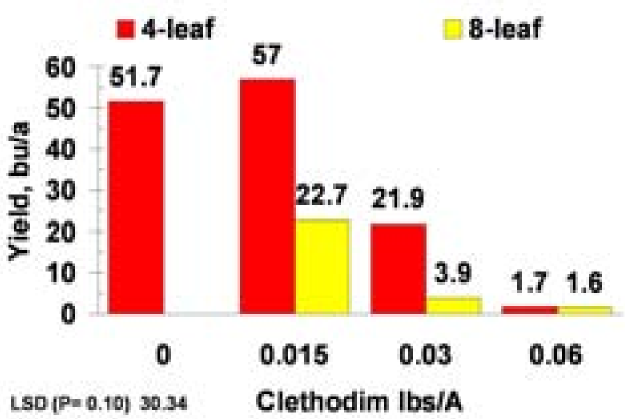


Fig. 2. Control of glyphosate-resistant with clethodim in Garden City.

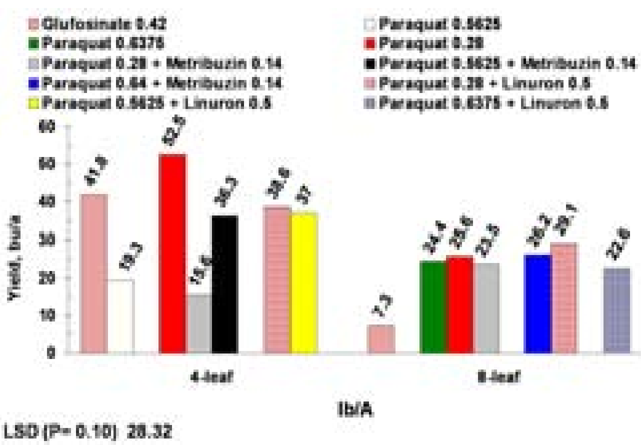


Fig 3. Control of glyphosate-resistant corn in Garden City.

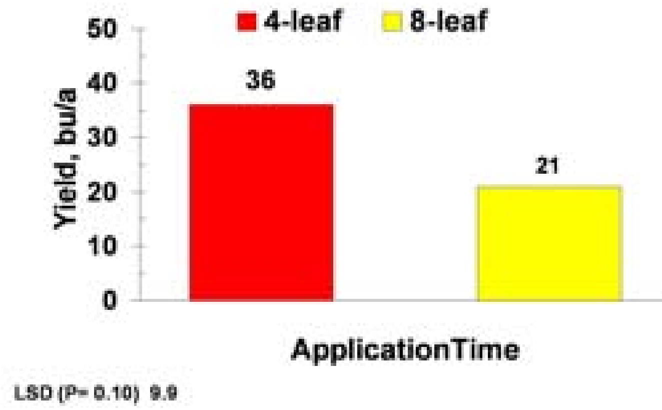


Fig. 4. Effect of application time of non-clethodim treatments at Garden City.

Slide taken by Dave Regehr near Quinter, Kansas.

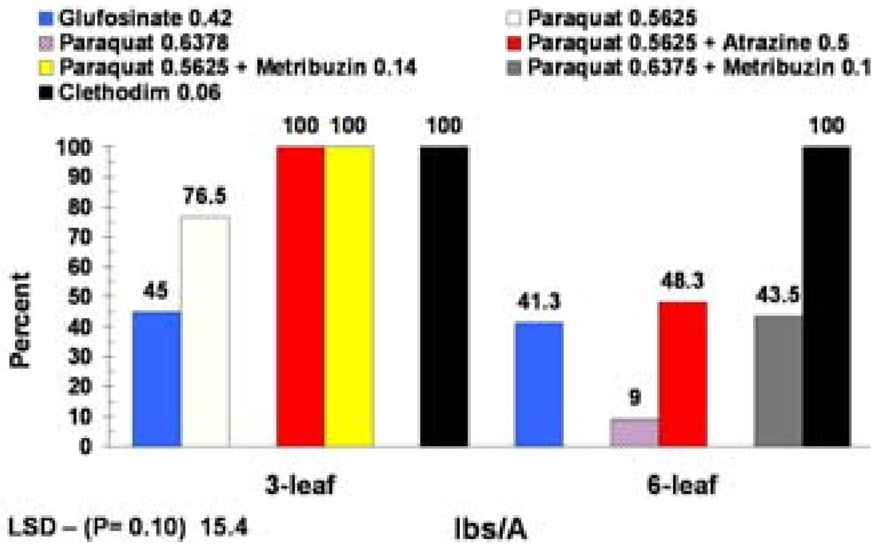


Fig. 5. Control of glyphosate-resistant corn in Stillwater.

THE IMPACT OF MULTIPLE-SEASON REDUCTIONS IN HERBICIDE AND IRRIGATION INPUTS ON CORN YIELD AND WATER USE EFFICIENCY

by
Randall Currie, Norman Klocke, and James Lee

SUMMARY

In contrast to winter wheat as a cover crop (as shown by previous research), downy brome (often called cheat) did not consistently affect corn grain yield. During the second and third imposition of treatments on the plot area, downy brome at planting had declined to less than 10% cover. Higher herbicide rates increased corn yield (7.8 bu/a) in only one combination of location and year. The presence of downy brome at planting time depressed corn yield between 3.7 and 12.1 bu/a in two of the five location-year combinations and increased yield by 8.9 bu/a in one location-year. The decision to control downy brome prior to planting is complex and affected other production inputs.

INTRODUCTION

Previous work has shown that a wheat cover crop can improve water-use efficiency (WUE), weed control, and yield of irrigated corn. Therefore, we hypothesized that downy brome may not need to be controlled in irrigated corn if it provides some of the same benefits as a wheat cover crop.

PROCEDURES

A split-plot experiment was established within four blocks, with irrigation as the main plot and a random factorial four-way split consisting of densities of downy brome and two rates of herbicide. The main plots were 120 by 98 feet with 49 by 60-foot subplots. Downy brome was allowed to naturally reseed in the fall of 2003. In March 2004, two of four subplots were treated with 0.75 lb ae/a of glyphosate to remove downy brome. Just prior to planting in the first week of May, the entire plot area was sprayed with glyphosate at 0.75 lbs ae/a and corn was planted at 26,000 kernels per acre across the whole plot area with no-till techniques. Two rates of preemergence herbicides, Isoxaflutole+atrazine+S-metolachlor at .05 +1.5+2 lbs/a or at half of this rate, were applied on each of the two levels of downy brome within the larger main plot. Irrigation began when total soil available water in the top four feet was depleted 25-40% in the high water treatments. The high-water treatment simulated a well capacity of 5 gal/min/a to supply a maximum of 2 inches of water per week. The low-water treatment simulated half of the full capacity with a maximum application of 1 inch per week. Corn was harvested when grain moisture dropped below 15.5%. Irrigation-water-use efficiencies (IWUE) were calculated by dividing total corn grain mass by total water applied. The experiment was repeated in 2005 at a separate location. Further, these same treatments were imposed on the same plots at location 1 in 2005 and 2006. The experiment was repeated at location 2 in 2005 and 2006. The third season of location 2 will be executed in the spring of 2007. Johnsongrass was present in the second and third seasons. Therefore, nicosulfuron was applied at 0.031 lb ai/a, or half this rate, to the high- and low-input herbicide plots, respectively.

RESULTS AND DISCUSSION

During the second and third imposition of treatments on the plot area, downy brome at planting had declined to less than 10% cover so impact of this factor was due to the history of brome control, not presence of heavy cover prior to planting. There were no three-way interactions of corn grain yield, irrigation, or herbicide inputs, nor level of downy brome in any of the five location-year combinations. In four of the five location-year combinations, irrigation increased yield from 3.8 to 120 bu/a (Fig. 1). The higher herbicide rates increased corn yield (7.8 bu/a) in only one location-year combination (Fig. 2). The presence of downy brome at planting time depressed corn yield between 3.7 and 12.1 bu/a in two of the five location-year combinations and increased yield by 8.9 bu/a in one location-year (Fig. 3).

IWUE at location 1 in 2004 and location 2 in 2006 produced a complex interaction of three inputs. At both of these locations, the presence of downy brome at planting did not change IWUE at the high level of irrigation regardless of the

level of herbicide input. However, with less irrigation, the presence of brome at planting decreased IWUE, regardless of the level of herbicide inputs at location 1 in 2004 (Fig. 4). In subtle contrast, at location 2 in 2006 (with reduced irrigation inputs and in the presence of downy brome), IWUE increased with added herbicide inputs (Fig. 5). In the other three location-years, IWUE was increased from 3.9 to 5.4 bu/in with reduced irrigation inputs (Fig. 6). More herbicide inputs increased IWUE (0.8 bu/in) in only one of these three location-year combinations (Fig. 7). At a single location, IWUE was depressed (0.2bu/in) by the presence of downy brome at planting (Fig. 8). Clearly, the decision to control downy brome prior to planting is complex and affected other production inputs.

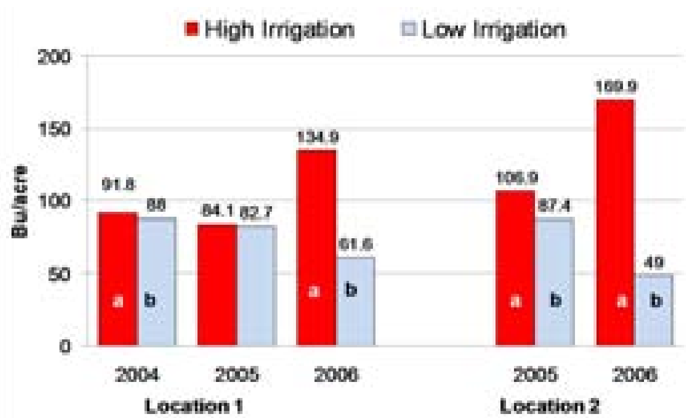


Fig. 1. Corn grain yields at 2 levels of irrigation.

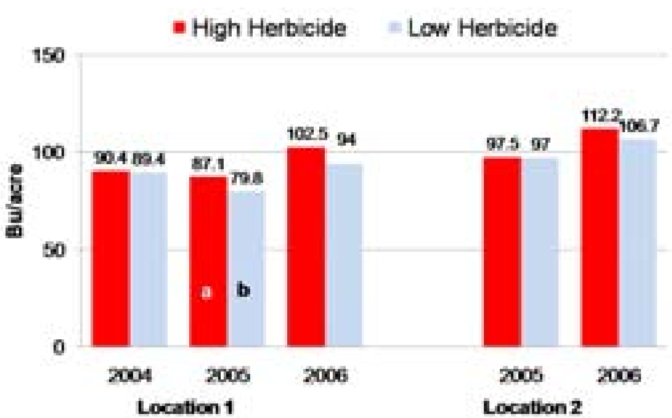


Fig. 2. Corn grain yield at 2 levels of herbicide

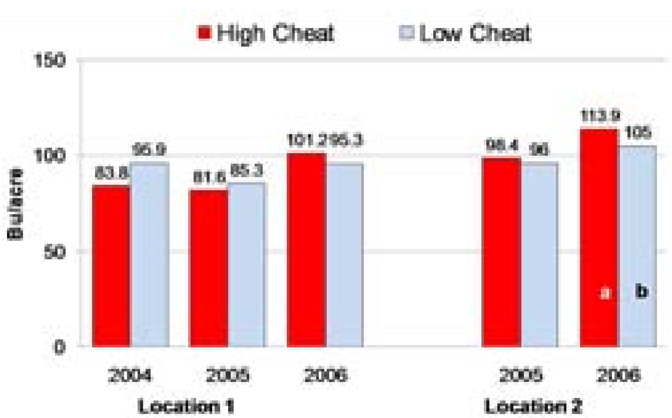


Fig. 3. Corn grain yield at 2 levels of cheat.

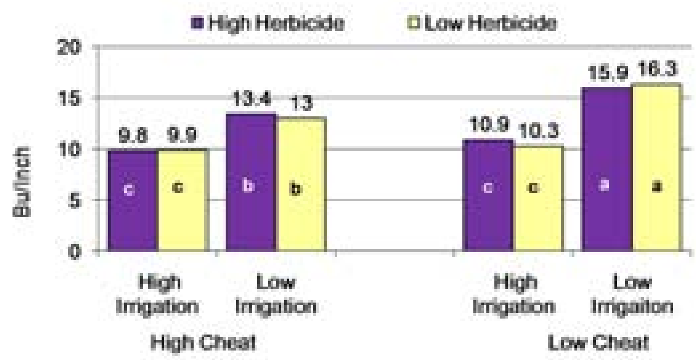


Fig. 4. WUE of irrigation water only at location 1 in 2004.

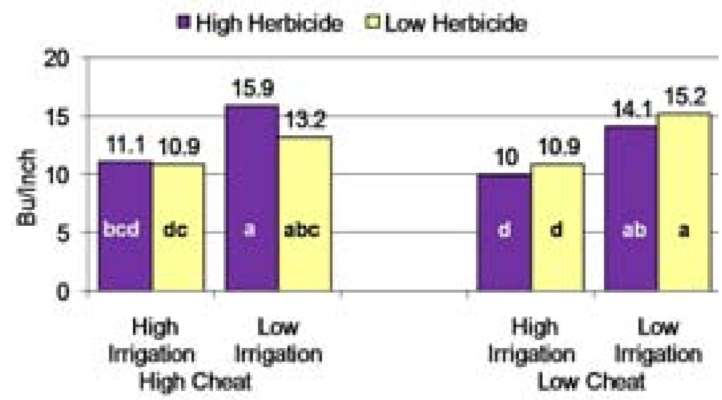


Fig. 5. WUE of irrigation water only at location 2 in 2005.

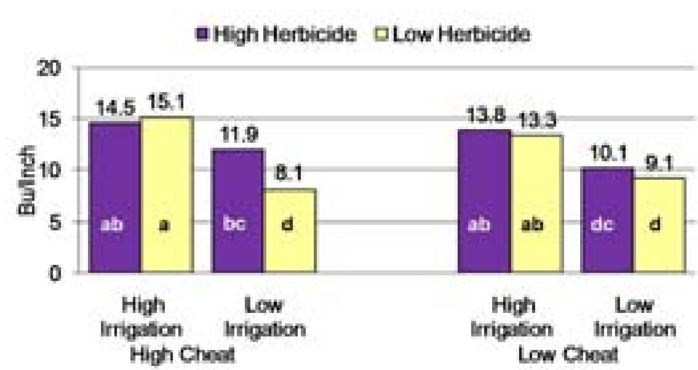


Fig. 6. WUE of irrigation water only at location 2 in 2006.

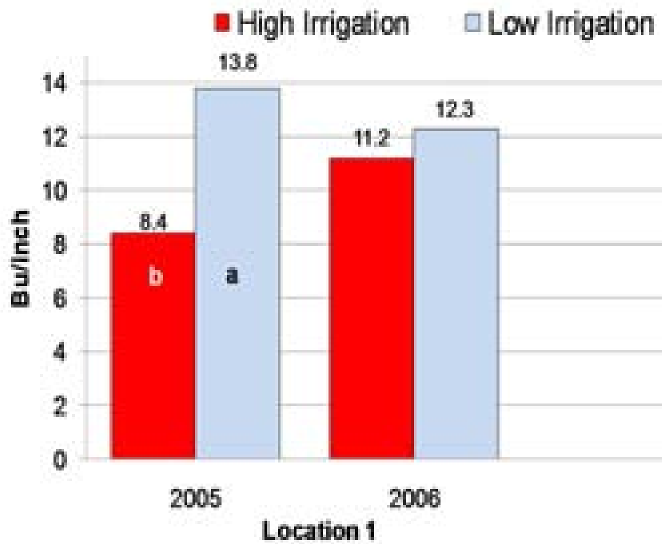


Fig. 7. WUE of irrigation water only at two levels of irrigation.

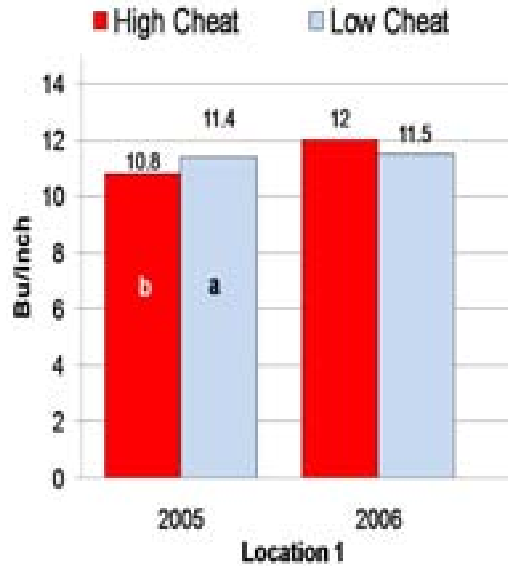


Fig. 9. WUE of irrigation water only at two levels of cheat.

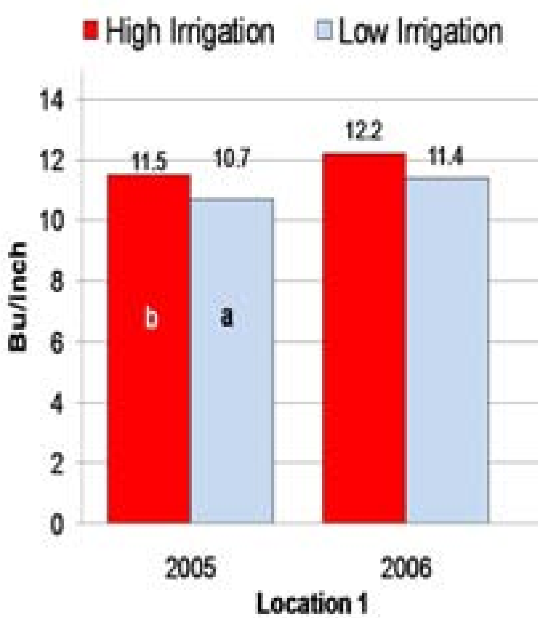


Fig 8. WUE of irrigation water only at two levels of herbicide.

COMPARISONS OF 47 HERBICIDE TANKMIXES FOR WEED CONTROL IN IRRIGATED CORN

by
Randall Currie and James Lee

SUMMARY

Six treatments had season-long control of all weeds that was not statistically different from the best treatment. These six treatments had corn yields that were not statistically different from 245 bu/a. Over- irrigation and timely rainfall allowed even the untreated controls to produce a very competitive corn canopy which produced corn yields in excess of 190 bu/a.

INTRODUCTION

With the advent of glyphosate-resistant weeds, the profit potential in herbicide development might be returning to crop protection companies. Therefore, they have begun to release new non-glyphosate herbicides such as the herbicides Impact (topramezone) and Laudis (tembotrione). These emerging herbicides have some similarities to Calisto (Mesotrione) and Balance (Isoxaflutole). Therefore it was the objective of this experiment to compare herbicide standards from the early 1990s to Glyphosate tank mixes and these new herbicides.

PROCEDURES

The field was bedded in the fall of 2004 and planted to winter wheat. In the fall of 2005, irrigation furrows were reformed by interow cultivation that left the wheat stubble on top of the beds while removing enough wheat residues to allow efficient furrow irrigation in the spring of 2006. To avoid the poor emergence seen in last year's studies the plot area was prewatered with 11 inches. Due to the level nature of the field and its small size, this excessive amount of water need to be applied to insure uniformity. As any good pessimist could have predicted this excessive irrigation was followed by rain fall that delayed the start of the experiment 10 days past what is often considered the optimum planting date.

Palmer amaranth, yellow foxtail, crabgrass, sunflower, barnyard grass, and shatter cane were seeded at 700,000; 344,124; 9,800,000; 40,000; 817,000; and 119,000 seeds/acre, respectively, into prepared fields on May 24, just before the corn was planted. All weeds except shatter cane 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. Shatter cane was simulated by drilling the forage sorghum 'Rox orange' separately, with every third hole set at 1 inch deep, at 2 inches deep, or with the tube pulled for seed to be dropped on the soil surface. Weed seed was planted in 10-inch rows and soil moisture was ideal.

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 planter. The experimental design was a randomized complete block with four replicates. The crop emerged on May 31 prior to the first major flush of weed.

Irrigation was begun before tasseling, on June 28 and 29th. Two inches of rainfall fell in a two-day period on or around the 4th of July. The topography of the field field does not permit run off once irrigation pipe is laid. Therefore all subsequent rainfall and irrigation was absorbed. Although locally derived irrigation models were used to supply enough water to carry the crop to physiological maturity, timely rain fell after many of the irrigation events, which supplied the crop with abundant soil moisture without causing injury to the crop. Corn was combine-harvested and yields were adjusted to 15.5 % moisture.

RESULTS AND DISCUSSION

Enough rain fell within two days of planting to incorporate the preemergence herbicides without crusting in the corn, which allowed the crop to emerge before the first flush of weeds. This was followed by three gentle rains totaling 1.3 inches at or near crop emergence. This was followed by 15 days with no significant rainfall. This gave the crop a tre-

mendous competive edge over the weeds even in the control plots. The corn yield in the control plots were the highest seen in 15 years at this location. (Table1). However, the excellent weed control treatments still elevated crop yield 55 bu/A, which would return more than 10 times their cost at current corn prices.

Data presented in bold print within a column were not statistically different from the best treatment in that column (Table 1 and Table 2). Treatments 4, 7, 9, 34, 43, and 47 had yields that were not statistically different from 245 bushels per acre and had season long control of all weeds measured that was not statistically different from the best programs. Treatments 4, 7, and 9 had isoxaflutole augmented by glyphosate or another older herbicide, whereas treatments 34, 43, and 47 were tank mixes of common herbicides used in the early 1990s buttressed with glyphosate or other older compounds. All these treatments had some herbicide with preemergence activity, along with another herbicide with excellent postemergence activity.

	Herbicide	Rate	Unit	Application Timing	Shatter Cane 7/11 weed/ 30 ft of corn	Shatter Cane 8/7 weed/ 30 ft of corn	Shatter Cane 10/18 % control	Foxtail weed/30 ft of corn	Corn yield Bu/a
1	UNTREATED				14.5	5.3	0	14	190.6
2	Define SC	9	oz ai/a	PREPRE	1	1.5	75	1.5	238.7
	Aatrex 4L	24	oz ai/a	PREPRE					
3	Radius	5	oz ai/a	PREPRE	7.5	5	75	3.8	210.6
	Aatrex 4L	16	oz ai/a	PREPRE					
4	Radius	5	oz ai/a	PREPRE	1.3	0	100	0	228.5
	Aatrex 4L	16	oz ai/a	PREPRE					
	Roundup Weathermax	15.1	oz ai/a	MIPOWE					
	Ammonium Sulfate	27.2	oz ai/a	MIPOWE					
5	Balance Pro	0.5	oz ai/a	PREPRE	3	1.8	75	1.3	235.2
	Aatrex 4L	16	oz ai/a	PREPRE					
6	Balance Pro	0.5	oz ai/a	PREPRE	0	0	100	0	219.3
	Aatrex 90	16	oz ai/a	PREPRE					
	Roundup Weathermax	15.1	oz ai/a	MIPOWE					
	Ammonium Sulfate	20.4	oz ai/a	MI POWE					
7	Balance Pro	0.5	oz ai/a/a	PREPRE	1.3	0.3	97.5	0	230.7
	Aatrex 4L	16	oz ai/a	PREPRE					
	AE 0172747 02 SC52 A1	1.31	oz ai/a	MIPOWE					
	Aatrex 4L	8	oz ai/a	MIPOWE					
	Methylated Seed Oil	20	oz ai/a	MIPOWE					
	UAN 28%	14	oz ai/a	MIPOWE					
8	Balance Pro	0.5	oz ai/a	PREPRE	**0**	**0**	**95**	**0**	209.6
	Aatrex 4L	16	oz ai/a	PREPRE					
	AE 0172747 02 SC52 A1	1.31	oz ai/a	MIPOWE					
	Aatrex 4L	8	oz ai/a	MIPOWE					
	Crop Oil Concentrate	20	oz ai/a	MIPOWE					
	UAN 28%	14	oz ai/a	MIPOWE					
9	AE 0172747 02 SC52 A1	0.438	oz ai/a	MIPOWE	**0.3**	**0.5**	**100**	**0.3**	**227.1**
	Roundup Weathermax	15.1	oz ai/a	MIPOWE					
	Ammonium Sulfate	20.4	oz ai/a	MIPOWE					
	Aatrex 4L	16	oz ai/a	MIPOWE					

	Herbicide	Rate	Unit	Application Timing	Shatter Cane 7/11 weed/ 30 ft of corn	Shatter Cane 8/7 weed/ 30 ft of corn	Shatter Cane 10/18 % control	Foxtail weed/30 ft of corn	Corn yield Bu/a
10	Roundup Weathermax	15.1	oz ai/a	MIPOWE	**1**	**0**	**100**	**4.5**	211.2
	Aatrex 4L	16	oz ai/a	MIPOWE					
	Ammonium Sulfate	20.4	oz ai/a	MIPOWE					
11	Roundup Weathermax	15.1	oz ai/a	MIPOWE	**0.8**	**0**	**100**	**0**	222.8
	AE 0172747 02 SC52 A1	0.438	oz ai/a	MIPOWE					
	Aatrex 4L	16	oz ai/a	MIPOWE					
	Ammonium Sulfate	20.4	oz ai/a	MIPOWE					
12	AE 0172747 02 SC52 A1	1.31	oz ai/a	EAPOWE	**0**	**1.8**	**98.8**	**8.8**	215.4
	Option	1.05	oz ai/a	EAPOWE					
	Methylated Seed Oil	20	oz ai/a	EAPOWE					
	UAN 28%	14	oz ai/a	EAPOWE					
13	Untreated Check				**2.8**	**0.5**	0	15	196.8
14	AE 0172747 02 SC52 A1	1.31	oz ai/a	EAPOWE	**0.5**	**1.3**	**97.5**	**5.3**	218.6
	Accent	0.187	oz ai/a	EAPOWE					
	Methylated Seed Oil	20	oz ai/a	EAPOWE					
	UAN 28%	14	oz ai/a	EAPOWE					
15	AE 0172747 02 SC52 A1	1.31	oz ai/a	MIPOWE	12.8	6.3	**92.5**	11.3	217.6
	Aatrex 4L	16	oz ai/a	MIPOWE					
	Methylated Seed Oil	20	oz ai/a	MIPOWE					
	UAN 28%	14	oz ai/a	MIPOWE					
16	AE 0172747 02 SC52 A1	1.31	oz ai/a	MIPOWE	11	6.3	86.3	**2.3**	210.8
	Aatrex 4L	32	oz ai/a	MIPOWE					
	Methylated Seed Oil	20	oz ai/a	MIPOWE					
	UAN 28%	14	oz ai/a	MIPOWE					
17	AE 0172747 02 SC52 A1	1.31	oz ai/a	MIPOWE	17	11	62.5	10.5	**226.8**
	Aatrex 4L	16	oz ai/a	MIPOWE					
	Crop Oil Concentrate	26.7	oz ai/a	MIPOWE					
	UAN 28%	14	oz ai/a	MIPOWE					
18	AE 0172747 02 SC52 A1	1.31	oz ai/a	MIPOWE	18.5	8.3	40	**7.3**	214
	Aatrex 4L	32	oz ai/a	MIPOWE					
	Crop Oil Concentrate	26.7	oz ai/a	MIPOWE					
	UAN 28%	14	oz ai/a	MIPOWE					

	Herbicide	Rate	Unit	Application Timing	Shatter Cane 7/11 weed/ 30 ft of corn	Shatter Cane 8/7 weed/ 30 ft of corn	Shatter Cane 10/18 % control	Foxtail weed/30 ft of corn	Corn yield Bu/a
19	Callisto	1.5	oz ai/a	MIPOWE	16.3	10.8	35	**9**	221.9
	Aatrex 4L	16	oz ai/a	MIPOWE					
	Methylated Seed Oil	20	oz ai/a	MIPOWE					
	UAN 28%	14	oz ai/a	MIPOWE					
20	Guardsman Max	45	oz ai/a	PREPRE	8.5	5	78.8	15	219.4
21	Guardsman Max	45	oz ai/a	PREPRE	**3**	**2.5**	**95**	**3.8**	220.8
	Balance Pro	0.5	oz ai/a	PREPRE					
22	Guardsman Max	45	oz ai/a	PREPRE	6.5	3.8	81.3	**8.3**	**229.4**
	Hornet	2.57	oz ai/a	PREPRE					
23	Lexar	52	oz ai/a	PREPRE	**5.5**	3.8	80	11.8	214.5
24	Lumax	39.5	oz ai/a	PREPRE	9	7.5	85	**7**	217.5
25	Dual II Magnum	23	oz ai/a	PREPRE	6.8	3.8	90	**0.8**	**226.3**
26	Dual II Magnum	64	oz ai/a	PREPRE	**4.3**	**3**	**95**	**4.3**	214.1
	Callisto	1.5	oz ai/a	EAPOWE					
	Crop Oil Concentrate	26.7	oz ai/a	EAPOWE					
	Ammonium Sulfate	27.2	oz ai/a	EAPOWE					
27	Guardsman Max	40	oz ai/a	PREPRE	10.8	9.8	70	13.5	**231**
	BAS 799	3.43	oz ai/a	EAPOWE					
	NIS	6.7	oz ai/a	EAPOWE					
	Ammonium Sulfate	16	oz ai/a	EAPOWE					
28	Roundup Weathermax	12.4	oz ai/a	EAPOCR	**0.5**	**0.3**	**100**	**1.8**	**226.5**
	Ammonium Sulfate	48	oz ai/a	EAPOCR					
29	Roundup Weathermax	12.4	oz ai/a	MDPOCR	**0**	**0**	**100**	**0**	222.4
	Ammonium Sulfate	48	oz/a	MDPOCR					
30	Glyphosate	12	oz ai/a	EAPOCR	**1**	**1.3**	**100**	**4**	**228.9**
	BAS 799	1.72	oz ai/a	EAPOCR					
	Ammonium Sulfate	48	oz ai/a	EAPOCR					
31	Glyphosate	12	oz ai/a	EAPOCR	**0.5**	**0**	**100**	**1.3**	218.8
	Outlook	9	oz ai/a	EAPOCR					
	Clarity	4	oz ai/a	EAPOCR					
	Ammonium Sulfate	48	oz ai/a	EAPOCR					

	Herbicide	Rate	Unit	Application Timing	Shatter Cane 7/11 weed/30 ft of corn	Shatter Cane 8/7 weed/30 ft of corn	Shatter Cane 10/18 % control	Foxtail weed/30 ft of corn	Corn yield Bu/a
32	Glyphosate	12	oz ai/a	EAPOCR	**1**	**0**	**98.8**	**6.8**	**229.7**
	Prowl H2O	19	oz ai/a	EAPOCR					
	Ammonium Sulfate	48	oz ai/a	EAPOCR					
33	Guardsman Max	30	oz ai/a	PREPRE	**0.3**	**0.3**	**100**	**3.8**	**245.5**
	Glyphosate	12	oz ai/a	EAPOCR					
	Ammonium Sulfate	48	oz ai/a	EAPOCR					
34	Guardsman Max	30	oz ai/a	PREPRE	**0**	**0**	**100**	**0**	**225.2**
	Glyphosate	12	oz ai/a	EAPOCR					
	BAS 799	1.72	oz ai/a	EAPOCR					
	Ammonium Sulfate	48	oz ai/a	EAPOCR					
35	Dual II Magnum	23	oz ai/a	PREPRE	8.5	3.8	81.3	**3.8**	197.5
36	Dual II Magnum	23	oz ai/a	PREPRE	18.8	11.8	80	**0.3**	216.5
	Impact	0.263	oz ai/a	EAPOWE					
	Aatrex 4L	8	oz ai/a	EAPOWE					
	Methylated Seed Oil	26.7	oz ai/a	EAPOWE					
	UAN 28%	67	oz ai/a	EAPOWE					
37	Dual II Magnum	23	oz ai/a	PREPRE	17	11.3	80	11.5	**228.5**
	Callisto	1.5	oz ai/a	EAPOWE					
	Aatrex 4L	4	oz ai/a	EAPOWE					
	Crop Oil Concentrate	26.7	oz ai/a	EAPOWE					
	UAN 28%	67	oz ai/a	EAPOWE					
38	Dual II Magnum	23	oz ai/a	PREPLA	**5**	5.3	**93.8**	**0.8**	**241.8**
	Callisto	1.5	oz ai/a	EAPOWE					
	Aatrex 4L	16	oz ai/a	EAPOWE					
	Crop Oil Concentrate	26.7	oz ai/a	EAPOWE					
	UAN 28%	67	oz ai/a	EAPOWE					
39	Dual II Magnum	23	oz ai/a	PREPRE	**4.8**	**3**	**91.3**	**1**	**237.2**
	Callissto	1.5	oz ai/a	EAPOWE					
	Aatrex 4L	32	oz ai/a	EAPOWE					
	Crop Oil Concentrate	26.7	oz ai/a	EAPOWE					
	UAN 28%	67	oz ai/a	EAPOWE					

	Herbicide	Rate	Unit	Application Timing	Shatter Cane 7/11 weed/ 30 ft of corn	Shatter Cane 8/7 weed/ 30 ft of corn	Shatter Cane 10/18 % control	Foxtail weed/30 ft of corn	Corn yield Bu/a
40	Dual II Magnum	23	oz ai/a	PREPRE	15	13.5	70	18.8	209.6
	Clarity	0.5	lb ai/a	EAPOWE					
	NIS	6.7	oz ai/a	EAPOWE					
	UAN 28%	67	oz ai/a	EAPOWE					
41	Impact	0.263	oz ai/a	EAPOWE	7.3	8.5	**92.5**	**8.3**	**234.1**
	Aatrex 4L	26.7	oz ai/a	EAPOWE					
	Methylated Seed Oil	26.7	oz ai/a	EAPOWE					
	UAN 28%	67	oz ai/a	EAPOWE					
42	Keystone	59	oz ai/a	PREPRE	**0**	**0**	**100**	**1.3**	**235.1**
	Durango	16.2	oz ai/a	MDPOCR					
	Ammonium Sulfate	40	oz ai/a	MDPOCR					
43	Keystone	59	oz ai/a	PREPRE	**3.8**	5	**93.8**	**0.8**	**233.9**
	Starane	2	oz ai/a	MDPOCR					
	Aatrex 90	7.9	oz ai/a	MDPOCR					
	Crop Oil Concentrate	26.7	oz ai/a	MDPOCR					
44	Keystone	59	oz ai/a	PREPRE	**4.8**	**2.8**	**95**	**4.3**	199.1
	Hornet	2.36	oz ai/a	MDPOCR					
	Callisto	0.5	oz ai/a	MDPOCR					
	Aatrex 90	3.96	oz ai/a	MDPOCR					
	Crop Oil Concentrate	26.7	oz ai/a	MDPOCR					
45	Python WDG	0.8	oz ai/a	PREPRE	7.5	**3.3**	87.5	7	**235.8**
	Balance Pro	0.5	oz ai/a	PREPRE					
	Glyphomax XRT	16.2	oz ai/a	PREPRE					
	Ammonium Sulfate	40	oz ai/a	PREPRE					
46	Keystone	59	oz ai/a	PREPRE	8.8	3	87.5	**6.3**	**228**
	Starane	2	oz ai/a	MDPOCR					
	Callisto	0.5	oz ai/a	MDPOCR					
	Aatrex 90	3.96	oz ai/a	MDPOCR					
	Crop Oil Concentrate	26.7	oz ai/a	MDPOCR					

					Shatter Cane			Foxtail	Corn yield
					7/11	8/7	10/18	weed/30 ft	
	Herbicide	**Rate**	**Unit**	**Application Timing**	**weed/ 30 ft of corn**		**% control**	**of corn**	**Bu/a**
47	Stalward Xtra	46	oz ai/a	EAPOCR	**0.8**	**0**	**100**	**0.3**	**234.5**
	Roundup Original Max	13.5	oz ai/a	EAPOCR					
	Clarity	2	oz ai/a	EAPOCR					
48	Impact	0.263	oz ai/a	EAPOWE	9.8	6.3	72.5	15	218
	Aatrex 4L	8	oz ai/a	EAPOWE					
	Renegade	29.2	oz ai/a	EAPOWE					
49	Impact	0.176	oz ai/a	EAPOWE	18.8	12.8	78.8	16.3	**227.1**
	Aatrex 4L	3	oz ai/a	EAPOWE					
	Renegade	29.2	oz ai/a	EAPOWE					
	In Place	0.78	oz ai/a	EAPOWE					
LSD (P=.10)					5.8	3.4	9.3	10.3	21.7

PREPRE=Herbicide applied on 5-25-06 the morning after planting.
EAPOWE=Herbicide applied on 6-21-06 to 12 inch corn with 6-7 leaf collars there were 0-6 pigweed/ft2 @ 2-9” tall: 0-3 shatter cane/ft2 @3-7” tall with 0-2 tillers: 0-20 crabgrass/ft2 @1-3” tall with 0-3 tillers.
MIDPOCR and MIPOWE=Herbicide applied on 6-26to 17 inch corn with 7-8 leaf collars there were 0-12 pigweed/ft2 @ 4-14” tall: 0-3 shatter cane/ft2 @4-15” tall with 0-2 tillers: 0-20 crabgrass/ft2 @0.5-3” tall with 0-5 tillers.

Table 2. Effect of corn herbicide tank mixes on Palmer amaranth and crabgrass, Southwest Research-Extension Center, Garden City, KS, 2006.

					Palmer amaranth			Crabgrass		
					7-11	8-7	10-18	7-11	8-7	10-18
	Herbicide	Rate	Unit	Application Timing	plant/30 ft of corn		% control	plant/30 ft of corn		% control
1	U2NTREATED				32.8	14	0	13.8	4.8	0
2	Define SC	9	oz ai/a	PREPRE	**3.5**	**1.8**	**97.5**	**1.5**	**0**	**100**
	Aatrex 4L	24	oz ai/a	PREPRE						
3	Radius	5	oz ai/a	PREPRE	**6**	**1**	**100**	**2.5**	**0.8**	**97.5**
	Aatrex 4L	16	oz ai/a	PREPRE						
4	Radius	5	oz ai/a	PREPRE	**0.3**	**0.5**	**100**	**0**	**0**	**98.8**
	Aatrex 4L	16	oz ai/a	PREPRE						
	Roundup Weathermax	15.1	oz ai/a	MIPOWE						
	Ammonium Sulfate	27.2	oz ai/a	MIPOWE						
5	Balance Pro	0.5	oz ai/a	PREPRE	**3.5**	**1**	**100**	6	**0.8**	**98.8**
	Aatrex 4L	16	oz ai/a	PREPRE						
6	Balance Pro	0.5	oz ai/a	PREPRE	**0**	**0.5**	**100**	**0**	**0.3**	**98.8**
	Aatrex 90	16	oz ai/a	PREPRE						
	Roundup Weathermax	15.1	oz ai/a	MIPOWE						
	Ammonium Sulfate	20.4	oz ai/a	MIPOWE						
7	Balance Pro	0.5	oz ai/a	PREPRE	**0.8**	**2**	**100**	**0**	**0.3**	**95**
	Aatrex 4L	16	oz ai/a	PREPRE						
	AE 0172747 02 SC52 A1	1.31	oz ai/a	MIPOWE						
	Aatrex 4L	8	oz ai/a	MIPOWE						
	Methylated Seed Oil	20	oz ai/a	MIPOWE						
	UAN 28%	14	oz ai/a	MIPOWE						
8	Balance Pro	0.5	oz ai/a	PREPRE	**0**	**0**	**100**	**0.3**	**0**	**100**
	Aatrex 4L	16	oz ai/a	PREPRE						
	AE 0172747 02 SC52 A1	1.31	oz ai/a	MIPOWE						
	Aatrex 4L	8	oz ai/a	MIPOWE						
	Crop Oil Concentrate	20	oz ai/a	MIPOWE						
	UAN 28%	14	oz ai/a	MIPOWE						

Note: Table was not included in August 2007 printed version of SRP 980.

	Herbicide	Rate	Unit	Application Timing	Palmer amaranth 7-11 (plant/30 ft of corn)	Palmer amaranth 8-7 (plant/30 ft of corn)	Palmer amaranth 10-18 (% control)	Crabgrass 7-11 (plant/30 ft of corn)	Crabgrass 8-7 (plant/30 ft of corn)	Crabgrass 10-18 (% control)
9	AE 0172747 02 SC52 A1	0.438	oz ai/a	MIPOWE	**0**	**0.3**	**100**	**0**	**0**	**100**
	Roundup Weathermax	15.1	oz ai/a	MIPOWE						
	Ammonium Sulfate	20.4	oz ai/a	MIPOWE						
10	Roundup Weathermax	15.1	oz ai/a	MIPOWE	**0**	**0**	**100**	**0**	**0**	**100**
	Aatrex 4L	16	oz ai/a	MIPOWE						
	Ammonium Sulfate	20.4	oz ai/a	MIPOWE						
11	Roundup Weathermax	15.1	oz ai/a	MIPOWE	**1**	**0**	**98.8**	**0**	**0.5**	**95**
	AE 0172747 02 SC52 A1	0.438	oz ai/a	MIPOWE						
	Aatrex 4L	16	oz ai/a	MIPOWE						
	Ammonium Sulfate	20.4	oz ai/a	MIPOWE						
12	AE 0172747 02 SC52 A1	1.31	oz ai/a	EAPOWE	**7.8**	7	80	12.3	3.8	**100**
	Option	1.05	oz ai/a	EAPOWE						
	Methylated Seed Oil	20	oz ai/a	EAPOWE						
	UAN 28%	14	oz ai/a	EAPOWE						
13	Untreated Check				30.8	18.3	0	**7.8**	**3**	0
14	AE 0172747 02 SC52 A1	1.31	oz ai/a	EAPOWE	**1.8**	**1.5**	95	**7.3**	**0.8**	92.5
	Accent	0.187	oz ai/a	EAPOWE						
	Methylated Seed Oil	20	oz ai/a	EAPOWE						
	UAN 28%	14	oz ai/a	EAPOWE						
15	AE 0172747 02 SC52 A1	1.31	oz ai/a	MIPOWE	**1.3**	**0.8**	**100**	**2**	**0.3**	**100**
	Aatrex 4L	16	oz ai/a	MIPOWE						
	Methylated Seed Oil	20	oz ai/a	MIPOWE						
	UAN 28%	14	oz ai/a	MIPOWE						
16	AE 0172747 02 SC52 A1	1.31	oz ai/a	MIPOWE	**0**	**1**	**100**	0.8	**0.3**	**100**
	Aatrex 4L	32	oz ai/a	MIPOWE						
	Methylated Seed Oil	20	oz ai/a	MIPOWE						
	UAN 28%	14	oz ai/a	MIPOWE						

Note: Table was not included in August 2007 printed version of SRP 980.

	Herbicide	Rate	Unit	Application Timing	Palmer amaranth 7-11 (plant/30 ft of corn)	Palmer amaranth 8-7 (plant/30 ft of corn)	Palmer amaranth 10-18 (% control)	Crabgrass 7-11 (plant/30 ft of corn)	Crabgrass 8-7 (plant/30 ft of corn)	Crabgrass 10-18 (% control)
17	AE 0172747 02 SC52 A1	1.31	oz ai/a	MIPOWE	**0**	**0**	**100**	6	**0.3**	**97.5**
	Aatrex 4L	16	oz ai/a	MIPOWE						
	Crop Oil Concentrate	26.7	oz ai/a	MIPOWE						
	UAN 28%	14	oz ai/a	MIPOWE						
18	AE 0172747 02 SC52 A1	1.31	oz ai/a	MIPOWE	**0**	**0**	**100**	6.3	**1**	**95**
	Aatrex 4L	32	oz ai/a	MIPOWE						
	Crop Oil Concentrate	26.7	oz ai/a	MIPOWE						
	UAN 28%	14	oz ai/a	MIPOWE						
19	Callisto	1.5	oz ai/a	MIPOWE	**0**	**0**	**100**	**8**	**1.3**	**100**
	Aatrex 4L	16	oz ai/a	MIPOWE						
	Methylated Seed Oil	20	oz ai/a	MIPOWE						
	UAN 28%	14	oz ai/a	MIPOWE						
20	Guardsman Max	45	oz ai/a	PREPRE	**0.8**	**1**	**100**	5.8	3.8	80
21	Guardsman Max	45	oz ai/a	PREPRE	**1**	**0**	**100**	2	**0.5**	**95**
	Balance Pro	0.5	oz ai/a	PREPRE						
22	Guardsman Max	45	oz ai/a	PREPRE	**4**	**0.8**	**98.8**	**2.8**	**1.8**	90
	Hornet	2.57	oz ai/a	PREPRE						
23	Lexar	52	oz ai/a	PREPRE	**1.5**	**1**	**100**	10.5	**2.3**	**80**
24	Lumax	39.5	oz ai/a	PREPRE	**0**	**0**	**100**	**3**	**0**	**100**
25	Dual II Magnum	23	oz ai/a	PREPRE	**0.3**	**0**	**100**	**0.8**	**0**	**98.8**
26	Dual II Magnum	64	oz ai/a	PREPRE	**0**	**0**	**100**	**0**	**0**	**100**
	Callisto	1.5	oz ai/a	EAPOWE						
	Crop Oil Concentrate	26.7	oz ai/a	EAPOWE						
	Ammonium Sulfate	27.2	oz ai/a	EAPOWE						
27	Guardsman Max	40	oz ai/a	PREPRE	**0**	**0.3**	**100**	10	**2.5**	**100**
	BAS 799	3.43	oz ai/a	EAPOWE						
	NIS	6.7	oz ai/a	EAPOWE						
	Ammonium Sulfate	16	oz ai/a	EAPOWE						

Note: Table was not included in August 2007 printed version of SRP 980.

	Herbicide	Rate	Unit	Application Timing	Palmer amaranth 7-11	Palmer amaranth 8-7	Palmer amaranth 10-18	Crabgrass 7-11	Crabgrass 8-7	Crabgrass 10-18
					plant/30 ft of corn		% control	plant/30 ft of corn		% control
28	Roundup Weathermax	12.4	oz ai/a	EAPOCR	**0.3**	**2.5**	**97.5**	**1.3**	12.5	92.5
	Ammonium Sulfate	48	oz ai/a	EAPOCR						
29	Roundup Weathermax	12.4	oz ai/a	MDPOCR	**0.5**	**0**	**98.8**	**0**	**0**	**97.5**
	Ammonium Sulfate	48	oz/a	MDPOCR						
30	Glyphosate	12	oz ai/a	EAPOCR	**0.3**	**0.5**	95	**8.5**	**5**	**95**
	BAS 799	1.72	oz ai/a	EAPOCR						
	Ammonium Sulfate	48	oz ai/a	EAPOCR						
31	Glyphosate	12	oz ai/a	EAPOCR	**0**	**0**	**100**	**0.3**	**0**	**95**
	Outlook	9	oz ai/a	EAPOCR						
	Clarity	4	oz ai/a	EAPOCR						
	Ammonium Sulfate	48	oz ai/a	EAPOCR						
32	Glyphosate	12	oz ai/a	EAPOCR	**5.8**	**3.5**	95	**1.5**	**1.5**	**100**
	Prowl H2O	19	oz ai/a	EAPOCR						
	Ammonium Sulfate	48	oz ai/a	EAPOCR						
33	Guardsman Max	30	oz ai/a	PREPRE	**0.3**	**0**	**97.5**	**2.3**	4.5	90
	Glyphosate	12	oz ai/a	EAPOCR						
	Ammonium Sulfate	48	oz ai/a	EAPOCR						
34	Guardsman Max	30	oz ai/a	PREPRE	**0**	**0**	**100**	**1.8**	**0**	**100**
	Glyphosate	12	oz ai/a	EAPOCR						
	BAS 799	1.72	oz ai/a	EAPOCR						
	Ammonium Sulfate	48	oz ai/a	EAPOCR						
35	Dual II Magnum	23	oz ai/a	PREPRE	**2.5**	**1.8**	95	**6.5**	**0.8**	**100**
36	Dual II Magnum	23	oz ai/a	PREPRE	**0.5**	**0.3**	**100**	**1.5**	**0.3**	**100**
	Impact	0.263	oz ai/a	EAPOWE						
	Aatrex 4L	8	oz ai/a	EAPOWE						
	Methylated Seed Oil	26.7	oz ai/a	EAPOWE						
	UAN 28%	67	oz ai/a	EAPOWE						

Note: Table was not included in August 2007 printed version of SRP 980.

	Herbicide	Rate	Unit	Application Timing	Palmer amaranth 7-11	Palmer amaranth 8-7	Palmer amaranth 10-18	Crabgrass 7-11	Crabgrass 8-7	Crabgrass 10-18
					plant/30 ft of corn		% control	plant/30 ft of corn		% control
37	Dual II Magnum	23	oz ai/a	PREPRE	**0.8**	**0**	**100**	**6.5**	**0.8**	**100**
	Callisto	1.5	oz ai/a	EAPOWE						
	Aatrex 4L	4	oz ai/a	EAPOWE						
	Crop Oil Concentrate	26.7	oz ai/a	EAPOWE						
	UAN 28%	67	oz ai/a	EAPOWE						
38	Dual II Magnum	23	oz ai/a	PREPLA	**0**	**0**	**100**	**0.8**	**0.5**	**100**
	Callisto	1.5	oz ai/a	EAPOWE						
	Aatrex 4L	16	oz ai/a	EAPOWE						
	Crop Oil Concentrate	26.7	oz ai/a	EAPOWE						
	UAN 28%	67	oz ai/a	EAPOWE						
39	Dual II Magnum	23	oz ai/a	PREPRE	**0.5**	**1.3**	**100**	**8.8**	**1**	**100**
	Callisto	1.5	oz ai/a	EAPOWE						
	Aatrex 4L	32	oz ai/a	EAPOWE						
	Crop Oil Concentrate	26.7	oz ai/a	EAPOWE						
	UAN 28%	67	oz ai/a	EAPOWE						
40	Dual II Magnum	23	oz ai/a	PREPRE	**1**	**0**	**100**	11.5	**1.3**	**95**
	Clarity	0.5	lb ai/a	EAPOWE						
	NIS	6.7	oz ai/a	EAPOWE						
	UAN 28%	67	oz ai/a	EAPOWE						
41	Impact	0.263	oz ai/a	EAPOWE	**1**	**0.3**	**100**	**4**	**1.3**	**100**
	Aatrex 4L	8	oz ai/a	EAPOWE						
	Methylated Seed Oil	26.7	oz ai/a	EAPOWE						
	UAN 28%	67	oz ai/a	EAPOWE						
42	Keystone	59	oz ai/a	PREPRE	**0**	**0**	**100**	**0**	**0.5**	**100**
	Durango	16.2	oz ai/a	MDPOCR						
	Ammonium Sulfate	40	oz ai/a	MDPOCR						
43	Keystone	59	oz ai/a	PREPRE	**1.5**	**0.3**	**98.8**	**0**	**0**	**98.8**
	Starane	2	oz ai/a	MDPOCR						
	Aatrex 90	7.9	oz ai/a	MDPOCR						
	Crop Oil Concentrate	26.7	oz ai/a	MDPOCR						

Note: Table was not included in August 2007 printed version of SRP 980.

	Herbicide	Rate	Unit	Application Timing	Palmer amaranth 7-11 (plant/30 ft of corn)	Palmer amaranth 8-7 (plant/30 ft of corn)	Palmer amaranth 10-18 (% control)	Crabgrass 7-11 (plant/30 ft of corn)	Crabgrass 8-7 (plant/30 ft of corn)	Crabgrass 10-18 (% control)
44	Keystone	59	oz ai/a	PREPRE	**0.3**	**0.3**	**97.5**	**0**	**0.8**	**97.5**
	Hornet	2.36	oz ai/a	MDPOCR						
	Callisto	0.5	oz ai/a	MDPOCR						
	Aatrex 90	3.96	oz ai/a	MDPOCR						
	Crop Oil Concentrate	26.7	oz ai/a	MDPOCR						
45	Python WDG	0.8	oz ai/a	PREPRE	**0.3**	**0.8**	**100**	**4**	**2.8**	**95**
	Balance Pro	0.5	oz ai/a	PREPRE						
	Glyphomax XRT	16.2	oz ai/a	PREPRE						
	Ammonium Sulfate	40	oz ai/a	PREPRE						
46	Keystone	59	oz ai/a	PREPRE	**0**	**0**	**100**	**3**	**0.3**	**100**
	Starane	2	oz ai/a	MDPOCR						
	Callisto	0.5	oz ai/a	MDPOCR						
	Aatrex 90	3.96	oz ai/a	MDPOCR						
	Crop Oil Concentrate	26.7	oz ai/a	MDPOCR						
47	Stalwart Xtra	46	oz ai/a	EAPOCR	**0**	**1.8**	**100**	**1.3**	**0**	**100**
	Roundup Original Max	13.5	oz ae/a	EAPOCR						
	Clarity	2	oz ai/a	EAPOCR						
48	Impact	0.263	oz ai/a	EAPOWE	**0**	**0**	**100**	**7.8**	4.8	81.3
	Aatrex 4L	8	oz ai/a	EAPOWE						
	Renegade	29.2	oz ai/a	EAPOWE						
49	Impact	0.176	oz ai/a	EAPOWE	**1.8**	**3.5**	92.5	14.3	**0.8**	90
	Aatrex 4L	3	oz ai/a	EAPOWE						
	Renegade	29.2	oz ai/a	EAPOWE						
	In Place	0.78	oz ai/a	EAPOWE						
LSD (P=.10)					8.3	4.8	4.5	8.9	3.2	6.7

PREPRE=Herbicide applied on 5-25-06 the morning after planting.

EAPOWE=Herbicide applied on 6-21-06 to 12 inch corn with 6-7 leaf collars there were 0-6 pigweed/ft2 @ 2-9" tall: 0-3 shatter cane/ft2 @3-7" tall with 0-2 tillers: 0-20 crabgrass/ft2 @1-3" tall with 0-3 tillers.

MIDPOCR and MIPOWE=Herbicide applied on 6-26to 17 inch corn with 7-8 leaf collars there were 0-12 pigweed/ft2 @ 4-14" tall: 0-3 shatter cane/ft2 @4-15" tall with 0-2 tillers: 0-20 crabgrass/ft2 @0.5-3" tall with 0-5 tillers.

Note: Table was not included in August 2007 printed version of SRP 980.

EFFICACY OF FIPRONIL APPLIED AS A FOLIAR TREATMENT ON SIX COMMERCIAL SOYBEAN VARIETIES TO CONTROL DECTES STEM BORERS IN SOYBEAN, SCANDIA, KS, 2006

by

Larry Buschman, Teru taka Niide[1], William Schapaugh[2], and Barney Gorden[3]

SUMMARY

We tested a foliar fipronil insecticide treatment applied to six soybean varieties to determine effectiveness in reducing Dectes stem borers (Dectes texanus) in soybean. The foliar application of fipronil significantly reduced Dectes stem borer infestations between 76% and 88%. However, these treatments increased yield only 2.9%, and this was not statistically significant. Dectes stem borer infestation averaged 55% infested plants.

PROCEDURES

Seed of six commercial soybean varieties in maturity groups II through to IV was machine-planted at 16 seed per row-foot on May 17, 2005, at the irrigation experiment field near Scandia,. The plots were four rows wide and 20 feet long. There was a 3-foot-wide alley at each end of the plot. The design was a randomized block experiment with three replications. There was a treated and untreated plot of each variety in each replication. The foliar treatment of fipronil was applied July 18 during the beetle flight. This treatment targeted the first two instars developing inside the plants. The foliar treatment was applied with a backpack sprayer, using a hand-held boom with two nozzles (Conejet TXVS 6) directed at a single row. The nozzles were held 6-8 inches from the plants to maximize coverage of the upper canopy. The sprayer was calibrated to deliver 20 gal/acre (8.0 sec per 20 ft row at 30 psi). A chronometer was used to measure the time spent on each row to help maintain appropriate speed. The experiment was analyzed as a two-factor experiment with six levels of variety and two levels of treatment.

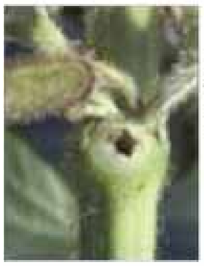
Dectes stem borer infestations were recorded at the end of the season (September 22) by dissecting five consecutive plants from each of the four rows in each plot for a total of 20 plants. The plants were dissected to record entry nodes, upper stem tunneling, tunneling that reached the base of the plant, and presence of live Dectes larvae. Grain yield data was collected by machine harvesting the plots October 12 and converted to bushels per acre based on 12% moisture.

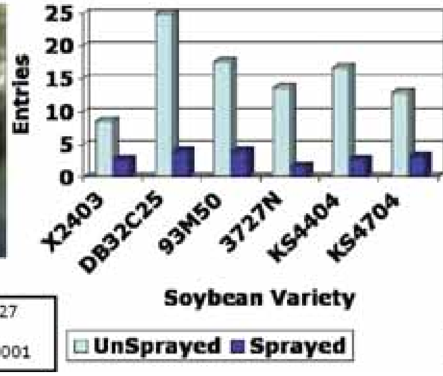
RESULTS AND DISCUSSION

Dectes stem borer infested 55% of plants in 2006. This was similar to the infestation of 2004, when we were able to show yield responses with fipronil treatment. In this 2006 trial, the fipronil treatment significantly reduced Dectes stem borer infestations (81%, 78%, 82% and 88% for entry nodes, stem tunneling, base tunneling and live larvae, respectively; Table 1). However, the fipronil treatment only increased grain yield 2.9%, and this was not a significant increase. There were some significant differences in Dectes infestation across the different varieties, but there was no significant yield difference across the varieties. This was surprising because there was such a wide difference in maturity across the varieties. The 2006 results suggest there was no physiological yield loss associated with Dectes stem borer infestations. We were not able to show differences in tolerance of the different varieties to Dectes stem borer infestations.

[1] Department of Entomology, Kansas State University, Manhattan
[2] Department of Agronomy, Kansas State University, Manhattan
[3] Department of Irrigation and North Central Kansas Experimental Fields, Kansas State University, Scandia

Dectes Stem Borer
Entry Nodes per 20 Plants

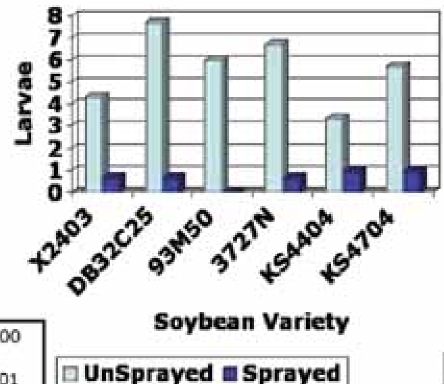




Variety P=0.0027
Treatment P=>0.0001

81% Control

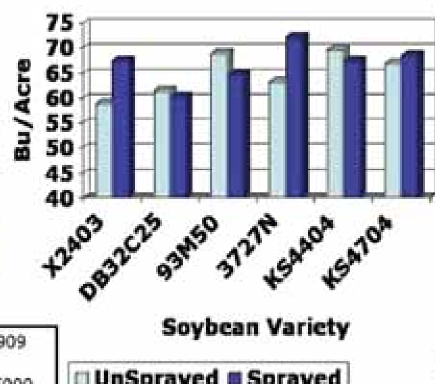
Dectes Stem Borer
Larvae per 20 Plants



Variety P=<0.5000
Treatment P=>0.0001

88% Control

Grain Yield Bu/Acre
Sprayed and Unsprayed Soybean Varieties



Variety P= 0.3909
Treatment P=<0.5000

2.9% Increase

Table 1. F-test Probability values for the ANOVA tests of the two main effects, variety and insecticide treatment. Fipronil treatments were applied as foliar treatments. Irrigation Experiment Field, Scandia, Kansas, 2006.

	Soybean Maturity Group	Entry Nodes /20 plants	Stem Tunneling /20 plants	Base Tunneling /20 plants	Live Larvae /20 plants	Grain Yield Bu/Acre
ANOVA F-Test Probability						
Replication		**0.001**	**0.0191**	0.0669	0.0566	**0.0383**
Variety		**0.0027**	0.3505	**0.0087**	<0.5000	0.3909
Insecticide		**>0.0001**	**>0.0001**	**>0.0001**	**>0.0001**	<0.5000
V x I Interaction		**0.0175**	<0.5000	**0.0465**	<0.5000	<0.5000
Variety Means—Untreated						
Nex2403K2RR	Mid II	8.7	7.3	4.7	4.3	58.9
Dyna-GroDB32C25	Early III	25.0	12.7	2.3	7.7	61.4
Pioneer 93M50	Mid III	17.7	13.3	2.0	6.0	69.0
Ohlde 3727NRS	Late III	13.7	10.3	8.0	6.7	63.2
KS4404RR	Early IV	16.7	12.0	6.0	3.3	69.7
KS4704RR	Mid IV	13.0	9.7	5.3	5.7	66.9
Mean		15.8	10.9	4.7	5.6	64.85
Variety Means—Fipronil—Treated						
Nex2403K2RR	Mid II	2.7	2.7	1.0	0.7	67.5
Dyna-GroDB32C25	Early III	4.0	3.0	1.0	0.7	61.4
Pioneer 93M50	Mid III	4.0	3.0	0.0	0.0	69.0
Ohlde 3727NRS	Late III	1.7	1.0	1.0	0.7	63.2
KS4404RR	Early IV	2.7	2.7	1.0	1.0	69.7
KS4704RR	Mid IV	3.3	2.3	1.0	1.0	66.9
Mean		3.06	2.5	0.8	0.7	66.76

EFFICACY OF SYSTEMIC INSECTICIDES APPLIED AS FOLIAR OR SEED TREATMENTS TO CONTROL DECTES STEM BORERS IN SOYBEAN AT GARDEN CITY, KS, 2006

by
Larry Buschman, Larry Buschman, Holly Davis[1], Randal Currie and Phil Sloderbeck

SUMMARY

We tested systemic insecticides applied as seed treatments for their effectiveness in reducing Dectes stem borers (Dectes texanus) in soybean. Fipronil was applied to the foliage later in the season as a positive check based on previous studies. Of the seed treatments tested, only fipronil significantly reduced Dectes stem borer infestations, but it gave 100% control. The foliar application of fipronil also significantly reduced Dectes stem borer infestations, but it gave 85% control. Dectes stem borer infestation averaged 34% infested plants.

PROCEDURES

Soybean seed (Pioneer 93B85, maturity group 3.8) was machine-planted at 10 seeds per row-foot on May 27, 2006, in a half circle of irrigated soybeans of the same variety on the Ramsey Brothers Farm four miles north of Garden City, Kansas. A quantity of seed was sent to be treated with the seed treatments. Other seed without seed treatments was saved and planted in plots designated to receive foliar treatments later in the season or to serve as check plots. The plots were four rows wide and 20 feet long. There was a 3-foot-wide alley at each end of the plot. The original design was compromised when some plots were over-sprayed with insecticides later in the season, so the experiment was analyzed as a completely randomized experiment. We analyzed only those treatments with three or four surviving plots together with 14 check plots and 14 plots receiving the foliar fipronil treatment. The foliar treatment of fipronil was applied August 3, after the plants had recovered from hail damage. This treatment targeted the first two instars of the insect developing inside the plants. The foliar treatment was applied with a backpack sprayer, a hand-held boom, and two nozzles (Conejet TXVS 6) directed at a single row. The nozzles were held 6-8 inches from the plants to maximize coverage of the upper canopy. The sprayer was calibrated to deliver 20 gal/acre (8.0 sec per 20 ft row at 30 psi). A chronometer was used to measure the time spent on each row to help maintain appropriate speed. For statictical analysis, we used multiple t-test comparisons of the least square means (LSMeans) produced with the SAS-GLM procedure. LSMeans were compared with the check LSMean.

Dectes stem borer beetle populations were estimated by making 100 sweeps across the plants in single rows. Sweep samples were made at irregular intervals during the flight and the numbers were plotted to determine the relationship between the treatment timing and the beetle flight. Dectes larval infestations were recorded at the end of the season (September 18-20) by dissecting 20 plants in each plot. Five consecutive plants were taken from each of the four rows in each plot. The plants were dissected to record entry nodes, upper stem tunneling, tunneling that reached the base of the plant, and presence of live Dectes larvae. When dissected, plants showed very few larvae had tunneled to the base of the plant, so that variable is not reported. Grain yield data was not collected because infestations were low and the plants had been heavily damaged by a hail storm.

RESULTS AND DISCUSSION

Dectes stem borer populations were lower in 2006 than in 2005. On July 11, a hail storm seriously defoliated the soybeans. This defoliation not only damaged plants, but also knocked off many leaf petioles in which the Dectes beetles had oviposited, thus reducing the potential infestation. The hail also broke or bruised the stems, making it difficult for the larvae to tunnel to the base of the plants. Although the plants recovered, the resulting plants were smaller, later maturing, and more branched than normal. The plants were almost a month late in developing the larger petioles that are attractive to the Dectes beetles. This meant most of the plants escaped Dectes infestation. The Dectes infested an average of 34% of the plants. The delayed development of

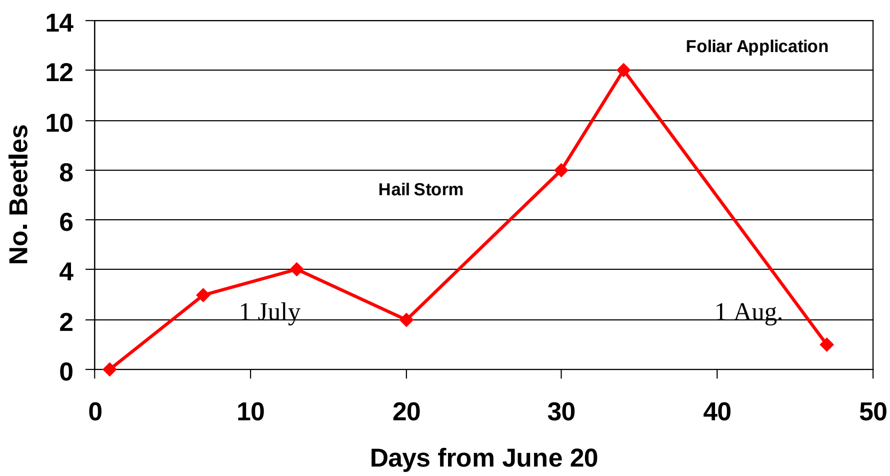
[1] Department of Entomology, Kansas State University, Manhattan

the Dectes infestation also made it difficult to time the foliar treatment.

Of the seed treatments tested, only fipronil appeared to suppress the Dectes stem borer. It gave 100% control, significantly reducing Dectes stem borer infestations (Table 1). The foliar treatment of fipronil also gave a significant (69-85%) control of the Dectes stem borer. It was clear that the timing of the foliar application was late, because many of the larvae had begun tunneling in the main stem, but were killed there. The fipronil treatment was able to kill larvae tunneling in the main stem and thus prevent them from girdling the plants later in the season. It is hoped the fipronil seed treatments can be registered for use in soybean production, because it appears to be an extremely effective treatment option for the Dectes stem borer.

In 2004, we were able to show a significant difference in yield (4.6 to 6.6 bu/acre) for the fipronil treatments. However, we were not able to take yield data in this trial due to the heavy hail damage and resulting low infestation rate.

Fig 1. Dectes Stem Beetles in 100 sweeps in soybeans 2006



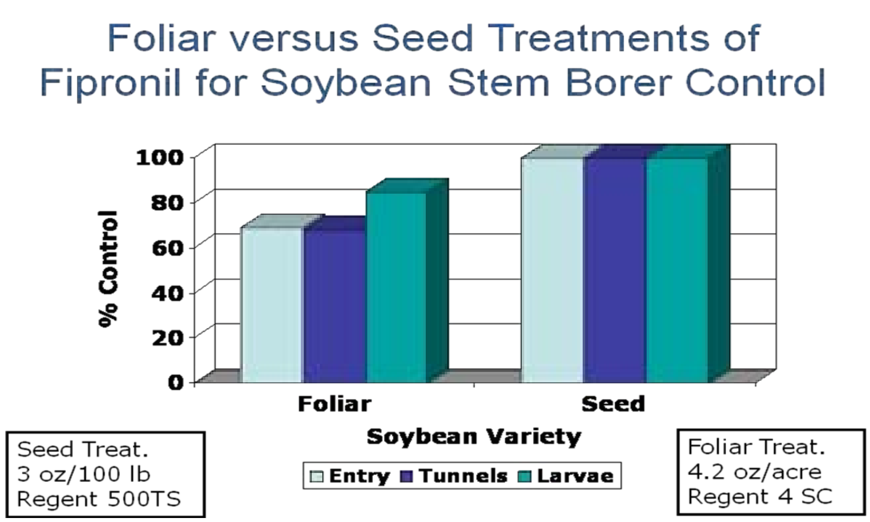


Table 1. F-test Probability values for the ANOVA tests of the two main effects, variety and insecticide treatment. Fipronil treatments were applied as foliar treatments. Irrigation Experiment Field, Scandia, Kansas, 2006.

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Mean		3.06	2.5	0.8	0.7	66.76

CROP YIELD IMPROVEMENTS OVER THE PAST 50 YEARS AS MEASURED BY SWREC CROP PERFORMANCE RESULTS

by
Curtis Thompson and John Holman

SUMMARY

The greatest crop improvements over the past 50 years clearly have occurred in irrigated corn hybrid development. In addition to hybrid improvement, increasing plant populations and improving weed and insect control have been contributors to the increased yields. Irrigated and dryland wheat improvements have trended upward, but year-to-year yield variability continues to plague wheat. Hot temperatures during grain fill, spring freezes, rust, and hail contribute to the variability. In addition, seasonal precipitation variation contributes to variability in dryland wheat varieties. These environmental challenges likely mask yield improvements made in wheat varieties. Irrigated grain sorghum has consistently yielded 100 to 140 bu/a and has a flat yield trend since 1956. Standability and yield potential have been improved, allowing irrigated sorghum growers to harvest standing grain sorghum. Dryland grain sorghum has had a slight upward trend. Hybrid development and improved farming practices contribute to this yield increase. Irrigated soybeans also have a slight upward yield trend. Variety/hybrid performance tests have and will continue to assist the producer making decisions of what varieties or hybrids should be planted. It is always most important to plant more than one variety or hybrid, as well as more than one crop, to minimize production risk due to environmental and economic conditions.

PROCEDURES

Crop variety/hybrid performance tests, irrigated corn, irrigated wheat, dryland wheat, irrigated grain sorghum, dryland grain sorghum, and irrigated soybeans have been conducted at the SWREC annually over the past 50 years. For each crop, the varieties/hybrids yields were averaged for each year from 1956 through 2006. These trial averages were regressed against year to measure the level of crop yield improvement throughout the 50-year period.

RESULTS AND DISCUSSION

Advancements in irrigated corn yields since 1956 have exceeded all other crops evaluated during the same period of time at the SWREC. Regression analysis of the irrigated corn performance test averages predicts that irrigated corn yields have increased 2.2 bu/a/year (Figure 1). The development of corn hybrids, as well as fertility, plant population increases, improved weed control practices, and genetically modified organism GMO corn borer resistance have all contributed to the increased corn yields. Annual average yields are shown on Figure 1. The lowest average yields were less than 100 bu/a in 1956 and 1957, while the two highest average yields occurred in 2002 and 2003 (both exceeding 250 bu/a).

Irrigated wheat has had a slight upward trend over the 50-year period (Figure 2). The regression predicts wheat yield improvements of 0.28 bu/a/year from 1956 through 2006. Although huge improvements have been made on wheat standability, earlier maturity, disease resistance, and variety yield potential, environmental conditions continue to control wheat yields, resulting in significant year-to-year variation. High temperatures during grain fill, freeze damage, rust, and hail contribute to low-yielding years. Omitting the zero yielding years, two years had average yields of less than 30 bu/a and two years have had average yields exceeding 80 bu/a.

Dryland wheat, like irrigated, has had a similar upward trend of 0.25 bu/a/yr (Figure 3). Growing-season precipitation variability, along with spring freezes, high temperatures during grain fill, rust, and hail contribute to large variability in dryland wheat yields masking the true increase in wheat variety yield potential improvement. The long term yields indicate that we raise wheat in a harsh environment. In only 17 years since 1956 has the dryland wheat variety trial averaged more than 40 bu/a. In fact, 12 years have had average yields of 20 bu/a or less. This includes 1967, 1979, 1987, and 1996, when the dryland wheat variety trial was abandoned.

Irrigated grain sorghum yield does not trend upward but remained flat from 1956 through 2006 (Figure 4). The excellent yields in the 1950s and ’60s perhaps were higher than farmer yields because plots were primarily hand harvested. Varieties and hybrids at that time were prone to lodging,

which significantly reduced the amount of crop a producer could machine harvest. Improvements have been made in sorghum standability and hybrids have been shortened in height. They also possess improved stalkrot resistance, which has allowed producers to harvest standing irrigated grain sorghum, resulting in increased harvested yields. Greater variation in sorghum yield has occurred since 1983. Four years of the irrigated sorghum hybrid trials have been abandoned, including three years to hail (1967, 1979, and 1992) and one to freeze (1983) . It is amazing that the irrigated hybrid sorghum yield averages have equaled or exceeded 100 bu/a in all but four years that yield data has been collected; yet, in only three years did the average irrigated sorghum yield exceed 140 bu/a. From 1957 through 2006, irrigated sorghum has consistently yielded 100 to 140 bu/a.

Dryland grain sorghum (conventional tilled sorghum/fallow) yield has trended upward 0.67 bu/a/year (Figure 5). The trend is a result of hybrid improvements for dryland, as well as improved farming practices for fertility and weed control. Since 1990, the occurrence of average yields exceeding 80 bu/a has increased. Like dryland wheat, year-to-year variation is high due to variability in precipitation and other environmental challenges, such as hail.

Irrigated soybean yields have had a slight upward trend of 0.22 bu/a/year (Figure 6). In 1984, the soybean variety trail was split into Group II & III or Group IV bean experiments and remained in that format until 2002. Data in Figure 6 from the periods prior to 1984 and after 2001 include all groups of soybean varieties. The Group IV bean variety averages remained flat from 1984 through 2001 (Figure 7).

Variety/hybrid performance tests have and will continue to assist the producer making decisions about what varieties or hybrids should be planted. It is always most important to plant more than one variety or hybrid, as well as more than one crop, to minimize production risk to environmental and economic conditions.

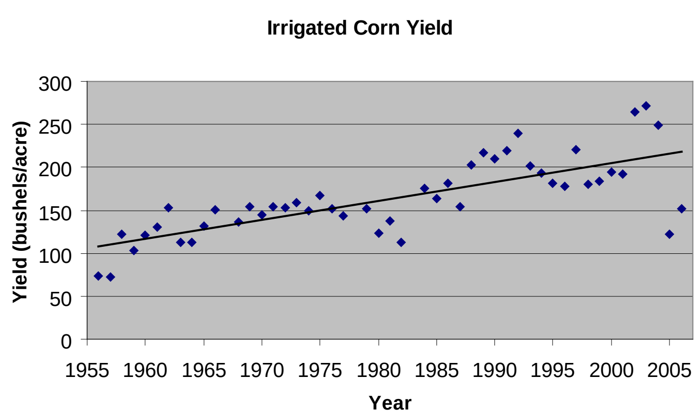

Figure 1. Irrigated Corn Yield. Yield increased 2.2 bu/year (P<0.0001)

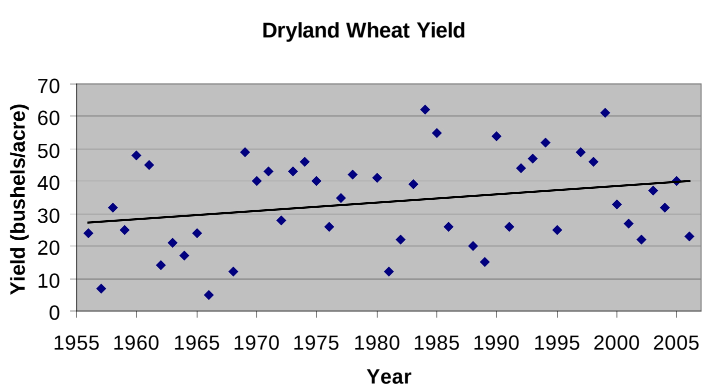

Figure 3. Dryland Wheat Yield. Yield increased 0.25 bu/year (P<0.07).

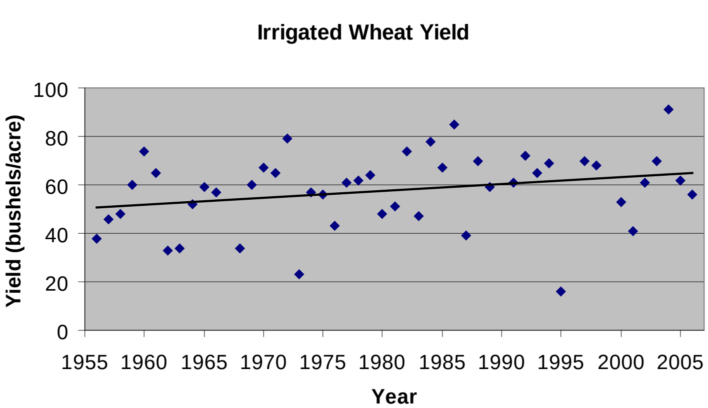

Figure 1. Irrigated Wheat Yield. Yield increased 0.28 bu/year (P<0.07)

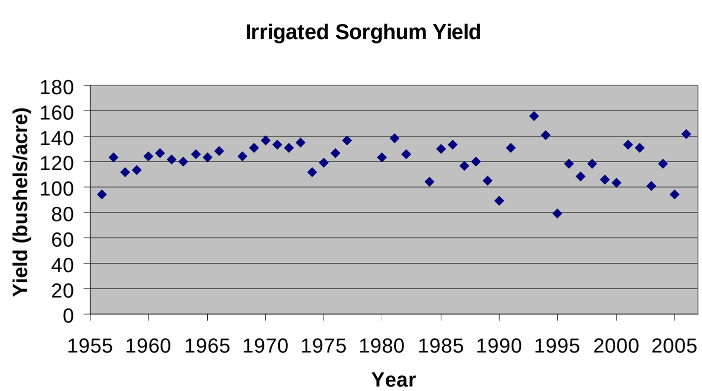

Figure 4. Irrigated Sorghum Yield. Irrigated sorghum yield averaged 121 bu/year.

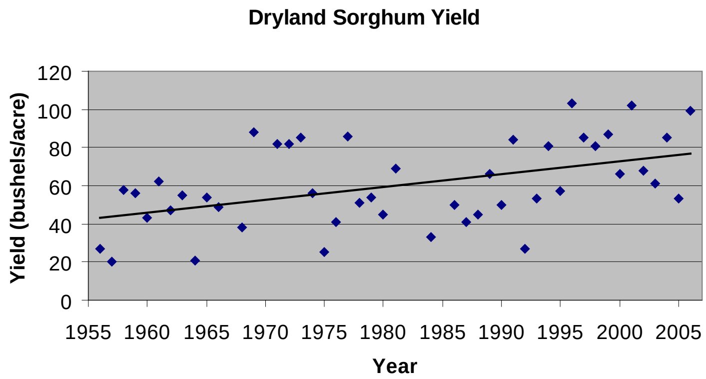

Figure 5. Dryland Sorghum Yield. Yield increased 0.67 bu/year (P < 0.001).

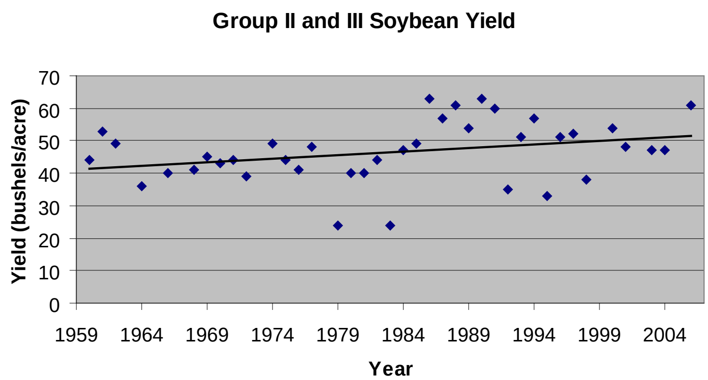

Figure 6. Group II and III Irrigated Soybean Yield. Yield increased 0.22 bu/year (P < 0.06).

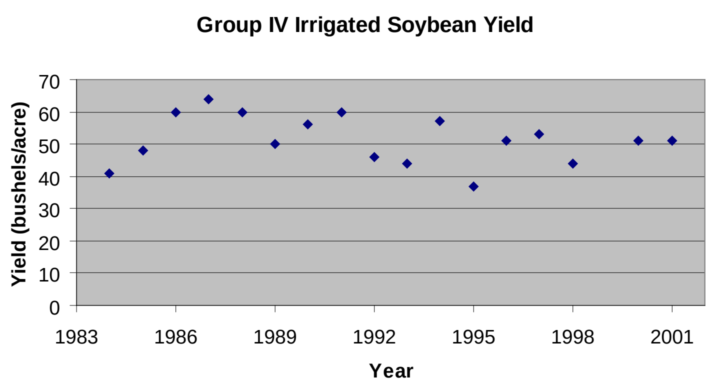

Figure 7. Group IV Irrigated Soybean Yield. No change in Group IV irrigated soybean yield, yield averaged 51.4 bu/acre.

ACKNOWLEDGMENTS

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

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Kansas Grain Sorghum Commission
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Sorghum Partners
Stine Seed Farms
Triumph Seed Co., Inc.
Watley
WestBred
WestBred/AGSECO
W-L Research
Z-Public

Notes

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.

John Holman—Cropping Systems Agronomist. John received his B.S. and M.S. from Montana State University and his Ph.D. from the University of Idaho. He joined the staff in 2006. His research involves crop rotations, forages, and integrated weed management.

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.

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