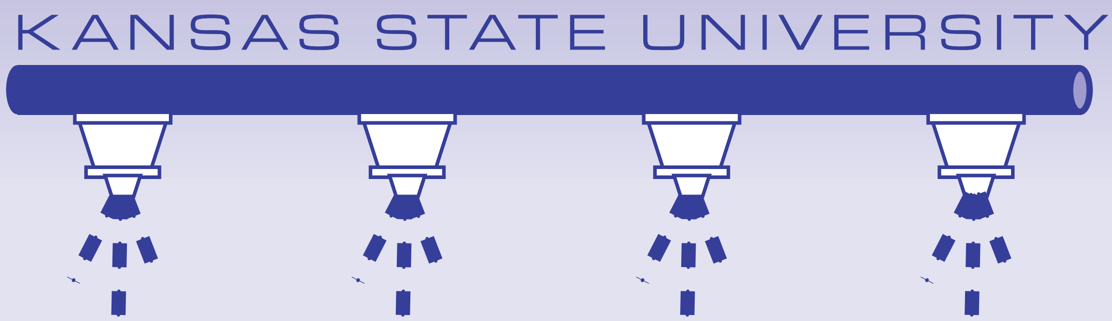

Kansas Fertilizer Research 2007

Report of Progress 993

Kansas State University
Agricultural Experiment Station and
Cooperative Extension Service

INTRODUCTION

The 2007 edition of the Kansas Fertilizer Research Report of Progress is a compilation of data collected by researchers across Kansas. Information was contributed by faculty and staff from the Department of Agronomy, Kansas agronomy experiment fields, and agricultural research and research-extension centers.

We greatly appreciate the cooperation of many K-State Research and Extension agents, farmers, fertilizer dealers, fertilizer equipment manufacturers, agricultural chemical manufacturers, and representatives of various firms who contributed time, effort, land, machinery, materials, and laboratory analyses. Without their support, much of the research in this report would not have been possible.

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TABLE OF CONTENTS

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Precipitation Data

Month	Precipitation (in.)				
	Manhattan	Southwest Research-Extension Center Tribune	Southeast Agricultural Research Center Parsons	East Central Experiment Field Ottawa	Harvey County Experiment Field Hesston S
2006					
Aug.	10.91	3.94	3.85	7.37	5.12
Sept.	1.99	1.00	0.64	2.17	1.17
Oct.	1.95	4.05	1.88	3.09	2.09
Nov.	0.11	0.15	1.36	1.53	0.10
Dec.	1.57	3.82	2.92	2.58	1.69
Total 2006	32.08	20.96	26.29	32.28	25.56
Departure from normal	-2.72	+3.52	-15.80	-6.93	-7.51
2007					
Jan.	0.63	0.77	2.18	1.25	1.06
Feb.	1.24	0.40	0.77	1.41	0.46
Mar.	4.31	1.46	5.35	4.09	3.88
Apr.	3.67	3.32	9.84	4.37	3.92
May	11.10	1.09	13.54	6.81	9.00
June	5.93	1.43	3.97	9.75	4.19
July	4.66	0.50	1.42	8.61	3.51
Aug.	2.24	3.31	2.37	1.01	2.75
Sept.	3.77	0.73	5.05	3.71	0.92

Month	North Central Experiment Field Belleville	Kansas River Valley Experiment Field	South Central Experiment Field Hutchinson	Fort Hays Experiment Station Hays	Harvey County Experiment Field Hesston N
2006					
Aug.	6.22	2.36	2.52	4.85	5.04
Sept.	5.18	1.57	0.69	2.17	1.13
Oct.	1.39	1.92	1.49	1.43	1.28
Nov.	0.08	0.89	0.08	0.27	0.05
Dec.	1.60	1.93	2.44	2.81	1.42
Total 2006	26.72	18.55	23.10	23.28	25.48
Departure from normal	-4.13	-15.66	-7.22	-3.43	-7.59
2007					
Jan.	0.55	0.20	0.90	0.51	1.10
Feb.	1.56	0.68	0.48	2.04	0.38
Mar.	2.18	2.52	5.34	4.83	2.71
Apr.	2.46	1.72	2.87	1.77	2.84
May	9.30	7.17	10.31	5.39	4.83
June	2.39	3.59	7.34	2.60	4.72
July	6.23	2.09	0.65	6.02	3.88
Aug.	2.93	1.50	1.68	2.55	3.32
Sept.	4.05	1.45	0.65	1.95	0.95

LONG-TERM FERTILIZATION OF IRRIGATED GRAIN SORGHUM

Alan Schlegel

SUMMARY

Long-term research shows that phosphorus (P) and nitrogen (N) fertilizer must be applied to optimize production of irrigated grain sorghum in western Kansas. In 2007, N and P applied alone increased yields about 70 and 15 bu/a, respectively; N and P applied together increased yields up to 90 bu/a. Averaged over the past 10 years, N and P fertilization increased sorghum yields up to 60 bu/a. Application of 40 lb/a N (with P) was sufficient to produce more than 85% of maximum yield, although yields continued to increase at N rates of 120 lb/a N in 2007. Application of potassium (K) has had no effect on sorghum yield throughout the study period.

INTRODUCTION

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

PROCEDURES

Fertilizer treatments initiated in 1961 were N rates of 0, 40, 80, 120, 160, and 200 lb/a N without P and K; with 40 lb/a P_2O_5 and zero K; and with 40 lb/a P_2O_5 and 40 lb lb/a K_2O. All fertilizers were broadcast by hand in the spring and incorporated prior to planting. The soil is a Ulysses silt loam. Sorghum (Pioneer 8500/8505 from 1998-2007) was planted in late May or early June. Irrigation was used to minimize water stress. Furrow irrigation was used through 2000, and sprinkler irrigation has been used since 2001. The center two rows of each plot were machine harvested after physiological maturity. Grain yields were adjusted to 12.5% moisture.

RESULTS

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

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

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

LONG-TERM NITROGEN AND PHOSPHORUS FERTILIZATION OF IRRIGATED CORN

Alan Schlegel

SUMMARY

Long-term research shows that phosphorus (P) and nitrogen (N) fertilizer must be applied to optimize production of irrigated corn in western Kansas. In 2007, N applied alone increased yields about 110 bu/a, but P applied alone had no effect on yield. When N and P were applied together, yields were increased up to 180 bu/a. Averaged over the past 10 years, corn yields were increased up to 135 bu/a by N and P fertilization. Application of 120 lb/a N (with P) was sufficient to produce more than 90% of maximum yield in 2007, which was slightly less than the 10-year average. In 2007, P increased corn yields an average of 80 bu/a when applied with at least 120 lb/a N. Application of 80 lb/a instead of 40 lb/a P_2O_5 increased yields 8 bu/a.

INTRODUCTION

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

PROCEDURES

Initial fertilizer treatments in 1961 were N rates of 0, 40, 80, 120, 160, and 200 lb/a N without P and K; with 40 lb/a P_2O_5 and zero K; and with 40 lb/a P_2O_5 and 40 lb/a K_2O. Treatments were changed in 1992; the K variable was replaced by a higher rate of P (80 lb/a P_2O_5). All fertilizers were broadcast by hand in the spring and incorporated prior to planting. The soil is a Ulysses silt loam. Corn hybrids were Pioneer 3395IR (1998), Pioneer 33A14 (2000), Pioneer 33R93 (2001 and 2002), DeKalb C60-12 (2003), Pioneer 34N45 (2004 and 2005), Pioneer 34N50 (2006), and Pioneer 33B54 (2007) planted at about 30,000 to 32,000 seeds/a in late April or early May. Hail damaged the 2005 and 2002 crop and destroyed the 1999 crop. Corn was irrigated to minimize water stress. Furrow irrigation was used through 2000, and sprinkler irrigation has been used since 2001. The center two rows of each plot were machine harvested after physiological maturity, and grain yields were adjusted to 15.5% moisture.

RESULTS

Corn yields in 2007 were higher than the 10-year average (Table 1). Nitrogen alone increased yields 110 bu/a; P alone increased yields only 2 bu/a. However, N and P applied together increased corn yields up to 180 bu/a. Only 120 lb/a N with P was required to obtain more than 90% of maximum yield. Over the past 10 years, 120 lb/a N with P has produced 95% of maximum yield. Averaged across all N rates, application of 80 lb/a instead of 40 lb/a P_2O_5 increased corn yields 8 bu/a, which is similar to the 10-year average.

Table 1. Effect of N and P fertilizers on irrigated corn yields, Tribune, 1998-2007[a]

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

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

LAND APPLICATION OF ANIMAL WASTES ON IRRIGATED CORN[1]

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

SUMMARY

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

INTRODUCTION

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

PROCEDURES

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

The study was established in border basins to facilitate effluent application and flood irrigation. Swine effluent was flood applied as part of a preplant irrigation each year. At the same time, plots not receiving swine effluent were irrigated to balance water additions. Cattle manure was hand broadcast and incorporated. The N fertilizer (granular NH_4NO_3) was applied with a 10-ft fertilizer

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

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

applicator (Rogers Mfg.). The entire study area was uniformly irrigated during the growing season with flood irrigation in 1999-2000 and sprinkler irrigation in 2001-2007. The soil is a Ulysses silt loam. Corn was 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 2007, as was the case in previous years except 2002 when yields were greatly reduced by hail damage (Table 3). Type of animal waste affected yields in 6 of the 8 years; higher yields occurred from cattle manure than swine effluent. Averaged across the 8-year period, corn yields were 15 bu/a greater following application of cattle manure than swine effluent on an N application basis. Over-application (2X N) of cattle manure had no negative effect on grain yield in any year. In 2004, over-application of swine effluent reduced corn yield. However, no adverse residual effect from the over-application has been observed.

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

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

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

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

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

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

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

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

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

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

John Holman and Alan Schlegel

SUMMARY

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

INTRODUCTION

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

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

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

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

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

PROCEDURES

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

RESULTS

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

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

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

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

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

REFERENCES

Brady, N. and Weil, R. 2002. Micronutrients and other trace elements. p. 645, 654-655 in The nature and properties of soils. 13th ed. New Jersey: Prentice Hall.

Lamond, R. and Leikam, D. 2002. Chloride in Kansas: Plant, soil, and fertilizer considerations. Publication MF-2570. Manhattan, KS: Kansas State University.

Mengel, D., Martin, K., and Tucker, D. 2007. Chloride fertilization and soil testing in Kansas. Soil and Plant Analyst Workshop.

Mortvedt, J. 2000. Bioavailability of micronutrients. p. D-85 in M. Sumner (Ed.). Soil fertility and plant nutrition. Boca Raton, FL: CRC Press.

Table 1. Chloride fertilizer recommendations from soil test

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

EFFECTS OF PHOSPHORUS AND POTASSIUM FERTILIZER RATE AND TIME OF APPLICATION IN A WHEAT DOUBLE-CROPPING SYSTEM

Kenneth W. Kelley

SUMMARY

Grain yields of grain sorghum, wheat, and double-crop soybean were not significantly affected by phosphorous (P) and potassium (K) fertilizer rates or time of application during the initial stages of this long-term study.

INTRODUCTION

Timing and rate of fertilizer P and K application are important crop production management decisions. In southeastern Kansas, producers often plant wheat following harvest of a feed-grain crop, such as grain sorghum or corn, and then plant double-crop soybean after wheat, giving three crops in 2 years. In these multiple-crop systems, producers typically apply fertilizer P and K only to the feed-grain and wheat crops. Because fertilizer costs are increasing, this research seeks to determine the direct and residual effects of rate and timing of P and K fertilizer application on grain yields in a double-cropping system.

PROCEDURES

This study was established in 2004 at the Columbus Unit of the Southeast Agricultural Research Center. Crop rotation consists of grain sorghum/wheat/double-crop soybean, giving three crops in a 2-year period. Grain sorghum is planted with conventional tillage, and wheat and double-crop soybean are planted with no-till. Different P and K fertilizer rates are applied preplant to the grain sorghum crop only or to both the grain sorghum and wheat crops. Initial soil test values before study establishment were 23 ppm Bray-1 P and 160 ppm exchangeable K for the 0- to 6-in. soil depth.

RESULTS

Effects of the various P and K fertilizer treatments on grain sorghum, wheat, and double-crop soybean yields are shown in Table 1. Grain yields have been affected very little by fertilizer treatments during the initial years of study establishment. The non-significant yield response was not unexpected because initial soil test values indicated that soil P and K values were sufficient for the expected yield goals.

The amount of nutrient removal in harvested grain for 100 bu/a grain sorghum, 50 bu/a wheat, and 25 bu/a double-crop soybean is 87 lb/a P_20_5 and 72 lb/a K_20. Thus, this study will continue for several cropping cycles to monitor the residual effects of P and K fertilizer treatments on grain yields and soil nutrient concentrations of P and K. Additional treatments, such as starter fertilizer effects, likely will be imposed in the study as soil test values change with time.

Table 1. Effects of phosphorus and potassium fertilizer rate and time of application on grain yield in a double-cropping system, Columbus unit

Fertilizer Rate						Grain Yield[1]		
Grain Sorghum			Wheat					
N	P_2O_5	K_2O	N	P_2O_5	K_2O	Grain Sorghum	Wheat	Soy
------------------------ lbs/a ------------------------						-------------- bu/a --------------		
120	0	0	120	0	0	86	51	30
120	40	40	120	40	40	89	52	31
120	80	80	120	0	0	91	52	30
120	60	60	120	60	60	90	52	30
120	120	120	120	0	0	92	54	30
120	80	80	120	80	80	93	51	31
LSD (0.05)						NS	NS	NS

Note. Initial soil test values before study establishment were 23 ppm Bray-1 P and 160 ppm exchangeable K for the 0- to 6-in. soil depth.

[1]Values represent average grain yields from 2005 to 2007, except no grain yields were reported for wheat in 2007 because of early April freeze damage.

EFFECTS OF NITROGEN FERTILIZER AND PREVIOUS DOUBLE-CROPPING SYSTEMS ON SUBSEQUENT CORN YIELD

Kenneth W. Kelley and Joseph L. Moyer

SUMMARY

Corn yields were greatest following wheat/double-crop soybean and least following wheat/double-crop grain sorghum. Corn yield response to nitrogen (N) fertilizer differed among previous wheat/double-crop systems.

INTRODUCTION

In southeastern Kansas, producers typically double-crop soybean after wheat, but other double-crop options are suitable for the growing conditions of this region. Grain sorghum can be grown successfully as a double-crop option if planted by early July. If wet conditions follow wheat harvest, double-crop sunflower can be planted as late as mid- to late July. Small-seeded legumes, such as lespedeza or sweet clover, typically are seeded into wheat in late winter. Lespedeza commonly is grown for seed or cut for hay, and sweet clover is planted primarily for soil amendment purposes. Other producers summer fallow land after wheat harvest.

Previous wheat and double-crop systems likely affect growth of subsequent crops, such as corn. In addition, N fertilizer requirements for corn might need to be adjusted depending on the previous wheat double-crop system.

PROCEDURES

The study was conducted at the Parsons Unit of the Southeast Agricultural Research Center. The experimental design was a split-plot arrangement with three replications.

Main plots consisted of six different systems:

1. wheat/double-crop soybean
2. wheat/double-crop grain sorghum
3. wheat/double-crop sunflower
4. wheat/sweet clover
5. wheat/lespedeza
6. wheat/chemical fallow

Double-crop grain sorghum and sunflower plots each received 75 lb/a N. Subplots consisted of six preplant fertilizer N rates (0, 30, 60, 90, 120, and 150 lb/a) for corn following wheat/double-crop options. Nitrogen source was 28% N solution preplant applied with a coulter-knife applicator. Because residual soil test values were relatively high, neither phosphorus nor potassium fertilizer was applied. Corn was planted with conventional tillage.

RESULTS

Corn yields in 2005 and 2007 were greatest following wheat/double-crop soybean and lowest following wheat/double-crop grain sorghum (Table 1). Differences in corn yield among previous double-crop options were less pronounced at higher N rates than at lower N rates. In 2004 and 2006, sweet clover growth was reduced because of dry soil conditions during mid-summer, which likely affected subsequent corn yield responses. The higher N fertilizer requirement following wheat/double-crop grain sorghum likely is the result of greater immobilization of N fertilizer following the high-residue sorghum crop.

Table 1. Effects of nitrogen and previous wheat/double-crop systems on subsequent corn production, Parsons unit

Previous Wheat/ Double-Crop System	N Rate	Corn Yield 2005	Corn Yield 2007
	lb/a	---------------bu/a ---------------	
Chemical fallow	0	50.6	65.9
	30	75.5	100.2
	60	117.6	139.8
	90	137.9	146.9
	120	149.9	169.2
	150	158.7	178.7
Soybean	0	69.1	105.2
	30	90.3	137.4
	60	108.4	151.9
	90	135.6	156.4
	120	154.7	158.3
	150	157.2	168.3
Grain sorghum	0	28.8	43.6
	30	58.7	75.3
	60	78.7	96.1
	90	101.4	123.2
	120	128.0	149.3
	150	139.3	159.9
Sunflower	0	44.0	80.4
	30	70.8	100.2
	60	117.6	150.5
	90	129.7	159.2
	120	144.5	169.9
	150	158.0	178.3
Sweet clover	0	59.6	67.0
	30	86.3	71.9
	60	119.6	124.4
	90	134.5	138.3
	120	148.1	161.6
	150	152.5	163.0
Lespedeza	0	49.2	84.7
	30	68.7	99.0
	60	103.8	125.6
	90	127.6	147.9
	120	142.5	155.9
	150	142.1	168.3

(Continued)

Table 1, continued. Effects of nitrogen and previous wheat-double-crop systems on subsequent corn production, Parsons Unit

Previous Wheat/ Double-Crop System	N Rate	Corn Yield 2005	Corn Yield 2007
		---------------bu/a---------------	
LSD (0.05)		7.8	11.5
Same cropping system		8.8	14.0
Different system			
Mean Values			
Chemical fallow		115.0	133.5
Soybean		119.2	146.3
Grain sorghum		89.2	107.9
Sunflower		110.8	139.8
Sweet clover		116.8	121.0
Lespedeza		105.6	130.3
LSD (0.05)		5.7	10.3

EFFECTS OF NITROGEN FERTILIZER RATE AND TIME OF APPLICATION ON CORN AND GRAIN SORGHUM YIELDS

Kenneth W. Kelley and Daniel W. Sweeney

SUMMARY

Corn and grain sorghum yield responses to nitrogen (N) fertilizer rate and time of application varied with environmental conditions. However, for the initial 2 years of data, yield differences between preplant N and side-dress N have been small. Fertilizer N rate has influenced grain yields more than time of N application.

INTRODUCTION

Because of recent increases in N fertilizer prices, producers are looking for ways to reduce production costs for feed-grain crops, such as corn and grain sorghum. One method that has gained renewed interest is applying some of the fertilizer N requirement after the crop has emerged, referred to as side-dressing. Some research has shown that a subsurface application of banded N after the crop has emerged results in more efficient N use and often increases net return. In southeastern Kansas, excessive spring rainfall also increases the potential for greater N loss where fertilizer N is applied preplant.

PROCEDURES

Studies were established at the Columbus Unit of the Southeast Agricultural Research Center in 2006 and 2007 to evaluate the effects of time and rate of N fertilizer application on both corn and grain sorghum. Fertilizer (28% liquid N) treatments consisted of different N rates applied preplant or side-dressed. Preplant N fertilizer was subsurface applied in mid-March on 15-in. centers at a depth of 4 to 6 in. Side-dress N also was subsurface applied between 30-in. rows. All plots received 30 lb/a N preplant as 18-46-0. The previous crop was double-crop soybean.

RESULTS

Corn and grain sorghum yield responses to N fertilizer rate and time of application varied with year and environmental conditions (Table 1). Grain yields were higher in 2007 than in 2006 because of timely rainfall during the growing season. In 2007, corn yield increased linearly with increasing rates of N fertilizer, but time of application did not have a significant effect. In 2007, grain sorghum yields were slightly greater when N fertilizer was side-dressed compared with preplant N treatments, although differences were not large. Grain sorghum yields in 2007 showed little response above the 120 lb/a N rate.

This study will continue for several more cycles to investigate N fertilizer responses under varying environmental conditions.

Table 1. Effects of nitrogen fertilizer rate and time of application on corn and grain sorghum yields, Columbus unit

Rate of Fertilizer N[1]		Grain Yield			
		Corn		Grain Sorghum	
Preplant	Side-dress	2006	2007	2006	2007
---------- lb N/a ----------		------------------------------ bu/a ------------------------------			
30	0	81.6	74.5	69.8	93.9
60	0	94.6	91.8	70.7	109.4
90	0	103.9	117.7	72.3	109.9
120	0	106.7	129.8	70.3	125.2
150	0	105.4	149.8	68.2	122.0
30	30	92.4	90.6	73.2	112.2
30	60	99.4	119.3	73.4	123.6
30	90	106.2	133.1	68.8	134.3
30	120	112.4	154.0	65.6	131.3
LSD (0.05)		10.6	11.3	NS	6.8

[1] 30 lb/a N applied preplant as 18-46-0 to all treatments.

NITROGEN MANAGEMENT FOR SEED AND RESIDUAL FORAGE PRODUCTION OF ENDOPHYTE-FREE AND ENDOPHYTE-INFECTED TALL FESCUE

Daniel W. Sweeney and Joseph L. Moyer

SUMMARY

Dry conditions in 2006 resulted in overall low seed yields. Nitrogen (N) rates up to 100 lb/a produced about twice as much seed as with no fertilizer N. Forage aftermath yield was increased with increasing N rates up to 200 lb/a. Endophyte infection had no effect on yields of clean seed or aftermath forage.

INTRODUCTION

Nitrogen fertilization is important for fescue and other cool-season grasses, but N management for seed production is less defined. Endophyte-free tall fescue might need better management than infected stands. Nitrogen fertilization has been shown to affect forage yields, but data on yield and quality of the aftermath remaining after seed harvest are lacking. The objective of this study was to determine the effects of timing and rate of N applied to endophyte-free and endophyte-infected tall fescue for seed and aftermath forage production.

PROCEDURES

The experiment was established as a split-plot arrangement of a completely randomized block design with three replications. Whole plots were endophyte-free and endophyte-infected tall fescue. Subplots were a 3 × 5 factorial arrangement of fertilizer N timing and N rate. The three N timings were 100% in late fall (December 1, 2003, December 17, 2004, and December 13, 2005), 100% in late winter (February 26, 2004, March 7, 2005, and February 28, 2006), and 50% in late fall and 50% in late winter. The five N rates were 0, 50, 100, 150, and 200 lb/a. In all treatments, N fertilizer was broadcast applied as urea ammonium-nitrate (UAN) solution. Each fall, all plots received broadcast applications of 40 lb/a P_2O_5 and 70 lb/a K_2O. Seed harvest was on June 7, 2004, June 15, 2005, and June 16, 2006; and forage aftermath was harvested on June 14, 2004, June 20, 2005, and June 20, 2006.

RESULTS

In 2006, dry conditions reduced seed yield to less than 40 lb/a. Although yields were low, clean seed production was increased with N rates up to 100 lb/a (Figure 1). However, this trend was more apparent in the split late-fall and late-winter application than when all N was applied in the fall or in the spring (interaction data not shown). Aftermath forage yields were increased by N rates up to 200 lb/a, but the increased response diminished at N rates greater than 100 lb/a (Figure 1). Endophyte infection had no effect on yield of clean seed or aftermath forage.

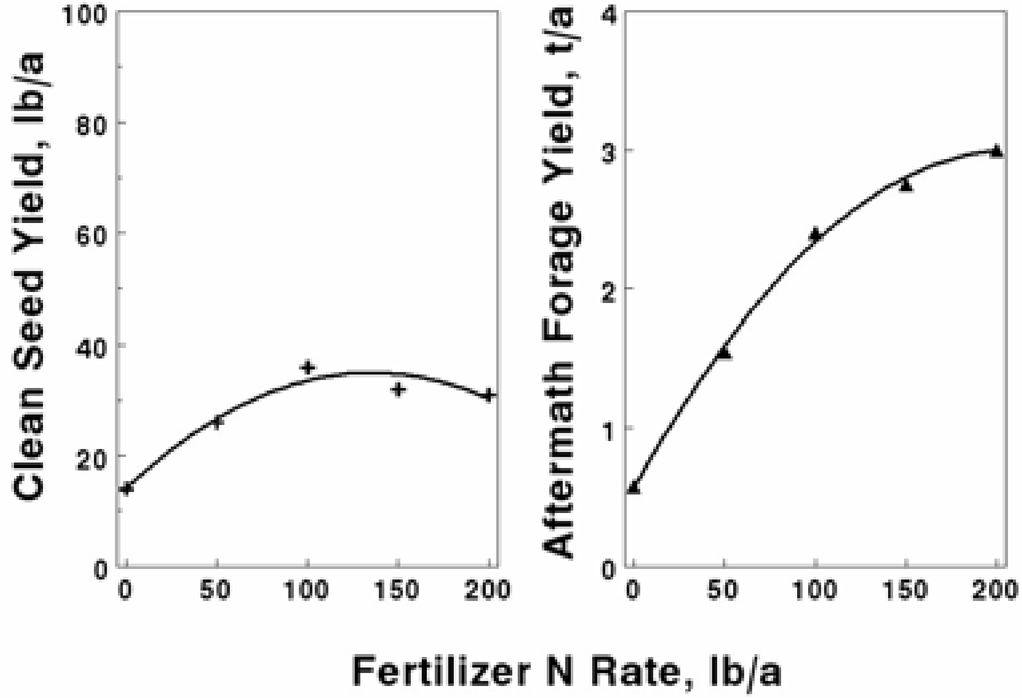

Figure 1. Effects of nitrogen fertilizer rate on clean-seed yield and aftermath forage yield during 2006, Southeast Agricultural Research Center

TILLAGE AND NITROGEN PLACEMENT EFFECTS ON YIELDS IN A SHORT-SEASON CORN/WHEAT/DOUBLE-CROP SOYBEAN ROTATION

Daniel W. Sweeney and Kenneth W. Kelley

SUMMARY

In 2006, adding nitrogen (N) increased wheat yields, but placement or tillage did not. Double-crop soybean yields were greater following poor wheat in the controls but were unaffected by tillage or residual N placement.

INTRODUCTION

Many crop rotation systems are used in southeastern Kansas. This experiment was designed to determine the long-term effect of selected tillage and N fertilizer placement options on yields of short-season corn, wheat, and double-crop soybean in rotation.

PROCEDURES

A split-plot design with four replications was initiated in 1983 with tillage system as the whole plot and N treatment as the subplot. In 2005, the rotation was changed to begin a short-season corn/wheat/double-crop soybean sequence. Use of three tillage systems (conventional, reduced, and no-till) continued in the same areas as during the previous 22 years. The conventional system consists of chiseling, disking, and field cultivation. Chiseling occurred in the fall preceding corn or wheat crops. The reduced-tillage system consists of disking and field cultivation prior to planting. Glyphosate (Roundup) was applied to the no-till areas. The four N treatments for the crop were: no N (control), broadcast urea-ammonium nitrate (UAN; 28% N) solution, dribble UAN solution, and knife UAN solution at 4 in. deep. The N rate for the corn crop grown in odd years was 125 lb/a. The N rate of 120 lb/a for wheat was split as 60 lb/a applied preplant as broadcast, dribble, or knifed UAN. All plots, except controls, were top dressed in the spring with broadcast UAN at 60 lb/a.

RESULTS

In 2006, adding fertilizer N, in general, nearly doubled wheat yields compared with the no-N controls (Figure 1). However, there were no differences in yield due to placement method in any of the tillage systems. In contrast, double-crop soybean yields were greater following wheat in the controls where yields had been low (Figure 2). Tillage did not affect either wheat or following double-crop soybean yields.

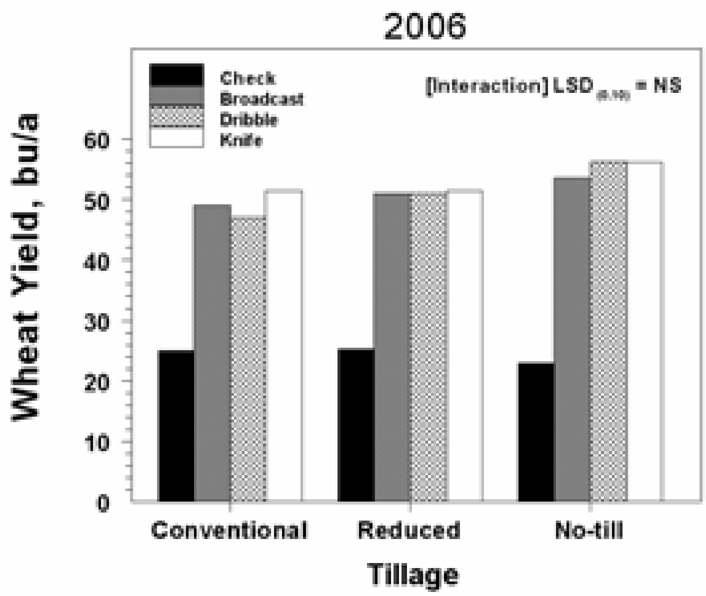

Figure 1. Effect of tillage and nitrogen placement on wheat yield in 2006, Southeast Agricultural Research Center

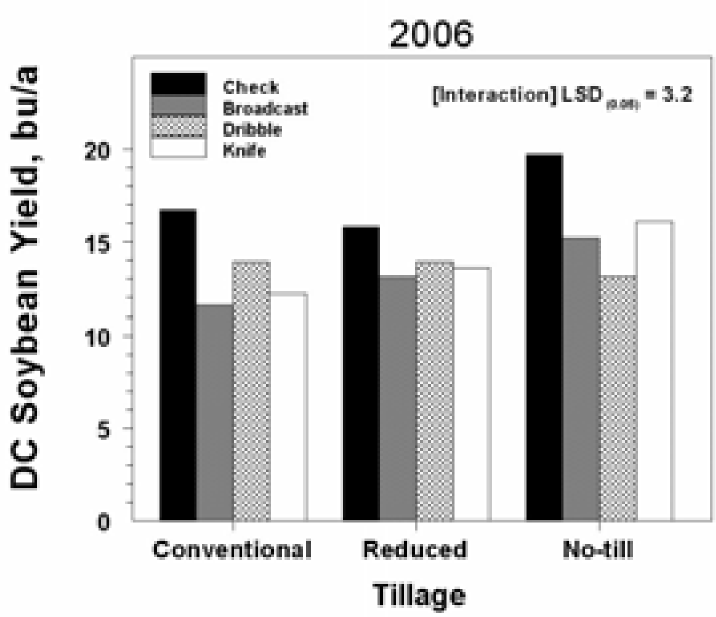

Figure 2. Effects of tillage and residual nitrogen placement on soybean yield plated as a double crop after wheat in 2006, Southeast Agricultural Research Center

SURFACE RUNOFF NUTRIENT LOSSES FROM CROPLAND RECEIVING FERTILIZER AND TURKEY LITTER

Daniel W. Sweeney and Gary M. Pierzynski[1]

SUMMARY

Phosphorus (P) losses were greater when turkey litter was applied based on crop nitrogen (N) needs. Applying turkey litter based on crop P needs reduced P losses, especially when incorporated. Nitrogen losses appeared to be a bit more variable, but values seemed low. Incorporation by conventional tillage generally resulted in greater sediment loss; however, losses were small on this soil, which is typical of southeastern Kansas.

INTRODUCTION

Nutrient and sediment losses due to surface runoff are significant threats to surface water quality. Little information is available on relative losses of nutrients from animal wastes compared with losses from commercial fertilizers, especially in southeastern Kansas. Current nutrient management guidelines in Kansas require P-based, rather than N-based, applications of animal wastes when risk of offsite P movement is high, but the water quality benefits from this strategy are not known. Objectives of this study were to: 1) compare surface runoff losses of nutrients and sediment from fertilizer and turkey litter manure nutrient sources and 2) determine the influence of tillage on nutrient and sediment losses in surface runoff from use of fertilizer and turkey litter.

PROCEDURES

The experiment was initiated in 2005 near Girard on the Greenbush educational facility grounds. Soil was a Parsons silt loam overlying a claypan B horizon. Five treatments were replicated twice:

1) Control—no fertilizer or turkey litter applied
2) Fertilizer—only commercial fertilizer to supply N and P with no turkey litter
3) Turkey litter (N-based)—turkey litter applications to supply all N (that also provides excess P)
4) Turkey litter (P-based)—turkey litter applications to supply all P with supplemental fertilizer N
5) Turkey litter (P-based)—same as treatment 4 but with incorporation of litter and fertilizer

Treatments 1 through 4 were planted with no tillage, but Treatment 5 was planted after chisel and disk incorporation of the litter and fertilizer. Individual plot size was 1 acre. ISCO-brand samplers were used to determine runoff volume and sample runoff water. Water samples were analyzed for NH_4-N, NO_3-N, ortho-P, bio-available P, total N, total P, and total suspended solids (TSS) by standard methods.

Runoff was measured, and samples were obtained from six events in 2005: June 3, June 9, June 10-12 (weekend), June 30, July 4, and July 19. The first three events were before turkey litter and fertilizer application, and the last three events were after applications. Rainfall amounts were: 0.96 in. (June 3); 1.48 in. (June 9); 2.29 in. (June 10-12); 1.52 in. (June 30); 1.22 in. (July 4, estimated from regional data because of instrument malfunction); and 1.42 in. (July 19). In 2006, there were also three runoff events prior to new application of turkey litter and fertilizer: May 4 (1.54 in. rainfall); May 6 (0.68 in. rainfall); and May 9 (1.39 in. rainfall).

RESULTS

With one exception, average runoff volume and concentrations as well as total volume and loadings were unaffected by treatment assigned prior to mid-June in 2005. Because turkey litter and fertilizer had not yet

[1] Kansas State University Department of Agronomy

been applied in 2005, the single difference in total N must be a small residual from previous farming operations on those plots. Most concentrations and loadings were small in 2005 prior to turkey litter and fertilizer applications (Table 1).

The first runoff event after application may be expected to produce the most losses of nutrients. Ortho-P, bio-available P, total N, and total P concentrations of the first event were significantly affected by treatments. In general, the various P concentrations were highest in the N-based treatment, followed by the no-till fertilizer and P-based treatments (Table 2). However, when the P-based treatment was incorporated, values were similar to those in the control. Phosphorous loadings were not affected by treatment in the first event after application. Unless incorporated, NH_4-N loadings were greater from fertilizer and turkey litter treatments than from the control. TSS was greater from the P-based turkey litter treatment that received conventional tillage, but the value was small (less than 0.1 ton/a).

For the three runoff events in 2005 after turkey litter and fertilizer application, average concentrations were affected by treatment, except for TSS. Ammonium-N concentration was greater in the P-based no-till treatment than when incorporated (Table 3). Nitrate-N concentration was greatest in runoff from the fertilized and P-based turkey litter treatments. Phosphorus concentrations were generally greatest in runoff from the N-based turkey litter treatment, followed by the no-till and fertilizer P-based treatments. Incorporation of turkey litter significantly reduced the various P concentrations in runoff compared with runoff from the no-till P-based treatment, and these values were similar to those from the control. Phosphorus loadings, however, were greater from the N-based turkey litter treatment with no differences in loadings from the other treatments. So, P loadings were small prior to treatment applications and tended to be increased by the N-based treatment in the first event, but this was only significant when considering the total of the three events after application in 2005 (Figure 1).

In 2006, runoff events prior to turkey litter and fertilizer applications should give an indication of residual effects of the treatments on runoff volume, nutrient concentrations, and nutrient loadings. Several average concentrations, average flow, total loadings, and total flow were significantly affected by the treatments. As in the previous year, P concentrations and loadings were greater in runoff from the N-based turkey litter treatment (Table 4). It is unclear why average and total flow was greater from the no-till N-based and P-based treatments than from the no-till control and fertilized treatments.

Overall, this field study demonstrates the excessive P losses that can occur if a producer applies turkey litter based on crop N needs. Applying turkey litter based on crop P needs reduced P losses, especially when incorporated. Nitrogen losses appeared to be a bit more variable, but values seemed low. Incorporation by conventional tillage generally resulted in greater sediment loss; however, losses were small on this soil, which is typical of southeastern Kansas.

Table 1. Average concentrations and total loadings of selected chemical parameters in runoff water of the first three events in 2005 prior to application of turkey litter and fertilizer

	Concentrations							
Amendment	NH_4-N	NO_3-N	Ortho-P	Bio-Avail P	Total N	Total P	TSS	Avg. Flow
	-----ppm-----		ppb	---------ppm---------			mg/L	ft^3/a
Control	0.3	1.8	750	0.78	3.9	0.84	295	3750
Fertilizer	0.3	0.7	760	0.85	3.6	0.93	61	1730
Litter–N based	0.1	0.8	470	0.51	2.4	0.40	17	4980
Litter–P based	4.8	0.1	920	0.77	16.5	1.78	165	4170
Litter–P based–CT	1.0	0.6	540	0.58	3.5	0.55	166	3130
LSD (0.10)	NS	NS	NS	NS	NS	NS	NS	NS

	Loadings							
Amendment	NH_4-N	NO_3-N	Ortho-P	Bio-Avail P	Total N	Total P	TSS	Total Flow
	------------------------------lb/a------------------------------							ft^3/a
Control	0.09	0.07	0.11	0.11	0.59	0.09	14	7150
Fertilizer	0.05	0.14	0.22	0.24	0.93	0.25	19	5200
Litter–N based	0.13	0.49	0.39	0.42	2.12	0.32	13	14930
Litter–P based	0.62	0.06	0.31	0.26	3.83	0.44	73	9150
Litter–P based–CT	0.31	0.32	0.26	0.27	1.67	0.24	78	9390
LSD (0.10)	NS	NS	NS	NS	1.94	NS	NS	NS

Note. NS = nonsignificant.

Table 2. Average concentrations and total loadings of selected chemical parameters in runoff water of the first single event in 2005 after application of turkey litter and fertilizer

	Concentrations							
Amendment	NH_4-N	NO_3-N	Ortho-P	Bio-Avail P	Total N	Total P	TSS	Flow
	-----ppm-----		ppb	---------ppm---------			mg/L	ft^3/a
Control	0.9	1.9	1030	1.9	10.1	1.2	560	1220
Fertilizer	19.5	11.5	5070	5.2	38.8	6.0	530	1090
Litter–N based	11.5	0.0	15170	15.5	48.5	17.1	640	2050
Litter–P based	20.9	7.0	4570	3.6	46.4	4.9	580	2210
Litter–P based–CT	0.4	3.2	520	0.8	8.4	1.5	1640	1260
LSD (0.10)	NS	NS	2520	2.4	26.0	3.1	NS	NS

	Loadings						
Amendment	NH_4-N	NO_3-N	Ortho-P	Bio-Avail P	Total N	Total P	TSS
	-----------------------------lb/a-----------------------------						
Control	0.07	0.17	0.06	0.06	0.97	0.07	54
Fertilizer	1.62	0.96	0.42	0.45	3.24	0.50	64
Litter–N based	1.47	0.00	1.97	1.99	5.95	2.21	84
Litter–P based	2.62	1.29	0.63	0.53	6.32	0.67	58
Litter–P based–CT	0.04	0.29	0.05	0.06	0.77	0.14	132
LSD (0.10)	1.80	NS	NS	NS	NS	NS	36

Note. NS = nonsignificant.

Table 3. Average concentrations and total loadings of selected chemical parameters in runoff water of the first three events in 2005 after application of turkey litter and fertilizer

	Concentrations							
Amendment	NH_4-N	NO_3-N	Ortho-P	Bio-Avail P	Total N	Total P	TSS	Avg. Flow
	-----ppm-----		ppb	---------ppm---------			mg/L	ft^3/a
Control	0.61	2.03	610	0.66	8.9	0.85	520	960
Fertilizer	5.82	10.01	1780	2.38	22.5	2.83	350	870
Litter–N based	5.42	2.43	7230	7.43	29.1	8.13	550	1480
Litter–P based	9.17	7.24	2250	1.98	25.9	2.72	520	1630
Litter–P based–CT	0.47	3.21	410	0.51	9.7	0.93	1490	1400
LSD (0.10)	5.38	3.37	1720	1.01	8.2	0.99	NS	NS

	Loadings							
Amendment	NH_4-N	NO_3-N	Ortho-P	Bio-Avail P	Total N	Total P	TSS	Total Flow
	-----------------------------lb/a-----------------------------							ft^3/a
Control	0.13	0.36	0.09	0.10	1.60	0.12	93	2890
Fertilizer	1.18	1.45	0.37	0.43	3.46	0.48	34	2610
Litter–N based	1.83	0.52	2.50	2.55	8.76	2.77	150	4450
Litter–P based	3.13	2.53	0.80	0.71	8.82	0.92	117	4880
Litter–P based–CT	0.09	0.79	0.10	0.12	2.20	0.21	326	4200
LSD (0.10)	1.54	NS	1.36	1.35	NS	1.41	134	NS

Note. NS = nonsignificant.

Table 4. Average concentrations and total loadings of selected chemical parameters in runoff water of the first three events in 2006 prior to application of turkey litter and fertilizer

	Concentrations							
Amendment	NH_4-N	NO_3-N	Ortho-P	Bio-Avail P	Total N	Total P	TSS	Avg. Flow
	-----ppm-----		ppb	---------ppm---------			mg/L	ft^3/a
Control	0.9	0.2	420	0.58	3.0	0.67	302	920
Fertilizer	1.0	0.2	730	0.79	3.0	0.83	42	840
Litter–N based	0.7	0.3	2380	2.12	3.9	2.14	92	2230
Litter–P based	0.6	0.1	600	0.77	2.5	0.74	24	2660
Litter–P based–CT	0.6	0.4	400	0.56	3.0	0.63	246	1870
LSD (0.10)	NS	NS	1000	0.81	NS	0.69	151	1020

	Loadings							
Amendment	NH_4-N	NO_3-N	Ortho-P	Bio-Avail P	Total N	Total P	TSS	Total Flow
	------------------------------lb/a------------------------------							ft^3/a
Control	0.22	0.03	0.12	0.16	0.64	0.18	59	2750
Fertilizer	0.16	0.03	0.10	0.13	0.42	0.11	4	2510
Litter–N based	0.24	0.10	0.88	0.83	1.37	0.81	29	6690
Litter–P based	0.26	0.06	0.28	0.34	1.15	0.34	11	7970
Litter–P based–CT	0.14	0.08	0.10	0.14	0.79	0.15	60	5600
LSD (0.10)	NS	NS	0.38	0.23	NS	0.22	NS	3060

Note. NS = nonsignificant.

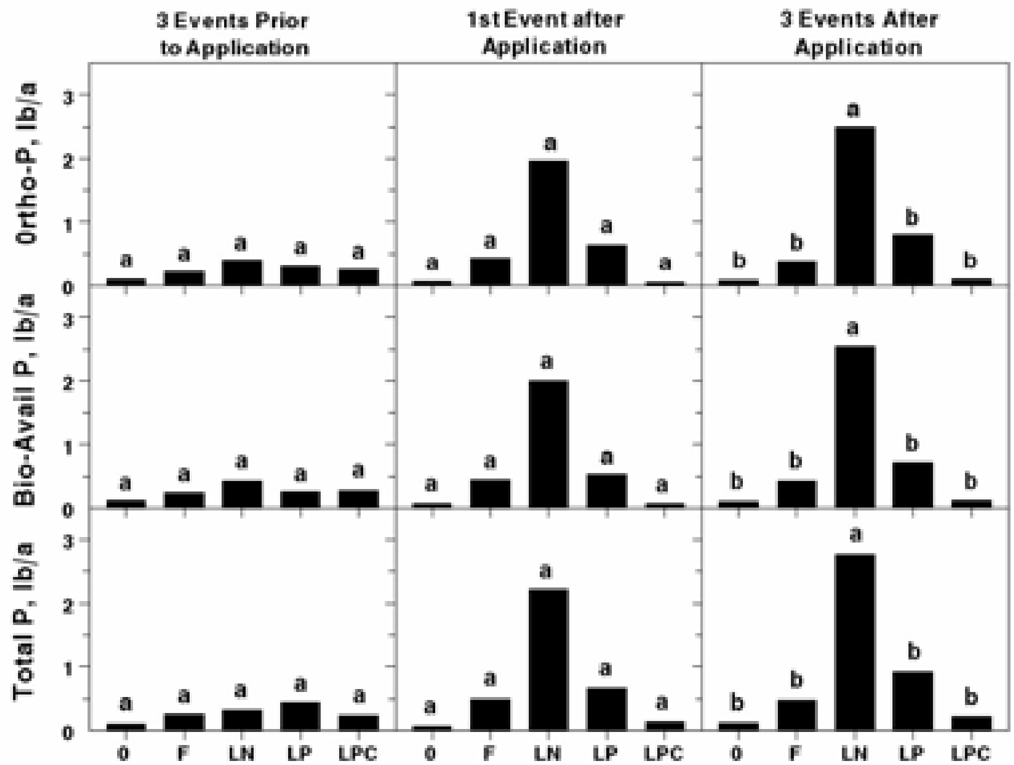

Figure 1. Effect of treatments on ortho-P, bio-available P, and total P loadings in 2005
Treatment abbreviations are: 0 - no turkey litter or fertilizer; F - fertilizer N and P; LN - N-based turkey litter application; LP - P-based turkey litter application with supplemental fertilizer N; and LPC - same as LP but incorporated by chisel and disk conventional tillage. (Treatments 0, F, LN, and LP are with no-till). Within a grid, treatments with the same letter are not significantly different at $p = 0.10$.

EFFECT OF NITROGEN AND PHOSPHORUS STARTERS ON SHORT-SEASON CORN GROWTH IN CONSERVATION TILLAGE SYSTEMS

Daniel W. Sweeney and David B. Mengel[1]

SUMMARY

Yields were low in 2006, averaging less than 80 bu/a. Applying nitrogen (N) and phosphorus (P) increased yields about 15 bu/a more than with no fertilizer, but there were no differences between starter treatments or tillage systems. In contrast to yield, dry matter production was greater with reduced tillage throughout the season, but the difference became less as the plant aged. Early in the season, increasing P rate in the starter resulted in significantly greater dry matter production, but this response declined rapidly by reproductive growth.

INTRODUCTION

In recent years, corn acreage has been on the rise in southeastern Kansas because of the introduction of short-season cultivars, which enable producers to plant in the upland, claypan soils typical of the area. Short-season hybrids reach reproductive stages earlier than full-season hybrids and thus may partially avoid mid-summer droughts, which are often severe on these claypan soils with limited plant-available moisture storage. However, soil fertility and other management options have not been well defined for short-season corn production in southeastern Kansas. Optimum corn production results from use of proper management options that include soil fertility and tillage selections. Reducing tillage has the potential to reduce losses to the environment, but maintaining proper plant nutrition is critical for crop production. Starters have been used to improve early plant growth in no-till or reduced-tillage systems, and this often translates to additional yield. However, data are limited regarding the effect of starter fertilization on yield of short-season corn grown on the claypan soils found in areas of the eastern Great Plains. The objective of this study was to determine the effect of N and P rates in starter fertilizers on short-season corn planted with reduced or no tillage.

PROCEDURES

The experiment was conducted in 2006 at the Parsons Unit of the Southeast Agricultural Research Center. The soil was a Parsons silt loam with a claypan subsoil. Selected background soil chemical analyses in the 0- to 6-in. depth were 6.5 pH (1:1 soil:water), 5 ppm P (Bray-1), 65 ppm K (1 M $NH_4C_2H_3O_2$ extract), 5.3 ppm NH_4-N, 6.4 ppm NO_3-N, and 2.8% organic matter. The experimental design was a split-plot arrangement of a randomized complete block with three replications. Whole plots were tillage system (reduced and no-till), and subplots were starter N-P combinations. Nine of the subplots were starter fertilizer combinations in which N rates were 20, 40, and 60 lb/a and P rates were 0, 25, and 50 lb/a P_2O_5. In addition, there were two reference subplot treatments: a no starter treatment (all N and P applied preplant) and a no N or P control. All plots except the no N-P control were balanced to receive a total of 120 lb/a N and 50 lb/a P_2O_5. The N and P fertilizer sources were 28-0-0 and 10-34-0 fluids. All plots received 60 lb/a K_2O as solid KCl broadcast preplant. Pioneer 35P80 Roundup-Ready corn was planted at 25,000 seeds/a on April 3, 2006. Starter solutions were applied 2 x 2 with the planter. Grain was harvested for yield on August 14, 2006.

RESULTS

Rainfall was sporadic, especially during reproductive growth. This resulted in low overall yields averaging less than 80 bu/a, with no differences due to starter or starter rates (data not shown). All starter treatments averaged 79.8 bu/a compared with 77.2 bu/a when all fertilizer was applied broadcast before planting. The

[1] Kansas State University Department of Agronomy

control treatment receiving no N or P fertilizer yielded 62.2 bu/a. The response of corn to N and P fertilizer appeared to be related to increased number of kernels per ear, but starter N and P rates did not affect yield components. Additionally, there were no differences in yield or yield components between tillage systems nor were there any significant interactions between tillage and starter fertilizer treatments.

In contrast to yield, dry matter production was affected by tillage at all four growth stages and by P starter early in the season. However, dry matter accumulation during the growing season was not affected by interactions of tillage with N or P starter fertilizer. At V6, reduced tillage resulted in more than twice as much growth as with no-till (Table 1). Reduced tillage resulted in significantly greater dry matter production throughout the season, but the difference became less as the plant aged. Early in the season, increasing P rate in the starter resulted in significantly greater dry matter production. However, this response declined rapidly and was not significantly different by the time the corn plant entered reproductive growth.

Table 1. Effect of conservation tillage systems and starter P rates on dry matter accumulation at the V6, V12, R1, and R4 growth stages during the 2006 season

	Dry Weight			
Treatments	V6	V12	R1	R4
	---------- lb/a ----------			
Tillage				
Reduced	230	3470	5840	9400
No-till	100	2160	4060	7120
LSD (0.05)	30	380	900	1570
Starter P_2O_5 rate, lb/a				
0	140	2700	4940	8380
25	170	2810	4910	7990
50	190	2940	5000	8420
LSD (0.05)	20	180*	NS	NS
All N-P Broadcast	130	2400	4750	7370
Control (No N or P)	70	1760	3810	7420

* Significant at $p = 0.10$.

EFFECTS OF LATE-MATURING SOYBEAN AND SUNN HEMP SUMMER COVER CROPS AND NITROGEN RATE IN A NO-TILL WHEAT-GRAIN SORGHUM ROTATION

Mark M. Claassen

SUMMARY

Wheat and grain sorghum were grown in three no-till crop rotations, two of which included either a late-maturing Roundup Ready soybean or a sunn hemp cover crop established following wheat harvest. Nitrogen (N) fertilizer was applied to both grain crops at rates of 0, 30, 60, and 90 lb/a. Experiments were conducted on adjacent sites where different phases of the same rotations were established.

On the first site, late-maturing soybean and sunn hemp were grown in the third cycle of the rotations in 2006. These crops produced 1.37 and 2.08 ton/a of above-ground dry matter with 68 and 113 lb/a of potentially available N, respectively. Both legumes tended to increase grain sorghum leaf N concentration and grain yield but more so at low N rates and more consistently in the case of sunn hemp. At 90 lb/a N, sorghum leaf N levels were similar in all rotations. Grain sorghum yield tended to be higher at most N rates following soybean than in the rotation without a cover crop, but differences often were not significant. Conversely, sorghum yields following sunn hemp were consistently highest at each N rate with a top yield of 112.8 bu/a at 90 lb/a N. However, at this N rate, sorghum yields did not differ significantly between the rotation with sunn hemp vs. no cover crop.

On the second site, wheat followed grain sorghum after these cover crops had been grown for the first time in the rotations in 2005. In that season, soybean and sunn hemp produced an average of 2.42 and 4.14 ton/a with corresponding N yields of 103 and138 lb/a, respectively. Wheat suffered severe freeze damage in early April 2007, resulting in yields of only 19 to 22 bu/a in the best treatments. Grain test weights as well as yields were low and not meaningfully affected by residue from cover crops. Wheat plant N was relatively high at zero N fertilizer in all rotations because of low dry matter production but tended to be highest at 90 lb/a N in rotations with cover crops. Nitrogen content and grain yield were greatest at 90 lb/a N, but yield increase with the last increment of fertilizer was small.

INTRODUCTION

Research at the Kansas State University Harvey County Experiment Field over an 8-year period explored the use of hairy vetch as a winter cover crop following wheat in a winter wheat-sorghum rotation. Results of long-term experiments showed that between September and May, hairy vetch can produce a large amount of dry matter with an N content of approximately 100 lb/a. However, using hairy vetch as a cover crop also has significant disadvantages including cost and availability of seed, interference with control of volunteer wheat and winter annual weeds, and the possibility of hairy vetch becoming a weed in wheat after sorghum.

New interest in cover crops has been generated by research in other areas showing the positive effect these crops can have on overall productivity of no-till systems.

In the current experiment, late-maturing soybean and sunn hemp, a tropical legume, were evaluated as summer cover crops for their effect on no-till sorghum grown in the spring after wheat harvest as well as on double-crop, no-till wheat after grain sorghum. In 4 site-years during the period 2002 through 2006, soybean and sunn hemp produced average N yields of 102 and124 lb/a, respectively. Averaged over N rates, soybean and sunn hemp resulted in 4-year average grain sorghum yield increases of 7.3 and 13.5 bu/a, respectively. Residual effects of soybean and sunn hemp on wheat after sorghum averaged over N rates were minor, with 3-year yields averaging 1.6 and 1.7 bu/a, respectively, more than wheat in the rotation without cover crops.

PROCEDURES

Experiments were established on adjacent Geary silt loam sites that had been used for hairy vetch cover crop research in a wheat-sorghum rotation from 1995 to 2001. In accordance with the previous experimental design, soybean and sunn hemp were assigned to plots where vetch had been grown, and remaining plots retained the no cover crop treatment. The existing factorial arrangement of N rates on each cropping system also was retained. In 2007, grain sorghum was grown on Site 1 in the third cycle of the rotations. Wheat was produced on Site 2 at the end of the first cycle of the rotations.

Grain Sorghum

Cover crop planting in the preceding summer was delayed by late seed arrival. Weeds in wheat stubble were controlled with glyphosate application in early July and follow up treatment 1 day before planting. Asgrow AG7601 Roundup Ready soybean and sunn hemp seed were treated with respective rhizobium inoculants and no-till planted in 7.5-in. rows with a JD 1590 drill on August 8, 2006, at 60 lb/a and 10 lb/a, respectively. Both crops emerged approximately 1 week later. Sunn hemp began flowering in early to mid-October. At that time, soybean had little pod development. Cover crops were terminated on October 13 by rolling with a crop roller. Plots were subsequently sprayed with glyphosate to control crop or weed escapes. The first killing frost of the fall occurred 5 days later. Forage yield of each cover crop was determined by harvesting a 3.28 ft^2 area in each plot just before termination. Samples were subsequently analyzed for N content.

Weeds were controlled during the fallow period after cover crops with glyphosate, 2,4-D_{LVE} and Clarity. Pioneer 85G01 grain sorghum treated with Concep III safener and Cruiser insecticide was planted in 30-in. rows at approximately 42,000 seeds/a on June 6, 2007. Atrazine and Dual II Magnum were applied preemergence for residual weed control before and/or shortly after sorghum planting. All plots received 37 lb/a P_2O_5 banded as 0-46-0 at planting. Nitrogen fertilizer treatments were applied as 28-0-0 injected 10 in. from the row on June 11. Grain sorghum was combine harvested on October 3, 2007.

Wheat

Grain sorghum on Site 2 was combine harvested on November 9, 2006. Nitrogen rates were immediately reapplied as broadcast 34-0-0. Variety Jagger winter wheat was no-till planted in 7.5-in. rows with a JD1590 drill the same day at 90 lb/a with 32 lb/a P_2O_5 fertilizer banded as 0-46-0 in the furrow. Wheat was harvested on July 9, 2007.

RESULTS

Grain Sorghum

During the 5 days preceding cover crop planting in 2006, rainfall totaled 1.02 in. The next rains occurred 2 and 6 days after planting; a total of 1.52 in. was received. Stand establishment of both soybean and sunn hemp was good. Although August rainfall was well above normal, September and October were much drier than usual. Late-maturing soybean reached an average height of 19 in., showed limited pod development, and produced 1.37 ton/a of above-ground dry matter with an N content of 2.50% or 68 lb/a (Table 1). Sunn hemp averaged 53 in. in height and produced 2.08 ton/a with 2.70% N or 113 lb/a of N. Soybean and sunn hemp suppressed volunteer wheat to some extent but failed to give the desired level of late summer control. Volunteer wheat control was similar for both crops, averaging 67%.

The 2007 grain sorghum crop emerged 5 days after planting; final stands averaged 38,700 plants/a. The season brought some drought stress, but only 5 days had temperatures at or above 100°F. Summer was generally favorable for sorghum, with better-than-average conditions overall.

Both cover crop and N rate effects on grain sorghum were significant. Soybean and sunn hemp significantly increased sorghum nutrient concentration by 0.17% and 0.27% N, respectively, at the zero N rate. Where sorghum followed soybean and N fertilizer was applied, leaf N levels were comparable to those of sorghum in rotation without a cover crop. However, in rotations with sunn hemp vs. no cover crop, sorghum leaf N was significantly greater at 30 and 60 lb/a N but not at 90 lb/a N. The main effect of soybean and sunn hemp, averaged across N fertilizer rates, significantly increased sorghum leaf nutrient levels by 0.07% N and 0.17% N, respectively. Leaf N averaged over cropping systems increased significantly with each increment of N fertilizer.

Soybean cover crop tended to increase sorghum yields at all but the highest N rate, but the increase was significant only at the 60 lb/a N rate. Conversely, with sunn hemp in the rotation, sorghum yields increased across all N rates. However, the sunn hemp benefit was not significant at the 90 lb/a N rate. The positive effect of soybean and sunn hemp cover crops was seen in sorghum yield improvements of 4.0 and 12.2 bu/a, respectively, averaged over N rate. Yields averaged over cropping systems increased significantly at all but the 90 lb/a rate of N fertilizer.

Cover crops did not affect grain sorghum plant population or grain test weight and had no meaningful effect on half-bloom date. The number of heads/plant tended to increase slightly with N rate in sorghum rotations with soybean or no cover crop. In sorghum after sunn hemp, the number of heads/plant increased only at the highest N rate.

Wheat

The first cycle of the crop rotations on Site 2 began in 2005, when soybean and sunn hemp produced an average of 2.42 and 4.14 ton/a with corresponding N yields of 103 and138 lb/a, respectively (Table 2). In 2006, averaged across N rate, grain sorghum yielded 96.1 bu/a after soybean and 101.4 bu/a following sunn hemp. The 2007 wheat growing season was overshadowed by severe cold temperatures in early April that resulted in serious damage to the crop. Grain test weights as well as yields were low and not meaningfully affected by residue from cover crops. Similarly, plant heights were not affected by cropping history. Wheat plant N was relatively high at the zero N fertilizer rate in all rotations because of low dry matter production but tended to be highest at 90 lb/a N in rotations with cover crops. Effect of N rate on most wheat variables was significant. Plant height, N content, and grain yield were greatest at 90 lb/a N, but yield increase with the last increment of fertilizer was small. Yields of 19 to 22 bu/a at top N rates were respectable under existing conditions.

Table 1. Effects of soybean and sunn hemp summer cover crops and nitrogen rate on no-till grain sorghum after wheat, Hesston, KS, 2007

		Cover Crop Yield		Grain Sorghum					
Cover Crop[1]	N Rate[2]	Forage	N	Grain Yield	Bushel Wt	Stand	Half[4] Bloom	Heads/ Plant	Leaf N[5]
	lb/a	ton/a	lb/a	bu/a	lb	1000s/a	days	no.	%
None	0	---	---	68.8	56.2	38.7	57	0.97	1.75
	30	---	---	85.5	56.9	38.5	56	1.03	2.10
	60	---	---	96.5	56.9	38.3	56	1.07	2.29
	90	---	---	107.1	57.4	39.5	56	1.11	2.54
Soybean	0	1.14	58	77.2	57.0	39.1	56	1.00	1.92
	30	1.38	70	89.5	56.9	38.1	56	1.05	2.10
	60	1.43	71	106.9	56.8	38.0	56	1.10	2.37
	90	1.52	73	100.5	57.2	37.8	56	1.14	2.55
Sunn hemp	0	1.87	112	90.9	56.6	38.9	56	1.04	2.02
	30	2.08	109	97.9	57.1	39.5	56	1.04	2.29
	60	2.41	127	105.4	57.1	40.2	56	1.04	2.43
	90	1.96	103	112.8	56.9	37.7	56	1.27	2.62
LSD .05		0.61	40	11.3	NS	NS	0.6	0.07	0.12
Means:									
Cover Crop									
None		---	---	89.5	56.8	38.8	56	1.05	2.17
Soybean		1.37	68	93.5	57.0	38.2	56	1.07	2.24
Sunn hemp		2.08	113	101.7	56.9	39.1	56	1.10	2.34
LSD .05		0.31	20	5.6	NS	NS	NS	0.04	0.06
N Rate									
0		1.50	85	79.0	56.6	38.9	56	1.00	1.89
30		1.73	89	91.0	56.9	38.7	56	1.04	2.17
60		1.92	99	102.9	56.9	38.8	56	1.07	2.36
90		1.74	88	106.8	57.1	38.3	56	1.17	2.57
LSD .05		NS	NS	6.5	NS	NS	NS	0.04	0.07

[1] Cover crops planted August 8, 2006 and terminated in early fall.
[2] N applied as 28-0-0 injected June 11, 2007.
[3] Oven dry weight and N content for sunn hemp and soybean on October 13, 2006.
[4] Days from planting to half-bloom.
[5] Flag leaf at late boot to early heading.

Table 2. Residual effects of soybean and sunn hemp summer cover crops and nitrogen rate on no-till wheat after grain sorghum, Hesston, KS, 2007

Cover Crop[1]	N Rate[2]	Cover Crop Yield[3] Forage	N	Sorghum Yield 2006	Wheat Yield	Wheat Bushel Wt	Wheat Plant Ht	Wheat Plant N[4]
	lb/a	ton/a	lb/a	bu/a	bu/a	lb	in.	%
None	0	---	---	61.1	5.5	44.4	17	1.38
	30	---	---	74.5	12.6	47.0	24	1.02
	60	---	---	100.6	20.5	48.4	27	1.08
	90	---	---	98.3	21.0	46.7	29	1.24
Soybean	0	2.41	101	92.0	5.1	43.9	17	1.31
	30	2.06	85	98.5	14.8	47.2	25	1.09
	60	2.89	125	98.4	19.4	45.8	27	1.17
	90	2.33	100	95.2	21.6	47.1	28	1.48
Sunn hemp	0	3.74	116	95.8	7.0	44.1	18	1.29
	30	4.13	150	102.7	16.0	47.2	25	1.12
	60	4.34	142	109.0	20.5	48.1	28	1.18
	90	4.37	145	98.2	21.5	46.3	29	1.46
LSD .05		0.72	31	9.4	2.2	2.2	2.5	0.14
Means:								
Cover Crop								
None		---	---	83.6	14.9	46.6	24	1.18
Soybean		2.42	103	96.1	15.2	46.0	24	1.26
Sunn hemp		4.14	138	101.4	16.3	46.4	25	1.26
LSD .05		0.36	15	4.7	1.1	NS	NS	0.07
N Rate								
0		3.07	108	83.0	5.9	44.1	17	1.33
30		3.09	118	91.9	14.4	47.1	25	1.08
60		3.61	133	102.7	20.1	47.4	27	1.14
90		3.35	123	97.2	21.4	46.7	29	1.39
LSD .05		NS	NS	5.4	1.3	1.3	1.4	0.08

[1] Cover crops planted on July 9, 2005 and terminated by early fall.
[2] N applied as 28-0-0 injected July 19, 2006 for sorghum and 34-0-0 broadcast on November 9, 2006 for wheat.
[3] Oven dry weight and N content for sunn hemp and soybean on September 26, 2005.
[4] Whole-plant N concentration at early heading.

EVALUATION OF NITROGEN RATES AND STARTER FERTILIZER PLACEMENT METHODS FOR GROWING STRIP-TILL CORN IN EASTERN KANSAS

Keith A. Janssen

SUMMARY

Nitrogen (N) rates and Nitrogen-Phosphorus-Potassium (N-P-K) starter fertilizer placement methods were evaluated for strip-till corn grown on an upland soil at the East Central Kansas Experiment Field at Ottawa in 2006 and 2007. Under fairly dry rain-fed growing conditions, the 80 lb/a N rate following soybean optimized corn grain yields. Application of N-P-K starter at planting increased early-season corn growth compared with all of the starter applied in the strip-till zone when planting in 2006 was early but had no effect in 2007 when planting was in May. The increased early growth in 2006 did not increase grain yields. Generally, highest grain yields were produced when all of the starter fertilizer was included in the strip-till zone. Additional years of testing are needed before recommendations can be made regarding N rates and starter fertilizer placement options for producing strip-till corn on upland rain-fed soils in eastern Kansas.

INTRODUCTION

Corn growers in eastern Kansas might benefit from reducing traditional N rates when growing corn using an under-the-row strip-till fertilization program. The high cost of N demands prudent use. Research also considered whether there is a yield benefit from applying starter fertilizer at planting when growing corn using strip-till. Depending on the outcomes, strip-till corn producers may be able to reduce N rates, could refrain from purchasing costly planter fertilizer banding equipment, and might not have to apply fertilizer at planting time.

PROCEDURES

This was the second year for this study, which was designed to fine tune fertilization practices for growing strip-till corn in eastern Kansas. Six N rates and three N-P-K starter fertilizer placement methods were evaluated at the East Central Kansas Experiment Field near Ottawa on a Woodson upland soil. Rates of N compared were 60, 80, 100, 120, 140 and 160 lb/a including a check. Starter fertilizer placement methods evaluated were all of the N-P-K starter fertilizer applied 5 in. below the row during the strip-till operation, all of the N-P-K starter fertilizer placed 2.5 in. to the side and 2.5 in. below the seed row at planting, and a combination of half the starter fertilizer applied in the strip-till zone and half applied at planting. In all cases, 30 lb/a N was applied with the P and K starter fertilizers. Previous research at the North Central Experiment Field indicated that for best starter P response, at least a 1:1 ratio of N-P fertilizer mix should be used.

The experiment design was a randomized complete block with four replications. The previous crop both years was soybean. For pre-plant weed control, 1 qt/a atrazine 4L plus 0.66 pint/a 2,4-D_{LVE} plus 1 qt/a COC were applied. Pioneer 35P17 corn was planted April 6, 2006, and May 19, 2007. Planting in 2007 was delayed because of wet weather. Seed drop was 24,500 seeds/a in 2006 and 26,500 seeds/a in 2007. Preemergence herbicides containing 0.5 qt/a atrazine 4L plus 1.33 pint/a Dual II Magnum were applied the day after planting. Effects of the treatments on plant establishment were evaluated by counting all plants in the center two rows of each plot. Whole above-ground plant tissue samples were collected at the 6-leaf growth stage to measure treatment effects on early-season corn growth. Grain yields were measured by machine harvesting the center two rows of each 10-ft-wide × 40-ft-long plots. Harvest was on September 1, 2006, and September 20, 2007.

RESULTS

The 2006 and 2007 corn growing seasons were hot and drier than normal. Under these conditions and with corn following soybean, the 80 lb/a N rate was sufficient for optimizing corn grain yields at approximately 95 to 110 bu/a (Table 1, Figs. 2 and 4). In 2006, placement of starter fertilizer significantly affected early-season corn growth (Fig. 1). Application of starter fertilizer placed 2.5 in. beside and 2.5 in. below the seed row at planting in 2006 increased early-season corn growth 64% compared with placement of the starter all in the strip-till zone. The combination starter applications (half at planting and half in the strip-till zone) produced intermediate early-season growth effects. The increased early-season growth with the planter-applied starter did not increase grain yields (Fig. 2). Highest grain yields were produced when all starter fertilizer was applied in the strip-till zone. It is hard to say whether this is a reflection of improved positioning for the starter fertilizer or because of early season growth differences and subsequent moisture effects on yields. In 2007, with late planting, there were no differences in early-season corn growth or grain yields due to starter fertilizer placements (Table 1, Figs. 3 and 4). More years of testing with better moisture and higher yield levels are needed to fully evaluate N fertilizer needs and starter fertilizer options for growing strip-till rain-fed corn on upland soils in eastern Kansas.

Table 1. Effects of N rates and placement of N-P-K starter fertilizer on plant populations, V6 plant dry weights, and grain yields of strip-till corn, East Central Kansas Experiment Field, 2006 and 2007

Fertilizer Treatments		Plant Populations		V6 Dry Weights		Grain Yields	
Strip-till	Planter 2.5 in. × 2.5 in.	2006	2007	2006	2007	2006	2007
--------------- N-P-K, lb/a ---------------		x 1000		g/plant		bu/a	
Check 0-0-0		24.3	25.8	2.1	5.3	47	37
60-40-20		24.3	26.0	5.5	9.5	101	89
80-40-20		24.8	25.9	4.2	9.8	109	95
50	30-40-20	24.8	25.9	6.6	9.7	103	90
50-20-10	30-20-10	24.6	25.4	6.4	9.5	101	88
100-40-20		24.3	25.6	4.4	8.3	103	93
120-40-20		24.9	25.6	4.3	9.4	108	99
90	30-40-20	24.8	25.7	7.6	9.2	102	95
90-20-10	30-20-10	24.2	25.6	6.2	9.5	105	102
140-40-20		24.1	25.4	3.9	9.0	109	98
160-40-20		24.1	26.1	4.0	8.9	108	101
130	30-40-20	24.3	25.5	6.8	8.7	100	98
130-20-10	30-20-10	24.0	25.8	5.3	9.2	106	99
LSD 0.05		NS	NS	1.0	1.4	6	9

2006
(April 6 Planting)

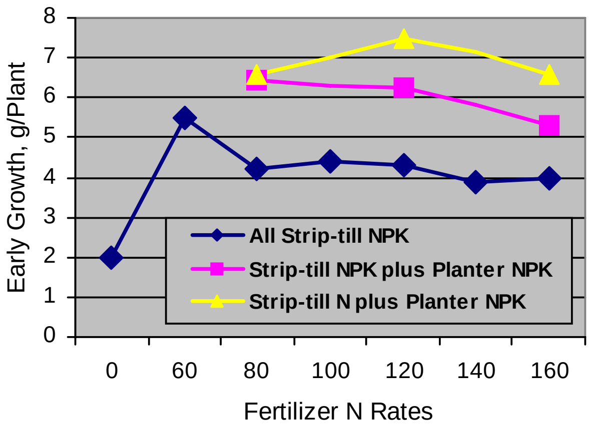

Figure 1. N Rates and NPK Starter Fertilizer Placement Effects on Early Growth of Strip-till Corn.

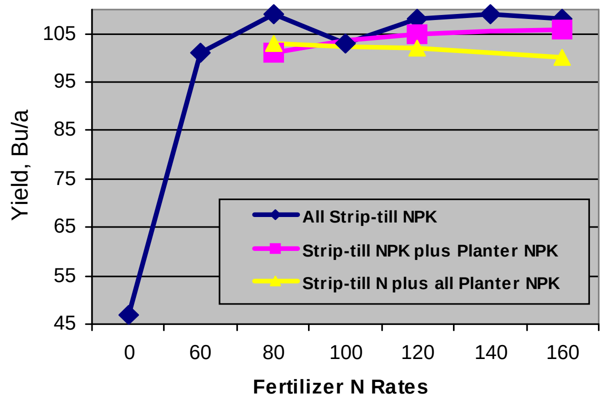

Figure 2. N Rates and NPK Starter Fertilizer Placement Effects on Yield of Strip-till Corn.

2007
(May 19 Planting)

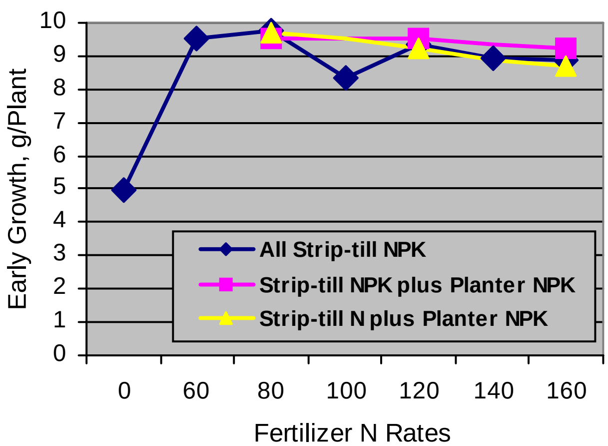

Figure 3. N Rates and NPK Starter Fertilizer Placement Effects on Early Growth of Strip-till Corn.

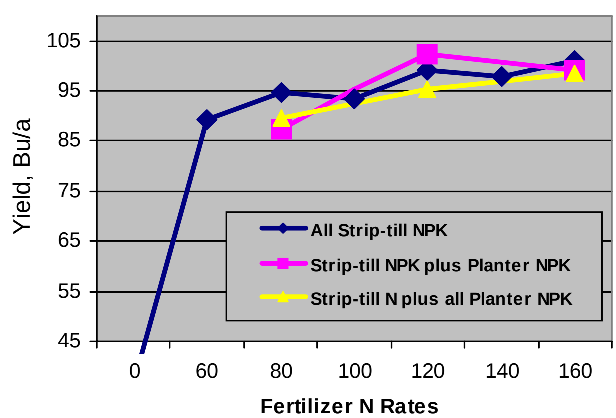

Figure 4. N Rates and NPK Starter Fertilizer Placement Effects on Yield of Strip-till Corn.

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