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Kansas Fertilizer Research

Report of Progress 976

Agricultural Experiment Station
and Cooperative Extension Service

INTRODUCTION

The 2006 edition of the Kansas Fertilizer Research Report of Progress is a compilation of data collected by researchers across Kansas. Information was contributed by staff members of the Department of Agronomy and Kansas Agricultural Experiment Station, as well as agronomists at Kansas agronomy experiment fields and agricultural research or research-extension centers.

The investigators whose work is cited in this report greatly appreciate the cooperation of many county agents, farmers, fertilizer dealers, fertilizer equipment manufacturers, agricultural chemical manufacturers, and the representatives of various firms who contributed time, effort, land, machinery, materials, and laboratory analyses. Without their support, much of the work reported here would not have been possible.

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Compiled by:
Dale F. Leikam
Extension Specialist
Nutrient Management
Department of Agronomy
Kansas State University
Manhattan, KS 66506-5504

Requests for copies of this report should be directed to Troy Lynn Eckart, Department of Extension Agronomy, 2014 Throckmorton Hall, Kansas State University, Manhattan, KS 66506-5504.

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TABLE OF CONTENTS

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Precipitation Data (Inches)

2005	Manhattan	SW KS RES-EXT CTR Tribune	SE KS EXP STA Parsons	E CEN EXP FLD Ottawa	HARVEY CTY EXP FLD Hesston S
August	5.61	3.85	4.53	9.59	7.01
September	4.36	0.34	1.55	3.99	1.19
October	3.25	3.59	2.35	1.86	1.15
November	0.68	0.19	0.86	1.29	0.25
December	0.78	0.24	0.13	1.26	0.25
Total 2005	35.52	19.10	32.68	49.18	38.58
Dept. Normal	+0.72	+1.66	-9.41	+9.97	+5.33
2006					
January	0.50	0.30	0.64	0.75	0.12
February	0.01	0.01	0.00	0.02	0.00
March	2.93	1.12	2.18	2.06	2.82
April	3.42	0.20	4.55	4.32	3.14
May	2.85	1.60	3.86	3.13	2.22
June	1.44	2.79	2.62	1.83	4.04
July	4.10	0.97	2.40	3.16	3.05
August	10.91	3.94	3.85	7.34	5.12
September	1.99	0.43	0.64	2.17	1.17

2005	N CEN EXP FLD Belleville	KANSAS RV VALLEY EXP FLD	S CEN EXP FLD Hutchinson	FT HAYS EXP STN Hays	HARVEY CTY EXP FLD Hesston N
August	4.81	9.56	6.94	3.04	5.29
September	1.01	5.40	0.47	1.75	1.69
October	5.96	3.97	1.02	2.67	0.99
November	0.76	0.41	0.19	0.76	0.32
December	0.21	0.34	0.31	0.16	0.26
Total 2005	32.61	38.96	32.22	23.28	36.12
Dept. Normal	+1.72	+4.75	+1.90	+1.21	+2.87
2006					
January	0.22	0.16	0.07	0.02	0.08
February	0.00	0.00	0.00	0.00	0.00
March	1.95	0.57	1.79	1.18	2.66
April	2.49	2.05	2.78	1.37	2.77
May	2.40	4.49	4.23	1.05	2.17
June	1.76	1.21	4.52	3.02	4.43
July	3.47	2.40	1.87	1.54	4.45
August	6.22	2.36	2.52	4.85	5.04
September	5.18	1.57	0.69	2.17	1.13

WHEAT FERTILIZATION STUDIES
KANSAS STATE UNIVERSITY DEPARTMENT OF AGRONOMY

NEW PHOSPHATE PRODUCTS FOR WHEAT PRODUCTION

D. Leikam and T. Maxwell

Summary

Wheat responded to various phosphorus (P) fertilizer products in Saline County and trended higher in Norton County. Soil test levels were about 15 ppm Mehlich-3 P in Saline County and 40 ppm in Norton County. Differences among products occurred. However, no conclusions about the superiority of one source over the others can be formed at this time.

Introduction

Fertilizer companies continue to evaluate different products and processing technology for crop-nutrient production. For several years, Mosaic Company has been looking at several new formulations of P fertilizer products. Studies have been conducted in several states and on crops; we are helping evaluate these products for wheat in the central Great Plains. Studies were established in Saline County in central Kansas and Norton County in northwest Kansas to evaluate several granular fertilizer products containing various amounts of nitrogen, sulfur and zinc.

Procedures

Soil tests for these locations are presented in Table 1. Broadcast or incorporated nitrogen (N), nitrogen phosphorus (NP) or nitrogen phosphorus sulphur (NPS) applications were applied on September 22, 2006, and wheat was planted within two weeks. Both locations were top-dressed (80 lbs/a N) in late February 2006.

Results

The year 2006 was a difficult year for wheat in parts of Kansas with drought conditions and late freezes in the western part of the state severely limiting yields. However, Saline and Norton Counties weren't affected by spring freezes and both locations caught a very timely spring rain. As a result, yields were very good, although each location was very dry from winter through early spring.

Grain yields were not significantly increased by P application at the Norton County site. However, all P application treatments were higher yielding than the check. Grain P contents were significantly improved by P product application (Table 2).

Both grain yield and grain P content were significantly increased by P application at the Saline County site (Table 3). These studies will be continued in 2007.

Table 1. Soil test results, Saline and Norton Counties, Kansas, 2006.

Location	pH	Bray-1 P	Olsen-P	Mehlich-P	OM
		ppm			%
Saline County	6.5	15	8	16	2.4
Norton County	7.7	36	20	40	2.2

Table 2. Effects of P fertilizer on wheat grain yield, Norton County, Kansas, 2006.

	Nutrient Rate			Grain	
	Balancing Urea N	P_2O_5	S	Yield	P
	- - - - -	lb/a	- - - - -	bu/a	lb/bu P_2O_5
Check	36	0	0	56.2	0.36
Product 1	15	70	10	62.1	0.43
Product 2	18	70	3	59.4	0.41
Product 3	18	70	5	60.0	0.41
Product 4	22	70	0	59.6	0.44
MAP	9	70	0	61.9	0.43
MAP + Amm Sulfate	0	70	10	63.7	0.42
Probability Level				0.36	0.01
LSD (0.10)				NS	.03

Table 3. Effects of P fertilizer on wheat grain yield, Saline County, Kansas, 2006.

	Nutrient Rate			Grain	
	Balancing Urea N	P_2O_5	S	Yield	P
	- - - - -	lb/a	- - - - -	bu/a	lb/bu P_2O_5
Check	36	0	0	49.9	0.36
Product 1	15	70	10	57.1	0.40
Product 2	18	70	3	55.2	0.37
Product 3	18	70	5	57.6	0.36
Product 4	22	70	0	54.7	0.42
MAP	9	70	0	55.1	0.39
MAP + Amm Sulfate	0	70	10	56.0	0.36
Probability Level				0.08	0.05
LSD (0.10)				4.1	0.036

SOIL FERTILITY RESEARCH
SOUTHWEST RESEARCH EXTENSION CENTER

NITROGEN AND PHOSPHORUS FERTILIZATION OF IRRIGATED CORN

A.J. 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, whereas N and P applied together increased yields as much as 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/a N (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/a N. Application of 80 lb/a P_2O_5 increased yields 20 bu/a when applied with at least 120 lb/a N.

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. No yield benefit to corn from K fertilization was observed in 30 years and soil K content 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/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. In 1992, the treatments were changed, with the K variable being replaced by a higher rate of P (80 lb/a P_2O_5). All fertilizers were broadcast by hand in the spring and incorporated before planting. 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 about 30-32,000 seeds/a in late April or early May. Hail damaged the 2005 and 2002 crop and destroyed the 1999 crop. The corn was irrigated to minimize water stress. Furrow irrigation was used through 2000 and sprinkler irrigation has been used 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, whereas P alone increased yields only 30 bu/a. But N and P applied together increased corn yields up to 162 bu/a. Only 120 lb/a N with P was required to obtain maximum yields. Over the past 10 years, 120 lb/a N with P has produced 95% of maximum yield. Corn yields (averaged across all N rates) were 13 bu/a greater with 80 lb/a than with 40 lb/a P_2O_5 in 2006, which is considerably greater than the 10-year average. In 2006, with N rates of 120 lb/a N or greater, the higher P rate increased yields more than 20 bu/a.

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

Nitrogen	P_2O_5	1997	1998*	2000	2001	2002	2003	2004	2005	2006	Mean
		Grain Yield									
- - - - lb/a - - - -		- - - bu/a - - -									
0	0	66	49	131	54	39	79	67	49	42	64
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											
N		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
P_2O_5		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic		0.001	0.001	0.001	0.001	0.007	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

There was no yield data for 1999 because of hail damage. Hail reduced yields in 2002 and 2005.

ANIMAL WASTE APPLICATIONS FOR IRRIGATED CORN

A.J. Schlegel, L. Stone, H.D. Bond, and M. 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 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 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 for 2004, when the effluent had much greater salt concentration than in previous years, causing 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 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 rate for the P-based treatments was 105 lb/a P_2O_5 because soil test P was less than 150 ppm Mehlich-3 P. The N recommendation model uses yield goal less credits for residual soil N and previous manure applications to estimate N requirements. For the N-based swine treatment, the residual soil N levels after harvest in 2001, 2002, and 2004 were great enough to eliminate the need for additional N the following year. 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 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 gallons of swine effluent (actual analysis of animal wastes as applied varied somewhat from 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. 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. Cattle manure was hand-broadcast and incorporated. The N fertilizer (granular NH_4NO_3) was applied with a 10-ft fertilizer applicator (Rogers Mfg.). The study area was uniformly irrigated during the growing season with flood irrigation in 1999 through 2000 and sprinkler irrigation in 2001 through 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 crops. The center four rows of each plot were machine harvested after physiological maturity, with yields adjusted to 15.5% moisture.

Results

Corn yields increased with all animal waste and N fertilizer applications in 2006, as was the case for all years except 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 after application of cattle manure than swine effluent on an N application basis. Over-application (2xN) of cattle manure had no negative impact on grain yield in any year. 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.

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.

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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. Effects 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/a	- -						
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	122	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.

Acknowledgement: Project supported in part by Kansas Fertilizer Research Fund and Kansas Department of Health and Environment.

NITROGEN AND PHOSPHORUS FERTILIZATION OF IRRIGATED GRAIN SORGHUM

A.J. 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 bu/a and 18 bu/a, respectively, but N and P applied together increased yields more than 65 bu/a. Averaged across the past 10 years, sorghum yields were increased more than 50 bu/a by N and P fertilization. Application of 40 lb/a N (with P) was sufficient to produce greater than 90% of maximum yield in 2006 and for the 10-year average. Application of potassium (K) 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/a K_2O. All fertilizers were broadcast by hand in the spring and incorporated before planting. Sorghum (Pioneer 8414 in 1997, and Pioneer 8500/8505 from 1998 to 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 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 were very good in 2006 and were greater than the 10-year average (Table 1). Nitrogen alone increased yields up to 50 bu/a, whereas P alone increased yields up to 18 bu/a. Nitrogen and P applied together increased yields as much as 60 bu/a. Averaged across the past 10 years, N and P applied together increased yields as much as 55 bu/a. In 2006, 40 lb/a N (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 true throughout the study period.

Table 1. Effects 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/a - - - -			- bu/a -										
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)													
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													
Nitrogen	0 lb/a		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	0 lb/a		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

SOIL FERTILITY RESEARCH
SOUTHEAST AGRICULTURAL RESEARCH CENTER

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

D.W. Sweeney and J. L. Moyer

Summary

Clean seed yield of endophyte-free tall fescue was greater with late fall nitrogen (N) application than with late winter application and increased with N rates up to 100 lb/a. Forage aftermath was increased with increasing N rates up to 200 lb/a and when all N was applied in late winter. 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 management of N for seed production is less defined, especially because endophyte-free tall fescue may need better management than infected stands. Nitrogen fertilization has been shown to affect forage yields, but data are lacking regarding the yield and quality of the aftermath remaining after seed harvest. 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 randomized block design with three replications. Whole plots were endophyte-free and endophyte-infected tall fescue. The subplots were a 3×5 factorial arrangement of N fertilizer timing and rate. The three N timings were 100% in late fall (Dec. 1, 2003, and Dec. 17, 2004), 100% in late winter (Feb. 26, 2004, and Mar. 7, 2005), 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, and June 15, 2005, and forage aftermath was harvested on June 14, 2004, and June 20, 2005.

Results

Averaged across years and endophyte-infected stands, application of all N fertilizer in late fall resulted in more than 15% greater clean seed yield compared with all N applied in late winter, with the split (50% late fall - 50% late winter) application being intermediate (Figure 1). Clean seed yield increased with increasing rates to 100 lb/a N, but did not seem to benefit from higher N rates. Endophyte infection had no effect on clean seed yield.

Averaged across years and endophyte-infected stands, yield of the forage aftermath left after seed harvest was increased by applying N fertilizer in late winter, compared with late fall, with the split application being intermediate (Figure 2). Increasing N rates up to 200 lb/a increased forage yield, but the amount of increase diminished with each additional N increment. Endophyte infection had no effect on yield of aftermath forage.

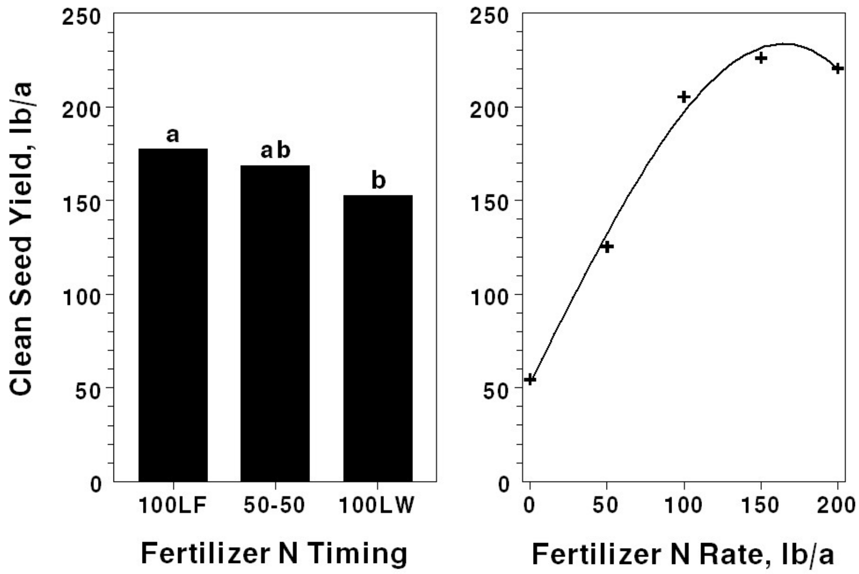

Figure 1. Effects of nitrogen timing and rate on clean seed yield averaged across years (2004-2005) and stands (endophyte-free and endophyte-infected) of tall fescue, Southeast Agricultural Research Center. (100LF=100% of fertilizer N applied in late fall; 100LW=100% of fertilizer N applied in late winter; 50-50=50% of fertilizer N applied in late fall and 50% applied in late winter)

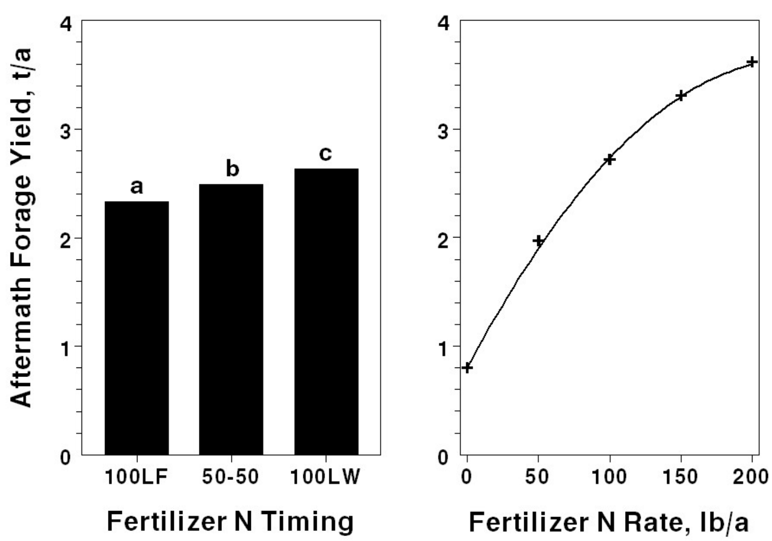

Figure 2. Effects of nitrogen timing and rate on aftermath-forage yield averaged across years (2004-2005) and stands (endophyte-free and endophyte-infected) of tall fescue, Southeast Agricultural Research Center. (100LF=100% of fertilizer N applied in late fall; 100LW=100% of fertilizer N applied in late winter; 50-50=50% of fertilizer N applied in late fall and 50% applied in late winter)

USE OF STRIP TILLAGE AND FLUID N-P MANAGEMENT FOR CORN PRODUCTION IN A CLAYPAN SOIL[1]

D.W. Sweeney, R.E. Lamond, and G.L. Kilgore

Summary

Corn yield response to tillage selection varied with year. In the second and third years, reduced tillage resulted in greater yields than with no-till and usually with either strip-tillage system. Across years, early spring fertilization and knife (subsurface band) applications of nitrogen (N) and phosphorus (P) solutions resulted in greater yield than N-P fertilizer application in late fall or dribble application.

Introduction

The use of conservation-tillage systems is promoted to reduce the potential for sediment and nutrient losses. In the claypan soils of southeastern Kansas, crops grown with no tillage may yield less than in systems involving some tillage operation. But strip tillage provides a tilled seed-bed zone where early spring soil temperatures might be greater, while leaving residues intact between the rows as a conservation measure similar to no tillage.

Procedures

The experiment was established on a Parsons silt loam in late fall 2002. The experimental design was a split-plot arrangement of a randomized complete block with three replications. The four tillage systems constituting the whole plots were: 1) strip tillage in late fall, 2) strip tillage in early spring, 3) reduced tillage (one pass with tandem disk in late fall and one pass in early spring), and 4) no tillage. The subplots were a 2×2 factorial arrangement of fertilizer timing and fertilizer placement. Fertilizer application timing was targeted for late fall or early spring. Fertilizer placement was dribble [surface band] or knife [subsurface band at 4 in-depth]. Fertilizer rates of 120 lb/a N and 40 lb/a P_2O_5 were applied in each fluid-fertilizer scheme. Fertilization was done on Dec. 17, 2002, and on April 1, 2003. Short-season corn was planted on April 3, 2003, and harvested on Aug. 25, 2003. For the second year, fertilization was done on Dec. 2, 2003, and on April 5, 2004. Short-season corn was planted on April 6, 2004, and harvested on Sept. 3, 2004. For the third year, fertilization was done on Dec. 29, 2004, and on March 31, 2005. Short-season corn was planted on March 31, 2005, and harvested on Aug. 29, 2005.

Results

Short-season corn yields were affected by a year × tillage interaction. In 2003, there were no differences in short-season corn yields as affected by tillage (Figure 1). In 2004, however, reduced tillage resulted in greater yield than with no-till or with strip tillage done in the spring. By 2005, reduced tillage resulted in 50% greater yield than with no tillage or either strip tillage system. Averaged across years, knife (subsurface band) applications resulted in nearly 11% greater yield than dribble (surface band) applications did (Figure 2). Fertilization done in early spring resulted in significantly greater corn yields (118 bu/a) than with late fall fertilization (107 bu/a).

[1]This research was partly funded by the Kansas Corn Commission.

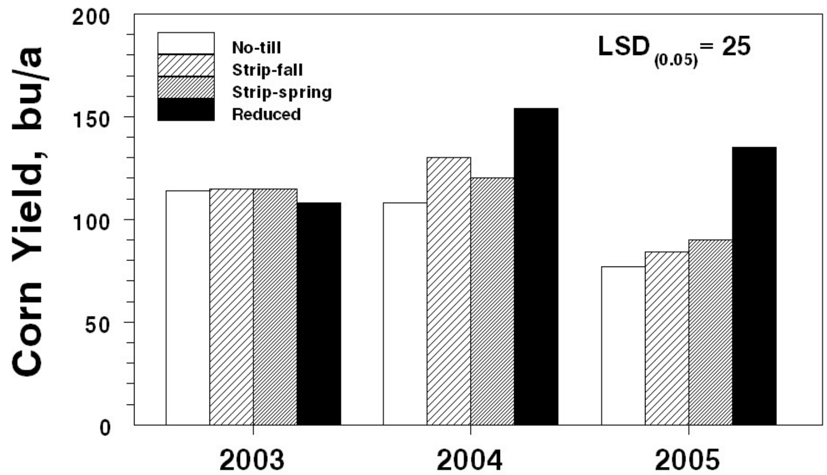

Figure 1. Effect of tillage systems on short-season corn yield during 2003, 2004, and 2005, Southeast Agricultural Research Center.

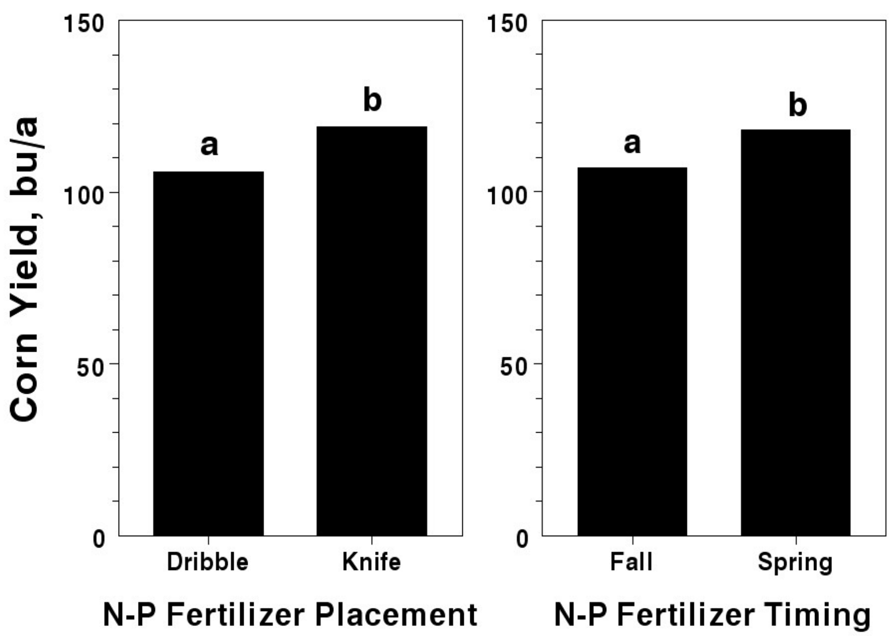

Figure 2. Effects of N fertilizer placement and timing on short-season corn yield averaged across years (2003, 2004, and 2005), Southeast Agricultural Research Center. (Bars with different letters are statistically different at $p<0.05$ according to the LSD test.)

EFFECTS OF TILLAGE AND NITROGEN PLACEMENT ON YIELDS IN A SHORT-SEASON CORN-WHEAT-DOUBLECROP SOYBEAN ROTATION

D.W. Sweeney and K.W. Kelley

Summary

In 2005, corn yields were lower with no tillage, likely due to reduced plant stand. There were no yield differences due to nitrogen (N) fertilizer placement in the conventional or reduced tillage systems, but knifed fertilizer N increased yields compared with broadcast and dribble application methods in no tillage.

Introduction

Many rotational systems are employed in southeastern Kansas. This experiment was designed to determine the long-term effect of selected tillage and N fertilizer placement options on the yields of short-season corn, wheat, and doublecrop 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. After 22 years, the rotation was changed in 2005 to begin a short-season corn-wheat-doublecrop soybean sequence. The three tillage systems were conventional, reduced, and no tillage and were continued in the same areas as during the previous years. The conventional system consisted of chiseling, disking, and field cultivation. The reduced-tillage system consisted of disking and field cultivation. Glyphosate (Roundup®) was applied to the no tillage areas. The four N treatments for the crop were: a) no N (check), b) broadcast urea-ammonium nitrate (UAN - 28% N) solution, c) dribble UAN solution, and d) knife UAN solution at 4 in. deep. Nitrogen rate for corn was 125 lb/a.

Results

In 2005, adding N fertilizer, in general, nearly doubled yields, compared with yields in the no-N control (Figure 1). There were no differences in yield due to placement method in the conventional and reduced-tillage systems. In the no tillage system, however, knife applications resulted in about 40 bu/a greater yield than with broadcast or dribble applications. The overall lower corn yields with no tillage were likely caused by lower plant stands than in conventional or reduced-tillage systems.

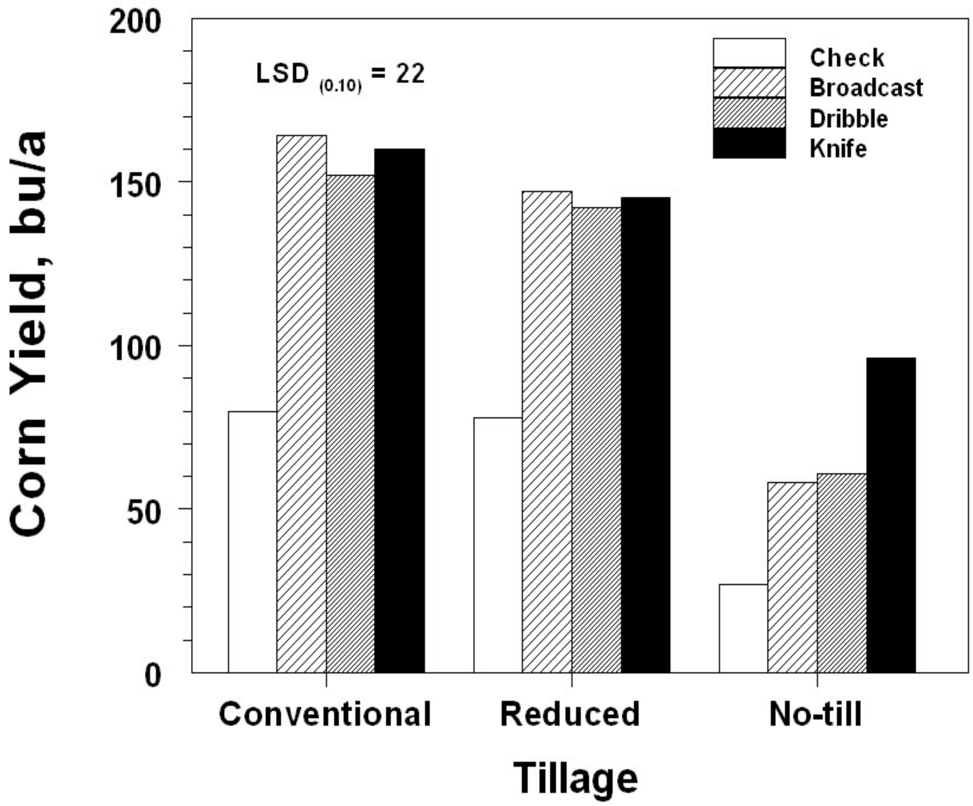

Figure 1. Effect of Tillage and N placement on short-season corn yield, Southeast Agricultural Research Center, 2005.

SOIL FERTILITY RESEARCH
SOUTH CENTRAL EXPERIMENT FIELD

EFFECTS OF NITROGEN RATE AND PREVIOUS CROP ON GRAIN YIELD IN CONTINUOUS WHEAT AND ALTERNATIVE CROPPING SYSTEMS IN SOUTH CENTRAL KANSAS

W. F. Heer

Summary

The predominant cropping systems in south central Kansas have been continuous wheat and wheat-grain sorghum-fallow. With continuous wheat, tillage is performed to control diseases and weeds. In the wheat-sorghum-fallow system only two crops are produced every three years. Other crops (corn, soybean, sunflower, winter cover crops and canola) can be placed in these cropping systems. To determine how winter wheat (and alternative crop) yields are affected by these alternative cropping systems, winter wheat was planted in rotations following the alternative crops. Yields were compared with yields of continuous winter wheat under conventional (CT) and no-till (NT) practices. Initially, the CT continuous wheat yields were greater than those from the other systems. Over time, however, wheat yields following soybean have increased, reflecting the effects of reduced weed and disease pressure and increased soil nitrogen. But CT continuous winter wheat seems to out-yield NT winter wheat, regardless of the previous crop.

Introduction

In south central Kansas, continuous hard red winter wheat and winter wheat-grain sorghum-fallow are the predominant dry-land cropping systems. The summer-fallow period following sorghum is required because the sorghum crop is harvested in late fall, after the optimum planting date for wheat in this region. Average annual rainfall is only 29 inch/yr, with 60 to 70% occurring between March and July. Therefore, soil moisture is often not sufficient for optimum wheat growth in the fall. NT systems often increase soil moisture by increasing infiltration and decreasing evaporation. But higher grain yields associated with increased soil water in NT have not always been observed.

Cropping systems with winter wheat following several alternative crops would provide improved weed control (through additional herbicide options) and reduced disease incidence (by interrupting disease cycles). It would also allow producers several options under the 1995 Farm Bill. But the fertilizer nitrogen (N) requirement for many crops is often greater under NT than under CT. Increased immobilization and denitrification of inorganic soil N and decreased mineralization of organic soil N have been related to the increased N requirements under NT. Therefore, evaluation of N rates on hard red winter wheat in continuous wheat and in cropping systems involving alternative crops for the area have been evaluated at the South Central Field.

The continuous-winter-wheat study was established in 1979 and was restructured to include a tillage factor in 1987. The first of the alternative cropping systems, in which wheat follows short-season corn, was established in 1986 and modified in 1996 to a wheat-cover crop-grain sorghum rotation. The second cropping system (established in 1990) has winter wheat following soybean. Both cropping systems use NT seeding into the previous crop's residue. All three systems have the same N rate treatments.

Procedures

Research was conducted at the KSU South Central Experiment Field, Hutchinson. Soil is an Ost loam. Sites had been in wheat before start of the cropping systems. The research was replicated five times in a randomized block design with a split-plot design. The main plot was crop and the subplot was six N rates (0, 25, 50, 75, 100, and 125 lb/a). Nitrogen treatments were broadcast applied as NH_4NO_3 before planting. Phosphate was applied in the row at planting. All crops were produced each year of the study. Crops were planted at the normal time for the area. Plots were harvested at maturity to determine grain yield, moisture, and test weight.

Continuous Wheat

These plots were established in 1979. The conventional tillage treatments are plowed immediately after harvest then worked with a disk as necessary to control weed growth. The fertilizer is applied with a Barber metered screw spreader before the last tillage (field cultivation) on the CT and before seeding of the NT plots. The plots are cross-seeded in mid-October to winter wheat. Because of an infestation of cheat in the 1993 crop, the plots were planted to oat in the spring of 1994. The fertility rates were maintained, and the oat was harvested in July. Winter wheat has been planted in mid-October each year since the fall of 1994. New herbicides have aided in the control of cheat in the NT treatments. In the fall of 2005, these plots were seeded to canola. The nitrogen rates and tillage treatments were retained. It is hoped that doing this will give us some field data on the effects of canola on wheat yields in a continuous-wheat cropping system.

Wheat after Corn/Grain Sorghum Fallow

In this cropping system, winter wheat was planted after short-season corn had been harvested in late August to early September. This early harvest of short-season corn allows the soil-profile water to be recharged (by normal late-summer and early-fall rains) before planting of winter wheat in mid-October. Fertilizer rates were applied with the Barber metered screw spreader in the same manner as for the continuous wheat. In 1996, the corn crop in this rotation was dropped, and three legumes (winter peas, hairy vetch, and yellow sweet clover) were added as winter cover crops. Thus, the rotation became a wheat-cover crop-grain sorghum-fallow rotation. The cover crops replaced the 25, 75, and 125 N treatments in the grain sorghum portion of the rotation. Yield data can be found in Field Research 2000 KSU Report of Progress SRP 854.

Wheat after Soybean

Winter wheat is planted after the soybean has been harvested in early- to mid-September in this cropping system. As with the continuous-wheat plots, these plots are planted to winter wheat in mid-October. Fertilizer rates are applied with the Barber metered screw spreader in the same manner as for the continuous wheat. Since 1999, a group III soybean has been used. This delays harvest from late August to early October. In some years, this effectively eliminates the potential recharge time before wheat planting.

Wheat after Grain Sorghum in Cover Crop/Fallow-Grain Sorghum-Wheat

Winter wheat is planted into grain sorghum stubble harvested the previous fall. Thus, the soil-profile water has had 11 months to be recharged before planting of winter wheat in mid-October. Nitrogen fertilizer is applied at a uniform rate of 75 lb/a with the Barber metered screw spreader in the same manner as for the continuous wheat. This rotation will be terminated after the harvest of each crop in 2006. For the 2007 harvest year, canola will be introduced into this rotation where the cover crops had been.

Winter wheat is also planted after canola and sunflower to evaluate the effects of these two crops on the yield of winter wheat. Uniform nitrogen fertility is used; therefore, the data is not presented. The yield for wheat after these two crops is comparable to wheat after soybean.

Results

Continuous Wheat

Grain yield data from plots in continuous winter wheat are summarized by tillage and N rate in Table 3. Data for years before 1996 can be found in Field Research 2000 KSU Report of Progress SRP 854. Conditions in 1996 and 1997 proved to be excellent for winter wheat production in spite of the dry fall of 1995 and the late-spring freezes in both years. Excellent moisture and temperatures during the grain-filling period resulted in decreased grain-yield differences between the conventional and no-till treatments within N rates. Conditions in the spring of 1998 and 1999 were excellent for grain filling in wheat.

However, the differences in yield between conventional and no-till wheat still expressed themselves (Table 3). In 2000, the differences were wider, up to the 100 lb/a N rate. At that point, the differences were similar to those of previous years. The wet winter and late spring of the 2003-2004 harvest year allowed for excellent tillering and grain fill and yields (Table 2). In 2005, the dry period in April and May seemed to affect the yields in the plots with 0 and 25 lb/a N rates.

Wheat after Soybean

Wheat yields after soybean also reflect the differences in N rate. When comparing the wheat yields from this cropping system with those where wheat followed corn, however, the effects of residual N from soybean production in the previous year can be seen. This is especially true for N rates between 0 and 75 lb in 1993 and between 0 and 125 lb in 1994 (Table 3). Yields in 1995 reflect the added N from the previous soybean crop with yield-by-N-rate increases similar to those of 1994. The 1996 yields for spring wheat reflect the lack of response to nitrogen fertilizer for the spring wheat. Yields for 1997 and 1998 both show the leveling off after the first four increments of N. As with the wheat in the other rotations in 1999, the ideal moisture and temperature conditions allowed the wheat yields after soybean to express the differences in N rate up to 100 lb N/a. In the past, those differences stopped at the 75 lb N/a treatment. When compared with the yields in the continuous wheat, the yield of rotational wheat is starting to reflect the presence of the third crop (grain sorghum) in the rotation. Wheat yields were lower in 2000 than in 1999. This is attributed to the lack of timely moisture in April and May and the hot days at the end of May. This heat caused the plants to mature early and also caused low test weights. In 2004, there was not as much cheat as in 2003; thus, the yields were much improved (Table 3). Yields in 2004 indicate that the wheat is showing a 50- to 75-lb N credit from the soybean and rotational effects. As with the continuous wheat cropping system, the yields in plots with the 0 and 25 lb/a N rate were less than in 2004. As the rotation continues to cycle, the differences at each N rate will probably stabilize after four to five cycles, with a potential to reduce fertilizer N applications by 25 to 50 lb/a where wheat follows soybean.

Wheat after Grain Sorghum/Cover Crop

The first year that wheat was harvested after a cover-crop grain sorghum planting was 1997. Data for the 1997-2005 wheat yields are in Table 4. Over these nine years, there does not seem to be a definite effect of the cover crop (CC) on yield. This is most likely due to the variance in CC growth within a given year. In years like 1998 and 1999, in which sufficient moisture and warm winter temperatures produced good CC growth, the additional N from the CC seems to carry through to the wheat yields. With the fallow period after the sorghum in this rotation, the wheat crop has a moisture advantage over the wheat after soybean. Cheat was the limiting factor in this rotation in 2003. A more aggressive herbicide control of cheat in the cover crops was started, and the 2004 yields reflect the control of cheat. Management of the grasses in the cover-crop portion of this rotation seems to be the key factor in controlling the cheat grass and increasing yields. This can be seen in the yields for 2005 when compared with the wheat yields, either continuous wheat or in rotation with soybean.

Other Observations

Nitrogen application significantly increased grain N contents in all crops. Grain phosphate content did not seem to be affected by increased N rate.

Loss of the wheat crop after corn can occur in years when fall and winter moisture is limited. This loss has not occurred in continuous winter wheat, regardless of tillage, or in wheat after soybean. Corn will have the potential to produce grain in favorable years (cool and moist) and silage in nonfavorable (hot and dry) years. In extremely dry summers, extremely low grain sorghum and soybean yields can occur. The major weed-control problem in the wheat-after-corn system is with grasses. Work is being done to determine the best herbicides and time of application to control grasses.

Soybean and Grain Sorghum in Rotations

Soybean was added to intensify the cropping system in the South Central area of Kansas. Being a legume, soybean also has the ability to add nitrogen to the soil system. For this reason, nitrogen is not applied during the time when soybean is planted in the plots for the rotation. This gives the following crops the opportunity to use the added N and allows checking the yields against the yields for the crop in other production systems. Yield data for soybean following grain sorghum in the rotation are given in Table 5. Soybean yields are affected more by the weather for the given year than by the previous crop. In three out of the nine years, there was no effect of N rates applied to wheat and grain sorghum in the rotation. In the two years that N application rate did affect yield, it was only at the lesser N rates. This is a similar effect that is seen in a given crop. The yield data for grain sorghum after wheat in the soybean-wheat-grain sorghum rotation are in Table 6. As with the soybean, weather is the main factor affecting yield. The addition of a cash crop (soybean), which intensifies the rotation (cropping system), will reduce the yield of grain sorghum in the rotation; compare soybean-wheat-grain sorghum vs. wheat-cover crop-grain sorghum in Tables 6 and 7. More uniform yields are obtained in the soybean-wheat-grain sorghum rotation (Table 6) than in the wheat-cover crop-grain sorghum rotation (Table 7).

Other systems studies at the field are a wheat-cover crop (winter pea)-grain sorghum rotation with N rates, and a date of planting, date of termination cover-crop rotation with small grains (oat) and grain sorghum.

Table 1. Precipitation at South Central Kansas Experiment Field, Hutchinson 10 SW 143930.

Month	Rainfall (inches)	30-yr Avg* (inches)	Month	Rainfall (inches)	30-yr Avg (inches)
2004			April	1.78	2.71
September	1.67	2.73	May	2.51	4.11
October	2.64	2.47	June	8.92	4.35
November	1.81	1.35	July	4.88	3.56
December	0.21	0.95	August	6.94	3.15
2005			September	0.47	2.73
January	2.35	0.69	October	1.02	2.49
February	1.75	1.10	November	0.19	1.38
March	1.07	2.70	December	0.31	0.90
			2005 Total	32.09	29.87

* Most recent 30 years.

Table 2. Wheat yields by tillage and nitrogen rate in a continuous-wheat cropping system, Hutchinson, Kansas.

N	Yield (bu/a)																			
Rate[1]	1996		1997		1998		1999		2000		2001		2002		2003		2004		2005	
	CT[2]	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT
0	46	23	47	27	52	19	49	36	34	15	50	11	26	8	54	9	66	27	47	26
25	49	27	56	45	61	37	67	51	46	28	53	26	34	9	56	9	68	41	63	36
50	49	29	53	49	61	46	76	61	52	28	54	35	32	8	57	22	65	40	68	38
75	49	29	50	46	64	53	69	64	50	34	58	36	34	7	57	42	63	37	73	43
100	46	28	51	44	55	52	66	61	35	33	54	34	35	5	56	35	64	43	73	40
125	45	25	48	42	56	50	64	58	31	32	56	36	32	5	57	38	63	31	69	35
LSD (0.01)*	NS	NS	8	8	5	5	13	13	14	14	10	10	6	NS	NS	18	NS	9	14	14

* Unless two yields in the same column differ by at least the least significant difference (LSD), there can be little confidence in one being greater than the other.

[1] Nitrogen rate in lb/a.

[2] CT conventional NT no-tillage.

Table 3. Wheat yields after soybeans in a soybean-wheat-grain sorghum rotation with nitrogen rates, Hutchinson, Kansas.

N	Yield (bu/a)														
Rate[1]	1991	1992	1993	1994	1995	1996[2]	1997	1998	1999	2000	2001	2002[3]	2003	2004	2005
0	51	31	24	23	19	35	13	21	31	26	12	9	31	40	30
25	55	36	34	37	26	36	29	34	46	37	16	10	48	46	43
50	55	37	41	47	34	36	40	46	59	46	17	9	59	48	49
75	52	37	46	49	37	36	44	54	66	54	17	7	65	46	52
100	51	35	45	50	39	36	45	55	69	55	20	8	67	43	50
125	54	36	46	52	37	36	47	57	68	50	21	8	66	40	48
LSD (0.01)*	NS	4	6	2	1	1	4	3	7	5	7	4	3	5	5
CV (%)	7	6	9	5	7	2	9	4	5	7	23	24	4	6	6

* Unless two yields in the same column differ by at least the least significant difference (LSD), there can be little confidence in one being greater than the other.

[1] Nitrogen rate in lb/a.

[2] Spring wheat yields.

[3] Yields severely reduced by hail.

Table 4. Wheat yields after grain sorghum in a wheat-cover crop-grain sorghum rotation with nitrogen rates, Hutchinson, Kansas.

N	Yield (bu/a)								
Rate[1]	1997	1998	1999	2000	2001	2002[3]	2003	2004	2005
0	17	25	26	4	45	10	9	47	59
HV[2]	43	50	39	16	45	10	5	36	63
50	59	52	50	21	41	8	4	35	56
WP[2]	43	51	66	21	41	9	8	37	60
100	52	56	69	26	39	5	5	32	55
SC[2]	53	54	70	22	42	6	6	36	55
LSD (0.01)*	21	12	5	5	5	3	NS	8	6
CV (%)	26	14	6	16	6	20	70	12	6

* Unless two yields in the same column differ by at least the least significant difference (LSD), there can be little confidence in one being greater than the other.

[1] Nitrogen rate in lb/a.

[2] HV hairy vetch, WP winter pea, SC sweet clover.

[3] Yields severely reduced by hail.

Table 5. Soybean yields after grain sorghum in soybean-wheat-grain sorghum rotation with nitrogen rates, Hutchinson, Kansas.

N	Yield (bu/a)									
Rate[1]	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	16	26	22	33	25	7	22	5	53	20
25	17	29	23	35	21	8	22	6	50	19
50	18	30	23	36	23	9	22	6	50	18
75	20	29	24	36	24	8	21	7	51	18
100	22	31	25	37	21	9	21	7	51	19
125	20	25	24	34	22	8	22	7	49	19
LSD (0.01)*	3	7	NS	NS	NS	NS	ns	1.4	5	NS
CV (%)	10	12	6	12	15	13	7	17	6	11

* Unless two yields in the same column differ by at least the least significant difference (LSD), there can be little confidence in one being greater than the other.

[1] N rate in lb/a; N rates are not applied to the soybean plots in the rotation.

Table 6. Grain sorghum yields after wheat in a soybean-wheat-grain sorghum rotation with nitrogen rates, Hutchinson, Kansas.

N	Yield (bu/a)									
Rate[1]	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	32	13	57	52	55	15	34	10	86	86
25	76	29	63	67	56	15	41	10	112	90
50	93	40	61	82	54	13	43	9	129	97
75	107	41	60	84	49	9	43	8	136	95
100	106	65	55	77	50	7	46	8	141	101
125	101	54	55	82	49	7	47	9	142	95
LSD (0.01)*	8	13	NS	13	NS	NS	8	NS	9	12
CV (%)	5	18	10	9	10	58	11	24	4	7

* Unless two yields in the same column differ by at least the least significant difference (LSD), there can be little confidence in one being greater than the other.

[1] Nitrogen rate in lb/a.

Table 7. Grain sorghum yields after cover crop in cover crop-grain sorghum-wheat rotation with nitrogen rates, Hutchinson, Kansas.

N	Yield (bu/a)									
Rate[1]	1996	1997	1998	1999	2000	2001	2002[3]	2003	2004	2005
0	73	26	69	81	68	17	22	21	92	84
HV[2]	99	36	70	106	54	17	21	16	138	93
50	111	52	73	109	66	13	25	15	135	90
WP[2]	93	35	72	95	51	19	23	17	138	101
100	109	54	67	103	45	12	25	14	136	89
SC[2]	94	21	72	92	51	19	19	19	94	80
LSD (0.01)*	13	14	NS	21	16	6	NS	5	19	16
CV (%)	8	22	13	12	16	21	20	22	9	10

* Unless two yields in the same column differ by at least the least significant difference (LSD), there can be little confidence in one being greater than the other.

[1] Nitrogen rate in lb/a.

[2] HV hairy vetch, WP winter pea, SC sweet clover.

[3] Yields affected by hot dry conditions in July and bird damage.

EFFECTS OF TERMINATION DATE OF AUSTRIAN WINTER PEA WINTER COVER CROP AND NITROGEN RATES ON GRAIN SORGHUM AND WHEAT YIELDS

W.F. Heer

Summary

The effects of the cover crop most likely were not expressed in the first year (1996) grain sorghum harvest (Table 1). Limited growth of the cover crop (winter peas), due to weather conditions, produced limited amounts of organic nitrogen (N). Therefore, the effects of the cover crop were limited and varied compared with those of fertilizer N. The wheat crop for 1998 was harvested in June. The winter pea plots were then planted and were terminated the following spring before 1999 grain sorghum plots were planted. The N rate treatments were applied and grain sorghum was planted on June 11, 1999. Winter wheat was again planted on the plots in October 2000 and harvested in June 2001. Winter peas were planted in September 2001 and terminated in April and May 2002. Grain sorghum was planted in June and harvested in October.

During 2003, this area was in sorghum fallow, and the plots were fertilized and planted to wheat in October 2003 for harvest in 2004. The winter pea cover crop was planted into the wheat stubble in the fall of 2004. These plots were terminated as indicated in Table 1, and were planted to grain sorghum in June 2005.

Introduction

There has been a renewed interest in the use of winter cover crops as a means of soil and water conservation, as a substitute for commercial fertilizer, and for the maintenance of soil quality. One of the winter cover crops that may be a good candidate is winter pea. Winter pea is established in the fall, over-winters, produces sufficient spring foliage, and is returned to the soil before planting of a summer annual. Because it is a legume, there is a potential for adding nitrogen to the soil system. With this in mind, research projects were established at the South Central Experiment Field to evaluate the effect of winter pea and its ability to supply N to the succeeding grain sorghum crop, compared with commercial fertilizer N, in a winter wheat-winter pea-grain sorghum rotation.

Procedures

The research is being conducted at the KSU Research and Extension South Central Experiment Field, Hutchinson. The soil in the experimental area is an Ost loam. The site had been in wheat before starting the cover-crop cropping system. The research used a randomized block design and was replicated four times. Cover-crop treatments consist of fall- planted winter peas with projected termination dates in April and May and no cover crop (fallow). The winter peas are planted into wheat stubble in early September at a rate of 35 lb/a in 10-inch rows with a double disk opener grain drill. Before termination of the cover crop, above-ground biomass samples are taken from a one-square-meter area. These samples are used to determine forage yield (winter pea and other) and forage nitrogen and phosphate content for the winter pea portion. Fertilizer treatments consist of four fertilizer N rates (0, 30, 60, and 90 lb/a N). Nitrogen treatments are broadcast applied as NH_4NO_3 (34-0-0) before planting of grain sorghum. Phosphate is applied at a rate of 40 lb P_2O_5 in the row at planting. Grain sorghum plots are harvested to determine grain yield, moisture, test weight, and grain nitrogen and phosphate content. The sorghum plots are fallowed until the plot area is planted to wheat in the fall of the following year. The fertilizer treatments are also applied before planting wheat.

Results

Winter Pea/Grain Sorghum

Results for winter pea cover crop and grain sorghum were summarized in the Field Research 2000 Report of Progress SRP 854 pages 139-142. The grain sorghum yields by N rate (Table 1) were similar to the wheat yields in the long-term N-rate study. The first increment of N resulted in the greatest change in yield, and the yields tended to peak at the 60 lb N rate treatment, regardless of the presence or lack of winter pea.

Winter Wheat

The fall of 2000 was wet, after a very hot, dry August and September. Thus, the planting of wheat was delayed. Fall temperatures were warm, allowing the wheat to tiller into late December. January and February both had above-normal precipitation. April, May, and June were slightly below normal in both precipitation and temperature. Wheat yields reflected the presence of the winter pea treatments, as well as the reduced yields in the grain sorghum for the no-pea treatment plots. Test weight of the grain was not affected by pea or fertilizer treatment, but was affected by the rainfall at harvest time. This was also true for the percentage of nitrogen in the seed at harvest. A concern with the rotation is weed pressure. The treatment with April-termination pea plus 90 lb/a N had significantly more weeds in it than any of the other treatments. Except for this treatment, there were no differences noted for weed pressure. Grain yield data are presented in Table 2. With the earlier planting for the 2004 crop, the wheat should have had a better chance to tiller, but the fall was wet and cold, limiting fall growth.

As this rotation continues and the soil system adjusts, it will reveal the true effects of the winter cover crop in the rotation. It is important to remember that in the dry (normal) years, the soil water (precipitation) during the growing season most likely will not be as favorable as it was in 1999, and the water use by the cover crop will be the main influence on the yield of succeeding crop.

Table 1. Grain sorghum yield as affected by nitrogen rate, winter pea cover crop, and termination date in a winter wheat-winter pea cover crop-grain sorghum rotation, KSU South Central Field, Hutchinson, Kansas.

		Flag leaf		Grain												
	N	1996		1996			1999			2002			2005			
Date	Rate[1]	N	P	N	P	Yield	N	P	Yield	N	P	Yield	N	P	Yield
	lb/a	%				bu/a	%		bu/a	%		bu/a	%		bu/a
April[2] N/pea	0	2.5	0.38	1.6	0.26	86.5	1.1	0.32	72.6	1.5	0.38	78.4	1.0	0.31	54
	30	2.7	0.44	1.6	0.27	93.9	1.2	0.29	90.9	1.6	0.40	87.5	1.1	0.29	76
	60	2.8	0.43	1.7	0.27	82.6	1.5	0.32	106.4	1.8	0.40	82.8	1.4	0.31	94
	90	2.8	0.44	1.7	0.25	90.4	1.7	0.34	101.8	1.8	0.35	92.5	1.5	0.31	96
April[2] W/pea	0	2.4	0.40	1.5	0.29	80.2	1.3	0.31	93.5	1.6	0.37	79.9	1.4	0.29	102
	30	2.7	0.39	1.6	0.26	85.7	1.3	0.32	97.4	1.7	0.38	91.1	1.4	0.31	107
	60	2.7	0.38	1.7	0.27	90.0	1.5	0.33	105.1	1.8	0.40	87.5	1.5	0.31	107
	90	2.9	0.41	1.8	0.23	83.8	1.8	0.32	97.9	2.0	0.37	77.2	1.6	0.32	98
May[3] N/pea	0	2.1	0.39	1.4	0.30	81.4	1.1	0.34	40.5	1.6	0.41	56.4	1.1	0.31	67
	30	2.4	0.39	1.5	0.28	88.1	1.1	0.32	66.6	1.7	0.40	71.6	1.1	0.30	92
	60	2.6	0.40	1.6	0.27	90.7	1.2	0.30	93.3	1.8	0.40	71.4	1.2	0.31	95
	90	2.6	0.40	1.6	0.26	89.6	1.4	0.31	105.9	1.9	0.40	82.6	1.4	0.33	95
May[3] W/pea	0	2.3	0.40	1.4	0.29	85.0	1.2	0.31	92.4	1.7	0.39	74.8	1.4	0.31	95
	30	2.5	0.40	1.5	0.31	92.4	1.3	0.31	97.7	1.8	0.38	81.5	1.5	0.30	98
	60	2.6	0.38	1.6	0.26	92.9	1.5	0.30	112.3	1.9	0.36	86.8	1.6	0.30	91
	90	2.7	0.41	1.6	0.25	90.5	1.5	0.32	108.7	1.8	0.39	90.3	1.6	0.31	98
LSD		0.2	0.02	0.1	NS	8.9	0.2	0.04	16.0	0.14	0.05	14.0	0.11	0.02	15

[1] Nitrogen applied after winter pea termination before planting grain sorghum.
[2] Early April termination. Actual termination May 16, 1996, April 21, 1999, April 13, 2002, and April 27, 2005.
[3] Early May termination. Actual termination June 4, 1996, May 19, 1999, May 25, 2002, and May 18, 2005.

Table 2. Winter wheat yield after grain sorghum as affected by nitrogen rate, winter pea cover crop, and termination date in a winter wheat-winter pea cover crop-grain sorghum rotation, KSU South Central Field, Hutchinson, Kansas.

Termination Date	N Rate[1]	Grain Yield 2001	Grain Yield 2004	Grain N 2001	Grain N 2004	Grain P 2001	Grain P 2004	Plant Height 2001	Plant Height 2004	Lodging 2004	Weeds 2001
	lb/a	bu/a		%				inch		%	rating[2]
April[3] N/pea	0	37	58	2.32	1.73	0.38	0.38	26	31	0	3
	30	40	56	2.43	1.94	0.36	0.36	28	29	3.8	5
	60	39	51	2.30	2.23	0.38	0.34	30	30	17.5	4
	90	37	44	2.24	2.27	0.38	0.35	30	29	35.0	7
April[3] W/pea	0	39	58	2.38	1.89	0.35	0.38	26	29	3.8	3
	30	42	55	2.33	1.97	0.37	0.34	27	32	8.8	4
	60	36	50	2.22	2.23	0.40	0.33	29	31	37.5	7
	90	37	47	2.18	2.46	0.37	0.32	28	30	60.0	10
May[4] N/pea	0	38	57	2.30	1.79	0.37	0.36	26	30	1.3	3
	30	38	53	2.32	2.13	0.37	0.34	26	30	32.5	5
	60	34	46	2.42	2.30	0.35	0.35	30	30	46.3	7
	90	38	44	2.24	2.37	0.35	0.35	30	30	50.0	8
May[4] W/pea	0	42	60	2.37	1.91	0.40	0.36	26	30	3.8	4
	30	37	50	2.38	2.19	0.38	0.35	28	30	27.5	6
	60	35	45	2.38	2.33	0.37	0.33	29	30	42.5	9
	90	37	45	2.34	2.42	0.38	0.34	28	30	42.5	10
LSD (P=0.05)		5	6	0.18	0.12	0.03	0.03	2	1	24	3

[1] Nitrogen applied as 34-0-0 before planting winter wheat.
[2] Visual rating 1= few to 10=most. Insufficient weeds were present in 2004 to rate.
[3] Early April termination.
[4] Early May termination. There was minimal lodging in 2001.

SOIL FERTILITY RESEARCH
HARVEY COUNTY EXPERIMENT FIELD

EFFECTS OF LATE-MATURING SOYBEAN AND SUNN HEMP SUMMER COVER CROPS AND NITROGEN RATE ON NO-TILL WHEAT AFTER GRAIN SORGHUM

M.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 cover crops grown for the second time in the rotations (2004) contained 90 and 125 lb/a of N, respectively. Residual effects of soybean on wheat were similar to those of sunn hemp. In the very dry wheat growing season of 2005 and 2006, plant heights and N levels showed no response to cover crop, but increased significantly with N rate. Wheat yield increases of 4.4 and 6.3 bu/a, respectively, in rotations with soybean and sunn hemp occurred only at 60 lb/a N. Grain test weight was not meaningfully affected by either cover crop or N rate.

On a second site, grain sorghum followed cover crops grown for the first time in the rotations. Soybean and sunn hemp produced an average of 2.42 and 4.14 ton/a of above-ground dry matter. Corresponding nitrogen (N) yields of 103 and138 lb/a were potentially available to the succeeding grain sorghum crop. In the rotation without a cover crop, grain sorghum leaf N concentrations were significantly higher only at the two highest rates of fertilizer N. A similar trend in leaf N occurred in grain sorghum following soybean. On the other hand, sorghum leaf N was higher at all rates of N and showed no response to N rate in the rotation with sunn hemp. When averaged across N fertilizer rates, soybean and sunn hemp significantly increased sorghum leaf nutrient levels by 0.12% N and 0.20% N, respectively.

Cover crops did not affect grain sorghum plant population or grain test weight and tended to shorten only slightly the length of time to reach half bloom stage. At zero fertilizer N, soybean and sunn hemp increased sorghum yields by 30.9 and 34.7 bu/a. Averaged over N rate, these respective yield increases were 12.5 and 17.8 bu/a . Without a cover crop in the rotation, sorghum yields increased with N rate and reached a maximum of 100.6 bu/a at 60 lb/a. N rate did not affect yield of sorghum after soybean and increased yield of sorghum following sunn hemp significantly only at 60 lb/a N with a maximum of 109 bu/a.

Introduction

Research at the KSU 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 on the order of 100 lb/a. But significant disadvantages also exist in the use of hairy vetch as a cover crop. These include the cost and availability of seed, interference with the 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 the 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 impact on no-till sorghum grown in the spring following wheat harvest as well as for residual effect on double-crop no-till wheat after grain sorghum. In 2002 and 2004, in the first two cycles of these rotations at the initial experiment location, the two cover crops produced average N yields of 118 and 122 lb/a, respectively. When averaged over N rates, soybean and sunn hemp resulted in two-year average grain sorghum yield increases of 6.3 and 12 bu/a. Residual effects of cover crops on wheat averaged over N rates at the beginning of the second cycle were evidenced by yield increases of 4.0 and 2.3 bu/a.

Procedures

The experiments were established on adjacent Geary silt loam sites which had been utilized for hairy vetch cover crop research in a wheat-sorghum rotation from 1995 to 2001. In keeping with the previous experimental design, soybean and sunn hemp were assigned to plots where vetch had been grown, and the remaining plots retained the treatment with no cover crop. The existing factorial arrangement of N rates on each cropping system also was retained. In 2006, wheat was produced on site 1 at the beginning of the third cycle of the rotations. Grain sorghum was grown on the second site in the first cycle of the rotations.

Wheat

Weeds in wheat stubble were controlled with Roundup Ultra Max II® herbicide applied nine days before planting the cover crop. Asgrow AG701 Roundup Ready® soybean and sunn hemp seed were treated with respective rhizobium inoculants and no-till planted in 8-inch rows with a CrustBuster stubble drill on July 9, 2004, at 60 lb/a and 10 lb/a, respectively. Sunn hemp began flowering in mid-September and was terminated at that time by a combination of rolling with a crop roller and applying 22 oz/a of Roundup Ultra Max II®. Soybean was rolled after initial frost in early October. Forage yield of each cover crop was determined by harvesting a 3.28 $feet^2$ area in each plot just before termination. Samples subsequently were analyzed for N content.

Weeds were controlled during the fallow period after cover crops with Roundup Ultra Max II®, 2,4-D_{LVE} and Clarity. Pioneer 8500 grain sorghum treated with Concept® safener and Cruiser® insecticide was planted at approximately 42,000 seeds/a on May 23, 2005. Atrazine and Dual II Magnum® were applied pre-emergence for residual weed control shortly after sorghum planting.

All plots received 37 lb/a of P_2O_5 banded as 0-46-0 at planting. Nitrogen fertilizer treatments were applied as 28-0-0 injected at 10 inches from the row on June 27, 2005. Grain sorghum was combine harvested on September 15. Nitrogen rates were reapplied as broadcast 34-0-0 on October 25, 2005. Jagger winter wheat was then no-till planted at 90 lb/a with 32 lb/a P_2O_5 fertilizer banded as 0-46-0 in the furrow. Wheat was harvested on June 15, 2006.

Grain Sorghum

Weeds were controlled and cover crops managed with procedures similar to those previously noted for site 1. Soybean and sunn hemp seed were no-till planted on July 9, 2005 and terminated in late September. Pioneer 8505 grain sorghum treated with Concept® safener and Cruiser® insecticide was planted at approximately 40,000 seeds/a on July 1, 2006. Atrazine and Dual II Magnum® were preplant applied for residual weed control. The entire site received 37 lb/a of P_2O_5 banded as 0-46-0 at planting. Nitrogen fertilizer treatments were applied as 28-0-0 injected at 10 inches from the row on July 19, 2006. Grain sorghum was combine-harvested on November 9.

Results

Wheat

During the nine days preceding cover crop planting in 2004, rainfall totaled 1.82 inches. The next rains occurred about two weeks after planting, when 4 inches were received over a three day period. Stand establishment was good with both soybean and sunn hemp. Although July rainfall was above normal, August and September were drier than usual. Late-maturing soybean reached an average height of 24 inches, showed limited pod development, and produced 2.11 ton/a of above-ground dry matter with an N content of 2.11% or 90 lb/a (Table 1). Sunn hemp averaged 72 inches in height and produced 3.19 ton/a with 1.95% N or 125 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.

In 2005, soybean increased sorghum yields at all but the 90 lb/a N rate, while sunn hemp in the rotation improved yields at all N rates. The positive effect of soybean and sunn hemp cover crops was seen in respective sorghum yield improvements of 9.7 and 13.4 bu/a when averaged over N rate. Yields averaged over cropping systems increased significantly with each 30 lb/a increment of fertilizer N.

The residual effect of cover crops in 2006 on winter wheat plant height was generally minor and, across cropping systems, increased by 4 to 7 inches with the first increment of N fertilizer. Plant N in wheat at early heading indicated that there was no residual N contribution from cover crops. Fertilizer significantly increased plant N incrementally with 60 and 90 lb/a of N. Wheat yields tended to be slightly greater in rotations with a cover crop. In the case of sunn hemp, the yield advantage of 3.2 bu/a was significant when averaged over N rates. But, most of the rotation effect on yield was observed at N rates less than 90 lb/a. Cover crops had a minor but positive effect on grain test weight, mainly at low N rates. Test weight tended to increase slightly with 30 and 60 lb/a of N.

Grain Sorghum

During the week preceding cover crop planting in 2005, rainfall totaled 1.89 inches. A 1-inch rain fell three days after planting, but the remainder of July had a total of only 0.58 inch. Stand establishment was good with both soybean and sunn hemp. August rainfall was well above normal. September was much drier than usual.

Late-maturing soybean reached an average height of 27 inches, had minor pod development, and produced 2.42 ton/a of above-ground dry matter with an N content of 2.11% or 103 lb/a (Table 2). Sunn hemp averaged 86 inches in height and produced 4.14 ton/a with 1.67% N or 138 lb/a of N. Soybean and sunn hemp gave partial suppression of volunteer wheat, but did not eliminate the need for herbicide control ahead of the wheat planting season.

Grain sorghum final stands averaged 26,717 plants/a. In 2006, July and August had a total of 31 days with temperatures of 95 degrees or higher, and 13 days with temperatures of 100 to 108 degrees F. July was dryer than usual. Above-normal rainfall in August, coupled with more moderate temperatures during the second half of the month, greatly benefitted the sorghum crop. Mean temperatures in September and October were 5.4 and 2.6 degrees F below normal. September rainfall was 1.8 inches below the long-term average, and October also was dryer than usual. The first freezing temperatures of fall arrived on October 18. This and subsequent freezes hastened sorghum grain maturation to some extent.

Where no cover crop was used in the rotation, grain sorghum leaf N concentration increased with each increment of N fertilizer, reaching significantly higher levels with 60 and 90 lb/a N. Similarly, where sorghum followed soybean, leaf N increased significantly only at the 60 and 90 lb/a rates, but without an incremental relationship to N rate. However, in the rotation with sunn hemp, sorghum leaf N tended to be higher at all rates of fertilizer and had no meaningful response to N rate. The main effect of soybean and sunn hemp, averaged across N fertilizer rates, significantly increased sorghum leaf nutrient levels by 0.12% N and 0.20% N, respectively.

Cover crops did not affect grain sorghum plant population or grain test weight. On average, sorghum following sunn hemp tended to reach half-bloom stage slightly earlier than in the other rotations. The number of heads/plant increased with both cover crops and N rates. At zero fertilizer N, sorghum after soybean and sunn hemp produced yields of 92.0 and 95.8 bu/a, representing increases of 30.9 and 34.7 bu/a. The main effects of cover crops averaged over all N rates were evidenced by respective yield increases of 12.5 and 17.8 bu/a . Without a cover crop in the rotation, sorghum yields increased with fertilizer rate and reached a maximum of 100.6 bu/a at 60 lb/a N. Sorghum following soybean averaged 96.1 bu/a and did not respond significantly to N rate. In the rotation with sunn hemp, sorghum grain production increased significantly only at 60 lb/a N, with the high of 109 bu/a.

Table 1. Residual effects of soybean and sunn hemp summer cover crops and nitrogen rate on no-till wheat after grain sorghum, Hesston, KS, 2006.

Cover Crop[1]	N Rate[2]	Cover Crop Yield[3]		Sorghum Yield 2005	Wheat			
		Forage	N		Yield	Bushel Wt	Plant Ht	Plant N[4]
	lb/a	ton/a	lb/a	bu/a	bu/a	lb	in.	%
None	0	----	----	49.2	5.1	61.1	15	1.51
	30	----	----	74.0	22.2	61.7	21	1.31
	60	----	----	84.5	29.8	61.9	22	1.68
	90	----	----	96.9	35.1	61.4	23	2.13
Soybean	0	2.30	93	73.4	8.4	61.7	16	1.46
	30	2.02	87	81.3	23.0	61.8	20	1.41
	60	2.53	109	92.8	34.2	62.0	24	1.73
	90	1.59	69	96.3	34.3	61.4	22	2.14
Sunn hemp	0	2.95	116	71.7	7.6	61.6	15	1.44
	30	3.10	118	87.2	24.3	62.1	22	1.50
	60	3.26	130	92.7	36.1	62.3	23	1.76
	90	3.47	136	106.7	36.6	61.5	23	1.97
LSD .05		0.71	32	9.7	4.9	0.57	2.3	0.20
Means: Cover Crop/ Termination								
None		----	----	76.2	23.1	61.5	20	1.65
Soybean		2.11	90	85.9	25.0	61.7	21	1.68
Sunn hemp		3.19	125	89.6	26.2	61.9	21	1.67
LSD .05		0.35	16	4.9	2.4	0.28	NS	NS
N Rate								
0		2.62	105	64.8	7.0	61.5	15	1.47
30		2.56	102	80.8	23.2	61.9	21	1.41
60		2.89	119	90.0	33.4	62.0	23	1.72
90		2.53	103	100.0	35.3	61.4	23	2.08
LSD .05		NS	NS	5.6	2.8	0.33	1.3	0.12

[1] Cover crops planted on July 9, 2004, and terminated by early fall.
[2] N applied as 28-0-0 injected June 27, 2005, for sorghum and 34-0-0 broadcast on October 25, 2005, for wheat.
[3] Oven dry weight and N content for sunn hemp and soybean on September 17 and October 4, 2004, respectively.
[4] Whole-plant N concentration at early heading.

Table 2. Effects of soybean and sunn hemp summer cover crops and nitrogen rate on no-till grain sorghum after wheat, Hesston, KS, 2006.

Cover Crop[1]	N Rate[2]	Cover Crop Yield[3] Forage	Cover Crop Yield[3] N	Grain Sorghum 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	----	----	61.1	57.3	25.7	61	1.39	2.19
	30	----	----	74.5	58.9	27.8	60	1.44	2.29
	60	----	----	100.6	59.1	27.2	59	1.73	2.54
	90	----	----	98.3	59.1	25.0	60	1.94	2.74
Soybean	0	2.41	101	92.0	59.3	27.6	59	1.60	2.44
	30	2.06	85	98.5	59.2	26.8	60	1.75	2.45
	60	2.89	125	98.4	59.0	25.7	60	1.89	2.67
	90	2.33	100	95.2	58.7	27.2	60	1.79	2.68
Sunn hemp	0	3.74	116	95.8	59.2	26.2	59	1.81	2.60
	30	4.13	150	102.7	59.0	27.8	58	1.70	2.49
	60	4.34	142	109.0	59.4	27.3	59	1.84	2.69
	90	4.37	145	98.2	59.0	26.5	60	1.83	2.76
LSD .05		0.72	31	9.4	NS	NS	1.6	0.25	0.31
Means: Cover Crop/ Termination									
None		----	----	83.6	58.6	26.4	60	1.62	2.44
Soybean		2.42	103	96.1	59.1	26.8	59	1.76	2.56
Sunn hemp		4.14	138	101.4	59.1	26.9	59	1.80	2.64
LSD .05		0.36	15	4.7	NS	NS	0.8	0.13	0.16
N Rate									
0		3.07	108	83.0	58.6	26.5	59	1.60	2.41
30		3.09	118	91.9	59.0	27.5	59	1.63	2.41
60		3.61	133	102.7	59.2	26.7	59	1.82	2.63
90		3.35	123	97.2	59.0	26.2	60	1.85	2.73
LSD .05		NS	NS	5.4	NS	NS	NS	0.15	0.18

[1] Cover crops planted July 9, 2005 and terminated in early fall.
[2] N applied as 28-0-0 injected July 19, 2006.
[3] Oven dry weight and N content for sunn hemp and soybean on September 26, 2005.
[4] Days from planting to half bloom.
[5] Flag leaf at late boot to early heading.

SOIL FERTILITY RESEARCH
EAST CENTRAL EXPERIMENT FIELD

STRIP-TILL AND NO-TILL TILLAGE/ FERTILIZER SYSTEMS COMPARED FOR CORN

K.A. Janssen, W.B. Gordon, and R.E. Lamond

Summary

Strip-till and no-till tillage/fertilizer systems were compared for corn at the East Central Kansas Experiment Field during 2003-2005. Averaged across all tillage and fertilizer treatments and years, fall strip-till with under-the-row banded fertilizers yielded best and had improved plant stands compared to no-till. No indication of reduced yields with fall strip-till applied fertilizers vs. spring planter-banded fertilizers occurred.

Introduction

Corn producers in East Central and Southeast Kansas need to offset rising fuel and fertilizer costs and must also reduce sediment and nutrient losses via crop land runoff. Cutting back on tillage and sub-surface banding fertilizers are possible management strategies. However, that can be a challenge for corn producers in these areas because of an abundance of imperfectly drained soils and frequent spring rains. The extra residue and slower soil drying associated with no-till can keep no-till fields cool and wet longer in the spring and can delay planting and slow early-season corn growth. Application of pop-up or beside-the-row starter banded fertilizers can offset most of the slowed early-season corn growth with no-till, but delayed planting, reduced plant stands, and the inconvenience of applying starter fertilizers at planting continue to be a deterrent to no-till acceptance.

Strip-tillage is a compromise conservation tillage system. It is a system that includes some tillage, but only where the seed rows are to be planted. Row middles are left untilled. The tilled in-the-row strips provide a raised, loosened seed bed, which improves drainage, warming, and drying. Strip-tillage also allows fertilizers to be precision applied under the row in the same tillage pass, which can offset the need for starter fertilizer application at planting. Strip-tillage with fertilizers banded under the row would seem to be a good fit for growing corn in East Central Kansas.

The objectives of this study were 1) to evaluate the performance of strip-till and no-till systems for corn in East Central Kansas using different nitrogen (N) fertilizer rates, timing and placement methods, and 2) to assess if there is any yield drag from applying strip-till nitrogen (N)-phosphorus (P)-potassium (K)-sulphur (S) fertilizers in the fall versus all fertilizers banded at planting.

Procedures

This study was conducted from 2003 to 2005 at the East Central Kansas Experiment Field near Ottawa, on a somewhat poorly drained Woodson silt loam soil. The field site had been managed no-till for five years prior to starting this study. The experiment design was a randomized complete block with four replications. Tillage and fertilizer treatments and dates that the tillage and fertilization operations were performed are shown in Table 1. The crop preceding the 2003 corn crop was corn and the crops preceding the 2004 and 2005 corn crops were soybean. The herbicides applied for pre-plant weed control were 1qt/a atrazine 4L + 0.66pt/a 2,4-D LVE + 1 qt/a COC. Corn planting was on April 10, 2003, April 15, 2004, and April 13, 2005. Pioneer 35P12 corn was planted all years. Seed-drop was 23,500 seeds/a. After planting, pre-emergence herbicides were applied which included 0.5 qt/a atrazine 4L and1.33 pt/a Dual II Magnum. Plant stand counts, early-season corn growth, and grain yields were taken to evaluate the tillage and fertilization systems. Plant stands were measured by counting all plants in the center two rows of each plot. Early-season corn growth was determined by harvesting, drying and weighing plant tissue from six randomly selected corn plants from each plot at the six-leaf corn growth stage. Grain yields were measured by machine harvesting and weighing the corn from the center two rows of each four-row, 10-ft wide x 40-ft long plots. Harvest was on August 23, 2003, July 10, 2004, and July 8, 2005.

Results

The 2003 corn growing season was hot and dry. Rainfall during April, May, and June was normal, but July and most of August were very hot and dry. There were 48 days during the summer of 2003 in which air temperatures exceeded 90°F. In 2004, rainfall was well distributed with no visual indication of any moisture stress. There were only 13 days in 2004 in which air temperatures exceeded 90°F. In 2005, a series of 29 to 30°F freezing temperatures occurred from April 30 through May 3. Visual evidence of freeze damage was more severe in the no-till plots than in strip-till. However, because the corn's growing point was still below the surface of the soil, most of the freeze-damaged plants recovered. The remainder of the 2005 corn growing season was normal with temperatures periodically exceeding 90°F and available moisture declining through late June, July and early August.

Plant Populations and Early Corn Growth

Tillage and fertilization systems produced statistically significant differences in plant populations and early-season corn growth (Table 1, Figure 1). Plant populations, overall, tended to be better and emergence was more uniform for corn planted using strip-tillage than with no-till. When averaged across all fertilizer treatments, plant populations for 2003 were 15% greater with strip-till compared to no-till. In 2004, strip-till stands increased 7%, and in 2005 plant stands increased 10% with strip-till compared to no-till. The fertilizer N rates and the placement and timing of the fertilizer applications had no effect on plant stands (Figure 1).

In addition to increasing plant stands, Strip-till also increased early-season plant growth compared to no-till. In 2003, V6 plant dry-weights, when averaged across all rates of N (0, 40, 80, and 120 lb/a N), were 25% greater with strip-till and fall-applied fertilizer and 39% greater with strip-till and planter banded fertilizer, compared to no-till (Table 1). Overall, the strip-till system with all the fertilizer applied at planting produced the most early-season corn growth. In 2004, both the strip-till and no-till systems with fertilizers banded at planting produced more early-season growth than strip-till with all fertilizers banded below the row. In 2005, the treatment effects were similar to 2003. Averaged across all growing seasons, most early-season growth occurred when strip tilled corn received 40 lb/a N plus P, K, and S at planting. As the rate of N in the planting time fertilizer bands increased above 40 lb/a, early-season corn growth tended to decline, suggesting possible sensitivity to fertilizer salts or free ammonia with high rates of N and planter-banded fertilizers (Figure 2).

Yield

Strip-tillage, overall, produced better yields compared to no-till (Table 1). In 2003, strip-tillage by itself increased corn yield 12 bu/a compared to no-till. In 2004 and 2005, yields were increased 9 and 10 bu/a, respectively. Yield increases were most likely the result of increased plant stands. There was no evidence that N-P-K-S fertilizers strip-till applied in the fall performed worse than fertilizers applied at planting time, suggesting a possible wide window for strip-till fertilizer applications (Figure 3). Splitting the strip-till fertilizer application (80-15-2.5-2.5 fall + 40-15-2.5-2.5 at planting) produced a significantly higher yield one year (Table 1). From a grower's perspective, that may not be sufficient enough to justify the application of fertilizers at planting time. The standard strip-till fertilization method, with all of the fertilizer injected below the row in the same tillage pass, would seem to be the most practical system. This system should eliminate many of the production concerns associated with no-till and also afford many of the environmental and moisture conservation benefits of no-till.

Table 1. Treatment-mean affects for corn plant population, v6 plant dry matter, and grain yields, East Central Experiment Field, Kansas.

Treatments Tillage x (N-P-K-S, lb/a	Plant Population x 1000 2003	2004	2005	V6 Dry Matter Grams/plant 2003	2004	2005	Grain Yield bu/a 2003	2004	2005
Strip-till with all strip-till banded fertilizer (5" below the row)									
Check 0-0-0-0	21.1	22.1	22.8	2.6	10.0	9.2	78	53	62
40-30-5-5	21.1	22.2	20.3	6.6	12.2	18.1	86	123	91
80-30-5-5	21.2	21.9	22.0	7.1	13.9	15.6	96	160	112
120-30-5-5	21.8	21.7	22.5	7.2	12.7	15.1	91	161	122
Strip-till with all planter banded fertilizer (2.5x2.5 from the seed row)									
40-30-5-5	21.0	22.4	21.3	9.1	17.6	18.0	90	116	91
80-30-5-5	21.3	22.1	20.6	7.6	18.1	16.2	88	144	108
120-30-5-5	22.2	22.1	20.9	6.7	16.7	12.4	78	160	118
Strip-till with some strip-till and some planter banded fertilizer									
80-15-2.5-2.5 fall + 40-15-2.5-2.5 at planting	21.1	21.9	22.2	7.8	17.8	15.2	89	167	133
No-tillage with all planter banded fertilizer (2.5x2.5 from the seed row)									
Check 0-0-0-0	18.4	20.2	19.3	2.4	8.5	8.5	66	44	52
40-30-5-5	18.8	21.1	18.4	6.2	16.9	15.7	80	101	82
80-30-5-5	18.8	20.3	18.9	5.4	15.8	14.6	90	133	99
120-30-5-5	18.1	21.1	18.9	4.8	16.5	12.8	86	149	117
No-tillage with all preplant deep-banded fertilizer (15" centers x 4" de[th)									
120-30-5-5	18.9	20.1	22.4	4.8	15.0	16.1	87	163	109
LSD 0.05	2.4	1.9	2.4	3.0	1.7	2.3	9	17	10

2003
Fall strip-till and fall banded fertilizer: 11/2/02
Pre-plant deep banded fertilizer, no-till: 3/26/03
Planter-banded fertilizer: 4/10/03

2004
Fall strip-till and fall banded fertilizer: 12/2/03
Pre-plant deep banded fertilizer, no-till: 4/14/04
Planter-banded fertilizer: 4/15/04

2005
Fall (*Spring*) strip-till and spring banded fertilizer 4/01/05
Pre-plant deep-banded fertilizer, no-till: 4/01/05
Planter-banded fertilizer: 4/13/05

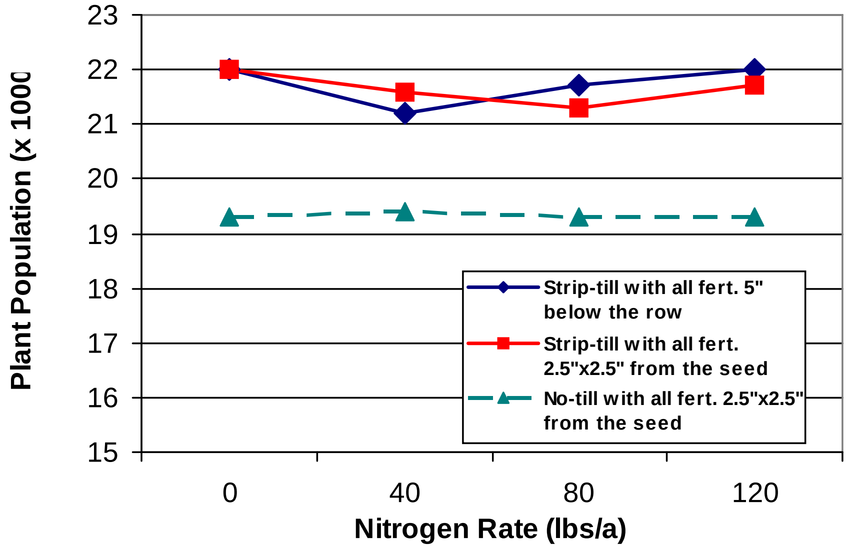

Figure 1. Three-year-average corn plant populations as affected by tillage, N rate, timing and placement of fertilizer.

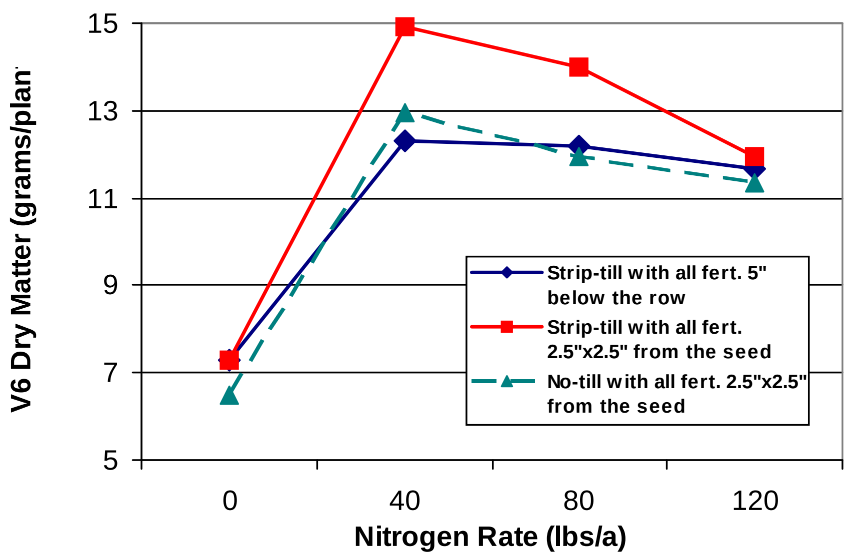

Figure 2. Three-year-average early-season corn growth as affected by tillage, N rate, timing and placement of fertilizer.

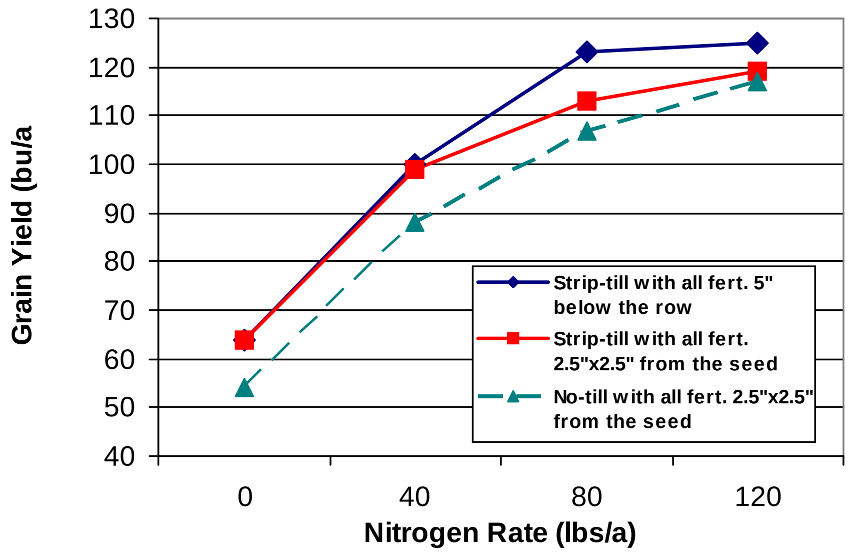

Figure 3. Three-year-average corn grain yields as affected by tillage, N rate, timing and placement of fertilizer.

CORN AND GRAIN SORGHUM FERTILIZATION STUDIES KANSAS STATE UNIVERSITY DEPARTMENT OF AGRONOMY

EFFECTS OF PHOSPHORUS APPLICATION ON GRAIN SORGHUM YIELD

D.F. Leikam and A.J. Schlegel

Summary

A series of corn and grain sorghum studies were conducted across the state over the past several years to help refine the information needed for crop nutrient recommendations. As part of this project, a long-term grain sorghum study was established at the Tribune Experiment Station. This location is irrigated in order to maximize the probability of obtaining meaningful information each crop year. Since 2004, this study has had annual phosphate application treatments of 0, 20, 40, 80, and 120 lb/a of P_2O_5 . Grain yields have generally increased with increasing phosphate rates of up to 80 lb/a of P_2O_5.

Introduction

Over the past four years, several corn and grain sorghum studies have been conducted across the state in order to improve crop nutrient phosphorus (P) and potassium (K) recommendations. In order to meet this objective, the following information is being gathered from various studies conducted across the state of Kansas; 1) crop response to various rates of P and/or K application at various soil test levels, 2) percent sufficiency (for maximum yield) at various soil test levels, 3) amounts of P and K nutrient application/ crop removal to change soil test levels, 4) amounts of P and K removed in the harvested grain, and, 5) relationship among common P soil test methods used in Kansas (Bray P1, Mehlich 3 and Olsen P).

This project was initiated for the 2003 crop and continued through the 2005 crop year – while this particular study was initiated in 2004 and will continue into the future. After a wide range of P soil tests are established with these treatments, the study treatments will change to fit evolving grain sorghum fertilization issues.

Procedures

Soil samples from the 0- to 6-inch depth were collected from individual plots. Phosphorus rates of 0, 20, 40, 80, and 120 lbs/a P_2O_5 were preplant broadcast applied in late winter and incorporated with subsequent tillage. Grain yields were obtained by harvesting the center two rows of each plot. The treatments were replicated six times.

Results

Grain yields for the 2004, 2005, and 2006 crop years are reported in Table 1. Harvested grain sorghum yield responded to P fertilizer application each year and were optimized with about 80 lb/a P_2O_5 per year. At this location, current Kansas State University P sufficiency recommendations would suggest about 45 lb/a P_2O_5 each year. This is a bit lower than the optimum rate for this study in these crop years.
a grain sorghum yield potential of 120 bu/a and a Mehlich-3 P soil test value of 7 ppm P,

Soil samples from the 0-6 inch depth were collected from individual plots at some locations and from individual replications at others. For phosphorus, Bray P1 and Mehlich-3 soil test procedures were run on individual samples. While some of the plots were calcareous (contained free calcium carbonate), the Bray P1 soil test extractant was highly correlated to the Mehlich-3 and Olsen P soil test procedures (Figure 1).

This study will continue in future years with soil samples and grain sorghum yields collected each year.

Table 1. Effects of potassium application to grain sorghum, Greeley Co., Kansas, 2004-06.

	Grain Sorghum Grain			
P_2O_5 Rate	2004 Yield	2005 Yield	2006 Yield	2004-06 Average
- lb/a -	bu/a			
0	92	77	124	98
20	108	108	135	115
40	108	93	134	112
80	117	102	142	121
120	120	100	137	119
Sig. Level	< 0.01	0.04	0.11	< 0.01

Initial Bray P1 soil test – average of 7 ppm.

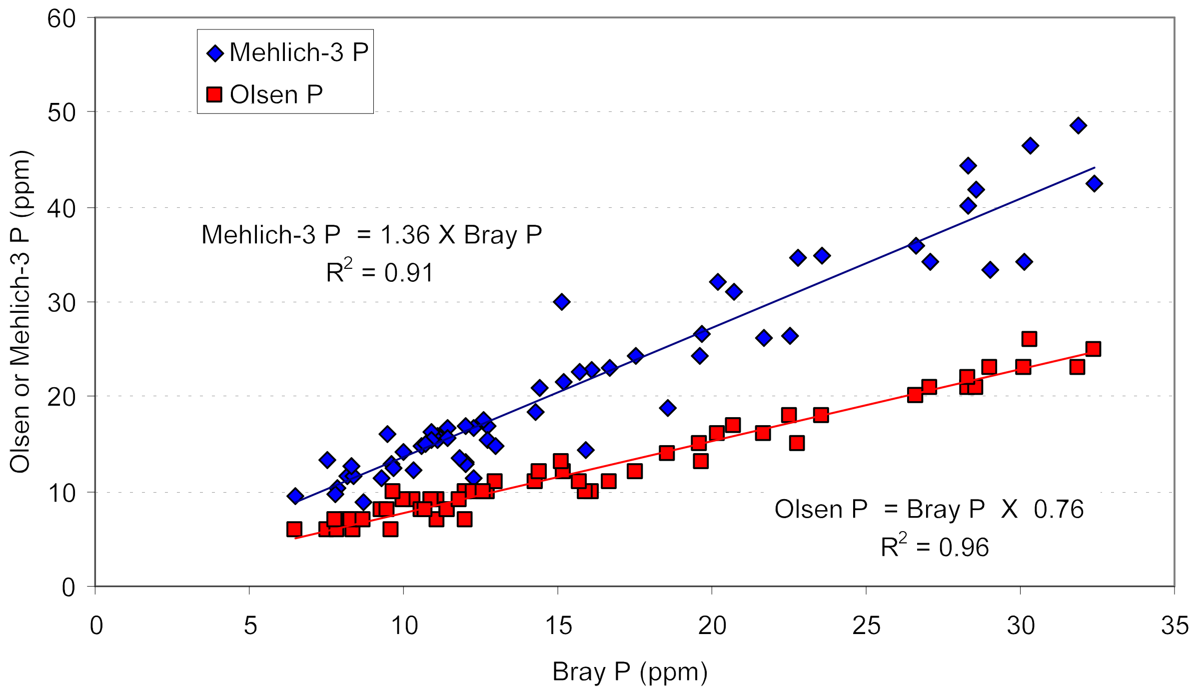

Figure 1. Relationship of Mehlich-3, Bray and Olsen P soil tests, spring 2006 samples, Tribune, KS.

EFFECTS OF PHOSPHORUS APPLICATION ON CORN YIELD

D.F. Leikam and A.J. Schlegel

Summary

A series of corn and grain sorghum studies have been conducted across the state over the past several years to help refine the information needed for crop nutrient recommendations. As part of this project, a long-term irrigated corn study was established at the Tribune Experiment Station. Since 2004, this study has had annual phosphate application treatments of 0, 20, 40, 80, and 120 lb/a P_2O_5. Grain yields generally increased with increasing phosphate rates up to 80-120 lb/a P_2O_5.

Introduction

Over the past four years, several corn and grain sorghum studies have been conducted across the state in order to improve crop nutrient phosphorus (P) and potassium (K) recommendations. In order to meet this objective, the following information is being compiled from various studies conducted across the state of Kansas; 1) crop response to various rates of P and/or K application at various soil test levels, 2) percent sufficiency (for maximum yield) at various soil test levels, 3) amount of P and K nutrient application/crop removal to change soil test levels, 4) amounts of P and K removed in the harvested grain, and, 5) relationship among common P soil test methods used in Kansas (Bray P1, Mehlich-3 and Olsen P).

This project was initiated in 2003 and continued through 2005. This particular study started in 2004 and will continue into the future. After a wide range of P soil tests are established with these treatments, the study treatments will change to fit evolving corn fertilization issues.

Procedures

Soil samples from the 0- to 6-inch depth were collected from individual plots. Phosphorus rates of 0, 20, 40, 80, and 120 lb/a P_2O_5 were preplant broadcast applied in late winter and incorporated with subsequent tillage. Grain yields were obtained by harvesting the center two rows of each plot.The treatments were replicated six times.

Results

Grain yields for the 2004, 2005 and 2006 crop years are reported in Table 1. Harvested corn grain yield responded to P fertilizer application each year and were optimized with about 80 to 120 lb/a P_2O_5 per year. At this location, current Kansas State University P sufficiency recommendations would suggest about 55 lbs/a of P_2O_5 each year for a 200 bu/a yield goal for corn. This is lower than the 80 lb/a to 120 lb/a P_2O_5 rate required for optimum production for this study in these years.

Soil samples from the 0- to 6-inch depth were collected from individual plots at some locations and from individual replications at others. For phosphorus, Bray P1 and Mehlich-3 soil test procedures were run on individual samples. While some of the plots were calcareous (contained free calcium carbonate), the Bray P1 soil test extractant was highly correlated to the Mehlich-3 and Olsen P soil test procedures (Figure 1).

This study will continue with soil samples and corn yields collected each year.

Table 1. Effects of phosphorus application to corn, Greeley Co., Kansas, 2004-2006.

	Corn Grain			
P_2O_5 Rate	2004 Yield	2005 Yield	2006 Yield	Avg. 2004-06
- lb/a -	- - - - - - - - - - - bu/a - - - - - - - - - - -			
0	180	118	122	140
20	191	145	163	166
40	206	154	187	182
80	222	163	204	196
120	222	170	208	200
Sig. Level	< 0.01	< 0.01	< 0.01	< 0.01

Initial Bray P1 soil test – range of 7-9 ppm; average of 8 ppm.

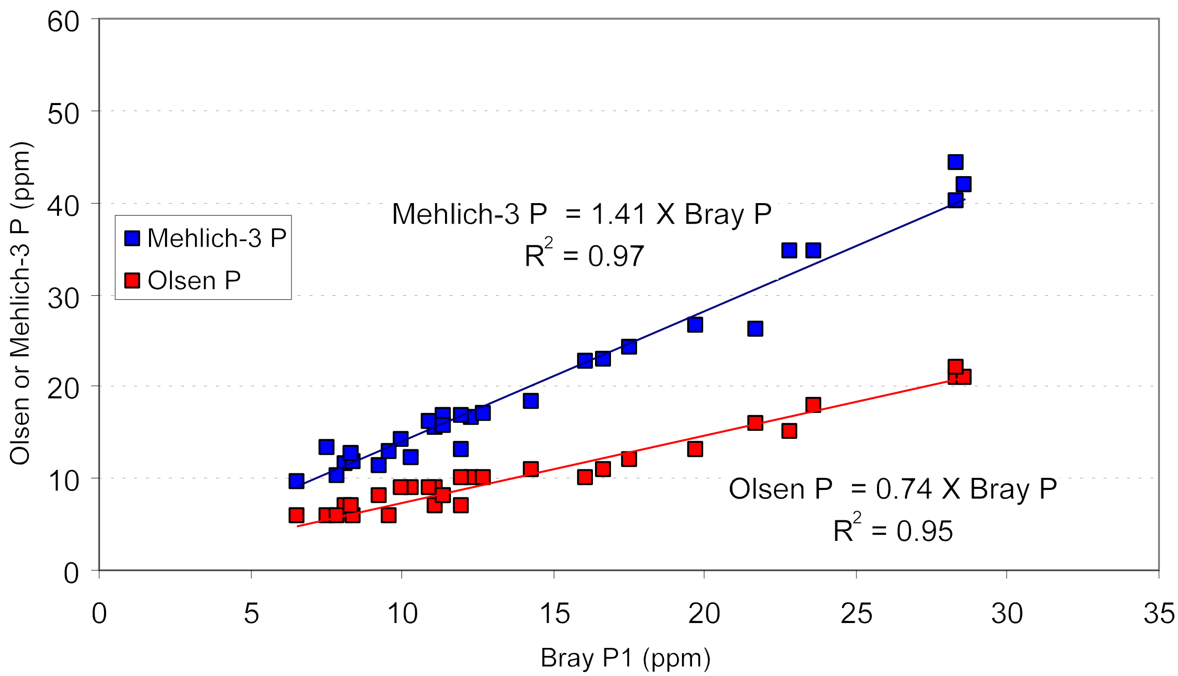

Figure 1. Relationship of Mehlick-3, Bray and Olsen P soil tests, spring 2006 samples, Tribune, KS.

EFFECTS OF POTASSIUM ON IRRIGATED CORN YIELD IN WESTERN KANSAS

D.F. Leikam and T. Roberts

Summary

While relatively low potassium (K) soil test values are found on some coarsely textured soils in southwest Kansas, it is generally thought that these soils would not be as responsive to K application as eastern Kansas soils with similar soil test values. Corn grain yields were significantly increased with K application at one site (15% level) and were not affected at another nearby site.

Introduction

Relatively low K soil test levels can be found on coarsely textured soils in much of south central and southwest Kansas. However, these soils do not seem to be as responsive to applied fertilizer K as medium-fine textured soils in the eastern part of Kansas. The number of fields exhibiting K deficiency of corn in the eastern part of the state on soils testing greater than commonly accepted critical values are increasing. As a result, there is more interest in determining if the commonly used K soil test and critical values are useful in western Kansas.

With this in mind, a simple application study with and without fertilizer K was conducted on low K soil test, irrigated sandy soils in Stevens county.

Procedures

Soil samples from the 0- to 6-inch soil depth were collected from two fields and analyzed for exchangeable soil test potassium. The west location was located on the top of a hill within a field and was finer textured than the east location. The east location was in a low spot within an irrigated field.

Potassium application rates of 0 and 120 lb/a K_2O were broadcast applied to these sprinkler irrigated fields and replicated four times in each of two studies. Corn grain was hand harvested from 20 feet of row in the center of each plot.

Results

Corn yields were somewhat variable within the studies and random variability relatively high. This is largely due to the variability in soils within these rather sandy fields.

Grain yields were significantly increased at the lower testing west location ($p > f = 0.15$), but were not significantly different at the east site (only trended higher). While no firm conclusions can be drawn from these efforts, it seems that these irrigated, coarsely textured soils may respond to fertilizer K but may be less responsive than eastern Kansas soils. The east location had soil test values higher than expected critical K soil test values, while the west location was precisely at the established critical K soil test value.

These sites were both initially thought to be lower in soil test potassium than what they were ultimately shown to be. At least part of this difference may be related to sampling depth. It seems that 0- to 6-inch soil samples do not provide as low of K soil test results as samples collected to a deeper depth. Initial samples were collected to a depth of about 10 to 12 inches.

Table 1. Effects of potassium application to corn, Stevens Co., Kansas, 2006.

	East location		West location	
	K Rate	Corn Yield	K Rate	Corn Yield
	lb/a K_2O	bu/a	lb/a K_2O	bu/a
	0	168	0	160
	120	178	120	171
Significance Level	0.34		0.15	

East location:

Soil Test Information
Exch. K = 265 ppm
Mehlich-3 P = 46 ppm

West location:

Soil Test Information
Exch. K = 151 ppm
Mehlich-3 P = 17 ppm

INDEX - 2006 KANSAS FERTILIZER REPORT

CROP

Corn

Cool-Season and Warm-Season Grasses

Grain Sorghum

Soybean

Wheat

Miscellaneous

CONTRIBUTORS TO THE REPORT

M. Alam, Extension Specialist, Southwest Area Extension Office, Garden City
H.D. Bond, Assistant Scientist, Southwest Research-Extension Center, Tribune
M.M. Claassen, Agronomist-in-Charge, Harvey County Experiment Field, Hesston
W.B. Gordon, Agronomist-in-Charge, North Central Kansas Experiment Field, Scandia
W.F. Heer, Agronomist-in-Charge, Southcentral Experiment Field, Hutchinson
K.A. Janssen, Agronomist-in-Charge, East Central Kansas Experiment Field, Ottawa
K.W. Kelley, Agronomist, Southeast Agricultural Research Center, Parsons
G.L. Kilgore, Agronomist, Southeast Area Extension Office, Chanute
R.E. Lamond, Extension Specialist, Soil Fertility & Management, Dept. of Agronomy, KSU, Manhattan
D.F. Leikam, Extension Specialist, Nutrient Management, Dept. of Agronomy, KSU, Manhattan
T.M. Maxwell, Saline County Agricultural Extension Agent, Salina
J.L. Moyer, Professor, Southeast Agricultural Research Center, Parsons
T. Roberts, Stevens County Agricultural Extension Agent, Hugoton
A.J. Schlegel, Agronomist, Southwest Research-Extension Center, Tribune
L.R. Stone, Professor, Soil and Water Management, Dept. of Agronomy, KSU, Manhattan
D.W. Sweeney, Agronomist, Southeast Agricultural Research Center, Parsons

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