K-STATE
Kansas State University

Kansas Fertilizer Research 2004

Report of Progress 939

Agricultural Experiment Station
and Cooperative Extension Service

INTRODUCTION

The 2004 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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Cover photo provided by Chad Godsey, KSU Soil Testing Laboratory

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TABLE OF CONTENTS

Publications, including this progress report, from K-State Research and Extension are available on the World Wide Web at *http://www.oznet.ksu.edu*

Precipitation Data (Inches)

2003	Manhattan	S.W. KS RES-EXT. CTR Tribune	S.E. KS EXP. STA. Parsons	E. CEN EXP. FLD. Ottawa	HARVY CTY EXP. FLD Hesston
August	5.03	1.08	6.23	5.14	4.78
September	3.22	0.92	3.51	7.44	4.55
October	2.57	0.03	2.47	1.49	4.53
November	1.00	0.22	2.83	0.77	0.09
December	1.09	0.21	3.44	2.62	1.37
Total 2003	33.44	16.09	44.61	36.51	32.43
Dept. Normal	-0.39	+0.13	+4.59	-2.86	-0.82
2004					
January	0.63	0.17	1.43	1.78	1.28
February	1.45	0.43	0.50	0.71	0.99
March	5.10	1.02	5.38	6.17	5.25
April	2.06	4.11	4.53	2.37	1.61
May	3.30	0.01	3.69	6.12	2.32
June	6.60	7.43	5.47	6.27	5.31
July	7.24	4.27	3.34	7.42	5.84
August	6.16	3.59	2.80	4.06	2.44
September	1.35	2.32	1.55	1.19	1.31

2003	N. CEN EXP. FLD. Belleville	KANSAS RV VALLEY EXP. FLD.	S. CEN. EXP. FLD. Hutchinson	FT. HAYS EXP. STN. Hays
August	5.71	6.17	5.15	2.99
September	6.70	1.95	1.83	6.46
October	0.37	0.67	3.65	0.39
November	1.10	0.43	0.05	0.15
December	0.62	1.26	1.44	0.43
Total 2003	32.23	23.52	28.94	23.35
Dept. Normal	+1.34	-14.52	-1.38	+0.75
2004				
January	1.16	0.24	0.51	0.32
February	0.91	0.79	0.63	0.68
March	3.50	2.78	5.71	2.03
April	0.58	1.42	5.08	1.49
May	6.14	3.61	3.29	1.55
June	3.79	5.51	6.78	4.27
July	2.05	5.90	7.39	7.45
August	0.68	7.02	2.39	1.76
September	2.07	0.91	1.67	2.12

WHEAT FERTILIZATION STUDIES
KANSAS STATE UNIVERSITY - DEPARTMENT OF AGRONOMY

EFFECTS OF SEVERAL NEW PHOSPHATE PRODUCTS ON WHEAT YIELD

T. Maxwell, S. Campbell, J. Massey, and D. Leikam

Summary

Wheat responded to phosphorus (P) application at the Saline County location. Drought severely limited grain yields in Ellis county precluding the possibility of yield response to applied P fertilizer. Although there was some difference among products, no conclusions about the superiority of one source over the others exists.

Introduction

Fertilizer companies continue to evaluate different products and processing technology for producing crop nutrients. Studies were established in Ellis County in western Kansas and Saline County in central Kansas to evaluate several P fertilizer products being evaluated by Cargill.

Procedures

Soil tests for these locations are presented below. Broadcast/incorporated N, NP, or NPS applications (rates below) were made on September 23, 2003 and wheat planted within the next two weeks. Both locations were topdressed (N rates of 50 and 80 lbs N/A at Ellis and Saline County, respectively) in late February 2004.

Results

It was a difficult year for wheat in parts of Kansas this year, with drought conditions and late freeze in the western part of the state severely limiting yields. In addition, persistent wet weather in June early July hampered wheat harvest across the state, with sprouting causing problems in local areas across the state.

The Ellis County location provided yields of about 15-20 bu/a with no response to applied P fertilizer. Saline County provided response to P application and some differences among P products. Tissue and grain P analysis data are presented along with grain yield data from the two locations in Tables 2 and 3.

Table 1. Soil test values for Saline and Ellis Counties, Kansas, 2004.

	pH	Bray-1 P	Olsen-P	Mehlich-P	OM
Location		ppm	ppm	ppm	%
Saline Co.	7.7	12.5	7.5	15.0	2.4
Ellis Co.	6.3	9.0	6.0	8.5	2.2

Table 2. Effects of phosphorus fertilizer on wheat grain yield, Saline County, Kansas, 2004.

	Balancing Urea N	P_2O_5	S	Leaf P	Grain Yield	Grain P
	- - - - - - - lb/a - - - - - - -			%	bu/a	lb P_2O_5/bu
Check	24	0	0	.27	47	.44
Product 1	11	40	18	.26	62	.49
Product 2	16	40	0	.27	55	.49
Product 3	13	40	10	.26	63	.48
Product 4	13	40	10	.26	60	.45
MAP	16	40	0	.28	66	.47
MAP + Amm Sulfate	0	40	18	.26	61	.48
		Probability Level		.22	.08	NS
		LSD (0.10)		NS	9.6	NS

Table 3. Effect of phosphorus fertilizer on wheat grain yield, Ellis County, Kansas, 2004.

	Balancing Urea N	P_2O_5	S	Leaf P	Grain Yield	Grain P
	- - - - - - - lb/a - - - - - - -			%	bu/a	lb P_2O_5/bu
Check	24	0	0	.22	18	.35
Product 1	11	40	18	.23	17	.37
Product 2	16	40	0	.25	16	.39
Product 3	13	40	10	.24	18	.39
Product 4	13	40	10	.24	19	.37
MAP	16	40	0	.24	16	.40
MAP + Amm Sulfate	0	40	18	.24	16	.37
		Probability Level		.13	NS	.12
		LSD (0.10)		.018	NS	.027

GRASS FERTILIZATION STUDIES
KANSAS STATE UNIVERSITY - DEPARTMENT OF AGRONOMY

EFFECTS OF CHLORIDE RATES AND SOURCES ON BROME IN KANSAS

C.B. Godsey, R.E. Lamond, and L.J. Ferdinand

Summary

Smooth bromegrass is an important agronomic crop in eastern Kansas. Preliminary work with chloride fertilizer on smooth bromegrass in Kansas indicates that soils testing low in chloride may be responsive to the addition of chloride.

Introduction

Limited research has focused on using chloride fertilizers to increase smooth bromegrass production. For wheat and some other cereal grains, chloride (Cl) has been reported to have an effect on plant diseases, either suppressing the disease organism or allowing the plant to be able to withstand infection. The objective of these studies were to evaluate the effects of Cl fertilization on forage yields of smooth bromegrass in Kansas.

Procedures

Three field sites in Kansas were identified that had a history of brome production. Sites were located in Riley County, Pottawatomie County, and Osage County. Treatments consisted of three chloride rates (0, 10, 20 lb Cl/a) and two chloride sources (KCl, NH_4Cl). All treatments were balanced at 90 lb N/a. Treatments were replicated four times in a randomized complete-block design. Treatments were applied in late February 2004 and plots were harvested on May 25, 2004. Yields were determined by harvesting a 30-in. section of each plot and weighing the biomass. A sub-sample from each plot was collected and dried to determine moisture content. Samples were then ground and analyzed for plant nitrogen and chloride concentration.

Results

Results from this study are presented in Tables 1 and 2. Chloride concentration in soil samples collected from each site indicated that the Osage County site was the only site that tested medium to low for chloride concentration ($\leq$6 ppm). On average, chloride concentration in tissue increased with increasing rates of chloride at all sites. However, nitrogen percentage in tissue was not effected by chloride fertilization. Forage yield was increased at Osage County with the application of 20 lb Cl/a as NH_4Cl, compared with the control. In addition, 10 lb Cl/a as KCl increased forage yield, compared with that of the control at Osage County. The results of this study indicate a yield response may be observed if chloride fertilizer is applied to bromegrass on low-testing chloride soils (6 ppm or below).

This study will be continued in 2005.

Table 1. Tissue concentration of nitrogen and chloride in brome.

Cl	Cl	N (%)			Cl^- (ppm)		
Rate	Source	Riley Co.	Pott. Co.	Osage Co.	Riley Co.	Pott. Co.	Osage Co.
lb/a		- lb/a -					
0	- - -	1.65	1.36	3.10	7116	2309	3736
10	NH_4Cl	1.70	1..50	3.12	7008	3313	5926
20	NH_4Cl	1.85	1.43	2.96	7728	5403	6666
10	KCl	1.50	1.51	3.00	6931	3799	4866
20	KCl	1.62	1.48	2.99	7630	3813	6281
LSD (.10)		NS	NS	NS	700	1272	1027

Nitrogen balanced at 90 lb/a on all treatments

Table 2. Forage yield of brome at all locations in 2004.

Cl	Cl		Forage Yield		
Rate	Source		North Farm	Pott. Co.	Osage Co.
lb/a			- - - - - - - - - - - lb/a - - - - - - - - - - -		
0	- - -		3180	6120	5410
10	NH_4Cl		3320	6630	5740
20	NH_4Cl		3490	6820	6110
10	KCl		3890	6410	5890
20	KCl		3560	6390	5760
LSD (.10)			NS	NS	370
Soil Test Cl, ppm			11	9	6

Nitrogen balanced at 90 lb/a on all treatments

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 2004, N and P applied alone increased yields about 95 and 30 bu/a, respectively; however, N and P applied together increased yields up to 173 bu/a. Averaged across the past 10 years, corn yields were increased more than 100 bu/a by N and P fertilization. Application of 120 lb N/a (with P) was sufficient to produce ≥95% of maximum yield in 2004, which was consistent with the 10-year average. Phosphorus increased corn yields from 72 to 131 bu/a (average about 100 bu/a) when applied with at least 120 lb N/a. Application of 80 lb P_2O_5/a increased yields 5 to 9 bu/a compared to 40 lb P_2O_5/a when applied with at least 120 lb N/a.

Introduction

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

Procedures

Initial fertilizer treatments in 1961 were N rates of 0, 40, 80, 120, 160, and 200 lb N/a without P and K; with 40 lb P_2O_5/a and zero K; and with 40 lb P_2O_5/a and 40 lb K_2O/a. In 1992, the treatments were changed, with the K variable being replaced by a higher rate of P (80 lb P_2O_5/a). All fertilizers were broadcast by hand in the spring and incorporated before planting. The soil is a Ulysses silt loam. The corn hybrids were Pioneer 3225 (1995-97), Pioneer 3395IR (1998), Pioneer 33A14 (2000), Pioneer 33R93 (2001 and 2002), DeKalb C60-12 (2003), and Pioneer 34N45 (2004) planted at about 32,000 seeds/a in late April or early May. Hail damaged the 2002 crop and destroyed the 1999 crop. The corn was irrigated to minimize water stress. Furrow irrigation was used through 2000, and sprinkler irrigation has been used since 2001. The center 2 rows of each plot were machine harvested after physiological maturity. Grain yields were adjusted to 15.5% moisture.

Results

Corn yields in 2004 were considerably higher than the 10-year average (Table 1). Nitrogen alone increased yields up to 95 bu/a, whereas P alone increased yields about 30 bu/a. However, N and P applied together increased corn yields up to 173 bu/a. Only 120 lb N/a with P was required to obtain ≥95% of maximum yields, which is consistent with the 10-year average. Corn yields were 2 bu/a greater with 80 than with 40 lb P_2O_5/a, compared to the 10-year average of 4 bu/a. However, with N rates of 120 lb N/a or greater, the higher P rate increased yields about 7 bu/a in 2004.

Table 1. Effects of nitrogen and phosphorus fertilizers on irrigated corn, Tribune, Kansas, 1995-2004.

		Grain Yield									
Nitrogen	P_2O_5	1995	1996	1997	1998*	2000	2001	2002	2003	2004	Mean
- - - - lb/a - - - -		- bu/acre- -									
0	0	22	58	66	49	131	54	39	79	67	63
0	40	27	64	79	55	152	43	43	95	97	73
0	80	26	73	83	55	153	48	44	93	98	75
40	0	34	87	86	76	150	71	47	107	92	83
40	40	68	111	111	107	195	127	69	147	154	121
40	80	65	106	114	95	202	129	76	150	148	121
80	0	34	95	130	95	149	75	53	122	118	97
80	40	94	164	153	155	205	169	81	188	209	157
80	80	93	159	155	149	211	182	84	186	205	158
120	0	39	97	105	92	143	56	50	122	103	90
120	40	100	185	173	180	204	177	78	194	228	169
120	80	111	183	162	179	224	191	85	200	234	174
160	0	44	103	108	101	154	76	50	127	136	100
160	40	103	185	169	186	203	186	80	190	231	170
160	80	100	195	187	185	214	188	85	197	240	177
200	0	62	110	110	130	165	130	67	141	162	120
200	40	106	180	185	188	207	177	79	197	234	173
200	80	109	190	193	197	218	194	95	201	239	182
ANOVA											
N		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
P_2O_5		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic		0.001	0.001	0.001	0.001	0.001	0.001	0.007	0.001	0.001	0.001
N x P		0.001	0.001	0.001	0.001	0.008	0.001	0.133	0.001	0.001	0.001
MEANS											
N, lb/a	0	25	65	76	53	145	48	42	89	87	70
	40	56	102	104	93	182	109	64	135	132	108
	80	74	139	146	133	188	142	73	165	178	137
	120	83	155	147	150	190	142	71	172	188	144
	160	82	161	155	157	190	150	71	172	203	149
	200	92	160	163	172	197	167	80	180	212	158
	$LSD_{0.05}$	7	10	12	11	10	15	8	9	11	6
P_2O_5, lb/a	0	39	92	101	91	149	77	51	116	113	92
	40	83	148	145	145	194	147	72	168	192	144
	80	84	151	149	143	204	155	78	171	194	148
	$LSD_{0.05}$	5	7	9	7	7	10	6	6	8	4

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

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 2003, N and P applied alone increased yields about 50 and 13 bu/a, respectively; however, 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 N/a (with P) was sufficient to produce >90% of maximum yield in 2003 and for the 10-year average. Application of K had no effect on sorghum yield in 2003 or averaged across all years.

Introduction

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

Procedures

Fertilizer treatments initiated in 1961 were N rates of 0, 40, 80, 120, 160, and 200 lb N/a without P and K; with 40 lb P_2O_5/a and zero K; and with 40 lb P_2O_5/a and 40 lb K_2O/a. All fertilizers were broadcast by hand in the spring and incorporated before planting. The soil is a Ulysses silt loam. Sorghum (Mycogen TE Y-75 from 1992-1996, Pioneer 8414 in 1997, and Pioneer 8500/8505 from 1998-2003) was planted in late May or early June. Irrigation was used to minimize water stress. Furrow irrigation was used through 2000, and sprinkler irrigation has been used since 2001. The center 2 rows of each plot were machine harvested after physiological maturity. Grain yields were adjusted to 12.5% moisture.

Results

Grain sorghum yields in 2003 were higher than the 10-year average (Table 1). Nitrogen alone increased yields up to 51 bu/a, whereas P alone increased yields 13 bu/a. Nitrogen and P applied together increased sorghum yields more than 65 bu/a. Only 40 lb N/a was required to obtain >90% of maximum yields which was consistent with the 10-year average. Sorghum yields were not affected by K fertilization, which has been true throughout the study period.

Table 2. Effects of nitrogen, phosphorus, and potassium fertilizers on irrigated sorghum yields, Tribune, Kansa, 1994-2003*.

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

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

ANIMAL WASTE APPLICATIONS FOR IRRIGATED CORN

A.J. Schlegel, L.R. 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 (effluent water from a lagoon) and cattle (solid manure from a beef feedlot) wastes have been applied annually since 1999 at rates to meet estimated corn P or N requirements, along with a rate double the N requirement. Other treatments were nitrogen (N) fertilizer (60, 120, and 180 lb N/a) and an untreated control. Corn yields were increased by application of animal wastes and N fertilizer. Over-application of cattle manure has not had a negative effect on corn yield. For swine effluent, over-application has not reduced corn yields except in 2004, when the effluent had much greater salt concentration than in previous years, which caused reduced germination and poor early growth.

Introduction

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

Procedures

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

The study was established in border basins to facilitate effluent application and flood irrigation. The swine effluent was flood-applied as part of a pre-plant irrigation each year. Plots not receiving swine effluent were also irrigated at the same time to balance water additions. The cattle manure was hand-broadcast and incorporated. The N fertilizer (granular NH_4NO_3) was applied with a 10-ft fertilizer applicator (Rogers Mfg.). The entire study area was uniformly irrigated during the growing season with flood irrigation in 1999 through 2000 and sprinkler irrigation in 2001 through 2004. The soil is a Ulysses silt loam. Corn was planted at about 33,000 seeds/a in late April or early May each year. Grain yields are not reported for 1999 because of severe hail damage. Hail also damaged the 2002 crop. The center four rows of each plot were machine harvested after physiological maturity, with yields adjusted to 15.5% moisture.

Results

Corn yields were increased by all animal-waste and N-fertilizer applications in 2004, as has been true for all years except 2002, in which yields were greatly reduced by hail damage (Table 3). The type of animal waste affected yields in 3 of the 5 years, with higher yields from cattle manure than from swine effluent. Averaged across the 5 yr, 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 has had no negative impact on grain yield in any year. However, over-application of swine effluent reduced yields in 2004 because of considerably greater salt content (2-3 times greater electrical conductivity than any previous year), causing germination damage and poor stands.

Table 1. Application rates of animal wastes, Tribune, Kansas, 1999 to 2004.

Appl. Basis*	Cattle Manure						Swine Effluent					
	1999	2000	2001	2002	2003	2004	1999	2000	2001	2002	2003	2004
	- - - - - - - - - - - - - - - ton/a - - - - - - - - - - - - -						- - - - - - - - - - - 1000 gal/a - - - - - - - - - - -					
P req.	15.0	4.1	6.6	5.8	8.8	4.9	28.0	75.0	62.0	63.4	66.9	74.1
N req.	15.0	6.6	11.3	11.4	0	9.8	28.0	9.4	38.0	0	0	40.8
2xN req.	30.0	13.2	22.6	22.8	0	19.7	56.0	18.8	76.0	0	0	81.7

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

Table 2. Analysis of animal waste as applied, Tribune, Kansas, 1999 to 2004.

Appl. Basis*	Cattle Manure						Swine Effluent					
	1999	2000	2001	2002	2003	2004	1999	2000	2001	2002	2003	2004
	- - - - - - - - - - - - lb/ton - - - - - - - - - - - - - -						- - - - - - - - - - - - 1000 gal/a - - - - - - - - - - - -					
Total N	27.2	36.0	33.9	25.0	28.2	29.7	8.65	7.33	7.83	11.62	7.58	21.42
Total P_2O_5	29.9	19.6	28.6	19.9	14.6	18.1	1.55	2.09	2.51	1.60	0.99	2.10

Table 3. Effects of animal waste and N fertilizer on irrigated corn, Tribune, Kansas, 2000-2004.

Nutrient Source	Rate Basis[†]	Grain yield 2000	2001	2002	2003	2004	Mean
		- - - - - -	- - - -	- - - bu/acre	- - -	- - - -	- - - - - -
Cattle manure	P	197	192	91	174	241	179
	N	195	182	90	175	243	177
	2 X N	195	185	92	181	244	179
Swine effluent	P	189	162	74	168	173	153
	N	194	178	72	167	206	163
	2 X N	181	174	71	171	129	145
N fertilizer	60 N	178	149	82	161	170	148
	120 N	186	173	76	170	236	168
	180 N	184	172	78	175	235	169
Control	0	158	113	87	97	94	110
$LSD_{0.05}$		22	20	17	22	36	14
ANOVA							
Treatment		0.034	0.001	0.072	0.001	0.001	0.001
Selected contrasts							
Control vs. treatment		0.001	0.001	0.310	0.001	0.001	0.001
Manure vs. fertilizer		0.089	0.006	0.498	0.470	0.377	0.200
Cattle vs. swine		0.220	0.009	0.001	0.218	0.001	0.001
Cattle 1x vs. 2x		0.900	0.831	0.831	0.608	0.973	0.747
Swine 1x vs. 2x		0.237	0.633	0.875	0.730	0.001	0.011
N rate linear		0.591	0.024	0.639	0.203	0.001	0.006
N rate quadratic		0.602	0.161	0.614	0.806	0.032	0.107

[†]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.

SOIL FERTILITY RESEARCH
SOUTHEAST AGRICULTURAL RESEARCH CENTER

TILLAGE AND NITROGEN FERTILIZATION EFFECTS ON YIELDS IN A GRAIN SORGHUM - SOYBEAN ROTATION

D.W. Sweeney and K.W. Kelley

Summary

During a 20-year grain sorghum-soybean rotation, grain sorghum yields were generally greater with conventional or reduced tillage than with no tillage and with N fertilization, especially as anhydrous NH_3. In contrast, during the 20 years, soybean yield was unaffected by tillage or residual N. At the end of the 20-year study, tillage options resulted in distribution differences of soil organic-matter content in the top six inches, but no overall difference in concentration. Soil bulk density at the end of 20 years was unaffected by tillage or N fertilization choices.

Introduction

Many rotational systems are employed in southeastern Kansas. This experiment was designed to determine the long-term effect of selected tillage and nitrogen (N) fertilization options on the yields of grain sorghum and 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. The three tillage systems were conventional, reduced, and no tillage. The conventional system consisted of chiseling, disking, and field cultivation. The reduced-tillage system consisted of disking and field cultivation. Glyphosate (Roundup®) was applied each year at 1.5 qt/a to the no-till areas. The four N treatments for the odd-year grain sorghum crops from 1983 to 2001 were: a) no N (check), b) anhydrous ammonia knifed to a depth of 6 in., c) broadcast urea-ammonium nitrate (UAN - 28% N) solution, and d) broadcast solid urea. The N rate was 125 lb/a. Harvests were collected from each subplot for both grain sorghum (odd years) and soybean (even years) crops. Effects of residual N were measured for soybean, even though N fertilizer was applied only to grain sorghum. Soil samples were collected at the end of the 20-year study and were analyzed for bulk density and organic-matter content.

Results

Analyzed across all grain sorghum years (odd-numbered years) from 1983 to 2001, yield was affected by tillage and nitrogen fertilization (Figure 1). Without N fertilizer, grain sorghum averaged approximately 40 bu/a in conventional and reduced tillage systems and around 30 bu/a in no-tillage. Anhydrous NH_3 application generally increased yields more than the other nitrogen fertilizers, except for broadcast urea in the reduced-tillage system. Although anhydrous NH_3 application improved yields in no-till, yields were still less than with anhydrous NH_3 applications in the other tillage systems. Grain sorghum yields were only statistically less with no-tillage in 5 of the 10 grain sorghum years (individual year data not shown). In those years, however, grain sorghum yield averaged 21 and 25 bu/a less with no-tillage than with reduced or conventional tillage, respectively. In contrast, analyzed across all soybean years (even-numbered years) from 1984 to 2002, soybean yield averaged 22.2 bu/a and was unaffected by tillage system or N residual (data not shown), even though growing conditions varied widely during this time, with soybean yields ranging from near 5 bu/a to more than 40 bu/a.

Long-term continuous use of different tillage systems and N fertilization schemes has the potential to affect soil quality. Two of the measures of soil quality are organic-matter content and bulk density. Soil organic-matter content in the 0- to 3-inch zone was less with conventional tillage than with either reduced or no-tillage (Table 1). In the 3- to 6-inch zone, however, organic-matter content was less with no tillage than with conventional or reduced tillage. As a result, when composited across the 0- to 6-inch zone, which is the typical soil-sampling depth, organic matter was not statistically affected by tillage. These data show that distribution of organic matter may change in the top 6-inch soil zone, but that the overall concentration is not affected by tillage.

Organic-matter content in the 6- to12-inch zone was also not affected by tillage. Nitrogen fertilization schemes also did not affect organic-matter content at any soil depth. Bulk density was not affected after twenty years by tillage system or N fertilization scheme at any soil depth (Table 2). In this claypan soil, soil quality, as indicated by organic-matter content and bulk density, was not greatly affected by twenty years of different tillage systems or N fertilization schemes.

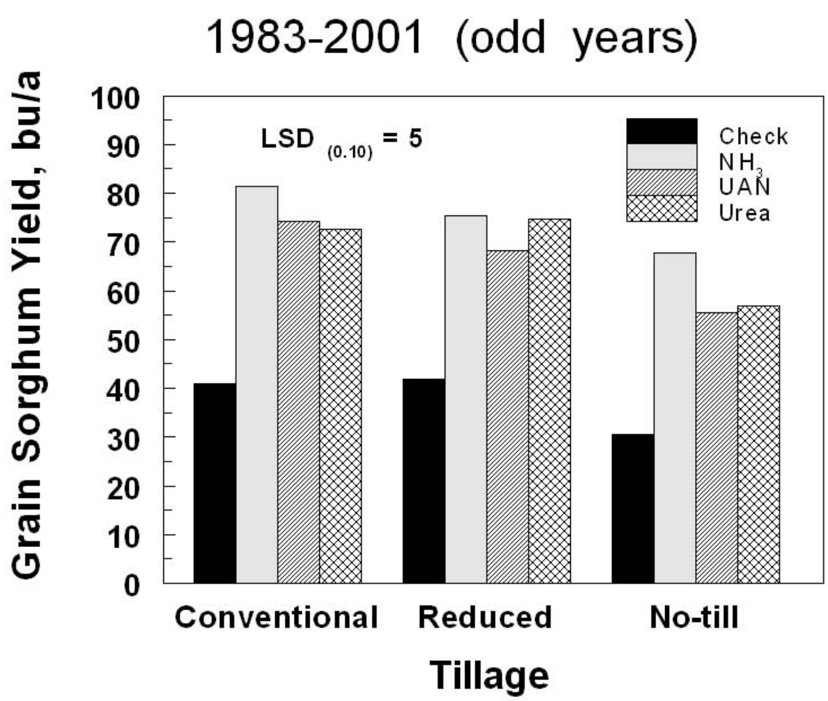


Figure 1. Effects of tillage system and N fertilization scheme on grain sorghum yield in odd-numbered years from 1983 to 2001, Southeast Agricultural Research Center.

Table 1. Soil organic-matter content after twenty years of a grain sorghum-soybean rotation, Southeast Agricultural Research Center, Parsons, Kansas, 2002.

	Organic Matter			
Treatment	0-3"	3-6"	0-6"	6-12"
	------------------%	------------------		
Conventional	2.30	1.82	2.09	1.35
Reduced	2.60	1.86	2.25	1.26
No-till	2.76	1.31	2.05	1.23
LSD (0.05)	0.30	0.41	NS	NS
Check (No N)	2.49	1.57	2.05	1.21
Anhydrous NH_3	2.52	1.63	2.08	1.23
UAN broadcast	2.68	1.73	2.23	1.40
Urea broadcast	2.53	1.72	2.15	1.28
LSD (0.05)	NS	NS	NS	NS

Table 2. Soil bulk density after twenty years of a grain sorghum-soybean rotation, Southeast Agricultural Research Center, Parsons, Kansas, 2002.

	Bulk Density			
Treatment	0-3"	3-6"	0-6"	6-12"
	------------------ g/cm^3	------------------		
Conventional	1.08	1.42	1.25	1.31
Reduced	1.06	1.39	1.22	1.30
No-till	1.11	1.45	1.28	1.26
LSD (0.05)	NS	NS	NS	NS
Check (No N)	1.08	1.42	1.25	1.28
Anhydrous NH_3	1.09	1.39	1.24	1.30
UAN broadcast	1.05	1.44	1.25	1.27
Urea broadcast	1.10	1.43	1.26	1.31
LSD (0.05)	NS	NS	NS	NS

EFFECTS OF RESIDUAL SOIL PHOSPHORUS AND POTASSIUM FOR GLYPHOSATE-TOLERANT SOYBEAN PLANTED NO-TILL

D.W. Sweeney

Summary

In 2003, greater amounts of residual soil K test produced greater soybean yield, whereas different soil P test concentrations did not increase yield.

Introduction

The response of soybean to phosphorus (P) and potassium (K) fertilization can be sporadic, and producers often omit these fertilizers. As a result, soil test values can decline. Acreage planted with no tillage may increase because of new management options such as glyphosate-tolerant soybean cultivars. But data are lacking about the importance of soil P and K concentrations on yield of glyphosate-tolerant soybean grown with no tillage.

Procedures

The experiment was established on a Parsons silt loam in spring 1999. Since 1983, fertilizer applications have been maintained to develop a range of soil P and K concentrations. The experimental design is a factorial arrangement of a randomized complete block, with three replications. The three residual soil P amounts averaged 5, 11, and 28 ppm, and the three soil K amounts averaged 52, 85, and 157 ppm at the conclusion of the previous experiment. Each year, Roundup Ready® soybean was planted during late May to mid June with no tillage.

Results

Environmental conditions in 2003 resulted in soybean yields averaging about 20 bu/a (Table 1). Soil P concentrations had no effect on soybean yields. But an increased number of pods per plant with the greatest soil test P may suggest a potential for increased yield under better growing conditions. Greater soil K amounts increased glyphosate-tolerant soybean yield by as much as 21%, compared with plots that have never received K fertilizer. This yield increase may have been related to changes in pods per plant and seeds per pod. Yield was affected by a P x K interaction in which an increase in soil K resulted in a yield increase in the absence of P fertilization or with greater amounts of P fertilization, but not in soil that had received lesser amounts of P fertilization.

Table 1. Effects of amounts of residual soil phosphorus and potassium on glyphosate-tolerant soybean yield and yield components, Southeast Agricultural Research Center, Parsons, Kansas, 2003.

Initial Soil Test	Yield	Population	Seed Weight	Pods/Plant	Seeds/Pod
	bu/a	plants/a	mg		
P (ppm)					
5	20.6	89,000	119	29	1.5
11	21.1	81,700	113	34	1.5
28	20.8	85,700	111	37	1.4
LSD (0.05)	NS	NS	NS	5	NS
K (ppm)					
52	18.5	85,800	110	30	1.4
85	21.4	82,300	119	37	1.4
157	22.5	88,200	113	32	1.6
LSD (0.10)	2.9	NS	NS	4	0.1
PxK Interaction	NS	NS	NS	NS	NS

USE OF STRIP TILLAGE FOR CORN PRODUCTION IN A CLAYPAN SOIL

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

Summary

Tillage selection did not significantly affect short-season corn yields in 2003. Early- spring fertilization with N and P solutions resulted in greater yield than did N-P fertilizer application in late fall.

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 those grown 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 (1 pass with tandem disk in late fall and 1 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 N/a and 40 lb P_2O_5/a were applied in each fluid-fertilizer scheme. Fertilization was done on December 17, 2002, and on April 1, 2003. Short-season corn was planted on April 3, 2003, and harvested on August 25, 2003.

Results

Strip tillage done either in late fall or early spring in 2003 resulted in short-season corn yields of 115 bu/a, not significantly different than yield with no tillage (114 bu/a) or reduced tillage (108 bu/a). Fertilization done in early spring 2003 resulted in average corn yields of 121 bu/a, significantly more than yield with late fall fertilization (105 bu/a). Knife (subsurface band) applications did not result in statistically greater yield than dribble (surface band) applications (115 vs. 111 bu/a).

INTEGRATED AGRICULTURAL MANAGEMENT SYSTEMS: NEOSHO RIVER BASIN SITE

D.W. Sweeney, G.M. Pierzynski, M. Buckley, and G.L. Kilgore

Summary

Total losses of sediment, nutrients, and pesticides have been variable during 2001 to 2003. Regardless, measured values seem small.

Introduction

The quality of our water resources is an important topic. Agricultural practices are perceived to impact surface water quality by being a non-point source of pollutants. Producers need to use voluntary practices, such as Best Management Practices (BMP), to protect and improve surface water quality in the state. Recent state-wide efforts in Kansas are designed to look at large, field-scale integrations of BMP to determine their effects on losses of sediment, nutrients, and pesticides into surface waters.

Procedures

The experiment was established on a Parsons silt loam in spring 1999 at the Greenbush Facility in Crawford County, but was not fully implemented until 2000. The four treatments were: 1) Conventional tillage (spring chisel, disk, field cultivate, plant); Low management: nitrogen (N) and phosphorus (P) broadcast, with incorporation by tillage; and atrazine and metolachlor herbicides applied preemergence, 2) Conventional tillage; High management: N and P knifed in, followed by tillage; metolachlor applied preemergence and atrazine applied post-emergence, 3) No tillage; Low management: N and P broadcast; atrazine and metolachlor applied preemergence, and 4) No tillage; High management: N and P knifed in; metolachlor applied preemergence and atrazine applied postemergence. For grain sorghum, the total N rate was 120 lb/a and P was 40 lb P_2O_5/a. The background crop in 1999 was soybean. Grain sorghum was planted in 2000, 2001, and 2003, and soybean was planted in 2002.

At the downslope end of each 1-acre plot, a soil berm was constructed to divert surface water flow through a weir. In March 2001, soil berms were planted with fescue grass and covered with erosion matting material to minimize the potential for berm erosion to affect sediment values from runoff samples, as it seemed had occurred in 2000. Each weir was equipped with an ISCO® sampler that recorded flow amounts and collected runoff samples. Water samples were analyzed at the Soil Testing Laboratory for sediment, nutrients, and selected herbicides.

Results

Runoff and loading rates during 2001 to 2003 have been variable (Table 1). No tillage with high management (NTH) often resulted in greater runoff and total losses of potential pollutants, although the differences are not always significant. Regardless, measured sediment, nutrient, and pesticide loadings (Table 1) and concentrations (Table 2) from all treatments generally seem small.

Table 1. Seasonal runoff volume and total losses of sediment, total nitrogen, ammonium, nitrate, total P, bioavailable P (BAP), soluble P, atrazine, and metolachlor at Crawford County in 2001 through 2003.

Treatment	Runoff	Sediment	Total-N	Ammonium	Nitrate	Total-P	BAP	Soluble-P	Atrazine	Metolachlor
	ac-in	-----------------	-----------------	-----------------	lb/a	-----------------	-----------------	-----------------	------------g/a------------	
					2001: Sorghum					
CHL†	3.7c‡	803a	3.8b	0.2a	1.3c	0.8b	0.4b	0.4a	3.0a	3.1a
CHH	5.2b	410a	4.0b	0.3a	1.8b	1.1b	0.6ab	0.8a	7.9a	4.4a
NTL	3.0c	205a	2.9c	0.2a	1.6bc	0.7b	0.5b	0.5a	13.4a	10.7a
NTH	8.0a	785a	9.1a	0.5a	5.1a	1.7a	1.0a	1.0a	7.4a	12.3a
					2002: Soybeans					
CHL	9.1b	78a	4.6b	0.7b	0.8b	6.2a	1.1a	1.0a	0.4a	12.3a
CHH	12.6b	89a	6.3b	1.0a	0.6b	7.5a	1.5a	1.4a	0.2a	11.5a
NTL	10.4b	89a	6.9b	0.7b	0.9b	13.9a	2.1a	1.9a	0.2a	40.8a
NTH	18.4a	178a	11.4a	1.0a	2.2a	10.0a	2.4a	2.1a	0.3a	19.0a
					2003: Sorghum					
CHL	4.1a	214a	5.8a	0.5b	3.6a	0.8a	0.5a	0.5a	2.1a	1.3b
CHH	3.0a	89a	13.8a	3.9a	5.3a	2.9a	1.3a	2.8a	0.9a	0.9b
NTL	2.0a	428a	8.8a	5.7a	3.0a	2.9a	2.5a	2.5a	2.3a	1.5ab
NTH	3.3a	89a	5.7a	1.2b	2.1a	0.9a	0.6a	0.6a	2.7a	2.5a

† CHL = conventional tillage with low management, CHH = conventional tillage with high management, NTL = no tillage with low management, NTH = no tillage with high management.

‡ Values within a column followed by the same letter are not significantly different at P=0.20.

Table 2. Volume-corrected season-total concentrations of sediment, total nitrogen, ammonium, nitrate, total P, bioavailable P (BAP), soluble P, atrazine, and metolachlor lost at Crawford County in 2001 through 2003.

Treatment	Sediment	Total-N	Ammonium	Nitrate	Total-P	BAP	Soluble-P	Atrazine	Metolachlor
	ppm						ppb		
				2001: Sorghum					
CHL†	660a‡	3.9a	0.3a	1.2a	0.9a	0.5a	500a	5.4a	5.9a
CHH	330a	3.5a	0.2a	1.6a	1.0a	0.6a	710a	10a	8.6a
NTL	350a	4.9a	0.3a	2.8a	1.1a	0.6a	820a	45a	28.0a
NTH	430a	5.1a	0.3a	2.8a	1.0a	0.5a	570a	6.3a	15.0a
				2002: Soybeans					
CHL	38a	2.0c	0.3a	0.4ab	0.6b	0.5b	460a	0.7a	14.0a
CHH	34a	2.3bc	0.3a	0.2c	0.6b	0.5b	500a	0.1a	11.0a
NTL	40a	2.7a	0.3a	0.3bc	0.9a	0.9a	750a	0.1a	36.0a
NTH	37a	2.6ab	0.2a	0.5a	0.6b	0.6b	490a	0.2a	9.3a
				2003: Sorghum					
CHL	290b	6.6a	0.6b	3.9a	0.9b	0.6a	570a	3.9a	2.9a
CHH	110b	14.0a	5.0b	7.0a	4.0ab	3.7a	3740a	2.9a	2.5a
NTL	930a	26.0a	12.0a	6.9a	6.4a	5.5a	5430a	8.7a	5.5a
NTH	110b	7.4a	0.8b	4.0a	1.1b	0.8a	800a	9.7a	13.0a

† CHL = conventional tillage with low management, CHH = conventional tillage with high management, NTL = no tillage with low management, NTH = no tillage with high management.

‡ Values within a column followed by the same letter are not significantly different at P=0.20.

EFFECT OF NITROGEN TOP-DRESSED POST-EMERGENCE ON SHORT-SEASON CORN

G.L. Kilgore and D.E. Stites

Summary

In 2004, corn yields were increased by top dressing nitrogen. Nitrogen rates were applied to corn that received 120 lbs N as anhydrous before planting. Nitrogen, side dressed at 45 or 60 lbs/a, increased yields by 10 bu/a over plots not side dressed.

Introduction

Many corn producers in Southeastern Kansas apply all their nitrogen on corn ground before planting. Most years, in the spring, the claypan soils become saturated, and denitrification can occur. This study was designed to determine if top dressing nitrogen to the growing crop improves yields.

Procedures

Study was conducted on a Parsons silt loam that is an upland, claypan soil on a farm north of McCune in Crawford County.

Before planting, anhydrous ammonia fertilizer was applied at the rate of 120 lbs N/a. Phosphorus and potassium were applied and incorporated. When the corn was 10 to 12 inches tall, nitrogen as urea was applied at: 0, 15, 30, 45, and 60 lbs/a was broadcast over soil surface. A 30 lb/a rate was also applied directly along side of the row to see if placement affected production.

The short-season Pioneer 35P12 hybrid was planted April 2, 2004, at kernel drop of 24,000/a. Nitrogen was broadcast May 6, when corn was 10 to 12 inches tall.

Results

2004 was a wonderful corn year. Adequate and timely rainfall resulted in high corn yields. Long-time average yields for short-season corn is 88 bu/a. Yields in the test plots ranged from 129 to 139 bu/a (Table 1). Nitrogen top-dress applications of 45 or 60 lbs/a resulted in yields of 139.0 and 135.3 bu respectively. The two 30-lb N applications resulted in yields being significantly higher when the nitrogen was sidedressed along the row and not broadcast over the entire surface. Yields were 131.4 and 127.2, respectively.

Did it “pay” to top dress corn? Forty-five lbs of N at $0.32/lb = $14.40/a plus application cost. Yield response of 10 bu/a at $1.80/bu = $18.00. It depends on yield response, corn price, and of course, fertilizer cost. Using anhydrous ammonia to sidedress would significantly reduce N cost.

Table 1. Effect of nitrogen rates top-dressed post-emergence on short-season corn, Crawford County, Kansas, 2004.

N Rate lbs/a	Final Stand Plants/a	Ears/Plant No.	Yield Bu/a
0	22,433	1.03	129.7
15	22,107	1.00	127.5
30	21,018	1.02	127.2
30 R*	21,780	1.05	131.4
45	21,780	1.02	139.0
60	22,542	1.00	135.3
LSD.05	NS	NS	3.5

*30R = Nitrogen placed along side of row, not broadcast over plot.

SOIL FERTILITY RESEARCH
HARVEY COUNTY EXPERIMENT FIELD

RESIDUAL 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

Winter wheat was grown in rotation with grain sorghum in three no-till cropping systems, two of which included either a late-maturing Roundup Ready® soybean or a sunn hemp cover crop established following wheat harvest in 2002. Nitrogen (N) fertilizer was applied for each grain crop at rates of 0, 30, 60, and 90 lb/a. Residual effects of soybeans on wheat were comparable to those of sunn hemp. At low N rates, wheat grew taller in systems with cover crops than where no legume had been grown. Increases in plant N attributed to cover crops ranged from 0.2% N to 0.27% N when N rates of 30 and 60 lb/a were applied. Differences in wheat N concentration among the cropping systems tended to disappear at the 90 lb/a N rate. Wheat yield increases of 5 to 9 bu/a from cover crops occurred at N rates of 0 and 30 lb/a, but higher N rates resulted in no significant differences in wheat production among cropping systems. Grain test weight and protein content were not affected by cover crop, but test weights tended to decrease somewhat with increasing N rate. Protein content increased only at the 90 lb/a N rate.

Introduction

Cover-crop research at the KSU Harvey County Experiment Field in the past has focused on the use of hairy vetch as a winter crop following wheat in a winter wheat-grain 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.

In 2002, an existing experiment was modified to include late-maturing soybean and sunn hemp, a tropical legume, in lieu of hairy vetch. These summer cover crops were grown from early July through mid-October following wheat harvest, and produced an average of 3.91 and 3.52 ton/a of above-ground dry matter. Corresponding N yields of 146 and119 lb/a were potentially available to the succeeding grain sorghum crop. It was subsequently observed that when averaged across N fertilizer rates, soybean and sunn hemp significantly increased sorghum leaf nutrient content by 0.24% N and 0.29% N. Sunn hemp increased grain sorghum yields by 10.6 bu/a, whereas soybean did not significantly benefit sorghum under existing conditions. In 2004, the residual effects of these cover crops, as well as those of fertilizer N, were determined in no-till winter wheat planted shortly after sorghum harvest.

Procedures

The experiment was established on a Geary silt loam site that had been used 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 no-cover crop treatment. The existing factorial arrangement of N rates on each cropping system also was retained.

After wheat harvest in 2002, weeds were controlled with Roundup Ultra Max®

herbicide. Hartz H8001 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 5 at 59 lb/a and 10 lb/a, respectively. Sunn hemp began flowering in late September and was terminated at that time by a combination of rolling with a roller harrow and application of 26 oz/a of Roundup Ultra Max®. Soybeans were rolled after initial frost in mid October. Forage yield of each cover crop was determined by harvesting a 3.28-feet^2 area in each plot just before termination. Samples were subsequently analyzed for N content.

Weeds were controlled during the fallow period and row crop season with Roundup Ultra Max®, atrazine, and Dual II Magnum®. Pioneer 8505 grain sorghum treated with Concept® safener and Gaucho® insecticide was planted at approximately 42,000 seeds/a on June 12, 2003.

All plots received 37 lb/a of P_2O_5 banded as 0-46-0 at sorghum planting. Nitrogen fertilizer treatments were applied as 28-0-0 injected at 10 inches from the row on July 9. Grain sorghum was combine harvested on October 24, 2003. N rates were reapplied as broadcast 34-0-0 on October 28, 2003. Jagger winter wheat was then no-till planted at 90 lb/a with 35 lb/a P_2O_5 fertilizer banded as 0-46-0 in the furrow. Wheat was harvested on June 24, 2004.

Results

Early summer rains were sufficient to facilitate good stand establishment by soybean and sunn hemp cover crops. Despite below-normal July and August rainfall in 2002, both crops developed well. Late-maturing soybean reached an average height of 35 inches, showed limited pod development, and produced 3.91 ton/a of above-ground dry matter with an N content of 1.86%, or 146 lb/a (Table 1). Sunn hemp averaged 82 inches in height and produced 3.52 ton/a dry matter with 1.71% N, or 119 lb/a of N. It was noted that sunn hemp roots had little or no nodulation, evidence that the inoculant was ineffective. Soybean and sunn hemp effectively suppressed volunteer wheat and, in the fall, reduced the density of henbit, in comparison with areas having no cover crop.

Grain sorghum planted in mid-June suffered extreme drouth stress during the summer of 2003. Cover crops shortened the period from sorghum planting to half bloom by an average of two days and increased leaf N concentration across N rates by 0.24% to 0.29% N. Sunn hemp increased grain sorghum yields by 10.6 bu/a, whereas soybean did not significantly benefit sorghum under existing conditions.

Winter wheat responded to prior cover crops with increases in plant heights on the order of 2 to 3 inches at zero fertilizer N. This effect diminished or disappeared at N rates of 60 or 90 lb/a. When averaged over fertilizer rates, an increase of 0.12% plant N in wheat at early heading was noted as a positive residual effect of both cover crops. At low N rates of 30 and 60 lb/a, the increases in plant N attributed to cover crops were larger, ranging from 0.2% N to 0.27% N. Wheat N concentration differences among cropping systems tended to disappear only at the 90 lb/a N rate. The main effect of cover crops on wheat yield was significant, with increases of 4 bu/a from soybeans and 2.3 bu/a from sunn hemp. This was attributable to yield increases of 5 to 9 bu/a from cover crops at N rates of 0 and 30 lb/a. Higher N rates resulted in no significant differences in wheat yield among cropping systems. Grain test weight was not significantly affected by cover crops, but tended to decrease with increasing fertilizer N as a dilution effect associated with higher grain yields. Grain protein also was not significantly affected by prior cover crops. A 1.4% grain protein increase occurred only at the 90 lb/a N rate.

Table 1. Residual effects of soybean and sunn hemp summer cover crops and nitrogen rate on no-till wheat after grain sorghum, Hesston, Kansas, 2004.

Cover Crop	N Rate[2]	Cover Crop Yield[3] Forage	Cover Crop Yield[3] N	Sorghum Yield 2003	Wheat Yield	Wheat Bushel Wt	Wheat Plant Ht	Wheat Plant N[4]	Wheat Grain Protein
	lb/a	ton/a	lb/a	bu/a	bu/a	lb	in.	%	%
None	0	----	----	49.2	11.4	58.9	22	1.25	12.1
	30	----	----	48.2	31.1	59.1	29	1.27	11.7
	60	----	----	48.8	43.7	58.6	30	1.66	12.1
	90	----	----	45.8	48.9	58.4	32	2.26	13.2
Soybean	0	3.54	130	47.9	20.5	59.4	25	1.36	12.1
	30	3.99	133	48.3	38.5	58.7	31	1.47	11.7
	60	3.88	152	56.2	46.2	58.2	31	1.93	12.6
	90	4.23	170	50.7	45.9	57.5	32	2.19	13.9
Sunn hemp	0	3.93	128	58.8	18.3	59.4	24	1.32	12.2
	30	3.44	122	53.0	36.3	58.5	30	1.48	11.8
	60	3.28	111	59.9	42.1	58.4	32	1.91	12.0
	90	3.42	114	62.6	47.6	57.7	32	2.18	13.5
LSD .05		NS	38	10.0	4.4	0.64	1.9	0.18	0.63
Means: Cover Crop/ Termination									
None		----	----	48.0	33.8	58.7	28	1.61	12.3
Soybean		3.91	146	50.8	37.8	58.5	30	1.73	12.6
Sunn hemp		3.52	119	58.6	36.1	58.5	29	1.72	12.4
LSD .05		NS	19	5.0	2.2	NS	0.9	0.09	NS
N Rate									
0		3.74	129	51.9	16.7	59.2	23	1.31	12.1
30		3.72	128	49.9	35.3	58.8	30	1.40	11.7
60		3.58	132	55.0	44.0	58.4	31	1.83	12.2
90		3.82	142	53.0	47.5	57.9	32	2.21	13.5
LSD .05		NS	NS	NS	2.5	0.37	1.1	0.10	0.36

[1] Cover crops planted on July 5, 2002, and terminated in mid October.
[2] N applied as 28-0-0 injected July 9, 2003, for sorghum and 34-0-0 broadcast on October 28, 2003, for wheat.
[3] Oven dry weight and N content on October 16, 2002.
[4] Whole-plant N concentration at early heading.
[5] Protein calculated as %N x 5.7.

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

EFFECTS OF POTASSIUM APPLICATION AND CORN HYBRID ON CORN YIELD AND NUTRIENT CONTENT OF GRAIN

J. Massey, J. Herman, L. Ferdinand, D. Locke, R. Ladd, J. Siemens, and D. Leikam

Summary

A potassium study was initiated on a field with presumed potassium deficiency. This study included K application rates of 0, 40, 80, and 120 lbs K_2O/a and was conducted in Atchison county, Kansas. All fertilizer was broadcast applied. Extreme K deficiency was observed across most of the field, except at the far west end of the affected field. Discussion with the seed dealer prior to study establishment indicated that the intended hybrid was a 'K responsive, western hybrid'. Additional discussions with the farmer indicated that he had planted a different hybrid in two of the eight replications on the western end of the field. The seed dealer indicated that this hybrid was a more 'K non-responsive hybrid'. Significant and large grain-yield and test-weight advantages were associated with K application to the 'K responsive' hybrid, but no response was noted on the 'K non-responsive' hybrid.

Introduction

Potassium deficiency in row crops has become much more common in the western corn belt over the past decade. The increased K deficiency is most often associated with no-till/ridge-till production, but has also been reported in minimum tillage systems. Often, traditional soil testing programs have not indicated a need for applied potassium because soil tests are often in a 'sufficient' range.

This study is part of a larger project to improve corn and grain sorghum crop nutrient recommendations. A follow-up to this study is planned in the 2005 crop year.

Procedures

Soil samples from the 0- to 6-inch depth were collected from individual plots of the study. Soil test values ranged from 112 to 229 ppm exchangeable K. These soil tests would not have been expected to result in the severe potassium-deficiency symptoms observed at this site. This study was located in a farmer field that had a history of production problems.

Potassium rates of 0, 40, 80, and 120 lbs K_2O/a were preplant broadcast applied in late winter. The applied K was incorporated on half of the plots and unincorporated in the other half. The treatments were replicated eight times across the field.

Most of the plot area (six replications) was planted to what the seed dealer referred to as a 'K responsive' hybrid, whereas the farmer planted a different 'non-responsive' hybrid on the two remaining replications. Two replications were lost to severe weed infestation. Grain yields were obtained by hand harvesting 20 feet of row from the center of each plot.

Results

Yields were not affected by incorporation of the K fertilizer, so tillage treatments were combined for analysis. A large yield response was measured with the hybrid referred to as a 'responsive' hybrid, whereas little if any response resulted in the non-responsive hybrid. This points to the fact that at least some seed sellers have hybrid-specific information that may be useful for making management decisions. In addition to grain-yield response, tests weights also benefitted from K application.

Table 1. Effects of potassium application to corn, Atchison County, Kansas, 2004, responsive hybrid, 4 replications.

	Corn Grain			
K_2O Rate	Yield	Test Weight	Moisture	K Content
lb/a	bu/a	lb/bu	%	lb K_2O/bu
0	125	56.3	14.1	0.27
40	170	58.8	15.0	0.27
80	189	58.4	15.0	0.26
120	179	58.8	15.4	0.27
Sig. Level	0.006	0.01	0.04	NS

Exch. K soil test - range of 112-179 ppm; average of 143 ppm.

Table 2. Effects of potassium application to corn, Atchison County, Kansas, 2004, non-responsive hybrid, 2 replications.

	Corn Grain			
P_2O_5 Rate	Yield	Test Weight	Moisture	K Content
lb/a	bu/a	lb/bu	%	lb K_2O/bu
0	199	60.8	16.3	0.29
40	208	61.1	16.1	0.32
80	204	61.0	16.9	0.30
120	203	62.0	15.8	0.29
Sig. Level	NS	0.25	0.32	NS

Exch. K soil test - range of 127-229 ppm; average of 181 ppm.

EFFECTS OF PHOSPHORUS APPLICATION ON CORN YIELD AND NUTRIENT CONTENT OF GRAIN

J. Massey, J. Herman, L. Ferdinand, A. Schlegel, G. Sohm, B. Gordon, and D. Leikam

Summary

A series of corn and grain sorghum studies have been initiated across the state over the past two years to help refine the information needed for crop nutrient recommendations. These studies were conducted for corn and included P rates of 0, 20, 40, 80, and 120 lbs P_2O_5/a and were conducted at three locations across the state. All fertilizer was broadcast applied. Significant, large yield responses were obtained at two of the locations. In addition, the P and K content of the grain increased with increasing P rate, whereas the grain moisture content decreased.

Introduction

Several corn and grain sorghum studies have been initiated across the state to improve crop nutrient P and K recommendations. 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 values, 2) percentage sufficiency (for maximum yield) at various soil test values, 3) amounts of P and K nutrient application/crop removal to change soil test values, and 4) amounts of P and K removed in the harvested grain.

This project was initiated for the 2003 crop and will continue for the 2005 crop year.

Procedures

Soil samples from the 0- to 6-inch depth were collected from individual plots at some locations and from individual replications at others. Bray P1, Mehlich 3 colorimetric, and Mehlich 3 ICP soil test procedures were run on individual samples. For this report, only the Bray P1 results will be presented.

The Greeley County study was located on the K-State research station; the Republic and Stevens County studies were located in farmer/cooperator fields. All locations were sprinkler irrigated.

Phosphorus rates of 0, 20, 40, 80, and 120 lbs P_2O_5/a were preplant broadcast applied in late winter. Applied P was incorporated at the Republic and Greeley County sites; the Stevens County site was no-till except for strip-till, spring-applied nitrogen application. The treatments were replicated six times in Greeley and Republic Counties and five times at the Stevens County site. Grain yields were obtained by hand harvesting 20 feet of row from the center of each plot.

Results

Significant, large yield responses were obtained at both the Greeley and Stevens County locations. The large response at Stevens County was particularly interesting because the surface broadcast applications were not incorporated. Grain P contents were increased with increasing P application rate, whereas grain moisture declined.

Table 1. Effects of phosphorus application to corn, Stevens County, Kansas, 2004.

	Corn Grain			
P_2O_5 Rate	Yield	Test Weight	Moisture	P Content
- lb/a -	bu/a	Lb/bu	%	lb P_2O_5/bu
0	141	52.3	27.2	0.18
20	160	53.1	27.3	0.19
40	192	54.4	24.5	0.22
80	213	52.9	26.9	0.24
120	226	55.1	21.7	0.26
Sig. Level	0.0003	0.02	0.18	0.0001

Bray P1 soil test – range of 4-8 ppm; average of 6 ppm.

Table 2. Effects of phosphorus application to corn, Republic County, Kansas, 2004.

	Corn Grain			
P_2O_5 Rate	Yield	Test Weight	Moisture	P Content
- lb/a -	bu/a	lb/bu	%	lb P_2O_5/bu
0	160	58.5	16.9	0.27
20	164	59.8	15.9	0.26
40	172	60.0	16.2	0.25
80	190	59.9	16.2	0.27
120	170	59.2	15.8	0.29
Sig. Level	NS	0.16	NS	0.08

Bray P1 soil test – range of 15-23 ppm; average of 17 ppm.

Table 3. Effects of phosphorus application to corn, Greeley County, Kansas, 2004.

	Corn Grain			
P_2O_5 Rate	Yield	Moisture	P Content	K Content
- lb/a -	bu/a	%	lb P_2O_5/bu	lb K_2O/bu
0	180	30.5	0.20	0.14
20	191	29.9	0.21	0.16
40	206	29.5	0.23	0.16
80	222	29.2	0.25	0.16
120	222	29.1	0.27	0.17
Sig. Level	0.0001	0.09	0.0001	0.004

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

EFFECTS OF PHOSPHORUS AND POTASSIUM APPLICATION ON CORN YIELD AND NUTRIENT CONTENT OF GRAIN

J. Massey, J. Herman, and D. Leikam

Summary

Corn and grain sorghum studies have been initiated across the state to help refine the crop nutrient recommendations for corn and grain sorghum. This study included P rates of 0, 20, 40, 80, and 120 lbs P_2O_5/a and K rates of 0, 40, 80, and 120 lb K_2O/a. All fertilizer was broadcast applied and incorporated with a disc. There was no response to applied P this year, but there was a 25-bu/a response to applied K (18%). In addition, the P and K content of the grain increased with increasing P rate, whereas the K content of the grain increased with increasing K application rate.

Introduction

Corn and grain sorghum studies have been initiated across the state to improve crop nutrient P and K recommendations. To meet this objective, the following information is being gathered; 1) average crop response to various rates of P and/or K application at various soil test values, 2) average percentage sufficiency (for maximum yield) at various soil test values, 3) amounts of P and K nutrient application/ crop removal to change soil test values, and 4) the amounts of P and K removed in the harvested grain.

Procedures

Studies involving both P and K were established at a Cherokee County location during the winter of 2003-04. Phosphorus soil tests ranged from 11-28 ppm Bray P1 and averaged 18 ppm across the whole study. Potassium soil test values ranged from 86-197 ppm exchangeable K and averaged 134 ppm.

Phosphorus rates of 0, 20, 40, 80, and 120 lbs P_2O_5/a and K rates of 0, 40, 80, and 120 lb K_2O/a were broadcast applied in late winter and subsequently incorporated by the farmer/cooperator. The treatments were replicated five times and arranged in a randomized complete-block design. Grain yields were obtained by hand harvesting 20 feet of row from the center of each plot.

Results

The results of these Cherokee County studies are summarized in Tables 1 and 2. Neither grain yield or moisture was affected by P application, whereas grain nutrient P and K contents increased with increasing P application rate. Grain yield and grain K content were significantly increased by K application. Both yield and grain K content were still increasing at the highest rate of application.

In 2002, in an adjacent field, grain yields trended higher with increasing P application and were not affected by K application. Soil samples from individual plots will be collected during the fall-winter of 2004-05.

Table 1. Effects of phosphorus application to corn, Cherokee County, Kansas, 2004.

		Corn Grain			
P_2O_5 Rate	K_2O Rate	Yield	Moisture	P Content	K Content
lb/a		bu/a	%	lb P_2O_5/bu	lb K_2O/bu
0	80	146	21.3	0.31	0.13
20	80	130	22.1	0.31	0.14
40	80	143	21.5	0.31	0.14
80	80	145	20.8	0.33	0.14
120	80	137	20.9	0.33	0.15
Significance Level		NS	NS	0.18	0.03

Table 2. Effects of potassium application to corn, Cherokee County, Kansas, 2004.

		Corn Grain			
P_2O_5 Rate	K_2O Rate	Yield	Moisture	P Content	K Content
lb/a		bu/a	%	lb P_2O_5/bu	lb K_2O/bu
80	0	138	20.0	0.33	0.14
80	40	143	20.8	0.33	0.14
80	80	145	20.8	0.33	0.14
80	120	163	20.4	0.32	0.15
Significance Level		0.03	NS	NS	0.10

CORN YIELD RESPONSE TO NITROGEN RATE AND TIMING IN SANDY IRRIGATED SOILS

R.J. Gehl, J.P. Schmidt, A.J. Schlegel, L.D. Maddux, and W.B. Gordon

Summary

Growing concern over elevated groundwater NO_3 concentrations has emphasized the importance of efficient N management, particularly on coarse irrigated soils that are highly susceptible to NO_3 leaching. A 2-yr study evaluating corn response to N rate and timing was completed in 2004. Average grain yield achieved at eight study sites throughout Kansas ranged from 58 to 209 bu/a. Maximum grain yield was achieved at eight study sites over two years with a split application of 165 lb N/a, and in most instances a split application of 110 lb N/a was sufficient to achieve maximum yield. The optimum N rate observed for each study site was generally less than the corresponding KSU N recommendation, especially when N was split-applied.

Introduction

Nitrogen management is of particular concern in areas of Kansas where irrigated corn production commonly occurs on coarse-textured soils with high yield potential. Nitrogen applied in excess of that required for maximum grain yield can lead to elevated concentrations of NO_3 in the soil profile and an increased susceptibility to NO_3 loss by leaching. Timing of N fertilizer application is central to efficient use of N, particularly on sandy-textured soils that are susceptible to downward movement of NO_3.

The negative environmental impacts associated with corn production can be minimized through efficient N management, including accurate N fertilizer recommendations. Recommendations for N must be formulated to address both yield concerns and environmental issues. The use of excess N, as an "insurance" mechanism, is perpetuated by the fact that a moderate amount of over-fertilization represents a smaller economic risk than a possible yield reduction associated with inadequate N. An improved effort is needed to confront the attitudes and motivations that influence the decisions concerning application rates of N fertilizer. Adjustments to the N recommendations currently used, such as reductions in N rate for more efficient N management or reductions in the yield goal factor used for some soil types (especially soils susceptible to N loss), will be an important part of this effort. Identifying N- and water-management practices that minimize the NO_3 leaching potential for corn production along Kansas rivers will be essential to improving N recommendations in this region, while maximizing economic return for Kansas producers. The objective of this study was to evaluate grain yield response to alternative N- and water-management strategies for irrigated corn in the sandy soils along major Kansas tributaries.

Procedures

Field experiments in 2001 and 2002 were established along the Republican, Kansas, and Lower Arkansas Rivers. Locations included Scandia, Manhattan, Rossville, St. John, Ellinwood, and Pretty Prairie. Each field was in continuous corn under conventional tillage and was sprinkler-irrigated. Plot dimensions were 20 ft (8 rows, 30-in. row width) wide and 30 ft long. Nitrogen treatments were arranged in a randomized complete-block design (RCBD) and included: 0, 110, 165, and 220 lb/a (split applications, preplant and V6); and 220 and 270 lb/a (single preplant applications). Nitrogen treatments were adjusted at Pretty Prairie and St. John to accommodate producer N-management practices. There were two irrigation treatments at the Ellinwood site (optimal water rate, 1.0X, and 25% greater than optimal, 1.25X), each of which included a RCBD with the described N treatments. Soil samples were collected preplant and post-harvest to 8 ft (1-ft incr.), and at V6 to 2 ft (1-ft incr.). Grain yield at all sites except Rossville (plot combine used) was determined by hand harvesting a 20-ft length of each of the middle two rows from each plot. The N recommendation (NREC) for each site and year was determined by using the formula developed at KSU (2003). Research data were used to compute each NREC. Yield goal for each site was determined by using the highest grain-yield mean (for a treatment) from the two research years. Soil profile N was calculated by using the average of pre-season sample NO_3 concentrations, 0 to 24 in, from a given site for each study year. Nitrogen credits from irrigation were calculated by using application rates estimated from actual field measurements or from values typical for each. Statistical analyses were performed according to General Linear Procedures (SAS), and F-tests for analysis of variance (ANOVA) were considered significant at the 0.10 probability level.

Results

Soil physical characteristics at these locations were representative of the sandy soils along Kansas' main rivers. Dry-bulk-density values ranged from 1.31 to 1.81 g cm^{-3} across all locations and depths (Table 1), and sandy-textured soils were predominant in the 0- to 8-ft soil profile at each site, with sand content often exceeding 80% (Table 2).

Average grain yield at sites ranged from 58 to 209 bu/a. Maximum grain yield was achieved at eight study sites over two years with a split application of 165 lb N/a, and in most instances a split application of 110 lb N/a was sufficient to achieve maximum yield (Tables 3 and 4). The optimum N rate observed for each study site was generally less than the corresponding KSU NREC (Table 5), and was greater than the NREC for only Pretty Prairie West in 2001. For each location except Pretty Prairie West, the KSU NREC ranged between 156 and 270 lb N/a, corresponding to between 6 and 213 lb N/a in excess of that required to achieve maximum grain yield. On average, across all sites that responded to any N fertilizer, the NREC was 75 lb N/a greater than that required to reach maximum yield. The major contributor to maintaining crop yield with reduced rates of N fertilizer may be the increased recovery of N by the corn plant when N is split-applied. Split applications provide some measure of N use efficiency not accounted for in the KSU NREC, although a single preplant application of 220 lb N/a, 51 lb N/a less than the maximum NREC, was sufficient for maximum yield for all but one site year (Ellinwood 1.0X, 2001). The KSU NREC was similar to the minimum N rate to achieve maximum yield at the Manhattan and Pretty Prairie West locations, which had the lowest yield goals of all the study sites (Table 5). Results from this research indicate that corn N rates on these coarse-textured, irrigated soils can be reduced by an average of about 40% of the current NREC, when N is split-applied, while maintaining corn grain yields.

Table 1. Dry bulk density by depth for each location.

Depth	Ellinwood	Manhattan	Pretty Prairie East	Pretty Prairie West	Rossville	Scandia	St.John
(in)	- - - - - - - - - - - -	- - - - - - - - - - - -	- - - - - - - - - - - -	g/cm³ - - - - - - - - - - - -	- - - - - - - - - - - -	- - - - - - - - - - - -	
0-12	1.41	1.33	1.55	1.54	1.43	1.54	1.61
12-24	1.54	1.31	1.61	1.70	1.39	1.36	1.63
24-36	1.67	1.33	1.71	1.68	1.41	1.36	1.51
36-48	1.67	1.36	1.69	1.70	1.43	1.41	1.81
48-60	1.60	1.44	1.71	1.72	1.47	1.65	1.77
60-72	1.66	1.31	1.69	1.77	1.57	1.63	1.76
72-84	1.67	1.35	1.60	1.79	1.47	1.69	1.73
84-96	1.71	1.45	1.71	1.72	1.54	1.71	1.71

Table 2. Sand and clay content by depth for each location.

Depth	Ellinwood		Manhattan		Pretty Prairie East		Pretty Prairie West		Rossville		Scandia		St.John	
	Sand	Clay	Sand	Clay	Sand	Clay	Sand	Clay	Sand	Clay	Sand	Clay	Sand	Clay
(in)			- - - - - -	- - - - - -	- - - - - -	- - - - - -	% - - - - - -	- - - - - -	- - - - - -	- - - - - -				
0-12	93	3	11	35	60	14	89	2	65	12	73	9	85	3
12-24	92	5	42	24	51	26	83	4	62	11	38	15	84	6
24-36	90	7	54	16	75	14	81	8	68	9	33	16	84	5
36-48	89	8	60	13	83	9	84	8	74	8	52	11	65	13
48-60	90	9	57	19	89	8	84	10	74	8	83	7	43	23
60-72	90	8	41	25	86	11	86	10	83	7	91	5	47	21
72-84	87	10	42	27	80	13	88	8	81	8	94	5	51	20
84-96	88	9	38	30	80	12	87	9	76	8	94	4	51	18

Table 3. Grain yield as a function of N treatment for four locations. Means followed by the same letter for a given location and year are not different as determined by LSD at α = 0.10.

Treatment	Ellinwood 1.0X		Ellinwood 1.25X		Rossville		Scandia		Manhattan	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
lbs N/a	bu/a									
0	43c	115b	56b	112b	125b	103b	118b	43	45c	102c
110 split†	144b	177a	179a	174a	192a	168a	178a	57	99b	141b
165 split‡	161ab	185a	180a	182a	216a	171a	188a	56	148a	154ab
220 split§	177a	186a	191a	166a	200a	175a	182a	65	142a	158ab
220	148b	177a	202a	155a	199a	182a	186a	64	169a	153ab
270	144b	168a	190a	164a	201a	180a	183a	60	167a	170a
Mean	136	168	167	159	189	163	173	58	128	146
$LSD_{0.10}$	19	19	24	32	32	19	19	NS¶	26	19

† Split N application: 20% at planting, 40% at V6, 40% at V10

‡ Split N application: 33% at planting, 67% at V6

§ Split N application: 50% at planting, 50% at V6

¶ NS, nonsignificant at the 0.1 level

Table 4. Grain yield as a function of N treatment for Pretty Prairie and St. John locations. Means followed by the same letter for a given location and year are not different as determined by LSD at α = 0.10.

Treatment	Pretty Prairie East†		Pretty Prairie West‡		Treatment	St. John§	
	2001	2002	2001	2002		2001	2002
lbs N/a	bu/a				lbs N/a		
0	175	182b	126	-	0	128c	172
100 split¶	212	220a	137	-	80 split¶	178b	178
150 split#	205	209a	113	-	130 split#	205a	207
200 split††	196	220a	99	-	190 split††	200a	198
200	188	213a	102	-	190	193ab	183
250	191	211a	118	-	240	192ab	199
Mean	195	209	116	-		183	190
$LSD_{0.10}$	NS‡‡	18	NS	-		22	NS

† Additional 60 lb N/a applied to all plots by producer in 2001, 50 lb N/ac in 2002

‡ Additional 120 lb N/a applied to all plots by producer in 2001, site not used in 2002

§ Additional 30 lb N/a applied to all plots by producer in 2001 and 2002

¶ Split N application: 20% at planting, 40% at V6, 40% at V10

Split N application: 33% at planting, 67% at V6

†† Split N application: 50% at planting, 50% at V6

‡‡ NS, nonsignificant at the 0.1 level

Table 5. Kansas nitrogen recommendation (NREC) and minimum nitrogen fertilizer application corresponding to maximum grain yield (N required).

Location		Year	Yield Goal	SOM †	Profile N	Irrigation N	Previous Crop	NREC	N Required
			bu/a	%	- lb N/a	- - - - - - - - - - - - - - - - - - - -			
Ellinwood	1.0X	2001	180	1.2	32	12	0	221	165
		2002			41		0	212	110
	1.25X	2001	180	1.2	28	15	0	222	110
		2002			57		0	192	110
Rossville		2001	195	1.5	38	2.7	0	241	110
		2002			35		0	244	110
Scandia		2001	190	1.7	64	13	40	154	110
		2002			59		0	198	0
Manhattan		2001	170	2.1	33	0.5	0	196	165
		2002			34		0	196	165
Pretty Prairie	East	2001	215	1.6	51	49	0	212	60
		2002			107		0	156	150
	West	2001	135	0.9	36	49	0	113	120
St. John		2001	205	0.9	24	16	0	271	165
		2002			52		0	243	30

† SOM, soil organic matter

EFFECTS OF PHOSPHORUS APPLICATION ON GRAIN SORGHUM YIELD AND NUTRIENT CONTENT OF THE GRAIN

J. Massey, J. Herman, B. Olson, A. Schlegel, B. Brauer, and D. Leikam

Summary

A series of corn and grain sorghum studies have been initiated across the state over the past two years to help refine the information needed for crop nutrient recommendations. These studies were conducted for grain sorghum, and included P rates of 0, 20, 40, 80, and 120 lbs P_2O_5/a and were conducted at three locations across the state. All fertilizer P was broadcast applied. Considerable variability exists in the data obtained from these studies due to droughty conditions in the western half of Kansas the summer of 2004. However, grain yields did trend higher with increasing P application rates. The grain P content of grain sorghum increased with P application at the Sheridan County location.

Introduction

Several corn and grain sorghum studies have been initiated across the state to improve crop nutrient P and K recommendations. 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 values, 2) percentage sufficiency (for maximum yield) at various soil test values, 3) amounts of P and K nutrient application/crop removal to change soil test values, and 4) The amounts of P and K removed in the harvested grain.

This project was initiated for the 2003 crop and will continue for the 2005 crop year.

Procedures

Soil samples from the 0- to 6-inch depth were collected from individual plots at some locations and from individual replications at others. Bray P1, Mehlich 3 colorimetric and Mehlich 3 ICP soil test procedures were run on individual samples. For this report, only the Bray P1 results will be presented.

All of the reported studies were located in farmer/cooperator fields and all locations were dryland. A fourth irrigated grain sorghum study was established at the Tribune Research Station in Greeley County, but had not dried enough for harvesting as of early November.

Phosphorus rates of 0, 20, 40, 80, and 120 lbs P_2O_5/a were preplant broadcast applied in late winter. Applied P was incorporated at the Republic and Ford County sites, whereas the Sheridan County site was a no-till location. The treatments were replicated six times at Ford and Republic Counties. Six replications were established at the Sheridan County location as well, but two replications were lost to drought. Grain yields were obtained by hand harvesting 20 feet of row from the center of each plot.

Results

Droughty conditions affected all locations, with the Sheridan County site being the most severely affected. As a result, significant variability existed in grain yield data at each site. However, grain yield was consistently improved with P applications at each location, although differences were not significant at traditional significance levels.

Table 1. Effects of phosphorus application to grain sorghum, Sheridan County, Kansas, 2004.

	Grain Sorghum Grain		
P_2O_5 Rate	Yield	Test Weight	P Content
- lb/a -	bu/a	lb/bu	lb P_2O_5/bu
0	37	56.9	0.30
20	69	57.6	0.30
40	50	57.2	0.31
80	58	57.5	0.31
120	57	56.3	0.35
Sig. Level	0.38	NS	0.09

Bray P1 soil test – range of 26-36 ppm; average of 32 ppm.

Table 2. Effects of phosphorus application to grain sorghum, Republic County, Kansas, 2004.

	Grain Sorghum Grain			
P_2O_5 Rate	Yield	Test Weight	Moisture	P Content
- lb/a -	bu/a	lb/bu	%	lb P_2O_5/bu
0	89	53.8	17.7	0.27
20	99	56.6	17.3	0.24
40	104	54.9	17.8	0.26
80	108	54.0	17.5	0.25
120	120	56.8	16.0	0.26
Sig. Level	0.20	0.34	0.28	NS

Bray P1 soil test – range of 9-15 ppm; average of 12 ppm.

Table 3. Effects of phosphorus application to grain sorghum, Ford County, Kansas, 2004.

	Grain Sorghum Grain	
P_2O_5 Rate	Yield	Test Weight
- lb/a -	bu/a	lb/bu
0	61	55.4
20	82	57.9
40	77	57.6
80	91	58.8
120	90	56.8
Sig. Level	0.15	NS

Bray P1 soil test – range of 15-47 ppm; average of 29 ppm.

EFFECTS OF NITROGEN MANAGEMENT AND TILLAGE SYSTEM ON GRAIN SORGHUM

R. Lamond, C. Godsey, L. Ferdinand, and D. Leikam

Summary

Since 1992, responses of grain sorghum to tillage system, N rate, N source, and N placement have been investigated. One half of the study has been continuous no-till and one half has been under conventional tillage. For 2004, N rates were 0, 30, 60, and 120 lb N/A broadcast applied in the spring. Nitrogen sources included urea, ammonium nitrate, and a polymer- coated, slow-release urea. Conventional tillage resulted in much higher grain yields at the lower N rates than no-till; however, conventional and no-till grain yields were similar at the high N rate examined. In general, all N sources performed similarly.

Introduction

Tillage methods can influence grain sorghum yields through a number of mechanisms. Residue that accumulates at the soil surface with no-tillage increases soil moisture and cools soil temperatures. Cool, wetter soils may affect N availability by altering the rate of microbial mineralization and immobilization. In addition, there is the potential for volatilization loss from unincorporated, surface-applied urea under certain conditions.

In addition to tillage system, this long-term study has evaluated several N management factors over the past 20 years, including N application rate, N application method, urease inhibitors, and more recently, slow-release urea.

Procedures

Three N sources at three rates (30, 60, and 120 lb N/a) were used. The three N sources used were ammonium nitrate, urea, and a slow-release urea N fertilizer. The conventional tillage includes fall chisel and field cultivation in the spring before planting. For the conventional tillage, the N was applied before spring cultivation. Treatments were replicated three times and arranged in a split-plot design, with tillage as the main plot treatment and N rate/source as split-plot treatments. Twenty feet of row were hand harvested from the center of each plot.

Results

Results are summarized in Table 1. Yields were increased with increasing N rate by all sources in both tillage systems. In general, both N sources performed similarly under conventional tillage, but urea and ammonium nitrate performed better than the slow-release product did under no-till at the lower N application rates. Conventional tillage resulted in much higher grain yields at the lower N rates than no-till; however, conventional and no-till grain yields were similar at the high N rate examined.

This research will continue in future years.

Table 1. Effects of nitrogen management on grain sorghum, Riley County, Kansas, 2004.

		Yield		Tissue M	
N Rate	N Source	Conv. Till	No-Till	Conv. Till	No-Till
- - - lb/a - - -		- - - - - bu/a - - - - -		- - - - - % - - - - -	
0	---	50	24	1.5	1.2
30	Amm. Nitrate	71	54	1.8	1.9
30	Coated Urea	71	31	1.9	1.4
30	Urea	90	45	2.2	1.4
60	Amm. Nitrate	117	96	2.4	1.9
60	Coated Urea	106	48	2.6	1.5
60	Urea	100	84	2.4	2.0
120	Amm. Nitrate	110	132	2.8	2.1
120	Coated Urea	126	124	2.9	2.4
120	Urea	128	123	2.9	2.0
	LSD $_{(0.10)}$	16.2		0.48	
Significance Level		0.00001		0.00001	

	Yield	**Tissue N**
	bu/a	%
Amm. Nitrate	97	2.05
Coated Urea	84	2.34
Urea	95	2.00
LSD $_{(0.10)}$	6.9	0.21
30	60	1.97
60	92	2.32
120	124	2.07
LSD $_{(0.10)}$	6.9	0.21
No-Till	82	2.20
Conventional Till	102	2.05
LSD $_{(0.10)}$	5.7	0.17

EFFECTS OF ZINC FERTILIZER PRODUCTS AND COMPOST ON DTPA ZINC SOIL TESTS

D. Seymore and D. Leikam

Summary

Zinc fertilizer products of differing water solubility increased zinc soil test values in relationship to water solubility of products. The greater the water solubility, the more that DTPA Zn soil tests increased, regardless of Zn application rate. As the applied Zn rate increased, DTPA soil test values increased regardless of inorganic Zn source. Only the low rate of compost has been applied so far, and soil tests have changed very little in response to compost application.

Introduction

There are many zinc fertilizer products on the market, and these products often differ considerably in water solubility. Although questions about efficacy of these products to increase soil test values are often raised, there is little information on which to base an answer. Questions abound as to the effect of manure/compost on resulting Zn soil test values. Presented are preliminary results of a study initiated early in 2003.

Procedures

Locations of these zinc studies are distributed across a broad section of western Kansas. Dryland locations included Thomas, Ness, and Ford (near Dodge City) Counties. In addition, an irrigated site was established in Ford County (near Ford). Soil samples (0-6”) were collected from each individual plot before fertilizer application. Products were broadcast applied.

Because of drought conditions, it was not possible to resample the Ness and Thomas County locations until 18 months after initial zinc product application. About 10 to12 individual soil cores were collected from each plot and combined into a composite sample, and the sample was then submitted to the laboratory for analysis.

Zinc products used included a zinc sulfate product (96% water soluble), an oxysulfate product (50% water solubility), an older zinc product with limited water solubility (15% water solubility), and a beef feedlot compost material.

Results

Although these results are preliminary, it seems that the efficacy of zinc fertilizer products is directly related to water solubility over the time frame studied. Follow-up sampling will continue in 2005 for these studies.

Location		Tillage System	Soil Acidity	Free Lime
Thomas Co.	Dryland	No-Till	5.4 – 6.5	None
Ness Co.	Dryland	Minimum Till	6.1 – 6.6	None
Ford Co. (Dodge)	Dryland	Minimum Till	6.3 – 8.0	None
Ford Co. (Ford)	Irrigated	Minimum Till	7.9 – 8.3	Slight - Moderate

Table 1. Effects of zinc fertilizer water solubility on DTPA Zn soil test change, Ness County, Kansas, 2004 (preliminary results).

			DTPA Zn Soil Test		
Zn Product	Zn Rate	Water Soluble Zn	Initial 2003 Zn Test	2004 Zn Soil Test	18 Month Soil Test Change
	lb/a	%	ppm	ppm	ppm
None	0	---	0.4	0.6	0.2
Product A	5	15	0.4	0.8	0.4
Product A	15	15	0.4	2.2	1.8
Product B	5	50	0.4	1.1	0.7
Product B	15	50	0.4	2.5	2.1
Product C	5	96	0.4	1.4	1.0
Product C	15	96	0.4	3.5	3.1
Significance Level			NS	0.0001	0.0001

Table 2. Effects of zinc fertilizer water solubility on DTPA Zn soil test change, Thomas County, Kansas, 2004 (preliminary results).

			DTPA Zn Soil Test		
Zn Product	Zn Rate	Water Soluble Zn	Initial 2003 Zn Test	2004 Zn Soil Test	18 Month Soil Test Change
	lb/a	%	ppm	ppm	ppm
None	0	---	0.4	0.6	0.1
Product A	5	15	0.6	0.9	0.3
Product A	15	15	0.5	2.1	1.6
Product B	5	50	0.6	1.0	0.4
Product B	15	50	0.6	2.9	2.3
Product C	5	96	0.7	1.4	0.7
Product C	15	96	0.6	3.4	2.8
Significance Level			NS	0.27	0.28

Table 3. Effects of zinc fertilizer water solubility on DTPA Zn soil test change Dodge City, Kansas, 2004 (preliminary results).

Zn Product	Zn Rate	Water Soluble Zn	DTPA Zn Soil Test: Initial 2003 Zn Test	2004 Zn Soil Test	18 Month Soil Test Change
	lb/a	%	ppm	ppm	ppm
None	0	---	0.5	0.8	0.3
Product A	5	15	0.4	2.0	1.6
Product A	15	15	0.5	1.8	1.3
Product B	5	50	0.5	1.4	1.0
Product B	15	50	0.4	3.2	2.8
Product C	5	96	0.4	1.8	1.4
Product C	15	96	0.8	4.6	3.8
Compost	5	---	0.6	1.4	0.8
Compost	5 (15)*	---	0.6	1.2	0.6
Significance Level			NS	0.0001	0.0001

Table 4. Effects of zinc fertilizer water solubility on DTPA Zn soil test change Ford County, Kansas, 2004 (preliminary results).

Zn Product	Zn Rate	Water Soluble Zn	DTPA Zn Soil Test: Initial 2003 Zn Test	2004 Zn Soil Test	18 Month Soil Test Change
	lb/a	%	ppm	ppm	ppm
None	0	---	2.0	1.9	- 0.2
Product A	5	15	2.2	2.6	0.3
Product A	15	15	2.1	2.9	0.8
Product B	5	50	2.0	2.2	0.2
Product B	15	50	2.0	3.8	1.9
Product C	5	96	2.0	3.8	1.8
Product C	15	96	2.1	4.5	2.4
Compost	5	---	1.9	2.1	0.2
Compost	5 (15)*	---	2.1	1.0	- 0.2
Significance Level			NS	0.01	0.01

* Only the 5-lb Zn/a compost rate had been applied as of this fall on the 15 lb Zn/a plots. Additional compost will be applied this winter.

RELATIONSHIP OF MEHLICH-3 ICP AND MEHLICH-3 COLORIMETRIC PHOSPHORUS DETERMINATIONS WITH THE BRAY-P1 EXTRACTANT

J. Herman, J. Massey, D. Leikam, and S. Harrold

Summary

More state universities and commercial laboratories are switching to the Mehlich 3 extractant and away from the Bray P1 extractant because it allows multiple nutrient analyses on a single extract. In addition, there continues to be a trend to laboratories using ICP analysis because it allows for simultaneous analyses of multiple nutrients with the same extract. High correlations exist among the three P soil test methods examined (BP1, M3-Col, and M3-ICP), although the BP1 test provided lower-than-expected values on calcareous samples. Both the M3-Col and M3-ICP tests worked well on both calcareous and non-calcareous soils and both were highly correlated with each other.

However, additional work will be conducted to examine the relationship between M3-Col and M3-ICP at soil test values in the crop response range (less than 30 ppm) because it seems that, at low P soil test values, the M3-ICP extracts relatively more P than the M3-Col method does. Also, additional work relating P soil test values for each of these three soil test methods to crop response and grain nutrient content will continue.

Introduction

The Bray P1 extractant has traditionally been the common extractant used for soil testing in the Midwest and Great Plains, whereas the Olsen P test has been the dominant phosphorus (P) extractant used in many western states. The use of the Mehlich-3 extractant for determining soil test P in private and state-operated soil test laboratories has become more commonplace in recent years. The ability to extract multiple elements is a major advantage of the Mehlich-3 test. Although the Mehlich-3 test is often run using the more traditional colorimetric procedure, the use of ICP in conjunction with the Mehlich-3 extractant is also becoming more commonplace as pricing declines. With changes in extractants and analytical techniques also comes the need to evaluate these new tests for agronomic and environmental-stewardship purposes. As part of a larger P management project, this study used 367 soil samples collected from 10 locations across Kansas and western Missouri that were analyzed by Bray P1 with colorimetric determination (BP1), Mehlich-3 with colorimetric determination (M3-Col), and Mehlich-3 with ICP determination (M3-ICP).

Procedures

A total of 367 soil samples were collected from individual plots at nine locations throughout Kansas and one from western Missouri. Selected soil properties for each location are presented in Table 1. Fifteen soil cores were collected from the 0- to 6-inch depth for each sample location at each site. The samples were analyzed for Bray-P1 soil test P, soil pH was determined, and free lime estimates were done at the Kansas State University soil test laboratory. Mehlich-3 colorimetric and ICP determinations and soil organic matter were run by Servi-Tech soil test laboratory. All soil test determinations were made using the same dried and ground sample.

Results

M3-Col and M3-ICP vs. Bray P1

In general, the M3-Col and BP1 procedure and the M3-ICP and BP1 procedures were well correlated at individual locations. The main exceptions were the Brown and the Dekalb sites (Table

2). It is unknown why these locations were so different from the rest of the sites. It is interesting that the Dekalb location was previously in pasture, with the sod being worked up in late winter 2003, and also had very low Bray P1 soil test values.

At Ellis County, 12 of the 90 samples collected contained appreciable amounts of free lime (calcareous soils). Although the correlations between both the M3-Col and M3-ICP procedures to the BP1 extractant were very good, many of these 12 samples appeared as outliers (Figure 1). These outliers resulted in lower-than-expected BP1 values relative to either Mehlich-3 determination. The r^2 value of the M3-ICP to BP1 comparison was not improved by removal of these soils (0.84 vs. 0.84), but the relationship of the M3-Col to BP1 was improved (0.79 to 0.85).

Both the M3-Col and M3-ICP methods were highly correlated with BP1 when all locations were combined for analysis (Figure 2). Calcareous samples were excluded for this analysis. Overall, the M3-Col method extracted about 12% more P than the BP1 extractant. The M3-ICP extracted more P than either the M3-ICP or BP1 procedures did.

M3-Col and M3-ICP

The M3-Col and M3-ICP determinations were very highly correlated, with r^2 values exceeding 0.70 at all locations except for the Dekalb County site (r^2 = 0.35); the r^2 values were greater than 0.96 at seven of ten locations. Although it is unknown at this time why the Dekalb location provided such results, the differences at Dekalb County were striking. The average soil test values at this location were 3.6, 3.2, and 9.8 ppm for the BP1, M3-Col, and M3-ICP determinations, respectively. It is possible that the only recently disturbed pasture residues resulted in greater amounts of organic P being measured by the M3-ICP procedure, compared with either the BP1 or M3-Col procedure.

When the samples from all locations are combined (Fig. 3), including the calcareous soils, the M3-Col and M3-ICP determinations were very highly correlated (r^2 = 0.98). At low soil test values, however, the M3-ICP procedure extracted relatively more P than the M3-Col procedure did. Figure 3 presents the ratio of the M3-Col determination divided by the M3-ICP determination. The data clearly suggests that the relationship between M3-Col and M3-ICP varies depending on the relative P soil test levels. It is hoped that this relationship will become clearer as additional years of data are included.

Overall

The BP1 test was highly correlated with both the M3-Col and M3-ICP procedures, especially for non-calcareous soils (r^2 = 0.91-0.93). Likewise, M3-Col and M3-ICP were highly correlated across all soils (r^2 = 0.98). However, the relationship of M3-Col to M3-ICP differs, depending on the M3-Col soil test value. Additional work to further define this relationship and the relationship of each of these tests to crop response and grain nutrient content will continue.

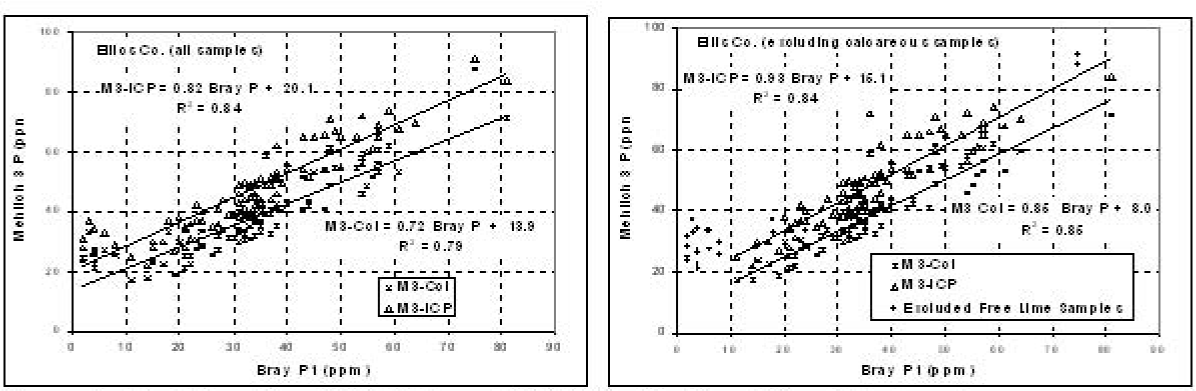


Figure 1. Relationship of M3-Col and M3-ICP with Bray P1 soil tests values on calcareous and non-calcareous soils, Ellis County, Kansas, 2003.

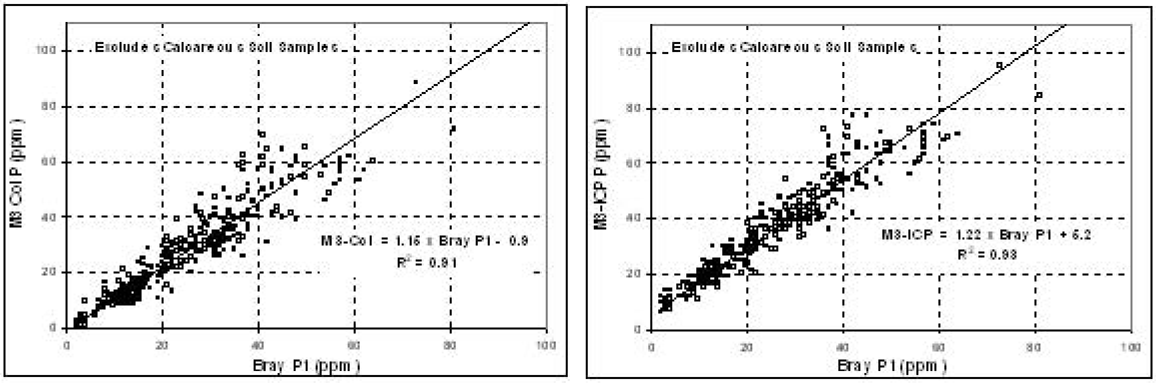


Figure 2. Overall relationship of M3-Col and M3-ICP with Bray P1 soil tests values on non-calcareous soils,10 locations, 2003.

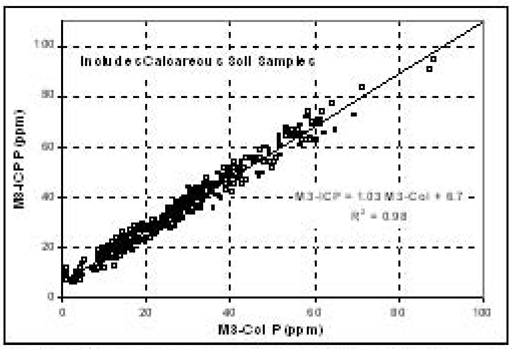


Figure 3. Overall relationship of M3-Col and M3-ICP P soil test values, 10 locations, 2003.

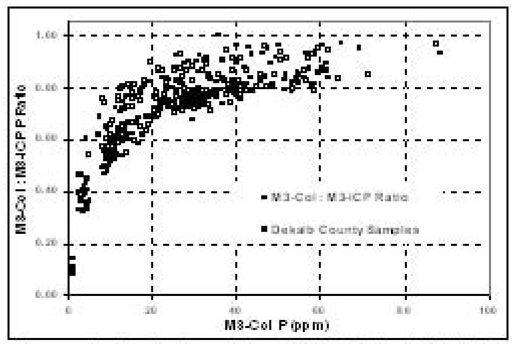


Figure 4. Relationship of M3-Col : M3-ICP P ratio to M3-Col soil test value, 10 locations, 2003.

Table 1. Soil sample locations and properties.

Location	Soil Organic Matter (%)	Soil pH	Free Lime	Number of Samples
Brown County	2.2 – 2.7	5.9 – 6.8	None	40
Clay County	1.7 – 3.2	4.9 – 5.5	None	32
Cherokee County	1.5 – 2.1	5.9 – 6.8	None	45
Decatur County	1.6 – 2.1	5.9 – 6.5	None	25
Dekalb County (MO)	2.5 – 3.4	5.7 – 6.8	None	30
Dickinson County	2.3 – 3.8	6.1 – 7.4	None	40
Ellis County	1.5 – 3.4	5.9 – 8.3	None - High	90
Gove County	2.2 – 3.3	5.9 – 7.0	None	24
Hodgeman County	1.6 – 2.2	6.1 – 7.3	None	9
Saline County	1.9 – 2.8	NA	NA	32

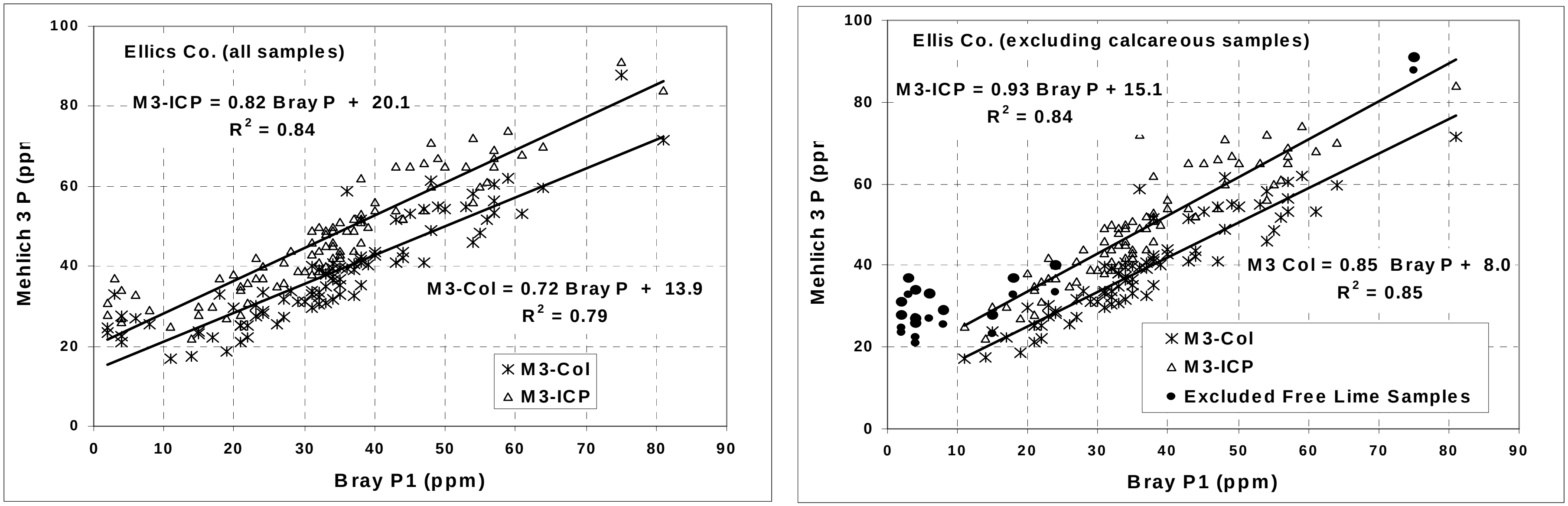
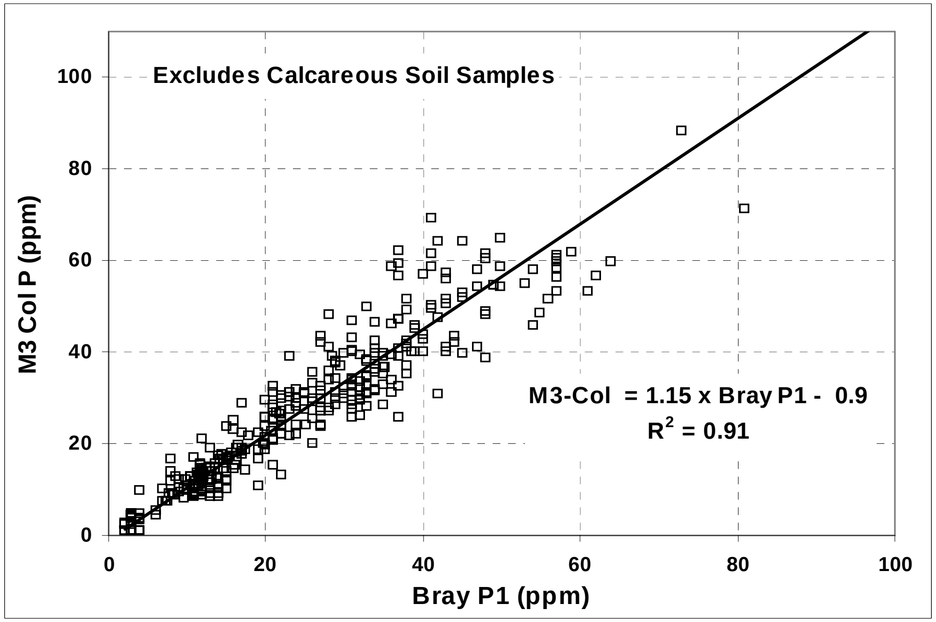


Figure 1. Relationship of M3-Col and M3-ICP with Bray P1 soil tests values on calcareous and non-calcareous soils, Ellis County, Kansas, 2003.



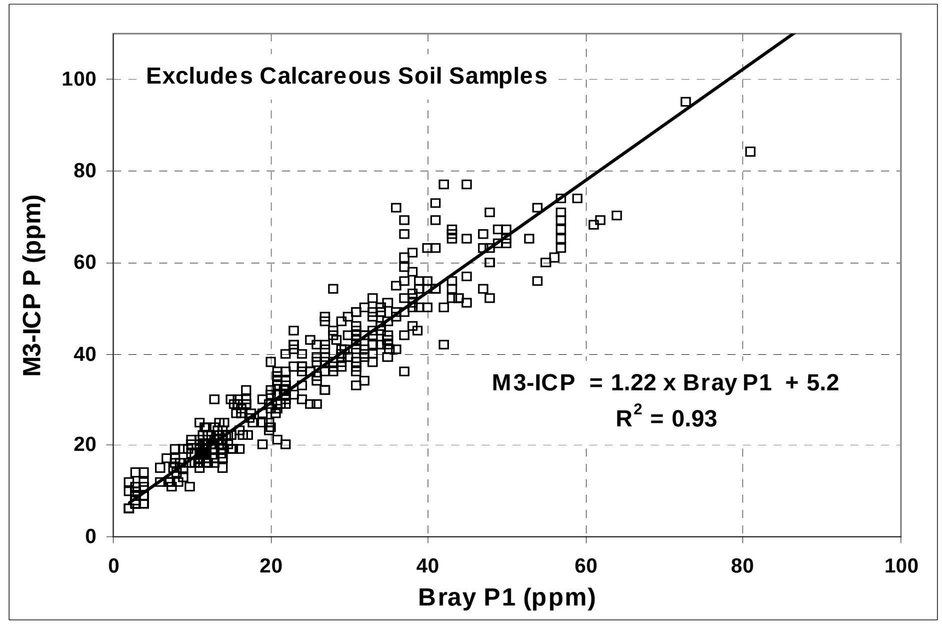


Figure 2. Overall relationship of M3-Col and M3-ICP with Bray P1 soil tests values on non-calcareous soils,10 locations, 2003.

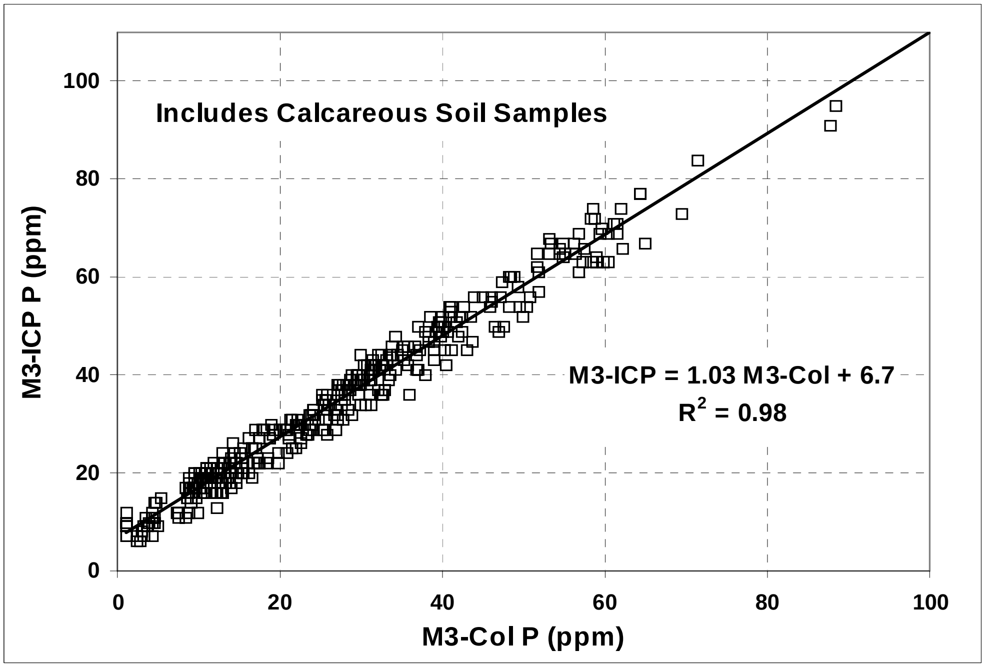


Figure 3. Overall relationship of M3-Col and M3-ICP P soil test values, 10 locations, 2003.

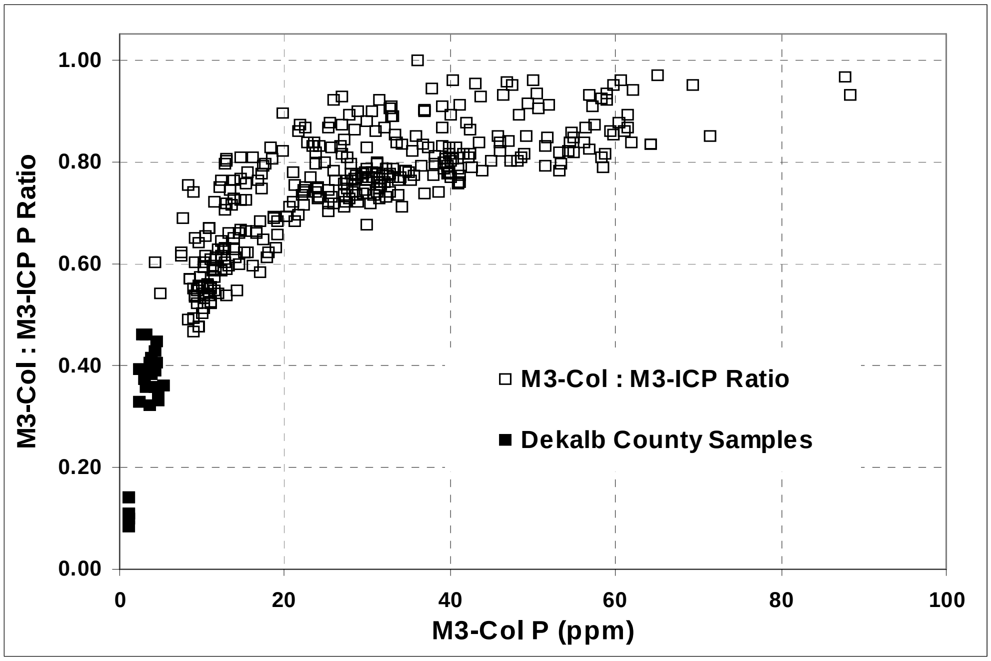


Figure 4. Relationship of M3-Col : M3-ICP P ratio to M3-Col soil test value, 10 locations, 2003.

INDEX - 2004 KANSAS FERTILIZER REPORT

CROP

Corn

Cool-Season Grass

Grain Sorghum

Soybean

Wheat

Miscellaneous

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