KS-23F
1990

PROJECT TITLE: EFFECT OF LONG TERM NITROGEN, PHOSPHORUS, AND POTASSIUM FERTILIZATION OF IRRIGATED CORN AND GRAIN SORGHUM

PROJECT LEADER:

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PROJECT LOCATION: West-central Kansas at the Tribune Unit, Southwest Research-Extension Center.

OBJECTIVES:

1. Determine the optimum nitrogen rate for irrigated corn and grain sorghum.

2. Determine whether phosphorus fertilization is necessary for optimum grain production of irrigated corn and grain sorghum.

3. Determine whether potassium fertilization is necessary for optimum grain production of irrigated corn and grain sorghum.

RESULTS:

1. Nitrogen fertilization is required for optimum production of irrigated corn and grain sorghum in western Kansas. Maximum corn yields are usually obtained with about 160 lb N/acre and maximum grain sorghum yields obtained with about 100 lb N/acre.

2. Phosphorus fertilization increases grain yields of irrigated corn and grain sorghum. A yield response from P fertilizer has been observed for the last 25 years in this long term study. This response has increased with time and this year, the 30th year of the study, corn yields were increased 75 bu/acre and sorghum yields increased 25 bu/acre by P fertilizer.

3. Corn and grain sorghum yields are not increased by K additions due to inherently high K content of the soil.

The results of this study can be cited by PPI/FAR.

PROJECT CHANGES:

Several additional objectives are being added to the project. They are to 1.) determine the effect of long term NPK applications on soil chemical properties, 2.) determine the effect of P fertilization on crop utilization of N fertilizer, and 3.) determine the effect of long term N fertilization on nitrate movement.

ECONOMIC ANALYSIS:

Substantially higher grain yields of irrigated corn and grain sorghum can be obtained when both N and P fertilizer are applied than from N alone. In 1990, the increase in yields from 40 lb P_2O_5/acre were about 75 bu/acre for corn and 25 bu/acre for sorghum when applied with adequate N fertilizer. The economic return from P fertilizer would be about $165/acre for corn and $50/acre for sorghum (corn at $2.20/bu and sorghum at $2.00/bu).

INTERPRETIVE SUMMARY:

Long term research shows that phosphorus fertilizer must be applied for optimum grain yields of irrigated corn and grain sorghum in western Kansas. In 1990, P fertilizer (40 lb P_2O_5/acre) increased corn yields 75 bu/acre and grain sorghum yields 25 bu/acre when adequate N was also applied. Optimum N rates are about 160 lb N/acre for corn and about 100 lb N/acre for grain sorghum. Potassium fertilizer is not needed for irrigated corn and grain sorghum due to the inherently high K content of the soil.

EFFECT OF NITROGEN, PHOSPHORUS, AND POTASSIUM FERTILIZATION OF IRRIGATED CORN AND GRAIN SORGHUM

Alan Schlegel

This study was initiated in 1961 to determine responses of continuous corn and grain sorghum grown under flood irrigation to nitrogen, phosphorus, and potassium fertilization.

Procedure

Corn and grain sorghum were grown on Ulysses silt loam in adjacent plot areas. Fertilizer treatments were N rates of 0, 40, 80, 120, 160, and 200 lb N acre^{-1} without P and K; with 40 lb P_2O_5 acre^{-1} and zero K; and with 40 lb P_2O_5 acre^{-1} and 40 lb K_2O acre^{-1}. Fertilizers were broadcast by hand on 13 April 1990 for corn and 15 May 1990 for sorghum. Corn (Pioneer 3379) was planted on 2 May, and sorghum (Golden Acres TE Y-75) was planted on 6 June. Rainfall from planting to harvest was 9.21" for corn and 6.52" for sorghum. Both studies were furrow irrigated as needed during the growing season. All plots were machine harvested (16 October for corn and 27 October for sorghum). Grain yields were adjusted to 15.5% moisture for corn and 12.5% for sorghum.

Surface soil samples (0 to 6 inches) were taken after harvest in 1989 in both studies and analyzed for phosphorus (Bray-1) and exchangeable potassium. Grain samples were taken at harvest in 1989 and analyzed for N, P, and K content.

Results

Corn yields in 1990 ranged from 71 to 212 bu acre^{-1} (Tables 1 and 2). Nitrogen applications increased yields for each increment of N up to 160 lb N acre^{-1}. Addition of phosphorus (40 lb P_2O_5 acre^{-1}) increased corn yields by 52 bu acre^{-1} when averaged across N rates. The benefit from P addition increased with increased N rates. At N rates of 120 lb N acre^{-1} and greater, P increased yields by about 75 bu acre^{-1}.

Grain sorghum yields ranged from 66 to 126 bu acre^{-1} in 1990 (Tables 1 and 3). Grain yields increased with increased N up to 120 lb N acre^{-1}. When averaged across N rates, P increased yields by 17 bu acre^{-1}. Similar to corn, P increased sorghum yields more when N as adequate. Yields were 25 bu acre^{-1} higher from added P at N rates of 120 lb N and higher.

Potassium applications had no significant effect on corn or sorghum yields in 1990. The plot area is located on a soil inherently high in K, and the effect of K additions has always been negligible.

Grain N content and removal increased with increased N rates for both corn and sorghum in 1989 (Tables 4 and 5). At optimum N rates, the total amount of N in the grain was about 100 lb N for corn and 50 lb N for sorghum. Grain removal of P was also lower for sorghum than corn reflecting the reduced sorghum yields.

Soil P was in the medium range at 17 ppm when the corn study was initiated. Soil P has been maintained in the medium range with P fertilization (Table 6). However, without fertilizer P, soil P levels decreased about 10 ppm and are now in the low P range. In the sorghum study, initial soil P was 18 ppm and with P fertilization has increased to about 25 ppm. Without fertilizer P, soil P levels have decreased to about 8 ppm.

Conclusions

Grain yields of irrigated corn and grain sorghum are increased by N and P applications but not by K additions. For the 30 years of this study, maximum corn yields have consistently been obtained with N rates of 160 lb N acre^{-1} and maximum sorghum yields obtained with 80-120 lb N acre^{-1}. The addition of P, averaged over the past 10 years, has increased corn yields by approximately 45 bu acre^{-1} and grain sorghum yields by 20 bu acre^{-1} when N rates are 120 lb N acre^{-1} or greater.

Soil P levels have been maintained with 40 lb P_2O_5 acre^{-1} with corn and slightly increased with sorghum. Without fertilizer P, soil P levels have declined to the low soil P range. Soil K levels increased with K fertilization, however initial soil K levels were maintained without fertilizer K.

Table 1. Effect of N, P, and K fertilization on grain yield of irrigated corn and grain sorghum, Tribune, KS. 1990.

N Rate	Corn yields P_2O_5-K_2O (lb/a)				Sorghum yields P_2O_5-K_2O (lb/a)			
	0-0	40-0	40-40	Mean	0-0	40-0	40-40	Mean
lb/a	bu/acre							
0	71	73	80	75	66	67	67	67
40	94	125	125	115	88	102	97	96
80	124	160	161	149	98	106	120	108
120	120	195	199	171	94	126	122	114
160	118	212	207	179	97	123	123	114
200	130	207	209	182	102	125	126	117
Mean	110	162	163		91	108	109	
$LSD_{.05}$	Nitrogen			8				7
	P-K			6				5

Table 2. Effect of nitrogen, phosphorus, and potassium on grain yield of irrigated corn, 1961-1990, Tribune, KS.

N	P_2O_5	K_2O	Year 81	82	83	84	85	86	87	88	89	90	81-90	61-90
- lb/a -			- - - - - - - - - - - bu/a[1] - - - - - - - - - - - - -											
0	0	0	74	100	91	115	72	107	52	62	82	71	82	70
40	0	0	93	135	110	147	104	130	93	86	106	94	110	108
80	0	0	92	135	104	153	98	138	102	104	118	124	116	123
120	0	0	91	138	112	149	93	132	98	98	111	120	114	125
160	0	0	103	133	119	168	99	144	109	105	122	118	121	132
200	0	0	101	130	112	158	97	149	95	107	121	130	120	133
0	40	0	69	106	105	126	68	112	53	59	96	73	86	72
40	40	0	102	154	124	174	117	161	107	101	134	125	130	119
80	40	0	119	157	133	169	133	165	135	128	164	160	146	143
120	40	0	124	176	124	193	135	194	146	150	170	195	160	158
160	40	0	145	176	133	194	144	200	158	172	180	212	171	167
200	40	0	135	170	134	194	139	170	157	169	182	207	167	165
0	40	40	70	109	106	139	79	109	58	60	89	80	90	75
40	40	40	111	149	136	180	103	162	102	103	131	125	130	119
80	40	40	119	156	128	190	119	176	136	128	160	161	147	142
120	40	40	125	179	137	201	141	185	145	144	184	199	165	159
160	40	40	133	164	125	177	142	186	151	161	169	207	160	163
200	40	40	155	154	122	203	129	198	161	169	172	209	168	166

[1] Grain yields adjusted to 15.5% moisture.

Table 3. Effect of nitrogen, phosphorus, and potassium on yield of irrigated grain sorghum, 1961-1990, Tribune, KS.

N	P_2O_5	K_2O	Year 81	82	83	84	85	86	87	88	89	90	81-90	61-90
- - lb/a - -			- - - - - - - - - - - bu/a[1] - - - - - - - - - - - - - -											
0	0	0	57	73	73	90	70	103	67	62	37	66	71	72
40	0	0	76	114	71	97	90	108	79	76	50	88	85	93
80	0	0	76	108	76	111	103	115	83	93	62	98	92	105
120	0	0	67	106	81	106	99	104	76	90	57	94	88	103
160	0	0	74	105	79	100	99	114	74	90	62	97	89	103
200	0	0	71	114	72	111	107	101	84	99	68	102	93	105
0	40	0	54	87	85	94	66	99	62	61	35	67	71	73
40	40	0	73	120	95	117	116	137	103	105	75	102	104	106
80	40	0	78	134	81	109	113	141	104	112	67	106	105	113
120	40	0	87	132	87	119	112	137	98	124	80	126	110	118
160	40	0	83	128	85	129	124	149	101	130	79	123	113	121
200	40	0	83	129	90	123	120	144	99	129	80	125	112	121
0	40	40	59	103	81	86	65	96	65	62	41	67	73	74
40	40	40	84	114	89	112	113	134	97	108	77	97	103	106
80	40	40	83	129	87	118	120	146	103	121	82	120	111	117
120	40	40	83	135	84	116	117	134	98	129	79	122	110	120
160	40	40	82	129	85	106	117	147	98	124	70	123	108	119
200	40	40	88	131	85	121	118	140	99	130	88	126	113	120

[1] Grain yields adjusted to 12.5% moisture.

Table 4. Effect of nitrogen, phosphorus, and potassium on grain yield; grain N, P, and K content; and grain removal of N, P, and K of irrigated corn. Tribune, KS, 1989.

N	P_2O_5	K_2O	Grain Yield	Grain N	Grain P	Grain K	Grain Removal N	Grain Removal P	Grain Removal K
- - lb/a - -			bu/a	- - - - % - - - -			- - - - lb/a - - - -		
0	0	0	82	0.95	0.21	0.26	37	8.3	10.3
0	40	0	96	0.91	0.26	0.30	42	11.9	13.7
0	40	40	89	0.88	0.26	0.31	37	11.1	13.0
40	0	0	106	1.06	0.20	0.25	53	10.1	12.3
40	40	0	134	0.98	0.25	0.29	62	15.9	18.3
40	40	40	131	0.98	0.24	0.28	61	15.2	17.7
80	0	0	130	1.19	0.17	0.22	67	9.7	12.2
80	40	0	164	1.09	0.24	0.27	85	18.3	20.8
80	40	40	160	1.08	0.23	0.27	82	17.6	20.3
120	0	0	111	1.23	0.18	0.23	65	9.7	11.9
120	40	0	170	1.13	0.22	0.25	91	17.4	19.7
120	40	40	184	1.14	0.24	0.27	99	20.7	23.3
160	0	0	122	1.21	0.17	0.21	69	9.6	12.1
160	40	0	180	1.17	0.24	0.26	100	20.2	21.9
160	40	40	169	1.16	0.21	0.25	93	16.8	19.7
200	0	0	121	1.24	0.19	0.23	71	10.9	13.4
200	40	0	182	1.18	0.22	0.25	102	19.4	21.3
200	40	40	172	1.19	0.22	0.25	97	18.2	20.4
ANOVA									
Nitrogen			**	**	**	**	**	**	**
P-K			**	**	**	**	**	**	**
N * P-K			**	ns	ns	ns	**	**	**

MEANS

Nitrogen	Yield	N	P	K	N	P	K
lb/a	bu/a	- - - - % - - - -			- - - lb/a - - -		
0	89d	0.91e	0.246a	0.29a	39d	10.4c	12.3c
40	124c	1.01d	0.232b	0.27b	59c	13.7b	16.1b
80	147b	1.12c	0.214c	0.25c	78b	15.2a	17.8a
120	155ab	1.17b	0.212c	0.25cd	85a	15.9a	18.3a
160	157a	1.18ab	0.205c	0.24d	87a	15.5a	17.9a
200	158a	1.21a	0.213c	0.24cd	90a	16.1a	18.3a
$LSD_{.05}$	9	0.04	0.013	0.01	6	1.4	1.4
P-K (lb/a)							
0-0	110b	1.15a	0.188b	0.23b	60b	9.7b	12.0b
40-0	154a	1.08b	0.238a	0.27a	80a	17.2a	19.3a
40-40	151a	1.07b	0.236a	0.27a	78a	16.6a	19.1a
$LSD_{.05}$	7	0.03	0.009	0.01	4	1.0	1.0

Table 5. Effect of N, P, and K fertilization on grain yield; grain N, P, and K content; and grain removal of N, P, and K of irrigated grain sorghum. Tribune, KS, 1989.

N	P_2O_5	K_2O	Grain				Grain removal		
			Yield	N	P	K	N	P	K
- - -lb/a - -			bu/a	- - - - - - % - - - - -			- - - lb/a - - -		
0	0	0	37	1.03	0.31	0.49	19	5.5	8.7
0	40	0	35	1.07	0.35	0.50	18	6.0	8.5
0	40	40	41	1.09	0.34	0.49	22	6.8	9.7
40	0	0	50	1.15	0.26	0.45	28	6.4	10.9
40	40	0	75	1.08	0.31	0.43	39	11.6	15.6
40	40	40	77	1.15	0.32	0.46	44	12.1	17.5
80	0	0	62	1.26	0.23	0.47	38	7.1	14.0
80	40	0	67	1.19	0.32	0.46	39	10.5	15.0
80	40	40	82	1.26	0.30	0.46	50	12.2	18.2
120	0	0	57	1.31	0.22	0.46	37	6.2	12.8
120	40	0	80	1.30	0.31	0.49	51	12.1	19.1
120	40	40	79	1.33	0.32	0.49	51	12.7	19.0
160	0	0	62	1.40	0.23	0.45	43	6.9	13.7
160	40	0	79	1.37	0.32	0.49	53	12.5	18.4
160	40	40	70	1.37	0.30	0.49	47	10.4	16.4
200	0	0	68	1.39	0.24	0.47	46	8.1	15.5
200	40	0	80	1.36	0.30	0.49	53	11.9	18.9
200	40	40	88	1.36	0.31	0.50	58	13.4	21.3
ANOVA									
Nitrogen			**	**	**	**	**	**	**
P-K			**	ns	**	ns	**	**	**
N * P-K			ns	ns	ns	ns	ns	ns	ns
MEANS									
Nitrogen			Yield	N	P	K	N	P	K
lb/a			bu/a	- - - - - - % - - - - - -			- - - lb/a- - - -		
0			38c	1.06e	0.33a	0.49a	20d	6.1b	9.0c
40			67b	1.13d	0.30b	0.45c	37c	10.0a	14.7b
80			70ab	1.24c	0.29b	0.46b	42bc	10.0a	15.7b
120			72ab	1.31b	0.28b	0.48a	46ab	10.4a	17.0ab
160			70ab	1.38a	0.28b	0.48a	47ab	9.9a	16.2ab
200			79a	1.37ab	0.28b	0.48a	53a	11.1a	18.6a
$LSD_{.05}$			11	0.06	0.02	0.02	7	2.0	2.4
P-K (lb/a)									
0- 0			56b	1.26a	0.25b	0.46b	35b	6.7b	12.6b
40- 0			69a	1.23a	0.32a	0.48a	42a	10.8a	15.9a
40-40			73a	1.26a	0.32a	0.48a	45a	11.3a	17.0a
$LSD_{.05}$			8	0.04	0.01	0.02	5	1.4	1.7

Table 6. Effect of N, P, and K fertilization of irrigated corn and grain sorghum on soil P and soil K levels. Tribune, KS, 1989.[1]

N	P_2O_5	K_2O	Corn		Grain sorghum	
			Bray-1 P	Exch. K	Bray-1 P	Exch. K
- - -lb/a - -			- - - - - - - - - - - - - ppm		- - - - - - - - - - -	
0	0	0	6	580	9	560
0	40	0	30	610	38	540
0	40	40	31	680	36	600
40	0	0	6	630	9	560
40	40	0	22	610	32	570
40	40	40	24	740	29	600
80	0	0	7	600	6	540
80	40	0	17	630	26	580
80	40	40	15	770	26	610
120	0	0	6	590	6	550
120	40	0	13	680	18	540
120	40	40	16	770	23	590
160	0	0	7	630	8	580
160	40	0	14	680	22	530
160	40	40	13	750	17	600
200	0	0	9	620	8	550
200	40	0	13	700	18	530
200	40	40	13	770	22	590
ANOVA						
Nitrogen			**	**	**	ns
P-K			**	**	**	**
N * P-K			**	ns	**	ns
MEANS						
Nitrogen			Bray-1 P	Exch. K	Bray-1 P	Exch. K
lb/a			- - - - - - - - - - - - - ppm		- - - - - - - - - - -	
0			22a	620b	27a	570ab
40			17b	660ab	23b	580ab
80			13c	670a	19c	580a
120			11c	680a	16d	560ab
160			12c	690a	15d	570ab
200			12c	700a	16d	560b
$LSD_{.05}$			4	40	3	18
P-K (lb/a)						
0- 0			7b	610c	8b	560b
40- 0			18a	650b	26a	550b
40-40			19a	740a	25a	600a
$LSD_{.05}$			3	30	2	13

[1] Initial soil P levels were 17 ppm for corn and 18 ppm for sorghum. Initial soil K was 500 ppm or greater for both studies.

CORN AND GRAIN SORGHUM RESPONSE TO TILLAGE, PREPLANT IRRIGATION, AND PHOSPHORUS PLACEMENT

Alan Schlegel

This research was conducted to determine the feasibility of ridge tillage for flood irrigated corn and grain sorghum in western Kansas. Additional objectives were to 1.) determine the benefit from preplant irrigation for ridge and conventional tillage, and 2.) determine whether phosphorus placement was affected by tillage practices.

Procedures

Corn and grain sorghum have been grown continuously since 1988 under conventional and ridge tillage systems. Phosphorus fertilizer has been applied since 1989. Conventional tillage consists of stalk shredding and discing in the fall followed by spring discing and furrowing prior to planting. With ridge tillage, the only operation between harvest and planting is shredding stalks. Tillage (two cultivations) during the growing season was the same for both systems. Preplant irrigation treatments were applied 2 to 4 weeks prior to planting. In-season irrigations were applied uniformly to all plots when needed. Phosphorus was broadcast and band applied at planting at a rate of 40 lb P_2O_5/acre along with a zero P check. All plots were machine harvested and grain yields adjusted to 15.5% for corn and 12.5% for sorghum.

Results

Similar corn yields have been obtained with ridge and conventional tillage (Table 1). Preplant irrigation did not significantly increase corn yields. Grain sorghum yields in 1989 were extremely low due to an earlier than normal frost. Sorghum yields in 1990 were not affected by tillage, but were increased slightly by preplant irrigation. Both corn and grain sorghum yields were increased by P fertilization, however, placement had no effect on yields.

Table 1. Effect of tillage, preplant irrigation, and phosphorus placement on grain yield of corn and grain sorghum. Tribune, KS, 1989-1990.

Tillage	Preplant Irrigation	Phosphorus Placement	Corn 1989	Corn 1990	Sorghum 1989	Sorghum 1990
			------ bu/acre	-----		
Conv	Yes	None	162	148	41	97
		Bdct	170	165	45	100
		Band	176	167	46	106
	No	None	163	143	52	89
		Bdct	166	163	50	100
		Band	173	165	33	101
Ridge	Yes	None	161	140	40	99
		Bdct	170	164	53	107
		Band	166	159	44	103
	No	None	155	141	34	92
		Bdct	179	169	38	101
		Band	172	158	59	100
ANOVA[1]						
Tillage			*	ns	ns	ns
Irrigation			ns	ns	ns	*
P Placement			**	**	ns	**
Tillage * Irrigation			ns	ns	ns	ns
Tillage * P placement			ns	ns	ns	*
Irrigation * P placement			ns	ns	ns	ns
MEANS						
Tillage		Conv	169a	159a	47a	99a
		Ridge	164b	155a	47a	100a
		$LSD_{.05}$	4	4	9	4
Preplant irrigation		Yes	168a	157a	49a	102a
		No	165a	157a	45a	97b
		$LSD_{.05}$	4	4	9	4
P placement		None	158b	143b	43b	94b
		Bdct	170a	165a	51a	102a
		Band	173a	163a	47ab	102a
		$LSD_{.05}$	6	6	8	3

[1] *, ** Significant at the .05 and .01 levels of probability.

EFFECT OF COMPOSTED MANURE AND NITROGEN FERTILIZER ON IRRIGATED GRAIN SORGHUM

Alan Schlegel

This study was initiated in 1987 to determine the fertilizer value of composted manure from a beef feedlot for irrigated grain sorghum production and the effect of annual compost and N fertilizer applications on soil chemical characteristics.

Procedure

Compost and nitrogen fertilizer were applied to the same plot area since 1987. The experimental design was a complete factorial with 5 compost rates (0, 0.9, 1.8, 3.6, and 7.2 ton/a) and 4 N fertilizer rates (0, 55, 110, and 165 lb N/a). All treatments were applied and incorporated prior to planting of grain sorghum. The compost contained approximately 30 lb N and 35 lb P_2O_5 per ton. Irrigations were made as needed during the growing seasons. All plots were machine harvested and grain yields adjusted to 12.5% moisture.

Surface soil samples (0 to 6 inches) were collected after harvest in 1989 and analyzed for phosphorus, potassium, iron, and sodium.

Results

Sorghum yields were increased by compost and N fertilizer applications in all years (Table 1). Compost alone increased grain yields up to 39 bu/acre averaged over 4 years. Grain yields increased by about 5.5 bu/acre for each ton of compost. Nitrogen alone increased yields up 36 bu/acre averaged over 4 years with about 70% of the yield increase obtained with 55 lb N/acre. However, in all years, greater yields were obtained with a combination of compost and N fertilizer than with either alone.

Soil P levels were increased from an initial level of 13 ppm Bray-1 P (medium range) up to 77 ppm P (very high range) after three years of compost applications. Soil K was also increased by compost applications, although K is not limiting on this soil. Sodium levels were increased by compost additions but not to levels detrimental to crop production.

This study shows that compost can be used as a nutrient source by irrigated grain sorghum. A combination of compost and N fertilizer tend to produce greater yields than either do alone. Compost was effective in increasing levels of soil nutrients, especially phosphorus.

Table 1. Effect of compost and N fertilizer applications on grain yield of irrigated grain sorghum, Tribune, KS, 1987-1990.

Compost	Nitrogen rate	Grain yield 1987	1988	1989	1990	1987-1990
ton/a	lb/a	bu/a				
0	0	69	58	40	59	57
	55	72	100	79	78	82
	110	79	101	82	86	87
	165	77	113	90	92	93
0.9	0	69	64	51	66	63
	55	86	107	86	89	92
	110	85	111	98	102	99
	165	78	113	97	106	98
1.8	0	72	70	58	67	67
	55	81	112	88	98	94
	110	90	118	103	107	104
	165	84	108	96	105	98
3.6	0	72	87	60	79	75
	55	83	118	97	105	101
	110	86	125	98	102	103
	165	89	117	107	106	105
7.2	0	87	108	89	100	96
	55	95	122	107	111	109
	110	96	134	110	107	112
	165	85	127	104	104	105
$LSD_{.05}$		15	16	12	11	7
ANOVA[1]						
Compost		**	**	**	**	**
Nitrogen		**	**	**	**	**
Compost * Nitrogen		ns	ns	*	**	**
MEANS						
Compost (ton/a)	0	74c	93d	73d	79d	80d
	0.9	80bc	99cd	83c	91c	88c
	1.8	82b	102c	86bc	94bc	91c
	3.6	83b	112b	91b	98b	96b
	7.2	91a	123a	102a	106a	105a
$LSD_{.05}$		7.5	7.9	6.1	5.6	3.4
Nitrogen (lb/a)	0	74b	78b	60c	74c	71c
	55	83a	112a	91b	96b	96b
	110	87a	118a	98a	101ab	101a
	165	83a	115a	99a	102a	100a
$LSD_{.05}$		6.7	7.1	5.5	5.0	3.0

[1] *, ** Significant at the .05 and .01 levels of probability.

Table 2. Soil chemical concentrations following three years of manure compost and nitrogen fertilizer applications, Tribune, KS, 1989.

Compost	Nitrogen	Bray-1 P	Exch. K	DTPA Fe	Exch. Na
ton/a	lb/a	- - - - - - - - - ppm	- - - - - - - - - -		
0	0	12	690	7	56
	55	10	660	7	53
	110	9	660	6	52
	165	9	630	6	49
0.9	0	16	690	6	57
	55	20	720	7	57
	110	12	690	6	53
	165	12	690	7	55
1.8	0	34	730	7	63
	55	24	700	7	64
	110	19	730	7	60
	165	24	680	7	54
3.6	0	32	780	7	65
	55	41	790	7	71
	110	31	770	7	71
	165	31	740	7	59
7.2	0	77	890	8	90
	55	66	880	8	88
	110	64	880	7	84
	165	61	880	7	91
$LSD_{.05}$		10	45	1	13
ANOVA[1]					
Compost		**	**	**	**
Nitrogen		**	*	ns	ns
Compost * Nitrogen		ns	ns	ns	ns
MEANS					
Compost					
0 ton/a		10e	660d	6.4c	52d
0.9		15d	700c	6.4c	56cd
1.8		25c	710c	7.2ab	60bc
3.6		34b	770b	6.8bc	66b
7.2		67a	880a	7.4a	88a
$LSD_{.05}$		5	23	0.6	7
Nitrogen					
0 lb/a		34a	760a	7.1a	67a
55		32a	750a	6.8a	66a
110		27b	740ab	6.8a	64a
165		27b	730b	6.8a	62a
$LSD_{.05}$		4	20	0.5	6

[1] *, ** significant at the .05 and 0.01 probability levels.