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Long-Term Nitrogen and Phosphorus Fertilization of Irrigated Corn

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Abstract

Long-term research shows that phosphorus (P) and nitrogen (N) fertilizer must be applied to optimize production of irrigated corn in western Kansas. In 2015, N applied alone increased yields 70 bu/a, whereas P applied alone increased yields only 12 bu/a. Nitrogen and P applied together increased yields up to 129 bu/a. This is below the 10 year average, where N and P fertilization increased corn yields up to 144 bu/a. Application of 120 lb/a N (with P) produced about 98% of maximum yield in 2015, which is 5% more than the 10-year average. Application of 80 instead of 40 lb P_2O_5/a increased average yields only 1 bu/a. Average grain N content reached a maximum of 0.6 lb/bu while grain P content reached a maximum of 0.15 lb/bu (0.34 lb P_2O_5/bu).

Keywords

Nitrogen fertilization, phosphorus fertilization, irrigated corn, long-term fertility, nutrient removal

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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 2015, N applied alone increased yields 70 bu/a, whereas P applied alone increased yields only 12 bu/a. Nitrogen and P applied together increased yields up to 129 bu/a. This is below the 10 year average, where N and P fertilization increased corn yields up to 144 bu/a. Application of 120 lb/a N (with P) produced about 98% of maximum yield in 2015, which is 5% more than the 10-year average. Application of 80 instead of 40 lb P_2O_5/a increased average yields only 1 bu/a. Average grain N content reached a maximum of 0.6 lb/bu while grain P content reached a maximum of 0.15 lb/bu (0.34 lb P_2O_5/bu).

Introduction

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

Procedures

This field study is conducted at the Tribune Unit of the Southwest Research-Extension Center. Fertilizer treatments initiated in 1961 are N rates of 0, 40, 80, 120, 160, and 200 lb/a without P and K; with 40 lb/a P_2O_5 and zero K; and with 40 lb/a P_2O_5 and 40 lb/a K_2O. The treatments were changed in 1992; the K variable was replaced by a higher rate of P (80 lb/a P_2O_5). All fertilizers were broadcast by hand in the spring and incorporated before planting. The soil is a Ulysses silt loam. The corn hybrids [Pioneer 34N50 (2006), Pioneer 33B54 (2007), Pioneer 34B99 (2008), DeKalb 61-69 (2009), Pioneer 1173H (2010), Pioneer 1151XR (2011), Pioneer 0832 (2012-2013), Pioneer 1186AM (2014), and Pioneer 35F48 AM1 (2015)] were planted at about 32,000 seeds/a in late April or early May. Hail damaged the 2008 and 2010 crops (slight damage on 2015 crop). The corn is irrigated to minimize water stress. Sprinkler irrigation has been used since 2001. The center two rows of each plot are machine harvested after physiological maturity. Grain yields are adjusted to 15.5% moisture. Grain samples were collected at harvest, dried, ground, and analyzed for N and P concentrations. Grain N and P content (lb/bu) and removal (lb/a) were calculated.

Results

Corn yields in 2015 were 17% greater than the 10-year average (Table 1). Nitrogen alone increased yields 70 bu/a, whereas P alone increased yields only 12 bu/a. However, N and P applied together increased corn yields up to 129 bu/a. While maximum yield was obtained with the highest N and P rate, 160 lb/a N with 80 lb/a P_2O_5 caused less than a 2% yield reduction. Corn yields in 2015 (averaged across all N rates) were only 1 bu/a greater with 80 than with 40 lb/a P_2O_5.

The 10-year average grain N concentration (%) increased with N rates but tended to decrease when P was also applied, presumably because of higher grain yields diluting N content (Table 2). Grain N content reached a maximum of 0.6 lb/bu. Maximum N removal (lb/a) was greatest at the highest yield levels, which were attained with 200 lb N and 80 lb P_2O_5/a. Similar to N, average P concentration increased with increased P rates but decreased with higher N rates. Grain P content (lb/bu) of about 0.15 lb P/bu (0.34 lb P_2O_5/bu) was greater at the highest P rate with low N rates. Grain P removal averaged less than 30 lb P/a at the highest yields.

Table 1. Nitrogen and phosphorus fertilization on irrigated corn yields, Tribune, KS, 2006-2015

Fertilizer		Yield										
N	P_2O_5	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Mean
------ lb/a ------		---------- bu/a ----------										
0	0	42	49	36	85	20	92	86	70	86	92	66
0	40	68	50	57	110	21	111	85	80	95	103	78
0	80	72	51	52	106	28	105	94	91	98	104	80
40	0	56	77	62	108	23	114	109	97	106	113	87
40	40	129	112	105	148	67	195	138	125	153	164	133
40	80	123	116	104	159	61	194	135	126	149	162	133
80	0	79	107	78	123	34	136	128	112	117	131	104
80	40	162	163	129	179	85	212	197	170	187	195	168
80	80	171	167	139	181	90	220	194	149	179	193	168
120	0	68	106	65	117	28	119	134	114	115	124	99
120	40	176	194	136	202	90	222	213	204	213	212	186
120	80	202	213	151	215	105	225	211	194	216	216	195
160	0	84	132	84	139	49	157	158	122	128	144	120
160	40	180	220	150	210	95	229	227	199	211	215	194
160	80	200	227	146	223	95	226	239	217	233	216	202

continued

Table 1. Nitrogen and phosphorus fertilization on irrigated corn yields, Tribune, KS, 2006-2015

Fertilizer		Yield										
N	P_2O_5	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Mean
------ lb/a ------		---------- bu/a ----------										
200	0	115	159	99	155	65	179	170	139	144	162	139
200	40	181	224	152	207	97	218	225	198	204	214	192
200	80	204	232	157	236	104	231	260	220	238	221	210
ANOVA (P>F)												
Nitrogen		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Phosphorus		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
N × P		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
MEANS												
Nitrogen, lb/a												
0		61e	50f	48e	100e	23e	103d	88f	80e	93e	100e	75f
40		103d	102e	91d	138d	50d	167c	127e	116d	136d	146d	118e
80		137c	146d	115c	161c	70c	189b	173d	143c	161c	173c	147d
120		149bc	171c	118c	178b	74bc	189b	186c	171b	181b	184b	160c
160		155ab	193b	127b	191a	80ab	204a	208b	179ab	190ab	192ab	172b
200		167a	205a	136a	199a	89a	209a	218a	186a	196a	199a	180a
$LSD_{(0.05)}$		15	11	9	12	9	13	10	10	10	9	8
P_2O_5, lb/a												
0		74c	105b	71b	121c	36b	133b	131c	109b	116c	128b	102c
40		149b	160a	122a	176b	76a	198a	181b	163a	177b	184a	159b
80		162a	168a	125a	187a	81a	200a	189a	166a	186a	185a	165a
$LSD_{(0.05)}$		11	8	6	9	7	9	7	7	7	6	6

*Note: Hail events on 7/23/10 and 5/28/15.

Table 2. Nitrogen and P fertilization on grain N and P content of irrigated corn, Tribune, KS, 2006-2015

Fertilizer		Grain				Grain removal	
N	P_2O_5	N	P	N	P	N	P
-------- lb/a --------		-------- % --------		------- lb/bu -------		-------- lb/a --------	
0	0	1.02	0.233	0.48	0.110	31	7
0	40	0.97	0.310	0.46	0.147	35	11
0	80	0.97	0.318	0.46	0.151	36	12
40	0	1.16	0.185	0.55	0.087	47	7
40	40	0.99	0.298	0.47	0.141	62	19
40	80	1.00	0.321	0.47	0.152	62	20
80	0	1.26	0.178	0.60	0.084	62	9
80	40	1.07	0.257	0.51	0.121	84	20
80	80	1.05	0.306	0.50	0.145	83	24
120	0	1.25	0.173	0.59	0.082	58	8
120	40	1.15	0.228	0.54	0.108	101	20
120	80	1.12	0.296	0.53	0.140	103	27
160	0	1.26	0.178	0.60	0.084	70	10
160	40	1.19	0.243	0.57	0.115	109	22
160	80	1.19	0.282	0.56	0.133	113	27
200	0	1.26	0.185	0.60	0.088	82	12
200	40	1.21	0.240	0.57	0.114	109	22
200	80	1.20	0.296	0.57	0.140	119	29
ANOVA (P>F)							
Nitrogen		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
Quadratic		0.001	0.001	0.001	0.001	0.001	0.001
Phosphorus		0.001	0.001	0.001	0.001	0.001	0.001
Linear		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
N × P		0.001	0.001	0.001	0.001	0.001	0.001

continued

Table 2. Nitrogen and P fertilization on grain N and P content of irrigated corn, Tribune, KS, 2006-2015

Fertilizer		Grain				Grain removal	
N	P_2O_5	N	P	N	P	N	P
-------- lb/a --------		-------- % --------		------- lb/bu -------		-------- lb/a --------	
MEANS							
Nitrogen, lb/a							
0		0.99e	0.287a	0.47e	0.136a	34f	10e
40		1.05d	0.268b	0.50d	0.127b	57e	16d
80		1.13c	0.247c	0.53c	0.117c	76d	18c
120		1.17b	0.232d	0.56b	0.110d	87c	18bc
160		1.21a	0.234d	0.57a	0.111d	97b	20b
200		1.22a	0.240cd	0.58a	0.114cd	103a	21a
$LSD_{(0.05)}$		0.02	0.012	0.01	0.006	5	1
P_2O_5, lb/a							
0		1.20a	0.189c	0.57a	0.089c	58b	9c
40		1.10b	0.263b	0.52b	0.124b	83a	19b
80		1.09b	0.303a	0.52b	0.143a	86a	23a
$LSD_{(0.05)}$		0.01	0.008	0.01	0.004	3	1