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Long-Term Nitrogen and Phosphorus Fertilization of Irrigated Grain Sorghum

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Abstract

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 2014, N applied alone increased yields 49 bu/a, whereas N and P applied together increased yields up to 81 bu/a. Averaged across the past 10 years, N and P fertilization increased sorghum yields up to 73 bu/a. Application of 40 lb/a N (with P) was sufficient to produce more than 80% of maximum yield in 2014, which almost equals the 10-year average. Application of potassium (K) has had no effect on sorghum yield throughout the study period.

Keywords

irrigated grain sorghum, nitrogen and phosphorus fertilization, southwest Kansas

Long-Term Nitrogen and Phosphorus Fertilization of Irrigated Grain Sorghum

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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 2014, N applied alone increased yields 49 bu/a, whereas N and P applied together increased yields up to 81 bu/a. Averaged across the past 10 years, N and P fertilization increased sorghum yields up to 73 bu/a. Application of 40 lb/a N (with P) was sufficient to produce more than 80% of maximum yield in 2014, which almost equals the 10-year average. Application of potassium (K) has had no effect on sorghum yield throughout the study period.

Introduction

This study was initiated in 1961 to determine responses of continuous grain sorghum grown under flood irrigation to N, P, and K fertilization. The study is 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

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 N without P and K; with 40 lb/a P_2O_5 and zero K; and with 40 lb/a P_2O_5 and 40 lb/a K_2O. All fertilizers are broadcast by hand in the spring and incorporated before planting. The soil is a Ulysses silt loam. Sorghum (Pioneer 8500/8505 from 2003–2007, Pioneer 85G46 in 2008–2011, and Pioneer 84G62 in 2012–2014) was planted in late May or early June. Irrigation is used 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 12.5% moisture.

Results

Grain sorghum yields in 2014 were 18% greater than the 10-year average (Table 1). Nitrogen alone increased yields 49 bu/a, whereas P alone increased yields only 4 bu/a. However, N and P applied together increased yields up to 81 bu/a. Averaged across the past 10 years, N and P applied together increased yields up to 73 bu/a. In 2014, 40 lb/a N (with P) produced about 82% of maximum yield, which almost equals the 10-year average of 83%; 120 lb/a N (with P) and 160 lb/a N (with P) produced 92% and 97% of

maximum yield, respectively. Sorghum yields were not affected by K fertilization, which has been the case throughout the study period.

Table 1. Effects of nitrogen, phosphorus, and potassium fertilizers on irrigated grain sorghum yields, Tribune, KS, 2005–2014

Fertilizer			Grain sorghum yield										
N	P_2O_5	K_2O	2005[1]	2006	2007	2008	2009	2010	2011	2012	2013	2014	Mean
lb/a			bu/a										
0	0	0	58	84	80	66	64	51	75	78	62	90	71
0	40	0	53	102	97	60	70	51	83	90	77	94	79
0	40	40	54	95	94	65	76	55	88	93	72	96	80
40	0	0	63	102	123	92	84	66	106	115	94	115	97
40	40	0	84	133	146	111	118	77	121	140	114	144	120
40	40	40	84	130	145	105	109	73	125	132	110	142	117
80	0	0	76	111	138	114	115	73	117	132	102	120	111
80	40	0	81	132	159	128	136	86	140	163	136	151	133
80	40	40	92	142	166	126	108	84	138	161	133	164	133
120	0	0	77	101	138	106	113	70	116	130	100	116	108
120	40	0	95	136	164	131	130	88	145	172	137	162	138
120	40	40	98	139	165	136	136	90	147	175	142	170	141
160	0	0	77	123	146	105	108	74	124	149	117	139	118
160	40	0	106	145	170	138	128	92	152	178	146	171	144
160	40	40	91	128	167	133	140	88	151	174	143	176	141
200	0	0	86	134	154	120	110	78	128	147	119	139	123
200	40	0	108	143	168	137	139	84	141	171	136	165	141
200	40	40	101	143	170	135	129	87	152	175	138	170	142
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			0.005	0.004	0.001	0.001	0.001	0.001	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	0.001
Zero P vs. P			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
P vs. P-K			0.803	0.578	0.992	0.745	0.324	0.892	0.278	0.826	0.644	0.117	0.967
N × P-K			0.195	0.210	0.965	0.005	0.053	0.229	0.542	0.186	0.079	0.012	0.077

continued

Table 1. Effects of nitrogen, phosphorus, and potassium fertilizers on irrigated grain sorghum yields, Tribune, KS, 2005–2014

Fertilizer			Grain sorghum yield										
N	P_2O_5	K_2O	2005[1]	2006	2007	2008	2009	2010	2011	2012	2013	2014	Mean
---------- lb/a ----------			---------- bu/a ----------										
MEANS													
Nitrogen, lb/a													
0			55	93	91	64	70	52	82	87	70	94	77
40			77	121	138	103	104	72	117	129	106	134	112
80			83	128	155	123	120	81	132	152	124	145	126
120			90	125	156	124	126	82	136	159	126	149	129
160			92	132	161	125	125	83	142	167	135	162	134
200			98	140	164	131	126	84	141	165	131	158	135
$LSD_{(0.05)}$			10	11	9	7	11	5	8	9	8	9	6
P_2O_5-K_2O, lb/a													
0	-	0	73	109	130	101	99	68	111	125	99	120	105
40	-	0	88	132	151	117	120	80	130	152	124	148	126
40	-	40	87	130	151	117	116	79	133	152	123	153	126
$LSD_{(0.05)}$			7	7	6	5	7	4	6	6	5	6	4

[1] 2005 yields used only blocks 3, 4, and 5.