EFFECTS OF PHOSPHORUS APPLICATION METHOD AND RATE ON FURROW-IRRIGATED RIDGE-TILLED GRAIN SORGHUM[1]

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Abstract

The objective of this research was to investigate the effects of method of phosphorus (P) placement and rate on irrigated grain sorghum grown in a ridge-tillage system on a soil low in available P. This experiment was conducted from 1993-1995 on a producer's field near the North Central Kansas Experiment Field Experiment Field at Scandia, Kansas on a Carr sandy loam soil. Treatments consisted of fertilizer application methods: surface broadcast, single band starter (2 inches to the side and 2 inches below the seed), dual band starter (one band on each side of the row), and knifed in the center of the row middle. Each of these treatments was made at either 20 or 40 lb P_2O_5 /acre, and nitrogen (N) also was included at the rate of 10 lb/acre. Additional treatments were: a combination of 10 lb N and 40 lb P_2O_5 /acre applied half broadcast and half as a single band starter, a 1:1 N P_2O_5 ratio (40 lb N and 40 lb P_2O_5 /acre) applied as a single band starter, and a 3:1 ratio 120 lb N and 40 lb P_2O_5 /acre applied as a single band starter. A no-P check plot was also included. Broadcast and center-of-row middle knife applications were made approximately 1 week before planting. After planting, N was balanced on all plots to give a total of 160 lb/acre. Applied P treatments improved grain yield and nutrient uptake and consistently shortened the time from emergence to mid-bloom in all 3 years of the experiment. On this low soil test P soil, treatments that subsurface banded P increased grain yield by 20 bu/acre compared to broadcast treatments. Placing N and P in a single starter band 2 inches to the side and 2 inches below the seed was as effective as placing a band on each side of the row. Knife applying N and P in the center of the row was not as effective as placement beside the row. Single band starter application of N and P in a 1:1 or 3:1 ratio consistently increased yields and shortened the time to mid-bloom as compared to the single band starter treatment that provided only 10 lb N/acre. Over the 3 years of the study, the 1:1 and 3:1 N:P_2O_5 ratio starters were clearly superior to all other treatments.

Introduction

Use of conservation tillage systems has increased greatly in recent years because of their effectiveness in conserving soil and water. Interest in ridge-tillage is also growing. Ridge-tillage has several advantages over other conservation tillage methods. The large amounts of residue left in the seed zone in no-tillage systems can decrease soil temperature and cause crop emergence and early season growth to be slow. Ridge-tillage can maintain warmer soil temperatures because of the ridge configuration and removal of residue from the seed zone during the planting operation. Ridge-tillage

[1] Presented at the North Central Extension/Industry Soil Fertility Conference St. Louis, MO. Nov. 1999.

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also has been reported to be one of the most economical tillage systems in many areas. A major disadvantage of the ridge system, however, is that nutrient placement options are limited because of the lack of primary tillage operations. Ridge-tillage may also alter the crop's rooting pattern and nutrient uptake characteristics.

Although many studies have examined P placement in no-tillage situations, little information is available about optimum P placement for grain sorghum grown in a ridge-tillage production system. The objective of this experiment was to investigate the effects of P rate and placement method on irrigated grain sorghum grown in a ridge-tillage system on a soil low in available P.

Materials and Methods

This experiment was conducted on a producer's field near the North Central Kansas Experiment Field on a Carr sandy loam soil from the spring of 1993 to the fall of 1995. Analysis by the Kansas State University Soil Testing laboratory showed that the initial soil pH (March 1993) was 6.9; organic matter content was 1.5%; and Bray-1 P and exchangeable potassium (K) in the top 6 inches of soil were 12 ppm (low) and 450 ppm (very high), respectively. The experimental area had been in ridge-tillage production for 3 years prior to the establishment of this study.

The experimental design was a randomized complete block replicated four times. Treatments consisted of liquid fertilizer application methods: surface broadcast, single band starter (2 inches to the side and 2 inches below the seed), dual band starter (one band on each side of the ridge), and knifed in the center of the row middle (15 inches from each adjacent row). Each of these treatments was made at two rates (20 or 40 lb P_2O_5 /acre), and N was also included at the rate of 10 lb/acre. Additional treatment were: a combination of 10 lb N and 40 lb P_2O_5 /acre applied half broadcast and half as a single band starter, a 1:1 N:P_2O_5 ratio (40 lb N and 40 lb P_2O_5 /acre) applied as a single band starter, and a 3:1 N:P_2O_5 ratio (120 lb N and 40 lb P_2O_5 /acre applied as a single band starter. A no P check plot was also included. Broadcast and center-of the-row middle knife applications were made 7-10 days prior to planting each year. Starter applications were made at planting. After planting but before emergence, knife applications of 28% urea-ammonium nitrate solution were made to bring the total amount of N applied to each plot to 150 lb/acre. Grain sorghum (Dekalb 40Y) was planted in mid-May each year at the rate of 100,000 seed/acre. Plots were irrigated once in 1993 and twice in 1994 and 1995. Approximately 3 inches of water were applied at each irrigation. All irrigation water was applied in-furrow.

Results and Discussion

Applied P treatments significantly improved grain yields over those of the no-P check in all three years of the experiment (Table 1). Orthogonal contrasts were used to compare rate and placement effects. When averaged over the years, applied P compared to no P improved yields by over 40 bu/acre (Table 2). Surface broadcasting P_2O_5 at 40 lb/acre increased yields by 7.8 bu/acre, compared to the 20 lb/acre rate. On this low soil test P soil, banding P proved to be more effective than broadcasting. Comparison of all band treatments showed that 20 lb P_2O_5 was just as effective as the 40 lb P_2O_5 rate.

On this Carr sandy loam soil, a single band beside the row was just as effective as bands placed on each side of the row. Broadcasting half of the P and placing half as a single starter band was as effective as a single starter band. Knifing P in the center of the row middle was not as effective as placing P in a band beside the row. Nitrogen and P applied in either a 1:1 or 3:1 ratio produced the greatest 3-year yields. The 1:1 N:P_2O_5 (40 lb N and 40 lb P_2O_5 /acre ratio applied as a single band starter treatment increased yields by 19 bu/acre over the single band treatment that provided only 10 lb N/acre. The 1:1 and 3:1 ratio starters were equally effective.

In all 3 years of the experiment, thermal unit accumulation was below the long term average. Delay in anthesis of grain sorghum increases the risk of plants being exposed to freezing temperatures in the fall prior to physiological maturity, thus reducing yield and quality. All P treatments significantly reduced the time to mid-bloom compared to the no-P check (Table 1). Starter fertilizer (10 lb N and 40 lb P_2O_5 /acre) applied in a single band reduced the number of days from emergence to mid-bloom by 4 days as compared to broadcast P. Single band starter fertilizer applied in a 1:1 N:P_2O_5 ratio decreased the time to mid-bloom by 8 days compared to broadcast P.

Conclusions

In this ridge-tillage system, surface broadcast applications of P were not as effective as placing fertilizer in a band 2 inches to the side and 2 inches below the seed at planting. Applying starter fertilizer in a band on both sides of the row did not improve grain yield compared to application of a single starter band. A single starter band increased yields by 12 bu/acre compared to knifing N and P in the center of the row middles. Application of starter fertilizer in a single band in either a 1:1 or 3:1 N:P_2O_5 ratio resulted in the greatest grain yields in all 3 years of the experiment.

Table 1. Effects of P application method and rate on grain sorghum yield and number of days from emergence to mid-bloom.

No.	Application Method	Fertilizer N	Fertilizer P_2O_5	Yield 1993	Yield 1994	Yield 1995	Yield Avg.	Days to Mid-Bloom 1993	Days to Mid-Bloom 1994	Days to Mid-Bloom 1995	Days to Mid-Bloom Avg.
		lb $acre^{-1}$		----------bu $acre^{-1}$----------				---------no. of days----------			
1	No P check	0	0	76	114	62	84	67	65	64	65
2.	Broadcast	10	20	95	117	99	104	63	61	61	62
3.	"	10	40	102	124	108	111	65	60	60	62
4.	Single band 2x2 starter	10	20	119	140	114	124	62	57	58	59
5.	"	10	40	125	143	120	129	61	56	57	58
6.	Dual band 2x2 starter	10	20	118	145	115	127	62	57	57	59
7.	"	10	40	114	145	118	126	62	56	56	59
8.	Knife center of row middle	10	20	110	128	102	113	62	60	59	60
9.	"	10	40	112	131	106	116	61	58	58	59
10.	Broadcast plus 2x2 starter	10	20+ 20	125	140	118	128	61	60	59	60
11.	1:1 N:P_2O_5 single band 2x2 Starter	40	40	134	160	136	143	58	53	52	54
12.	3:1 N:P_2O_5 Single and 2x2 starter	120	40	135	160	134	143	56	52	51	53
	LSD(0.05)			7.9	7.8	4.6	7.5	2.0	1.0	1.0	2.0
	CV%			5.7	4.7	2.5	4.8	2.0	1.6	1.4	1.6

Table 2. Contrast of 3-year grain sorghum yield as affected by P application rate and method.

Contrast	Contrasted Treatments	Yield Difference	Pr>F
		bu ac^{-1}	
No-P check vs applied P	1 vs 2,3,4,5,6,7,8,9,10,11,12	40.5	0.001
Broadcast vs band	2,3 vs 4,5,6,7,8,9,11,12	20.2	0.001
Broadcast 20 vs 40 lb P_2O_5 ac^{-1}	2 vs 3	7.8	0.027
Band treatments 20 vs 40 lb P_2O_5 ac^{-1}	4,6,8 vs 5,7,9	2.2	0.149
Single 2x2 band vs dual 2x2 bands	4,5 vs 6,7	0.0	------
Knife center of row vs single 2x2 band	4,5 vs 8,9	11.6	0.001
Broadcast vs knife center of row middle	2,3 vs 8,9	7.3	0.022
Broadcast + single 2x2 band vs single band 2x2	10 vs 5	1.6	0.181
1:1 Ratio single band 2x2 vs 3:1 ratio	11 vs 12	0.2	0.897
1:1 and 3:1 ratio vs all other non-broadcast 40 lb P_2O_5 ac^{-1} treatments	11,12 vs 5,7,9	20.6	0.001
1:1 Ratio single 2x2 band (40 kg N ha^{-1}) vs single 2 x 2 band (10 lb N ac^{-1})	11 vs 5	19.6	0.005

PROCEEDINGS OF THE

TWENTY-NINTH NORTH CENTRAL EXTENSION-INDUSTRY SOIL FERTILITY CONFERENCE

Volume 15

November 17-18, 1999
St. Louis Westport Holiday Inn
St. Louis, Missouri

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Published by:
Potash & Phosphate Institute
772 – 22nd Avenue South
Brookings, SD 57006
605/692-6280