IMPACT OF PHOSPHORUS AND POTASSIUM FERTILIZATION ON CORN AND SOYBEAN PRODUCTIVITY AND SOIL NUTRIENT LEVELS

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Abstract

A common production practice in the Eastern Corn Belt is to supply enough phosphorus (P) and potassium (K) in the fall prior to corn planting to satisfy the nutrient needs of both corn and soybeans in a rotation. This practice is most likely a viable option for fields with more than adequate soil nutrient levels, but on marginal fields this practice may be limiting production (specifically with regard to K). Two field experiments were established to evaluate the impact of P and K fertilization rate (based on estimated crop removal) on crop yields, within two cropping rotations (corn-soybean and corn-corn-soybean). The first year's data was only collected for corn at each of the three locations. Crop yield was increased at one location by application of both P and K fertilizer, but the other two did not show an increase in yield or yield increases were inconsistent. The site that did respond to additional P and K fertilizer did have soil test levels considered adequate, thus perhaps the established critical levels were a little low for this particular soil.

Materials and Methods

The two experiments were located at the Western Research Station near South Charleston and the East Badger Farm near Wooster. The experiment evaluated two different crop rotations (corn-corn-soybean and corn-soybean), three rates of P_2O_5 (as triple-superphosphate) fertilizer (0, 1X, and 2X crop removal) and three rates of K_2O (potash) fertilizer (0, 1X, and 2X crop removal). Crop removal was based on average corn and soybean yields in the state of Ohio (145 and 40 bu/acre, respectively). The assumed crop removal values pounds per unit of yield were taken from the Tri-State Fertilizer Recommendation Bulletin (Vitosh et al.,. 1996) (0.37 and 0.27 for P_2O_5 and K_2O for corn, respectively; 0.80 and 1.4 for P_2O_5 and K_2O for soybeans, respectively). Thus the 1X and 2X P_2O_5 rate for the corn-corn-soybean rotation was 140 and 280 lbs of P_2O_5 per acre, and the 1X and 2X K_2O rate for the corn-corn-soybean rotation was 140 and 280 lbs of K_2O per acre. The 1X and 2X P_2O_5 rate for the corn-soybean rotation was 85 and 170 lbs of P_2O_5 per acre, and the 1X and 2X K_2O rate for the corn-corn-soybean rotation was 95 and 190 lbs of K_2O per acre. To simulate a typical production system in Ohio, tillage only occurred in the fall following soybeans which was also be the time when P and K were applied. Corn following soybeans received only 140 lbs of N per acre compared to corn following corn that received 180 lbs of N per acre.

Corn and soybean tissue samples were collected for P and K analysis. Corn leaf samples were collected from the ear leaf at silking – R2 (Ritchie et al., 1997). Soybean tissue samples were collected from the uppermost fully expanded leaf at R1 (Pedersen, 2004). Tissue samples were submitted to the STAR lab at the OARDC main campus for P and K concentration determination (not reported). Plots were 10 ft wide by various lengths (dependent upon location), and only the center two rows (corn) or center 6.56 ft (soybeans) were harvested. The two locations employed a three-way factorial arrangement with four replications in a randomized complete block. Statistical analysis of the data was conducted using a GLM model to determine significance between treatments (SAS Institute, 2000). Available soil P was measured using a Bray-Kurtz P1 extractant, and exchangeable soil K was measured using ammonium acetate. Soil pH was measured using a 1:1 ratio of soil to water.

Results and Discussion

East Badger Farm

Initial soil test P and K levels were slightly above the established critical levels of 15 and 100 ppm, respectively (Table 1). Thus response to additional P and K supplementation was improbable. In 2006, a significant corn yield response to the 2x rate of P in the corn-corn-soybean rotation was observed (Table 3). A similar corn yield response was not observed for the corn-soybean rotation (Table 5), thus the response was likely an aberration. Additionally, a corn yield response to potassium was noted at the 2x rate in corn-soybean rotation (Table 6). This yield response was not however noted in the corn-corn-soybean rotation (Table 4). In 2007, no corn or soybean yield response to either P or K supplementation was noted (Tables 3-6). In 2008, a significant corn yield response was observed when the 1x and 2x rate of phosphorus was supplied in the corn-soybean rotation (Table 5).

Evaluation of the changes in soil test level reveals that individual plot soil test P levels measured in the fall after the first crop year were slightly above the initial bulk soil test level (Tables 1 and 11). Potassium levels were similar between both sampling densities. Soil test levels did change as expected over time, although a mass balance evaluation in changes in soil test level have not been done at this time.

Western Research Station

Initial soil test levels of P were just above the established critical level, but soil test K level was just below the established critical level (Table 2). In 2006, a significant corn yield response to P fertilization was observed at the 2x rate in the corn-corn-soybean rotation, and a significant corn yield response to P fertilization was observed at the 1x rate in the corn-soybean rotation (Tables 7 & 9). The lack of a consistent response (when the absolute rate is considered) brings the validity of the observations into question. Similarly, corn yield responses to K fertilization were noted in the corn-corn-soybean and corn-soybean rotations at the 2x and 1x rates, respectively (Tables 8 & 10). Considering the low soil test K level at this experimental location, a response to K fertilization was likely, but the lack of consistent response is a cause for concern. Corn or soybean grown in 2007 did not respond to either P or K fertilization (Tables 7-10). Soybeans grown in the corn-corn-soybean rotation did respond to K fertilization in 2008 (Table 8). Additionally, corn in the corn-soybean rotation did respond to P fertilization at the 2x rate in 2008 (Table 9).

Soil test level from individual plots was similar to the bulk soil collected at the establishment of the experiment (Tables 2 & 12).

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Table 1. Initial soil test information at the East Badger Farm measured in the spring of 2006.

pH	Available P (mg/kg)	Exchangeable K (mg/kg)	Soil CEC (meq/100 g)
6.2	17	109	10.5

Table 2. Initial soil test information at the Western Research Station measured in the spring of 2006.

pH	Available P (mg/kg)	Exchangeable K (mg/kg)	Soil CEC (meq/100 g)
6.2	20	102	13.7

Table 3. Main effect of phosphorus application rate on yields in the corn-corn-soybean rotation at the East Badger Farm.

Phosphorus rate, lb/acre	Corn yield 2006	Corn yield 2007	Soybean yield 2008
	-------------------------bu/acre--------------------------		
0	147	155	27
140	147	151	29
280	161	159	29
$LSD_{0.1}$	11	16	3

Table 4. Main effect of potassium application rate on yields in the corn-corn-soybean rotation at the East Badger Farm.

Potassium rate, lb/acre	Corn yield 2006	Corn yield 2007	Soybean yield 2008
	--------------------------bu/acre---------------------------		
0	154	152	29
140	152	155	28
280	149	158	28
$LSD_{0.1}$	11	16	3

Table 5. Main effect of phosphorus application rate on yields in the corn- soybean rotation at the East Badger Farm.

Phosphorus rate, lb/acre	Corn yield 2006	Soybean yield 2007	Corn yield 2008
	--------------------------bu/acre--------------------------		
0	147	54	141
85	157	49	153
170	150	52	154
$LSD_{0.1}$	11	6	11

Table 6. Effect of potassium application rate on yields in the corn-soybean rotation at the East Badger Farm.

Potassium rate, lb/acre	Corn yield 2006	Soybean yield 2007	Corn yield 2008
	--------------------------bu/acre--------------------------		
0	146	52	151
95	148	51	145
190	161	53	152
$LSD_{0.1}$	11	6	11

Table 7. Effect of phosphorus application rate on yields in the corn-corn-soybean rotation at the Western Research Station.

Phosphorus rate, lb/acre	Corn yield 2006	Corn yield 2007	Soybean yield 2008
	--------------------------bu/acre---------------------------		
0	219	127	56
140	221	130	57
280	232	138	53
$LSD_{0.1}$	13	19	4

Table 8. Effect of potassium application rate on yields in the corn-corn-soybean rotation at the Western Research Station.

Potassium rate, lb/acre	Corn yield 2006	Corn yield 2007	Soybean yield 2008
	-----------------------	bu/acre	-----------------------
0	220	122	50
140	222	139	60
280	231	134	57
$LSD_{0.1}$	13	19	4

Table 9. Main effect of phosphorus application rate on yields in the corn- soybean rotation at the Western Research Station.

Phosphorus rate, lb/acre	Corn yield 2006	Soybean yield 2007	Corn yield 2008
	-----------------------	bu/acre	-----------------------
0	209	60	191
85	225	52	182
170	215	58	213
$LSD_{0.1}$	13	6	20

Table 10. Effect of potassium application rate on yields in the corn-soybean rotation at the Western Research Station.

Potassium rate, lb/acre	Corn yield 2006	Soybean yield 2007	Corn yield 2008
	-----------------------	bu/acre	-----------------------
0	206	56	189
95	228	59	202
190	216	54	195
$LSD_{0.1}$	13	6	20

Table 11. Soil test information from fall soil samplings by treatment at the East Badger Farm.

Rotation	P Rate	K rate	Available P		Exchangeable K	
			2006	2008	2006	2008
	------lb/acre------		-----------------mg/kg------------------			
CCS	0	0	37	25	123	138
CCS	140	0	39	27	110	109
CCS	280	0	45	32	112	108
CCS	0	140	30	22	146	134
CCS	0	280	27	21	154	150
CCS	140	140	40	24	151	139
CCS	140	280	46	28	160	143
CCS	280	140	48	27	135	135
CCS	280	280	51	31	180	165
CS	0	0	25	21	96	77
CS	85	0	34	28	116	99
CS	170	0	37	38	129	107
CS	0	95	28	20	117	109
CS	0	190	30	25	145	134
CS	85	95	39	30	122	120
CS	85	190	36	33	149	135
CS	170	95	36	38	113	101
CS	170	190	36	38	130	135

-CCS – corn, corn, soybeans; CS – corn, soybeans

Table 12. Soil test information from fall soil samplings by treatment at the Western Research Station.

			Available P		Exchangeable K	
Rotation	P Rate	K rate	2006	2008	2006	2008
	------lb/acre------		-----------------mg/kg------------------			
CCS	0	0	27	22	113	110
CCS	140	0	32	25	113	101
CCS	280	0	28	38	110	102
CCS	0	140	27	18	107	111
CCS	0	280	29	20	120	115
CCS	140	140	37	27	121	128
CCS	140	280	27	28	127	131
CCS	280	140	21	27	115	125
CCS	280	280	27	35	115	112
CS	0	0	28	18	112	90
CS	85	0	18	27	117	97
CS	170	0	28	31	116	96
CS	0	95	33	23	114	111
CS	0	190	31	23	109	117
CS	85	95	25	24	120	117
CS	85	190	27	33	107	121
CS	170	95	21	21	110	107
CS	170	190	29	27	124	129

-CCS – corn, corn, soybeans; CS – corn, soybeans

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