PHOSPHORUS AND POTASSIUM RESPONSE IN NO-TILL CORN AND SOYBEAN PRODUCTION

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INTRODUCTION

Current UWEX fertilizer recommendations and plant analysis interpretation guidelines were developed prior to the release of GMO corn. There is some concern amongst University soil fertility specialists and industry agronomists that corn and soybean response to P and K fertilizer applications may be different with modern corn hybrids and soybean varieties. In addition, in the UW recommendation system, an estimate of the amount of nutrients removed in the harvested portion of the crop is used to determine the fertilizer recommendations based on soil test levels (Laboski and Peters, 2012). If crop removal rates have changed in modern hybrids is it essential to determine current removal rates and use those numbers in fertilizer recommendations.

This study is designed to provide initial information on corn and soybean yield and nutrient concentration response to applied P and K fertilizer for modern hybrids and varieties in Wisconsin. This information will be the first step in determining how to approach a broader P and K calibration study across Wisconsin in the future. The objectives of this study are to: 1) assess corn yield response to P and K fertilizer applications; and 2) assess the effect of P and K fertilizer applications on corn plant nutrient concentrations at V4, V10-12, VT-R1, and grain for corn and R1, R3, and R5 for grain; and 3) evaluate effects of P and K fertilizer application on soil test levels. This paper will report on objectives 1 and 3.

MATERIALS AND METHODS

A P and K response study was established at the University of Wisconsin Agricultural Research Station at Arlington (43.323098, -89.343959) on a Saybrook silt loam. The field selected had very low soil test P and K levels (Table 1) and had been cropped to alfalfa/grass for the previous five or more years. A no-till soybean corn rotation was established in 2011 on Field 602S and in 2012 in Field 602C. Initial treatments in 2011 included a complete factorial of all combinations of four rates (0, 30, 60, and 90 lb/a) of P_2O_5 as triple superphosphate (0-46-0) and four rates (0, 40, 80, 120 lb/a) of K_2O as potash (0-0-60) with four replications. Additional treatments of 160 lb K_2O/acre at the four P rates were included in 2012 to make certain we had encompassed a non-limiting K rate. For these treatments, we added additional P and K in 2012 to equal the two-year application rate total (adjusted for soybean grain removal in 2011). In all subsequent years, the same rates of P and K were broadcast in each plot prior to planting.

Each plot was 10 ft. wide by 30 ft. long and trimmed to 25 ft. Both crops were planted in 30-inch rows. All crop management practices followed University of Wisconsin Extension recommendations.

In the spring prior to initial establishment of the plots, composite 6-inch soil samples were collected from each replication. In subsequent years, each plot was soil sampled to 6 inches prior to fertilizer application in the spring. Soil samples were dried at 90^{o}F and ground to mass a 2-mm sieve prior to analysis. Grain was harvested from the center two rows of each plot using a plot combine. Whole plant corn biomass was collected at physiological maturity. Corn grain yield is reported at a 15.5 % moisture content and soybean grain yield at 13% moisture content.

Data were subjected to an analysis of variance using PROC MIXED and regression analysis using PROC REG and PROC NLIN (SAS Institute, 2002). Phosphorous and K rate treatments were treated as fixed variables, whereas replication was treated as a random variable. Significant differences among treatment means were evaluated using Fisher's LSD test for mean separation at the 0.10 probability level unless otherwise noted.

RESULTS AND DISCUSSION

Grain Yield

Visual differences in K treatments were observed each year for both corn and soybean. However, there were no apparent differences in P treatments for either crop in any year.

Corn grain yield ranged from 46 to 152, 28 to 233, 27 to 243, and 4 to 242 bu/a in 2012, 2013, 2014, and 2015, respectively. Low yields in 2012 were a results of drought conditions which persisted throughout the growing season. There was a significant yield response to K application in each year (Figure 1). Based on means separation of the main effect of K application, the lowest K application rate with yields not significantly different than the highest yield was observed at 120, 120, 80, 120 lb K_2O/a in 2012, 2013, 2014, and 2015, respectively. There was no significant effect of P application on yield in 2012 or 2013. In 2014, there was a significant P x K interaction where there was no yield response to P at K application rates of 0 or 40 lb K_2O/a and there was a significant P response at K rates greater than or equal to 80 lb K_2O/a (Figure 2). The optimum P application rate based on regression was 50 lb P_2O_5/a. Averaged across all P rates, soil test K levels in the spring were 65 ppm or greater where P responses occurred and 60 ppm or less where no P response was observed. In 2015, there was no significant P x K interaction; however, there was a significant yield response to P with an optimum P application rate of 61 lb P_2O_5/a. Soil test K levels averaged across all P rates were 62 ppm or greater where P response occurred.

Corn biomass yields ranged from 3.63 to 7.41, 2.60 to 10.89, 2.80 to 12.08, and 1.64 to 11.57 T DM/a in 2012, 2013, 2014, and 2015, respectively. There was a significant yield response to K application in each year (Table 2). Based on means separation of the main effect of K application, the lowest K application rate with biomass yields not significantly different than the highest yield was observed at 80, 120, 80, 80 lb K_2O/a in 2012, 2013, 2014, and 2015, respectively. There was no significant effect of P application on biomass yield in any year. However, in both 2014 and 2015 biomass yield generally increased with P application (main effect) and the trend is more evident at the 120 and 160 lb K_2O/a rates in 2015 and the 120 lb K_2O/a rate in 2014.

Soybean yield ranged from 34 to 58, 9 to 23, 36 to 73, 28 to 60, and 23 to 62 bu/a in 2011, 2012, 2013, 2014, and 2015, respectively. Low yields in 2012 were a results of drought conditions which persisted throughout the growing season. Yield increased significantly with K application in each year (Table 3). Based on means separation of the main effect of K application, the lowest K application rate with yields not significantly different than the highest yield was observed at 120, 120, 40, 80, 120 lb K_2O/a in 2011, 2012, 2013, 2014, and 2015, respectively. In 2013, any K application rate significantly increased yield over no K application, and there were no significant yield differences between K application rates. This observation may be a subsequent effect of the drought in 2012 which resulted in low K removal in corn grain. There was no soybean yield response to applied P in any year (Table 2). The lack of a P response is surprising considering initial soil test P levels were 8 and 1 ppm on Fields 602S and 602C, respectively.

Soil Test Results

Consecutive applications of P and K fertilizer have altered soil test levels during the course of this experiment. Soil samples collected in spring 2015 prior to treatment application demonstrate this effect (Tables 4 and 5). In both fields, soil test P levels increased significantly with P application rate and decreased significantly with K application rate (Table 4). The reduction in soil test P levels with increasing K application rates is a result of greater yields and K removal, which occurred at higher K application rates. Soil test K levels increased with increasing K application rate (Table 5). In Field 602C, after three consecutive fertilizer applications, there was no effect of P application on soil test K. This was also observed for Field 602S after three consecutive fertilizer applications (spring 2014, data not shown). After four consecutive fertilizer applications on Field 602S, P application significantly affected soil test K levels. Soil test K was significantly lower at the 90 lb P_2O_5/a application rate compared to all other P application rates. This observation is attributed to the fact that the first corn yield response to P in this project was observed on this field (602S) the previous growing season. Larger corn yields at high rates of P resulted in more removal of K.

SUMMARY

Yield response to K resulted in yield increases over the no K control from 3 to 60 fold for corn grain and 1.7 to 3.7 fold for soybean. Soybean did not respond to P application even at very low soil test levels. Corn yield increased with P application once soil test K levels increased to at least 65 ppm. These data clearly demonstrate that K is more limiting to corn and soybean production than P. It also demonstrates that soybeans relative need for P is less than corn.

In recent years, soil test K levels have been declining on many Wisconsin farms. Lower available K may result in not only lesser crop production but also a more rapid increase in soil test P levels where manure or fertilizer P is applied because lower production results in lower crop removal of P and K.

REFERENCES

Laboski, C.A.M. and J.B. Peters. 2012. Nutrient application guidelines for field, vegetable, and fruit crops in Wisconsin. UWEX Publication A2809.

Table 1. Initial soil test level at the time of plot establishment.

Soil Test	Field 602S (est. 2011)	Field 602C (est. 2012)
pH	7.1	7.1
OM, %	3.8	4.0
Bray 1 P, ppm	8, very low	1, very low
Bray 1 K, ppm	59, very low	48, very low

Table 2. Corn biomass yield in 2014 (Field 602S) and 2015 (Field 602C) after four consecutive years of fertilizer applications.

P_2O_5 rate	Field 602S, est. 2011 †						Field 602C, est. 2012 ‡					
	K_2O rate						K_2O rate					
	0	40	80	120	160	mean	0	40	80	120	160	mean
	-------------- 2014 Yield, T DM/a --------------						-------------- 2015 Yield, T DM/a --------------					
0	3.61	8.61	10.05	9.64	10.21	8.42	1.87	5.77	9.28	9.14	7.76	6.76
30	2.39	9.36	10.70	10.46	9.58	8.49	1.70	6.59	8.64	8.87	8.83	6.93
60	2.80	7.57	11.03	11.72	10.61	8.75	1.91	6.08	9.37	9.50	10.99	7.57
90	3.45	9.80	10.16	12.08	10.57	9.21	1.64	4.85	9.92	11.57	11.14	7.82
mean §	3.06d	8.83c	10.4ab	10.97a	10.24b		1.78 c	5.82 b	9.30 a	9.77 a	9.68 a	

† P_2O_5 rate $p = 0.13$. K_2O rate $p < 0.01$. P_2O_5 rate x K_2O rate $p = 0.07$. CV = 13%.
‡ P_2O_5 rate $p = 0.16$. K_2O rate $p < 0.01$. P_2O_5 rate x K_2O rate $p = 0.26$. CV = 23%.
§ Mean values followed by the same letter are not significantly different at the 0.10 probability level.

Table 3. Soybean yield in 2015 after five (2011 to 2015) consecutive fertilizer applications on Field 602S and in 2014 after three (2012 to 2014) consecutive fertilizer applications on Field 602C.

P_2O_5 rate	Field 602S, est. 2011 †						Field 602C, est. 2012 ‡					
	K_2O rate						K_2O rate					
	0	40	80	120	160	mean	0	40	80	120	160	mean
	--------------- 2015 Yield, bu/a ---------------						--------------- 2014 Yield, bu/a ---------------					
0	30	50	54	57	60	50	33	49	54	53	53	48
30	27	48	57	58	61	50	28	51	51	55	54	48
60	23	49	57	61	62	50	33	48	58	58	60	51
90	24	48	58	61	57	50	28	47	58	57	58	50
mean §	26 d	49 c	56 b	59 a	60 a		31 c	49 b	55 a	56 a	56 a	

† P_2O_5 rate $p = 0.97$. K_2O rate $p < 0.01$. P_2O_5 rate x K_2O rate $p = 0.14$. CV = 8%.
‡ P_2O_5 rate $p = 0.35$. K_2O rate $p < 0.01$. P_2O_5 rate x K_2O rate $p = 0.75$. CV = 13%.
§ Mean values followed by the same letter are not significantly different at the 0.10 probability level.

Table 4. Soil test P levels in spring 2015 after four (2011 to 2014) or three (2012 to 2014) consecutive fertilizer applications on Field 602S and 602C, respectively.

P_2O_5 rate	Field 602S, est. 2011 †						Field 602C, est. 2012 ‡					
	K_2O rate						K_2O rate					
	0	40	80	120	160	mean	0	40	80	120	160	mean
	--------------- Soil test P, ppm ---------------						--------------- Soil test P, ppm ---------------					
0	8	9	7	5	5	7 d §	5	4	3	4	4	4 d
30	18	11	11	8	7	11 c	8	8	6	5	5	6 c
60	25	17	12	13	13	16 b	14	12	10	8	9	11 b
90	30	26	22	21	21	24 a	16	14	17	13	14	15 a
mean	20 a	16 b	13 c	12 c	11 c		11 a	9 ab	9 abc	7 c	8 bc	

† P_2O_5 rate $p < 0.01$. K_2O rate $p < 0.01$. P_2O_5 rate x K_2O rate $p = 0.20$. CV = 24%.

‡ P_2O_5 rate $p < 0.01$. K_2O rate $p = 0.01$. P_2O_5 rate x K_2O rate $p = 0.76$. CV = 31%.

§ Mean values followed by the same letter are not significantly different at the 0.10 probability level.

Table 5. Soil test K levels in spring 2015 after four (2011 to 2014) or three (2012 to 2014) consecutive fertilizer applications on Field 602S and 602C, respectively.

P_2O_5 rate	Field 602S, est. 2011 †						Field 602C, est. 2012 ‡					
	K_2O rate						K_2O rate					
	0	40	80	120	160	mean	0	40	80	120	160	mean
	--------------- Soil test K, ppm ---------------						--------------- Soil test K, ppm ---------------					
0	68	73	81	89	102	82 a	60	64	65	78	92	72
30	64	73	78	90	116	84 a	56	59	69	80	90	71
60	62	69	77	90	107	81 a	54	68	73	69	82	69
90	50	57	68	77	94	69 b	56	57	67	78	85	69
mean §	61 e	68 d	76 c	86 b	105 a		56 e	62 d	68 c	76 b	87 a	

† P_2O_5 rate $p < 0.01$. K_2O rate $p < 0.01$. P_2O_5 rate x K_2O rate $p = 0.93$. CV = 11%.

‡ P_2O_5 rate $p = 0.21$. K_2O rate $p < 0.01$. P_2O_5 rate x K_2O rate $p < 0.01$. CV = 7%.

§ Mean values followed by the same letter are not significantly different at the 0.10 probability level.

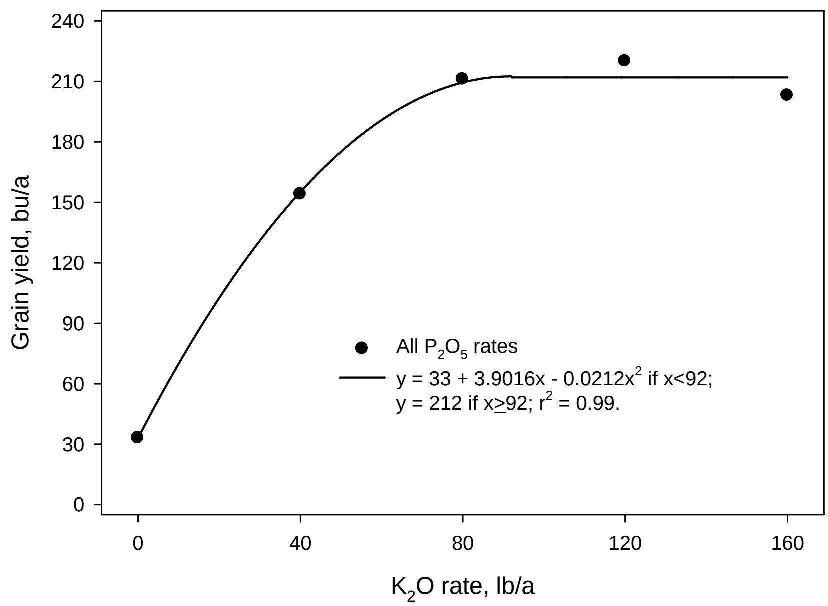

Figure 1. Relationship between K_2O fertilizer rate and corn grain yield averaged across all P_2O_5 rates (0 to 90 lb/a) in 2014 (Field 602C).

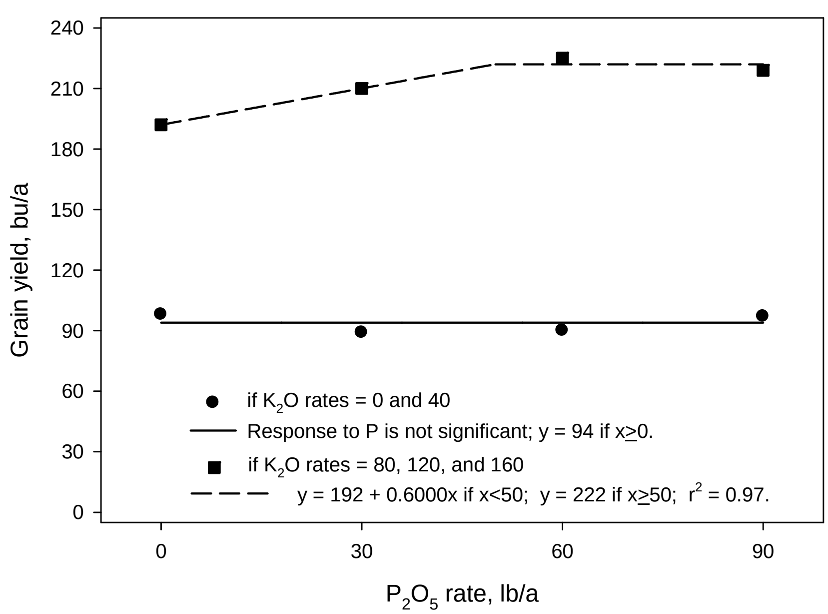

Figure 2. Relationship between P_2O_5 fertilizer rate and corn grain yield at two K_2O rate groupings (0 and 40; 80 to 160 lb/a) in 2014 (Field 602C).

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