EVALUATION OF PHOSPHORUS AND POTASSIUM FERTILIZATION ON CORN AND SOYBEAN YIELDS AND SOIL TEST LEVELS IN OHIO

S.W. Culman[1*], A.M. Fulford[1], C.E. Dygert[1], E.M. Lentz[1], R.W. Mullen[2]
[1]The Ohio State University, [2]Potash Corporation
*culman.2@osu.edu

ABSTRACT

The most recent fertilizer phosphorus (P) and potassium (K) recommendations for corn and soybean grown in Ohio were established in the mid-90s and research is required to verify the appropriateness of these recommendations after 20 years. In this study, corn and soybean rotations were established and maintained at three sites from 2006 to 2014 and fertilizer P and K were applied at 1) zero rates, 2) estimated nutrient removal rates and 3) twice the estimated nutrient removal rates for each rotation. Surface soil (0 – 8 inch) P and K availability as well as grain yield were measured to evaluate corn and soybean response to P and K fertilization. Initial soil test levels in 2006 were within the recommended maintenance range for P (15 – 30 ppm) and K (100 – 155 ppm) or slightly above the range at all three sites. Overall, P and K fertilization significantly increased corn and soybean grain yield in 10 of 42 site-years. Corn yield was evaluated for 24 site-years and responded positively in 17% and 4% of site-years as a result of P and K fertilization, respectively. While soybean yield was evaluated for 18 site-years and responded positively in 11% and 17% of site-years as a result of P and K fertilization, respectively. The general lack of positive grain yield responses following nine years of corn and soybean production suggest the current maintenance range for soil test P and K levels generally provided an appropriate basis for fertilizer P and K recommendations in Ohio

INTRODUCTION

Maintaining or building soil fertility can be influenced by soil test trends that become apparent only after years of crop production. Results from nearly 30 years of corn and soybean production have been used to document the buildup, maintenance, or decline of soil P as influenced by initial soil test P (McCollum, 1991; Dodd and Mallarino, 2005). Long-term nutrient budgets have also been developed from over 30 years of corn and soybean production to assess the soil balance of P and K in the U.S. (Fixen and Murrell, 2002; Bruulsema et al., 2011). Fertilizer recommendations aimed at replacing nutrients lost through crop removal can be influenced by the long-term trend of soil test values and nutrient budgets.

In Ohio, corn and soybean fertilizer recommendations widely follow those outlined in the, "Tri-state Fertilizer Recommendations for Corn, Soybeans, Wheat and Alfalfa" (Vitosh et al., 1995). This publication has served as a cornerstone for field crop soil fertility in the region, but after 20 years, a re-examination of these fertility recommendations is necessary, as a number of factors have changed in field crop production. In this study, fertilizer P and K rates that were estimated to equal or exceed crop removal were used to examine grain yield and soil test P and K trends that developed from nine years of corn and soybean production in Ohio.

MATERIALS AND METHODS

The study was initiated in 2006 at one site in Clark, Wayne, and Wood counties in Ohio and continued until 2014. At each site, a corn-soybean (CS) and a corn-corn-soybean (CCS) rotation was established and subsequently managed according to the phase of each cropping sequence. Corn was planted at 30,000 seeds per acre with a 30 inch row spacing and soybean was planted at 150,000 seeds per acre with a 7.5 inch row spacing. Fertilizer N was supplied as urea (40 lb N/A) at planting and urea ammonium nitrate (140 to 180 lb N/A) when corn was between the V4 to V6 growth stages. The total fertilizer N rate applied to corn was 180 lb N/A following soybean and 210 lb N/A following corn. Phosphorus was supplied as triple superphosphate (2006 to 2009) or diammonium phosphate (2010 to 2014), while K was supplied as muriate of potash (2006 to 2014) for each crop rotation.

An average corn and soybean yield of 145 and 40 bu/A, respectively, was used to estimate the nutrient removal rate of P and K in the harvested grain for each crop rotation based on state yield averages. Estimated crop removal of pounds of nutrient per bushel was taken from the Tri-State Fertilizer Recommendations (0.37 and 0.27 for P_2O_5 and K_2O for corn; 0.80 and 1.4 for P_2O_5 and K_2O for soybeans, respectively; Vitosh et al., 1995). Therefore the respective 1x and 2x P_2O_5 rate for the CS rotation was 85 and 170 lbs of P_2O_5 per acre, and 95 and 190 lbs of K_2O per acre. The respective 1x and 2x P_2O_5 rate for the CCS rotation was 140 and 280 lbs of P_2O_5 per acre, and 140 and 280 lbs of K_2O per acre. Soil sampling occurred in the fall prior to the broadcast application and surface incorporation of fertilizer P and K. Grain yield was measured for each crop in the rotation and soil test P (i.e., Bray P), and K (i.e., ammonium acetate extractable-K) were measured for each site. Soil test level changes were interpreted with respect to the maintenance range for plant-available P and K for corn and soybeans grown in Indiana, Michigan, and Ohio (Vitosh et al., 1995).

For each rotation, only one crop within that rotation (i.e., one entry point) was present for any given year. In other words, 2006, 2010, and 2012 were corn years for both CS and CCS; 2011 were soybean years for both rotations. The influence of crop rotation on grain yield was evaluated in these four (out of the nine years) but was not significantly different between the two rotations. Accordingly, yields were averaged across rotations in these four years to simplify the results.

RESULTS AND DISCUSSION

Corn and Soybean Yield

Corn grain yield ranged from 127 to 246, 112 to 224, and 85 to 159 bu/A in Clark, Wayne, and Wood counties, respectively, when no fertilizer K was applied from 2006 to 2014. Corn grain yield was significantly increased as a result of K fertilization in one of 24 site-years (Figure 1). Corn yield responded positively to K fertilization at the Clark County site in 2006 and exhibited an increase of 7 and 12 bu/A with the application of the 1x and 2x fertilizer K rate, respectively, compared to no fertilizer K application. Corn yield responded positively to fertilizer P application more frequently compared to fertilizer K application as four of 24 site-years exhibited a significant yield increase as a result of P fertilization. A positive yield response occurred in 2010 (Clark County), 2012 (Clark and Wood counties), and 2014 (Wayne County) with corn yield increased by as much as 39, 27, and 6 bu/A as a result of P fertilization at Clark, Wayne, and Wood counties, respectively (Figure 1).

Soybean yield ranged from 39 to 55, 29 to 63, and 28 to 69 bu/A in Clark, Wayne, and Wood counties, respectively, with no fertilizer K application from 2007 to 2014. Soybean grain yield was significantly increased by K fertilization in 3 of 18 site-years (Figure 2). Soybean yield was increased at the Clark County site in 2008, 2011, and 2013 by as much as 9, 5, and 9 bu/A, respectively. Potassium fertilization did not increase soybean grain yield at the Wayne and Wood county sites. Soybean grain yield was significantly increased by P fertilization in 2 of 18 site-years. Soybean yield was increased by as much as 9 bu/A at the Wayne County site in 2013 and by as much as 5 bu/A at the Wood County site in 2014 (Figure 2).

Soil Test Phosphorus

Initial soil test P values in 2006 were within or above the recommended maintenance range of 15 to 30 ppm at all three sites (Figure 3). Nine years of cropping with no fertilization across both rotations resulted in a decrease in soil test P from 27 to 5 ppm at Clark, 29 to 14 ppm at Wayne, and 22 to 10 ppm at Wood County. When no P was applied, all three sites had STP values in 2014 that were below the lower limit of the maintenance range (15 ppm Bray P1).

Nine-year trends in soil test P levels in the 1x and 2x treatments appear to differ across sites and rotations (Figure 3). Soil test P appears to be declining more rapidly in Clark and Wayne Counties as compared to Wood County. This is consistent with yields averaged across years at these sites, as Clark and Wayne yield more than 145 bu corn/A and 40 bu soybean/A, while Wood County yielded less. (Respective corn and soybean yields averaged across nine years were: Clark, 182 and 51 bu/A; Wayne, 163 and 51 bu/A; Wood 130 and 55 bu/A.)

Soil Test Potassium

Initial soil test K values in 2006 were within or above the maintenance range of 100 to 155 ppm for all three K rates at each site (Figure 4). Nine years of cropping with no fertilization across both rotations resulted in a decrease in soil test K from 112 to 70 ppm at Clark, 110 to 79 ppm at Wayne, and 204 to 155 ppm at Wood County. When no K was applied, two of the three sites had STK values in 2014 that were below the lower limit of the maintenance range (100 ppm Ammonium Acetate).

Nine-year trends in soil test K levels in the 1x and 2x treatments appear to be declining at all fertilization levels (Figure 4). This trend along with some similar declines in soil test P levels raise questions about estimated crop removal rates and soil test levels. Nine-year nutrient budgets of nutrient applied vs. nutrient removed show nearly two-fold amounts of fertilizer applied vs. estimated fertilizer removed (data not shown). This raises two (or more questions), which should be addressed in future research: 1) Do current estimated nutrient concentrations in corn and soybean grain accurately reflect what is removed? 2) Are soil test P and K levels relatively stable from year to year if nutrient applied approximates nutrient removed?

SUMMARY

Grain yield of corn and soybean responded positively to P and K fertilization in 10 of 42 site-years in Ohio. Results from 24 site-years of corn production indicated 17% and 4% of site-years responded positively to P and K fertilization, respectively. While the results from 18 site-years of soybean production revealed a positive response to fertilizer P and K application in 11% and 17% of site-years, respectively. The site at Clark County accounted for all four positive grain yield responses to fertilizer K for corn and soybean. The lack of crop grain yield responses to P and K fertilization suggest the current maintenance range for soil test P and K values are not too

low and are able to reflect the status of plant-available P and K for corn and soybean grown in rotation. However, questions remain about observed soil test P and K downward trends, despite application of P and K in excess of two times the estimated crop removal rate.

REFERENCES

Bruulsema, T.W., R.W. Mullen, I.P. O'Halloran, and D.D. Warncke. 2011. Agricultural phosphorus balance trends in Ontario, Michigan and Ohio. Can. J. Soil Sci. 91(3):437-442.

Dodd, J.R. and A.P. Mallarino. 2005. Soil-test phosphorus and crop grain yield responses to long-term phosphorus fertilization for corn-soybean rotations. Soil Sci. Soc. Am. J. 69(4):1118-1128.

Fixen, P.E. and T.S. Murrell. 2002. P and K reserves growing thinner. Fluid J. 10(37):8-11.

McCollum, R.E. 1991. Buildup and decline in soil phosphorus: 30-year trends on a Typic Umprabuult . Agron. J. 83(1):77-85.

Vitosh, M.L., J.W. Johnson, and D.B. Mengel. 1995. Tri-State Fertilizer Recommendations for Corn, Soybeans, Wheat and Alfalfa. Extension Bulletin, E-2567.

Figure 1. Corn grain yield response to fertilizer P or K applied at 0, 1x, and 2x the estimated crop removal rate for Clark, Wayne, and Wood counties in Ohio. Asterisk denotes a significant grain yield increase compared to unfertilized (0 lb/A P or K) corn.

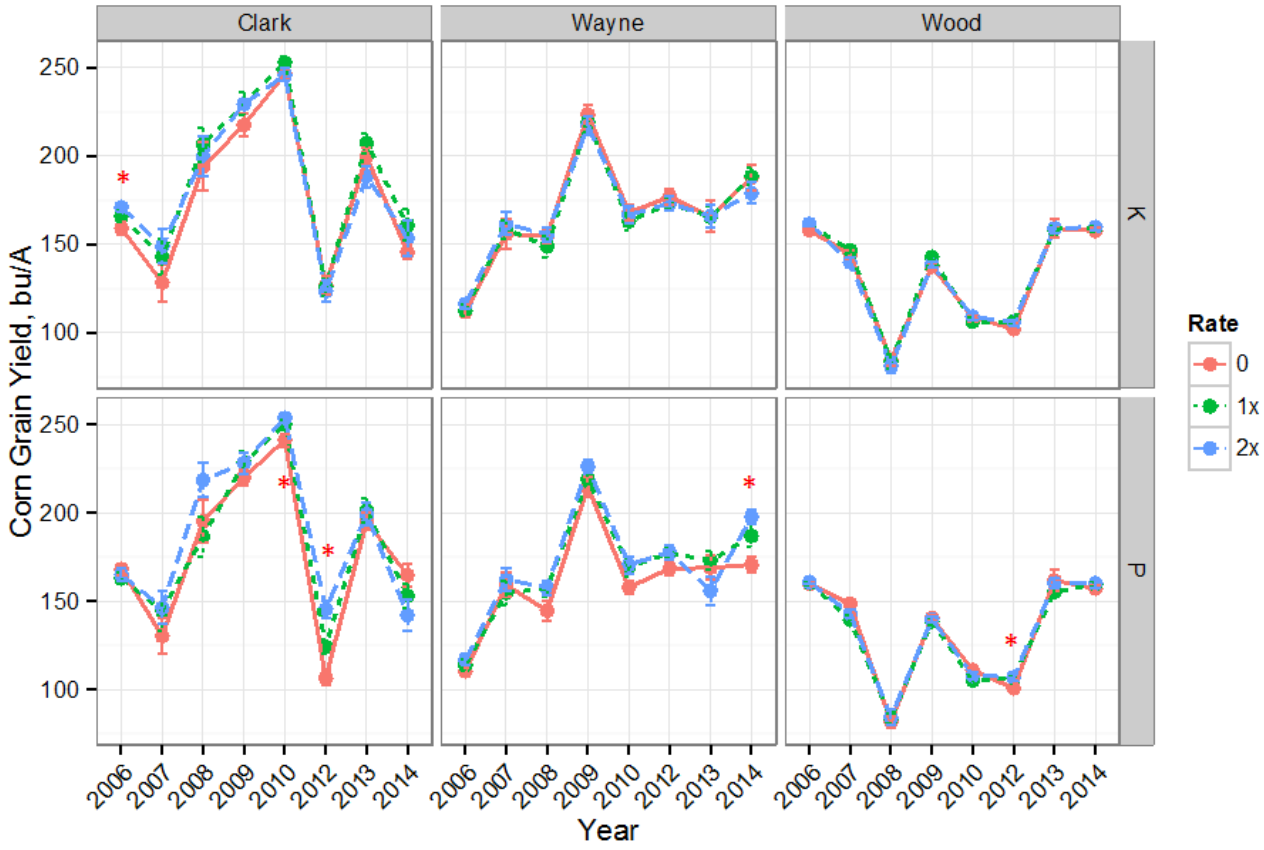


Figure 2. Soybean grain yield response to fertilizer P or K applied at 0, 1x, and 2x the estimated crop removal rate for Clark, Wayne, and Wood counties in Ohio. Asterisk denotes a significant grain yield increase compared to unfertilized (0 lb/A P or K) soybean.

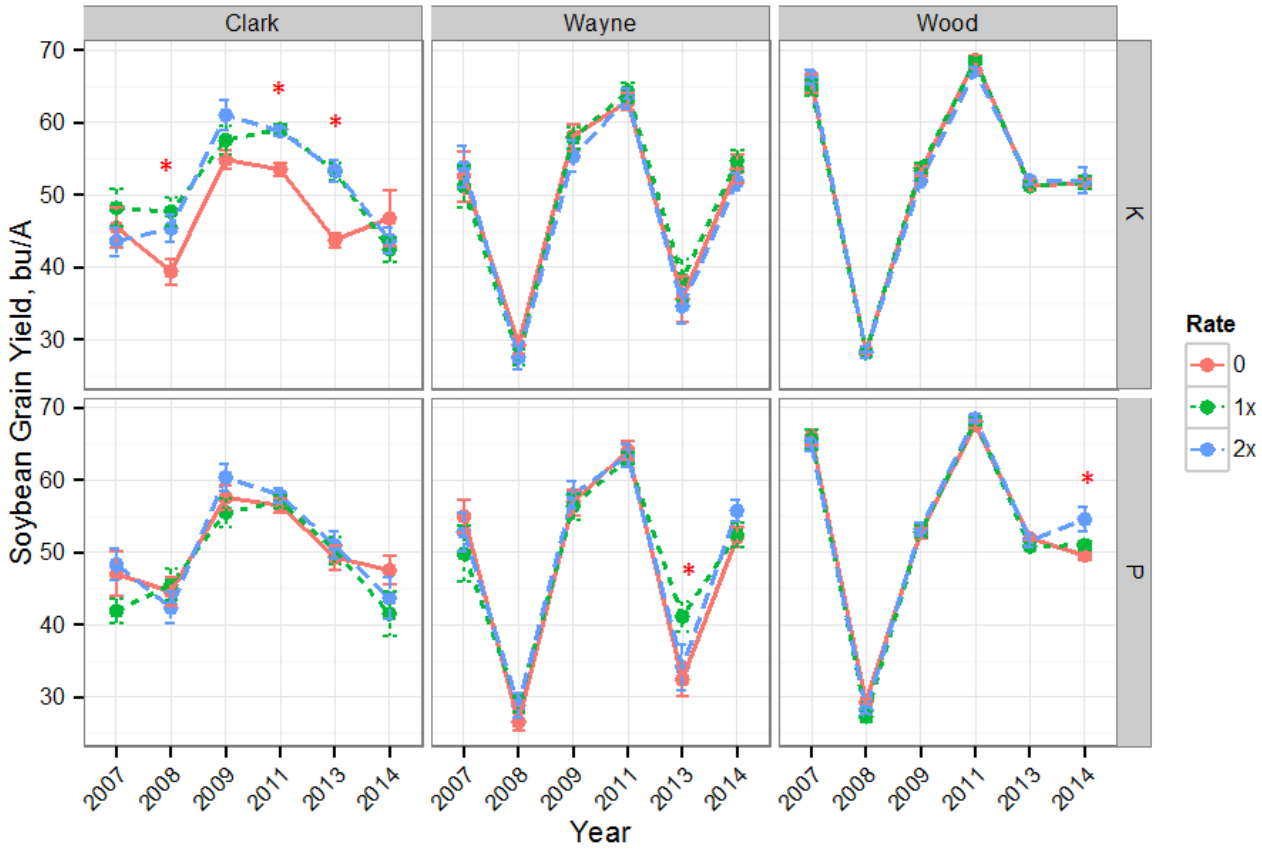


Figure 3. Soil test phosphorus (Bray P) trends for two corn and soybean rotations (CS or CCS) in response to fertilizer P applied at 0, 1x, and 2x the estimated crop removal rate for Clark, Wayne, and Wood counties in Ohio. Dotted lines represent the maintenance range (15-30 ppm) for soil test P. Fertilizer was applied in 2006, 2009 and 2012 in the CCS rotation and every other year starting in 2006 in the CS rotation.

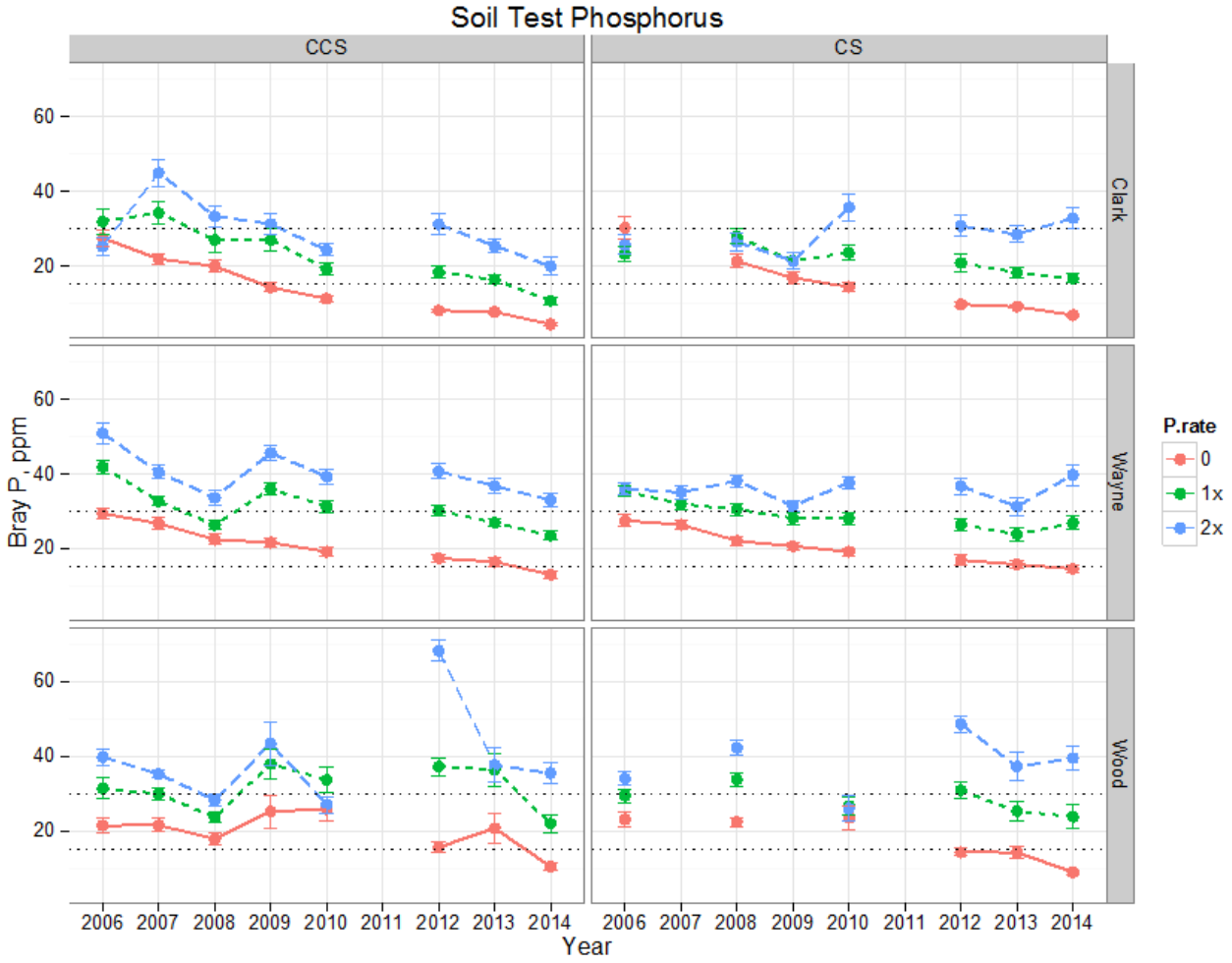
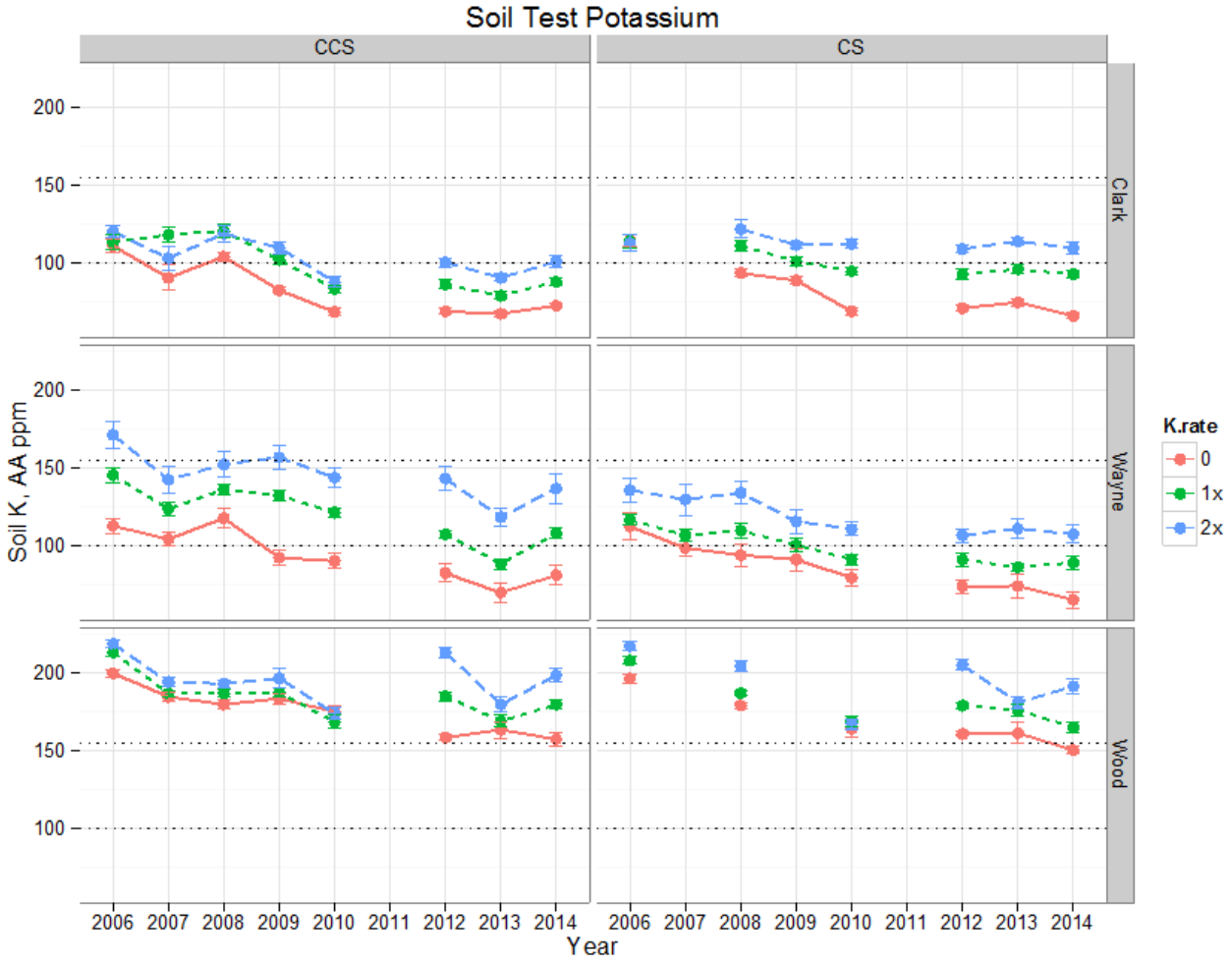


Figure 4. Soil test potassium (K) trends for two corn and soybean rotations (CS or CCS) in response to fertilizer K applied at 0, 1x, and 2x the estimated crop removal rate for Clark, Wayne, and Wood counties in Ohio. Dotted lines represent the maintenance range (100-155 ppm) for soil test K. Fertilizer was applied in 2006, 2009 and 2012 in the CCS rotation and every other year starting in 2006 in the CS rotation.



PROCEEDINGS OF THE

45th

NORTH CENTRAL EXTENSION-INDUSTRY SOIL FERTILITY CONFERENCE

Volume 31

November 4-5, 2015
Holiday Inn Airport
Des Moines, IA

PROGRAM CHAIR:
John E. Sawyer
Iowa State Univ
Ames, IA 50011
(515) 294-7078
jsawyer@iastate.edu

PUBLISHED BY:
International Plant Nutrition Institute
2301 Research Park Way, Suite 126
Brookings, SD 57006
(605) 692-6280
Web page**: www.IPNI.net**

ON-LINE PROCEEDINGS:
http://extension.agron.iastate.edu/NCE/