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Impact of Cover Crops and Phosphorus Fertilizer Management on Nutrient Cycling in No-Tillage Corn-Soybean Rotation

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Abstract

The objective of this study was to quantify the effects of cover crops and different fertilizer management techniques on the amount of nutrients being removed and recycled in the soil system. This study was conducted at Ashland Bottoms, KS, from 2014-2016. A 2 × 3 factorial design with three replicates was utilized in this study. The fertilizer management treatments included a control of 0 lb/a P_2O_5, along with fall broadcast and spring injected applications of P_2O_5 based on a build and maintain recommendation system. Results show that total uptake of K_2O and recycling of P_2O_5 and K_2O are directly influenced by cover cropping. Application of P_2O_5 fertilizer also statistically impacted the yield of soybeans during the 2016 growing season.

Keywords

cover crop, phosphorus, nutrient uptake

Authors

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Summary

The objective of this study was to quantify the effects of cover crops and different fertilizer management techniques on the amount of nutrients being removed and recycled in the soil system. This study was conducted at Ashland Bottoms, KS, from 2014-2016. A 2 × 3 factorial design with three replicates was utilized in this study. The fertilizer management treatments included a control of 0 lb/a P_2O_5, along with fall broadcast and spring injected applications of P_2O_5 based on a build and maintain recommendation system. Results show that total uptake of K_2O and recycling of P_2O_5 and K_2O are directly influenced by cover cropping. Application of P_2O_5 fertilizer also statistically impacted the yield of soybeans during the 2016 growing season.

Introduction

This study began in 2014 to determine the effect of cover cropping and fertilizer management on phosphorus (P) loss from a no-tillage corn-soybean rotation. By studying the effects of cover cropping and fertilizer management, this study looks to protect soil and water resources all while maximizing net returns and management flexibility for the producer. As part of this study, crop yield, nutrient uptake, and nutrient removal was determined.

Procedures

This trial was conducted at the Kansas Agricultural Watershed (KAW) Field Research Facility, located at Ashland Bottoms Research Farm in Manhattan, KS, on a Smolan silty clay loam with an average slope of 6-8%. The KAW research facility consists of 18 plots varying from 1.2 to 1.6 acres in size. Six different management systems are expressed in this study. These systems include fall broadcast (FB) application of phosphorus fertilizer, spring injected (SI) phosphorus fertilizer, and no phosphorus (CN) fertilizer. All fertilizer application methods were studied both with cover crop (CC), and no cover crop (NC). Treatments for this study were arranged in a 2 × 3 factorial design and replicated three times using randomized complete block orientation.

For the 2015 growing season, a cover crop mix of winter wheat, rapeseed, and hairy vetch was planted in November 2014 on all cover crop treatments followed by corn planting in April of 2015 for the entire experiment. Cover crop was terminated by herbicide at the time of corn planting. The FB plots received 75 lb P_2O_5/a as diammonium phosphate (DAP) broadcast in January 2015 and the SI plots received 75 lb P_2O_5/a as ammonium polyphosphate (APP), applied in a 2 × 2 placement at seeding. All applications of phosphorus fertilizer were based on build and maintain recommendations. Nitrogen (N) fertilizer was injected as 28% urea ammonium nitrate at various rates to each treatment to bring the total applied nitrogen up to 130 lb N/a per treatment. Corn ears were hand harvested from two 30-ft-long rows at three sub-plot locations. Care was taken to leave the corn husk attached to the stalk. Biomass samples were collected by harvesting ten stalks from each sub-plot location.

For the 2016 growing season, a winter wheat cover crop was planted in September of 2015 and terminated with herbicide in May 2016. Soybean was planted in June of 2016. The FB plots received 55 lb P_2O_5/a as DAP broadcast in November 2015 and the SI plots received 55 lb P_2O_5/a APP, applied in a 2 × 2 placement at seeding. Fertilizer applications rates were based on build and maintain recommendations. Biomass samples were collected from 3 feet of the planted row at three sub-plot locations. Grain was harvested from two rows across the entirety of each plot using a plot combine.

Three composite soil samples were collected at 0 to 2 and 2 to 6 inches deep from each plot following grain harvest but prior to fertilizer application each year of the experiment and analyzed for pH, P, potassium (K), nitrate (NO_3-N), and organic matter. Soil analysis for 0 to 6 inches was computed as the weighted average from the 0 to 2 and 2 to 6 inch data.

Results

Cover crop and fertilizer treatments did not affect soil organic matter, soil pH, potassium, or nitrate concentrations in the soil ($P > 0.05$), therefore, these data were summarized by year (Table 1). The FB fertilizer increased the 0- to 2-inch soil test P each year (Figure 1). The SI treatment maintained or increased soil test P, while the CN decreased soil test P (Figure 1).

Analysis of cover crop nutrient uptake data revealed no statistical differences between fertilizer management practices for either year (Table 2). There was greater nutrient uptake in 2016 compared to 2015, which can be attributed to variance in growth between the two years. In 2015, cover crop growth was minimal due to cover crop being planted after soybean and being harvested prior to planting corn. There was much greater growth and therefore greater nutrient uptake during 2016.

Neither cover crop nor fertilizer management influenced corn growth, yield, or nutrient uptake in 2015 ($P > 0.05$; Table 3). The only effect of cover crop on soybean yield and nutrient uptake was decreased N content in soybean residue (Table 4). This could be caused by N uptake by the cover crop, but more data are required to be conclusive. Phosphorus fertilizer application increased soybean grain yield, total P uptake, and N, P, and K removal in the grain (Table 4). Greater N removal by P-fertilized soybean can be attributed to greater grain yield. Greater P and K removal by P-fertilized soybean is

because of both greater yield and greater nutrient concentrations in the seed (data not shown).

In Table 5, the total nutrient uptake and removal for the 2015 and 2016 growing seasons are analyzed. Statistical differences were found in the total amount of K_2O uptake along with P_2O_5 and K_2O returned to the soil in the residue for the CC versus NC plots. Plots grown with CC had statistically greater uptake of all three categories which is correlated to the CC plots having greater amounts of P_2O_5 and K_2O deposited on the surface with the plant residue. Statistical differences were also observed when comparing fertilizer management interactions. The FB and SI plots had statistically greater removal of K_2O in the grain. This increased K_2O content of the grain could be a result of heathier or greater root mass caused by the application of phosphorus fertilizer.

Table 1. Soil analysis for 0 to 6 inches deep prior to the experiment (2014) and following grain harvest each year of the experiment (95% confidence intervals in parentheses)

Year	Organic matter[1]	pH[2]	Potassium[3]	NO_3-N[4]
	%		ppm	
2014	1.5 (+/- 0.1)	6.0 (+/- 0.1)	323 (+/- 12)	3.6 (+/- 0.6)
2015	1.6 (+/- 0.1)	6.7 (+/- 0.1)	328 (+/- 12)	2.5 (+/- 0.6)
2016	1.6 (+/- 0.1)	6.7 (+/- 0.1)	349 (+/- 12)	4.5 (+/- 0.6)

[1]Total C/0.75; where total carbon measured by combustion.
[2]1:1 soil:water pH; lime was applied after soil sample collection in 2014 because preliminary soil analysis indicated soil pH of 5.6 to 6.0.
[3]Ammonium acetate extractable potassium.
[4]Potassium chloride extraction.

Table 2. Two-year biomass and nutrient uptake of nitrogen, phosphorus (P_2O_5), and potassium (K_2O) of cover crops grown at KAW Field Research Facility

	2015				2016			
	Biomass	Nitrogen	P_2O_5	K_2O	Biomass	Nitrogen	P_2O_5	K_2O
	lb/a							
CN	248	9.6	1.5	9.9	1190	10.2	5.8	15.2
FB	216	9.0	1.4	8.6	1910	15.7	9.7	25.9
SI	192	7.4	1.0	7.5	1620	16.1	7.4	23.3
P-value	0.23	0.12	0.30	0.25	0.27	0.31	0.26	0.24

All data are expressed in lb/a.
CN = No phosphorus fertilizer.
FB = fall broadcast application of phosphorus fertilizer.
SI = spring injected phosphorus fertilizer.
P-value < 0.05 indicate significant differences between treatments.

Table 3. Effect of cover crop, fertilizer management, and cover crop by fertilizer management on nutrient uptake and yield in 2015 corn crop

	Total					Grain			Residue			
	Yield	Biomass	Nitrogen	P_2O_5	K_2O	Nitrogen	P_2O_5	K_2O	Biomass	Nitrogen	P_2O_5	K_2O
	bu/a	lb/a										
CC	160	15800	172	76	156	113	53	32	8250	58	23	123
NC	162	15400	175	72	153	117	52	32	7700	58	20	122
P-value	0.68	0.41	0.73	0.44	0.76	0.36	0.78	0.85	0.09	0.92	0.17	0.85
CN	161	15600	174	73	154	117	52	32	7950	57	21	123
FB	158	15300	165	73	148	110	52	31	7790	56	22	117
SI	164	15900	181	77	162	118	54	33	8180	60	21	127
P-value	0.66	0.59	0.35	0.79	0.48	0.31	0.75	0.54	0.57	0.99	0.71	0.52
CN-CC	158	15700	166	73	158	110	52	31	8240	58	23	129
CN-NC	165	15400	182	72	149	125	53	32	7660	57	20	118
FB-CC	160	15600	164	78	147	109	53	32	8070	55	25	115
FB-NC	156	14900	167	69	148	111	50	30	7510	57	19	119
SI-CC	162	16100	186	77	163	120	54	33	8430	60	21	124
SI-NC	166	15800	176	76	162	117	54	33	7920	60	22	129
P-value	0.71	0.92	0.49	0.71	0.90	0.29	0.86	0.70	0.99	0.93	0.42	0.59

All data are expressed in lb/a.
CC = cover crop.
NC = no cover crop.
P-value < 0.05 indicate significant differences between treatments.
CN = No phosphorus fertilizer.
FB = fall broadcast application of phosphorus fertilizer.
SI = spring injected phosphorus fertilizer.

Table 4. Effect of cover crop, fertilizer management, and cover crop by fertilizer management interaction on nutrient uptake and yield in 2016 soybean crop

	Total					Grain			Residue		
	Yield	Biomass	Nitrogen	P_2O_5	K_2O	Nitrogen	P_2O_5	K_2O	Nitrogen	P_2O_5	K_2O
	bu/a	lb/a									
CC	62.3	11,300	346	66	216	233	45	79	113	21	137
NC	61.9	11,800	385	66	219	229	44	77	156	23	142
P-value	0.83	0.29	0.06	0.94	0.78	0.63	0.44	0.49	0.02	0.66	0.69
LSD									41.27		
Control	58.3	10,700	338	56	203	216	38	70	122	18	133
FB	65.3	12,000	388	73	227	245	49	84	143	25	144
SI	62.6	11,800	371	69	222	232	46	80	140	23	142
P-value	0.04	0.08	0.13	0.02	0.10	0.04	<0.01	0.01	0.52	0.74	0.60
LSD	5.29			4.36		21.70	1.84	5.80			
CN-CC	59.3	10,300	316	56	199	220	39	73	96	17	126
CN-NC	57.2	11,200	360	56	208	213	36	68	147	20	140
FB-CC	64.3	11,800	366	73	230	244	49	84	121	25	145
FB-NC	66.4	12,200	411	73	225	246	49	83	165	25	142
SI-CC	63.2	11,700	357	69	221	235	47	80	122	22	141
SI-NC	62.0	11,900	385	70	223	228	46	80	157	24	143
P-value	0.66	0.84	0.92	0.99	0.94	0.87	0.70	0.88	0.92	0.92	0.77

CC = cover crop.
NC = no cover crop.
P-value < 0.05 indicate significant differences between treatments.
LSD = least significant difference.
CN = No phosphorus fertilizer.
FB = fall broadcast application of phosphorus fertilizer.
SI = spring injected phosphorus fertilizer.

Table 5. Effect of cover crop, fertilizer management, and cover crop by fertilizer management on total nutrient uptake and removal for 2015-2016

	Total			Grain			Residue		
	Nitrogen	P_2O_5	K_2O	Nitrogen	P_2O_5	K_2O	Nitrogen	P_2O_5	K_2O
	lb/a								
CC	547	152	407	346	98	112	193	53	290
NC	561	139	372	347	96	109	214	43	263
P-value	0.56	0.07	0.03	0.99	0.58	0.49	0.25	0.02	0.03
LSD			24.9					3.6	23.5
CN	523	134	371	334	90	102	189	43	269
FB	566	152	393	355	100	115	211	52	278
SI	573	150	405	351	101	113	211	49	284
P-value	0.19	0.07	0.16	0.24	0.09	0.04	0.49	0.22	0.51
LSD						8.8			
CN-CC	504	139	384	330	92	104	174	47	280
CN-NC	542	129	358	338	89	100	204	40	258
FB-CC	554	162	411	353	102	116	201	61	295
FB-NC	579	142	374	357	99	113	222	43	260
SI-CC	583	155	425	356	101	114	206	52	296
SI-NC	562	146	385	345	100	113	217	46	272
P-value	0.57	0.76	0.91	0.76	0.99	0.96	0.90	0.46	0.87
LSD									

CC = cover crop.
NC = no cover crop.
P-value < 0.05 indicate significant differences between treatments.
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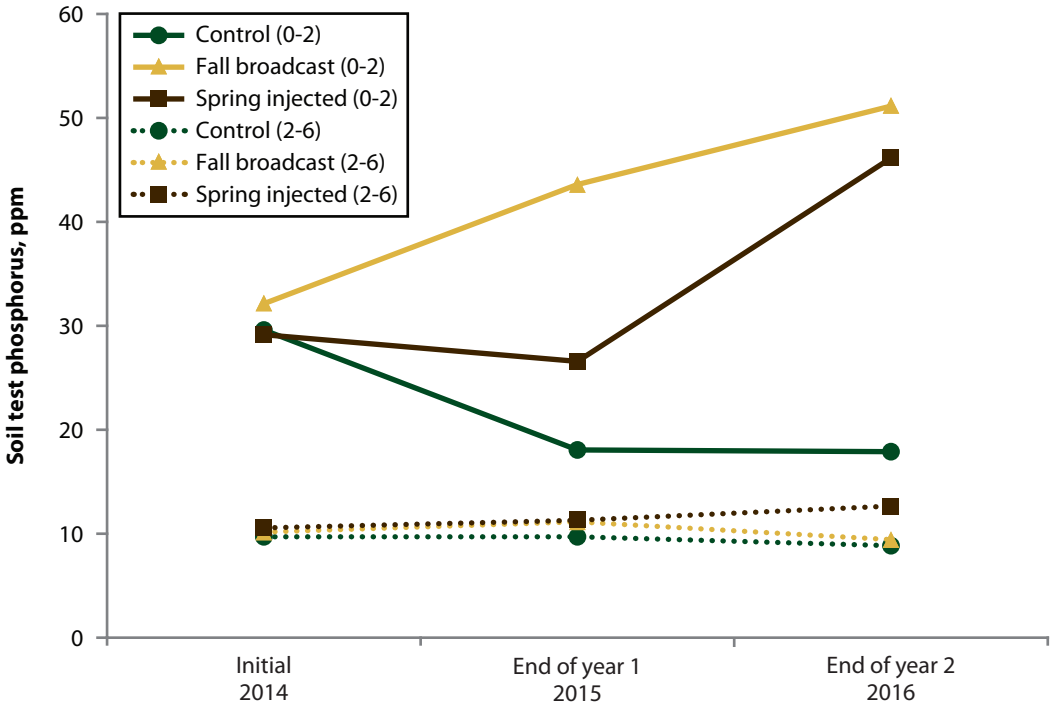

Figure 1. Fertilizer management effects on Mehlich 3 soil test P at 0- to 2-inch (solid lines) and 2- to 6-inch (dotted lines) depths. Letters indicate significant differences within year at the 0- to 2-inch depth ($P < 0.05$). There were not any significant differences at the 2- to 6-inch depth.