Minimizing Phosphorus Loss with 4R Stewardship and Cover Crops

Nelson, N.O., K.L. Roozeboom, P. Tomlinson, P.L. Barnes, J.R. Williams, and G.J. Kluitenberg

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The overall objective of this research is to determine how interactions between cover crops and P fertilizer management impact P loss, P use efficiency, crop yield, and net return. We have established a replicated small watershed study to achieve this objective. The study site is at the Kansas Agricultural Watershed (KAW) Field Laboratory near Manhattan, KS. The KAW field lab consists of 18 small watersheds (1.2 to 1.5 ac in size) equipped with automated runoff monitoring equipment. The following treatments have been applied to the watersheds (replicated 3 times):

1. No P fertilizer applied, no cover crop
2. No P fertilizer applied, with cover crop
3. Fall broadcast P fertilizer, no cover crop
4. Fall broadcast P fertilizer, with cover crop
5. Spring injected P fertilizer, no cover crop
6. Spring injected P fertilizer, with cover crop

Field activities during the reporting period (Jan. 1, 2016 to Dec. 31 2016)

Cover crop biomass was collected on May 5, 2016 piror to cover crop was termination on May 6, 2016. The experiment was planted to soybean on June 6, 2016. Phosphorus fertilizer (10-34-0) was injected at planting for treatments 5 and 6. The broadcast fertilizer treatments received P fertilizer (18-46-0) on November 12, 2015. P fertilizers were applied at an average of 54 lb P_2O_5/ac. Soybean biomass was harvested at R7 growth stage on Sept. 19, 2016 and grain was harvested on October 17 and 19, 2016. A mixture of triticale and rapeseed was planted as a cover crop on October 19 and 20. Soil samples were collected from three locations in each plot in November. Diammonium phosphate was applied to fall broadcast treatments on Dec. 2, 2016 at a rate of 50 lbs P_2O_5/ac.

Rainfall and runoff was monitored throughout the growing season. There were a total of 27 runoff events between October 1, 2015 and Sept 30, 2016, the first of which occurred on Nov. 19, 7 days after fertilizer application. Over 85% of all runoff occurred in only 7 events, each with greater than 0.2 inches (5 mm) of runoff. The remaining 20 events had less than 0.2 inch of runoff each, with most less than 0.1 inches of runoff. Equipment malfunctions and missing data were minimal.

Summary of results

Runoff in the 2015/2016 season was similar to that of the prior year (6.3 to 6.5 inches) but sediment loss was 85% less in 2016 because of high corn residue and no-till production. For simplification, results are only summarized for the large (>0.2 inches) runoff events. Cover crop did not impact runoff, but cover crop still reduced sediment loss by 70% (Table 1, Figure 1). However, the cover crop had little impact on total P loss (Figure 2) due to an increase in dissolved P loss (Figure 3).

Fall-broadcast fertilizer application increased total P loss for two of events in the spring, but did not increase result in a significant season long effect due to high variability ($p>0.05$ for main effect of

fertilizer; Table 1; Figure 4). Fall broadcast fertilizer did increase the dissolved P concentration and loss for events through May. However, there was no difference between dissolved P concentrations or losses for fall broadcast and spring injected treatments from July through the end of the year (Figure 5).

Addition of fertilizer has significantly increased the surface soil test P concentrations of both spring injected and fall broadcast treatments, with little change at the 2 to 6-inch depth (Figure 6). Fertilizer addition increased soybean yield by 10 % in 2016 ($p<0.05$), for an average of 64 bu/ac with fertilizer compared to 58 bu/ac without. Fertilizer application increased P uptake and P removal, but did not have a significant impact on P recycled in residue (Table 2).

Presentation of results

Results from the first two years of the study were summarized in an M.S. Thesis defended in December 2016 (Abel, 2017).

Abel, D.S. 2017. Cover crop effects on soil moisture and water quality. M.S. thesis. Kansas State Univ. Manhattan, KS. http://hdl.handle.net/2097/34650.

Results from the first and second year of the study were presented at the conferences listed below. Copies of these presentations are available on the project web site, http://www.ksu.edu/kaw.

Nelson, N., D. Able, K. Roozeboom, G. Kluitenberg, P. Tomlinson, J. Williams, and P. Barnes. 2016. Minimizing Phosphorus Loss with 4R Nutrient Stewardship & Cover Crops. 4R Nutrient Stewardship Summit, June. 15-16, 2016. Indianapolis, IN.

Abel, D., N.O. Nelson, K. Roozeboom, P. Tomlinson, and G. Kluitenberg. 2016. Cover Crop and Fertilizer Management Impacts on Water Quality. ASA-CSSA-SSSA International Annual Meeting. Nov. 6-9, 2016. Phoenix, AZ.

Nelson, N. 2016. Can Cover Crops Reduce Phosphorus Loss from Surface-applied Fertilizer? USDA-NRCS Area Resource Conservationist Meeting. Feb. 16, 2016. Salina, KS.

Nelson, N. 2016. Can Cover Crops Reduce Phosphorus Loss from Surface-applied Fertilizer? Natural Resources and Environmental Sciences Secondary Major Seminar Series. Feb. 18, 2016. Manhattan, KS.

Plans for the 2016 Growing Season

Corn will be planted following cover crop termination in April 2017, at which time the remaining fertilizer treatments will be applied. Cover crop biomass and nutrient uptake will be measured at the time of termination. Corn growth will be monitored throughout the 2017 growing season. Runoff measurement and sampling will continue throughout the season as was done for 2016. Corn biomass will be measured at maturity along with grain yield, nutrient uptake, and nutrient removal. The fourth year of the study will begin following corn harvest when cover crops will be direct seeded into corn residue.

Table 1. Results (p-values) of the repeated measures ANOVA for treatment effects of cover crops and fertilizer management on runoff volume, sediment concentration (TSS), sediment load (Sed), total P concentration (TP), total P load (TP load), dissolved P concentration (DP), and dissolved P load (DP load for runoff events larger than 0.2 inches from October 2015 through September 2016.

	Runoff	TSS	Sed	TP	TP load	DP	DP load
Fert¥	0.327	0.967	0.709	0.002	0.076	<0.001	<0.001
Cover¥	0.778	<0.001	<0.001	0.485	0.725	<0.001	0.003
Fert*Cover¥	0.027	0.702	0.372	0.657	0.638	0.396	0.206
Event¥	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Event*Fert¥	0.107	0.392	0.175	<0.001	0.002	<0.001	<0.001
Event*Cover¥	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Event*Cover*Fert¥	0.003	0.368	0.168	0.469	0.320	0.127	0.807

¥ Fertilizer Management (Fert), Cover Crop (Cover), Fertilizer Management by Cover Crop Interaction (Fert*Cover), Runoff Event (Event), Runoff Event by Fertilizer Management Interaction (Event*Fert), Runoff Event by Cover Crop Interaction (Event*Cover), Runoff Event by Cover Crop by Fertilizer Management Interaction (Event*Cover*Fert).

Table 2. Phosphorus balance (uptake, deposition, and removal) as influenced by cover fertilizer management in no-till soybean for the 2015-2016 growing season.

	Control	Fall Broadcast	Spring injected	LSD
	——— lb P_2O_5 a^{-1}c ———			
P applied	0.0	54.0	54.0	
P cycling with cover crop (uptake/deposition)	5.7	9.6	7.2	3.9
P uptake by soybean	55.3	72.2	68.3	10.0
P removal in soybean seed	37.3	47.8	45.5	4.2
P returned with soybean residue	18.0	24.3	22.7	NS
Total P lost in runoff	1.7	2.7	2.0	NS
DP lost in runoff	0.3	1.4	0.7	
Yield (bu/ac)	58.3	65.3	62.6	5.3

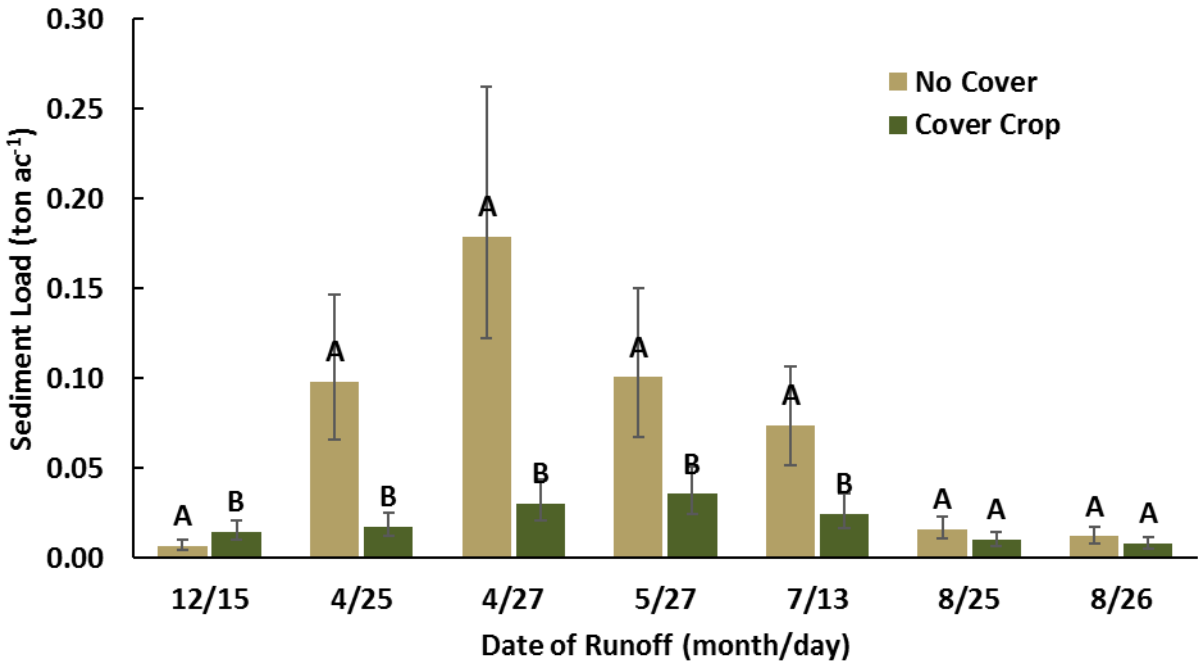

Figure 1. Effect of cover crop on sediment load for all events with more than 0.2 inches of runoff from October 2015 to September 2016 (bars with different letters are significantly different within an event at p<0.05).

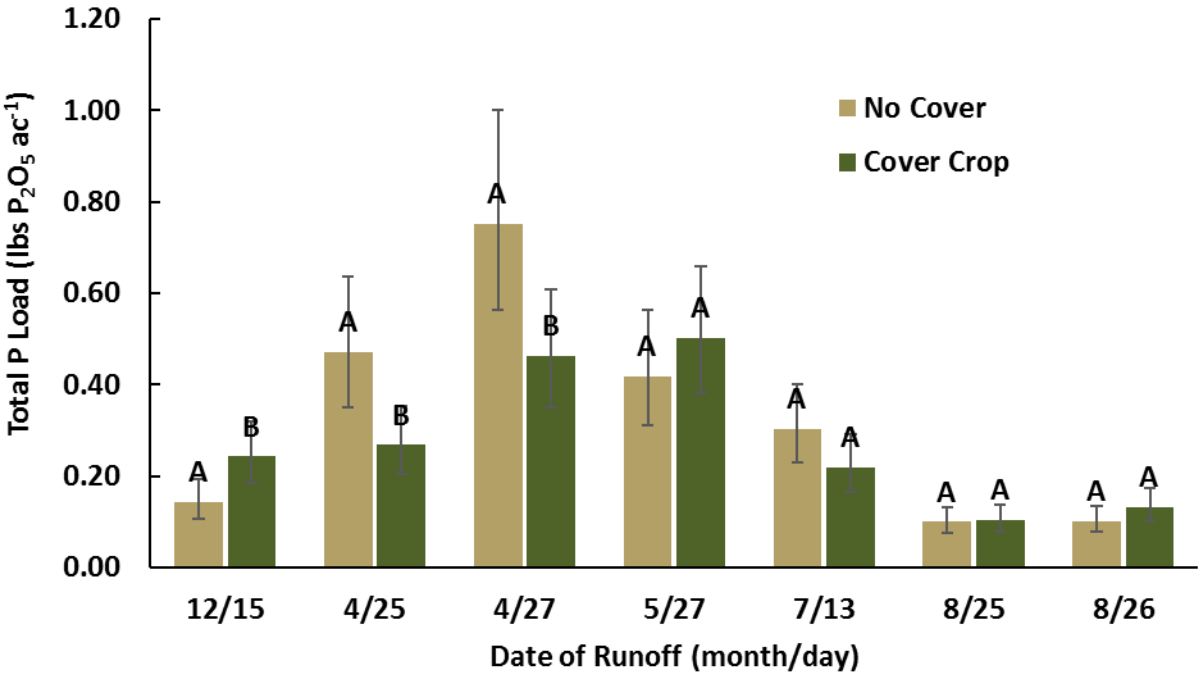

Figure 2. Effect of cover crop on total P loss for all events with more than 0.2 inches of runoff from October 2015 to September 2016 (bars with different letters are significantly different within an event at p<0.05).

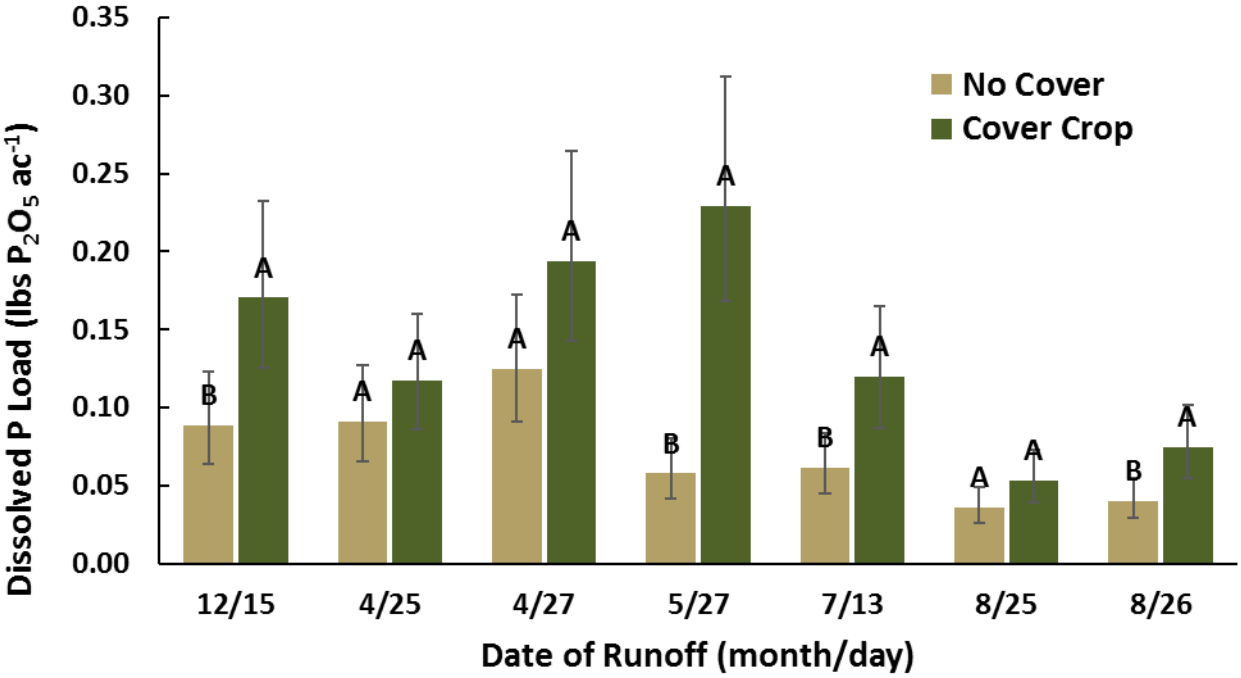

Figure 3. Effect of cover crop on dissolved P loss for all events with more than 0.2 inches of runoff from October 2015 to September 2016 (bars with different letters are significantly different within an event at p<0.05).

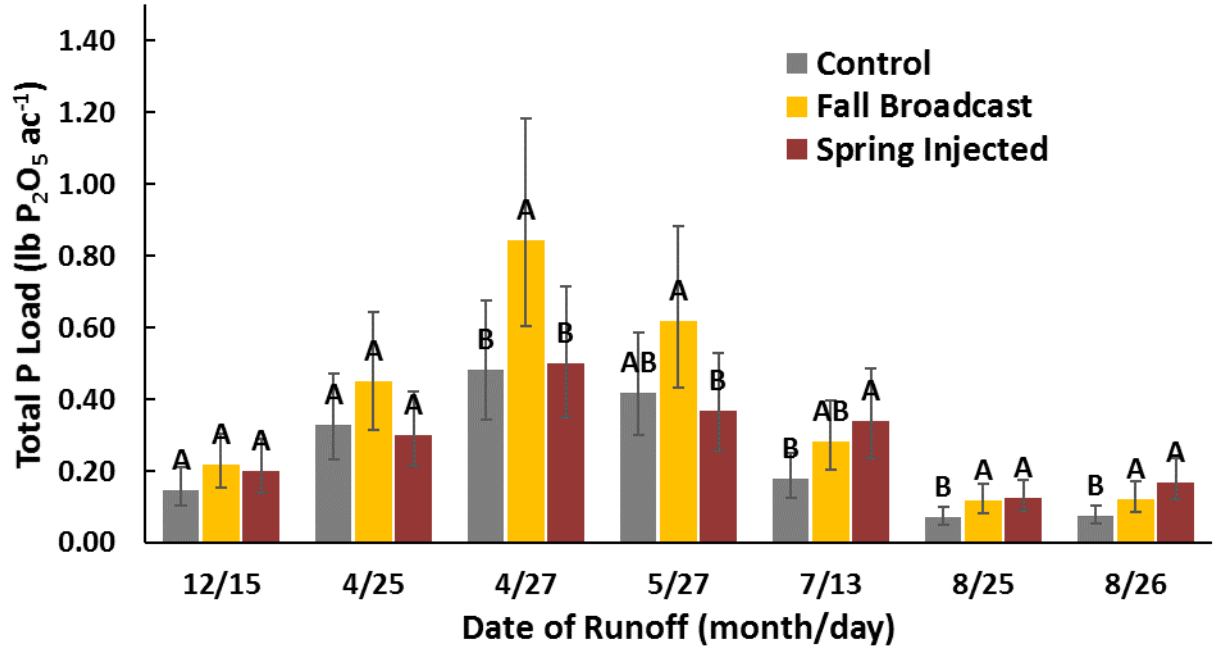

Figure 4. Effect of fertilizer management on total P loss for all events with more than 0.2 inches of runoff from October 2015 to September 2016 (bars with different letters are significantly different within an event at p<0.05).

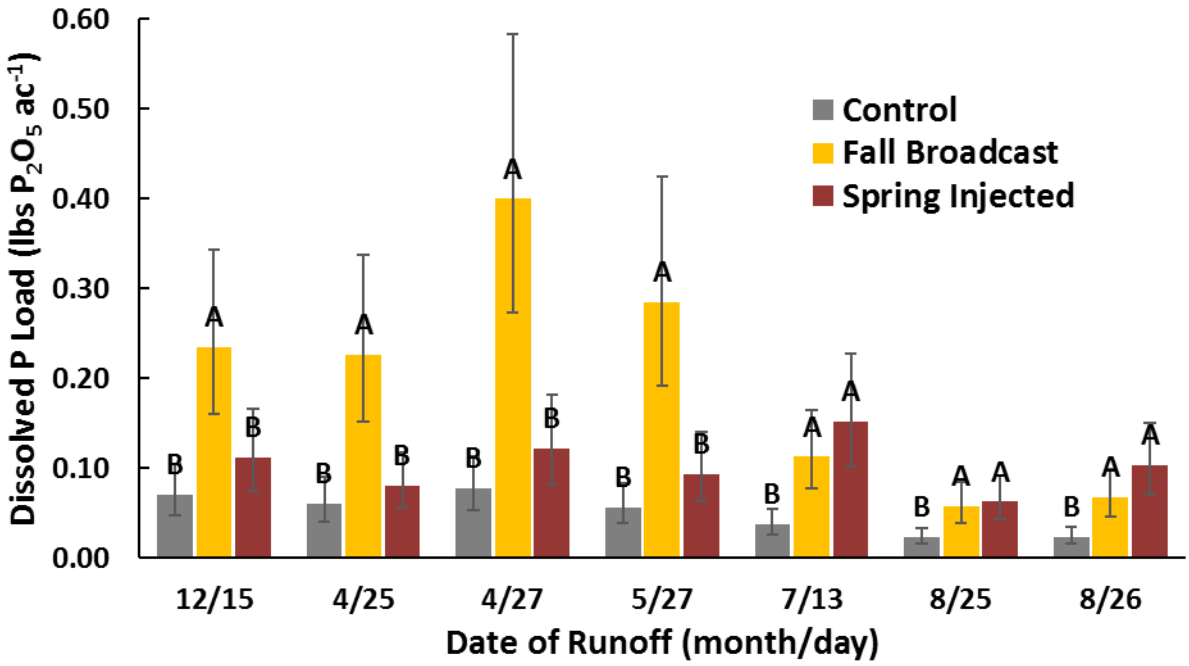

Figure 5. Effect of fertilizer management on dissolved P loss for all events with more than 0.2 inches of runoff from October 2015 to September 2016 (bars with different letters are significantly different within an event at p<0.05).

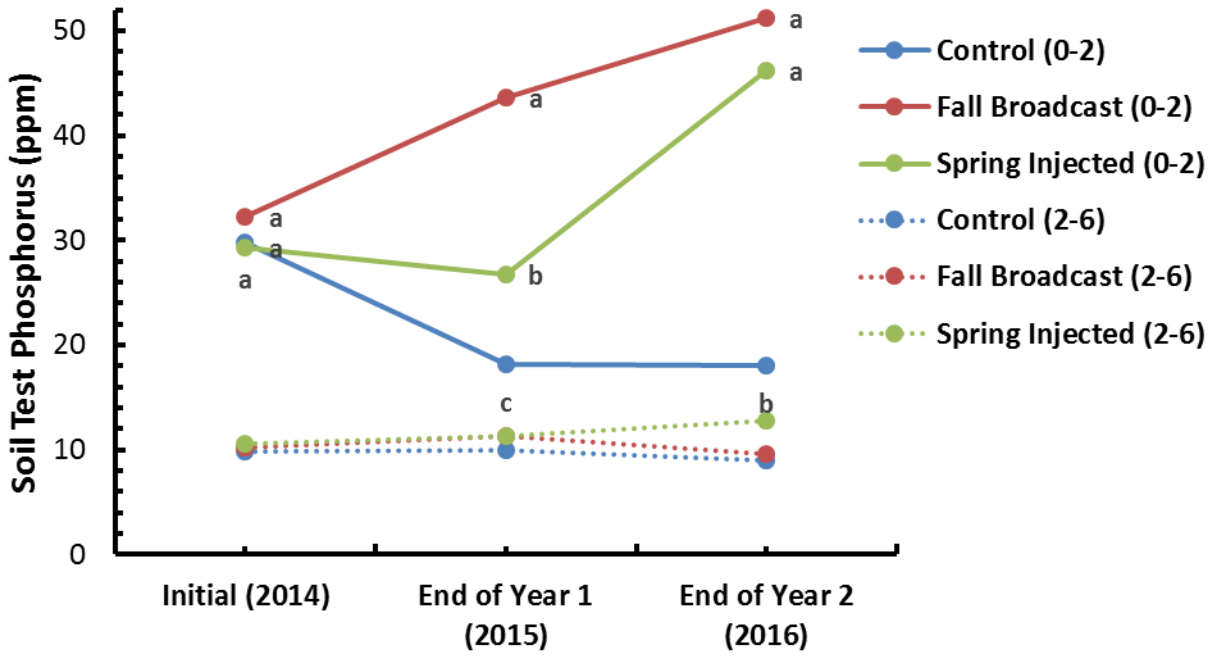

Figure 6. Effect of fertilizer management on fall soil test P at 0-2 inches (solid line) and 2-6 inches (dotted lines). Different letters indicate significant difference at p<0.05 within depth and sampling date. There were not any significant differences at the 2 to 6-inch depth.