Minimizing Phosphorus Loss with 4R Stewardship and Cover Crops

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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, 2015 to Dec. 31 2015)

The experiment was planted to corn on April 14, 2015. 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 January 12, 2015. All P fertilizers were applied at 82 lb P_2O_5/ac. Cover-crop biomass samples were harvested prior to termination at the time of corn planting. Nitrogen fertilizer (28-0-0) was injected after corn planting at rates sufficient to balance N applications at 140 lb N/ac. Corn biomass samples were collected prior to harvest on Sept. 18 and 21, 2015.

Rainfall and runoff was monitored throughout the growing season. There were a total of 12 runoff events between fertilizer application and corn harvest, the first of which occurred on May 4, 2015. As this was the first year of the study, there were some missing data points resulting from equipment malfunction. With 12 runoff events, there were potentially 216 values for each parameter measured (runoff volume, sediment and nutrient concentrations, etc.). We collected 91% of all runoff volume measurements, 63% of all concentration data (sediment, total P, dissolved P) and 61% of all constituent load data (sediment, total P, and dissolved P). The majority of the missing data values were from excess sediment loss that the interfered with sample collection. We fixed the problems with sample collection by reconfiguring the sample collection tubes. We expect that higher residue cover in future years will decrease sediment loss and improve data collection.

Main effects of cover crop and fertilizer management can be analyzed for all 12 runoff events. However, due to missing data, analysis of cover crop and fertilizer management interactions could only be done with five events (5/11, 5/18, 5/21, 6/11, and 9/11). Statistical analysis was done with repeated measures ANOVA using SAS proc mixed with runoff “event” repeated. Data required either a square-root (runoff and dissolved P) or log (sediment and total P) transformation prior to statistical analysis. Means were back-transformed for data presentation.

A cover crop of winter wheat was planted on September 22, 2015. The broadcast fertilizer was applied on November 10 and 13, 2015 at a rate of 50 lbs P_2O_5/ac. There was a very small runoff event that occurred on November 18 and a larger runoff event that occurred on November 26. No other runoff has occurred since fertilizer application.

Summary of results

Runoff, sediment loss, total P concentration, and total P loss were all significantly affected by the cover crop treatment (Table 1). Cover crop reduced runoff by 16% over the course of the season. The effect of cover crop appeared to be more pronounced early in the season (Figure 1), however, the event by cover crop interaction was not significant. Cover crop also decreased sediment and total P loss by over 50% (Figures 2 and 3). Again there was a tendency for the cover crop to have less of an impact later in the season, however, the interaction over time (cover crop by event) was only significant for TP loss (Table 1).

Fertilizer treatments only affected the dissolved P loss (Table 1). Dissolved P concentration and loss were significantly greater with the fall broadcast treatment (Figure 4). Although the dissolved P loss was over 7x greater with fall broadcast fertilizer, the total P loss was not affected by fertilizer treatment (data now shown). This is because the dissolved P was only about 10% of the total P loss. Total P loss had greater variability, therefore the differences were not significant even though there appeared to be greater total P loss from broadcast treatments. The majority of P losses in this year were sediment-bound because the soils had historically been conventionally tilled and the soil had negligible residue on the surface at the time of corn planting. We expect the sediment-bound P to decrease substantially as we will be using no-till production practices for the rest of the study.

There was a significant cover crop by fertilizer management interaction for the dissolved P losses on the five events with complete data (Table 2). The cover crop did not impact dissolved P loss for the control or sub-surface injected treatments. However, cover crop reduced dissolved P loss by over 60% for the fall broadcast treatment (Figure 5). This indicates that cover crops are potentially a best management practice to reduce P loss when using fall-broadcast P fertilizer.

Presentation of results

Results from 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. 2015. Can Cover Crops Reduce Phosphorus Loss from Surface-applied Fertilizer? Soil and Water Conservation Society Nutrient Management and Edge of Field Monitoring Conference, Dec. 1-3, 2015. Memphis, TN.

Abel, D., N.O. Nelson, K. Roozeboom, G. Kluitenberg, P. Tomlinson, J. Williams, and P. Barnes. 2015. Cover Crop and Fertilizer Management to Improve Water Quality. ASA-CSSA-SSSA International Annual Meeting. Nov. 15-18, 2015. Minneapolis, MN.

Nelson, N., K. Roozeboom, P. Tomlinson, G. Kluitenberg, P. Barnes, and J. Williams. 2015. Minimizing Phosphorus Loss with 4R Nutrient Stewardship & Cover Crops. 4R Nutrient Stewardship Summit, May 12, 2015, Washington D.C.

Plans for the 2016 Growing Season

Soybean will be planted following cover crop termination in May, at which time the remaining fertilizer treatments will be applied. Cover crop biomass and nutrient uptake will be measured at the time of termination. Soybean growth will be monitored throughout the 2015 growing season. Runoff measurement and sampling will continue throughout the season as was done for 2015. The soybean biomass will be measured at maturity along with grain yield, nutrient uptake, and nutrient removal. The third year of the study will begin following soybean harvest when cover crops will be direct seeded into soybean residue.

Table 1. Results (p-values) of the repeated measures ANOVA for main treatment effects of cover and fertilizer management on runoff volume, sediment load (Sed), total P load (TP load), dissolved P load (DP load), total P concentration (TP concn.) and dissolved P concentration (DP concn.) for 12 runoff events from May 2015 through September 2015.

	Runoff	Sed	TP Load	DP load	TP concn.	DP concn.
main effect of cover						
Cover	0.006	<0.001	<0.001	0.053	<0.001	0.233
Event	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Event*Cover	0.919	0.103	0.022	<0.001	0.096	0.342
main effect of fertilizer						
Fertilizer	0.938	0.993	0.463	<0.001	0.267	<0.001
Event	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Event*Fertilizer	0.998	0.962	0.985	<0.001	0.641	0.002

Table 2. Results (p-values) of the repeated measures ANOVA for treatment main effects and interaction effects on runoff volume, sediment load (Sed), total P load (TP load), dissolved P load (DP load), total P concentration (TP concn.) and dissolved P concentration (DP concn.) for 5 runoff events with complete data from May 2015 through September 2015.

	Runoff	5 events (5/11, 5/18, 5/21, 6/11, 9/11)				
	(all data)	Sed	TP Load	DP Load	TP concn.	DP concn.
Fertilizer	0.903	0.490	0.377	<0.001	0.238	<0.001
Cover	0.016	0.002	0.003	0.050	0.008	0.146
Fertilizer*Cover	0.797	0.433	0.455	0.023	0.924	0.057
Event	<0.001	<0.001	<0.001	<0.001	<0.001	0.063
Event*Fertilizer	0.994	0.794	0.966	0.046	0.515	0.059
Event*Cover	0.841	0.161	0.072	0.228	0.393	0.382
Event*Cover*Fertilizer	0.079	0.151	0.640	0.977	0.461	0.903

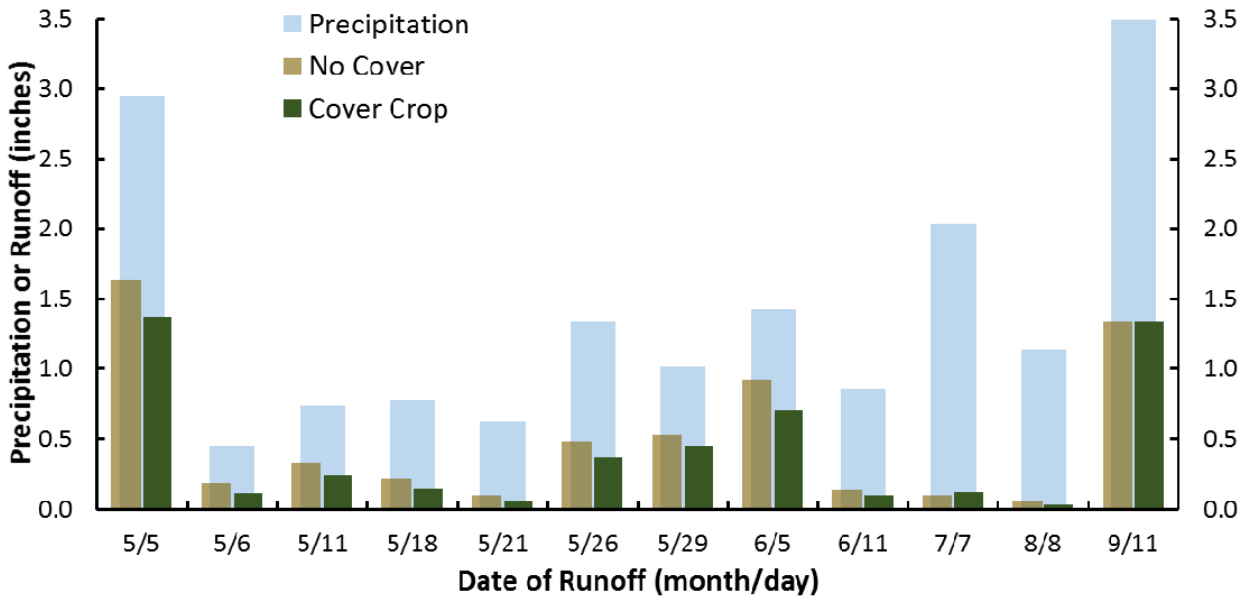

Figure 1. Cover crop effect on runoff volume for 2015. Cumulative runoff was 6.0 inches for no cover crop and 5.1 inches for cover crop treatment.

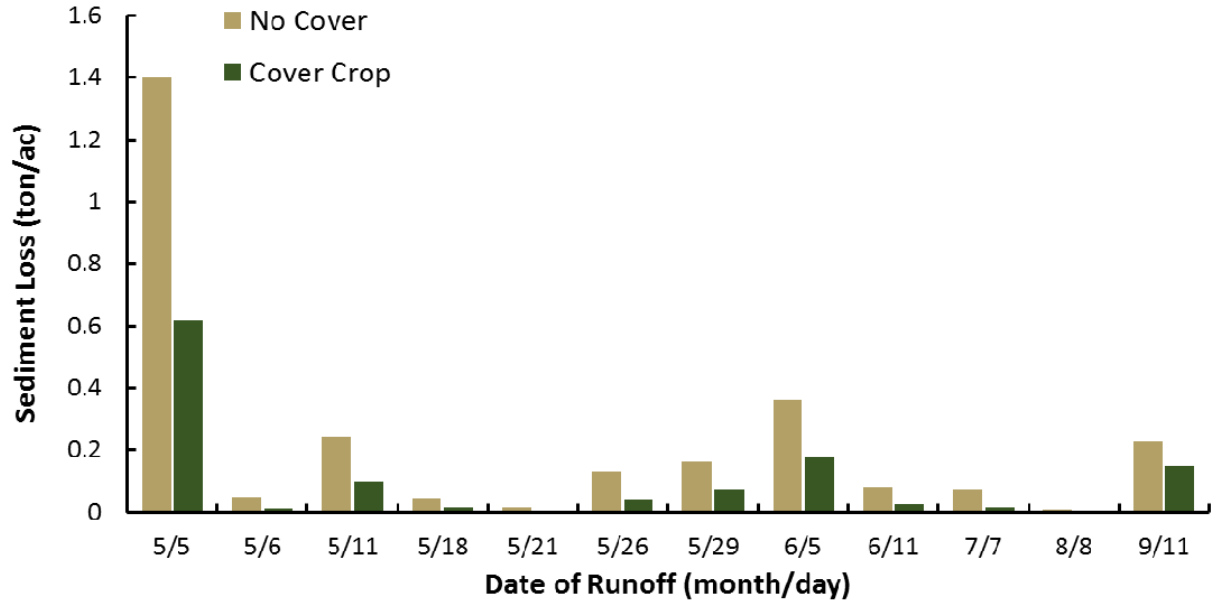

Figure 2. Cover crop effect on sediment loss. Cumulative sediment loss was 2.8 ton/ac for no cover crop and 1.2 ton/ac for cover crop treatment.

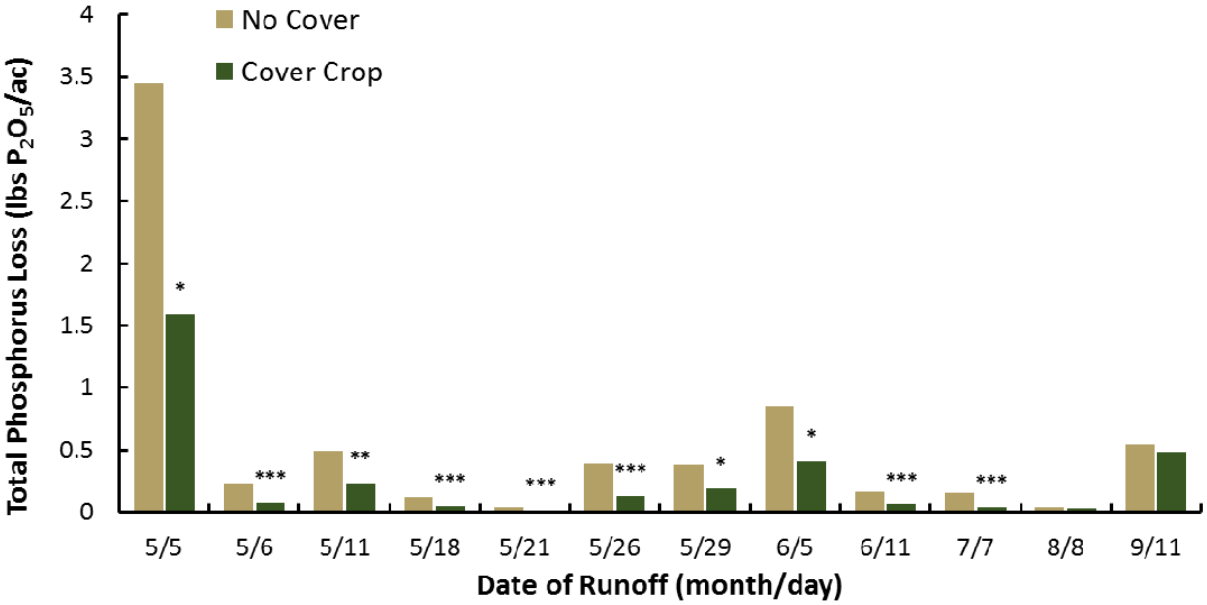

Figure 3. Cover crop effect on total P loss. Cumulative P loss was 6.8 lb P_2O_5/ac for no cover crop and 3.3 lb P_2O_5/ac for cover crop treatment.

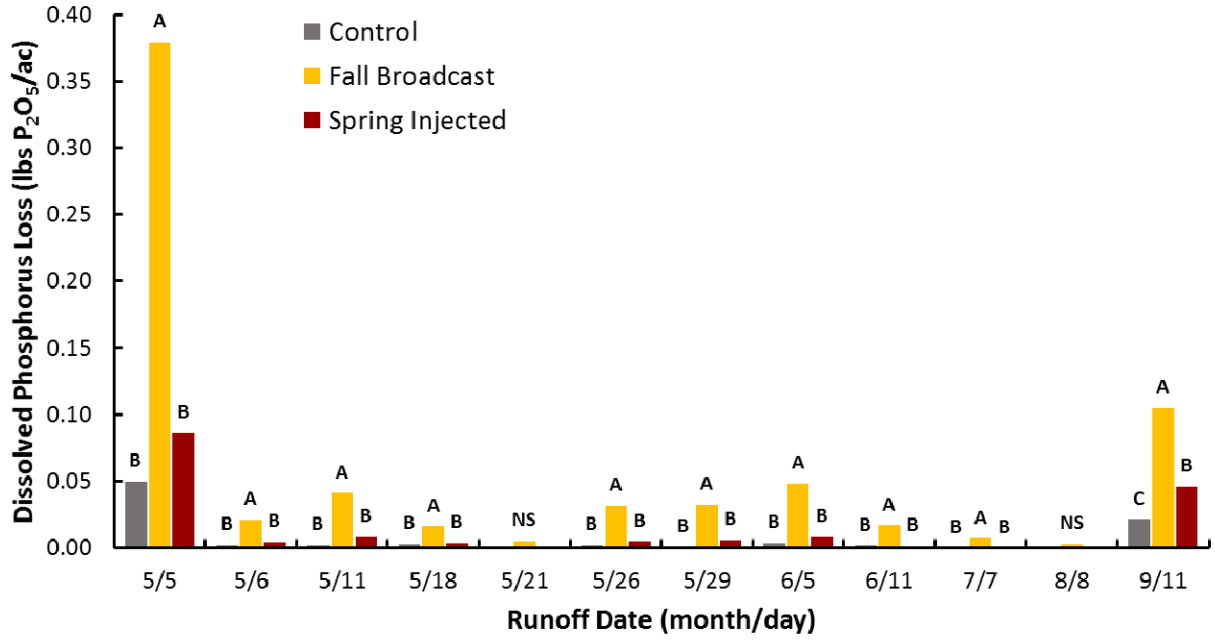

Figure 4. Fertilizer management effect on dissolved P loss. Cumulative dissolved P loss was 0.1, 0.7, and 0.2 lb P_2O_5/ac for control, fall broadcast, and spring injected treatments respectively.

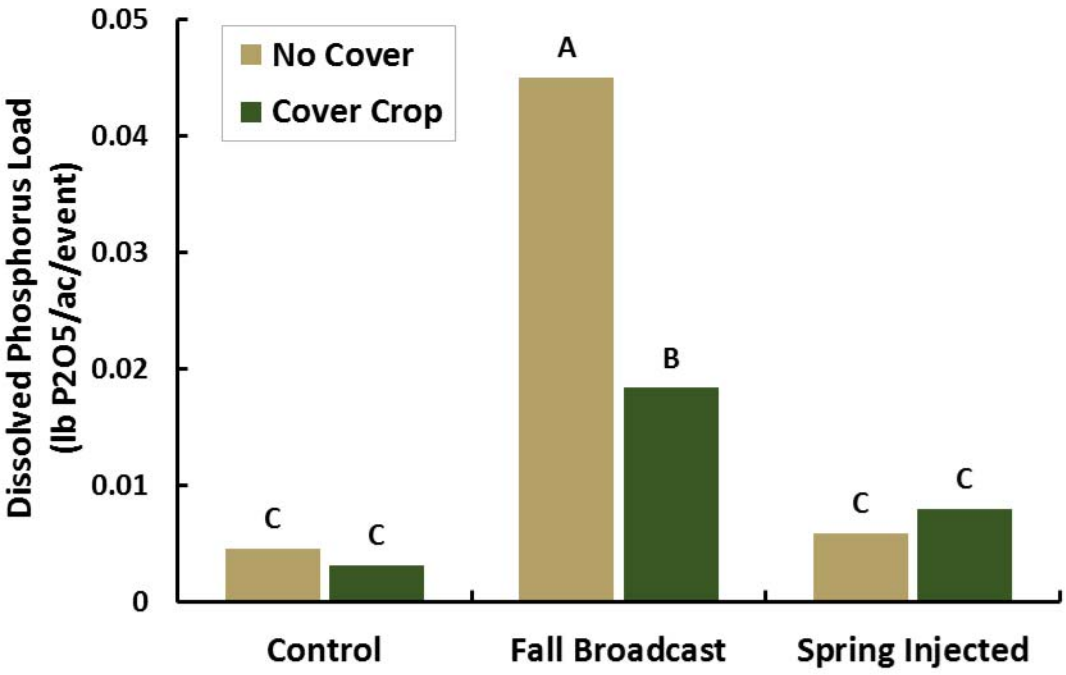

Figure 5. Fertilizer management and cover crop interaction effect on dissolved P loss. Data are the average loss from events on 5/11, 5/18, 5/21, 6/11, and 9/11.