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Impacts of Cover Crops on Phosphorus Loss

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ABSTRACT

Non-point source phosphorus (P) loss in surface runoff from agriculture is a major contaminant of surface waters. Therefore, agricultural management strategies that reduce P loss in surface runoff must be identified. The aim of this study was to determine the impacts of winter cover crops on total P, dissolved P, and total suspended solids concentration of surface runoff from a no-tillage corn-soybean rotation. This study was conducted in the Central Great Plains (Manhattan, KS) on a Smolan silty clay loam (fine, smectitic, mesic Pachic Argiustoll), and consisted of a 2x3 factorial structure arranged in randomized complete block design replicated in triplicate. Treatments included two cover cropping methods (cover crop and no cover crop) each implemented with three phosphorus fertilizer management systems (no P, fall broadcast P, and spring sub-surface injected P).

Flow-weighted composite samples were collected from natural runoff for precipitation events resulting in greater than equal to 0.08 inches of runoff from October 1, 2015 through September 30, 2017 and analyzed for total phosphorus, dissolved phosphorus, and total suspended solids concentrations. The present analysis only examines cover crop effects (examined over fertilizer management systems) There was an event by cover crop interaction for total phosphorus, dissolved phosphorus, and total suspended solids concentrations in surface runoff across both water years. Cover crops increased dissolved P concentration compared to no cover crops in both water years. However, cover crops dramatically reduced total suspended solid concentrations in surface runoff for both 2015-2016 and 2016-2017. Data collected for this study represents one cycle through the crop rotation. An additional cycle through the crop rotation needs to be completed to confirm these findings.

INTRODUCTION

Phosphorus (P) loss from agricultural production is a known contributor to the degradation of surface water quality. Excess P inputs to surface waters can lead to eutrophication, potentially causing an increase in aquatic plant and algal growth resulting in an overall drop in ecosystem health and water quality (Correll, 1998; Carpenter et al., 1998). The degradation of surface waters caused by P loss has created the need for new agricultural best management practices (BMP) to help decrease P loss through surface runoff.

Among many factors, cropping system selection can influence nutrient loss from an agricultural system (Liu et al., 2014). A popular approach to controlling nutrient loss from agricultural fields is though the utilization of a cover crop during traditionally fallow periods (DeBaets et al., 2011). Hartwig and Ammon (2002) define a cover crop as any living ground cover sown prior to, during, or after a cash crop but is terminated before planting the subsequent crop. Cover crops can reduce erosion, decrease nutrient loss/leaching, and suppress weeds all while providing greater water infiltration, slower surface runoff, and improved soil properties (Dabney et al., 2001). However, there is inconclusive evidence quantifying the effects of cover crops on P concentration in natural runoff from no-till cropping systems (Christianson et al., 2017). This study aims to quantify the impacts of cover crops as a BMP on the concentration of P in surface runoff from a no-tillage corn soybean rotation on a precipitation event basis.

MATERIALS AND METHODS

This study was conducted near Manhattan, Kansas, at the Kansas Agricultural Watershed (KAW) field laboratory. The KAW facility has eighteen small-scale watersheds (plots). Plots averaged 1.2 acres in size and were equipped with a 1.5 ft H-flume and automated water sampling equipment. All plots were under a no-tillage corn-soybean rotation.

A total of six management practices were utilized in this study. Three P fertilizer application practices were used: fall broadcast (FB), spring injected (SI), and a no P fertilizer control (CN). Each P application method is expressed both without a winter cover crop (NC) and with a winter cover crop (CC). Each management practice (treatment) was replicated in triplicate and arranged in randomized complete block design. Treatments were structured in a 2x3 factorial.

A flow-weighted composite surface runoff sample was collected for each precipitation event. Samples were analyzed for total P, dissolved P, and total suspended solids (TSS). Events with runoff averaging less than 0.08 inches were omitted from analysis due to the high number of missing data points for small events. Omitted events account for less than 7% of total runoff for 2015-2016 and less than 8% for 2016-2017. A water year runs from October 1 through September 30 of the following year.

2015-2016 Water Year

On September 22, 2015, a cover crop mixture of winter wheat and rapeseed was planted. The FB treatments received a surface application of 60 lb P_2O_5 ac^{-1} applied as diammonium phosphate (DAP, 18-46-0) on November 12, 2015. On May 6, 2016, prior to planting soybeans, the CC was terminated with herbicide. Soybean was sown on June 6, 2016, approximately one month after termination of the CC. The SI treatments received 60 lb P_2O_5 ac^{-1} as ammonium polyphosphate (APP, 10-34-0) applied at planting in a 2x2 band. All P fertilizer rates were based on the Kansas State University build and maintain fertilizer recommendation system using initial soil test P levels (Leikam et al., 2003).

2016-2017 Water Year

On October 19 & 20, 2016, a CC mixture of triticale and rapeseed was sown immediately following soybean harvest. The FB treatment received 56 lb P_2O_5 ac^{-1} as DAP on December 2, 2016 and the SI treatment received 53 lb P_2O_5 ac^{-1} as APP on April 24, 2016. The NC treatment received an early spring burndown application of herbicide on March 8, 2017. The CC was terminated with herbicide on April 24 and 25, 2017. Termination of the cover crop corresponded with the timing of corn planting for all plots. Nitrogen (N) was applied to all treatments, for a total N rate of 155 lb N ac^{-1}, as urea ammonium nitrate (UAN, 28-0-0) utilizing a disk-coulter injection unit within days following planting. All treatments received an additional 40 lb N ac^{-1} on June 12, 2017 (V8) with streamer bars.

Statistical Analysis

SAS version 9.4 was used to analyze all data. A proc glimmix procedure with repeated measures analysis of variance was utilized to examine treatment effects. All data required transformation to satisfy the assumption of normal variance. Figures depict back-transformed least-square means estimates.

RESULTS AND DISCUSSION

There was a precipitation event by cover crop interaction for total P concentration in surface runoff for both 2015-2016 and 2016-2017 water years. For both 2015-2016 and 2016-2017, there was an inconsistent influence of CC on total P concentration, where runoff from the CC treatment had greater total P concentrations for some events and less total P for other events (**Figure 1**). Main effect of cover crop on total P concentration was not significant for either wateryear.

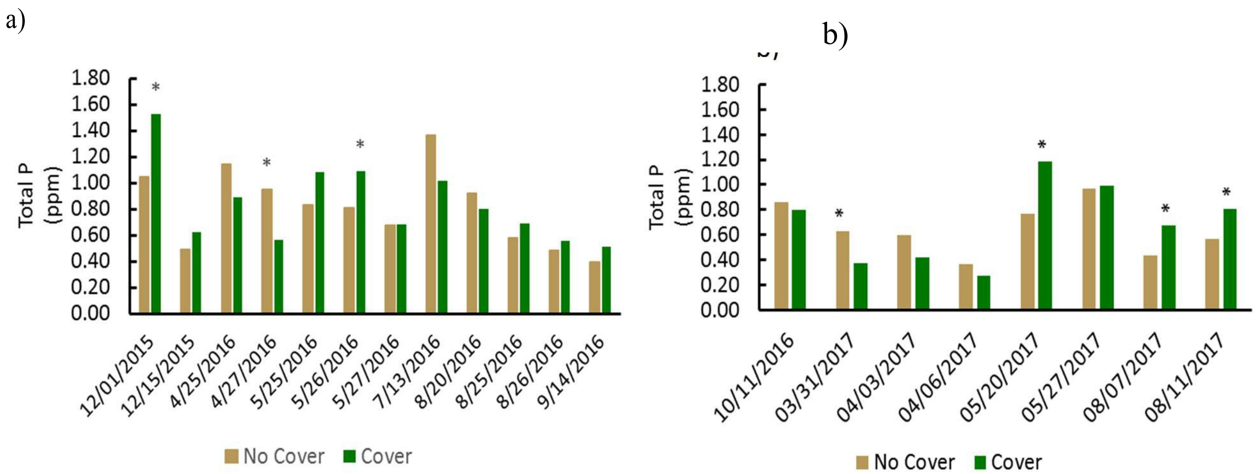

Figure 1. Winter cover crop effects on total P concentration in surface runoff for events with greater than 0.08 inches of runoff during the 2015-2016 (a) and 2016-2017 (b) water years (averaged across fertility treatments). Asterisks indicate a significant difference between treatments within an event at $p<0.05$.

There was a significant event by cover crop interaction on dissolve P concentration in surface runoff for both 2015-2016 and 2016-2017 water years. In the 2015-2016 water year, the CC treatment has greater dissolved P concentrations in the runoff compared to the NC treatment for 75% of the runoff events. In the 2016-2017 water year, the dissolved P concentration was higher in CC treatment for 50% of runoff events. No significant differences were seen between CC and NC for the remaining events in both 2015-2016 and 2016-2017. Increases in dissolved P concentration in surface runoff from the CC treatment occurred after termination of the cover crop for both water years.

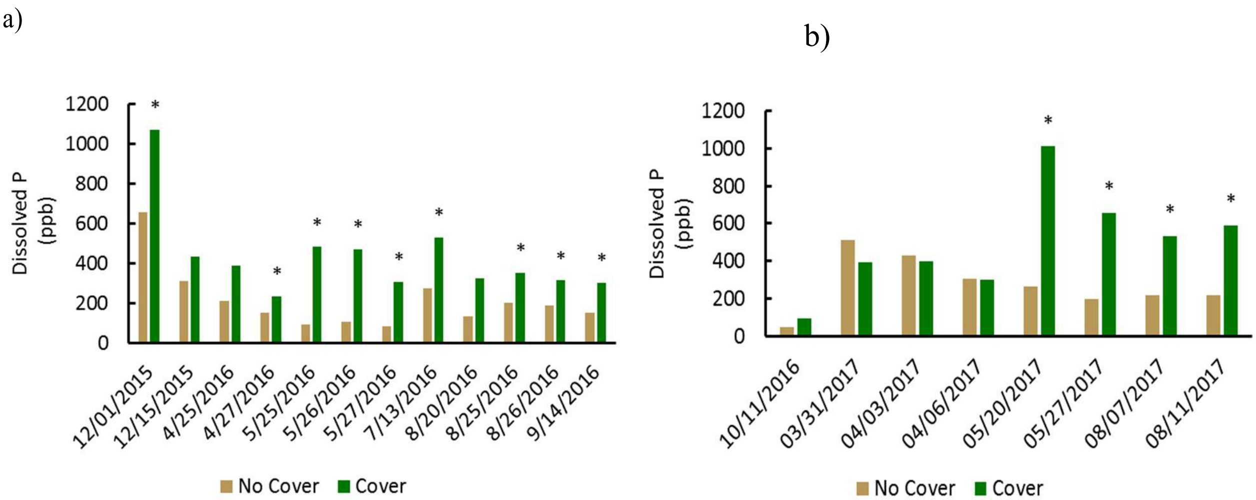

Figure 2. Effect of winter cover crop on dissolved P concentration in surface runoff for events with greater than 0.08 inches of runoff during the 2015-2106 (a) and 2016-2017 (b) water years (averaged across fertility treatments). Asterisks indicate a significant difference between treatments within an event at p<0.05.

The cover crop main effect significantly influenced dissolved P concentration in runoff for both water years (**Figure 3**). This increase runs counter to the often touted benefits of cover crops pertaining to nutrient loss. Miller et al. (1994) stated that cover crops could potentially increase the quantity of nutrients lost in surface runoff from the agricultural system due to plant tissue leaching during rainfall events. This phenomenon, in conjunction with the no-tillage management system used in this study, could contribute to the increase in dissolve P concentration of surface runoff. For 65% of observed runoff events across both water years examined in this study, the CC treatment had higher dissolved P concentration comparted to NC. In both water years, he CC treatment never had lower dissolved P concentrations than the NC treatment.

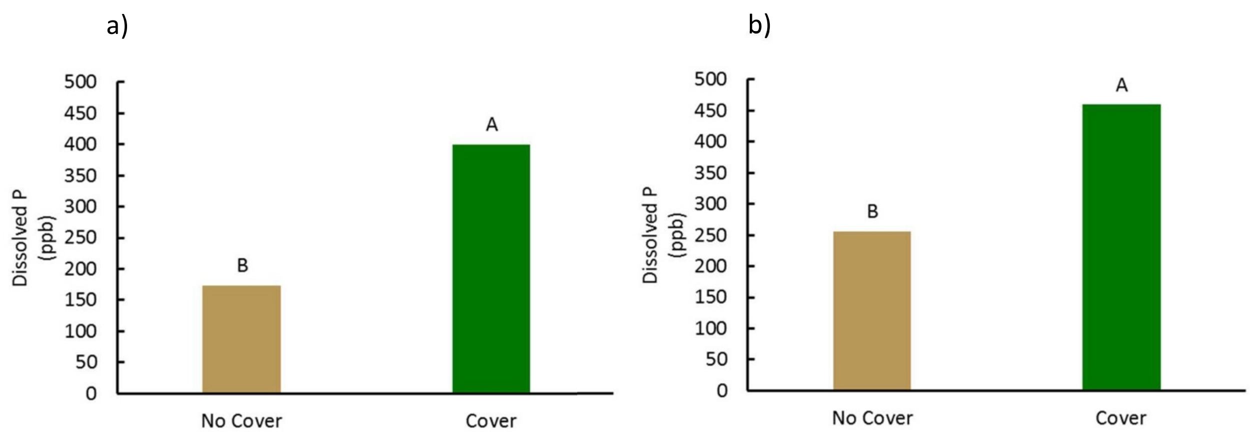

Figure 3. Effect of winter cover crop on dissolved P concentration for 2015-2016 (a) and 2016-2017 (b) water years. Bars with same letters are not different at p<0.05.

Although cover crops increased dissolved P concentration in surface runoff, cover crops dramatically reduced the TSS in surface runoff for both water years. A main effect of cover crop as well as an event by cover interaction were observed in both water years. The NC treatment had greater TSS concentration in surface runoff for 85% of all observed runoff events occurring in 2015-2016 and 2016-2017 (**Figure 4**). The NC treatment had over 50% greater TSS concentration for 2015-2016 and over 70% greater TSS concentration for 2016-2017 (Figure 5).

a) b)

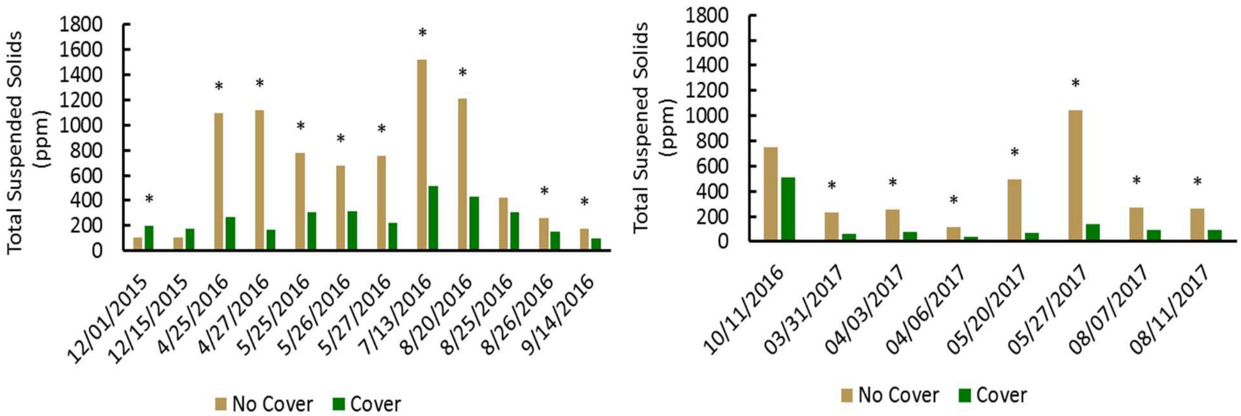

Figure 4. Impact of winter cover crops on TSS concentration in surface run off for events with greater than 0.08 inches of runoff during the 2015-2016 (a) and 2016-2017 (b) water years (averaged across fertility treatments). Asterisks indicate a significant difference between treatments within an event at $p<0.05$.

a) b)

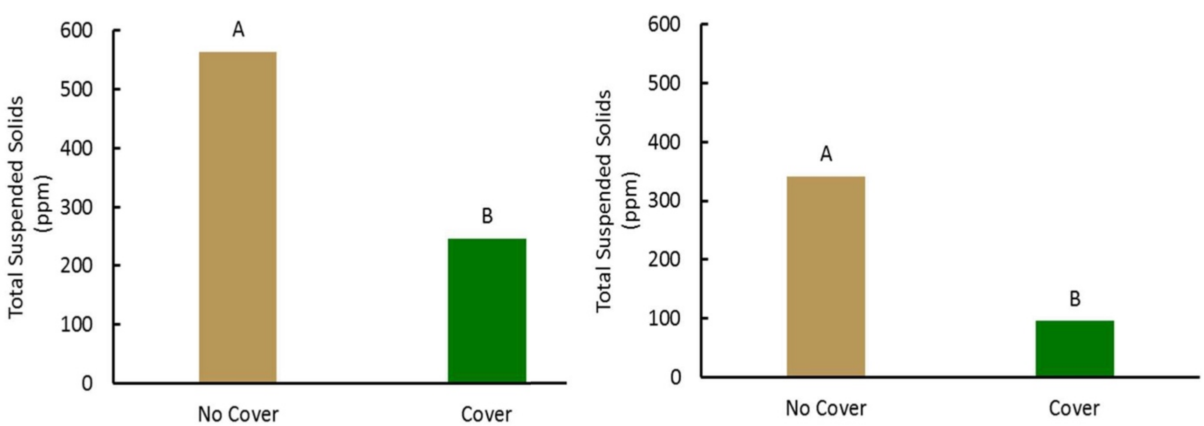

Figure 5. Effect of winter cover crops on TSS concentration in surface runoff= for 2015-2016 (a) and 2016-2017 (b) water years). Asterisks indicate a significant difference between treatments within an event at $p<0.05$.

SUMMARY

This study found an event by cover crop interaction for total P, dissolved P, and TSS concentrations in surface runoff for both water years. The CC treatment had greater dissolved P concentration in surface runoff compared to the NC treatment. However, the CC treatment drastically reduced TSS concentration in surface runoff compared to the NC treatment for both observed water years. A second cycle through the cropping rotation will be examined to confirm these findings.

ACKNOWLEDGEMENTS

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