PHOSPHORUS FERTILIZER MANAGEMENT AND COVER CROP EFFECTS ON PHOSPHORUS LOSS FROM NO-TILL CORN AND SOYBEAN

R. Elliott Carver, Nathan O. Nelson, Kraig L. Roozeboom, Peter J. Tomlinson, and Gerard J. Kluitenberg
Kansas State University, Manhattan, KS
recarver@ksu.edu

ABSTRACT

Loss of phosphorus from non-point source agricultural sources is a known contributor to the degradation and contamination of surface waters. Therefore, it is imperative to adapt agricultural best management practices which promote and preserve surface water quality. The goal of this study was to quantify the impacts of phosphorus fertilizer management practice (placement and timing) and winter cover crop on concentrations of total suspended solids, total phosphorus, and dissolved reactive phosphorus in surface runoff from natural precipitation events for a no-till, corn (*Zea mays*)-soybean (*Glycine max*) rotation. The study was conducted between October 1, 2015 and September 30, 2019, in the Central Great Plains (Manhattan, KS) and featured a 3x2 complete factorial treatment structure arranged in a randomized complete block design replicated in triplicate. Treatments used included three phosphorus fertilizer management practices (no P, fall broadcast P, and spring injected P), each implemented with and without a winter cover crop. Flow-weighted composite surface runoff samples from natural precipitation events generating more than 0.08 inches of surface runoff were collected throughout the year and analyzed for total suspended solids, total phosphorus, and dissolved reactive phosphorus concentrations. Analysis of runoff from the 2018 water year revealed a clear runoff event by fertilizer management practice by cover crop interaction for both total phosphorus and dissolved reactive phosphorus. Additionally, a main effect of cover crop on total suspended solids concentration was found where the absence of a cover crop resulted in sediment concentrations at least 65% greater than those from the cover crop treatment.

INTRODUCTION

Minimizing phosphorus loss from agricultural production systems is a fundamental factor in protecting surface water quality. As excess phosphorus moves into surface waters, mineral enrichment of surface water may occur, leading to eutrophication, promotion of harmful algal growth, and potential increased water treatment costs (Correll, 1998; Carpenter et al., 1998). While excessive phosphorus input into surface water can lead to a decrease in surface water quality, farmers throughout the world apply phosphorus-based fertilizers to help increase crop yields.

Studies have shown when phosphorus-based fertilizers are applied below the soil surface, phosphorus losses may decrease compared to surface application. Kimmel et al. (2001) found that, under no-till management, subsurface placement of phosphorus-based fertilizers decreased total and dissolved reactive phosphorus loss by 30 and 75%, respectively. Similarly, Zeimen et al. (2009) showed that subsurface placement of phosphorus-based fertilizers resulted in similar or less phosphorus loss compared to surface application of phosphorus-based fertilizer.

Additionally, rainfall simulation studies have found that surface application of phosphorus-based fertilizer, when applied at the same time as subsurface placed fertilizer, results in greater losses of phosphorus (Baker & Laflin, 1982; Mostaghimi et al., 1988).

A common proposed best management practice (BMP) to reduce nutrient loss is the addition of a cover crop during a normally fallow period (DeBaets et al., 2011). Cover crops have been shown to benefit the soil through reduced erosion, enhanced water infiltration, and improved soil properties (Dabney et al., 2001). Although cover crops are often proposed as a BMP to curb phosphorus loss, there is inconclusive evidence as to their effectiveness to do so (Sharpley & Smith, 1991; Dabney et al., 2001; Christianson et al., 2017).

The objectives of this study were to quantify the impacts of phosphorus fertilizer management and the addition of a winter cover crop on total suspended solids, total phosphorus, and dissolved reactive phosphorus concentrations of surface runoff from natural precipitation events throughout the year.

MATERIALS AND METHODS

This large-scale field study ran from October 1, 2015 through September 30, 2019 and was conducted at the Kansas Agricultural Watershed (KAW) field laboratory located near Manhattan, KS. The KAW field lab is comprised of eighteen small-scale watersheds with an average size of approximately 1.2 acres. Each watershed was fitted with a 1.5 ft H-flume and automated water sampling equipment. This study examined total suspended solids and phosphorus concentrations of edge-of-field runoff from natural precipitation events from a no-till, corn (*Zea mays*)-soybean (*Glycine max*) rotation.

A total of six management practices (treatments) were used and treatments were structured in a randomized complete block design with three replicates. Three levels of phosphorus fertilizer management were used: control (0 lb P_2O_5/ac), fall broadcast (55 lb P_2O_5/ac), and spring subsurface injected (55 lb P_2O_5/ac). Each level of phosphorus fertilizer management practice was expressed with and without a winter cover crop.

Flowweighted composite samples of surface runoff were collected when natural precipitation events generated greater than 0.08 inches of surface runoff. Events with less than 0.08 inches of surface runoff were omitted due to a large number of missing data points.

Data are presented from the 2018 water year (October 1, 2017-September 30, 2018). Data from the 2016, 2017 and 2019 water years will be presented if available.

2018 Water Year

In Fall 2017, a winter cover crop mixture of triticale (*x Triticosecale* var. *TriCal 780*) and rapeseed (*Brassica napus* var. *Dwarf Essex*) was sown at a seeing rate of 50 lb/ac and 5 lb/ac, respectively, immediately following corn harvest. The fall broadcast treatment received 55 lb P_2O_5/ac applied as diammonium phosphate (DAP, 18-46-0) after harvest and prior to soil freezing. The spring injected plots received 55 lb P_2O_5/ac injected as ammonium polyphosphate (APP, 10-34-0), approximately 2 inches below and 2 inches to the side of the seed at the time of soybean planting. Phosphorus fertilizer rates were based on the Kansas State University build-and-maintain fertilizer recommendation system and were calculated using initial soil test phosphorus levels (Leikam et al., 2003).

Prior to soybean planting, all cover crop plots where chemically terminated.

Statistical Analysis

All data were analyzed using SAS ver. 9.4 (SAS Institute, Cary, NC). A PROC GLIMMIX procedure with repeated measures analysis of variance was used to test for treatment effects. All data required transformation to satisfy the assumption of normal variance.

RESULTS AND DISCUSSION

In the 2018 water year, a main effect of cover crop was observed with the cover crop treatment resulting in a lower concentration of total suspended solids in 80% of all observed runoff events. The presence of a cover crop reduced erosion losses by over 65% in the 2018 water year.

While the cover crop dramatically reduced sediment concentration in surface runoff during the 2018 water year, it also increased both total and dissolved reactive phosphorus concentrations across the majority of runoff events in the 2018 water year. Three out of five observed runoff events in 2018 showed that cover crop, regardless of fertilizer practice, increased total phosphorus concentration of surface runoff, and four out of five events showed that cover crop, again regardless of fertilizer placement, increased dissolved reactive phosphorus concentrations in surface runoff. This finding runs counter to the often touted benefit that cover crops help to curb phosphorus loss from agricultural fields. In 1994, Miller et al. stated nutrient leaching from crop tissue during rainfall events may increase the potential for nutrient loss from fields. Additionally, Liu et al. (2019) found that cover crops grown in areas which may exhibit sub-freezing temperature could result in increased phosphorus loss from fields.

In the 2018 water year, no differences in total phosphorus and dissolved reactive phosphorus concentrations of surface runoff between the fall broadcast and spring injected phosphorus fertilizer treatments were observed. This runs contrary to the findings of Kimmell et al. (2001) and Zeimen et al. (2009) who both found that subsurface placement of phosphorus fertilizer resulted in less phosphorus loss compared to surface applied phosphorus fertilizer. However, it is important to note the timing of collected runoff events observed in the 2018 water year. The first two collected runoff events occurred in October 2017. The next such event occurred ten months later. This extreme lag between runoff events precluded the possibility of capturing potential differences in phosphorus loss based on phosphorus fertilizer application method.

ACKNOWLEDGEMENTS

This research is supported by the 4R Research Fund, Kansas Soybean Commission, Kansas Corn Commission, USDA-NRCS Grant #69-3A-75-17-32, the Kansas Agricultural Experiment Station, and the Kansas State University Department of Agronomy.

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