Corn and Soybean Yield as Affected by Cover Crop and Phosphorus Fertilizer Management

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Summary

Phosphorus (P) fertilizer additions are often required to meet crop nutrient demands, but over-fertilization can have economic consequences, as well as environmental consequences from agricultural P loss. Therefore, we require management strategies that balance crop P demand and the need to minimize environmental P loss. The objective of this study was to investigate the effect of cover crop addition and P fertilizer management strategy [build and maintain (BM), sufficiency (SF), and a zero-P control (CN)] on crop yield of a no-till, corn-soybean system for 2020, 2021, and 2022 crop years for a site near Manhattan, KS. The addition of a cover crop decreased corn yield in 2021, and soybean yield in 2022, compared to the no cover treatment. In all three years of the study, both BM and SF management increased crop yield compared to the control, and BM and SF yields were similar, overall.

Introduction

Adequate phosphorus (P) fertility management is critical for agronomic productivity, and P fertilizer additions are often required to meet crop P demands. Although P additions are an important consideration for crop productivity, P loss from agricultural fields is a substantial environmental quality concern. Management strategies that simultaneously meet agronomic crop demand while conserving P in the system to reduce P loss to the environment are critical for the sustainability of our production systems.

In the Midwest, P fertilizer management often follows either a build and maintain (BM) or a sufficiency (SF) philosophy. Build and maintain fertilizer programs are comprised of two phases: a build phase—wherein soil test P (STP) is increased with P fertilizer applications greater than P removal—to build STP beyond the critical threshold for yield response. This is then followed by a maintenance phase, wherein the STP is maintained within a range of STP, typically 20–30 ppm Mehlich-III in Kansas (Leikam et al., 2003). However, with SF management, fertilizer applications are based on the likelihood of P response in the year of application, where P fertilizer is not applied unless STP is below the critical threshold for crop response. At any given STP value, SF management results in less P fertilizer application than BM. Recent research has shown that BM and SF management practices result in similar corn yield (Fabrizzi

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et al., 2017) but additional information is needed in Kansas cropping systems and environments.

Cover crops are often recommended as a conservation practice for improving soil structure, reducing erosion, and increasing soil organic matter and nutrient cycling (Blanco-Canqui et al., 2015; Lal et al., 1991). Cover crop effects on yield of the succeeding grain crop are mixed, with some studies showing increased yield, others showing no effect, and some showing decreased yield (Chim et al., 2022; Dozier et al., 2017; Plastina et al., 2020; Qin et al., 2021). The effect of cover crops on grain yield may be different for BM vs. SF phosphorus fertilizer management.

The objective of this study was to determine the effects of cover crop and P fertilizer management on corn and soybean yield.

Procedures

The Kansas Agricultural Watershed (KAW) field laboratory was established in 2014 in response to producers' questions regarding the challenge of balancing agronomic P supply with the need to reduce P loss from agricultural systems. The focus has been on developing management strategies to reduce P loss from no-till, corn-soybean production systems. Since 2020, work at the site has focused on the effect of cover crop addition and P fertilizer management strategy on agronomic performance and P loss.

The KAW is comprised of 18 plots, each about 1.2 acres in size, in a no-till corn-soybean cropping system, with all plots planted to corn in 2021 and soybean in 2020 and 2022. The experiment has a randomized complete block design, with a 2 × 3 factorial treatment design. There are two levels of cover crop treatment, with cover crop and no cover crop, and three levels of P fertilizer management, the control (CN), SF, and BM treatments. Each fall, cereal rye was planted in cover crop plots following harvest of the main crop. Cover crop was terminated prior to or immediately following planting of the main crop each spring, using herbicide.

Phosphorus fertilizer rate decisions for BM were based on Kansas State University's (K-State) P fertilizer recommendations (Leikam et al., 2003) using soil test data collected in the fall, after harvest of the previous main crop. Soil samples were collected from three sub-plot locations within each plot in the fall of each year to a depth of 6 inches and split into 0- to 1-inch, 1- to 2-inch, and 2- to 6-inch layers. These samples were analyzed for Melich-III STP by the K-State Research and Extension Soil Testing Laboratory, Manhattan, KS. The 0- to 6-inch Mehlich-3 P concentrations were calculated as the depth-weighted average of the split soil samples. Phosphorus fertilizer was not applied to the SF treatment during 2020, 2021, or 2022 because STP was above the thresholds required for significant corn or soybean response to P fertilizer. Maintenance rates of 35 lb/a of P_2O_5, 63 lb/a of P_2O_5, and 47 lb/a of P_2O_5 were applied as ammonium polyphosphate (APP) to the BM treatment in 2020, 2021, and 2022, respectively.

In addition to the P treatments, nitrogen was applied to give a total of 160 lb N/a prior to planting in 2021 as urea ammonium nitrate, also according to K-State recommendations. Nitrogen was balanced across treatments, factoring in the N contribution from APP applications in the BM plots.

In corn production years, yield was determined from hand harvested cobs in a 2-row by 30-ft area at three data collection points within each plot. Yield data were corrected to a moisture content of 15.5% for corn. For soybean yield determination, a plot combine was used to harvest two rows, for a length of ~300 ft. Yield data were corrected to a moisture content of 13.3% for soybean.

Results

The cover crop significantly decreased STP in 2019 but had no effect on STP in 2020 or 2021 (Table 1). Phosphorus fertilizer management significantly affected STP in all three years ($P < 0.001$). The BM and SF fertilizer management had greater STP in comparison to the CN at the beginning of the study (2019) and both remained greater than CN throughout the study. There was no significant difference between BM and SF in 2019; however, this difference was significant for 2020 and 2021 mainly because P fertilizer was not applied to the SF treatment during 2020 or 2021, so the BM treatment resulted in greater STP. The interaction of cover by P fertilizer management was not significant for any of the three years.

Analyzed by year, the main effect of cover crop on yield was significant in 2021 and 2022, and the main effect of P fertilizer management influenced crop yield in all three years (Table 2). The cover × fertilizer interaction was not significant for any of the three years of the study, indicating cover crop treatment did not change the way P fertilizer management affected crop yield.

Cover crop treatment led to a decrease in crop yield for corn in 2021, and soybean in 2022 (Table 3). In all three years of the study, both SF and BM fertilizer management increased yields compared to the CN (Table 4). The SF and BM strategies did not differ between one another in yield, for corn or soybean years.

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Table 1. Effect of cover crop and P fertilizer management on STP (mg/kg), analyzed by year

Cover crop treatment	P fertilizer management treatment	2019 (prior to soybean)	2020 (prior to corn)	2021 (prior to soybean)
No cover crop		22.1 *A*	14.7 *A*	16.5 *A*
With cover crop		18.9 *B*	13.2 *A*	13.1 *A*
	Control	5.5 *B*	4.0 *C*	3.0 *C*
	Build and maintain	28.9 *A*	21.6 *A*	27.1 *A*
	Sufficiency	27.0 *A*	16.3 B	14.3 *B*
Cover × fertilizer interaction (n.s.) †				
No cover crop	Control	6.1	4.8	3.3
No cover crop	Build and maintain	30.0	21.2	29.0
No cover crop	Sufficiency	30.0	18.2	17.2
With cover crop	Control	4.8	3.2	2.7
With cover crop	Build and maintain	27.7	22.0	25.2
With cover crop	Sufficiency	24.0	14.0	11.4

Note: Cover × fertilizer interaction was not significant.
Means within columns followed by the same letter are not significantly different, with upper-case letters used for cover crop effect and lower-case letters used for P fertilizer management effect ($\alpha = 0.05$) (cover crop by P fertilizer management interaction was not significant, means provided for reference only).

Table 2. *P*-values for the main effects and interaction of cover crop and P fertilizer management on crop yield by year ($\alpha = 0.05$)

Effect	2020 (soybean)	2021 (corn)	2022 (soybean)
Cover	0.514	<0.001	0.010
Fertilizer	0.033	0.004	0.007
Cover × fertilizer	0.689	0.111	0.759

Table 3. Effect of cover crop and P fertilizer management on crop yield (bu/a), analyzed by year

Effect	2020 (soybean)	2021 (corn)	2022 (soybean)
No cover	69.7 *A*	157.1 *A*	47.4 *A*
Cover	68.0 *A*	133.9 *B*	43.8 *B*

Means within columns followed by the same letter are not significantly different ($\alpha = 0.05$).

Table 4. Effect of P fertilizer management on crop yield (bu/a), analyzed by year

Effect	2020 (soybean)	2021 (corn)	2022 (soybean)
Control	63.7 *B*	131.4 *B*	41.1 *B*
Build and maintain	72.6 *A*	159.1 *A*	49.3 *A*
Sufficiency	70.4 *A*	146.0 *A*	46.4 *A*

Means within columns followed by the same letter are not significantly different ($\alpha = 0.05$).