Fertilizer Management and Cover Crop Effects on Phosphorus Use Efficiency, Environmental Efficiency and Crop Yield

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Background and Justification

Loss of phosphorus (P) from agricultural systems is a known contributor to the degradation of surface water quality. To help mitigate P loss, sub-surface P placement and cover crops have been proposed as alternative agricultural management practices. While the benefits of sub-surface P placement and cover crops are often touted, additional information is needed to determine what impacts these management strategies have on efficiency and crop yield of the agricultural system.

Algal blooms at Milford Reservoir located in Geary, Clay & Dickinson Co., Kansas.

Objectives

1) Determine effect of P fertilizer application method on P loss and use efficiency.
2) Determine effect of cover crops on P loss and use efficiency.
3) Determine effect of different agricultural management strategies on environmental efficiency of the agricultural system.

Methods

Location

- This study occurred at the Kansas Agricultural Watershed Field Laboratory (KAW) located near Manhattan, Kansas, from 2015 through 2017.

Cropping System

- No-till corn-soybean rotation
- 2016 - soybeans
- 2017 - corn

Treatments and Experimental Design

- P fertilizer management treatments
  - Control – 0 kg P/ha
  - Fall Broadcast (FB) – 24 kg P/ha
  - Spring Injected (SI) – 24 kg P/ha
- Cover crop treatments
  - No cover crop
  - Winter cover crop (mix of winter wheat OR triticale and rapeseed)
- Treatment structure was a 3x2 factorial, arranged in a randomized complete block design with three replicates.

Runoff and P Loss

- The KAW contains eighteen 0.5-ha watershed which have been fitted with 0.46 m H-flumes and ISCO 6700 or 6712 automated water samplers allowing monitoring and collection of surface-water runoff during precipitation events.
- Flow-weighted composite water samples collected for each runoff event with one 200 mL sample collected for each 1 mm of runoff.
- Collected samples were analyzed for total P, dissolved P and total suspended solids.

P Uptake and Removal

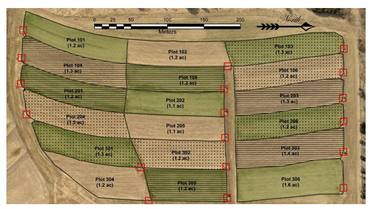
- 2016
  - Measured P uptake of entire soybean plant (stem, leaves AND grain) at R7.
  - Measured P removed in soybean grain
- 2017
  - Measured total P uptake of corn stalks at R6.
  - Measured P removed in corn grain.

Statistical Analysis

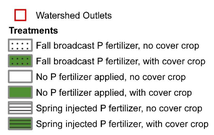
- Analysis of variance conducted using PROC GLMMIX in SAS 9.4 (α =0.05).

Efficiency Calculations

Term	Calculation
Fertilizer Recovery Efficiency, FRE	FRE = $(P_{uptake} - P_{uptake,control})/(P\ applied)$
Partial Nutrient Balance, PNB	PNB = $(P_{removed})/(P\ applied)$
Environmental Efficiency, EE	EE = (Yield, kg/ha)/(P Loss, g/ha)



Site map and location of treatments for KAW.



Results and Discussion

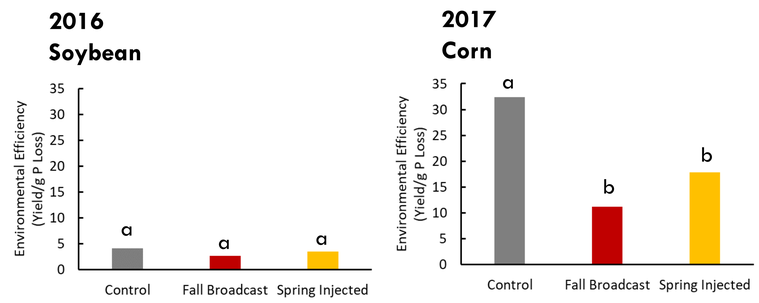


Figure 1: Impact of P fertilizer on environmental efficiency of P (letters indicate significant differences). P fertilizer did not influence environmental efficiency in 2016. However, in 2017 the control had greater environmental efficiency compared to fields with P fertilizer applied.

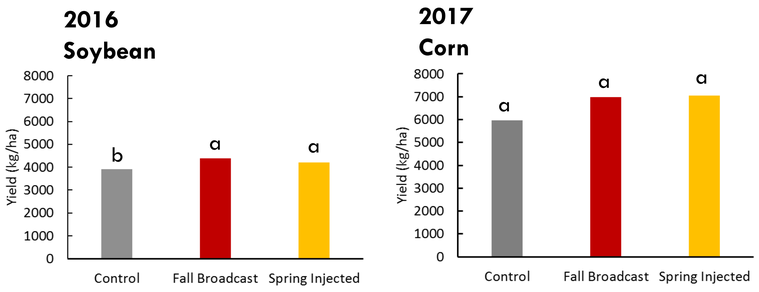


Figure 2: Impact of P fertilizer on grain yield of soybean and corn (letters indicate significant differences). In 2016, application of P fertilizer statistically increase the yield of soybean. For 2017, there was a tendency for P fertilizer to increase yield (p-value = 0.07).

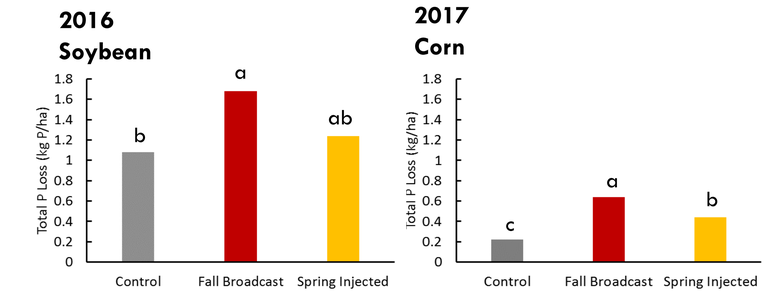


Figure 3: Effect of P fertilizer on total P loss (letters indicate significant differences). In 2016 and 2017, the FB application of P fertilizer had the greatest P loss from the field. For 2017, the SI application of P fertilizer had statistically lower P loss compared to the FB but was still greater than the control. Both years emphasize the impact of P fertilizer placement.

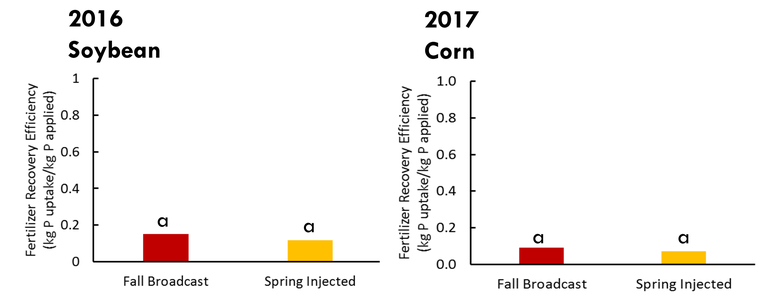


Figure 4: Effect of P fertilizer application method on fertilizer recovery efficiency (letters indicate significant differences). For both 2016 and 2017,P fertilizer application methods did not effect fertilizer recovery efficiency (FRE). FRE can used as an insight into the ratio of fertilizer being applied that is being taken up by the plant compared to what is being left in the field.

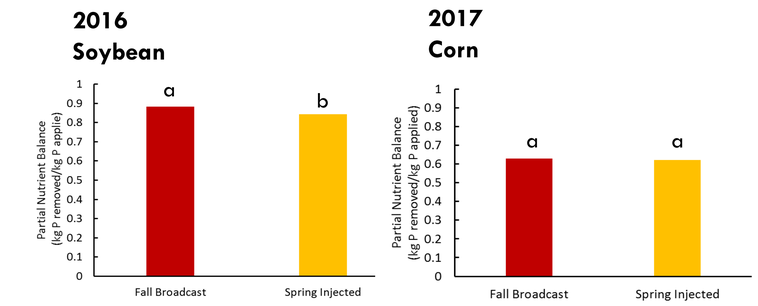


Figure 5: P fertilizer application method effect on partial nutrient balance (letters indicate significant differences). In 2016, the FB application of P fertilizer had a higher partial nutrient balance. However, in 2017, no difference were found in partial nutrient balance between P fertilizer application methods.

Results and Discussion

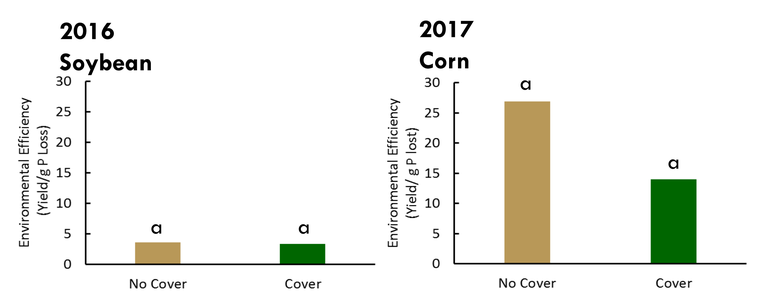


Figure 6: Cover crop effect on environmental efficiency of P (letters indicate significant differences). Use of cover crop did not influence environmental efficiency in both 2016 and 2017. Lack of difference in environmental efficiency is attributed to the lack of difference in total P loss from cover versus no cover fields (Figure 8).

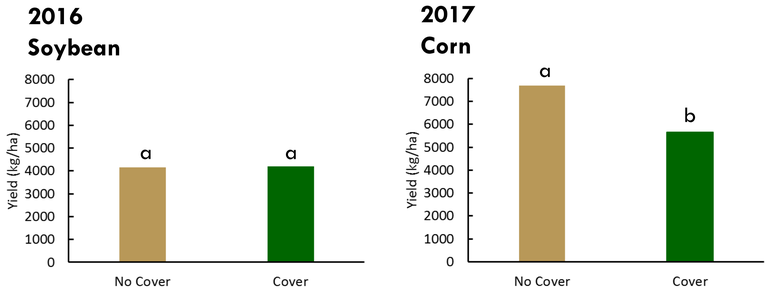


Figure 7: Cover crop effect on grain yield of soybean and corn (letters indicate significant differences). In 2017, cover crop field yielded lower than no cover fields. The cover crop fields appeared to be wetter/cooler at planting and generally appeared to be lagging behind the no cover fields.

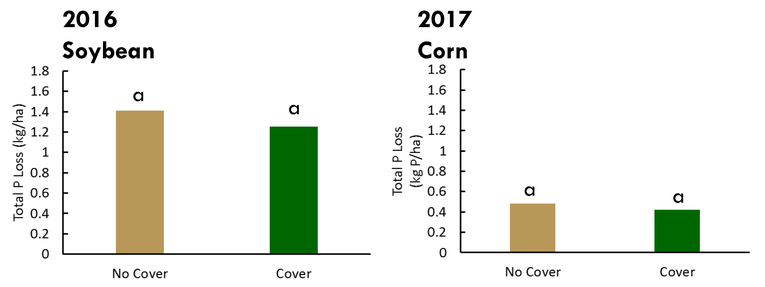


Figure 8: Effect cover crop on total P loss (letters indicate significant differences). No statistical differences where seen in quantity of total P lost when using a cover crop.

Conclusions

- Application of P fertilizer caused a decrease in environmental efficiency compared to the control. However, application method of P fertilizer influenced environmental efficiency of system. The greater environmental efficiency of the control can be attributed to the lower quantity of total P being lost from the system. While the control had the lowest yield, differences in P loss outweighed differences in yield.
- Use of P fertilizer increased total P loss from the field, but sub-surface placement of P show less loss compared to broadcast P.
- Application method and use of cover crop did not statistically effect P fertilizer recovery efficiency.
- Study will continue through additional rotation cycle to confirm these results.

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