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Evaluation of Long-Term Phosphorus Fertilizer Placement Effect on Soil Phosphorus and Crop Yield

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Abstract

Phosphorus (P) accumulation in soil with long-term P fertilizer placements can result in a potentially large available reserve of this nutrient for subsequent crop production. This study investigated the effect of phosphorus fertilizer management (placement: broadcast versus deep band) after ten years on soil P, and yield response of crop rotation. Field studies were conducted for a period of ten years in Manhattan, KS. Three treatments were evaluated: 1) control with no P fertilizer application and two fertilizer treatments (80 lb P_2O_5/a); 2) surface broadcast; and 3) deep band at approximately 4- to 6-in. depth. All treatments received strip-tillage. After ten years, soil samples were collected from the row at two sampling depths (0–3 and 3–6 in.), and the soil P and grain yield of 2015 were evaluated. The accumulation of large amounts of soil P was directly affected by P fertilizer placement. The broadcast P fertilizer placement increased the soil P by the resin method in the topsoil (0–3 in.) and deep band in the subsoil (3–6 in.). Broadcast and deep band placements had the same effect on grain yield of corn and soybean, however, the deep band showed an average lower grain yield for wheat than broadcast.

Keywords

Phosphorus, fertilizer placement, long-term

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Summary
Phosphorus (P) accumulation in soil with long-term P fertilizer placements can result in a potentially large available reserve of this nutrient for subsequent crop production. This study investigated the effect of phosphorus fertilizer management (placement: broadcast versus deep band) after ten years on soil P, and yield response of crop rotation. Field studies were conducted for a period of ten years in Manhattan, KS. Three treatments were evaluated: 1) control with no P fertilizer application and two fertilizer treatments (80 lb P_2O_5/a); 2) surface broadcast; and 3) deep band at approximately 4- to 6-in. depth. All treatments received strip-tillage. After ten years, soil samples were collected from the row at two sampling depths (0–3 and 3–6 in.), and the soil P and grain yield of 2015 were evaluated. The accumulation of large amounts of soil P was directly affected by P fertilizer placement. The broadcast P fertilizer placement increased the soil P by the resin method in the topsoil (0–3 in.) and deep band in the subsoil (3–6 in.). Broadcast and deep band placements had the same effect on grain yield of corn and soybean, however, the deep band showed an average lower grain yield for wheat than broadcast.

Introduction
Long-term experiments are essential to understand a large amount of residual P in the soil, with larger differences between P fertilizer placements in labile forms (Coelho et al., 2019), and how crop yield can be affected by different agricultural practices of P management under crop rotation (Adee et al., 2016; Hansel et al., 2017). Phosphorus can be analyzed by soil tests after inorganic, predominately soluble P fertilizers are used; the P Resin soil test can be compared to Mehlich-3 and Bray 1 tests. The objective of this study was to investigate the effect of phosphorus fertilizer management (placement: broadcast versus deep band) after ten years on available P and yield response of corn, soybean, and wheat in rotation.

Procedures
A ten-year field experiment (2006–2015) with corn, soybean, and wheat rotation was conducted at Agronomy North Farm Research and Extension site located in Manhattan, KS. Initial soil samples were collected in April 2006 before initiating the study by collecting a representative sample from the 0–3 and 3–6 inch layers for the characterization of soil properties of the experimental area (Table 1). Treatments included a control with no P application and two treatments of 80 lb of P_2O_5/a as a

broadcast or deep band in a randomized complete block experimental design with three replications. A strip-tillage operation was performed before planting corn, while soybean was planted into corn residue and wheat was planted into soybean residue, both with no prior tillage. Strip-tillage was used for all plots, including the control. Deep band P fertilizer application was completed with the strip-tillage operation at 30-inch row spacing and in the same row for ten years. Corn and soybean were planted in the center of the strip in the same row each year, and wheat was drilled on 7.5-inch spacing. The phosphorus fertilizer source for the broadcast treatment was triple superphosphate (0-45-0). The P fertilizer source for deep banding was ammonium polyphosphate (10-34-0). All P fertilizer application was made before corn. After the last crops were harvested in 2015, soil samples were collected from 0–3 and 3–6 inches depths from the row.

Soil P was determined by the anion exchange resin (P Resin) method. Grain yield was evaluated for the 2015 harvest season. All statistical analyses were completed in SAS v. 9.4 (SAS Inst. Inc., Cary, NC) with a 0.05 probability level.

Results

Figure 1 shows the results of the Resin extractable P, corresponding to P available in the soil solution. Using a reference critical value of 20 ppm, the broadcast and deep band in the soil surface (0–3 in.) and deep band in subsoil (3–6 in.) showed values above 20 ppm. These results agree with the results obtained by Coelho et al. (2019) for soils in Scandia, KS. Surface broadcast P application shows an accumulation of P in the upper 3 inches, with little movement to the 3- to 6-inch layer.

The P fertilizer placement did not affect the grain yield for corn and soybean, with no differences between broadcast, deep band, and control treatment in 2015 (Figure 2). However, the control treatment showed a lower yield compared to broadcast and deep band treatment for wheat. Although it was not statistically different, the deep band P placement showed an average lower yield for wheat. The P fertilizer application with the deep band was spaced every 30 inches, and it is likely that this is affected wheat root access to P; row spacing for wheat was 7.5 inches.

References

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Table 1. Initial soil parameters for Agronomy North Farm Research and Extension site in Manhattan, KS

Depth	pH	TON	TOC	K	Ca	Mg	Na	CEC	Clay	Silt	Sand
in.		------ % ------		--------------- ppm ---------------				$cmol_c\ kg^{-1}$	----------- % -----------		
0-3	5.7	0.21	0.23	131	2124	377	15	22	26	60	14
3-6	5.2	0.19	0.18	109	2275	344	27	27	32	58	10

TON = total organic nitrogen. TOC = total organic carbon. K = potassium. Ca = calcium. Mg = magnesium. Na = sodium. CEC = cation exchange capacity.
Maximum phosphorus adsorption capacity (MPAC) at the 0- to 6-in. sampling was 424 ppm.

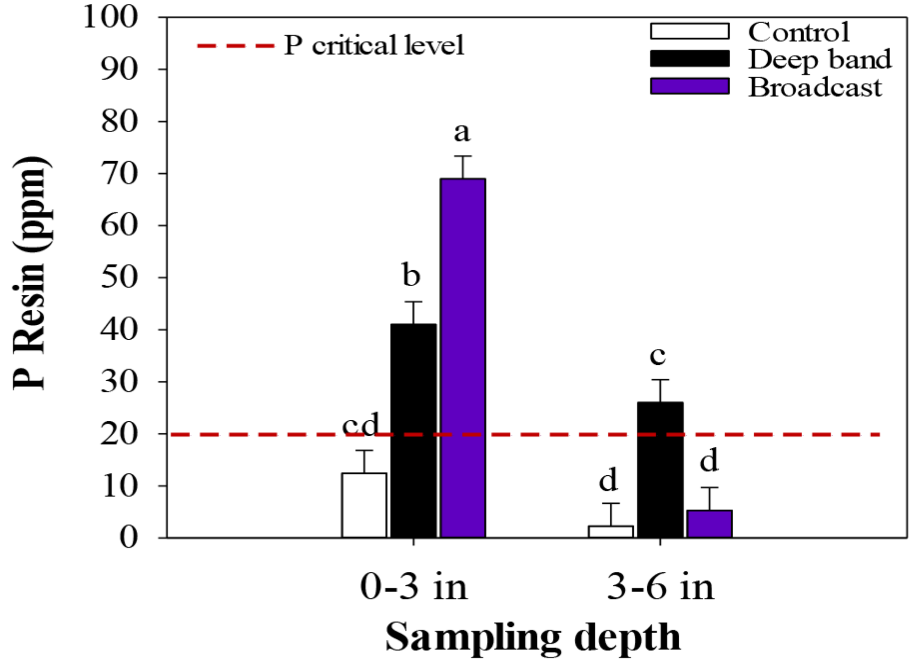

Figure 1. Phosphorus Resin: inorganic P readily diffusing into solution for two soil sampling depths in Manhattan, as affected by P fertilizer treatments (deep-band, broadcast, and control) after ten years of a corn-soybean-wheat rotation. Mean values followed by the same letter are not statistically different ($P > 0.05$).

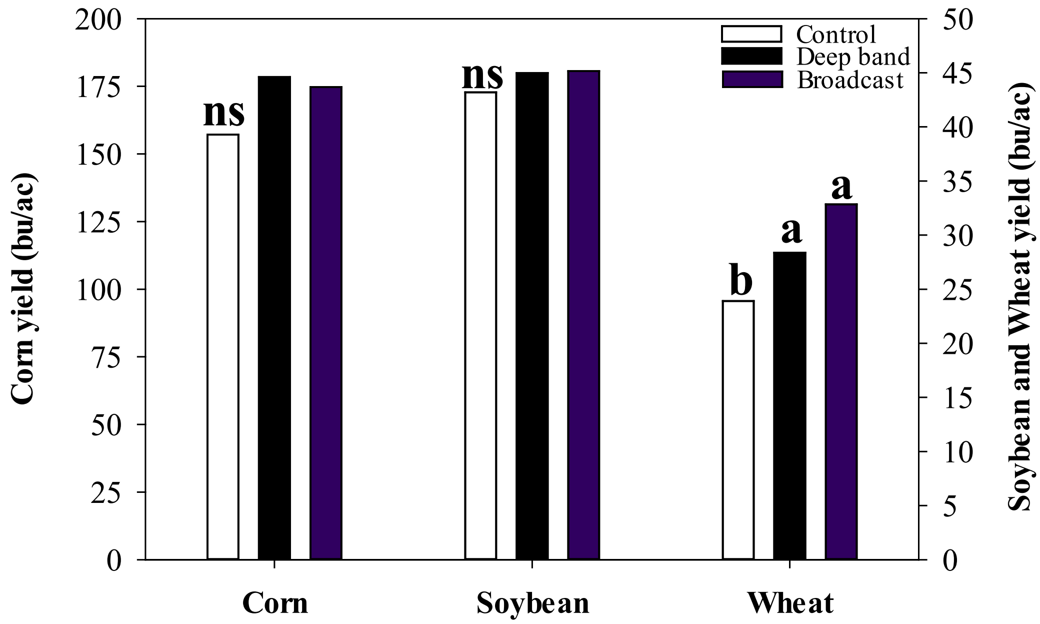

Figure 2. Grain yield for corn, soybean, and wheat at the Manhattan experimental field, as affected by P fertilizer treatments (deep-band, broadcast, and control) after ten years of a corn-soybean-wheat rotation. Mean values followed by the same letter are not statistically different ($P > 0.05$). ns = not significant. Data from the 2015 season.