EVALUATION OF SOYBEAN RESPONSE TO SURFACE AND SUB-SURFACE PHOSPHORUS FERTILIZER PLACEMENT

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ABSTRACT

Phosphorus (P) fertilizer placement can affect P plant uptake during the growing season and yield at harvest; in addition, sub-surface placement of P fertilizer can provide environmental benefits by minimizing losses. The objective of this study was to evaluate the yield response and plant uptake to surface and sub-surface P fertilizer application in soybean. This study was conducted in 2022 at two locations (Scandia and Manhattan, Kansas). The average soil P level (Mehlich 3), was 17 ppm in Manhattan and 3 ppm in Scandia. Phosphorus fertilizer was applied before planting at 0, 40, 80, and 120 lbs P2O5 /acre. Two placements included surface broadcast and sub-surface with the drill (7.5 inches spacing). Rates and placement were arranged in a complete factorial combination of treatments. Measurements included P uptake at the V4 stage, trifoliate P concentration at the R3 stage, and seed yield. Statistical analysis was performed with the R software. In Manhattan, the early season P uptake (V4) showed a statistically significant response to rates and placement. Higher values were attained with sub-surface placement. In Scandia, soybean P uptake at V4 showed no significant response to placement, with a numerically higher value for the sub-surface placement. Trifoliate P concentration at the R3 stage showed a statistical difference for P rates in Scandia, with a higher P concentration for the high rates of P fertilizer of 80 and 120 lbs. P2O5 acre^{-1}. In Manhattan, with higher soil test P (17 ppm) there was a general trend for a clearer placement response in the early season; whereas in Scandia, with very low soil test P (3 ppm), there was a significant response to P fertilizer rates regardless of placement.

INTRODUCTION

Phosphorus fertilizer placement can influence the nutrient absorption by the plant and can change the dynamics and availability due to its interaction with the soil (Arruda Coelho et al., 2019). Phosphorus management can affect soybean yield by influencing plant nutrient uptake and, in some cases modifying plant root development (Hansel et al., 2017). Furthermore, Phosphorus placement is essential for improving nutrient use efficiency and reducing the risk of loss when applied in sub-surface (Preston et al., 2019).

Phosphorus placement via broadcast is the easiest method of applying phosphorus (Randall and Hoeft, 1988). However, applying subsurface phosphorus can have some advantages (Hansel et al., 2017b). The objective of this study was to evaluate the yield response and plant uptake to surface and sub-surface P fertilizer application in soybean.

MATERIALS AND METHODS

This study was conducted in 2022 at two locations (at the North Central Kansas Experiment field in Scandia, KS, and at the North Agronomy Farm in Manhattan, KS). The field in Scandia was irrigated while Manhattan was on dryland. In Manhattan, the soybean was planted into wheat residue, and in Sandia, it was planted into corn residue, both with no prior tillage. Before fertilizer application, soil samples were collected at a depth of 0 to 6 inches using a hand probe. The average soil P level (Mehlich 3), was 17 ppm in Manhattan and 3 ppm in Scandia.

Treatments included a control with no P application and three P rates of 40, 80, and 120 lbs P2O5 /acre, using mono-ammonium phosphate (MAP). The P rates had two different placements: surface broadcast and sub-surface with the drill (7.5 inches spacing). Rates and placement were arranged in a complete factorial combination of treatments.

Measurements included plant biomass at the V4 stage, P uptake at the V4 stage, trifoliate P concentration at the R3 stage, and seed yield at harvest. The plant tissue samples were digested using nitric-perchloric acid digestion and analyzed using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). Statistical analysis was performed with the R software version 4.2.1.

RESULTS AND DISCUSSION

Early-season phosphorus uptake (V4) showed a significant response to the highest phosphorus rate when applied via sub-surface in Manhattan (Figure 1A). There were no statistically significant differences in Scandia as the P fertilizer rates were increased, but there were greater uptake values when the fertilizer was applied subsurface (Figure 2B). This increase in P uptake when the fertilizer was applied via sub-surface is perhaps due to the proximity of the nutrient and the root, improving P availability for the plants (Borkert and Barber 1985).

There was an increase in the trifoliate P concentration with higher fertilizer rates in Scandia, with no statistical difference between placements (Figure 2B). There was likely an increase in P uptake by the plant multiple days after fertilization (Comerford et al., 1987). Therefore, the increase in the concentration of P in the trifoliate when higher P rates are applied in Scandia is likely due to the lower soil test P value (3 ppm). Resulting in a greater P uptake when P fertilizer is applied. In Manhattan, with a higher soil test P value (17 ppm), there was no difference in trifoliate P concentration for both rates and placement (Figure 2A). Seed yield followed trends similar to P concentration in R3 for both Manhattan (Figure 3A) and Scandia (Figure 3B).

In Manhattan, with higher soil test P (17 ppm) there was a general trend for a placement response in the early season, whereas in Scandia, with very low soil test P (3 ppm), there was a significant response to P fertilizer rates regardless of placement.

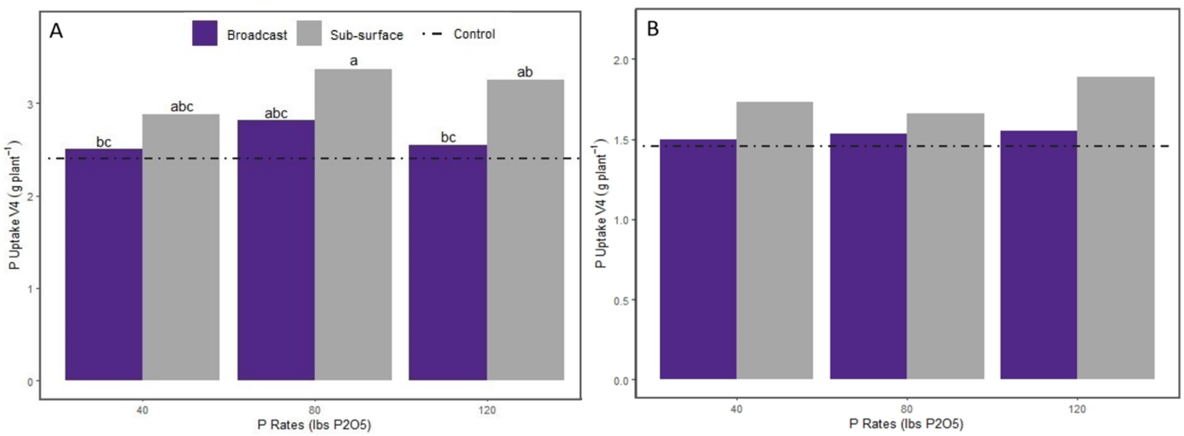

Figure 1: Phosphorus uptake (g plant^{-1}) as affected by different P placement and rates in Manhattan (A) and Scandia (B). Values followed by different letters indicate significant differences at the p≤ 0.05 probability level.

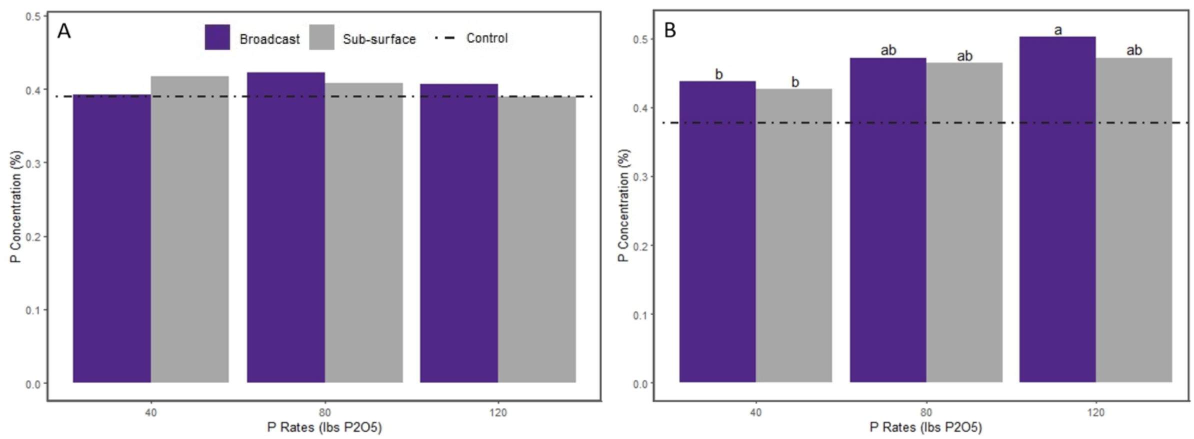

Figure 2: Phosphorus Concentration (%) as affected by different P placement and rates in Manhattan (A) and Scandia (B). Values followed by different letters indicate significant differences at the p≤ 0.05 probability level.

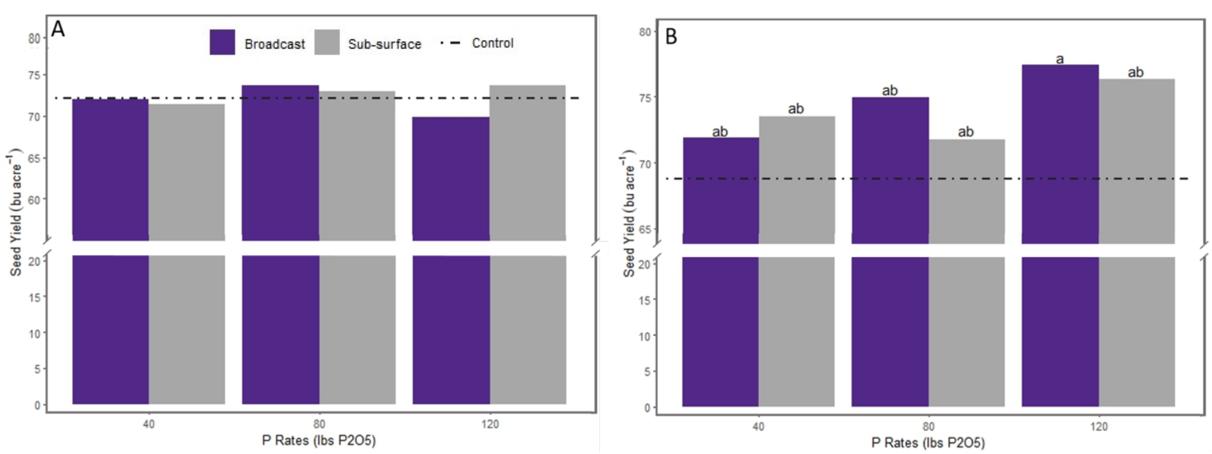

Figure 3: Seed yield (bushels acre^{-1}) as affected by different P placement and rates in Manhattan (A) and Scandia (B). Values followed by different letters indicate significant differences at the p≤ 0.05 probability level.

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