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Evaluation of Soil Test Phosphorus Extractants and Tissue Analysis for Corn

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Summary

The objective of this study was to evaluate the relationship of four different soil test phosphorus methods (Mehlich 3, Bray 1, Bray 2, and Haney H3A) for corn production, and determine critical P tissue concentration at different growing stages. The experiment was conducted at 12 locations, and the fertilizer treatments consisted of five phosphorus fertilizer rates applied by broadcast pre-plant. Soil samples were collected at 0- to 6-in. depth, then samples were collected before treatment application by block. Tissue samples were collected at the V6 and R1 growth stages. The relationship between the different soil test phosphorus methods and the R^2 varies between 0.24–0.93. Mehlich 3 and Bray 1 have a higher correlation, and Bray 1 and Bray 2 have a lower correlation. Linear plateau determined the critical phosphorus levels for the V6 growth stage was 0.42%, and for the R1 stage was 0.22%. The relationship between the concentration at V6 and R1 was moderately correlated with $R^2 = 0.62$, having a higher phosphorus concentration in the early stage.

Introduction

Phosphorus (P) is a macronutrient that plays several essential roles in plants and is required in relatively large quantities. The available fraction of the total soil phosphorus is typically low, and phosphorus fertilizer is needed to meet crop phosphorus requirements. Understanding the adequate phosphorus rate in corn production is necessary to sustain high yield potentials. Phosphorus fertilizer may not be enough to replace what the crop is removing in the long term if rates are too low. Therefore, soil testing should be performed to determine the correct fertilizer rate for an economic yield response (Mallarino and Blackmer, 1992; Coelho et al., 2019). Critical concentrations of soil test phosphorus (STP) and critical tissue concentrations can be used to identify the response to phosphorus fertilization that should be expected. Critical levels could depend on many factors, including specific crops as well as soil characteristics, environmental, and other factors. Determining an appropriate concentration of STP and its relationship is a fundamental step required to make fertilizer recommendations. Error in determining the critical concentration results in an incorrect decision relating to fertilizer application (Mallarino and Blackmer, 1992). New STP methods for corn have not been evaluated recently in Kansas. The objective of this study was to evaluate the relationship of four different STP methods for corn production and determine critical P tissue concentration at different growing stages.

Procedures

Field experiments were conducted at 12 locations across Kansas (Table 1). The experimental design was a randomized complete block design with four replications; plots were 10-ft width × 40-ft length. Fertilizer treatments were four rates of P fertilizer (30, 60, 90, and 120 lb/a of P_2O_5), using mono-ammonium phosphate (MAP) (11-52-0). Five treatments were established, including one control; all fertilizer was applied one time by broadcast pre-plant. Before treatment application, soil samples were collected, and composited by blocks at 0- to 6-in. depth using a hand probe. Corn was harvested, and yield was calculated and corrected to 15.5% moisture. Soil samples were dried at 104°F (40°C), plant tissue samples were dried at 140°F (60°C), and both were ground to pass a 2-mm sieve. Soil samples were analyzed for pH, Mehlich 3, Bray 1, Bray 2 and Haney H3A, each with their respective methods extractions. Extractable P was measured at 660 nm using a colorimeter. The plant tissue samples were digested using nitric-perchloric acid digestion and analyzed using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). Relationships between different STP levels were evaluated using linear regression models. Critical levels were performed between relative yield and plant tissue concentrations using linear plateau models. Data analyses were performed in R version 4.1.

Results

Correlations Between Different Soil Test Phosphorus Methods

Results showed that methods Mehlich 3 vs. Bray 1 and Mehlich 3 vs. Haney H3A were strongly correlated (R^2 = 0.93 and 0.80, respectively) and exhibit a linear relationship (Figure 1a, and Figure 1b). The Bray 1 and Haney H3A relationship was moderately correlated with R^2 = 0.60 (Figure 1c). All methods correlated with Bray 2 (Mehlich 3 vs. Bray 2, Bray 1 vs. Bray 2, and Haney H3A vs. Bray 2) were poorly correlated, with R^2 = 0.31, 0.24 and 0.47, respectively (Figure 1d, 1e, 1f).

Critical Phosphorus Concentrations

The critical tissue P levels for the whole plant at the V6 growth stage were 0.42 %, and the model R^2 value was 0.26 (figure 2a), as determined by a linear plateau. The critical P levels for the ear leaf at the R1 stage were 0.22%, and the model R^2 value was 0.18 (Figure 1b). Both R^2 values are low, with the ear leaf at R1 having lower value than the whole plant at V6. Stammer and Mallarino (2018) found a similar critical P concentration with a linear plateau for the whole plant at growth stage V6 of 0.48% and 0.25% for the ear leaf at the R1.

The relationship between the concentration in the whole plant at V6 and the ear leaf at R1 was moderately correlated with R^2 = 0.62 (Figure 3). The P tissue concentrations ranged from 0.25 to 0.64% for V6 and 0.15 to 0.42% for R1. The tissue P concentrations at the V6 stage were higher than at the R1 stage; this suggests that the value of tissue testing to assess plant phosphorus nutritional status may differ during the growing season.

References

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Table 1. Study sites and soil properties for corn studies in 2021

Location	County	Soil series	pH	Mehlich 3 P	Bray 1 P	Bray 2 P	Haney H3A P
				ppm			
1	Republic	Crete	6.5	5	6	31	5
2	Republic	Crete	6.1	7	8	41	7
3	Franklin	Woodson	6.0	9	11	28	9
4	Dickinson	Geary	5.8	21	23	65	14
5	Shawnee	Bismarckgrove	7.6	21	19	70	23
6	Gove	Keith	7.2	20	19	183	25
7	Logan	Keith	6.4	22	21	145	23
8	Gove	Keith	6.6	25	23	160	30
9	Gove	Ulysses	6.2	35	37	148	26
10	Saline	Longford	5.4	38	41	79	23
11	Riley	Bourbonais	6.3	45	34	134	55
12	Brown	Kennebec	6.3	45	43	96	40

Samples were collected at 0- to 6-in. depth.

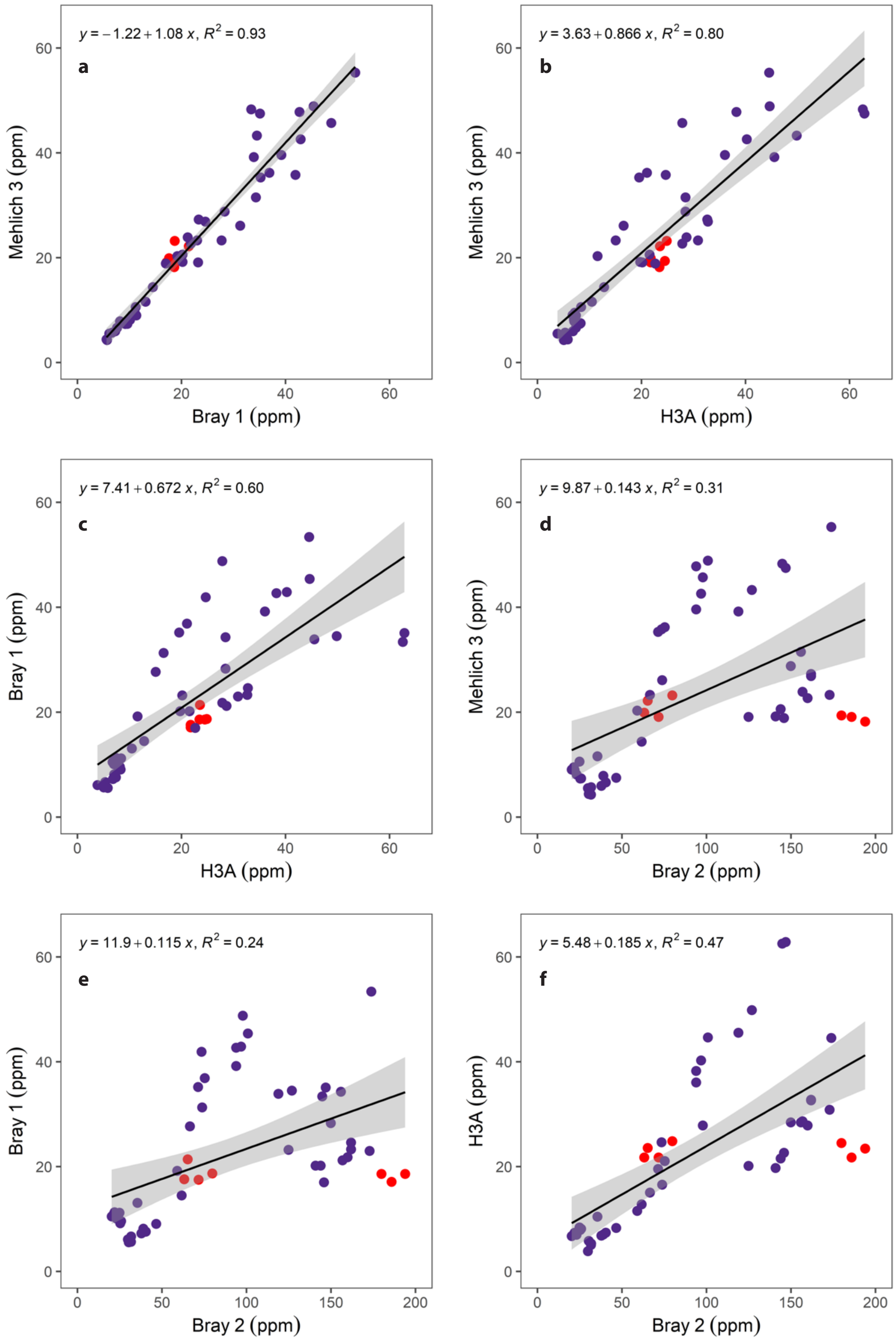

Figure 1. Relationship between different soil test phosphorus methods (a) Mehlich 3 vs. Bray 1, (b) Mehlich 3 vs. H3A, (c) Bray 1 vs. H3A, (d) Mehlich 3 vs. Bray 2, (e) Bray 1 vs. Bray 2, and (f) H3A vs. Bray 2. Soils with a pH > 7.0 are indicated by red dots.

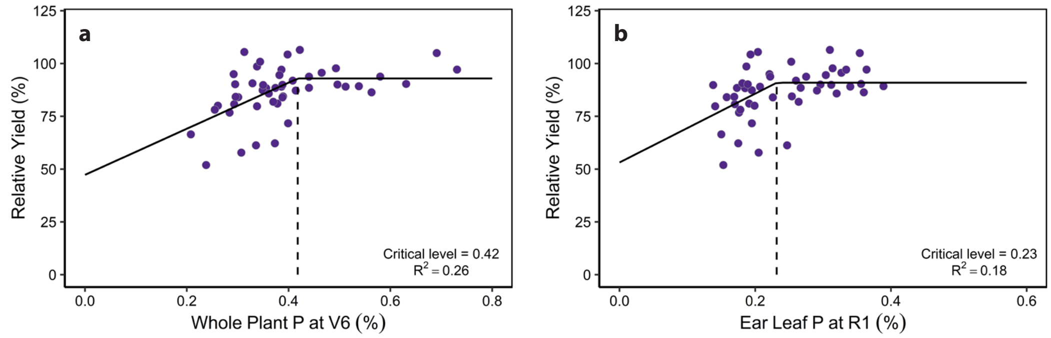

Figure 2. Relationship between relative yield and the P concentration of (a) whole plants at the V6 growth stage or (b) ear leaf blades at the R1 stage. Vertical lines indicate a critical P level with a linear plateau.

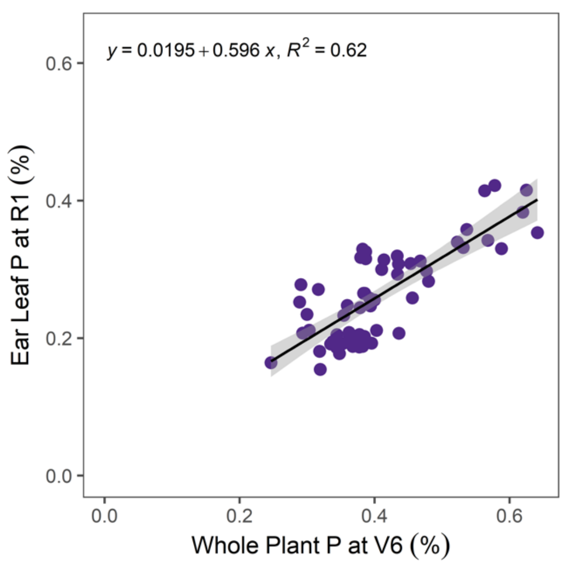

Figure 3. Relationships between P concentrations at the ear leaf at the R1 stage and the whole plant at the V6 growth stage.