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Abstract

The Haney H3A soil test procedure has gained popularity in recent years for soil health evaluation and has been used in some circles to adjust fertilizer management practices. However, data relating this test to current soil tests, relative crop yield, or total nutrient uptake are nonexistent in Kansas soils. The objective of this study is to evaluate the correlation between H3A soil test phosphorus (P) and potassium (K) with soil tests currently used in Kansas (e.g. Mehlich-3). Soils from a nitrogen response study were extracted using both Mehlich-3 and H3A (version 4) soil test procedures. Mehlich-3 and Haney extractable P and K were positively correlated ($r = 0.90$ and 0.91 , respectively) in data combined from all sites. Linear regression models fit to the combined data indicate that Mehlich-3 extracts approximately 25% more P and 250% more K. The Root Mean Square Error (RMSE) of these models (15.4 ppm P and 83.4 ppm K) indicate that existing calibration based on Mehlich-3 values are likely not suitable for use with H3A-4.

Keywords

soil test, phosphorus, potassium

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E.B. Rutter and D.A. Ruiz Diaz

Summary

The Haney H3A soil test procedure has gained popularity in recent years for soil health evaluation and has been used in some circles to adjust fertilizer management practices. However, data relating this test to current soil tests, relative crop yield, or total nutrient uptake are nonexistent in Kansas soils. The objective of this study is to evaluate the correlation between H3A soil test phosphorus (P) and potassium (K) with soil tests currently used in Kansas (e.g. Mehlich-3). Soils from a nitrogen response study were extracted using both Mehlich-3 and H3A (version 4) soil test procedures. Mehlich-3 and Haney extractable P and K were positively correlated ($r = 0.90$ and 0.91 , respectively) in data combined from all sites. Linear regression models fit to the combined data indicate that Mehlich-3 extracts approximately 25% more P and 250% more K. The Root Mean Square Error (RMSE) of these models (15.4 ppm P and 83.4 ppm K) indicate that existing calibration based on Mehlich-3 values are likely not suitable for use with H3A-4.

Introduction

The availability of phosphorus (P) and potassium (K) is typically assessed with a soil test and a calibration curve relating test values to relative yield or nutrient uptake. Several soil tests for P and K have been introduced over the years. Historically, Bray-1 and Olsen have been the dominant soil test methods used for P analysis in the Central Plains region, while ammonium acetate has been used for base cations (e.g. K, Ca, Mg, Na). Usage of Bray-1 vs. Olsen is largely dependent on soil pH, where Bray-1 is preferred in acidic soils and Olsen in calcareous soils. The Mehlich-3 (M3) procedure has gained popularity in recent years, and is intended for use in acidic to neutral pH soils. It has been dubbed a “universal” extractant by some, due to its ability to extract multiple nutrients across a wide range of soil pH. When combined with modern spectroscopic techniques (e.g. ICP-OES), this procedure allows for the simultaneous measurement of multiple macro and micronutrients from a single extract. This has led to wide adoption of the M3 soil test procedure at labs across the US.

The Haney H3A extracting solution is intended to simulate the chemistry of actively growing roots more closely (Haney et al., 2006). The H3A extracting solution is comprised of a dilute mixture of organic acids, but has undergone numerous iterations since its initial development (Haney et al., 2017). The current iteration, version

4, is comprised of malic, citric, and oxalic acids, and has a weakly buffered pH of approximately 3.75 (Haney et al., 2017). The primary objectives of this study were to investigate relationships between M3 and H3A soil test P and K in selected Kansas soils.

Procedures

Field studies were initiated at multiple sites across the state of Kansas during the 2017, 2018, and 2019 corn growing seasons, 14 site-years in total (Table 1). Treatments consisted of nitrogen (N), P, and K fertilizer combinations applied at rates ranging from 0 to 200 lb N/a, 0 or 80 lb P₂O₅/a, and 0 or 100 lb K₂O/a. Soil samples were collected from each plot using a hand probe to a depth of six inches prior to treatment application. Soil measurements include soil pH, OM, M3 and H3A-4 extractable P, K, Ca, Mg, Al, Cu, Fe, Mn, and Zn.

Relationships between Mehlich-3 and H3A-4 extractable nutrients were evaluated using linear regression models. Data analyses were performed in R version 3.6 (R Core Team, 2019) and evaluated at the 95% confidence level.

Results

Mehlich-3 and H3A extractable P and K were highly correlated ($r = 0.90$ and 0.91 , respectively) and exhibit a linear relationship in combined data (Figures 1, 2). On average, M3 extracted approximately 25% more P and 250% more K than H3A-4 (Figures 1, 2). The RMSE of these regression models (15.4 mg P kg soil⁻¹ and 83.4 mg K kg soil⁻¹) is too large to allow for estimation of M3 P or K from H3A-4 P or K for the purposes of fertility recommendations. Existing calibration curves for soil test P and K for Kansas soils are based on either Mehlich-3 or Bray-1. These data clearly illustrate that separate calibrations would be required to make fertilizer recommendations from H3A-4 P or K soil tests.

In summary, Mehlich-3 and H3A-4 extractable P and K appear highly correlated in Kansas soils. However, RMSE values of regression models indicate that these relationships are not strong enough to simply convert H3A-4 soil test values to M3 values for fertilizer recommendations. Existing calibration and correlation data relating conventional soil tests to relative yield and nutrient uptake are likely not appropriate for use with the H3A-4 soil test.

References

- Haney, R. L., E. B. Haney, L.R. Hossner, J.G. Arnold. (2006). "Development of a New Soil Extractant for Simultaneous Phosphorus, Ammonium, and Nitrate Analysis." *Communications in Soil Science and Plant Analysis* 37(11-12): 1511-1523.
- Haney, R. L., E. B. Haney, D.R. Smith, and M.J. White. (2017). "Removal of Lithium Citrate from H3A for Determination of Plant Available P." *Open Journal of Soil Science* 07(11): 301-314.

Table 1. General site descriptions, and soil chemical and textural parameters for 14 experimental sites included in the study

| SiteID | Year | County | Tillage | pH | OM % | P ----- soil ppm ----- | K | CEC cmol _c kg ⁻¹ | Sand | Silt % ----- | Clay |
|--------|------|----------|---------|-----|---------|---------------------------|-----|---|------|-----------------|------|
| 1 | 2017 | Riley | Conv. | 6.7 | 2.8 | 41 | 250 | - | 16 | 60 | 24 |
| 2 | 2017 | Riley | Conv. | 6.9 | 2.9 | 41 | 260 | - | 8 | 54 | 38 |
| 3 | 2017 | Mitchell | No-till | 5.8 | 3.0 | 26 | 430 | - | 18 | 60 | 22 |
| 4 | 2017 | McPhers. | Conv. | 7.7 | 3.4 | 83 | 718 | - | 26 | 44 | 30 |
| 5 | 2018 | Franklin | Conv. | 6.1 | 3.0 | 15 | 96 | 22.2 | 14 | 62 | 24 |
| 6 | 2018 | Mitchell | No-till | 5.7 | 2.7 | 56 | 520 | 27.7 | 16 | 52 | 32 |
| 7 | 2018 | Mitchell | No-till | 5.2 | 3.2 | 30 | 234 | 27.1 | 26 | 44 | 30 |
| 8 | 2018 | Mitchell | No-till | 5.6 | 3.9 | 23 | 463 | 24.7 | 22 | 48 | 30 |
| 9 | 2019 | Mitchell | No-till | 4.9 | 3.4 | 68 | 368 | 25.7 | 16 | 56 | 28 |
| 10 | 2019 | Mitchell | No-till | 5.4 | 3.3 | 75 | 534 | 25.5 | 8 | 60 | 32 |
| 11 | 2019 | Riley | Conv. | 5.8 | 1.8 | 32 | 270 | 13.8 | 34 | 52 | 14 |
| 12 | 2019 | Shawnee | Conv. | 6.7 | 1.6 | 42 | 140 | 8.0 | 52 | 38 | 10 |
| 13 | 2019 | Republic | Conv. | 5.7 | 3.6 | 6 | 408 | 22.2 | 20 | 56 | 24 |
| 14 | 2019 | McPhers. | No-till | 6.2 | 3.4 | 139 | 560 | 21.3 | 24 | 52 | 24 |

All sites were located across Kansas. Soil parameters were measured from composite soil samples representing the site. Phosphorus (P) and potassium (K) were determined using Mehlich-3 soil test.

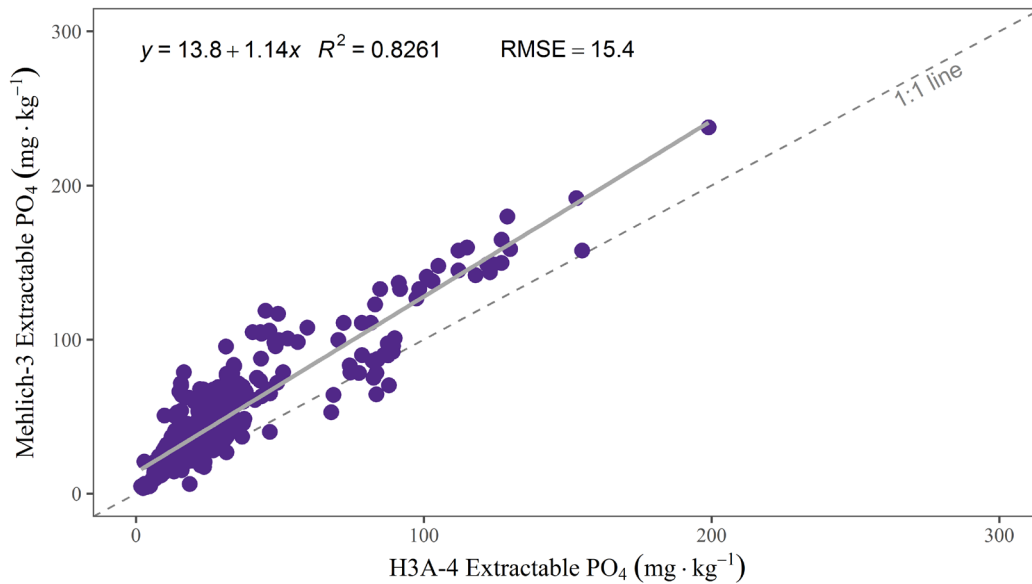


Figure 1. Mehlich-3 (horizontal axis) and H3A-4 (vertical axis) extractable phosphorus (P) from soils collected from plots at each site. The combined data show a positive linear relationship between the two soil test methods for P, with M3 extracting approximately 30% more P than H3A-4.

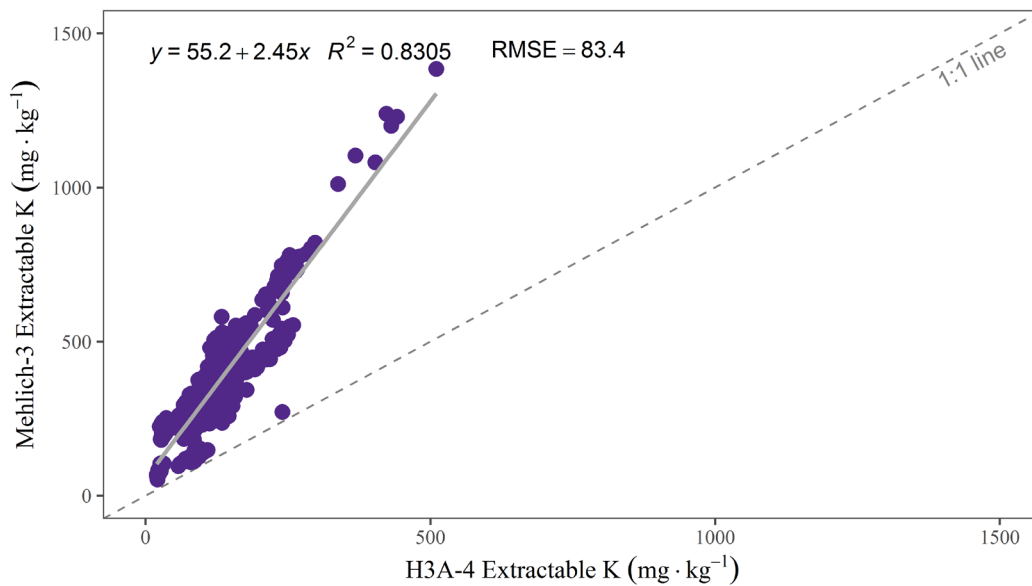


Figure 2. Mehlich-3 (horizontal axis) and H3A-4 (vertical axis) extractable potassium (K) measured from soil samples representing the 0–6 in. (15 cm) soil layers. M3 K and H3A-4 K exhibit a positive linear relationship in these combined data, with M3 extracting approximately three times more K than H3A-4.