W 1318

Relationship Between Haney Soil Health Test's (HSHT) H3A-4 and Mehlich-3 Extractable Nutrients in West TN Soils

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Soil testing is the best available technology for predicting crop nutrient needs and prescribing the appropriate fertilizer recommendation prior to the growing season. A soil test extractant extracts easily exchangeable nutrients to estimate the soil's nutrient-supplying capacity. There are several soil extractants used by soil testing laboratories in the U.S. including Mehlich-1 and 3, Bray I, DTPA, Lancaster, etc. (Zhang et al., 2021). However, Mehlich-1 and 3 are commonly used by most university and private soil testing laboratories in the Southeast U.S. (Southern Cooperative Series, 2014).

More recently, with emphasis on sustainable crop production, there are a number of tests that assess soil health. Some of the soil health tests such as the Haney Soil Health Tool (HSHT), which is adopted by USDA-NRCS, assess soil quality parameters as well as nutrient availability. The HSHT uses the H3A-4 extractant to estimate "plant available" nutrients. Actual nutrient availability may change with specific crop, soil minerology, along with rainfall frequency and intensity. This is why most soil test interpretations are indexes (low, medium, high, etc.) associated with soil test values across different crops, soils, and regions. The H3A-4 extractant simulates plant root environment by using organic acid plant exudates and has been touted as more representative of phosphorus availability (Haney et al., 2017). Some commercial soil testing laboratories offer HSHT and provide corresponding fertilizer recommendations. Some growers have asked how the soil test values from H3A-4 relates to Mehlich-3 extraction and if there is possible conversion between these two tests. Publicly available information relating H3A-4 to Mehlich-3 extractable is limited to nonexistent. To address this concern a study was conducted to (i) investigate the relationship between HSHT's H3A-4 and Mehlich-3 extractable nutrient elements and (ii) compare the P_2O_5 and K_2O fertilizer recommendations by the University of Tennessee and Haney Soil Health Test from a North Central US Laboratory recommendation with a yield goal of 200 bu/a.

Field trials were established at multiple sites in Tennessee during the 2021 and 2023 corn growing seasons to assess the adequacy of mineralizable nitrogen (N) to predict crop response to N. These trials were leveraged to evaluate the relationship between HSHT's H3A-4 and Mehlich-3 extractable nutrients. Specialists and scientists at the University of Tennessee recommend

Table 1. General site description

Site ID	Year	Location	Soil series	Tillage	Previous Crop	Cover crop
1	2021	Jackson, TN	Calloway Silt Loam	No-till	Soybean	Legume-grass mix
2	2021	Medina, TN	Lexington Silt Loam	No-till	Cotton	No cover crop
3	2023	Jackson, TN	Collins Silt Loam	No-till	Corn	No cover crop
4	2023	Milan, TN	Routon Silt Loam	No-till	Soybean	No cover crop

Table 2. Selected soil properties for all the experimental sites.

Site ID	Year	pH	OM	P	K	Ca	Mg	S	Na	B	Fe	Mn	Cu	Zn
			%	------ppm – Mehlich-3------										
1	2021	6.1	2.0	24	108	1148	98	10	10	0.4	206	320	1.7	2.7
2	2021	6.1	2.4	16	99	1573	118	10	11	0.7	157	166	1.2	1.4
3	2022	5.9	2.3	25	131	1604	170	17	20	0.4	142	190	1.1	1.5
4	2022	6.5	2.4	49	124	1671	51	11	11	0.3	128	192	1.1	0.8

The nutrient concentrations were determined using Mehlich 3 soil test.

phosphorus (P) and potassium (K) fertilizer applications for only low- and medium-test soils, so only the sites with low or medium test P and K soils were included in the trials. Plots were four rows wide by 30 feet long, and each treatment combination was replicated four times in a randomized complete block design.

The N fertilizer treatments included: 0, 60, 120, 180, 210 and 240 lb N ac^{-1}. General site description and selected soil properties for each site are presented in Table 1 and 2, respectively. Soil samples were collected at multiple depths, however only the 0-6-inches depth is discussed in this publication for the purpose of fertilizer recommendations. Soils were air dried, ground to pass through a 2-mm sieve and thoroughly mixed and analyzed for soil organic matter, soil pH, Mehlich-3 extractable nutrients and HSHT's H3A-4 extractable nutrients (Haney et al., 2017). The relationship between Mehlich-3 and HSHT's H3A-4 extractable nutrients of interest with regards to row crop production in Tennessee—P, K, sulfur (S), zinc (Zn) and boron (B)—were evaluated using linear model with Sigma Plot 15.0. Fertilizer recommendations for Mehlich-3 were made from UT fertilizer recommendations; H3A-4 fertilizer recommendations were provided by a commercial laboratory.

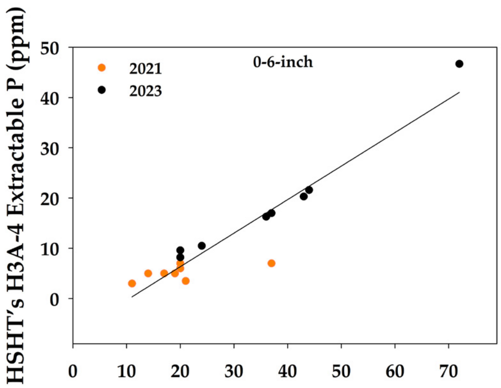

Figure 1. *Relationship between HSHT's H3A-4 and Mehlich-III extractable P.*

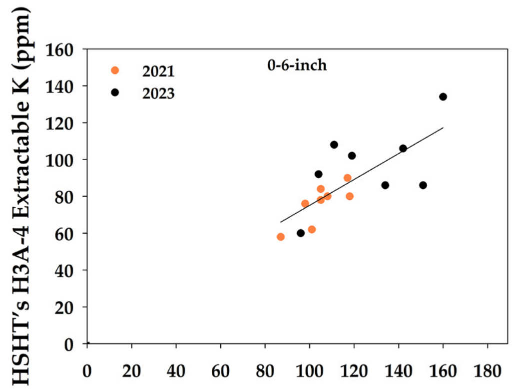

Figure 2. *Relationship between HSHT's H3A-4 and Mehlich-III extractable K*

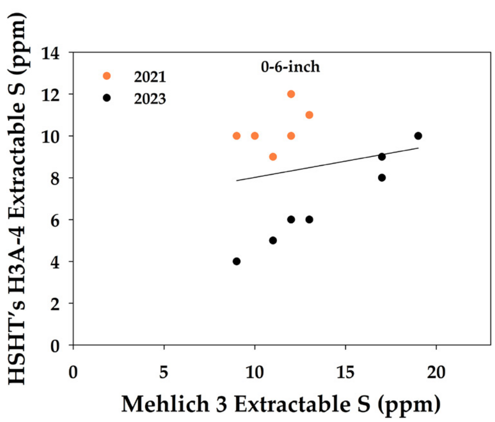

Figure 3. *Relationship between HSHT's H3A-4 and Mehlich-III extractable S*

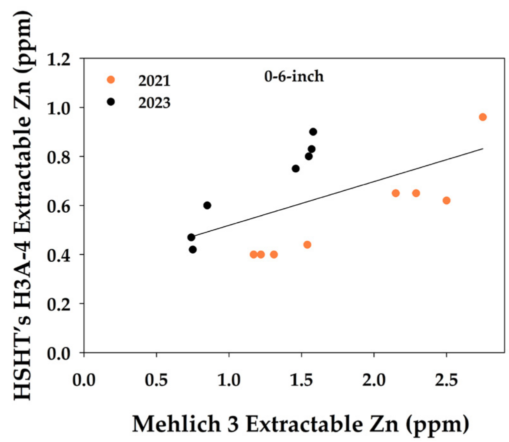

Figure 4. *Relationship between HSHT's H3A-4 and Mehlich-III extractable Zn*

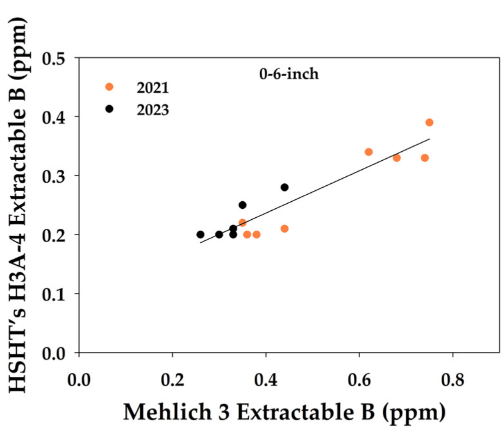

Figure 5. *Relationship between HSHT's H3A-4 and Mehlich-III extractable B*

RELATIONSHIP BETWEEN EXTRACTS

The relationship between HSHT's H3A-4 and Mehlich-3 extractable P, K, S, Zn and B is presented in Figures 1-5. Mehlich-3 and H3A-4 extractable nutrients were significantly correlated and showed a positive linear relationship between the two tests

Table 3. The equation, root mean square error (RMSE) and R2 for the relationship between HSHT's H3A-4 and Mehlich-III extractable P, K, S, Zn and B across locations

Nutrient	Equation	R^2	RMSE (ppm)	P value
P	H3A = 0.6679M3- 6.9893	0.89	5.22	<0.0001
K	H3A = 0.7019M3+ 4.9589	0.55	30.7	0.001
S	H3A = 0.1555M3 + 6.4606	0.04	14.8	0.4837
Zn	H3A = 0.1785M3 + 0.3406	0.32	0.09	0.0274
B	H3A = 0.3587M3 + 0.0931	0.87	0.06	<0.0001

across years except S. Nonetheless, there was a significant and strong positive relationship between the two tests for S in 2023. Phosphorus and boron highly correlated well (R^2 = 0.87 and 0.89, respectively) while potassium and zinc were moderately correlated (R^2 = 0.39 and 0.55, respectively) as shown in Table 3.

On average, Mehlich-3 extracted approximately 60 percent more P, 25 percent more K, 30 percent more S, 50 percent more Zn and 40 percent more B than H3A-4. The lower concentration of H3A-4 extractable nutrients is because of the composition of the H3A-4 extracting solution. The solution consists of a dilute mixture of four weak acids with a weakly buffered pH of approximately 3.75, which is higher than the buffered 2.5 pH of Mehlich-3. Although the relationships between some nutrients appear highly correlated, the magnitude of RMSE observed makes it inappropriate to estimate Mehlich-3 extractable P, K, S, Zn and B from H3A-4 extractions for fertilizer recommendations. Hence, conversion equations generated for these two soil tests can be misleading and would result in inappropriate fertilizer recommendations. An example would be if H3A-4 was 20 ppm P and translated to Mehlich-3 it would be 40 ppm, but the translation error could be +/- 10 ppm. This large error may be driven by two data points that are far from the predicted line. Further research into why some samples fall farther from the predicted line may help explain extracting differences between the two extracts. Maybe the fluoride in the Mehlich-3 is extracting a P fraction not exchangeable with H3A-4 on those soils. Data shows that H3A-4 may not translate to Mehlich-3 well, and that is acceptable. They were both designed with different goals in mind. Mehlich-3 had chelating agents added to extract more micronutrients on soil exchange sites. Mehlich-3 also had fluoride added to extract P that may be retained on iron and aluminum complexes, which Mehlich-1 could not extract. The H3A-4 is designed to be used in soil health and more closely mimic organic acids exuded by plant roots while also allowing for use in measuring nitrogen in the soil. The Mehlich-3 cannot be used to measure nitrogen fractions in the soil. These differences are why it is important to have crop yield correlation and calibration trials for each extract so producers can have both options to use in their nutrient management program.

COMPARISON OF FERTILIZER RECOMMENDATIONS

Differences in fertilizer recommendations for 200-bushel corn based on the different tests were observed. This observation indicates that more work should be conducted to explain the difference. Calibration is needed since the Haney test uses a different extracting acid than Mehlich-3. The reliable means to generate appropriate fertilizer recommendations for Tennesseans is by conducting response trials to develop calibration curves.

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FURTHER READING

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