COMPARATIVE ANALYSIS OF SOIL TESTS FOR SOIL HEALTH AND NUTRIENT MANAGEMENT

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ABSTRACT

Options for soil tests to address soil health and nutrient management objectives have diversified. We compare different soil test methods to evaluate their similarities for providing recommendations. Traditional soil tests, ion exchange membranes and analyses using the Haney Soil Health Nutrient Tool and Soil Health Index were compared for soil sampled from long-term cropping system trials near Ritzville Washington and from the R.J. Cook Agronomy Farm near Pullman WA. Despite strong differences in surface soil organic matter between no-tillage (NT) and reduced tillage (RT), the Haney Soil Health Index was not appreciably different. Relationships between the H3A test and traditional soil test P were weak and tended to be influenced by tillage regime. Relationships between H3A and traditional soil test K were stronger but still tended to be influenced by tillage. Measures of labile soil carbon from incubation studies were strongly related to more easily measured analyses of permanganate oxidizable C (POXC) and water extractable organic carbon (WEOC). Both POXC and WEOC should be considered in addition to soil organic matter for soil health tests.

INTRODUCTION

Interest in soil testing to assess soil health and to explore alternative analyses on which to base fertilizer recommendations has been increasing. Examples include the Haney Soil Health Index, the Haney developed H3A extractant for macro- and micro-nutrients, various measures of more biologically active soil carbon, ion exchange membranes and the continued use of more traditional soil tests. Our objectives were to examine the utility of these various tests including a comparative analysis to examine relationships among new and more traditional soil tests.

METHODS

Soil samples (0-4 and 4-8 inches) were collected in the spring of 2017 at 60 geo-referenced points at the Cook Agronomy Farm (CAF) near Pullman, WA (Fig. 1). Thirty points were associated with a long-term continuous no-tillage (NT) site initiated in 1998 and the other 30 points were at an adjacent field that had been managed with similar crops but with reduced tillage (RT). The two sites comprise a paired watershed study for the USDA Long-Term Agroecosystem Research (LTAR) network. The samples were air dried and sent to commercial labs for a suite of traditional soil tests as well as the Haney Soil Health Index (which included a 24-hr CO_2 burst test, Solvita) and the Haney H3A test. In addition, soil samples representative of soil profiles (0-5 ft) were collected in 2015 at 25 geo-referenced points at the CAF NT site, incubated in the laboratory for 350 days to determine labile carbon pools (carbon with mean residence times of 5 and 60 days) and also analyzed for water extractable organic carbon (WEOC) and permanganate oxidizable carbon (POXC). A subset of samples was also incubated with ion exchange membranes (PRS probes) and subsequently extracted for macro- and micro-nutrients. In another long-term NT cropping systems experiment near Ritzville, WA, soil samples (depth increments to 1 foot) were collected in the spring of 2018 from diverse rotation experiments with wheat, peas and canola in rotation. Analyses included linear regression and spatial maps using inverse distance squared interpolation.

RESULTS AND DISCUSION

Soil organic matter (SOM) and pH ranged considerably across the two fields with SOM predominantly lower while pH was higher on RT compared to NT (Fig. 1). The Haney Soil Health Index was primarily driven by the CO_2 burst which was similar for NT and RT despite differences in SOM with CO_2 burst values considered high (>100) in the surface 4 inches, but decreased considerably in both NT and RT for the 4 to 8 inch depth-increment. Both of these measures were very sensitive to soil depth sampled. Other studies across the dryland cropping region of the inland Pacific Northwest have also shown that the Haney Soil Health Index is not very sensitive to differences in soil tillage management.

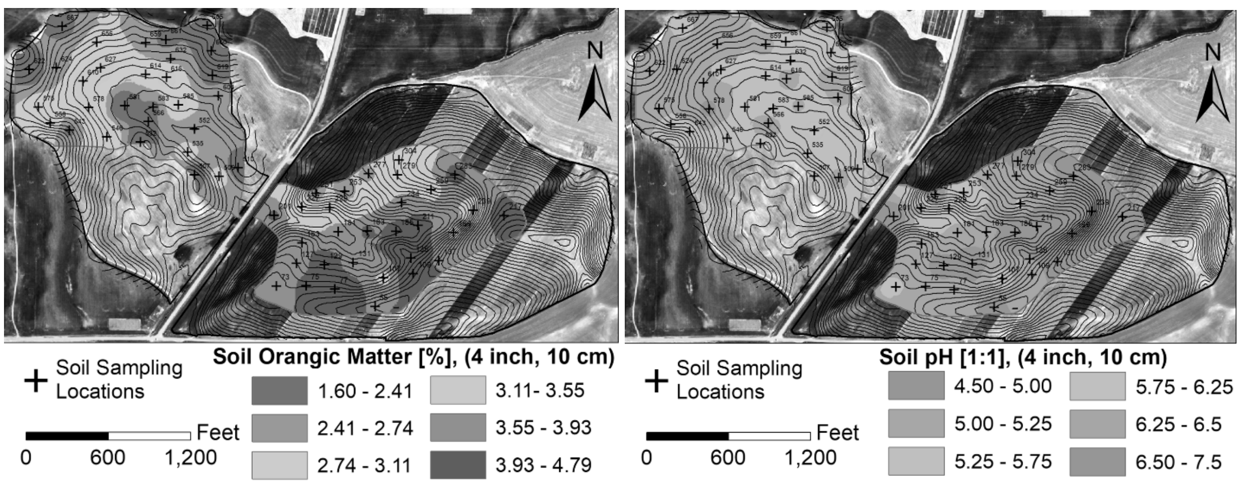


Figure 1. Geo-referenced locations for soil samples at the Cook Agronomy Farm and inverse distance squared interpolations of soil organic matter and pH (0-4 in).

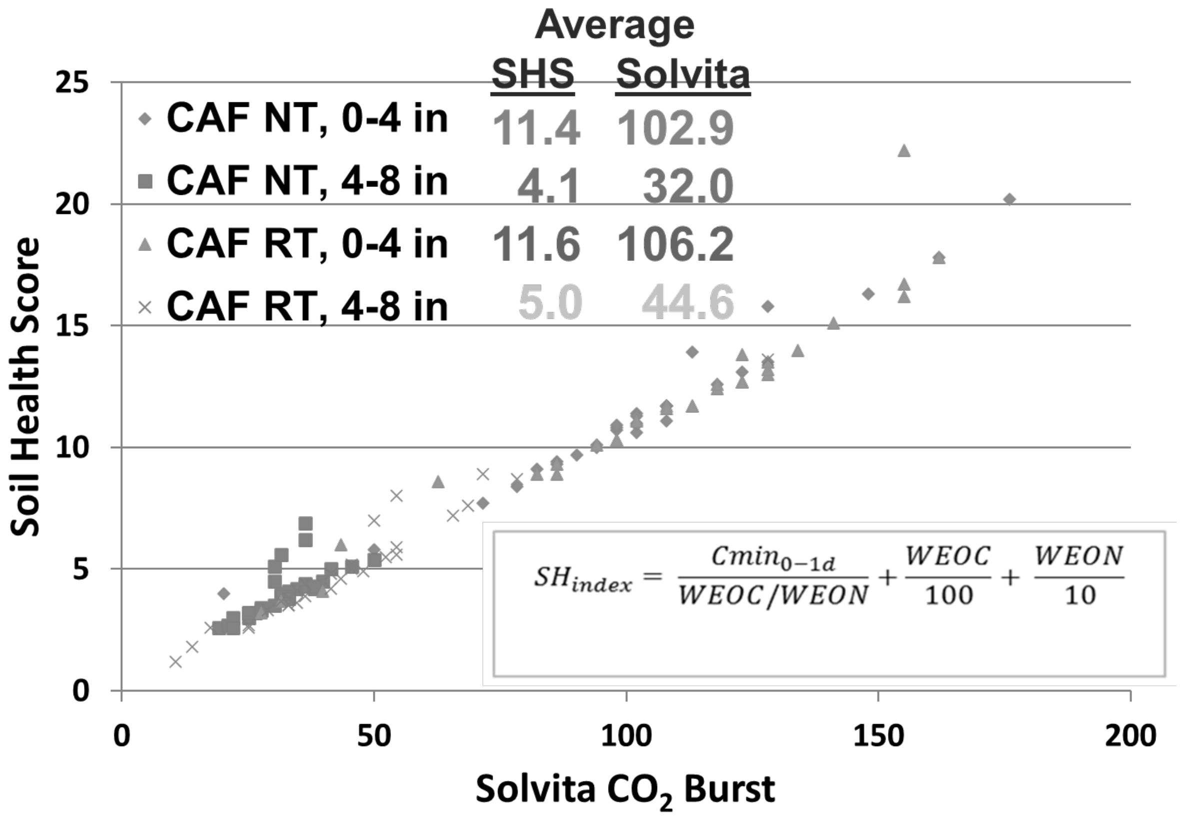
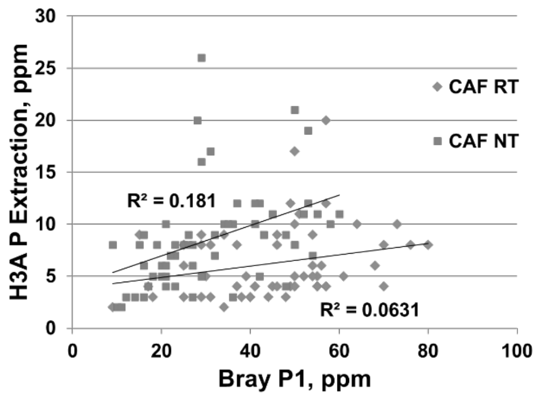


Figure 2. The Haney Soil Health Index (SH_{index}) and Solvita CO_2 burst ($Cmin_{0-1d}$) for 0-4 and 4-8 inch depth-increments in NT and RT for the Cook Agronomy Farm. WEOC is water extractable organic carbon; WEON is water extractable organic N.

Weak positive relationships occurred between Bray 1 P and H3A and also tended to be different for RT and NT (Fig. 3). In addition, the H3A test did not trend as the Bray, bicarbonate and ion exchange membrane (PRS) tests did across slope positions at the CAF (Fig. 3). Positive relationships were stronger between soil test K and H3A K, although the relationship was impacted by tillage regime (Fig. 4). As with P, the soil tests for bicarbonate K and ion exchange membrane (PRS) values were not well related with the H3A test across slope positions at the CAF (Fig. 4).



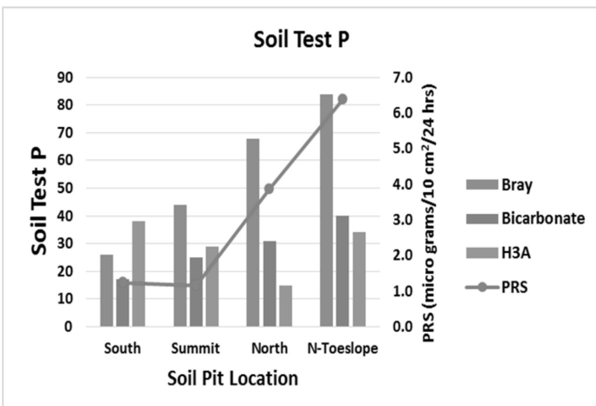


Figure 3. Comparison of H3A and Bray P1 for the CAF NT and RT. Also comparison of P soil tests (Bray, bicarbonate, H3A and PRS probe) at 4 landscape positions at the CAF.

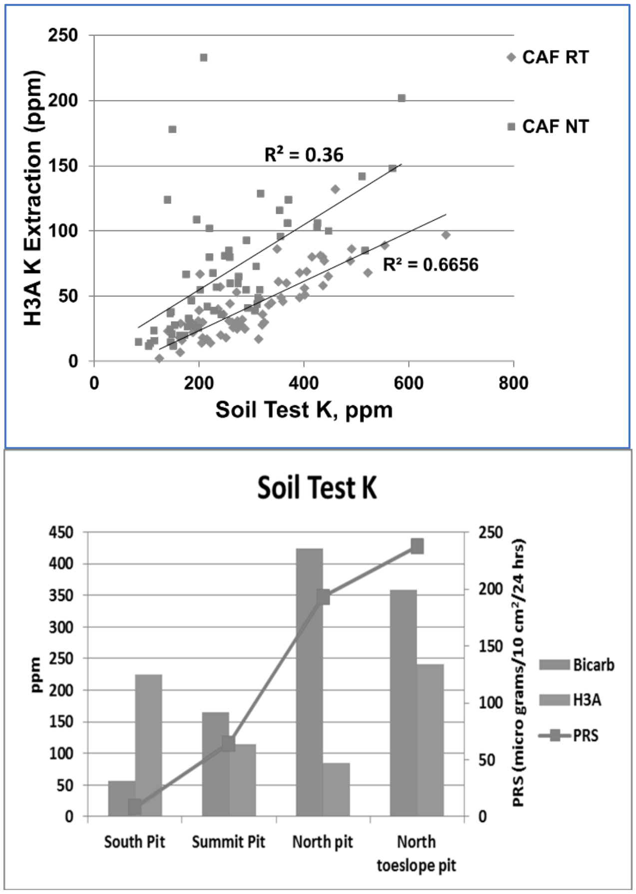


Figure 4. Comparison of H3A and soil test K for the CAF NT and RT. Also comparison of K soil tests (bicarbonate, H3A and PRS probe) at 4 landscape positions at the CAF.

Soil analyses from the long-term cropping system site near Ritzville, WA showed much stronger, positive, linear relationship between traditional soil test nitrate, ammonium, P and K and the H3A extractant. The field studies in this case did not have a tillage component, rather different crop rotation treatments (Fig. 5). In contrast, relationships between the tests were not as strong for S, Ca and Al (Fig. 5).

Soil management such as tillage tends to impact more labile constituents of soil organic matter (SOM). Labile constituents of SOM readily decompose serving as an energy source for the microbial community and stimulating its' activity. Quantities of labile SOM can be estimated through laboratory incubation studies that can extend for many months to measure quantities of CO_2 respired over time. Results in Figs. 6 and 7 show the relationship between labile C pool estimates from long-term incubation studies of soil from the Cook Agronomy Farm and two other more rapid analyses: WEOC and POXC. The relationships in each case are positive and linear, indicating that the more readily analyzable WEOC and POXC can serve as good estimates of more labile SOM constituents.

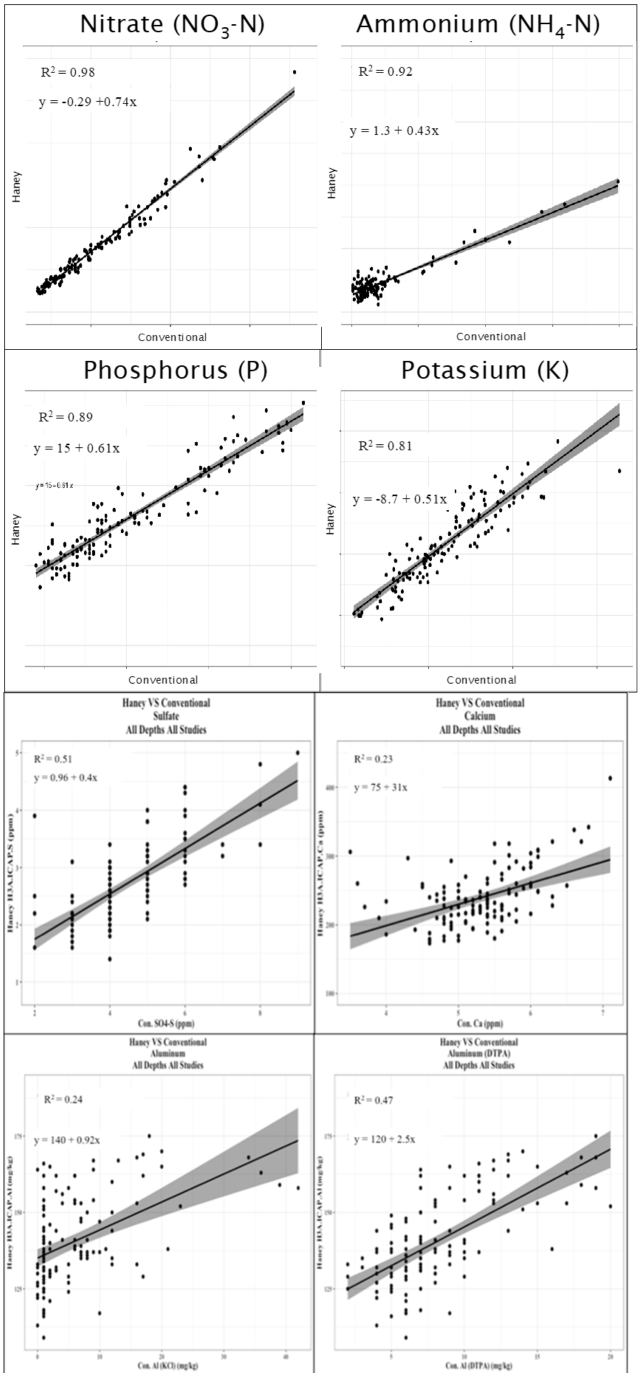


Figure 5. Relationships between conventional soil tests and the H3A test for nitrate, ammonium, P, K, S, Ca and Al at the long-term rotation study near Ritzville, WA.

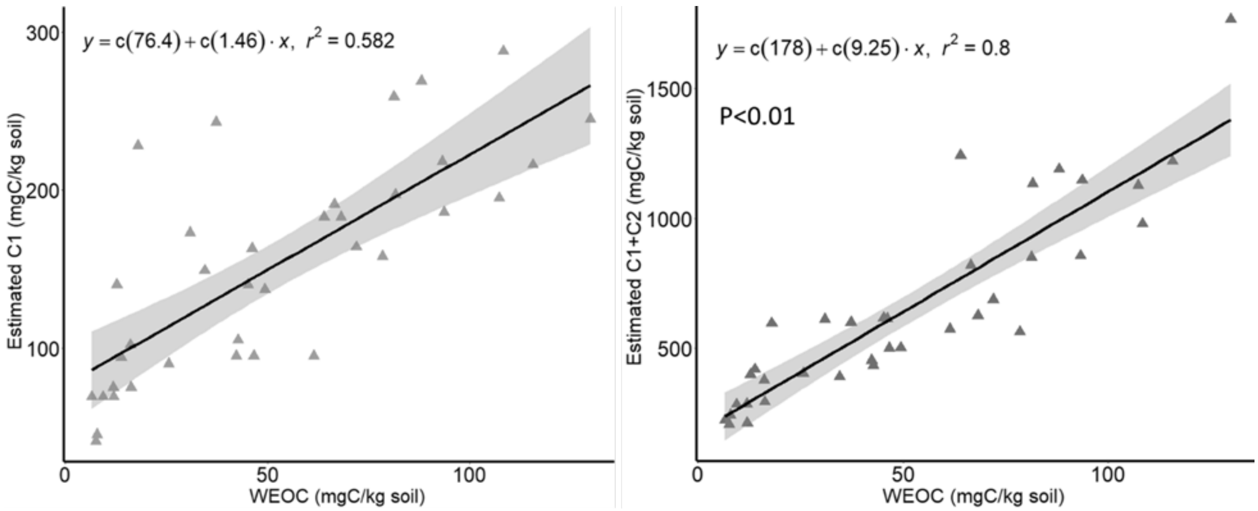


Figure 6. Relationship between water extractable organic carbon (WEOC) and labile soil carbon pools (C1 carbon has a mean residence time of 5 days while C2 carbon has a mean residence time of 60 days under controlled laboratory conditions).

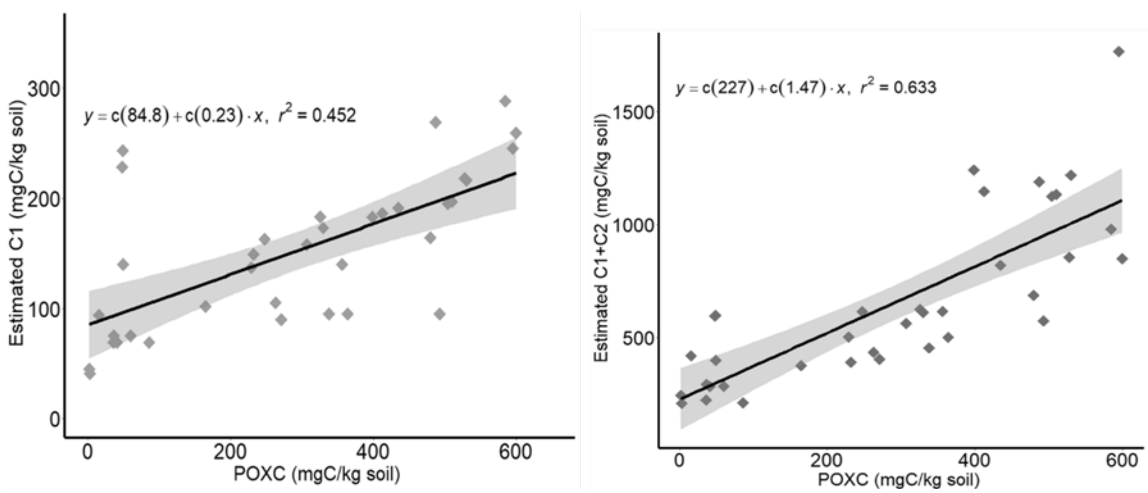


Figure 7. Relationship between permanganate oxidizable carbon (POXC) and labile soil carbon pools (C1 carbon has a mean residence time of 5 days while C2 carbon has a mean residence time of 60 days under controlled laboratory conditions).