PRELIMINARY ASSESSMENT OF THE SOLVITA-CO_2 TEST IN CHARACTERIZING MANAGEMENT EFFECTS ON SOIL BIOLOGICAL ACTIVITY IN SOME SOILS OF HAWAII

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ABSTRACT

The health of agricultural soils depends to a great degree on management practices that promote soil organic matter accumulation. While total soil organic carbon (C) is the standard measure of soil organic matter, it changes slowly and does not provide a sensitive enough test to assess short term management effects on soil health. However, a key indicator of healthy soil is potential biological activity, which can be measured rapidly with soil testing via short-term carbon (C) mineralization following rewetting of dried soil, i.e. mineralizable C. The Solvita® test is currently being proposed as a rapid test for mineralizable C as a proxy measure for (a) the active pool of soil organic C and (b) the overall biological activity of the soil. We present a preliminary dataset evaluating the sensitivity of the Solvita test to discern management effects on soil C pools and biological activity across a range of soils differing in physical and mineralogical properties and farm management approaches. The results suggest that the Solvita test has the potential to be an important tool in helping farmers quickly diagnose management effects on soil biological health across a wide range of agricultural soils of Hawaii.

INTRODUCTION

Soil testing laboratories provide routine services characterizing a range of soil physical and chemical properties specifically related to soil fertility evaluation. Although essential for the diagnosis of nutrient availability and subsequent recommendation, chemical indicators of inorganic N, P, K and pH do not provide a complete assessment of soil fertility and function. Increasingly, farmers, agricultural professionals, and the general public are requesting soil tests that address the broad notion of soil health with an emphasis on addressing the biological component of soils. To address the notion of soil health, soil testing must identify and adopt appropriate methods to assess soil biological activity.

Measuring the flush of CO_2 from an incubated soil has been proposed as a rapid test for soil biological activity (Franzluebbers, 2016). This method is a broad measure soil microbial processes related to a soil's functional capability to decompose organic matter and cycle essential nutrients (N, P, S). Furthermore, it is suitable for routine soil testing because it is rapid, inexpensive, reproducible across a wide range of soils, and correlated to crop nutrient needs. The Solvita Test, is a commercial product that enables the assessment of a 24-hr flush of CO_2 in a single test further reducing time and analytical equipment. The objective of the present study was (i) to evaluate the use of the Solvita Test across a range of soils differing in soil properties

(organic matter, clay mineralogy, and pH) and management history, (ii) assess the sensitivity of the test to short-term changes in soil management practices.

METHODS

A total of 19 surface soil samples (0-6") were collected from Hawaii, Maui and Oahu islands covering five soil orders (Andisols, Aridisols, Mollisols, Oxisols, and Vertisols) and three management conditions (conventional, organic and uncultivated) (Table 1). An additional set of surface soil samples were collected from a controlled field experiment evaluating soil management effects on soil properties and vegetable production on an Aridisol. All soils were air-dried and carefully passed through a 4 mm sieve without crushing to minimize destruction of natural soil aggregation. The soils were incubated following the procedures outlined in the Solvita protocol with a modification to the adjustment of soil moisture content. All soils were adjusted 50% water filled pore space immediately prior to incubation. All soils were analyzed for total organic carbon (TOC), total N (TN), hot and cold water extractable C (HWC and CWC, respectively), pH and extractable nutrients. Additionally, a density fractionation procedure was used to separate particulate organic matter into a pool representing free light fraction C (FL-C) and an occluded light fraction C (OL-C).

Table 1. Classification, management type and island location of soils used in the assessment of the Solvita test.

Soil Series and Classification	Management	Island
Wahiawa, very-fine, kaolinitic, isohyperthermic rhodic haplustox	C[a], O[b]	Oahu
Waialua, very-fine, mixed, superactive, isohyperthermic pachic haplustolls	C, O, U[c]	Oahu
Keahua, fine, kaolinitic, isohyperthermic ustic haplocambids	C, O, U	Maui
Pamoa, clayey fragmental, mixed, semiactive, isothermic Aridic Haplustolls	C	Maui
Waimea, medial, amorphic, isothermic Humic Haplustands	C, O, U	Hawaii
Maile, hydrous, ferrihydritic, isothermic Acrudoxic Hydrudands	C, U	Hawaii
Paauhau, medial hydrous, amorphic, isohyperthermic Dystric Haplustands	O	Hawaii
Lualualei, fine, smectitic, isohyperthermic typic gypsitorrerts	C, O, U	Oahu

[a]conventional, [b]organic, [c]uncultivated

RESULTS AND DISCUSSION

In five of the samples, the gel pads used to absorb the CO_2 appeared to have reached their maximum analytical limit as all of their readings read 179.08 ppm. Across the six soil types, the 24- hr CO_2 flush as measured by the Solvita test showed significant differences depending on soil management practices (Fig. 1). The long-term conventional management in the Mollisol, Aridisol, Vertisol and wet Andisol (Udand) produced an average CO_2 flush of 31.6 ppm, which is considered indicative of "low" biological activity according to the interpretation in the Solvita Users Manual (CITATION). The mean CO_2 flush for the seven sites under organic management was 153.6 ppm, which was matched (152.7 ppm) by the mean for the five uncultivated soils. Results of Spearman rank order correlation analysis indicated that the 24-hr CO_2 flush was not related to total organic C in the soil, but highly correlated with the hot water soluble pool of organic C (0.710, $P<0.0005$), which had declined by 44 and 147% in the conventionally managed soils compared to the organic and uncultivated soils, respectively.

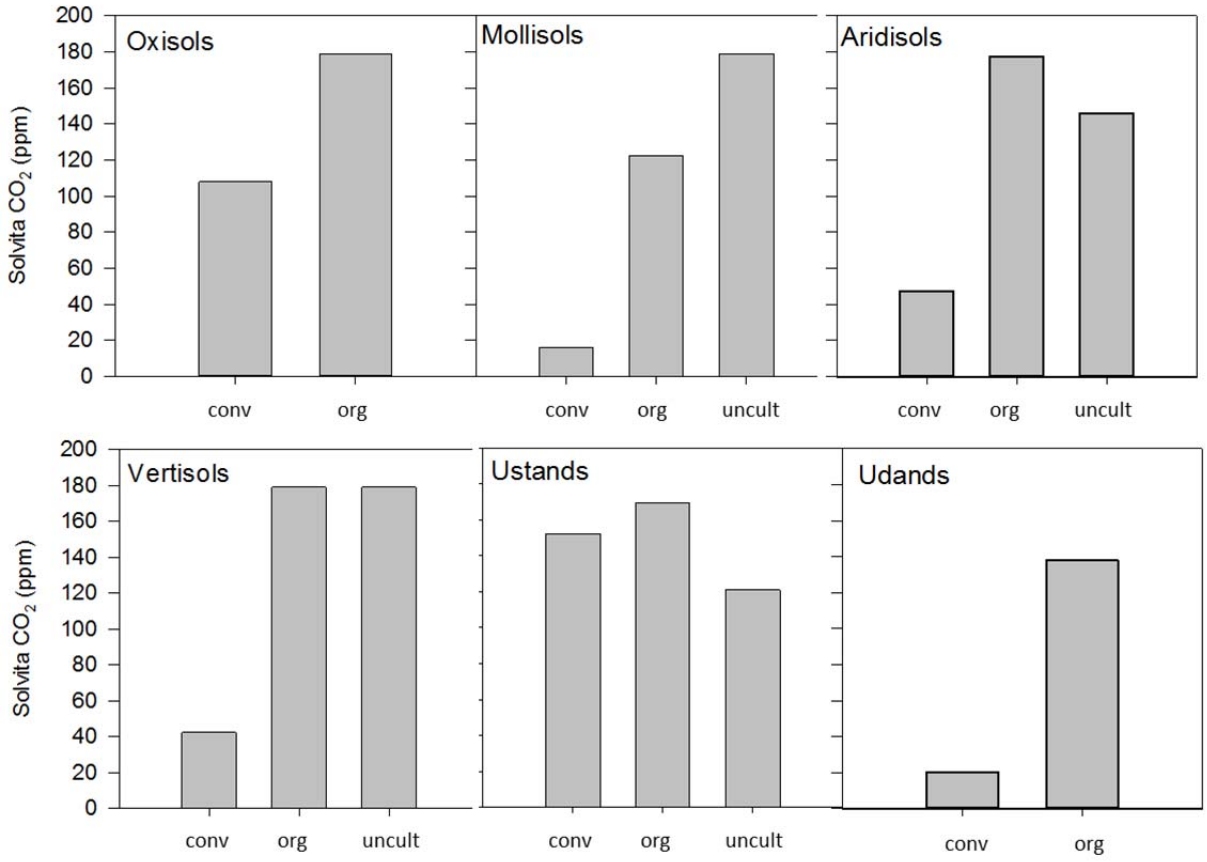


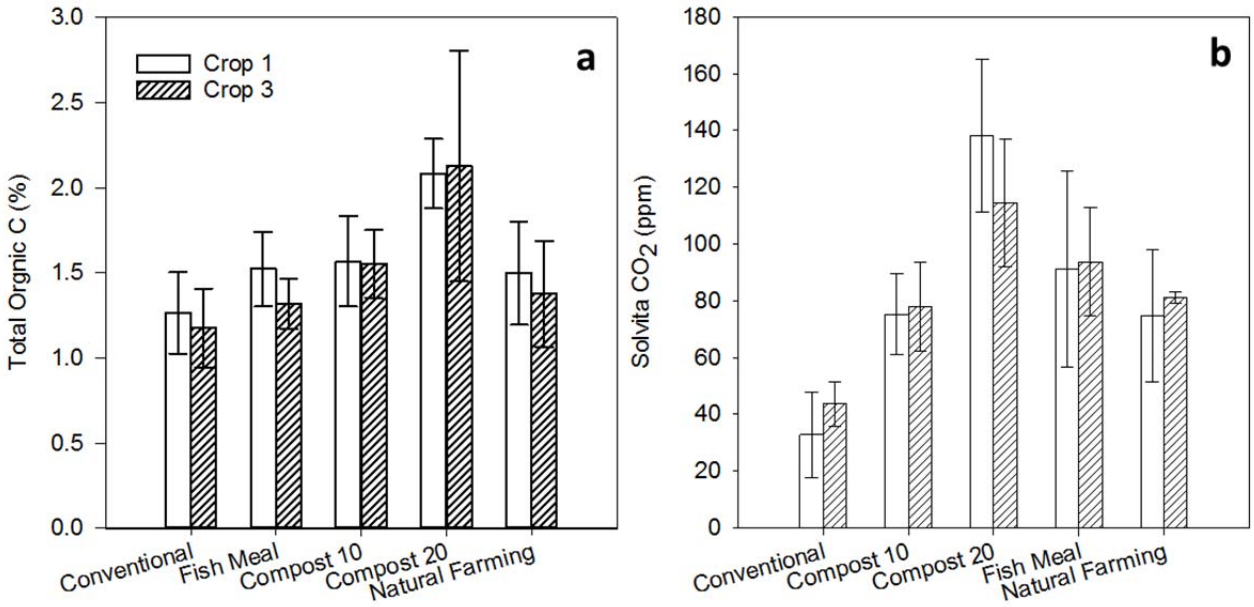
Figure 1. Twenty-four hour CO_2 flush measured by Solvita in five soil orders under conventional (conv), organic (org), and uncultivated (uncult) conditions.

The 24-hr CO_2 flush data presented in Figure 1 demonstrate that the Solvita test is able to detect long-term effects of contrasting soil management effects on biological activity. Currently, soil testing services do not provide methodologies capable of detecting the effects of soil management practices on soil biological activity in the short-term. For example, total organic C is the only parameter used in routine soil testing that can be used to indirectly assess the effect of alternative soil management practices on soil biology. While it may reflect changes in soil biological activity in cases where differences are large due to the effect of time (Table 2), it is not a sensitive enough procedure to detect potential changes in biological activity in the short-term. Data from the controlled field experiment illustrates the limitations of using total organic C

Table 2. The long-term effects of management on total organic C and CO_2 flush.

Soil	Management	Total Organic C (%)	CO_2 Flush (ppm)
Aridisol	Conventional (>30 yrs)	1.66	47.6
	Organic (10 yrs)	2.55	178
Mollisol	Conventional (>30 yrs)	1.40	16.2
	Organic (10 yrs)	1.92	122

to detect short-term effects of introducing alternative soil management strategies. Soil total organic C shows no difference in the effect of organic soil management strategies after 3 crops of lettuce, except when compost was added at 20 T/ca (Fig. 1a). On the other hand, the Solvita test showed significant increases in soil CO_2 respiration after the first crop, which were sustained in the organic treatments through the third cropping cycle compared to the conventional treatment (Fig. 2b). The elevated flush of CO_2 in the treatments receiving organic amendments indicate elevated biological activity.



CONCLUSION

Including a routine test for soil biological activity in commercial testing has been elusive. The results presented in this preliminary study suggest that the 24-hr CO_2 flush shows promise in assessing alternative management effects on soil biological activity in the long and short-term. Including this rapid test as part of a routine soil test provides a more holistic assessment of the soil. Future research includes relating the 24-hr CO_2 flush to plant productivity, in-season plant N availability, and soil microbial community composition.

REFERENCES

Franzluebbers, A.J. 2016. Should soil testing services measure soil biological activity? Agric. Environ. Lett. 1:150009 doi:10.2134/ael2015. 11.0009.