MODIFIED SOIL SAMPLING TECHNIQUE TO QUANTIFY CARBON SEQUESTRATION IN ALLOPHANIC SOILS UNDER KIWIFRUIT MANAGEMENT SYSTEMS

M Hasinur Rahman, Allister W Holmes, Markus Deurer, Steven J Saunders, Alistair Mowat and Brent E Clothier

The Carbon in Orchard Soils Team (COST), Plus Group Ltd., Horticulture Innovation Centre, Newnham Park, Te Puna, Tauranga, New Zealand
Corresponding author's e-mail: technical@plusgroup.co.nz

Abstract

Because of differences in soil types as well as different research aims there is no specific strategy for the collection of soil samples for laboratory analysis. Having a simple and precise method to accurately measure the soil bulk density is necessary to determine the rate of carbon sequestration in soil. This will help to understand the potential role of soil in climate change mitigation. The present study was therefore undertaken to introduce a new, less invasive technique for measuring soil organic carbon (SOC) of a low bulk density soil (Andisol: Allophanic soils) to 100 cm depth accurately, quickly and inexpensively; and to evaluate how the new technique compares to digging a large pit to measure carbon stocks in allophanic soils. The advantages and disadvantages of the new technique are also discussed. Soil was collected from kiwifruit orchards using the existing method of opening a pit 1.5m x 1.0 m, a technique that causes much disruption to the orchard and is likely to limit the orchards that are available for sampling; and by the new modified technique of digging a small hole in order to collect both undisturbed and disturbed samples, respectively. Results show that the bulk density (BD) and concentration of soil organic carbon (SOC) were higher in wheel tracks followed by grass alley and the lowest was in plant (vine) row in all depths irrespective of methods. Regardless of sampling position, the bulk density showed slightly higher value measured by the new technique as compared to the existing method. Soil organic carbon measured by different techniques did not show any significant differences. The variation in SOC stock was highest in grass alley and lowest was in vine row measured by two methods. Regardless of sampling position, the average variation between two methods for SOC stock in 0-100cm depth of soil profile was very negligible.

Introduction

To characterise soils it is important to follow a suitable sampling design with precise techniques. Bulk density of soil is used to calculate porosity, pore-size distribution, void ratio, hydraulic conductivity and three phase composition. In order to measure all these properties, it is necessary that undisturbed soil samples are collected. The BD value is then used to convert percentage soil moisture and carbon by weight to a weight per unit volume. The determination of bulk density consists of drying and weighing of a soil sample collected in a core of known volume, or must be determined by the clod and excavation method. In order to use these different methods, the soil sample must be collected and its volume determined in different ways. Using the radiation method, transmitted or scattered gamma radiation is measured and with suitable calibration, the density of the combined gaseous-liquid-solid components of a soil mass is determined. In this system a correction factor is then employed to remove the components of density attributable to liquid and gas that are present

(Blake and Hartge, 1986). Using the core method to collect undisturbed samples from deeper in the soil profile the opening of a pit is highly recommended. The existing core method of obtaining undisturbed soil samples suitable for bulk density (BD) measurement is time-consuming, laborious, expensive, and also few growers are willing to have such a distruptive methodology carried out on their property. This study was undertaken to compare a new, less invasive technique for measuring soil organic carbon (SOC) of a low bulk density soil (Andisol: Allophanic soils) to 100 cm depth accurately, quickly and inexpensively; and to evaluate how the new technique compares with digging a large pit to measure carbon stocks in Allophanic soils.

Material and Methods

Soil was collected from kiwifruit orchards by the existing method of opening a pit 1.5 m x 1.0 m,; and by the new modified technique of digging a small hole for undisturbed and disturbed samples, respectively. The samples were the collected using the core method (Blake and Hartge, 1986) in the open pit and modified method (new technique) from four depths (0-10, 10-30, 30-50 and 50-100 cm) within 5 m distance with forty eight replicates from three positions e.g. grass alley, wheel track and vine row to provide information on vertical and spatial variations as well as provide sufficient representative samples. Soil bulk density was measured at pF 2.0 from undisturbed soils. Soil organic matter was measured by LOI and total organic carbon stock was estimated (Rahman et al., 2010).

Results and discussions

Results show that the bulk density (BD) and concentration of soil organic carbon (SOC) were highest in the wheel tracks, then the grass alley and the lowest was in vine row in all depths irrespective of the method of sample collection. Regardless of sampling position, the bulk density showed slightly higher values with the coefficient of variations of 3.04, 3.53, 2.57 and 5.72 % for depth of 0-10, 10-30, 30-50 and 30-90 cm, respectively, measured by the new technique as compared to the existing method (Table 1).

Table 1. Bulk density of soils collected by two techniques.

Depth cm	Position							
	Grass alley		Wheel track		Vine row		Average	
	Old	New	Old	New	Old	New	Old	New
0-10	0.83	0.86	0.83	0.87	0.81	0.85	0.82	0.86
10-30	0.85	0.88	0.85	0.89	0.83	0.88	0.84	0.88
30-50	0.86	0.88	0.84	0.89	0.80	0.82	0.83	0.86
50-100	0.81	0.85	0.82	0.87	0.79	0.90	0.81	0.87

Soil organic carbon measured by different techniques did not show any definite trends (Table 2).

Table 2. Organic carbon concentration of soils collected by two techniques.

Depth cm	Position							
	Grass alley		Wheel track		Vine row		Average	
	Old	New	Old	New	Old	New	Old	New
0-10	7.58	7.60	8.30	8.06	7.33	7.47	7.73	7.71
10-30	4.88	4.97	5.49	5.47	4.69	4.84	5.02	5.09
30-50	3.33	3.41	3.64	3.80	3.01	2.92	3.32	3.38
50-100	1.72	1.50	1.75	1.53	1.37	1.24	1.61	1.53

The variations in SOC stock were 2.33, 2.93 and 1.25% for grass alley, wheel track and vine row, respectively, measured between two methods (Table 3). Irrespective of position, the values for SOC measured by the new technique were 0.38 % and 5.54 % higher compared to the old method in the depth of 0-10 cm and 50-100 cm, respectively. However,, the values for SOC stock were 1.46 % and 1.56 % lower in the depth of 10-30 cm and 30-50 cm, respectively.

Table 3. Organic carbon stock of soils collected by two techniques.

Depth cm	Position							
	Grass alley		Wheel track		Vine row		Average	
	Old	New	Old	New	Old	New	Old	New
0-10	63.20	63.33	69.08	67.11	59.34	60.47	63.88	63.63
10-30	83.33	84.80	92.73	92.42	77.55	80.13	84.54	85.79
30-50	56.96	58.32	61.02	63.84	48.20	46.64	55.39	56.27
50-100	69.47	60.56	71.81	62.90	54.05	48.96	65.11	61.69
0-100	273.0	269.0	294.6	290.9	239.1	242.2	268.9	267.4

Regardless of sampling position, the average variation between two methods for SOC stock in 0-100 cm depth of soil profile was 0.58%.

Conclusions

Our findings show that it is possible to use the new modified method to accurately determine SOC and BD, rather than the traditional time-consuming and hugely disruptive pit methodology. Using the new methodology will allow soil sampling to occur on a wider range of soil properties and crop types, to determine many variables including SOC and nutrient status of soils, and allow BD to be determined to calculate results on a per hectare basis. Our new method allows the collection of undisturbed soil samples from any depth range in a diagnostic horizon, which definitely reflects the appropriate results for any soil properties measured. The new modified method will enable significant time, and therefore cost savings in the collection of soil samples to determine bulk density and other associated soil properties. In the course of a single study we estimate the use of this method has saved about 1400 man hours.

References

Blake, GR and KH Hartge. 1986. Bulk density. In Methods of Soil Analysis, Part 1: Physical and Mineralogical Methods, 2nd Edition. Ed. A Klute, SSSA Book Series 5, Madison Wisconsin, USA. pp. 363-375.

Rahman, MH, AW Holmes, AG McCurran and SJ Saunders. 2010. Carbon sequestration in kiwifruit soils of New Zealand. 19th World Congress of Soil Science: Soil Solutions for a Changing World, Brisbane, Australia pp. 66-69.