Understanding Spatial Variability Measuring and Monitoring Soil Carbon

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Introduction

Quantifying soil C presents a number of challenges, many of which associated with the high degree of spatial and temporal variability. New *in situ* methods, using soil probes and field measuring devices such as near-infra-red spectroscopy (NIRS) and other spectrographic methods, offer hope for more rapid, non destructive and less expensive measurements in the future. At present, however, these new technologies are not yet at an operational stage for widespread monitoring of soil C stocks.

Objectives

Our objective was to characterize soil carbon vertically and horizontally. Evaluate NIRS as a tool to measure soil carbon

Materials and Methods

5-8 locations per field were identified using either a soil electrical conductivity (EC) or NIRS map as having similar soil properties within a 3-4 m distance. At these locations, three soil profiles were sampled at an equal distance of 3 m. Each soil type was represented with at least one geo-referenced triangle. 0-75 cm profiles were collected using a hydraulic probe, and NIR/EC/force probe. At each corner of the triangle, one 0-75 cm core was retained in a plastic liner for future analysis, and one 0-75 cm core was segmented into 0-5, 5-15, 15-30, 30-45, 45-60 and 60-75 cm segments.

- Fields were mapped at 6 cm depth using Veris NIR (500-2200 nm) Spectrophotometer shank (Fig.1). The system collects NIR measurements through a sapphire window pressed directly against the soil, at a rate of 20 spectra/second with an 8 nm resolution. The field was mapped on 20 m transects at 8-10 km/hour. The system was also equipped with a soil EC mapping system, logging bulk soil EC from the 0-30 and 0-90 cm depths at 1 Hz.

- Fields were probed to 60 cm depth with Veris NIR Spectrophotometer Probe (Fig.2) utilizing the same spectrometers and sapphire window methodology as the shank unit. It has a force sensor to measure insertion force. Insertion speed was 2.5 cm/second.

Fig.1 Veris NIR Spectrophotometer (Shank)

Fig.2 Veris NIR Spectrophotometer (Probe)

Analysis

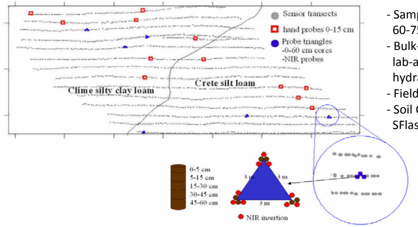

Fig.3 Sampling design and methodology

- Sampling depth: 0-5; 5-15; 15-30; 30-45; 45-60; 60-75 cm
- Bulk-density determined by layer from lab-analysis of cores collected with Geoprobe hydraulic probe
- Field NIRS measurement
- Soil C by dry combustion (Thermo-Finnigan SFlash EA 1112)

Results

Variability within and across field was evaluated through the use of Minitab regression procedures and Proc Mixed from SAS 9.1.

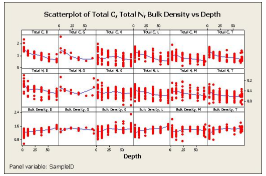

Fig.4 Changes in soil C (%), N (%) and bulk density (g cm^{-3}) as influenced by depth for different fields: (D)-Drummonds; (G)-Gypsum; (K)-Kerj; (L)-Lund; (M)-Markley; (T)-Tarn. Changes in soil C with depth followed the expected decreasing trend. The decline was however most pronounced for the Drummonds and Lund soils. Bulk density increased with depth.

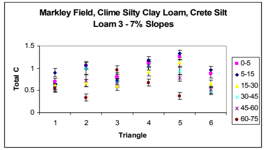

Fig.5 In field variations of soil carbon. The six triangles correspond to 18 geo-referenced sample locations. Triangles 1-3 representing the Clime soil had similar soil C. Triangles 4-6 representing the Crete soil showed much greater variability in soil C. The error bars represent the standard error.

Results cont.

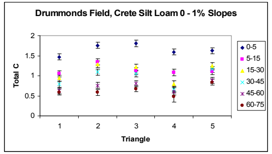

Fig.6 Soil C contents of five triangles, the five triangles correspond to 15 geo-referenced sample locations. The soil C content of the five triangles within the same soil type were fairly homogeneous in this field. The error bars represent the standard error. All triangles are within the same soil type (Crete silt loam).

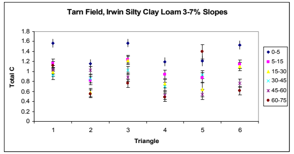

Fig.7 Variations of soil C contents in six triangles, the six triangles correspond to 18 geo-referenced sample locations. The soil C content between the six different triangles within the same soil type showed greater variability in this field/soil type than the Drummonds field. The error bars represent the standard error. All triangles are within the same soil type (Irwin silty clay loam)

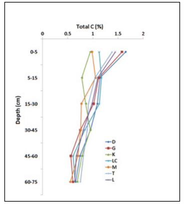

Fig.8 Vertical variations in soil carbon content for the various fields. Much of the variation in soil C between soils types occurred in the top 30 cm.

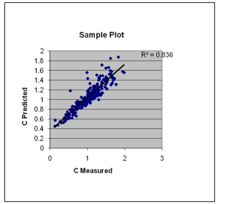

Fig.9 Carbon predicted by NIRS and measured by dry combustion.

Summary

- Soil C varied considerably in some fields even with a similar soil type. However in some fields, soil C had low spatial variation. Most of the variation occurred in the surface 30 cm.
- Small (3 m triangles) geo-referenced sampling points reduced spatial variation.
- Surface measurements of soil C by NIR provided a quick assessment of soil C with an R^2 of 0.836.
- The shank NIRS system provided a rapid method of mapping soil C on a field scale.
- Further research is required to better understand the drivers for spatial variability of soil. Soil type may help stratified sampling but does not always explain the spatial variability.

Acknowledgements

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