MALLEE CATCHMENT
TECHNICAL BULLETIN

Technical Bulletin #21

Quantifying and classifying soil carbon in Mallee soil

Above: Setting up a sampling grid with 10 sampling locations. Photo: DPI.

This technical bulletin summarises the findings of a soil sampling and analysis program conducted in 2010 to quantify the potential for increasing soil carbon in Mallee soils.

Contemporary management practices implemented by many Mallee farmers are thought to have the potential to increase the quantity of soil carbon. The project sampled and tested 62 sites within the Central Mallee land system for their Soil Organic Carbon (SOC) status. The historical paddock management information for each site was also collected to assess if the adoption of farming practices such as no-till, stubble retention and intensive cropping does in fact improve carbon levels in Mallee soils. If particular practices improve carbon levels, farmers may be able to make a positive contribution to future carbon trading schemes. Conversely, farmers also need to be aware of practices that reduce soil carbon.

Background

SOC is essential for soil health as it contributes to biological, chemical and physical functions of the soil. The role that soil carbon plays in the function of a healthy soil is illustrated in Figure 1.

At a glance

- Soil Organic Status (SOC) of 62 sites within the Central Mallee land system were tested to assess if particular management practices have the potential to increase soil carbon levels;
- Stocks of SOC are relatively low, with more than 50% of the SOC in the top 30cm of soil located within surface layer (0-10cm), making it vulnerable to losses through decomposition and/or directly through erosion;
- The potential for increasing SOC in these soils is quite small with a farmer only needing to sequester some 10t SOC/ha to move from the bottom 10% to the top 10% of SOC stocks measured;
- While improved farming systems may not be able to greatly improve carbon levels, they may however have an important role in arresting the decline in SOC levels that may be still occurring from clearing.

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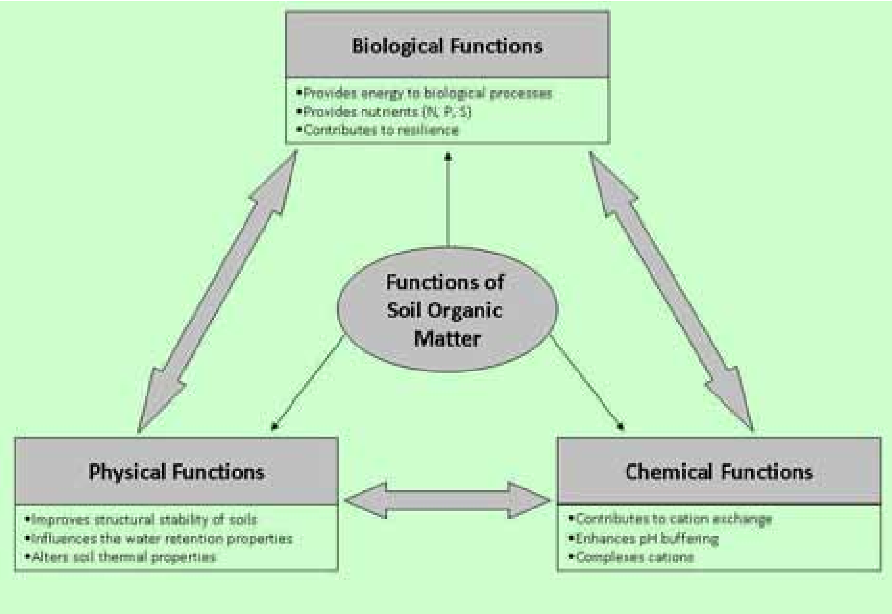

Figure 1: Functions performed by organic matter in soils. The thin black arrows identify the links between soil organic matter (carbon and its associated nutrients) and the soil properties that it contributes to. The thicker grey arrows indicate the potential interactions and dependencies between the various soil properties that organic matter (carbon) influences. Figure redrawn from Baldock et al.(2009).

SOC is made up of four biologically significant fractions:

- Crop residues
- Particulate organic carbon
- Humus
- Recalcitrant organic carbon

Each SOC fraction differs in its stability and biological availability and therefore has different functions in the soil. Particulate organic carbon is also broken down relatively quickly (but slower than crop residues) but is important for building soil structure, providing energy for biological processes and supplying nutrients. The humus fraction plays a key role in all soil functions and is especially important for the provision of nutrients. Available nitrogen is principally derived from the humus fraction. However, unlike the first three SOC fractions, recalcitrant organic carbon decomposes very slowly and does not have a significant role in soil function. Furthermore, many Australian soils have high levels of the recalcitrant SOC pool due to the presence of charcoal derived from historic burning of the landscape. Through linkages with a national Soil Carbon Research Project (SCaRP) this project was able to rigorously investigate organic carbon in Mallee soils, including measuring SOC in terms of total quantity and its various fractions.

Table 1: The potential of altering farm management practices to sequester SOC (Summarised from *Sanderman et al.* (2010).

Nil - Low	Low - Moderate	High
Increase water use efficiency; Increase nutrient use efficiency; Fertiliser application; Stubble retention; Reduced, minimum, zero tillage.	Replace fallow with crop; Increase proportion of pasture; Pasture-Cropping.	Import organic matter; Replace crops with perennial pasture; Retirement of agricultural land.

The potential to sequester soil carbon

The ability to sequester SOC is determined by the balance of carbon inputs and losses from the soil. Increasing carbon inputs is generally a result of improving the productivity of crops and pastures. Therefore fertiliser application, better rotations, new varieties and increased crop intensity can increase the quantity of crop residues that are returned to the soil. Inputs can also be enhanced by retaining plant residues through stubble retention, reduced tillage and modifying of grazing practices. Management practices such as cultivation, fallowing, stubble burning, and overgrazing can accelerate the decomposition of SOC, significantly reducing the level of carbon in the soil.

A recent review by the CSIRO (*Sanderman et al. 2010*) of the potential for soil carbon sequestration in Australian agriculture found SOC levels reduced over time and concluded that SOC levels may still be in a state of decline from the initial clearing and cultivation of the native soil. Improved management practices do have the potential to improve SOC in relation to the conventional management practice, but this increase is not enough to arrest the initial decline in SOC.

Relatively minor shifts in management practices will in most cases have only minor impacts on SOC levels; therefore, more radical management interventions are required (Table 1). National and local trial results suggest that a higher frequency of ley- pastures is likely to have the greatest potential to maintain or build SOC in Mallee farming systems. However, it is likely that this will be at odds with farmer productivity and profitability. When considering changing management practices for the purpose of carbon sequestration, the consequences on a secondary processes such as erosion must also be considered as this can also have a big impact on carbon losses.

Methodology

SOC was measured at 62 sites within the Central Mallee land system along a transect from the Victorian/South Australian boarder (near Murrayville) in the west, to Piangil in the east. The sites were randomly selected using a combination of Landsat Normalised Differential Vegetation Index (NDVI) imagery and the Mallee CMA Disaggregation of the Central Mallee and Hopetoun Land systems using the Digital Elevation Model (2009).

Soil cores were extracted at 10 sampling locations at each site and divided into depth increments of 0-10, 10-20, 20-30 and 30-40cm (Figure 2). Samples were analysed at CSIRO Adelaide through SCaRP. Total Organic Carbon

Figure 2: 0-40 cm soil cores extracted during sampling. Photo: DPI.

(TOC) was determined using the Acid Pre-treatment Dry Combustion LECO method. TOC, Particulate Organic Carbon (POC), Humus and Recalcitrant Organic Carbon (ROC) were also predicated using a Mid-Infra Red spectroscopy. Historical management information was also collected for the previous 10 years (2000–2010).

Results

The average SOC of the 62 sites was 11884kg/ha in the 0-30cm depth layer. The mean of the High NDVI sites was 12894kg SOC/ha which was significantly greater than SOC levels at the low NDVI sites (10874kg/ha). Just over half of SOC was present in the 0-10cm layer; this was the only layer where sites chosen on the basis of NDVI were significantly different.

SOC significantly correlated with other soil factors, the strongest being a positive correlation with mid infrared (MIR) iron and negative correlations with MIR silicon and bulk density. Analysis of variance with NDVI group as the treatment factor showed that it was significantly related to differences in many soil parameters. Although it was initially thought that NDVI would provide a robust method of picking differences between plant productivity (and therefore carbon inputs) due to management factors, it appears that differences in soil type have a significant role in the NDVI classification at each site.

There is little evidence from the data to suggest that management factors have had an impact on total SOC levels, but SOC was found to increase with increasing cereal yields. Paddocks with higher yielding cereal crops tend to have higher total carbon, nitrogen and SOC, but it is impossible to say whether management is causing the difference, or whether both higher yielding/more frequent cropping and improved soil carbon are both responding to the same underlying soil factor. The other management factor to have a significant impact on soil parameters was the nature of stubble management. In paddocks with more stubble retention, the ratio of SOC to nitrogen widened.

Table 2: Mean, 10th percentile, median, 90th percentile and the standard deviation of SOC for High and Low NDVI sites, across all depths and for individual depths. Photo: DPI.

kg SOC/ha (0-30)cm Layer)					
NDVI class	Mean	10th Percentile	Median	90th Percentile	Standard Deviation
High	12894(a)	8863	12091	17724	2149
Low	10874(b)	8044	10459	13415	3223
0-10cm layer					
High	6594(a)	5094	6616	8399	1327
Low	5288(a)	3856	5371	6437	1159
10-20cm layer					
High	3599	1829	3552	5223	1379
Low	3048	1767	2723	4839	1284
20-30cm layer					
High	2701	1484	2331	4127	1162
Low	2538	1182	2101	4165	1561

Letters indicate significant difference between means.

Implications of the Findings

The data from the sampling program highlights that stocks of SOC are relatively low, with more than 50% of the SOC in the top 30cm of soil located within surface layer (0-10cm). Therefore, the majority of SOC is vulnerable to losses through decomposition and/or directly through erosion. Both of these carbon loss pathways can be highly influenced by the management practices implemented.

The range of SOC suggests the potential for increasing SOC in these Mallee soils is quite small. A farmer would only need to sequester approximately 10t SOC/ha to move from the bottom 10% to the top 10% of SOC stocks measured.

The literature and local trial data suggests that management practices that local farmers are adopting such as no-till, stubble retention and intensive cropping do not have a great potential to increase SOC stocks. They may however have an important role in arresting the decline in SOC levels that may be still occurring from clearing and which has been shown to occur under conventional farming systems.

Although the data collected during this project does not support this view, it is possible that the short time which these management systems have been used has not allowed changes to be seen in SOC levels.

The literature also suggest that increasing the intensity of ley-pasture in the rotation has the greatest SOC sequestration potential ; however the local experience is that farmers are reducing the role of ley-pastures in their farming systems. Therefore, if the only consideration is to sequester SOC for carbon trading purposes, a price for carbon needs to be quite high to increase the profitability of this management option.

Further Work

One of the aims of this project was to investigate the levels of the different fractions (POC, humus, ROC) of SOC in Mallee soils. While this has been completed, the estimated values for TOC, POC, humus and ROC have been derived from the acquired MIR spectra using generic algorithms which do not fit the range of Mallee soils sampled in this project. Ongoing work within the national SCaRP is aiming to improve MIR predictions of carbon fractions and results will be available once complete.

The Victorian node of the national SCaRP is continuing to collect data through the wider Mallee region and across different soil types, ensuring that the region is well represented in any analysis of SOC levels nationally.

Acknowledgements

Mallee Sustainable Farming (MSF) undertook this project with funding from the Federal Governments 'Caring for our Country' initiative, administered by the Mallee CMA.

Project support was also provided by:

- Victorian SCaRP team - assistance in data collection and sample processing
- National SCaRP team - soil analysis
- Farmer participants – property access and the provision of historic paddock information.
- Mallee CMA community support officers - assistance in identifying landowners of selected sampling sites.

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Further Information

The information for this bulletin has been taken from: *Quantifying and Classifying Soil Carbon in Mallee Soils* – a report for the Mallee CMA by Mallee Sustainable Farming. A copy of this report can be downloaded from the Mallee CMA website: **www.malleecma.vic.gov.au**

Project Partners

Published December 2011