

Soil organic carbon in WA agricultural soils

FC Hoyle and A Bennett, Department of Agriculture and Food, Western Australia

KEY MESSAGES

- While soil type defines the potential amount of carbon a soil can store; in reality this potential is rarely reached because climate, soil and biological constraints interact to limit the amount of plant biomass that ends up as soil organic carbon.
- It is important to realise that not all soil organic carbon is the same—with the total soil organic pool composed of labile (easily decomposed) through to very stable pools. While it is relatively easy to increase the labile component of soil organic carbon, the short-lived nature of this pool means that it can take many years to lift a soil's total organic carbon to a new and stable level.
- The labile carbon pool plays a very important role in soil health in terms of biological activity and nutrient cycling.
- If soil carbon were included within an emissions trading scheme, land holders would be obliged to account for both the CO₂ emissions and the N₂O and CH₄ emissions arising from their land management practices.

INTRODUCTION

Carbon generally makes up about 50% and nitrogen between 0.5 and 10% (depending on residue type) of the molecules in organic matter; some of which are readily available and turn over rapidly (labile fraction), while others are more recalcitrant and contribute to the more stable (passive, slow fractions) organic matter pools. Soil organic carbon (SOC) is either capable of decay or is the product of decay and can be defined as fractions that vary in size, composition, ease of decomposition and age. In addition to the coarse material or residues greater than 2 mm commonly found on and in the soil surface, three SOC fractions or 'pools' should be considered in soil:

1. The 'resistant' SOC fraction is the most biologically stable and dominated by char type material. It is the largest pool of SOM and the least likely to be influenced by changes in management practice as it can take more than thousands of years to turn over.
2. The 'humus' fraction, with a turnover rate of 20–40 years, consists primarily of organic compounds less than 0.053 mm that are either resistant to decomposition or physically protected. Soil manipulations, such as tillage, that decrease the structural integrity of soil aggregates can influence the turnover of this pool by exposing previously protected SOM to microbial decomposition.
3. The 'particulate' SOC fraction consists of smaller pools of more labile carbon and is readily utilised by microorganisms. This active fraction originates from new residues and living organisms (including micro-organisms), is smaller than 2 mm but greater than 0.053 mm and turnover generally occurs within 2–3 years (sometimes within hours).

THE ROLE OF SOIL ORGANIC CARBON

Soil organic carbon is central to the functioning of many physical, chemical and biological processes in the soil ecosystem including the decomposition of plant/animal residues, nutrient transformation, soil structural stability, moisture retention, degrading pollutants, greenhouse gas emissions and soil buffering. Soil biota use SOC as an energy source, cellular building block and as nutrients for their growth and metabolism when they break down organic matter. In doing so, they release between 50 and 75% of the carbon in organic matter as CO₂—contributing to greenhouse gas emissions. The optimum amount of SOC required in any particular soil is difficult to quantify because each function may require different amounts and types of SOC. The carbon balance in soils is a net result of the inputs and losses, with a negative balance inferring loss of soil carbon.

To sequester carbon in soil, CO₂ must be removed from the atmosphere (usually through plant photosynthesis and biomass production) and stored for long periods of time, i.e. must be considered stable. The amount of SOC able to be stored is normally limited by soil type, climatic conditions and soil management. Due to higher clay content, heavier soils are generally able to physically protect SOC from decomposition and well aggregated soils can protect SOC from losses due to erosion. In

contrast, a more rapid turnover of SOC occurs in sandy soils with little or no clay content. Newly incorporated organic material is also about seven times more decomposable than inherent SOC. Therefore only a relatively small proportion of the carbon contained in fresh organic residues contributes to the more stable soil carbon pools.

MANAGEMENT OF SOIL ORGANIC CARBON

Extreme climatic conditions or episodic events (e.g. drought, disease) prevent farmers from improving SOC status because there is less organic input—providing a real challenge within rainfed agricultural systems. However, there are many options within current farming practices that help increase or stabilise soil organic carbon. These include growing high yielding, high biomass or high frequency crops in rotation that maximise organic matter production, whilst maintaining soil structural integrity.

Practices that can help build SOC include the management of soil constraints that limit plant growth and biomass production, the introduction of perennial and phase pasture systems, stubble retention, grazing management, green manuring, and the use of animal manures or other organic amendments (e.g. compost). It is also important to recognise the potential loss pathways. For example, a single erosion event can remove topsoil that may take years of good management to replace, whilst cultivation can increase the rate of loss of SOC through the breakdown of soil aggregates. Practices which can also deplete SOC include residue burning or removal, soil erosion, fertility decline, overgrazing, and low biomass crops.

Soil properties are often closely interlinked and thus many of the management practices which seek to improve crop productivity will also help in increasing SOC. **Thus, the management of carbon can easily be promoted within the context of retaining both a profitable and viable farming system.**

EMISSIONS TRADING AND AGRICULTURE

Agriculture accounts for 16% of Australia's emissions. Of the 16% (90 Mt), 77% is from methane which has a global warming potential 21 times that of carbon dioxide and 23% is from nitrous oxide with a global warming potential 310 times that of CO₂.

The Australian Government has indicated a preference to include agriculture emissions in the proposed Carbon Pollution Reduction Scheme (CPRS) by 2015 with a final decision on this to be made in 2013. If agriculture is included in the proposed emissions trading scheme (ETS), the White Paper indicates a preference for a removed point of obligation for emissions reporting. If agriculture is not included the government will consider alternative mitigation measures for the sector.

Domestic offsets, such as improvements in production practices or increased carbon stored in soil, will be considered for inclusion in 2013, along side the decision for agriculture. The scheme will not include domestic offsets from agriculture emissions in the period prior to coverage of these emissions. However, voluntary markets exist for those people who are not covered by the CPRS or those who wish to undertake additional action to reduce emissions. This may present opportunities for agriculture to trade into the voluntary market. There are some difficulties in covering the agricultural sector in the CPRS such as the diffuse nature of emissions and sinks from agriculture, the diversity in climates and production systems, and the costs associated with compliance and auditing. If agriculture was to be included in an ETS, it would require whole systems accounting including CO₂, N₂O and CH₄. Livestock producers are likely to be the most affected if covered by the CPRS.

A number of questions therefore remain in relation to carbon offsets in agriculture and many of the opportunities and risks are unknown at this point in time. With the reality of slow accumulation of carbon in soils, can land managers economically justify modifying their management practices to farm carbon and what are the associated risks with doing so? **Regardless of carbon trading issues, good farming practices that increase productivity will produce financial rewards and should result in enhanced soil carbon levels.**

KEY WORDS

soil organic carbon, emissions trading

Paper reviewed by: Janet Paterson