CARBON FARMING

FACT SHEET

GRDC
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Store carbon for healthy soils and better yields

Maintaining and increasing the level of organic carbon in the soil will have benefits in terms of maximising water-holding capacity and crop productivity but farmers should not expect large returns from carbon credits.

KEY POINTS

- Increase soil organic carbon (SOC) by retaining crop residues, green manuring or cover cropping and reducing stocking rates on cropping paddocks.
- Changes in SOC are often slow, but continual productivity growth and retention of residue carbon should contribute to increased SOC levels over time.
- At current price estimates for sequestered carbon, changing management solely to sell carbon credits would be hard to justify.

Role of carbon in the soil

Soil organic carbon (SOC) contributes to a variety of soil functions, which interact to influence crop production (see Figure 1). For example, soil biota obtains energy for growth and reproduction from the break down of carbon bonds in organic matter, which in turn contributes to improved soil structure. SOC also contributes to cation exchange, nutrient turnover and pH buffering.

A decline in soil organic carbon often has a negative effect on soil structure and fertility, increasing run-off and reducing yields.

Increasing organic matter will maintain or improve soil structure, soil water balance and the productivity of soils over time.

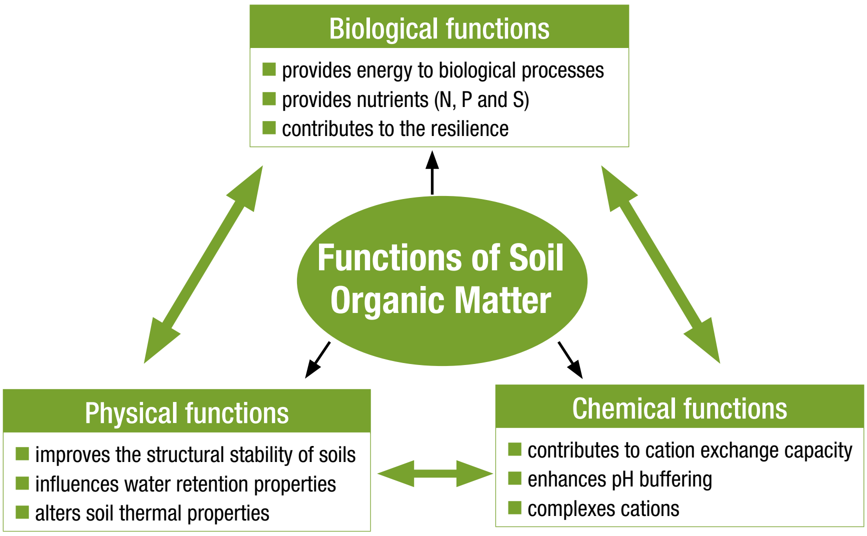
How is carbon stored in the soil?

The amount of carbon in a soil results from the balance between inputs (plant residues) and losses (microbial decomposition and mineralisation).

Organic carbon exists in the soil in fractions or ‘pools’. Some of these are readily available and turn over rapidly (that is, are more labile), while others are more stable and break down slowly. The higher the labile component

The key to maintaining and increasing soil organic carbon is to grow heavy crops and retain crop residues evenly across the paddock.

FIGURE 1 **FUNCTIONS PERFORMED BY ORGANIC MATTER PRESENT IN SOILS**



per year. Avoid excessive tillage at the end of the pasture phase or much of the added soil organic matter will be rapidly depleted.

Savings from carbon – fact or fiction?

Plant photosynthesis and biomass production are key processes involved in removing carbon dioxide from the atmosphere and potentially capturing it within the soil.

Australian soils could potentially store more SOC but achieving this goal while maintaining an economically viable farm enterprise remains a challenge.

Reduced tillage trials have shown a gain of 0.1 to 0.2t carbon per hectare per year may be possible in the northern grain belt.

At current estimates of $10 per tonne of sequestered carbon and the slow potential rates of SOC change, it will be hard to justify modifying management practices solely for the purpose of selling carbon credits.

If carbon offsets were valued at $20/tonne of carbon, then the payments would be $2-3/ha and likely to be less than the cost of monitoring and administering a carbon credit program.

At this stage, carbon credits should be considered as a secondary benefit that may be realised while attempting to enhance soil productivity by building soil carbon content.

Biochar

Biochar is a fine-grained charcoal high in organic carbon. Applied to soil, most types of biochar take hundreds of years to degrade and release carbon. It is produced by heating organic matter, such as crop waste, wood chips or manure in the absence of oxygen – a process known as pyrolysis. Biochar differs from ordinary charcoal in the way it is produced – in an oxygen-reduced, very controlled environment, with greater carbon capture and co-production of biofuel that can be used for energy. Whereas charcoal is only derived from plant material, biochar can be derived from a number of materials, including animal manure.

In terms of agriculture, biochar is attracting attention due to the apparent benefits it offers to soil quality, crop yield and as a method of sequestering carbon in the soil. Some of the reported benefits include enhancing soil fertility and increasing microbial activity but as much of the research is preliminary, more research is needed under Australian conditions to determine any real benefits.

Biochar added to soil contributes to the resistant organic matter pool, which is important for carbon sequestration. Adding biochar to soil may benefit crop production →

Removal of crop residues by burning or baling results in a decline in soil carbon.

TABLE 1 FOUR ORGANIC MATTER FRACTIONS HAVE BEEN IDENTIFIED. THESE HAVE A RANGE OF FUNCTIONS

Organic carbon fraction	Key functions
Crop residues – this is material greater than 2mm found in the soil and on the soil surface	These provide energy to soil biological processes and are readily broken down providing soil conditions (moisture, temperature, and oxygen) that favour soil biology.
Particulate organic matter (POM) – again found in the soil and on the soil surface but this material has a size range of 0.05–2mm	In suitable conditions this is broken down relatively quickly but more slowly than crop residues and is important for soil structure, energy for biological processes and provision of nutrients.
Humus – organic matter of unrecognisable structure (molecules) associated with particles <0.05mm	It plays a role in all key soil functions but is particularly important in the provision of nutrients. For example the majority of available soil nitrogen is found in the humus fraction.
Recalcitrant organic matter – this is biologically stable and typically in the form of charcoal	This decomposes very slowly and, if present in large enough quantities, can contribute significantly to soil cation exchange capacity in soils with less than 50% clay, as well as in controlling soil temperature.

of the total soil organic matter pool, the higher the biological fertility status of the soil (Table 1).

Most organic matter pools (apart from charcoal) decompose over years or decades and need to be replaced by fresh litter to maintain soil carbon levels.

As SOC decomposes the size of the particles decreases, residues become more nutrient rich and turn-over time increases from hours to days to decades to hundreds of years.

The amount of organic carbon results from the balance between inputs (plant and animal residues and off-farm inputs) and losses (mineralisation of SOM resulting in evolution of carbon dioxide, erosion and product removal).

The potential amount of organic carbon the soil can hold varies with factors such as clay content, soil depth and climate. For example, sandy soils can hold less SOC than clay soils (see Figure 2) and there is less in lower rainfall areas.

To build up SOC to its potential (determined by soil type and climate) under a managed cropping or grazing system, high levels of production need to be maintained and the removal of plant residues minimised.

Changes in soil carbon content are slow and measurements over several decades may be needed to define accurately the effects of particular management treatments on SOC content. Measurement of more labile pools can provide an earlier indication of potential longer-term change.

Impact of farming

Soil fertility and SOC in Australian soils have declined over decades of cropping. In many cropping soils organic carbon is still in decline.

In cropping systems the potential to build SOC depends on the capacity to produce large quantities of crop biomass and to return and retain carbon in the soil. Practices such as minimising tillage, retaining not burning or baling stubble and managing soil erosion all help to return or retain carbon in the soil.

Maintaining or increasing SOC is good farming practice. Higher soil organic carbon has benefits for nutrient turnover and improved soil structure, as well as other key soil functions.

While any build up in SOC is beneficial, increasing resource use efficiency and greater profitability of the farm business should be the main aim.

Organic matter levels can be increased or stabilised by growing high yielding, high biomass or a high frequency of crops in rotation. Well-managed pastures are also an effective way of increasing soil carbon.

Management that eliminates residue burning or removal, soil erosion, fertility decline, over-grazing and low biomass crops will help to build SOC levels.

Best practice for building soil carbon

One hundred per cent ground cover, 100 per cent of the time is the carbon farmer's goal. To reduce the risk of erosion, a minimum of 50 per cent ground cover should be maintained in most soils. Other practices for increasing SOC include:

- increase soil moisture capture – to grow bigger crops;
- introduce well managed pasture phases or increase cropping frequency;
- produce high biomass crops and pasture;
- reduce or eliminate tillage;
- retain stubble and crop residues; and
- consider organic amendments.

A grass-legume pasture can build soil carbon levels by more than one tonne per hectare per year, which could lift soil organic carbon by 0.05 per cent

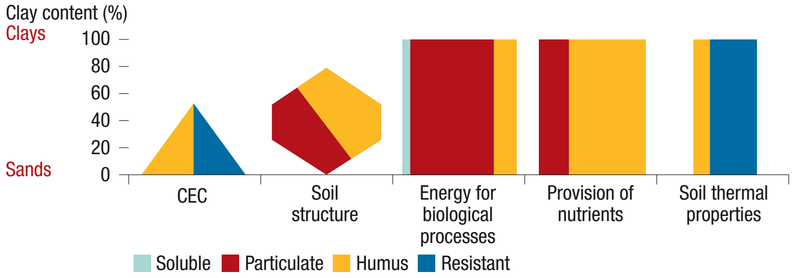
The speed of crop residue breakdown is determined by moisture, temperature and oxygen. Crop residues provide the carbon energy for biological processes and contribute to the liable carbon pool.

through its interaction with soil cation-exchange capacity, nutrient retention and release and the biological components of soil.

Biochar properties vary significantly, due mainly to the different types of feedstock (the material it is made from) and processing conditions. Some soil types are very receptive to biochar application and have shown increases in fertility and structural benefits, but other soil types showed no benefits at all.

Even if its effectiveness is proven, whether or not biochar stacks up as an economically viable proposition will depend on the cost of the feedstock and returns from renewable energy generated in the pyrolysis process. It will also depend on whether it is included in an emissions trading scheme where biochar producers or users may receive credit for stabilising organic carbon.

FIGURE 2 EFFECT OF SOIL ORGANIC MATTER COMPONENTS ON DETERMINING SOIL CHARACTERISTICS IN RELATION TO CLAY CONTENT



The findings reported here are from a study of 29 different soils, sampled between 0-10cm, from nine locations in south east Australia.

While animal residues add to the carbon pool, grazing needs to be managed to avoid excessive removal of crop residues.

Useful resources:

CSIRO biochar fact sheet	www.csiro.au/resources/Biochar-Factsheet.html
Australia and New Zealand Biochar Researchers Network	www.anzbiochar.org
Carbon Farmers Of Australia	www.carbonfarmersofaustralia.com.au
CSIRO technical publications	www.csiro.au/resources/Biochar-climate-change-and-soil.html

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