

HOW MUCH CARBON CAN SOIL STORE? — NEW SOUTH WALES

Key points

- Increasing the total organic carbon in soil may decrease atmospheric carbon dioxide and may increase soil quality.
- The amount of organic carbon in soil is the difference between inputs to soil (plant and animal residues) and losses from soil (decomposition, erosion) and offtake in plant and animal production.
- A soil's clay content plays a major role in influencing the amount of carbon that can be stored in a soil.
- Management practices that maximise organic matter addition will assist in maintaining soil carbon and may increase carbon storage in soil.
- Carbon is the main element present in soil organic matter.

Background

Recent interest in carbon sequestration has raised questions about how much organic carbon (OC) can be stored in soil. Organic carbon in the soil includes the carbon in the materials related to living organisms or derived from them. In Australian soils, total OC is usually less than 8% of total soil weight and under rainfed farming it is typically 0.7–4%. Increasing the amount of carbon stored in soil may be one option for decreasing the atmospheric concentration of carbon dioxide, a greenhouse gas.

Increasing the amount of OC stored in soil may also improve soil quality as OC enhances many beneficial physical, chemical and biological processes in the soil ecosystem (figure 1) (see 'Total Organic Carbon' fact sheet). When OC in soil is below 1%, soil health may be constrained and yield potential (based on rainfall) may not be achieved.

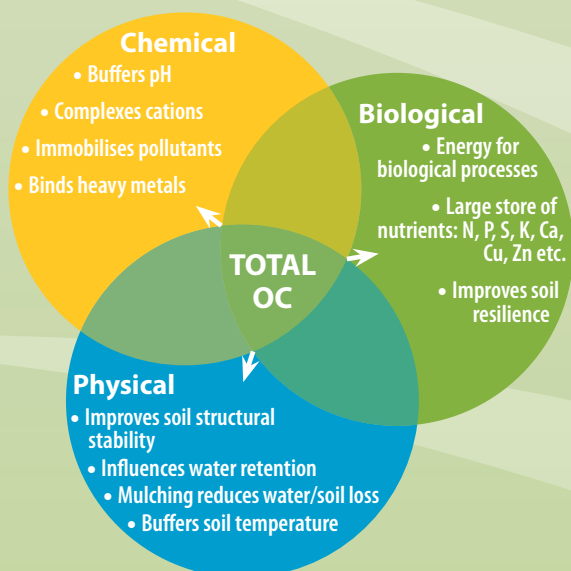


Figure 1: Some of the beneficial physical, chemical and biological processes in soil that total OC contributes to.

The balance of carbon in soil—inputs and losses of organic carbon

The amount of OC stored in soil is the difference between all OC inputs and losses from a soil. The main inputs of carbon to soil in rainfed farming systems are from organic matter in plant material, such as crop residues, plant roots, root exudates and animal manure. Inputs of plant material are generally higher when plant growth is greater.

Losses of carbon from soil are from decomposition of organic matter by microorganisms and erosion of surface soil. Decomposition occurs when microorganisms use organic matter in soil to obtain the nutrients and energy (C) they need to live. During decomposition, OC is lost from soil because microorganisms convert about half of the C in organic matter to carbon dioxide gas (CO₂) as they respire. Without continual inputs of organic matter, the amount of carbon stored in soil will decrease over time because organic matter is always being decomposed by microorganisms.

Losses of carbon via erosion of surface soil can have a large impact on the amount of OC stored in soil. Organic carbon is concentrated in the surface soil layer as small particles that are easily eroded. In some Australian agricultural situations, erosion can cause the annual loss of 0.2 t/ha of soil from a pasture, 8 t/ha from a crop and up to 80 t/ha from bare fallow.

Although not a loss from the soil, removal of OC in plant and animal products prevents carbon entering the soil and adding to soil carbon stores.

Soil type determines the potential storage of organic carbon

Soil type as it relates to clay content has a major influence on the accumulation of carbon in soils (figure 2). Clay particles and aggregates can protect organic matter both

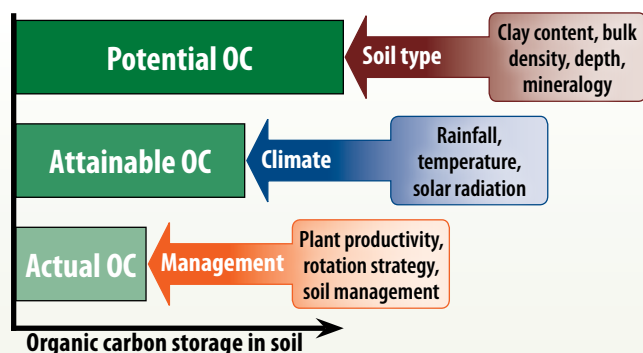


Figure 2: The influence of soil type, climate and management factors on the storage of organic carbon (OC) that can be achieved in a given soil. Based on Ingram and Fernandes (2001).

physically and chemically. Carbon can be adsorbed onto clay surfaces and organic matter can be coated with clay particles or 'hidden' in small pores within aggregates. All of these processes make it difficult for microorganisms to come in contact with organic matter so it is protected from decomposition. Therefore, the amount of OC stored in soil tends to increase with increasing clay content. In contrast, in sandy soil microorganisms are able to more easily access organic matter. This causes greater loss of OC by decomposition. The heavy clay Vertosols of inland New South Wales and red Ferrosols on the southern and northern highlands have the capacity to store greater amounts of carbon than the various lighter red and yellow soils commonly used for wheat growing.

The potential storage of OC in most soil is rarely achieved because climate influences the inputs and losses of OC to soil.

Climate determines the attainable storage of organic carbon

Climate determines the attainable storage of carbon in soil by influencing plant production and the rate of organic matter decomposition (figure 2). Under dryland agriculture, rainfall is the climatic factor that has most

influence on plant productivity and therefore supply of organic matter to soil. In regions with high rainfall, soils tend to have greater attainable storage of OC than the same soil type in a lower rainfall region. Research trials in New South Wales suggest that rainfall limits a soil's ability to accumulate carbon in minimum tillage systems in the short term if rainfall is <500 mm per annum in southern New South Wales or <700 mm per annum in northern New South Wales. Summer dominant rainfall combined with high temperatures in northern New South Wales promotes greater decomposition of crop residues and returns of carbon dioxide to the atmosphere than in southern New South Wales.

Although it is not possible to increase the attainable storage of OC in soil, management practices determine whether or not the attainable storage of OC in soil is achieved.

Management determines the actual storage of organic carbon in soil

Management practices determine the actual storage of OC in soil by increasing inputs of organic matter via plant production and decreasing losses (figure 2). Practices that can increase the amount of total OC stored in soil include:

- Providing optimal nutrition, increasing water use efficiency, and decreasing disease. Maximising plant growth generally increases inputs of OC to soil in shoot material, roots and root exudates.
- Maximising the period where plants are growing by shortening fallows, converting from cropping to pasture, or converting from annual to perennial pasture. Growing plants for longer periods each year generally increases inputs of OC to soil.
- Reducing soil disturbance by retaining stubble, maintaining ground cover and reducing compaction by vehicles and stock. Improving soil structure can increase the amount of OC stored in soil by reducing losses of OC from soil by decomposition and erosion.

Further reading and references

Ingram JSI and Fernandes ECM (2001) Managing carbon sequestration in soils: Concepts and terminology, *Agriculture, Ecosystems & Environment*, **87**: 111–117.

The New South Wales Department of Primary Industries has further information on soil carbon ([online](#))

Author: Jennifer Carson (The University of Western Australia); **revised for NSW:** Abigail Jenkins and Sally Muir (New South Wales Department of Primary Industries), 2013



**Department of
Primary Industries**



Soil Biology Initiative II
Supported by the GRDC

The National Soil Quality Monitoring Program is being funded by the Grains Research and Development Corporation, as part of the second Soil Biology Initiative.

GRDC Grains Research & Development Corporation
Your GRDC working with you

The participating organisations accept no liability whatsoever by reason of negligence or otherwise arising from the use or release of this information or any part of it.