Future Beef

Fact sheet

Soil organic matter and carbon in agriculture

Why is soil organic matter and carbon important?

Soil organic matter is crucial for healthy soils. Organic matter makes soils more productive and resilient by providing nutrients for soil microbes and bonding soil particles for a stable structure. Organic matter is about 60% carbon. Soils can store large quantities of carbon which can potentially have global benefits in mitigating greenhouse gas emissions.

What is soil organic carbon?

Soil organic carbon is the major component of soil organic matter which includes living and dead plants, animals and microbes within and on the soil surface. Organic matter decomposes at varying rates giving four main pools of soil organic carbon. For example 'plant residues' decompose to 'particulate' organic matter (0.053-2 mm size) which decomposes to 'humus' (< 0.053 mm) and finally to 'recalcitrant' organic carbon (e.g. charcoal). The rate of break down depends on the nutrient balance and quantity of organic matter, soil moisture and temperature.

Table 1. Organic carbon pools and decomposition rates.

Organic carbon pools	plant residues	particulate	humus	recalcitrant
Decomposition rate	weeks to years	years to decades	decades to centuries	centuries to millennia

What are typical levels of carbon in the soil?

Most agricultural soils in Queensland contain between 0.5-2.5% total soil organic carbon in the top ten centimetres of soil. This roughly equates to 5-25 t/ha of organic carbon or 8-40 t/ha of organic matter. Remnant scrub soils can have over 6% organic carbon. This capacity to store carbon makes soils the third largest carbon store on earth after oceans and geologic sinks like coal seams. There is 2-4 times more carbon in soils than there is in the atmosphere and about four times more in soils than in all the vegetation on the earth.

How do soil carbon levels change?

Soil carbon is slow to build and can be fast to deplete. Soil carbon levels depend on how much organic matter is grown or added to the soil compared with how much is decomposed to CO_2; removed, such as hay or grain; or lost, such as erosion or burning. Cropping typically reduces soil carbon levels while productive pastures, especially with legumes, generally maintain or increase soil carbon. Higher dry matter production and lower removal contributes to higher soil carbon levels and vice versa.

Why does cropping reduce soil organic carbon?

A study of 140 grain farms in Queensland showed that cropping reduced soil organic carbon levels by about 40%. This soil organic matter loss of between 8-17 t/ha reduces the soil's ability to

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support biological activity and supply nutrients such as nitrogen to crops. Soil carbon losses are due to lower organic matter inputs and stimulation of losses. For example:

- Annual crops produce less dry matter than perennial native systems. Fallows store only 20-25% of rainfall thereby limiting total dry matter production to go back to the soil
- Cultivation breaks soil aggregates and exposes organic carbon to decomposition
- Erosion removes surface soil that is rich in organic carbon
- Fallowing keeps soil more moist and leads to more decomposition of soil organic carbon over summer than native systems that keep the soil dry
- Crop species break down faster and have less extensive root systems
- Plant material (containing carbon) is harvested and removed for sale

The amount of dry matter returned to the soil is a key driver of soil organic matter and this can be maximised by growing as many good crops as possible, maintaining stubble and not burning or baling stubbles. The best way to increase soil organic carbon is with good grazing management promoting productive perennial pastures that have extensive roots and produce more dry matter.

Putting a value on soil organic matter and carbon

Organic matter contains not only 60% carbon but also nitrogen, phosphorus and other valuable nutrients. One tonne of soil organic carbon per ha (~0.1%) is associated with ~100 kg organic nitrogen and around $150 – $200 fertiliser replacement value of all nutrients. Therefore a 1% change in soil organic carbon is associated with about a $1500-2000 per ha gain or loss in soil nutrient value.

Table 2. Value of nutrients associated with soil organic carbon.

Soil organic carbon (0-10cm)	Carbon stock (t/ha)	Soil organic matter (t/ha)	Nutrient value
0.1%	1-1.25	1.7-2.1	$150-200
1%	10-12.5	17-21	$1500-2000

Actions that help build soil carbon

- Growing more productive pastures, especially including legumes to boost nitrogen levels
- Wet-season spelling to build grass root carbohydrate reserves during the peak growing period
- Appropriate stocking rates to preserve good ground cover and allow return of organic matter
- Maintain ground cover to increase infiltration, reduce erosion and evaporation
- Minimising erosion of the top soil containing most of the organic matter and minerals
- Consider organic or inorganic fertilising if economic
- Consider phosphorus fertiliser to boost legume productivity and nitrogen fixation
- Careful use of fire only for clearly identified benefits
- Looking after dung beetles which bury dung over summer
- Not removing hay or stubble

Further reading and reference

Bell M and Lawrence D (2012) 'Soil organic matter and carbon sequestration with pastures', Department of Agriculture and Fisheries, Queensland Government. (Online)
Or visit http://futurebeef.com.au/resources/projects/climate-clever-beef/

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