Soil Carbon Sequestration

Soil carbon is present in both inorganic (IC) and organic (OC) forms. IC is mineral-based, derived from weathering of parent material or reaction of soil chemicals with atmospheric carbon dioxide (CO_2). OC is the carbon associated with soil organic matter (OM) and is approximately 60% of OM by weight with the remaining 40% containing other important elements such as hydrogen, oxygen, nitrogen, phosphorus, sulphur, potassium calcium and magnesium.

Organic carbon (OC) is essential for a number of soil physical, chemical and biological processes and is strongly associated with soil health and plant productivity. Soil OC also plays a role in offsetting atmospheric CO_2 emissions that are contributing to climate change.

Sequestration

Globally, most agricultural ecosystems have lost 50 to 70% of their natural soil OC pool. It is important to identify and implement practices that minimise or reverse the decline in soil OC whilst balancing economic sustainability and global food needs. Restoring some of this OC is an opportunity for carbon sequestration.

For carbon sequestration to occur there needs to be a transfer of carbon from the atmosphere to the soil where it is stored for long periods of time (> 25 years). The amount of OC in soil is a balance between the inputs (plant and animal residues) and outputs (decomposition, erosion and removal in plant and animal production).

Building soil carbon

Building soil carbon in agricultural systems can take a long time. Success is strongly dependent on soil type, climate and management practices that affect not only the biomass that can be grown but also what is lost from the system. The production of food, and subsequent harvesting of plant and animal products, removes OC from the farming system and reduces the amount of OC that is able to enter and be stored in the soil.

About 10% of below ground soil OC is alive in the form of microorganisms such as bacteria, fungi, and nematodes. These are vital for the healthy function of soils. Of the OC that enters the soil, about half is lost due to conversion to CO_2 by microorganisms as they consume the organic matter for carbon, nutrients and the energy they need to live. The optimum moisture for microbial activity is between 20-60% of a soil's water holding capacity. Between 5-40˚C, it is estimated for every 10˚C increase in temperature, mineralisation will nearly double where OC is not limited (Hoyle 2013). This makes it harder to build soil OC in areas with high temperatures and optimum moisture. Without maintained inputs of OC, the amount stored in soil will decrease over time because of continued decomposition by microorganisms.

Climatic conditions or management practices that make soil susceptible to erosion will result in OC loss. OC is concentrated in the surface soil layer as small particles and losses from erosion can have a large impact on the amount of OC stored in soil. The loss of 1 tonne per hectare of a soil with 1% OC equates to the loss of 10 kg/ha of OC.

Increasing the root mass in soil is an important contributor to building soil carbon as roots contribute 2-6 times the OC of shoots. This is probably due to the higher amount of lignin in roots protecting them from degradation by microorganisms. As roots grow deeper, microorganisms follow the food source from root exudates, which in turn increases OC deeper in the soil.

Soil carbon stock

Soil carbon (or more precisely soil organic carbon) stock is used in soil carbon accounting and measured in tonnes per hectare (t/ha).

Soil samples are often collected from the top 10 cm layer of soil. OC stock needs to be measured to at least 30 cm. OC concentration (%), bulk density and the proportion of gravel in a soil sample are required to calculate OC stock as per the formula:

$$\text{Soil OC stock t C/ha} = \text{OC concentration (\%)} \times \text{bulk density (g/cm}^3\text{)} \times \text{soil depth (cm)} \times (100 - \text{gravel \%})$$

If there are OC and bulk density results for separate depth intervals (i.e. 0-10 cm, 10-20 cm, 20-30 cm) within 0-30 cm the stocks for each depth are added together to get the total SOC stock for the 0-30 cm depth.

Glossary of terms used in Soil Carbon Sequestration

Emission Reduction Fund (ERF) - established to help Australia meet its emission reduction target of 5% below 2000 levels by the year 2020. Through this fund, the Government purchases lowest cost abatement measures from a range of sources including soil carbon projects.

Paris Agreement - Australia committed to reduce greenhouse gas emissions by 26-28% below 2005 levels by 2030

ACCUs - Australian Carbon Credit Units are issued to projects registered to the ERF when they have a verified reduction in greenhouse gases. The ACCCus can be retained or sold to buyers to offset greenhouse gas emissions.

Carbon Methods – The type of project selected under the ERF are called methods. Methods explain how to carry out a project and measure the resultant reduction in emissions. A number of methods are applicable for agriculture http://www.cleanenergyregulator.gov.au/ERF/Choosing-a-project-type/Opportunities-for-the-land-sector/Agricultural-methods with the most appropriate soil carbon method being 'Measurement of soil carbon sequestration in agricultural systems'

Permanence obligation – an activity in a soil carbon method that stores carbon for either 25 or 100 years.

Soil organic matter (OM) - is derived from plants and animals and their decomposition products.

Soil organic carbon (OC) – is the carbon component of soil organic matter (approximately 60% of OM)

Bulk density – the weight of soil in a given volume (soil + pore spaces), measured in g/cm^3. Soils with a bulk density greater than 1.6 g/cm^3 are considered restrictive for root growth.

OC concentration units – many laboratories report OC concentration as a percentage (%). Some laboratories use mg of C per g of soil. mg C/g soil / 10 = OC%

Stock units – stocks are either reported as t/ha or Mg/ha. These units are interchangeable and equivalent

CO2e units – carbon dioxide equivalents are the standard unit for reporting greenhouse gas changes in carbon projects. This converts the impact of different greenhouse gases into a term that would create the same amount of warming.

OC stock t/ha x 3.67 = t CO2e/ha

References

Hoyle, FC 2013, Managing soil organic matter: A practical guide, Grains Research and Development Corporation, Australia.

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Natural Resources
SA Murray-Darling Basin

For more information

Written by Amanda Schapel, PIRSA

For information on SAMDB NRM Board Programs contact

Tony Randall, Team Leader, Sustainable Agriculture

P: (08) 8532 9101
M: 0427 834 396
E: tony.randall2@sa.gov.au
www.naturalresources.sa.gov.au/samurraydarlingbasin