Soil Organic Carbon Basics

What is it?

Soil organic carbon (OC) is the carbon component of organic matter (approximately 60%) and includes all living and dead organic material in the soil such as plants, soil organisms and animal materials. It does not include fresh, undecomposed plant material on the surface.

Organic matter is a source and store of plant nutrients, and binds soils aggregates together making them more resistant to erosion. It also provides energy for soil organisms, increasing their number and activity and their ability to cycle nutrients and compete with pests and pathogens.

This microbial activity boosts biomass production by providing nutrients, and improving water infiltration, drainage and retention in the soil for growing plants.

Soil OC is a mix of organic compounds, changing with different stages of decomposition in complex interactions with soil biota, water and nutrient cycles, and is continually entering and leaving the soil.

How does OC get into the soil?

Plant photosynthesis converts atmospheric carbon dioxide (CO_2) into plant sugars which feed shoots and roots. When plants are growing, roots and their associated beneficial fungi and other microorganisms build soil OC.

Carbon in root exudates provides a valuable food supply to soil biota. Bacteria, fungi and larger biota grow and reproduce, consuming OC and transforming it into other forms and eventually into humus. Soil biota activity concentrates and recycles nutrients. Over half of the OC inputs are broken down by microbes and returned to the atmosphere as CO_2. Some of the remaining OC stays in the soil as stable organic-mineral complexes.

If plant production slows or stops, so do carbon inputs. Soil biota then consume stored soil carbon sources to satisfy their energy requirements so soil OC declines.

How much of OC inputs stay in the soil?

The key factors that affect the total amount of OC in the soil are soil type, climate, management and soil biota.

All soils have a finite capacity to store OC. Sandy soils generally are less able to store OC than more clayey soils. Clay particles and aggregates can shield organic matter from breakdown by microbes, slowing the loss of OC through decomposition.

However, a soil's potential to store OC based on its clay content is rarely achieved because climate and management practices also influence supply of OC to the soil. In dryland agriculture, rainfall has the greatest influence on plant production and hence input of OC to soil. Soils in areas of high rainfall tend to have greater OC storage than their counterparts in a lower rainfall region.

Management influences the type and amount of organic material produced – crop selection, provision of nutrients and soil amendments, residue management, tillage practices and pest management strongly influence soil OC content. Losses of OC can occur from topsoil erosion and removal of plant and animal products.

How to build soil OC content

The potential of a soil to increase its OC content depends on the inherent capacity of the soil (clay content) to store more OC, the opportunity for increasing OC inputs so they exceed outputs, and the conversion of OC inputs into more stable forms of OC for long-term storage.

The most effective strategy to re-build soil OC levels is to maximise inputs of OC into the soil by growing more biomass and / or supplying organic materials such as composts or manures while maximising the return of plant residues to the soil. Supplying additional organic material to that grown in situ means that OC is exported from its site of origin and this can incur additional costs in transportation and handling. The overall goal in OC management is to match rates of decomposition with soil type and climate rather than stopping decomposition and CO_2 emissions altogether as effectively means the soil is biologically inactive and soil health and function with be impaired as a result.

Practices that can increase the amount of total OC stored in soil include:

- Increased plant growth through use of sound agronomic practices – appropriate fertilisation and use of soil amendment; sowing at optimal time; selection of appropriate and diverse range of plants suited to soil type and rainfall; and management of pests and diseases.
- Returning more organic material to the soil by managing grazing to maintain soil cover and increase plant growth; retention of crop and pasture residues.
- Growing plants for longer periods each year, e.g. shorter fallow periods, conversion from cropping to pasture, conversion from annual to perennial pasture.
- Minimising losses of OC from soil by decomposition and erosion, e.g. retaining stubble, maintaining pasture ground cover
- Stimulating plant growth rates through strategic grazing management practices Growing a more diverse range of plants for longer periods of time throughout the year.

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