# Carbon sequestration in agricultural soils

Carbon sequestration in agricultural soils is a natural process where some of the carbon contained in decomposing plant and animal material is stored in the soil in a stable form that takes many years to decompose. By contrast, some forms of soil organic carbon decompose relatively quickly. Both forms of carbon have important roles to play in agricultural soils.

Stubble is an important source of organic carbon to cropping soils.

## Types of soil organic carbon and their role in agricultural soils

**CROP RESIDUES**—above and below ground plant residues (leaves, stalks, roots) less than 2 mm long or wide:

- break down quickly
- are a source of energy for soil biological processes.

**PARTICULATE ORGANIC CARBON**—plant residues that are smaller than 2 mm but larger than 0.053 mm:

- break down relatively quickly but more slowly than crop residues
- are important for soil structure
- are a source of energy for biological processes
- are a source of nutrients.

**HUMUS**—decomposed materials less than 0.053 mm that are dominated by molecules stuck to soil minerals:

- are important for all key soil functions
- provide nutrients—for example the majority of available soil nitrogen derived from soil organic matter comes from the humus fraction.

**RECALCITRANT ORGANIC CARBON**—biologically stable carbon (the most common form is charcoal) which:

- decomposes very slowly and is therefore unavailable for use by micro-organisms
- is carbon that will not be readily-emitted to the atmosphere as $CO_2$.

## Importance of the different forms of soil organic carbon

Soil organic carbon is important for:

- **Water holding capacity in soils**—soil organic matter (~58 per cent carbon) acts like a sponge for soil water...

  **more carbon = more plant-available water holding capacity**.

Soil organic carbon input rates are primarily determined by the root biomass of a plant.

- **Cation exchange capacity** (CEC)—CEC indicates the potential capacity of soil to store nutrients. The three main cations essential for plant growth are potassium, calcium and magnesium. These influence soil structure, colour and aggregate stability.
- **Soil structure**.

Unfortunately, soils do not hold on to all of the carbon that is added. Carbon can leave the soil in the form of carbon dioxide ($CO_2$)—a greenhouse gas.

## How and why is carbon dioxide produced in soils?

1) As a result of roots and associated micro-organisms respiring the recently acquired plant carbon.
2) Micro- and macro-organisms, decomposing litter and organic matter in soil.

Decomposition of soil organic matter (~58 per cent organic carbon) by microbes is an important process. It causes the organic carbon content to separate into mineral nutrients so that these are available for plant use.

Is it possible to allow this to continue and sequester (capture and store) carbon? Sequestration of carbon will be achieved if we can have more organic carbon entering the soil than leaving the soil.

## How do we sequester carbon?

Plant photosynthesis is the only process by which carbon is taken from the atmosphere and a fraction deposited in the soil through inputs of plant organic matter.

Crop and pasture residues, including roots, are the major input of organic matter/carbon into agricultural soils. Soil organic carbon input rates are primarily determined by the root biomass of a plant, but also include stubble and leaf litter deposited from above-ground plant material.

Practices that improve plant water use and growth (e.g. early sowing) are desirable because they also increase organic inputs into soil. However, the capacity of a soil to store soil carbon over a long period of time is largely determined by the characteristics of that soil and complex soil processes that are influenced by soil management, such as tillage operations.

It follows that some soils have greater capacity for carbon sequestration than others (e.g. finer soils with higher clay content). Increasing the rate of organic inputs on coarse sandy soils may not result in stable increases in soil organic carbon but, importantly, helps to maintain the current soil carbon stock. Agricultural practices that improve the efficiency of nutrient use and plant growth also complement efforts to increase soil organic matter and soil health.

### The benefits of building soil carbon stocks in agricultural soils are:

- mitigating greenhouse gas emissions and therefore greenhouse gas-induced climate changes
- well-structured, stable soils that are an effective store of nutrients and water for plants to use.

## What options do we have to maintain soil carbon stocks or sequester carbon?

Options include:

- conservation tillage, most ideal is zero-tillage cropping practices
- crop residue retention
- allowing and assisting the regrowth of native vegetation
- eliminating or reducing the frequency of fallow in rotations
- shifting from annual to perennial pastures and crops
- improved grazing management by using relatively intensive rotational grazing
- using crops and pastures with maximum biomass production (given soil and climate constraints).

Perennial pastures can sequester more carbon than annuals because they are growing all year.

## Why do these practices support carbon sequestration?

- Limiting soil disturbance helps to ensure that the carbon protected from decomposition by soil microbes by clay or soil aggregates continues to be protected. The decomposition process converts organic carbon to carbon dioxide through respiration.
- Increasing plant cover, to ensure there is an input of carbon to the soil from root and above-ground biomass, helps to balance the input and output of carbon from the soil. Soil left fallow is a net source of carbon to the atmosphere because there is no addition of carbon to counterbalance the loss of carbon from erosion or microbial respiration.
- Plants use atmospheric $CO_2$ during photosynthesis. Having crops, trees or shrubs growing (especially on a perennial basis) helps to draw down atmospheric $CO_2$ and convert it into plant materials.



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