JANUARY 2022

Soil Wealth NURTURING CROPS
Integrated Crop Protection PROTECTING CROPS

THE CARBON SERIES

Part 2: Soil carbon and carbon sequestration

This four-part Carbon Series from the Soil Wealth ICP project breaks down the practicalities of carbon farming for vegetable growers and soil carbon management.

KEY MESSAGES

- ✔ **Soil carbon refers to the measure of carbon contained within soil organic matter, which is around 50% on average. It plays a key role in soil health.**
- ✔ **Vegetable growers can maintain or build soil carbon to improve soil health, crop resilience and productivity, and reduce greenhouse gas emissions.**
- ✔ **Carbon sequestration refers to increasing carbon within a farming system by capturing and storing carbon dioxide in soil and vegetation. All carbon captured in landscapes, in vegetation and soils, are sequestered via photosynthesis.**
- ✔ **Farming practices with the greatest potential to mitigate soil carbon losses involve increasing inputs of organic matter and reducing carbon dioxide losses. This can be achieved through composts and soil amendments; cover crops; high biomass cash crops; reforestation, afforestation and revegetation; reduced tillage; and minimising fallow periods. Tillage and fallows are the main ways to lose soil carbon.**

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January 2022

ABOUT THE CARBON SERIES

This four-part Carbon Series from the Soil Wealth ICP project breaks down the practicalities of carbon farming for vegetable growers and looks more closely at soil carbon management. It provides links to further information and project resources on the following topics:

- **Part 1: Carbon farming and its relevance to Australian vegetable growers**
- **Part 2: Soil carbon and carbon sequestration**
- **Part 3: Carbon emissions in vegetable production**
- **Part 4: Carbon accounting and the Emissions Reduction Fund.**

Additional resources were produced including a podcast on certified carbon neutral sweet corn developed by Mulgowie Farming Company in Queensland and a webinar recording of Carbon management on vegetable farms – emissions, sequestration and beyond.

The Carbon Series has been produced to help Australian vegetable growers to:

- Make decisions to manage soil carbon for increased productivity
- Calculate current emissions and assess the potential for emission reductions within their business
- Assess the viability of participating in an official carbon credit scheme
- Consider carbon neutrality as a path to differentiate products and their business on the market.

Part 2 of The Carbon Series discusses carbon sequestration with a focus on soil carbon.

CARBON'S ROLE IN VEGETABLE PRODUCTION

Soil organic matter is a key factor in soil health and refers to the organic (carbon-based) components of the soil such as plant and animal tissue in various states of decomposition.

Soil carbon refers to the measure of carbon contained within soil organic matter, which is usually around 50%. This includes labile carbon, which is the 'active', unstable component of soil carbon – humus for instance is a more stable form that occurs when soil organic matters breaks down over a longer period of time.

The greatest benefit that carbon can provide to vegetable production is its influence on soil health. Increasing soil carbon can lead to better soil condition and function which can result in reduced energy, water and fertiliser use, improved soil structure, increased soil biological activity, disease tolerance and improved nutrient cycling and holding capacity.

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WHAT IS CARBON SEQUESTRATION?

Carbon sequestration refers to increasing carbon within a farming system over the long-term by capturing and storing carbon dioxide from the soil and vegetation.

Carbon can only be sequestered via photosynthesis, the process by which plants use carbon dioxide to produce energy and ultimately organic material. This organic material can then end up as soil carbon via decomposition of plant or animal matter. In the case of carbon from animal matter, animals either have consumed plants or other animals that have consumed plants.

The easiest way to sequester carbon is by growing plants, as carbon can be sequestered in:

- **Soil carbon:** A variable amount of carbon can be stored in soils. The amount that can be built up is strongly dependent on the soil's potential to produce plant biomass (i.e. the soil type, climate and land management). There is a limit to how much carbon can be stored in certain soils and it is important to not only build soil carbon, but maintain it over the long-term. Soil carbon can be built up by 'importing' organic matter such as compost. The carbon in this compost has been sequestered elsewhere (e.g. in crops that partially end up in compost via food waste).
- **Permanent pastures/grassland and reforestation, afforestation and revegetation:** Reforestation and afforestation involve planting trees in agricultural areas, while revegetation is the process of replanting and rebuilding the soil of disturbed land.

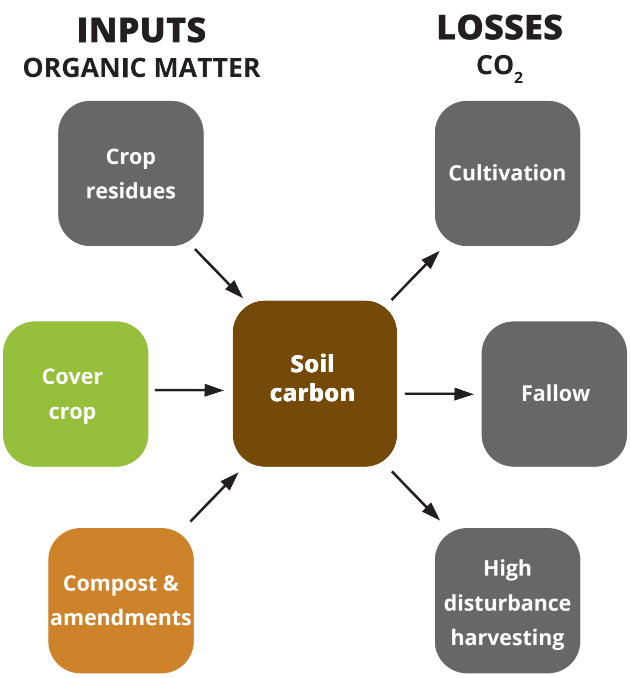
The intensity of vegetable production systems means that it is often difficult to sequester carbon in the soil for the long-term given high levels of soil disturbance through tillage, which promotes soil carbon loss through increased aeration and exposing soil organic matter to soil microbes.

The microbes break down organic mater and 'breathe out' carbon dioxide in the process, reducing soil carbon.

However, crop residues following harvest can be a valuable source of carbon and nutrients if incorporated back into the soil. Irrigation and fertiliser application during summer can create ideal conditions for soil microbial activity through warm, moist and usually well-aerated soil. This is great for biomass production but also carbon losses, if the soil cover is not good. Wet soil can lead to emissions via nitrous oxide losses from applied nitrogen fertilisers.

Farming practices with the greatest potential to mitigate soil carbon losses involve both increasing inputs of organic materials and reducing losses via carbon dioxide (Figure 1). More information on this can be found in this fact sheet on carbon storage in vegetable soils.

Figure 1: A change in soil carbon is predominately determined by how farming practices affect the inputs of organic matter and losses of carbon dioxide



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MEASURING SOIL CARBON

To evaluate the actual mass of carbon stored in or emitted from the soil, it is essential to know the **bulk density** of the soil. Compacted soils have a higher bulk density, while soils of the same type which are more porous and less compacted have a lower bulk density.

Different analytical methods are used by labs to measure soil carbon. The main difference between the measurements are using combustion to measure **total carbon (TC)** or using a chemical extraction method to measure **total organic carbon (TOC)**. TC picks up non-organic carbon sources (e.g. from limestone, applied lime or dolomite).

Soil carbon can be reported in a range of units; it is important to know the differences when comparing paddocks or reported changes over time.

DID YOU KNOW?

- **1 tonne of carbon is the equivalent of 3.67 tonnes of carbon dioxide (CO_2).**
- **For every tonne of soil carbon that is increased, 3.67 tonnes of CO_2 are removed from the atmosphere.**
- **For every tonne of soil carbon lost, 3.67 tonnes of CO_2 will be released into the atmosphere**
- **Increasing soil carbon by 1% to 1 cm depth would require 1.2 tonnes of carbon or about 2.4 tonnes of organic matter.**

Measurements of soil carbon can include:

- A percentage (%)
- Grams of carbon per kilogram of soil (g C/kg soil)
- Tonnes of carbon per hectare (t C/ha)
- Tonnes of carbon dioxide per hectare, which is the key measure for carbon accounting and sequestration projects (tCO_2/ha).

The soil carbon measurement procedures required for carbon accounting in carbon farming projects was updated on 8 December 2021.

It can be found in the Australian Government's Estimating soil organic carbon sequestration using measurement and models method.

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METHODS FOR SOIL CARBON MANAGEMENT

Table 1 describes a range of suitable methods that growers can use to increase or maintain soil carbon in vegetable production systems, including carbon sequestration.

Table 1: Methods of increasing soil carbon and reducing losses in vegetable production

PRACTICE	DESCRIPTION	SOIL WEALTH ICP / OTHER RESOURCES
	Increasing organic matter	
Composts and soil amendments	Regular applications of compost or other organic amendments can help to maintain or build soil carbon. There are some restrictions on the use of composts and other soil amendments in vegetable production systems due to food safety requirements. Biochar is a potential option for vegetable producers as it remains in the soil without decomposing for longer periods compared to compost. The productivity benefits from soil amendments may vary given the different source materials that can be used to produce composts and biochar.	• Organic soil amendments – global scan and review • Biochar – What is its potential for vegetable production? Fact sheet • South Australian grower compost trial – case study • Organic soil amendments trial full report: Richmond, Tasmania – demonstration site report • The effect of custom-made composts on the performance of a carrot crop and soil health – case study • Recycled organics compost for vegetable growers – fact sheet • The 'breakdown' on composts – fact sheet
Cover crops	Cover crops can produce bulk organic matter that can be returned to soils. Each species has different benefits due to rooting depth, root structure and overall biomass production. Cover crops can be used in fallow periods to capture and deposit nutrients and carbon deeper in the soil and improve soil structure. When introducing cover crops in vegetable production systems, the following should be considered: • Matching cover crops with cropping windows • Water and nutrient demand and supply for the cover crop • Managing the transition from cover to cash crop • Pest and disease considerations • Specific benefits of cover crop species.	• Cover crops for Australian vegetable growers – poster • Cover crops and soil biology in vegetable soils – webinar recording • Growing Matters #1: Basics of cover cropping – podcast • Growing Matters #2: Link between soil wealth and cover cropping – podcast • Managing cover crop residues in vegetable production – fact sheet • Biofumigation cover crops – What variety and when? webinar recording • Cover crops with Harvest Moon – podcast • Cover crop trial discussion at the East Gippsland Vegetable Innovation days – video • Mixed cover crops for soil health: Soil First Tasmania demonstration site – podcast

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PRACTICE	DESCRIPTION	SOIL WEALTH ICP / OTHER RESOURCES
Higher biomass cash crops	Organic matter can be increased by changing a crop rotation to include a higher biomass cash crop where less biomass is harvested (e.g. beans, some brassica vegetables, sweet corn) or pasture (e.g. lucerne for grazing or hay). If biomass is exported from the paddock via harvest or grazing, some of the carbon and nutrition benefits are lost. Using longer term cover crops may require more land area and may be well suited to more extensive mixed farming enterprises.	• Carbon storage in vegetable soils – fact sheet • How do you know your soil is healthy? – fact sheet
	Reducing losses of carbon dioxide	
Reforestation, afforestation and revegetation	Revegetating unproductive areas or converting productive areas to permanent vegetation can increase soil carbon storage, reduce erosion, provide protection to crops (e.g. shelterbelts) and support integrated pest management programs by promoting local biodiversity (including bees and other beneficial insects). These land areas could include land unsuitable for cropping, embankments, riparian zones or dam/pivot edges where plants will survive and not impede on production.	• Making cent$ of carbon and emissions on-farm – booklet
Reduced tillage	The use of reduced tillage can help to maintain soil carbon levels by reducing the amount of soil disturbance in a paddock. The use of reduced till systems typically involves a system change to permanent beds and specific equipment (e.g. to maintain beds or for strip-till). It is usually necessary to build soil carbon and associated soil structure through soil amendments and/or cover crops before using “softer” tillage practices.	• Reduced till in vegetable production – fact sheet and video • Strip-till in Tasmania: A reduced till farming system – video • Strip-till for corn production – Reducing erosion, building robust soils – video • Strip-tillage for vegetables and potatoes with Steve Peterson (USA) and Ben Pogiolli (QLD) – webinar recording • Cowra cover crop and strip-till a winning combination for soil health – case study
Minimising fallow periods	Minimising fallow periods can help to prevent carbon dioxide emissions by microbes as they continue to decompose soil organic matter (and breathe out carbon dioxide) when a soil is fallow. While there are no ongoing inputs for a grower from cash or cover crops during fallow periods, top soil can be lost through wind and water erosion, apart from losing the multiple carbon benefits.	• Refer to the information on cover crops

FURTHER READING

- **FertCare Soil Carbon Snapshot publication**
- **New South Wales Department of Primary Industries soil management guides**
- **Managing Soil Organic Matter: A Practical Guide**
- **Biochar in horticulture; Prospects for the use of biochar in Australian horticulture**

NEXT IN THE CARBON SERIES

- **Part 3: Carbon emissions in vegetable production**
- **Part 4: Carbon accounting and the Emissions Reduction Fund**
- **Catch up on Part 1: Carbon farming and its relevance to Australian vegetable growers**