



## Climate Change Research Program

Australia's Farming Future

research

# Reducing greenhouse gas emissions using soil carbon

The Soil Carbon Research Program is funded by the Australian Government through the Climate Change Research Program (CCRP).

The Soil Carbon Research Program is developing a scientific understanding of the potential of Australia's agricultural soils to sequester carbon.

Carbon sequestration will help reduce greenhouse gas emissions from Australian agriculture, increase farm productivity and potentially create offsets under the Carbon Farming Initiative, providing new economic opportunities for landholders.



The Soil Carbon Research Program is:

- > developing a standard for measuring soil carbon across Australia
- > assessing the capabilities of new cost-effective soil carbon measurement methods
- > providing a better understanding of the impacts of management practices on the amount of carbon stored in soils
- > providing soil carbon data to improve the National Carbon Accounting System.

Increasing the amount of carbon stored in soils could significantly help reduce Australia's emissions of greenhouse gases from agriculture by offsetting some of the carbon dioxide (CO<sub>2</sub>) emitted into the atmosphere. Any reduction in emissions from

Australian agriculture will contribute to Australia's efforts to mitigate future climate change.

Although there is already carbon stored in Australian agricultural soils as organic matter, opportunities exist to store more by altering current management practices. However, to increase soil carbon levels it will be necessary to:

- > have a rapid, economic and reliable method for measuring soil carbon
- > confidently estimate changes in the amount of carbon stored in soils from adopting different land uses and management practices
- > identify the best opportunities for storing carbon in soils.



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Gathering soil samples

## Measuring soil carbon

### Key points

- > Researchers are identifying affordable and effective ways to measure soil carbon levels across Australia's agricultural regions.
- > Soil samples have been taken from over 1,000 sites to help paint an accurate picture of how different farming practices affect soil carbon levels.
- > Early trials show that perennial grasses, including kikuyu grass, can increase soil carbon levels.
- > The Soil Carbon Research Program will help landholders make informed management decisions that may increase soil carbon levels.



### Traditional methods

Traditional methods for measuring the amount of organic carbon in soils are slow and laborious. It often involves taking a field sample and returning it to the laboratory to measure soil carbon levels. This makes them expensive to undertake regularly.

The three major steps in determining the amount of organic carbon in soils are:

1. taking enough soil samples to validly represent the field or farm
2. measuring soil density
3. measuring the concentration of carbon in the soil samples.

All this information is needed to precisely calculate the amount of organic carbon stored in soils so any changes in land management use can be measured accurately.

### Sampling improvements

The first step of the Soil Carbon Research Program has been to develop an appropriate method to measure the amount of organic carbon found in a range of soils from different farming systems. This work is being done to show the effects of agricultural land-use and management practices on soil carbon, at a regional level. Over 1,000 sites have been sampled across many of Australia's agricultural regions and results are showing strong variations in the amount of carbon stored in soil. As more samples are taken and data is compiled, we will become more confident about the potential for particular management practices to increase soil organic carbon.

### Improving measurement of soil density

In order to measure soil carbon levels confidently, the research program is investigating two new methods for estimating soil density.

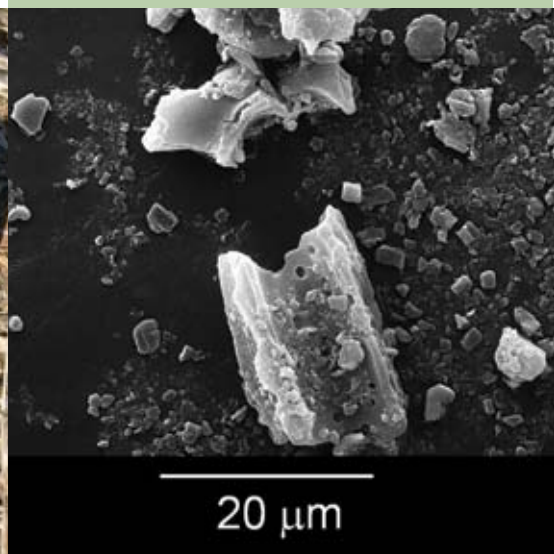
The nuclear density meter, originally designed to measure the density of road bases, can measure the density of soil samples on site without the need to collect soil cores. This meter was also tested on artificial soils and gave results of similar accuracy to traditional methods.

The second method uses a scanner to rapidly measure the density of the entire soil core. This method requires separately measuring the amount of water in the soil core. Combining these two measurements provides as good an estimate of soil density as that measured using conventional methods.

These two methods for measuring soil density are being tested across a wide range of soil types, densities and with varying soil water content to determine their usefulness for field measurements.

### What is the difference between organic and inorganic carbon?

Carbon exists in two forms in soils – organic and inorganic. Organic carbon includes decaying plant matter, soil organisms and microbes and can be increased through land management practices. Inorganic carbon is mineral-based and is relatively stable. With the exception of liming, inorganic carbon is not strongly influenced by land management practices.



Field sampling of soil cores. Left: trailer-mounted soil corers (Photo: L Macdonald, CSIRO). Middle: a soil core sample (Photo: Josh Tefler, Rural Solutions SA). Right: A magnified image of charred organic carbon fragments.

## New methods for measuring the concentration of carbon

The Soil Carbon Research Program is testing various techniques to automate and improve the measurements of both the amount and form of carbon in soils<sup>1</sup>. For example, improvements were made to an automatic sieving process for separating small pieces of plant residues, including roots, from the more biologically stable organic material in soil (referred to as humus). Researchers are working to develop a process that eliminates carbonate in order to obtain accurate measurements of total organic carbon.

The major new method for measuring the concentration of organic carbon is with a mid-infrared spectrometer (MIR). Once calibrations are complete,

this instrument can simply and affordably measure total organic carbon, inorganic carbon and potentially the amount of carbon in plant residues and humus.

The project is also looking at developing a method for measuring how much carbon exists as charcoal in soil samples. This form of carbon is very stable and generally accumulated in soils prior to the implementation of agricultural practices. Understanding how much carbon exists as charcoal, pieces of plant residue and humus is necessary in order to understand the influence of management practices on soil carbon. This information will also be important for modelling carried out by Australia's National Carbon Accounting System<sup>2</sup>.

## Predicting the impact of management on soil carbon change

Computer models can be used to predict the potential impact of changes in agricultural management practice on the amount of organic soil carbon. The research program is collecting information from 13 research experiments to improve the accuracy of such models, including one being used by the National Carbon Accounting System.

<sup>1</sup> For more information on the forms of carbon in soils please see *Bureau of Rural Sciences 2010 Soil Carbon Management and Carbon Trading*.

<sup>2</sup> The Australian Government established the National Carbon Accounting System (NCAS) in 1998 to provide a complete accounting and forecasting system for human-induced sources and sinks of greenhouse gas emissions from Australian land-based activities. It enables reporting on land use, land use change and forestry categories for both the United Nations Framework Convention on Climate Change National Greenhouse Gas Inventories and the Kyoto Protocol Greenhouse Gas Inventory.



## Managing changes in soil organic carbon

### How does soil organic carbon change?

The amount of carbon stored in the soil is the balance between the rate at which organic matter is added and the rate at which it decomposes, releasing CO<sub>2</sub> into the atmosphere.

Carbon can be added to the soil through the decay of plants, manure and microbes. For example, increasing the production of plant biomass could increase organic carbon in soils.

Carbon can be lost from the soil through the conversion of organic carbon to CO<sub>2</sub>, through erosion and by leaching of dissolved carbon through the soil.

There is limited information on the effect that different management practices (such as level of soil disturbance, crop rotations and land-use history) have on soil carbon levels in Australia. It is well known

that cultivation reduces soil carbon, although it is not known how much this is influenced by factors such as the intensity of cultivation, the type of soil, the type of plant material grown, crop residue handling practices and environmental conditions.

### What practices will increase soil carbon?

#### Perennial pastures

The Soil Carbon Research Program is investigating the effect on soil carbon when introducing perennial grasses into annual grass pastures. Early results suggest that where soil carbon was previously run down by more intensive practices, perennial grasses, including kikuyu grass, can capture more soil organic carbon. Where soil carbon contents were high prior to conversion to perennials, further build up of carbon under the perennial pastures has generally not occurred. Additionally, mixed panic

and Rhodes grass pastures appear to have provided only small changes in the amount of soil carbon.

#### Other practices being investigated

A range of other farm practices are being investigated to determine their long-term effect on soil carbon. These practices include:

- > fallow management
- > tillage practices
- > grazing practices in rangelands e.g. between cell grazing, rotational and continuous grazing
- > crop rotations in irrigation areas (with vegetables and pastures)
- > fertiliser application and timings.

### Where are the opportunities for sequestering soil carbon?

Understanding how much carbon is currently stored in Australian soils is important to identify a baseline for change. Once this baseline is established it will be easier to model changes in soil carbon and identify the areas with the highest potential for increasing soil carbon.

A wide-ranging and extensive program of soil sampling is underway across Australia. The results are feeding into a soil carbon database. Models will then be developed to help predict future soil carbon levels in many areas and the influence of soil type and rainfall.



Gathering soil samples

## About the Climate Change Research Program

The Climate Change Research Program is part of Australia's Farming Future, the Australian Government's climate change initiative for primary industries. The program funds research projects and on-farm demonstrations to help prepare Australia's primary industries for climate change. Research focuses on reducing greenhouse gas pollution, improving soil management and climate change adaptation. The program is providing practical management solutions to farmers and industries. The Department of Agriculture, Fisheries and Forestry manages the Climate Change Research Program.

## Partnerships

The Soil Carbon Research Program is supported by funding and in-kind support from the following partners:

- > CSIRO's Sustainable Agriculture Flagship
- > Department of Agriculture and Food, WA
- > Department of Environment and Natural Resources, SA
- > Department of Primary Industries, Vic
- > Grains Research and Development Corporation
- > Industry and Investment NSW
- > Murray Catchment Management Authority

- > Queensland Department of Environment and Resource Management
- > Tasmanian Institute of Agricultural Research
- > University of New England
- > University of Western Australia.

## Also in this fact sheet series:

- > Adapting to climate change
- > Reducing emissions using biochar
- > Reducing emissions from livestock
- > Reducing nitrous oxide emissions

## Acknowledgement

Information contained in this fact sheet was obtained from a CCRP progress report provided by CSIRO and:

Bureau of Rural Sciences. (2010). *Science for Decision Makers—Soil Carbon Management and Carbon Trading*. Canberra: Department of Agriculture, Fisheries and Forestry.

## Further information

For further information on the Climate Change Research Program or any of the funded projects please contact:

Australia's Farming Future Hotline

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