FARMING CARBON IN AUSTRALIA

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Abstract

The clearing of farming land over the last four hundred years has released large quantities of carbon dioxide into the atmosphere. This clearing and the subsequent decline in organic matter is estimated to have contributed almost twice the carbon released from fossil fuel use since 1850. The big opportunity is to reverse the decline of soil organic matter - storing carbon and the same time improving soil productivity. This potential to store carbon in Australia is lower than in temperate areas, such as the USA, where ten long-term studies of no-tillage show an increase of 0.6 t.carbon/ha/yr. A good outcome in Australia is a gain of 0.1-0.15 t. C/ha per year. While useful and much better than releasing carbon, this is not enough for farmers to receive a significant 'carbon credit' payment. Storing carbon is a win-win situation however – with improved organic matter resulting in better soil health and contributing to better crop yields. Saving energy on farms is also more profitable while reducing greenhouse emissions. A "Farming Carbon" program is being conducted by the author with 50 farmers in Queensland, helping them to monitor soil organic matter and discuss farming practices which can sequester carbon and save energy.

Keywords: carbon, energy conservation

Introduction

Farming has caused a serious decline in soil organic matter, which affects on productivity and at the same time contributes to atmospheric carbon levels and potential climate change.
There is an opportunity to reverse the decline of soil organic matter - storing carbon and at the same time improving soil productivity.
Storing carbon is a win-win situation, with improved soil health contributing to better crop yields. Some of the same practices also result in energy savings on farms, which is also more profitable while reducing greenhouse emissions.

Greenhouse Gases and Climate Change

The Intergovernmental Panel on Climate Change (IPCC) outlined in its Third Assessment on Climate Change in 2001, that carbon dioxide levels have risen substantially over the last 200 years and that climate change is now occurring as a result of an increase in global temperatures, most likely caused by an increase in carbon dioxide and other greenhouse gases in the atmosphere.

A Fourth Assessment Report is currently being completed and a *Summary for Policymakers* released in April 2007 (IPCC 2007) reported that: "Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases."

This summary concluded that a moderate increase in temperature will increase the potential for food production globally, but as the average temperature increases over a range of 1-3°C, it is projected to decrease.

However, food production in warm climates like Australia may not benefit from higher carbon dioxide levels and a small rise in temperature. The IPCC summary report projections are for production from agriculture and forestry to decline by 2030 over much of southern and eastern Australia, due to reduced precipitation, increased drought and fire.

Agriculture a Major Contributor to Global Carbon Dioxide

The clearing of farming land over the last four hundred years has released large quantities of carbon dioxide into the atmosphere. This release and the subsequent decline in organic matter and loss of carbon by other means, has been estimated (Lal 2004) to have contributed more carbon dioxide to the atmosphere, around 456 gigatons (Gt), than the 270 Gt estimated output from fossil fuel combustion since 1850. See table 1.

Table 1: Loss of carbon from farming land

Source	Carbon emission (Gt)
Pre-industrial crop lands	320
Post Industrial (1850-2000)	
- land use conversion	78
- soil erosion	26
- mineralisation of OM	52
Total loss from farm land conversion and farming	**476**
Fossil fuel use since 1850	**270**

Source: Lal 2004

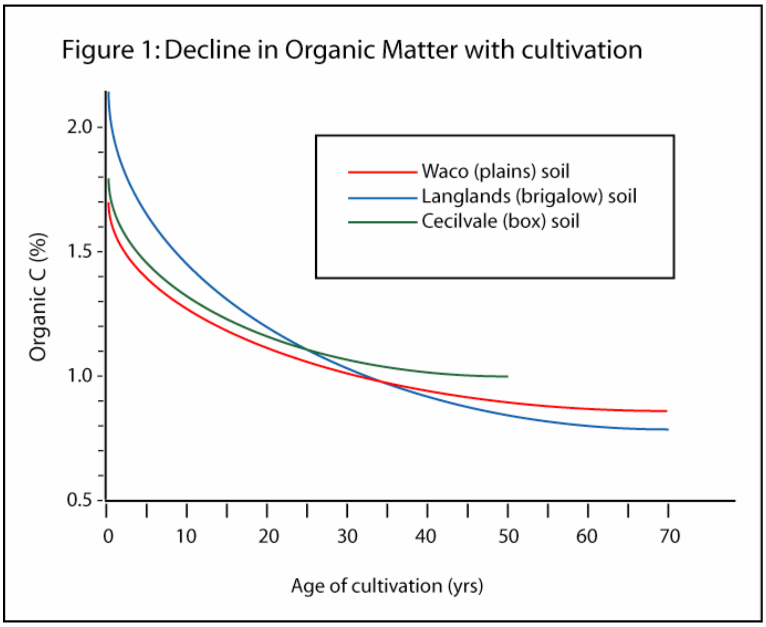
There is significant potential to reverse the decline of soil carbon according to Lal. The global soil C pool of around 2500 Gt is 3.3 times the size of the atmospheric pool (of 760Gt) and the carbon sink capacity is around half of the historic carbon loss of 42 to 78 Gt. Farming land has the potential to offset fossil fuel emissions by storing 0.8 gigatons (Gt) of carbon per year, or around 10% of global fossil-fuel emissions.

At the same time this will help achieve the 50% increase in crop yields required between now and 2050 to feed the world. An increase of 1 tonne of soil carbon/ha is estimated by Lal to increase crop yield by 20-40 kg/ha. Lal says the increase in crop yield can be much higher than this on degraded soils where water intake is improved by increasing organic matter.

Decline in Soil Organic Matter

Soil organic matter (SOM) has declined by around 50% over 50 to 100 years of cropping on clay soils in northern Australia. See Figure 1. This has important impacts on soil structure and nutrient supply. Increased rainfall runoff and reduced crop production can set off a cycle of decline, which results in reduced biomass being returned to the soil and a faster rundown in soil organic matter.

Figure 1: Decline in Organic Matter with Cultivation



Source: Redrawn from Dalal and Probert 1997.

Practices Which Build Soil Carbon

Farming practices which build rather than deplete soil carbon will not only reduce greenhouse emissions, they will improve soil health and productivity. Practices which enhance organic matter will maintain or improve soil structure, provide good conditions for soil biota, improve the soil water balance and the productivity of soils over time.

1. High Yield - High Biomass Crops

Wheat is the main dryland crop in Australia, but in the northern cropping areas, grain sorghum is important and will produce around 1.5 times the biomass of wheat and twice the biomass of dryland cotton and chickpea. Growing high yielding crops of sorghum has been shown to build SOM, while dryland cotton grown after a long fallow, combined with tillage for pupae busting is likely to deplete it.

2. Eliminate Tillage

In ten long-term studies of no-tillage in the USA an increase of 1.08t/ha/yr of SOM (0.6 t/ha C) was measured, compared to a decline of 0.3t SOM/ha/yr where ploughing was used (Reicosky 2001).

The effects of zero-tillage are less in Australia, because the potential to store carbon is lower than in the USA. Rainfall is generally lower (with lower biomass input) and there is a longer period of warmer weather during the year for mineralisation of SOM.

Freebairn (1998) reviewed tillage trial data for clay soils in northern Australia and found that zero-tillage was able to halt the decline in SOM, while one or more cultivations a year (minimum or reduced tillage) is likely to result in a continuing decline in SOM. Freebairn acknowledged that most of the tillage trials involved wheat. Some farmers in high yielding sorghum growing areas have measured increases in SOM with zero-tillage.

Chan (2003) reviewed field trials on conservation tillage on light textured soils in southern Australia and found zero-tillage could increase soil organic carbon levels only in the higher rainfall areas (>500mm). In the drier areas, soil organic carbon continued to decline, even under conservation tillage.

However some increases in SOM with zero-tillage have been reported by farmers in lower rainfall areas. One example is from Hyden in Western Australia, where monitoring of a number of paddocks over the period: 1994 to 2001, showed an average increase from 0.7% Organic Carbon to 1.2% OC when zero-tillage was used (Crabtree 2002).

While zero-tillage is essential to building SOM, it also has other effects on minimising greenhouse gases. Fuel use is reduce from 76 to 46 litres per hectare in cropping systems in southern Queensland (Tullberg and Wylie 1994) and in conjunction with controlled traffic, zero tillage will minimise compaction and reduce emissions of the greenhouse gas nitrous oxide. This loss of nitrous oxide mostly occurs on flat land. Zero-tillage reduces surface ponding after rainfall, which results from a plough pan or compaction layer below the cultivated depth.

3. Maintain Soil Fertility

A decline in soil fertility will reduce crop biomass and carbon input. Less ground cover is produced by nutrient limited crops, which in turn may result in less moisture stored and lower yields from subsequent crops. There has been a general increase in nitrogen fertiliser use in northern Australia, but applications are still much less than crop removal.

One of the problems of soils with low organic matter is that there is not enough organic N reserves to mineralise extra N to help produce big yields in years with good rainfall.

4. Feedlot, Pig and Poultry Manure

Animal manures can not only add nutrients more cheaply than mineral fertilisers, they also add useful amounts of organic matter.

Around 1.2 million tonnes of feedlot manure is produced in Australia each year, along with half a million tonnes of pig and poultry manure. The proportion of grain production used for animal feed continues to increase and have reached the point where exports of grain from eastern Australia are now less than half of total production. Use of animal manure will reduce the need for artificial fertilisers, add to soil carbon and boost soil fertility and soil health.

Farmers are often concerned that manure is difficult to manage compared to fertiliser. The use of manure can be simplified by applying it as a phosphate (P) fertiliser. If the optimum application of P is considered to be 8 kg P/ha/yr then an application of 10 tonnes of aged manure will apply 70 kg P/ha and last up to 8 years. Used in this way there is adequate potassium (K), but nitrogen needs to be boosted with other fertilizers, depending upon the mix of grain and legume crops and their yield and nitrogen demands.

5. Pasture Leys Will Build SOM.

A grass-legume pasture can build soil carbon levels by more than 1 t/ha/yr which could lift the organic carbon level in a typical soil by 0.05% p.a. Perennial grasses grow a big root system which contributes to below ground SOM return as well as surface litter.

In drier cropping areas it is common to use pasture leys of 3 to 4 years to restore fertility (boost nitrogen from legume input) and organic matter on rundown cropping soils. Excessive tillage should be avoided at the end of pasture phase, or much of the added SOM will be rapidly depleted.

6. Maximise Crop Frequency

In northern Australia, which receives both winter and summer rainfall, it is possible to grow more than one crop per year, in years of above average rainfall. In some cropping systems, particularly in dry years, long fallows are used, where the time interval between crops is more than 6 months. Cropping sequences with high crop frequency are likely to add more biomass and build carbon much better than cropping systems which have long fallows and low crop frequency.

Dryland cotton is generally grown after a long fallow and with low biomass input. Planting wheat as a double-crop after dryland cotton and using feedlot manure can offset some of the potential depletion of SOM.

What is a Good Level of Soil Carbon?

Firstly we should be clear about the difference between soil carbon and SOM. SOM is the organic fraction of the soil, exclusive of undecayed plant and animal residues. This is often referred to as humus, except that humus does not include soil microbial biomass.

In practice, SOM is measured as soil organic carbon (SOC) and includes all plant and animal residues, living or dead microorganisms, charcoal *and* humus. To convert SOC to SOM we multiply by 1.724.

The optimum level of soil carbon will depend upon the age of the cultivation and the rainfall, which affects biomass input. Most organic matter (apart from charcoal) is in a constant state of turnover, where it is decomposed and replaced by fresh litter or soil fauna over a short time period of 3 to 4 years.

The level of organic matter in the soil is in a fluid relationship between the amount of carbon being added and the rate of decline. In sub-tropical areas of Australia, the rainfall can produce a reasonable biomass input, but the high temperatures and mineralisation which can occur over the whole year results in a rapid rate of decline.

Organic carbon levels in soils in southern Queensland where rainfall is 600-700mm, often start around 2% and decline to around 1% after 50-80 years of cultivation (Figure 1). It is difficult to build OC back up, but with good management and high yielding crops, such as grain sorghum, a SOC level of 1.2-1.5% may be possible.

Further west, where rainfall is typically 500-600 mm, initial levels of SOC may be high due to the inputs from brigalow scrub or other native vegetation, but it is more difficult to maintain organic matter because crop yields and biomass input are lower and SOC levels of 1-1.2% appear more sustainable.

In southern Australia, it may be possible to maintain higher SOC levels in dry cropping areas, because the summer period (when high temperatures can cause rapid breakdown of SOM) is usually dry. It appears possible to maintain SOC levels of 1.2-1.5% at lower rainfall levels (350-400mm) than in southern Queensland. Optimum levels of SOC can rise above 2% where rainfall is in the vicinity of 500mm.

Carbon Credits for Good Practices

Good practices will halt the decline in soil carbon and in some cases a small increase may be achieved. The increase in levels involved are likely to be too small to provide any income from carbon credit schemes. Some tillage trials and soil carbon measurements have shown a gain of 0.1-0.15 t of carbon per ha per year may be possible in the northern grain belt. While useful and much better than releasing carbon, if carbon offsets were valued at $20/tonne of carbon, then the payments would be $2-3/ha and likely to be less than the cost of monitoring and administering a carbon credit program.

As mentioned earlier, zero-tillage may provide additional greenhouse gas savings by reducing energy inputs in farming and the outputs of nitrous oxide. This could add to the carbon credits, but the total value is still quite small. There is however plenty of incentive to build soil carbon if it results in better moisture storage, better nutrient reserves and higher crop yields. Farming carbon can provide a win-win outcome with improved farm profitability *and* a reduction in greenhouse gases.

Farming Carbon Program

The author of this paper is involved with several groups of farmers, totaling 50, in a *Farming Carbon* program, which aims to help them understand soil organic matter and best practices for increasing it. Small group discussions are held on farms each year. Organic carbon has been measured at two or three sites on each farm and three years of crop records were collected. The sites will be resampled at three years (in 2008) and compared on the basis of six years of crop and fertiliser records. The spread of farms and practices may show some differences in the balance of SOM in accordance with crop yields and fertiliser inputs or nutrient balance.

The study will provide further information on the practicality of improving and measuring any improvements of soil carbon over a three year time frame and how farmers in Queensland might contribute towards a lowering of greenhouse gas emissions or a storage of carbon.

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