Soil Carbon

Introduction

This info sheet summarises the key concepts of soil carbon.

The Big Picture

Soils are vital to life on earth and contain more carbon than vegetation and the atmosphere combined. Increasing soil carbon is beneficial for soil quality and functioning. While changes in soil carbon content can have a large effect on the global carbon budget, they tend not to be significant unless physical changes take place such as cultivation, drainage or deforestation. This is because soil respiration or more correctly, respiration of microbes in the soil, is the main mechanism for moving carbon between the soil and the atmosphere.

Contents

Life in the soil

The soil teams with life. It has been estimated, for example, that there might be as many as 100 billion (10^{10}–10^{11}) bacteria and 3-5 km of fungal growth in a single gram of forest or grassland soil, the value of which is not fully appreciated. These soil microbes break down carbon in organic matter (roots, plant litter etc) releasing it to the atmosphere as carbon dioxide as well as releasing nutrients for plant growth. The bulk of carbon dioxide captured by plants during photosynthesis is returned to the atmosphere by plant respiration. In a hectare of grazed dairy pasture, microbial respiration in the soil turns over 15 to 18 tonnes CO_2 Equivalents annually. Soil typically contains 300 to 400 tonnes CO_2 Equivalents in the top 30cm. The amount of carbon in the soil is a slowly changing balance of this large flow in and out of the soil.

Carbon in New Zealand soils

Soil and pasture carbon are not currently recognised under the current Emissions Trading Scheme, as they are assumed, on average, to remain unchanged under grassland. This 'steady state' assumption is based on results from monitoring over many decades. Added to this is the fact that it is difficult and expensive to accurately measure and validate changes in soil carbon. While there is scope to increase carbon in pasture soil, carbon cannot be increased indefinitely. Soils are generally considered to have an upper limit and tend towards a new equilibrium representing a balance between inputs and outputs. Figure 1 shows how even long term (160 years) addition of animal manure lifts soil carbon level initially until a new level is found.

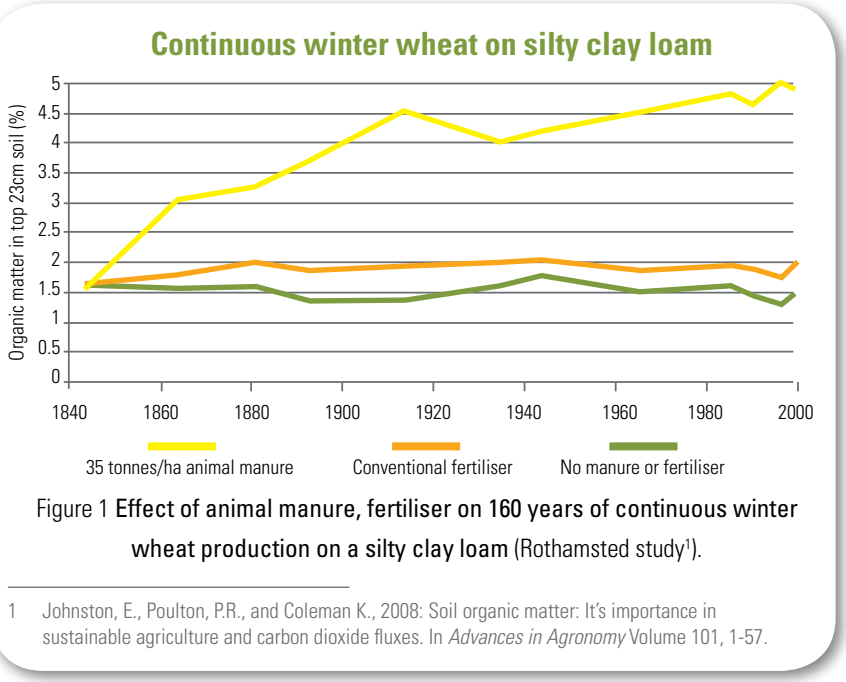

Figure 1 **Effect of animal manure, fertiliser on 160 years of continuous winter wheat production on a silty clay loam** (Rothamsted study[1]).

Changing management practices

Changes in fertiliser policy, stocking rate and/or productivity may lead to changes in soil carbon under pasture. For example if fertiliser use is increased,

1 Johnston, E., Poulton, P.R., and Coleman K., 2008: Soil organic matter: It's importance in sustainable agriculture and carbon dioxide fluxes. In *Advances in Agronomy* Volume 101, 1-57.

additional stock production would be expected, which may increase pasture utilisation and decrease soil carbon levels. Alternatively, if productivity is reduced soil carbon levels may increase. Where changes in soil management do occur, changes in soil carbon levels are unlikely to become apparent or measureable for up to 10 years and are subtle (4 tonnes CO_2 Eq /ha/yr). In contrast, activities such as cultivation may release as much as 37 tonnes CO_2 Eq in the first year. Growth of a new forest may accumulate as much as 35 tonnes CO_2 Eq/year.

Cropping management practices can make a difference to soil carbon levels. For example changing from burning or grazing crop residue to simply leaving it undisturbed or using no-till rather than cultivation for crop establishment can increase soil carbon levels (see Figure 2). Even so, going back to the big picture, a closer look at crop residue management shows that burning cereal straw for electricity generation instead of coal would actually lead to less net carbon discharge into the atmosphere than incorporation of straw into soil. This demonstrates that all farm management practices need to be thoroughly analysed in terms of net mitigation benefit and that the context is important.

Soil Carbon in Australia

To date there has only been limited sales of soil carbon from Australia on an unregulated, voluntary market, typically at a low value as there is little burden of proof or permanence required by the seller. The Chicago Climate Exchange is an example of this type of market (see info sheet 5 for details). Australia's equivalent to the Emissions Trading Scheme, the Carbon Pollution Reduction Scheme (CPRS) will apparently recognise soil carbon credits but the required legislation has not yet been passed so detail is not certain. It seems likely that soil carbon credits will be saleable on a regulated voluntary market where land management practices have been changed and accumulated carbon can be measured. Reports of the potential value of these credits range from $10 to $25/tonne CO_2 Eq. Land management changes include applying biological preparations in place of solid fertilisers[1] replacing annual with permanent pasture[2] and moving from conventional cultivation to no-till[3]. These are pilot schemes looking for Government backing. As these schemes are based on lifting soil carbon levels, a vexing problem is how to reward farmers who already have best soil carbon practise. Like foresters who sell carbon, losses from disasters such as fire will have to be repaid, for farmers, drought could steal away soil carbon and impose cost. Trading soil carbon has a double edged sword. Caution is required.

Unlike Australia, New Zealand grassland already has relatively high soil carbon contents (average around 11% organic matter). Adding more is not as easy as it might be in areas with very low carbon to start with (eg less than 2% OM in Figure 1). Most Australian soils fall into this category. Also, carbon accumulation rates are greater in cool than in warm climates, poorly drained rather than well-drained soils and in light rather than heavy textured soils. In contrast, New Zealand has a benign climate with relatively well-drained, medium to heavy textured soils.

Conclusion

Protecting or enhancing soil organic matter (carbon) is not a new concept to farmers. Lifting the level of organic matter in the soil improves physical, chemical and biological conditions and productivity. Given the potential economic implications of accounting for carbon, this old concept takes on a new importance. We advise that farmers ask for a soil organic matter test every 4 to 5 years as part of routine soil testing to establish trends for a property and improve their knowledge on soil carbon.

1. Prime Carbon – Ken Bellamy, www.primecarbon.com.au
2. Australian Soil Accreditation Scheme – Dr Christine Jones, www.amazingcarbon.com
3. Carbon farmers of Australia, Michael Kiely, www.http://www.carbonfarmersofaustralia.com.au

Long term (35 yrs) soil carbon

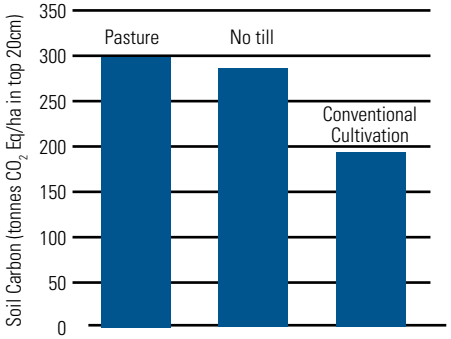

Figure 2: Effect of crop establishment method on long term soil carbon*

* Shepherd, T.G, Ross, C.W., Basher, L..R. and Saggar, S. 2000: *Visual Soil Assessment, Volume 2. Soil management guidelines for cropping and pastoral grazing on flat to rolling country. Part 1.* Horizons Regional Council and Landcare Research, Palmerston North, New Zealand

Further reading

Carbon Farming Information Report www.carbonfarming.co.nz

Visual Soil Assessment. Volume 1. Field guide for pastoral grazing and cropping on flat to rolling country. 2nd Edition. Horizons Regional Council, Palmerston North, New Zealand. 2009, 110pp.

Information prepared by P.A.Handford and Associates Ltd in conjunction with the Carbon Farming Group