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Carbon in Australian cropping soils

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Australian rainfed cropping soils are generally low in carbon, with the usual measure of organic carbon frequently at levels of less than 1%. In many of the more sandy loam soils (for example in Western Australia or the Mallee areas of the eastern cropping belt) levels of around 0.5% are common.

It would be inaccurate to suggest that prior to being cleared and farmed that these soils were higher in organic carbon than they are now. Much of Australia's remnant 'virgin' soil in the larger cropping areas have organic carbon levels at approximately 1.5%.

Any suggestion that farmers can increase soil carbon to levels of 3% or greater fails to understand that soil carbon is part of the carbon cycle, and heavily dependant on plant growth, soil microbial activity and seasonal conditions.

Given the age and degraded nature of Australian cropping soils and the 'natural' low levels of organic carbon, there is no scientific evidence to suggest that there is a real possibility that organic carbon levels can be increased by cropping or farming practices at anything other than slow rates, reaching an equilibrium point well below that of northern hemisphere soils.

Importantly, upon reaching any new or higher carbon equilibrium, these soils will require continued inputs of organic carbon at high levels just to remain at an elevated organic carbon level. This may lead to the areas involved becoming 'uneconomic' as farm land, as the cropping and grazing systems would have to be dramatically altered to retain the levels of organic matter needed to sustain higher soil carbon levels.

Changed circumstances on farm, such as drought, changed tillage system, crop types and rotations, pasture management and fertiliser practices can all have serious effects on levels of soil carbon.

Farmers involved in producing grain are generally net emitters of greenhouse gasses through the use of fossil fuels and fertiliser. Farming to produce grain includes some form of soil disturbance, at least at planting, and in some cases additional tillages are still used. These operations and inputs result in greenhouse gas emissions, comprising both carbon dioxide (CO_2) and nitrous oxide (N_2O), the latter a potent greenhouse gas.

The amount of tillage used has decreased dramatically in the last 20 or so years with the adoption of no-till practices, and the retention of crop stubbles. This has led to a dramatic reduction in fuel use. These practices reduce the emission of greenhouse gasses from soils (by virtue of less tillage), and also to add some carbon to soils by the reduction in disturbance and oxidation or plant matter, for example root systems.

However, the amounts 'added' to soil, even given these more conservative systems, are limited. Researchers, for example Prof. Peter Grace at the University of Technology in Queensland, attest to this limited ability for grain producers, even using the most conservative tillage and fertilise systems to 'add' much more than 100-200kg/ha of carbon to soil per year.

Carbon can only be added to soil under such farming systems by growing more biomass in the soil and either slowing its release by micro-organisms by reducing tillages and retaining crop remains. The problem for grain producers is that in the process of producing grain crops, greenhouse gasses are emitted, and the amounts emitted can far outweigh any carbon 'added' to soil.

Several models have been developed in recent years in Australia that estimate the emissions and potential amounts added to soil in the cropping industries.

These include:

1. The Grains Environment Datatool (GEDT) by the Centre of Excellence in Cleaner Production at Curtin University of Technology in WA by Professor Rene van Berkel. This spreadsheet based tool gives some guidance about emissions from various farming systems and crop production inputs.
2. A spreadsheet based tool produced by the National Greenhouse Gas Initiative, a joint project between the GRDC, Victorian DPI, University of Melbourne, CSIRO, the Department of Agriculture and Food in WA.

3. SOCRATES (Soil Organic Carbon Reserves and Transformation in agro-Ecological Systems. This simulation model was developed by the CRC for Soil and Land Management, at CSIRO Land and Water, Adelaide.

Whilst all of these tools urge caution in the interpretation of their outputs, they can give some useful guidance as to levels of both emissions and sequestration of greenhouse gasses in Australian cropping soils.

Farmers and interested observers need to remember that in any future carbon trading scheme, BOTH emissions and sequestration will be used in calculating any level of participation.

In the Australian Grains Industry any reasonable estimate will show a large net emission, rather than any significant sequestration.

Estimates from the models and from other sources in the scientific literature:

Carbon Sequestration

Using SOCRATES, and typical crop rotations and inputs in typical cropping areas of Australia, estimates of carbon sequestration range up to 0.01% in organic carbon per year. This equates to around 100kg/ha per year. Importantly this level of increase levels out after 10-20 years to reach a new slightly higher than native soil equilibrium.

To hold these increased levels of organic carbon, continual high inputs of organic matter will be needed to sustain the increased levels over time. Since carbon cycles in and out of the soil, reduced inputs of carbon in some years (for example from a drought or changed farming system) will allow soil organic carbon to be released, potentially ‘undoing’ some of the sequestration of previous years.

If 100kg/ha of carbon is able to be sequestered per year, this equates to 2 million tonnes over the 20 million hectares of crop grown in Australia.

For an individual farm, estimates of the organic carbon increase possible under the best tillage regime in typical soils are in the order of 100kg/ha of carbon per year.

Other scientific work suggests that over a 20 year period[1], up to 8 tonnes per ha of carbon can be added to soil. However, this level of addition is in high clay content soils, in high rainfall areas, where perennial pastures are a feature of the system. These are relatively rare circumstances in the cropping areas of Australia.

A more typical soil and cropping system may be able to sequester around 4 tonnes per ha of carbon over 20 years, equating to approximately 200kg/ha/yr of carbon. Very large areas of the cropping belt of Australia would show much lower figures for carbon sequestration, at 100kg/ha/yr or less.

Greenhouse Gas Emissions

The three models offer different estimates of potential emissions from a typical cropping operation, ranging from approximately 300kg/ha to 1500kg/ha. Other work suggests (over 20 years) average emissions to be approximately 440kg/ha/yr. Even if one takes a rough estimate of 500kg/ha, this greatly outweighs the amount sequestered, by 400kg/ha.

If, in this example, 500kg/ha is emitted from a cropping program, then across 20 million hectares, this equates to 10 million tonnes of emissions.

Simple arithmetic shows that the grains industry will be a net emitter of greenhouse gasses, to the tune of approximately 400 or more kg of emissions per hectare, or 8 million tonnes over the whole Australian crop.

On a hectare basis, it is likely that many cropping farms will be net emitters of greenhouse gasses, up to 400kg/ha, and potentially more, per year.

If carbon is valued at $20 per tonne under a carbon trading system, rather than farmers making a return from sequestering carbon, they may end up with paying around $8 per hectare, and potentially more.

It should also be remembered that carbon in soil is a dynamic system, and in drought years emissions will be potentially higher, and additions very much lower or non existent.

Nonetheless, grain producers have made considerable progress in reducing greenhouse gas emissions over the last 15 years from dramatically reducing fuel use. Figures show that since 1990, by virtue of embracing reduced and no-till systems, farmers have cut their on-farm fuel use by half. This has given a reduction in emissions of approximately 500 thousand tonnes of CO_2 per year compared to 1990 levels for the industry as a whole.

Other considerations

In any carbon trading system important considerations are:

1. Carbon sequestered must remain so for 70 or more years. In an agricultural system this is difficult to achieve and manage given the variable nature of production, seasons, and farming systems.
2. It is also very hard to verify that organic carbon is able to remain stable in the soil, since it is made up of several carbon fractions. These include humic and microbial carbon, resistant and decomposable plant material and charcoal. These all have very different properties and can cycle at different rates. They vary widely in their proportions in different soil types and in their ability to remain stable or be released under different farming systems and climates.
3. Carbon levels and the rate of cycling in soil are difficult to measure or estimate. Emissions can come from fuel use, nitrogen fertiliser use and cultivation of soil. At present, only fuel use is able to be accurately calculated into greenhouse gas emissions. Nitrous oxide and carbon dioxide emissions from soil are much more difficult to measure or accurately estimate, and are subject to strong influences of season and management.
4. Any participation in carbon trading will require verification and auditing, with these bringing considerable transaction and on-going costs. These could easily outweigh any carbon payment benefit.

Thus, grain producers should look with caution at any forecasts that there is money to be made out of carbon trading, since, in simple terms they will remain net emitters of greenhouse gasses, even if these have fallen greatly in recent years.

[1]Grace, P (2007) Carbon Farming – Facts and Fiction. Proceedings of the Healthy Soils Symposium, July 2007, Sunshine Coast, Queensland. Pp 92-99