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FarmLink Research Report 2015

Farmers leading and learning about the soil carbon frontier

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Project Partners

FarmLink, CSIRO

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Australian Government Department of Agriculture, clean energy future, GRDC Grains Research & Development Corporation

Trial Site Location

Temora Agriculture Innovation Centre

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Introduction

The soil organic matter content of Australian soils is either decreasing or remaining stable. Increasing soil organic matter content could be beneficial for improving soil water holding capacity, increasing nutrient supply (N and cations), better pH buffering capacity and improved soil structure).

How can Soil Organic Matter be increased?

The most active ingredient of SOM is humus, which consists of the remains of bacteria and other micro-organisms that consume and break down plant material returned to the soil from a crop or pasture. This plant material consists mainly of carbon (C). For soil microbes to consume this material they need nitrogen (N), phosphorus (P) and sulphur (S) otherwise they cannot thrive and multiply. Australian soils are inherently low in nutrients and in most soils there is insufficient N, P and S for soil micro-organisms to rapidly break down the plant material returned to the soil. To increase the stable humus fraction in the soil, we need to supply soil microbes with additional N, P and S; this may have to be supplied as extra fertiliser.

How much N, P and S need to be supplied to stubble to form humus?

Dr Clive Kirkby, from CSIRO, has been working on this question and found that:

- In humus, 1000 kg of C is balanced with 80 kg N, 20 kg P and 14 kg S.
- Dr Kirkby argues that for soil micro-organisms to breakdown stubble and form humus, we need to add sufficient nutrients (N, P and S) to feed these micro-organisms (Kirkby et al. 2011).
- For micro-organisms to efficiently break down wheat stubble to humus additional nutrients have to be added. Wheat stubble has a low nutrient:C ratio and 1t of cereal stubble needs to be balanced with 5.8 kg N, 2.2 kg P and 0.9 kg S.

The DAFF and GRDC funded trial is examining existing, new and alternative strategies for farmers in the cereal sheep zone to increase soil carbon. The trial will be used as base line data for carbon accumulation in soils and to:

- discuss the various forms of soil organic carbon (particulate, humus and resistant fractions),
- investigate how management affects each of these pools and how humus can be increased,
- communicate how soil organic matter affects soil productivity.

Identical trials are being run by eight farm groups in SE Australia (Victoria: Mallee Sustainable Farming, Birchip Cropping Group, Southern Farming Systems; NSW: FarmLink, Central West Farming Systems; SA: Hart and Eyre Peninsula Agricultural Research Foundation, both through Ag Ex Alliance; and Tasmania: Southern Farming Systems) so information can be collected on different soils and climates throughout the Southern Region.

Methods

2015 was the fourth year of the trial. Soil samples were collected pre-sowing for Yield Prophet® (0-10, 10-40, 40-70, 70-100 cm) to determine soil available nitrogen, soil moisture and model in season crop N requirements.

In April the stubble management treatments were imposed: (i) stubble left standing, (ii) stubble worked in with off-set discs prior to sowing and (iii) stubble removed by raking and burning. Nutrient application treatments at seeding were: (i) base practice for P at sowing and N in crop as per Yield Prophet® and (ii) base practice PLUS extra nutrients (N, P, S) required to break down the measured canola stubble from the 2014 crop. Based on the 2014 stubble load, the extra nutrients (17.5 units N, 2.7 units P and 5.2 units S) required to break down the stubble were applied on 13 February with a rainfall event. The extra nutrients (Plus treatment) were applied as DAP (18:20:0:0) @ 14 kg/ha, ammonium sulphate (21:0:0:24) @ 22 kg/ha and urea (46:0:0:0) @ 37.5 kg/ha. Treatments were replicated 4 times.

The trial was sown on 28 May with Suntop wheat @ 50 kg/ha and a base fertiliser of MAP (11:22:0:2) @ 70 kg/ha. Summer knockdown chemical applications were 1.5l/ha Roundup, 700ml/ha Amicide, 80ml/ha Garlon plus an adjuvant. Pre seeding chemical applications were Roundup @ 2 L/ha, . On 22nd of August, MCPA LVE was applied at 1.0l/ha with 5g/ha of Ally at 70l of water/ha. No additional N was applied to the trial as very wet winter conditions saw some temporary waterlogging within the trial.

Results 2015

Yield

There was no significant effect on yield from the Stubble treatment but there was from the application of Extra nutrients (Table 1). This result implies that insufficient nutrients were applied to the Base nutrient treatments to enable the crop to reach its yield potential, and the nutrients applied in the Extra nutrient treatments were used by the crop rather than the intended soil micro-organisms to breakdown the stubble remaining from 2014.

Stubble treatment	Nutrition treatment	Yield (t/ha)
Stubble removed	Base practice	2.56
Stubble removed	Base practice plus Extra N,P&S	3.23
Stubble standing	Base practice	2.76
Stubble standing	Base practice plus Extra N,P&S	2.82
Stubble worked	Base practice	2.74
Stubble worked	Base practice plus Extra N,P&S	3.40
P value Stubble treatment Nutrient treatment		NS P<0.01

Table 1 Grain yield as affected by stubble treatments and additional nutrients at Temora 2015

Soil Carbon 2012 to 2015

Initial soil samples for soil Carbon analysis were taken prior to sowing in 2012 and again three years later prior to sowing in 2015. After three years of implementing the stubble and nutrient management strategies, soil C content at Temora ranged between 1.4 and 1.6% for the topsoil (0-10cm) and 0.5 and 0.7% for the subsoil (10-30cm). There was no significant difference in SOC content between the 2012 and 2015 measurements (Figure 2).

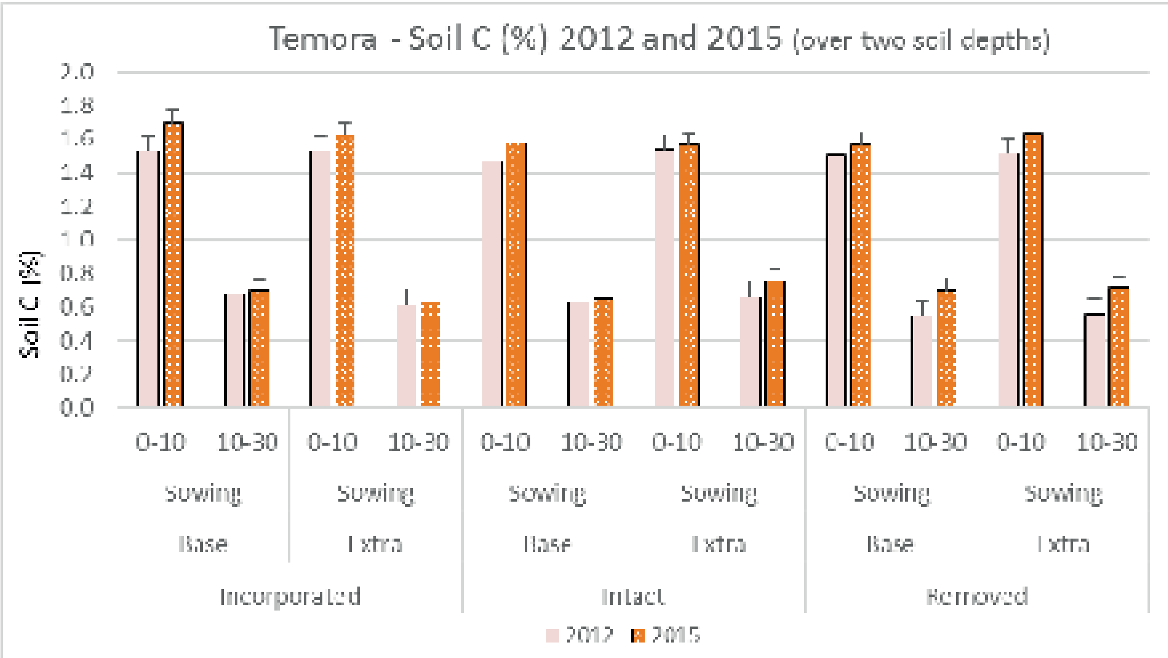

Figure 2. Soil Organic Carbon content (%) for the top and subsoil after three years of stubble and nutrient application treatments.

To measure the change in the amount of soil carbon over time, the soil mass per unit volume of soil has to be taken into account – in other words the amount of soil carbon is reported for a defined soil mass (ESM, Equivalent Soil Mass). The concept of ESM compensates for variations in the way samples were collected and also allows for variations in soil bulk density, resulting from different tillage practices.

Soil C stocks at Temora ranged from 40 to 45 t C/ha (Figure 3). There was no significant difference between soil C stocks for the different stubble and applied nutrient treatments between 2012 and 2015.

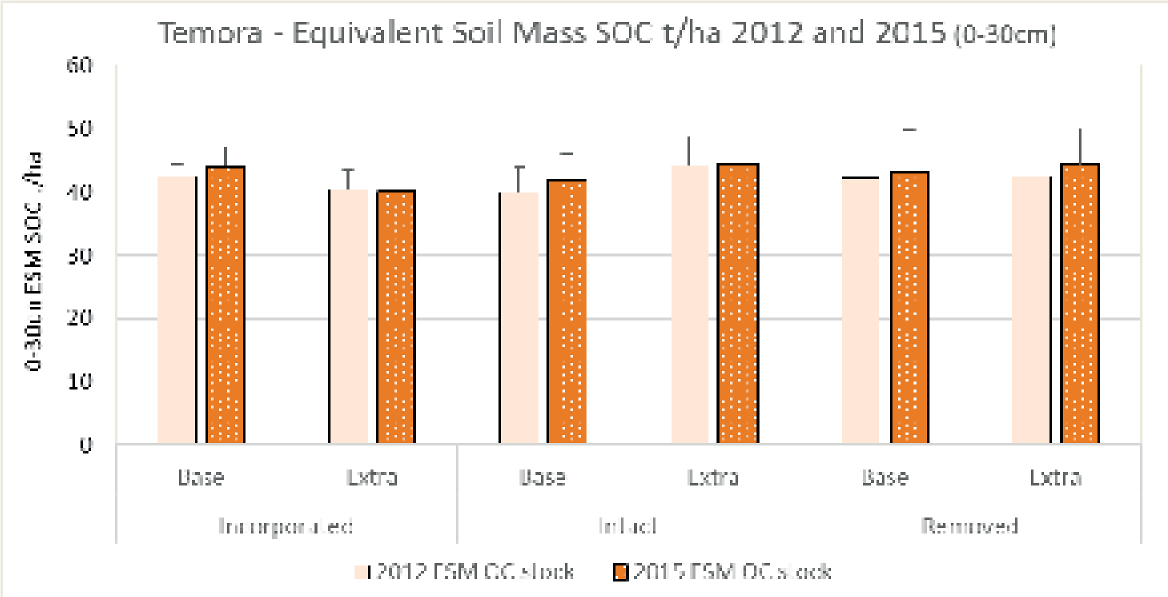

Figure 3. Soil C stocks (t C/ha) in in 2012 (start of the trial) and 2015 after three years of stubble and nutrient application treatments at Temora.

What does it mean?

It was expected that the imposed treatments to increase soil organic matter would take several years to become noticeable, especially in medium rainfall areas. Even after three reasonable seasons at Temora with good crop production there were no differences in Soil C stocks between the stubble and nutrient supply treatments.

The same result was found at the other seven trial sites located in SE Australia. This work shows that increasing soil C stocks is a long-term process, and three years was not long enough to measure significant changes with the practices selected. This is consist with a recent review indicating the largest gains in soil C stock were seen 5 to 10 years after adoption or change in practice (Sanderman et al. 2009). They also reported that improved management of cropland (eg. no-till or stubble retention) resulted, on average, in a relative gain in SOC of 0.2- 0.3 t C/ha/year compared with conventional management across a range of Australian soils. The Temora Soil C trial will be re-measured again on the completion of the 2016 season after five years of trial work.

Acknowledgements

Funding for this trial is provided from DAFF and GRDC. Yield Prophet is an on-line modelling service based on APSIM that provides simulated crop growth based on individual paddock information and rainfall, and is registered to BCG.

References

Kirkby, C., Kirkegaard, J., Richardson, A., Wade, L., Blanchard, C. and Batten, G. (2011). Stable soil organic matter: A comparison of C:N:P:S ratios in Australian and other world soils. Geoderma, 163, 197-208.

Sanderman, J., Farquharson, R., Baldock, J., (2009) Soil carbon sequestration potential: A review of Australian Agriculture. CSIRO p1-89