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Section 7

Soils

RESEARCH

Stubble and nutrient management trial to increase soil carbon

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Searching for answers

Location:
Minnipa Agricultural Centre
Paddock South 2/8
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2015 Total: 333 mm
2015 GSR: 258 mm
Yield
Potential: 3.0 t/ha (W)
Actual: 2.8 t/ha
Paddock History
2015: Mace wheat
2014: CL Grenade wheat
2013: Mace wheat
2012: Scout wheat
Soil Type
Red sandy loam
Plot Size
12 m x 3 m x 4 reps

Key messages

- **Average trial yield was 2.8 t/ha, approximately 1 t/ha below the nitrogen unlimited potential as identified by Yield Prophet® during the season.**
- **No significant differences in yield were found between stubble treatments (stubble retained, worked or removed) and nutrient treatments (normal practice, normal practice plus additional nutrients to enhance stubble breakdown).**
- **After three years of trial work, no significant differences in soil carbon were found between the stubble and nutrient treatments.**

Why do the trial?

The soil organic matter content of most Australian soils used for crop production is either decreasing or remaining stable. Trials have demonstrated that No-Till stubble retention systems are adding to the partially broken-down particulate organic carbon fraction but are not contributing to the stable humus fraction. Without an increase in soil humus the important functions of soil organic matter (i.e. improved soil water holding capacity, increased nutrient supply (nitrogen and cations), pH buffering capacity and better soil structure) are unlikely to be realised.

What is humus and how can it be increased?

Humus 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 also 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 of organic carbon 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 1 tonne 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 C. The trial will be used as base line data for C accumulation in soils and to:

- discuss the various forms of soil organic C (SOC, plant residues, particulate, humus and resistant fractions),
- investigate how management affects each of these pools and how humus can be increased over the medium to long term ,
- communicate how soil organic matter affects soil productivity (through nutrient and water supply, and improvements in soils structure).

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 in the Southern Region.

How was it done?

The trial commenced in autumn 2012 at which time soil samples were collected to establish the initial stocks and composition of soil C. 2015 was the fourth year of the trial and soil samples were again collected for soil C analysis prior to sowing the 2015 crop. Soil samples were also collected pre-sowing for Yield Prophet® (0-10, 10-40, 40-70, 70-100 cm) to determine soil available N and soil moisture.

In March-April of each year the stubble management treatments: (i) stubble left standing, (ii) stubble worked in with single operation of the seeder before sowing and (iii) stubble removed by raking and burning were imposed.

Nutrient application treatments at seeding were: (i) normal practice for P at sowing and N in crop as per Yield Prophet® and (ii) normal practice PLUS extra nutrients (N, P, S) required to break down the measured wheat stubble from the 2014 crop. Based on the initial 2015 stubble load of 6.8 t/ha, the extra nutrients (39 units N, 15 units P and 6 units S) required to break down the stubble were applied on 16 April with a rainfall event. The extra nutrients (plus treatment) were applied as DAP (18:20:0:0) @ 75 kg/ha, ammonium sulphate (21:0:0:24) @ 25 kg/ha and urea (46:0:0:0) @ 51 kg/ha. Treatments were replicated 4 times.

The trial was sown in drier conditions on 12 May with Mace wheat @ 60 kg/ha and a base fertiliser of DAP (18:20:0:0) @ 50 kg/ha. The trial area was sprayed on 8 May with 1.2 L/ha glyphosate and Cavalier at 100 ml/ha. Pre seeding chemical applications at seeding on 12 May were Roundup Attack @ 1.2 L/ha and Boxer Gold @ 2.5 L/ha. On 27 July, Tigrex was applied at 750 ml/ha and 100 ml/ha Lontrel. Emergence counts, flowering date, grain yield and grain quality were measured.

What happened?

Crop performance 2015

Emergence counts were taken on 21 May with an average of 163 plants/m^2 (range of 125 to 207 plants/m^2) which was good given the dry start to the season and variability with germination in other trials. The 2015 season was a decile 5 but drier seeding and early seasonal conditions did not allow early plant growth and the season finished quickly with a hot October long weekend. Flowering occurred (GS 65- when 50% of heads have anthers) on 15 September. The trial was harvested on 11 November. There were no differences between treatments in yield. There was a small increase in protein and screenings ($P<0.001$) for those treatments that received additional nutrients (Table 1).

Yield Prophet was used early in the season (3 July) to predict if extra N fertiliser was required to achieve potential yield given the drier seasonal conditions. Due to the dry conditions an extra 20 kg N/ha was applied on 9 July spread over all treatment plots, and 20 kg/ha was applied again on 3 August with rainfall events.

Soil Carbon 2012 to 2015

At the start of each season additional nutrients were applied to aid in the breakdown of stubble to soil organic matter.

After three years of implementing the stubble and nutrient management strategies, soil C content at Minnipa ranged between 1.1 and 1.3% for the topsoil (0-10cm) and 0.7 and 0.9% for the subsoil (10-30 cm). There was no difference in SOC content between the 2012 and 2015 measurements (Figure 1).

To measure the change in the amount of soil C over time, the soil mass per unit volume of soil has to be taken into account – in other words the amount of soil C is reported for a defined soil mass

Table 1 Grain yield and quality as affected by stubble treatments and additional nutrients at Minnipa 2015.

Stubble treatment	Nutrition treatment	Yield (t/ha)	Protein (%)	Screenings(%)
Stubble removed	normal practice	2.60	10.7	6.1
Stubble removed	normal practice plus N,P&S	2.90	12.1	10.2
Stubble standing	normal practice	2.73	10.7	8.7
Stubble standing	normal practice plus N,P&S	2.84	11.6	8.9
Stubble worked	normal practice	2.88	10.3	6.6
Stubble worked	normal practice plus N,P&S	2.97	11.8	11.8
P value Stubble treatment		*ns*	*ns*	*ns*
Nutrient treatment		*ns*	*P<0.001*	*P<0.001*

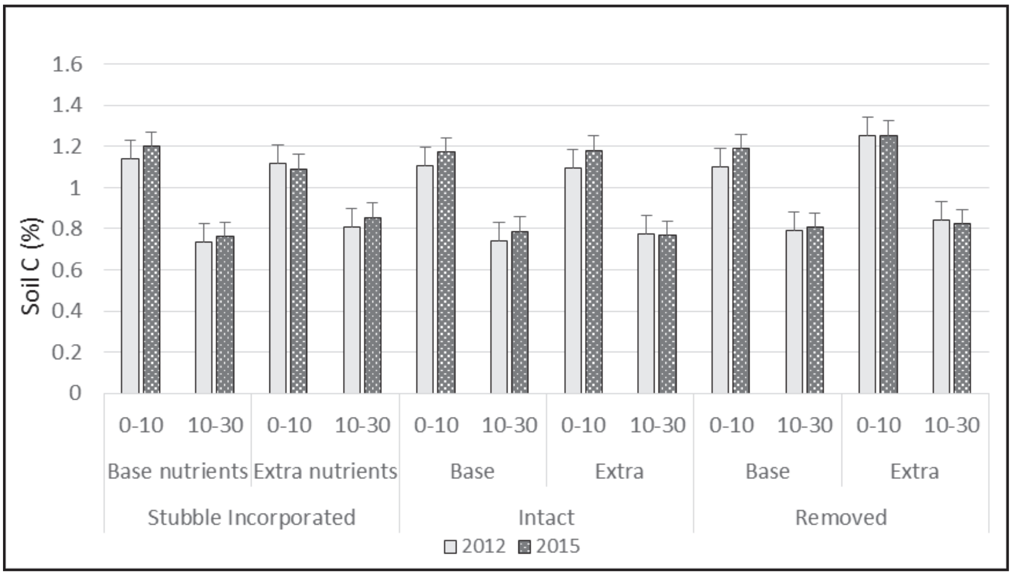

Figure 1 Soil organic carbon content (%) for the top and subsoil after three years of stubble and nutrient application treatments.

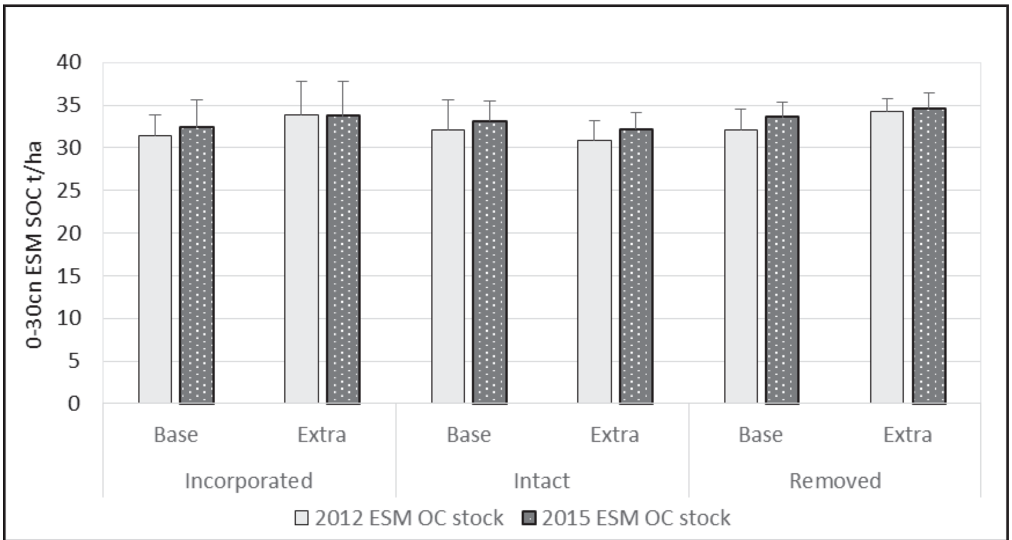

Figure 2 Equivalent soil mass C stocks (t C/ha) in 2012 (start of the trial) and 2015 after three years of stubble and nutrient application treatments at Minnipa.

(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 Minnipa ranged from 30 to 35 t C/ha (Figure 2). However, there was no difference between soil C stocks for the different stubble and applied nutrient treatments between 2012 and 2015.

What does this mean?

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

The same result applied to 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 consistent 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 (e.g. 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 Minnipa soil C trial will be re-measured again on the completion of the 2016 season after five years of trial work.

Acknowledgements

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References

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