Changes in Soil Organic Carbon and Yield in Response to Compost and Spading on a Sand

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Aim

To assess the effects of physical (spading), chemical (fertiliser) and biological (compost) treatments on soil organic carbon (SOC) in relation to changes in long term crop yields and quality.

Background

Growers are constantly assessing the long term profitability and sustainability of their farming systems. Often growers look to target an optimum gross margin rather than highest yield. This demonstration trial was established in 2013 and carried on into 2014 to determine whether measureable changes in soil organic carbon (SOC) and productivity could be associated with physical disturbance and/or higher levels of either chemical or biological inputs applied to the soil.

In this instance the influence of physical disturbance compared plus and minus spading, chemical inputs were compared by high and low chemical fertiliser inputs, and biological inputs compared plus and minus compost. The impact of different inputs was assessed by considering any changes in SOC storage, yield and/or profitability.

Trial Details

Property	Long Term Research Site, west Buntine
Plot size & replication	50m x 18.2m x 4 replications
Soil type	Deep yellow Sand (Tenosol, 13% clay 0-30 cm)
Soil pH ($CaCl_2$)	0-10cm: 6.0 10-30cm: 4.7
EC (dS/m)	0-10cm: 0.10 10-30cm: 0.04
Sowing date	06/05/2014
Seeding rate	78 kg/ha Brusher oats
Fertiliser	06/05/2014: All treatments 10 L/ha Flexi-N; 9 L/ha CalSap, Low treatment 25 kg/ha Urea, High treatment 50 kg/ha urea (top-dressed) 07/05/2014: Low treatment 34 kg/ha TSP, High treatment 80 kg/ha TSP (top-dressed) 18/07/2014: Low treatment 25 kg/ha Urea, High treatment 50 kg/ha Urea (top-dressed)
Herbicides	06/05/2014: 2 L/ha Spray.Seed, 0.5 L/ha Diuron, 0.5 L/ha Dual Gold 30/06/2014: 500 g/ha Diuron, 140 g/ha Cadence, 1.5 L/ha Precept, 1% Hasten
Paddock rotation	2010 wheat, 2011 wheat, 2012 canola, 2013 barley
Soil amelioration	17/05/2013: Rotary spading
Growing Season Rainfall	159mm (May-October); 129mm (includes consideration of summer rainfall and losses due to evaporation and run-off)

Results

2013

Soil (baseline)

In March 2013, soils were marginal for inorganic nitrogen (N) and below 10cm were low in pH with low level compaction in the 10-20cm layer (Table 1). Water holding capacity (0-10cm) was approximately 29%. The microbial biomass (mass of microorganisms) in surface soil to 10cm measured 92 kg/ha (63 mg/kg soil).

Table 1: Selected soil properties (0-30cm) for soil collected in March 2013 at the Buntine experimental site prior to treatments being imposed.

Depth	Phosphorus (Colwell, mg/kg)	Potassium (Colwell, mg/kg)	Sulfur (mg/kg)	Organic carbon (%)	Organic carbon (t C/ha)	pH ($CaCl_2$)	Bulk density (g/cm^3)	C/N ratio
0-10 cm	29	73	25	0.86	12.9	6.0	1.45	12
10-20 cm	18	51	15	0.50	8.7	4.7	1.76	10
20-30 cm	7	53	20	0.26	1.9	4.7	1.63	8

Grain Yield

In 2013 control (non-spaded) plots yielded 15% more than spaded treatments (2.2 t/ha versus 1.9 t/ha) but grain protein was lower (9.6% versus 11.3%) – resulting in a similar uptake of nitrogen (35kg N/ha). Compost showed no yield response with a nominal increase in grain protein, compared to fertiliser treatments which demonstrated higher N uptake due to both increased yield and protein (42kg N/ha). High screenings on the spaded treatments (42% screenings < 2.5mm) suggests the spaded areas may have experienced higher water stress later in the season and may explain the slightly lower grain weight compared to non-spaded areas (30% screenings < 2.5mm). This would be supported by seasonal observations that crop height and biomass were greater in spaded treatments than non-spaded treatments.

2014

No change in nutrient status was measured in 2014 following treatments imposed in 2013 (Table 2). Cation exchange capacity (CEC) was evenly distributed across all soil layers in spaded treatments as compared to non-spaded treatments where more than 50% was in the surface 0-10cm indicating changes in CEC associated with the burial of organic matter.

Table 2: Soil properties (0-30cm) in March 2014 – 12 months after treatments were imposed at Buntine. Data is the average of all treatments.

Depth	Nitrogen (NH_4, NO_3; mg/kg)	Phosphorus (Colwell, mg/kg)	Potassium (Colwell, mg/kg)	Sulphur (mg/kg)	Cation exchange capacity (meq/100g)	Organic carbon (%)	Organic carbon (t C/ha)	pH ($CaCl_2$)	Bulk density (g/cm^3)	C/N ratio
0-10cm	10	23	66	31	2.8	0.6	9.1	5.8	1.5	10
10-20cm	6	23	56	25	2.0	0.5	8.7	5.1	1.7	10
20-30cm	3	12	58	21	1.5	0.3	5.1	4.8	1.6	8

Changes in soil pH were evident as a result of spading across all soil depths and resulted in a profile which should arguably support higher productivity (Figure 1). Surface (0-10cm) pH decreased by approximately 0.5 units in spaded treatments, but increased at 10-20cm (0.7 pH units) and 20-30cm (0.5 units) taking these layer above the minimum pH of 4.8 recommended for these soil layers.

A large ($p<0.05$) decline in dissolved organic carbon of 39% was observed in spaded treatments, as well as a 60% decline in microbial biomass carbon (81 kg/ha) and 57% decline in potentially mineralisable nitrogen (6 kg/ha) compared to area that were not spaded.

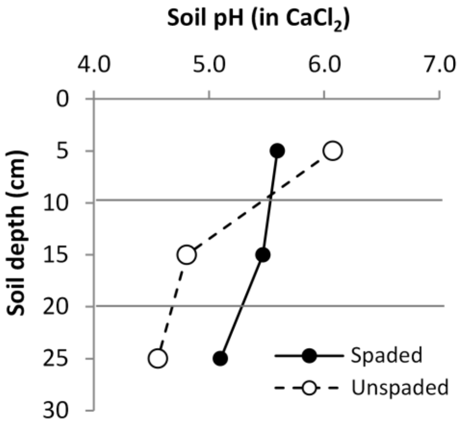

Figure 1: Effect of spading applied in 2013 on the soil pH profile (as measured in $CaCl_2$) to 30cm of in 2014 (data is the average of all treatments).

SOC stocks (0-30cm depth) averaged 22.4t C/ha in treatments which had no spading applied and 19.0t C/ha in spaded treatments indicating a significant decrease of approximately 15%. The surface layer (0-10cm) where most organic matter is located experienced the greatest losses with the spaded treatment approximately half that of unspaded treatments (SOC 0.4% versus SOC 0.8%). It appears a component of this was lost and the remainder redistributed to the 20-30cm soil layer which measured an increase in SOC (0.4% SOC versus 0.2% in unspaded areas).

No other treatment differences were measured as a result of either increased fertiliser or from applying compost (Figure 2).

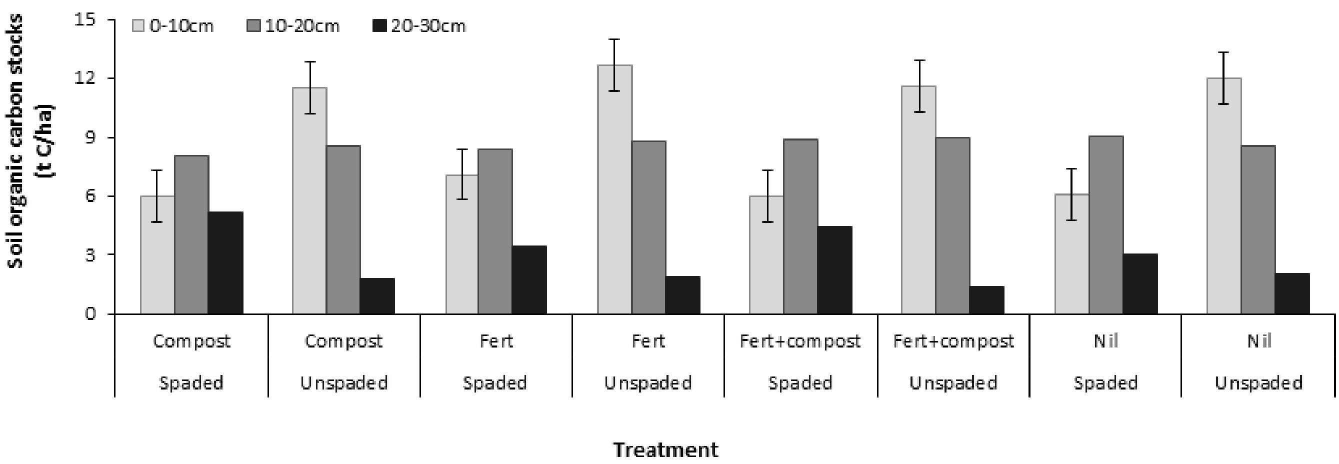

Figure 2: Effect of spading, compost and fertiliser application on soil organic carbon (t C/ha) measured in 2014 at depths of 0-10, 10-20, 20-30cm.

Hay Yield

No significant changes in hay yield were measured at this site associated with treatments in 2013/2014. A rainfall to yield conversion suggests approximately 15kg of hay yield per mm of growing season rainfall (May to October rainfall, plus one third of January-April rainfall) was achieved taking into consideration some loss of water through run-off and evaporation (one third of total growing season rainfall).

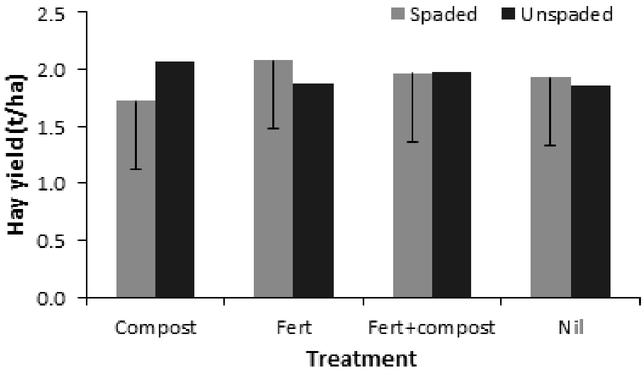

Figure 3: Effect of treatments applied in 2013 on hay yields in 2014.

Economic Analysis

In 2013 the application of 2 t/ha compost did not result in higher returns and the response under compost plus fertiliser treatments could be attributed to the application of fertiliser. Spading did not return any further gains in terms of yield or quality at this site in 2013 (Figure 4). The high cost of spading and compost has negatively influenced profit outcomes. Short term yield responses observed in both 2013 and 2014 suggest these treatments are unlikely to pay for themselves over the longer term at this site.

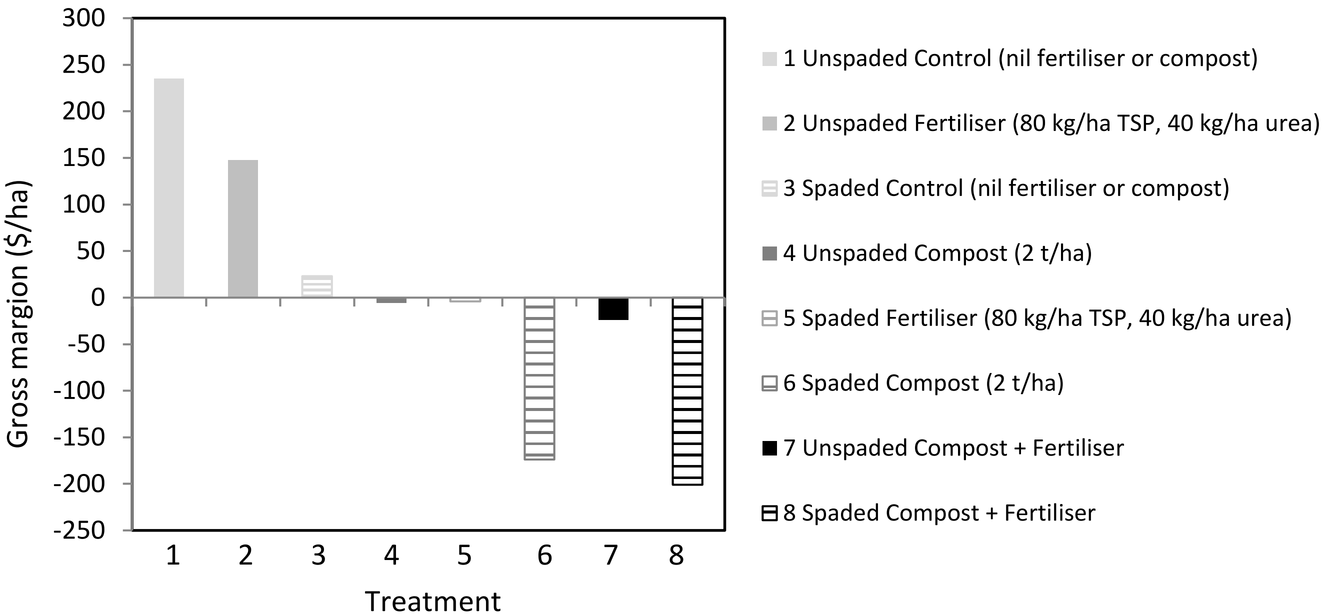

Figure 4: Gross margins ($/ha) for soil treatments applied to barley in 2013 on a deep sand at Buntine. Light shaded areas represent spaded treatments; dark shaded areas are non-spaded treatments. Treatment numbers are on the bottom axis of graph. Source: Nadine Hollamby Liebe Group.

Thus in this instance the most profitable treatments would have been the non-spaded control (Treatment 1) and the non-spaded fertiliser (Treatment 2; Figure 1). This is likely to reflect analyses of 2014 yield and quality results (not yet complete). The only measureable changes in soil condition noted in 2014 that would add value to the potential long term profit of this site was increasing soil pH at depth associated with spading.

Comments

Machinery used for composting caused some compaction and under dry post-sowing conditions as experienced in 2013 can cause patchy germination. In 2013 the trial site experienced significant moisture stress early in the season and may not be representative of seasons experiencing an average or wetter start. Extended moisture in spring supported good yields associated with high grain weights. In 2014 the site had good starting moisture and rainfall but experienced dry post sowing conditions through June and July.

This site has not responded greatly to fertiliser suggesting N was not a limiting factor in either season. Soil tests taken in March also suggest there would be no other limiting major nutrients (P, K, S) to crop growth. The control treatments which had a minimum fertiliser and background turnover of SOC (assumed at 3% per year) could have been expected to supply between 65 and 80kg N/ha.

Application of compost at 2 t/ha is nominal given the background SOC stocks of approximately 20 t/ha (0-30cm). To have an impact on soil function the rate of application required is likely much greater and would need to be maintained and applied at regular intervals to avoid losses.

Acknowledgements
Thanks to the Liebe Group and their growers for continued interest and support for this project and management of the trial site. Also thanks to Natalie Hogg (DAFWA), Richard Bowles (UWA) and Justin Laycock (DAFWA) for enabling this trial site to be implemented and sampled. This project is led by the Department of Agriculture & Food, WA in collaboration with the Liebe Group and is supported by funding from the Australian Government.

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