Does Increasing Soil Carbon in Sandy Soils Effect N Fertiliser Requirements and Grain Production?

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Key messages

- Adding organic matter (OM) to the soil during the last 10 years increased barley grain yield in 2013.
- Barley grown in a OM+tillage treatment met the quality standards required for malting barley (MALT1/BFOD1) without applying N fertiliser, whereas the barley grown in the Tillage only treatment did not meet grain quality standards even when N fertiliser was applied.
- The Liebe Group's Long Term Research Site provides an ideal opportunity to investigate the effect of soil organic carbon on crop yield and quality, and assess the capacity to decrease reliance on synthetic fertiliser inputs.

Aim

To investigate if increasing soil organic carbon alters crop productivity.

Background

Increasing SOC may influence the amount of N fertiliser required for crop production. Fertiliser application is the largest single variable expense for growers when producing crops. Better matching N fertiliser inputs to crop demand not only increases cropping profitability, but also decreases the risk of N leaching and soil nitrous oxide (N_2O) emissions. Utilising inorganic N fertiliser also greatly influences the carbon-foot print of agricultural production systems. Understanding the interactions between SOC and N fertiliser, and its influence on greenhouse gas emissions and crop yield is critical when assessing the effectiveness of soil carbon (C) sequestration to abate greenhouse gas emissions from the agricultural land sector.

Experimental Approach

A key question being addressed by the research project is does increasing soil organic carbon lower N fertiliser requirements and increase grain yield? We are utilising the Liebe Group's Long Term Research Site at Buntine to answer this question. The study site was established in 2003, and includes a variety of replicated treatments aimed to alter soil organic carbon. The current study is utilising field plots that have either been tilled annually with or without the addition of organic matter (OM) every three years.

In 2013, crop yield response to a range of N fertiliser applications (0, 25, 50, 75 and 100 kg N/ha) was determined on replicated (three) field plots of contrasting soil C contents (i.e., Tillage, OM+Tillage) at the Buntine study site (Table 1). Plots were planted to barley (*Hordeum vulgare* cv Hindmarsh) on 5 June 2013. All plots received 40 kg/ha of triple superphosphate (8 kg P/ha) drilled with the seed at 30mm. The N fertiliser (urea) treatments were applied by hand four weeks after seeding (3 July 2013). Further experimental details are listed below.

Table 1. Selected surface soil properties (0–10cm) for the Tillage and OM+Tillage treatments. Bulk soil samples were collected on 11 February 2013 and analysed by a commercial soil testing laboratory. Values represent the means (and standard errors) of three values.

Treatment	Phosphorus (Colwell)	Potassium (Colwell)	Sulfur	Organic Carbon	Electrical Conductivity	pH ($CaCl_2$)	pH (H_2O)
Tillage	32 (1.4)	98 (8.7)	30 (8.8)	1.2 (0.02)	0.13 (0.02)	6.5 (0.12)	7.0 (0.09)
OM+Tillage	62 (6.3)	286 (21)	49 (11)	1.8 (0.23)	0.23 (0.02)	6.6 (0.09)	7.2 (0.09)

Findings from Buntine are also being validated by establishing N fertiliser response curves for two additional study sites (planted to barley) per year in the Western Australian grain belt (2012–2014). In the past two growing seasons field sites have been planted to two barley varieties (*Hordeum vulgare* cv 'Baudin' or 'Buloke') at Cunderdin, Walebing, and York. The randomised block design at each location included two barley varieties by five N fertiliser rates (0, 25, 50, 75, 100 kg/N ha) by three replicates.

Trial Details

Property	Liebe Long Term Research Site, west Buntine
Experimental design	2 OM treatments x 2 N fertiliser rates x 3 replicates
Treatments	*OM treatments:* 1.Tillage only (annual tillage using offset disks) 2. OM + Tillage (OM applied every 3 years, last applied 2012 at rate of 20 t/ha; annual tillage using offset disks) *Nitrogen fertiliser treatments* Nitrogen treatments were applied 4 weeks after seeding and as urea 1. 0 2. 25 kg N/ha 3. 50 kg N/ha 4. 75 kg N/ha 5. 100 kg N/ha
Plot size & Replication	10.5m x 4.1m x 3 replications
Soil type	Deep yellow sand (Basic Regolithic Yellow-Orthic Tenosol)
Sowing date	05/06/13
Seeding rate	60 kg/ha barley (cv. Hindmarsh)
Fertiliser	05/06/13: 40 kg/ha of triple superphosphate 05/07/13: Urea applied as listed above
Paddock rotation	2012: canola; 2011: wheat; 2010: wheat.
Herbicides	21/05/13: Glyphosate 05/06/13: Sprayseed (2 L/ha), Boxer Gold (2.5 L/ha) , Metribuzin (130 gm/ha)
Harvest date	07/11/13
Growing Season Rainfall	189mm

Results

Grain Yield

Progressively adding OM to the soil during the last 10 years increased grain yield in 2013 (Figure 1). Applying N fertiliser did not affect yield in 2013. Consequently grain yield was 3.2 t/ha for the Tillage treatment (averaged across N fertiliser rates) and 3.9 t/ha for the OM+Tillage treatment (averaged across N fertiliser rates).

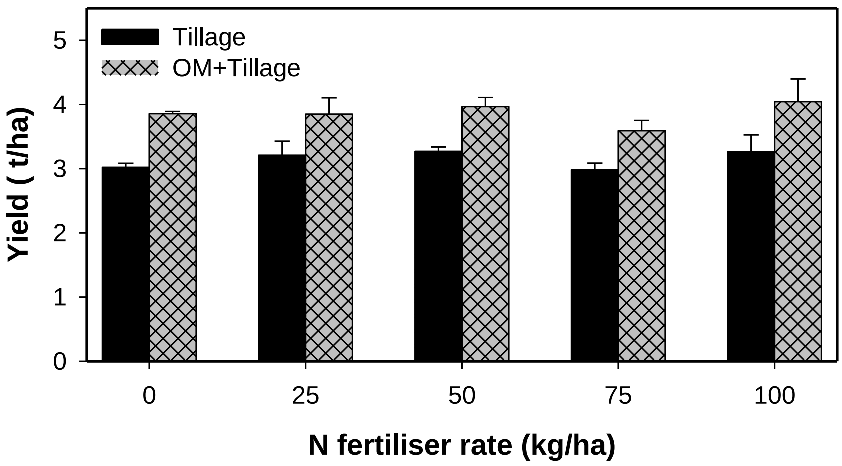

Figure 1. Barley grain yield response to varying nitrogen fertiliser application rates for the Tillage and OM+Tillage treatments at the Long Term Research Site (Buntine) in 2013. Yields represent means (± standard errors) of three replicates.

Grain Quality

Barley grown in OM+Tillage treatment met all the quality standards required for malting barley (MALT1/BFOD1, 2013/14 CSBP Malting Barley Receival Standards) without applying N fertiliser. Indeed, applying more than 25 kg N/ha to the OM+Tillage treatment would have risked the barley being classed as animal feed (BFED1) due to the high protein content (Figure 2). The barley grown in the Tillage treatment did not meet the malting barley standards for any of the N fertiliser rates due to high screenings and/or high protein contents (Figure 2).

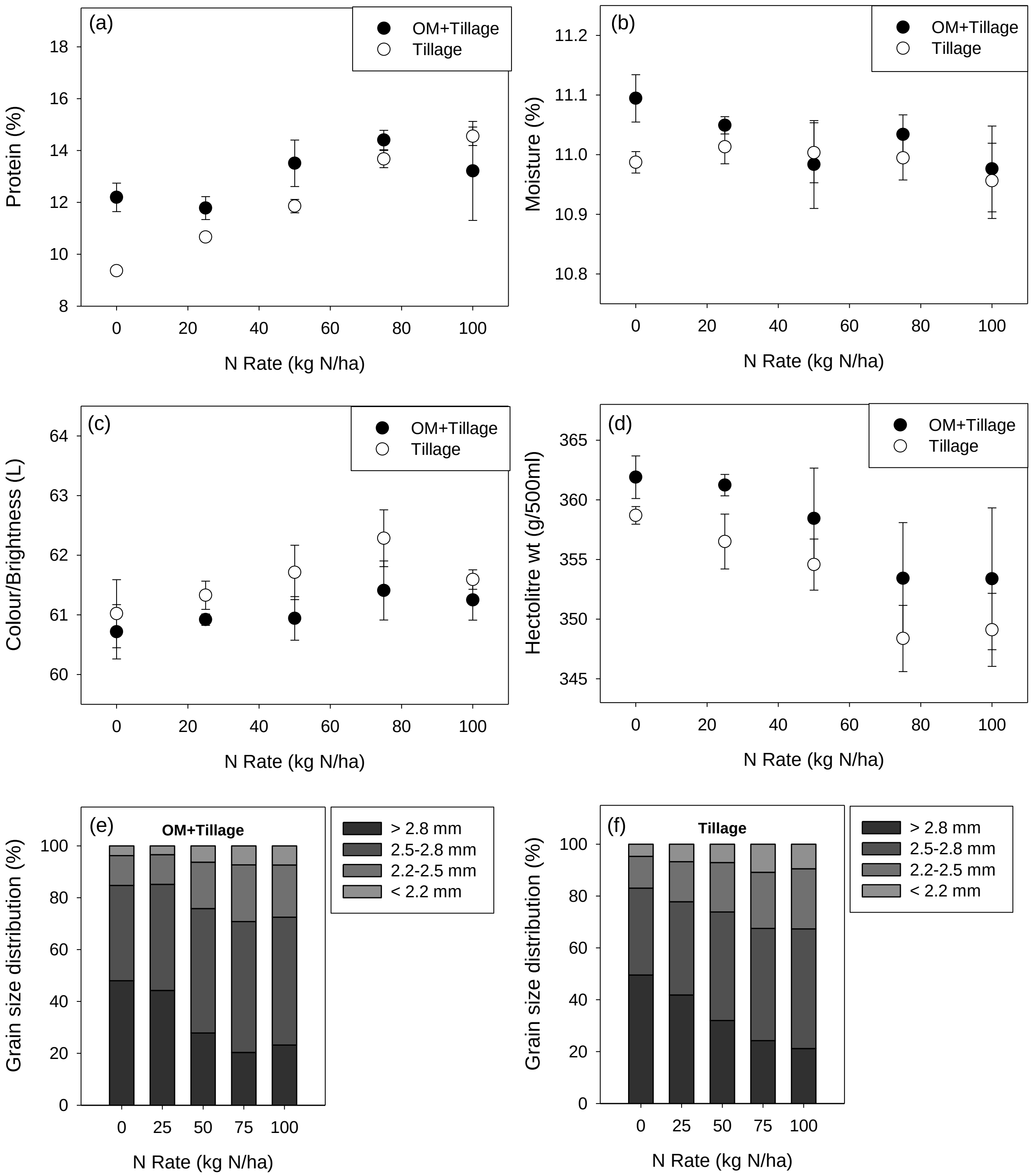

Figure 2. Grain quality parameters for barley at the Liebe Group's Long Term Research Site in 2013. Quality standards for malting barley (MALT1/BFOD1): Protein, 9.5–12.5%; Moisture, ≤12.5%; Colour (L) ≥ 56; Hectolitre weight ≥320 g/ 500mL; Grain size, contains ≤ 20% grain that is <2.5 mm. Quality standards are based on CBH 2013/14 Malting Barley Receival Standards. Values represent means of three replicates.

Comments
In 2013 increasing soil organic matter content improved grain yield and grain quality, and despite a poor start to the growing season. Furthermore, by increasing soil OM there was a potential to lower the N fertiliser inputs required to meet the quality standards for malting barley. The increase in yield in response to the OM additions is consistent with yield responses previously recorded at the study site by the Liebe Group (Figure 3).

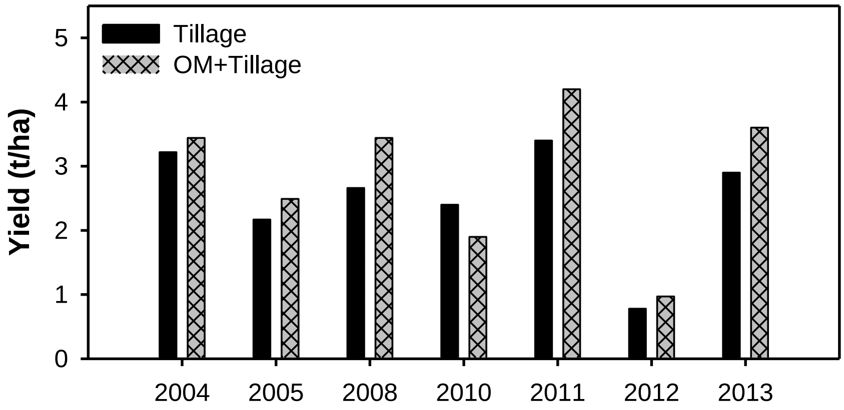

Figure 3. Historic cereal grain yields (t/ha) for the Liebe Group's Long Term Research Site. Data courtesy of the Liebe Group.

The current study is still ongoing and further data analysis will investigate how the addition of OM has benefited crop yield and quality. This will include examination of crop emergence and growth, as well as the availability of soil mineral N at seeding and immediately prior to applying N fertiliser.

The Liebe Group's Long Term Research Site provides an ideal opportunity to investigate the effect of soil OM content on crop yield and quality, as well as the capacity to decrease reliance on synthetic fertiliser inputs. Future trial research should consider investigating fertiliser requirements across a number of growing seasons to determine under what conditions increasing soil OM benefits crop production.

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