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Soils

Increasing carbon storage in alkaline sodic soils

RESEARCH

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Searching for answers

Location:
Minnipa Ag Centre
Paddock South 7
Rainfall
Av. Annual: 324 mm
Av. GSR: 241 mm
2013 Total: 334 mm
2013 GSR: 237 mm
Yield
Potential: 2.54 t/ha (W)
Actual: 1.83 t/ha (experiment average); 2.02 t/ha (highest yielding treatment)
Paddock History
2013: Wheat
2012: Medic
2011: Wheat
2010: Medic
Soil Type
Light brown sandy clay loam
Plot Size
1.5 m x 5 m x 3 reps
Water Use Efficiency
7.7 kg/ha/mm GSR (experiment average)
8.5 kg/ha/mm GSR (highest individual treatment)

Key messages

- **Alkaline soils can have high concentrations of dissolved organic C and the concentration is sensitive to pH.**
- **Soil organic C was strongly related to soil pH suggesting accumulation and retention of organic C in alkaline soils will be limited by high pH.**
- **Relatively small changes in pH may have a significant effect on the retention of organic C and a reduction in dissolved organic C.**
- **A gypsum application of between 2.5 and 5 t/ha reduced soil pH by 0.2-0.5 pH units over a year.**

Why do the trial?

- After rainfall, soil pH has been suggested to be a major influence on the amount of organic C in soils. Under high pH the solubility of organic C changes and the amount of water soluble C increases.
- Ultimately the amount and form of organic C influences important soil processes such as nutrient cycling, microbial biomass and diversity and soil structure.
- Much of the detailed work on soil C has been done on neutral to acidic soils and there is little research to understand organic C accumulation in alkaline soils and the influence of high pH on the changes in the chemical form of organic C in alkaline soils.
- Under acidic conditions soil pH can be changed by adding lime. Under alkaline conditions, the use of legumes and gypsum can potentially lower pH.
- The aim of the project is to improve our understanding of the accumulation and retention of soil organic C under high pH and to investigate ways of directly managing pH.
- Detailed studies of soil chemistry and buffering capacity are being conducted in the laboratory and glasshouse and field trials are being used to investigate these changes in the field.

Paddock survey

Surveys of soils conducted in three areas where alkaline soils occur – the upper Eyre Peninsula, western Victoria and the lower North of South Australia. These are being conducted to provide a benchmark of current levels of dissolved organic C. Initial sampling was conducted on upper Eyre Peninsula during autumn 2013. Samples were taken at 0-10, 10-20 and 20-30 cm depths, dried and sieved and analysed for pH (1:5 soil: water), total C, total organic C and dissolved organic C.

Table 1 Summary of a preliminary survey of pH, organic C and dissolved organic C (% of organic C) in paddocks on upper Eyre Peninsula in 2012. Values are shown as means ± standard error of the mean and the coefficient of variation (CV%)

Depth (cm)	pH	Organic C (%)	Dissolved organic C (%)
0 - 10	7.79 ± 0.143	1.25 ± 0.152	0.78 ± 0.097
CV (%)	4.5	24.3	24.9
10 - 20	8.34 ± 0.123	0.95 + 0.203	1.07 ± 0.214
CV (%)	3.6	42.8	40.1
20 - 30	8.66 ± 0.096	0.90 ± 0.247	1.04 ± 0.158
CV (%)	2.7	54.7	30.2

Rotation trials

Two short term rotation trials were established at Minnipa and Birchip in 2012 to examine the effects of legume, legume productivity and gypsum rate on soil pH. At each site three legumes [medic (a mixture of Herald, Paraggio, Caliph, Parabinga), peas (cv Morgan) and vetch (cv Morava)] were grown under standard and high inputs (doubled sowing rates and P fertiliser rates). The purpose of the high input treatment was to increase biomass production and hence the amount of N_2 fixation.

Each legume treatment was grown at three treatments (0, 2.5 t/ha and 5 t/ha of gypsum; gypsum quality ~60% $CaSO_4$). The treatments were replicated 3 times. Soil was sampled to a depth of 30 cm in May 2013, dried and sieved, and analysed for pH (1:5 soil: water), total C, total organic C and dissolved organic C. The trial was sown to wheat in 2013 and biomass production at stem elongation (GS 32), anthesis (GS 65) and grain yield and grain quality measured.

What happened?

Paddock survey

Soil organic C decreased with depth and there was a corresponding increase in the proportion of C found as dissolved organic C. These trends followed the increases in pH with depth. The high CV (%) indicates the high level of variability among the seven surveyed paddocks. The amount of dissolved organic C measured in these profiles was relatively high.

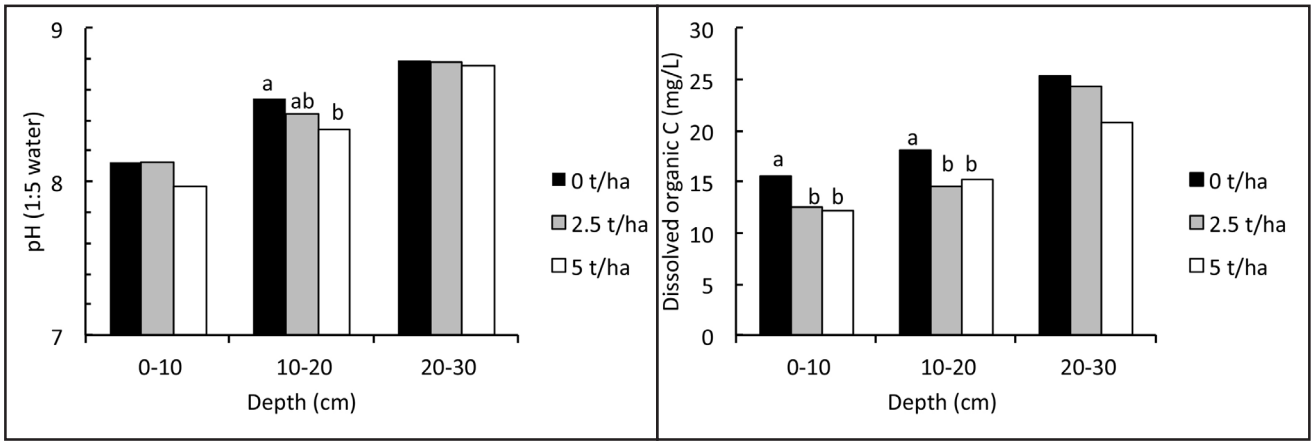

Figure 1 The effect of gypsum application rate in 2012 on soil pH and dissolved organic carbon in 2013 at Minnipa. Means within each depth with different letters are significantly different; where there are no letters means are not significantly different

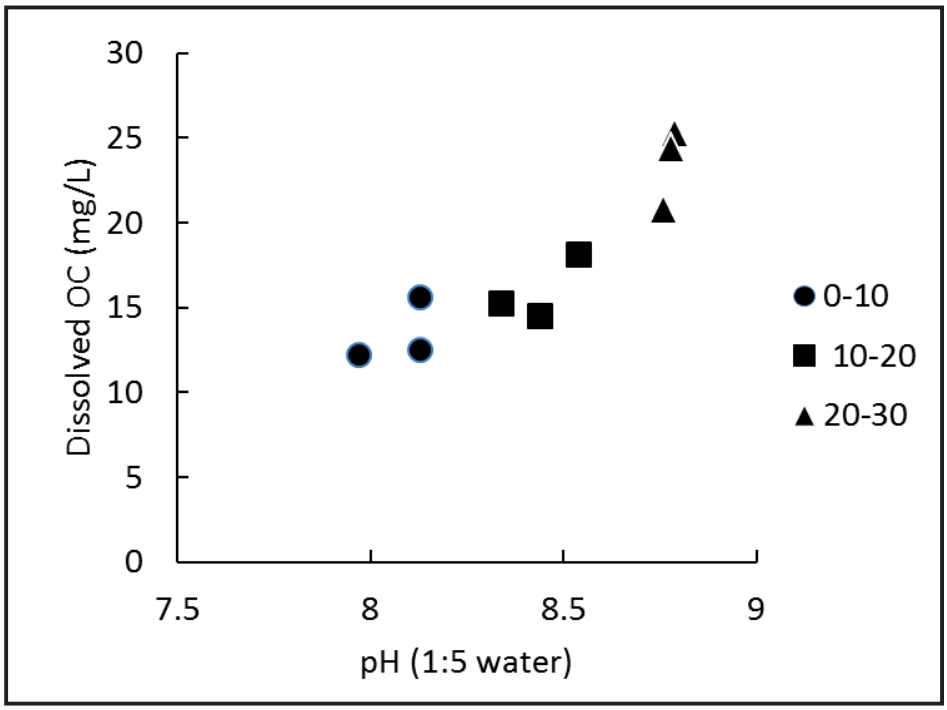

Figure 2 The relationship between pH and dissolved organic carbon in soils from Minnipa gypsum trial 2013

Rotation trial

In 2012, biomass production of legumes was not significantly affected by gypsum rate but it was increased by 50-60% when sowing rate and P rate were increased.

In 2013 both pH and dissolved organic C increased with depth (Figure 1). Applying gypsum in 2012 significantly reduced the pH at 10-20 cm by 0.2-0.5 pH units in 2013 and there was a corresponding reduction in the amount of dissolved organic C. There was no influence of the type of legume or the level of inputs on soil pH. The variation in dissolved organic C was proportional to the changes in pH within the profile (Figure 2). Comparable results were observed at Birchip.

While there were significant changes in pH from the 2012 gypsum treatments there were no measurable effects on the yield of wheat in 2013, the only effect of gypsum at Minnipa was a small reduction in grain protein concentration from 11.3% with no gypsum to 11.0% with 5 t/ha gypsum. In two similar experiments at Birchip, one showed a 12% increase in wheat yields from the 2012 gypsum treatment, while the other showed no effect of gypsum.

What does this mean?

- High soil pH can increase the solubility of organic carbon which is susceptible to washing out.
- The results showed that the concentration of dissolved organic carbon are significant and increase with depth in alkaline soils of SA.
- Dissolved organic carbon leached from decomposing organic matter is important in the leaching of nutrients from the root zone.
- Application of gypsum can significantly lower pH and reduce dissolved organic carbon over a single growing season. The effect of these changes on subsequent productivity of crops and whether the changes are long-lasting needs further investigation.

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