Effects of gypsum and legumes on soil pH and soil organic C

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Searching for answers

Location:
Minnipa Ag Centre, Paddock S7
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2014 Total: 407 mm
2014 GSR: 290 mm
Yield
Potential: 4.0 t/ha (W)
Actual: 2.5 t/ha
Paddock History
2014: Scope CL barley
2013: Mace wheat
2012: Medic pasture
Soil Type
Red loam
Plot Size
34 m x 2 m x 3 reps

Location:
Minnipa Ag Centre, Airport paddock
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2014 Total: 407 mm
2014 GSR: 290 mm
Yield
Potential: 4.0 t/ha (W)
Actual: 2.5 t/ha
Paddock History
2013: Mace wheat
2012: Kord wheat
Soil Type
Calcareous red sandy loam
Plot Size
10 m x 3 m x 3 reps

Key messages

- **Applying gypsum can reduce soil pH and lower the concentration of dissolved organic carbon (C) to 30 cm depth within a year.**
- **Soils with pH > 9 will benefit most from gypsum.**
- **The solubilisation of soil organic C increased markedly at pH above 8.5.**
- **The availability of aluminium (Al) in soil increases at pH above 9.**
- **There was no significant effect of gypsum on the biomass or yields of crops within 2 years.**

Why do the trial?

Although alkaline soils are widespread throughout southern Australia and are the basis of crop production in South Australia, our understanding of the chemistry and cycling of C in these soils is poor. A survey of paddocks on the upper Eyre Peninsula (EP) showed that the concentrations of soil organic C and dissolved organic C were sensitive to pH, with soil organic C decreasing and dissolved organic C increasing as pH increased (see article this publication). Reducing soil pH may be a means of helping to retain soil organic C.

Many soils on the upper EP have pH values in the top 10 cm greater than 8.5 and this increases with depth. The subsoils can have a pH above 9 with high concentrations of sodium carbonate and are sodic; it is these properties that are especially damaging to plants. Past work on the reclamation of highly alkaline sodic soils has demonstrated that applying gypsum in conjunction with growing legumes can be effective in lowering soil pH. The greatest benefit is achieved by lowering soil pH from very high values (e.g. 9 or above) to about 8.5. Reducing pH further will be difficult because of the high buffering capacity of soils due to calcium carbonate at this pH.

To examine the effect of gypsum on the calcareous soils typical of the upper EP, two rotation experiments were conducted commencing in 2012 and 2013. The aim was to examine the effect of gypsum on soil pH and soil C and whether changes in soil pH could alter productivity of the following cereal crops.

How was it done?

Two short term rotation experiments were run, commencing in 2012 and 2013 on the Minnipa Agricultural Centre. The first experiment was conducted in paddock S7 (Experiment 1) and the second experiment was conducted in the Airport paddock (Experiment 2). Each experiment in the first year was a factorial combination of legume species, input levels and gypsum rates. In the first year three legumes (peas cv Morgan), vetch (cv Morava) and medic (a mix of Paraggio, Caliph and Parabinga) were grown at standard sowing rates (80 kg/ha for peas; 20 kg/ha for vetch and 5 kg/ha for medic) and fertiliser rates (10 kg P/ha for all crops) and at double these rates. All seeds were inoculated with commercially available rhizobia. Three rates of gypsum (0, 2.5 t/ha and 5 t/ha) were superimposed on these treatments. The gypsum was obtained from a local source and had a purity of 60%. The gypsum was spread prior to sowing and incorporated with the sowing operations.

The experiment in S7 commenced in 2012 and wheat (cv Mace) was sown in each plot in 2013 and barley (cv Scope CL) in 2014. The experiment in the Airport paddock commenced in 2013 and wheat (cv Mace) was grown in 2014. In 2012 only legume biomass was measured, while legume biomass and grain yield were measured in 2013. In 2013 and 2014 soil cores were taken in 10 cm increments to 30 cm in each plot to measure pH, soil organic C and dissolved organic C.

In the following cereal crops biomass was measured during the growing season and grain yield was measured by harvesting each plot. Grain quality was measured on the wheat crop after the legume phase. In this report only the cereal yields and protein contents are presented.

What happened?

Effects on legumes growth and yield

Gypsum had no significant effect on the biomass production or the grain yield of the legumes. Increasing P inputs significantly increased biomass production in both trials (by 30% in 2012 and 17% in 2013) but had no significant effect on yield. The grain yield of peas in 2013 was 1.44 t/ha, which was significantly greater than that of vetch (1.15 t/ha).

Soil measurements

The only factor to influence soil pH was the gypsum rate and the effect was consistent in both experiments. Applying gypsum significantly decreased pH in both experiments by between 0.2 and 0.4 pH units, with the largest reduction mainly occurring following the addition of 2.5 t/ha (Table 1). There was a corresponding decrease in the amount of dissolved organic C but soil organic C was not affected (data not shown). The effects of gypsum on pH and dissolved organic C were evident two years after application in the 2012 experiment. The concentration of dissolved organic C increased markedly once pH increased above 8.5 (Figure 1a). The concentration of Al was also sensitive to pH and increased at pH values greater than 9 (Figure 1b).

Table 1 The effects of gypsum applied during the legume phase on the pH and dissolved organic C concentration to 30 cm depth in two experiments. Experiment 1 was commenced in 2012 and measurements were made in the two successive years after applying gypsum, while Experiment 2 commenced in 2013

Gypsum rate (t/ha)	pH (water)			Dissolved organic C (% soil organic C)		
	Depth (cm)					
	0-10	10-20	20-30	0-10	10-20	20-30
	Experiment 1: 2013					
0	8.76	9.17	9.42	0.56	0.76	1.16
2.5	8.76	9.07	9.41	0.45	0.57	1.10
5	8.61	8.98	9.38	0.41	0.60	0.93
F Prob	ns	P=0.025	ns	P=0.03	P=0.018	ns
LSD (P=0.05)		*0.134*		*0.112*	*0.141*	
	Experiment 1: 2014					
0	8.48	8.86	9.03	0.63	0.81	0.96
2.5	8.30	8.40	8.74	0.45	0.42	0.51
5	8.26	8.45	8.68	0.40	0.43	0.46
F Prob	P=0.014	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001
LSD (P=0.05)	*0.155*	*0.131*	*0.152*	*0.059*	*0.099*	*0.127*
	Experiment 2: 2014					
0	8.98	9.02	9.10	0.62	1.13	1.71
2.5	8.79	8.89	8.94	0.46	0.55	0.83
5	8.59	8.80	8.90	0.41	0.45	0.76
F Prob	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001
LSD (P=0.05)	*0.086*	*0.093*	*0.086*	*0.055*	*0.103*	*0.223*

Effects on cereal yields and protein contents

Table 2 Grain yield of cereals and grain protein concentration of wheat grown after different legumes

Legume (year 1)	Wheat (year 2)		Barley (year 3)
	Grain yield (t/ha)	Grain protein (%)	Grain yield (t/ha)
Experiment 1			
Medic	1.81	11.2	2.78
Peas	1.87	11.2	2.85
Vetch	1.80	11.2	2.81
F Prob	ns	ns	ns
Experiment 2			
Medic	3.40	9.6	
Peas	3.13	9.5	
Vetch	3.04	9.4	
F Prob	P=0.024	ns	
LSD (P=0.05)	*0.262*		

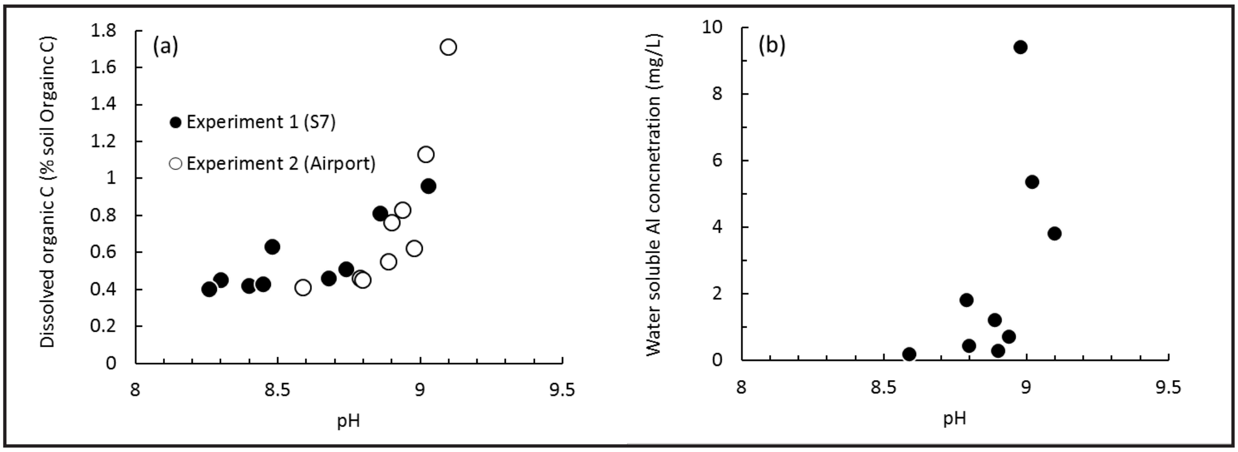

Figure 1 The effects of soil pH on the concentration of dissolved organic C in two experiments and the concentration of water-soluble Al in Experiment 2. The differences in pH were due to the effects of gypsum at three sampling depths

The gypsum treatments did not significantly affect the grain yield of the following cereal crops. The only effect of any of the first year treatments was in Experiment 2 where wheat yields were significantly highest after medic and lowest after vetch (Table 2).

What does this mean?

The pH of the top 30 cm of highly alkaline soils can be reduced within a year by applying gypsum at 2.5 t/ha. As the gypsum used had a purity of only 60%, lower rates of higher quality gypsum could be used to achieve the same result. A target pH in these soils is about 8.5 as below this changes in pH are highly buffered and there is no change in some soil properties (Figure 1). Highly alkaline soils (pH > 9) are the ones that would potentially benefit most from applications of gypsum.

Dissolved organic C is the most labile C fraction in soil. The reduction in dissolved organic C with the application of gypsum may help to stabilise soil organic C reserves.

There was no immediate benefit of the reduction in pH to the growth and yield of crops. It may take more than two seasons to allow any beneficial effects to become evident. Further long term studies are needed to assess whether gypsum can be effective in improving productivity and to measure the longevity of any effects.

There is growing evidence that Al toxicity can be an important limitation to yield on highly alkaline soils. The data suggest that soils with pH > 9 are at greatest risk. The reduction in pH following the application of gypsum reduced the concentration of Al in the soil.

Acknowledgements

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