pH amendment trial

September 2021

Soil pH has a profound effect on nutrient availability to plants and microorganisms, and thus soil and plant health.

This factsheet shares the results of a field trial using several treatments to raise pH in an acidic soil and a cost benefit analysis.

About pH

Two important things about pH:

1. It's a measure of concentration of free hydrogen ions (written as H^+) in the soil
2. It's measured on a logarithmic scale (see Table 1 and Figure 1).

In a neutral pH soil (pH = 7.0) the concentration of hydroxyl ions (OH^-) is the same as that of hydrogen ions (H^+). In an acid soil there are more positively charged hydrogen (H^+) ions than hydroxyl (OH^-) ions. In an alkaline soil there are more hydroxyl ions than hydrogen ions present in the soil (see Table 2).

Table 1 pH as a logarithmic scale

pH	
6	10 times the no. of H^+ ions / acidity as pH 7
5	100 times the no. of H^+ ions / acidity as pH 7
4	1,000 times the no. of H^+ ions / acidity as pH 7

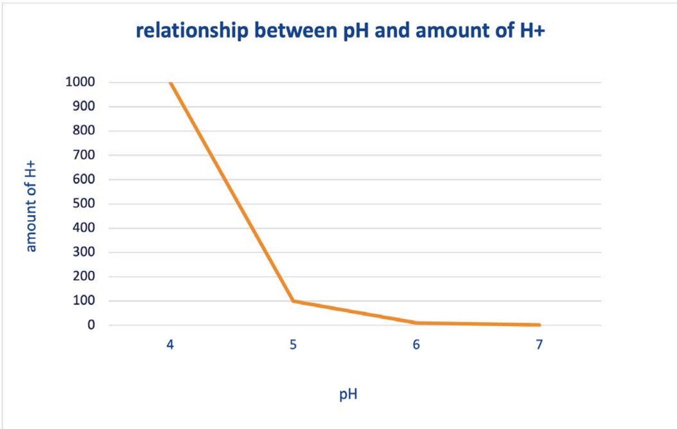


Figure 1 pH and relative H^+ concentration

Table 2 Relationships between hydrogen ions (H^+), hydroxyl ions (OH^-) and soil pH

	Acid soil	Neutral soil	Alkaline soil
H^+ vs OH^- available	more H^+	$H^+ = OH^-$	more OH^-
pH	pH less than 7, e.g. 4.7	pH = 7.0	pH more than 7, e.g. 8.5
pH number	smaller number	7.0	bigger number

This project is supported by the Cradle Coast Authority, through funding from the Australian Government's National Landcare Program.

pH and soils

Causes of soil acidity

Soil acidification can be due to several factors including:

- leaching of nitrate nitrogen,
- nutrient uptake by crops and release of root exudates,
- build-up of soil organic matter and
- use of nitrogenous fertilisers containing ammonium and urea.

Some phosphorus fertilisers and others containing sulphur will also contribute to acidification. High rainfall and excess irrigation can accelerate acidification which involves the leaching of carbonate (CO_3^{2-}).

Adding lime (calcium carbonate, $CaCO_3$, or dolomite, $MgCO_3$) in some form to the soil essentially mops up hydrogen ions (H^+) by forming hydrogen carbonate (HCO_3^-). This increases the pH (makes the soil more alkaline and less acidic; it is not the calcium that changes the pH but the carbonate).

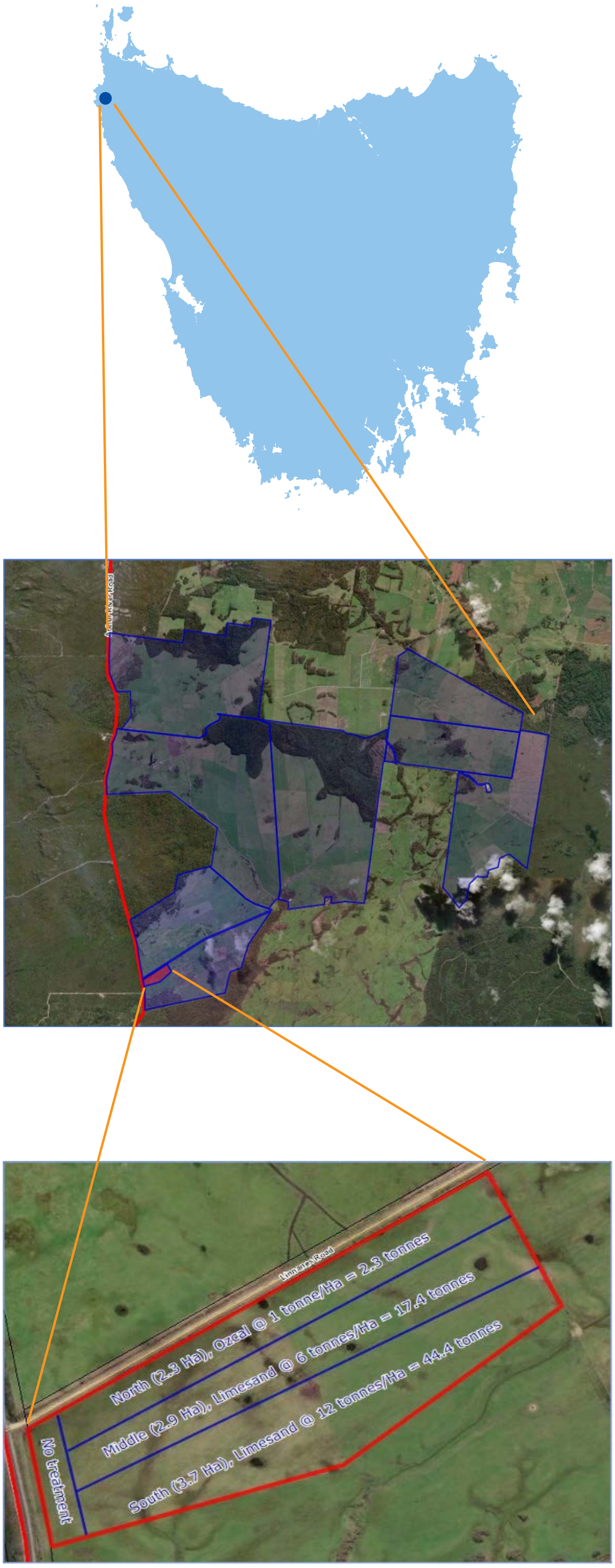
To change the soil pH from pH 6 to pH 7 requires far less lime than to change the pH from 5 to 7 (see Table 1 and Figure 1).

Commercial scale demonstration trial

The site (see Figure 2) has an acidic soil type (organosol) in a high rainfall coastal production district. The aim of the 10 hectare trail was to raise the pH (lower the soil acidity) and improve pasture production in the most cost effective manner.

Baseline pH was established from soil samples taken on 26 February 2020. The amendments were applied to the three treated plots on 18 May. Sward length was measured on 20 August, 1, 16 and 23 September 2020.

Figure 2 Location of trial site at Westmore farm, Arthur River, North West Tasmania.
Trial site highlighted red



Trial site: Treatment plots in Arthurs north paddock at Westmore farm

Treatments

The treatments implemented were (see Table 3):

- no treatment (control),
- application of two different rates of lime sand (with a neutralising value of 30%), and
- application of Ozcal.

The lime sand was from a local quarry and is a relatively economical option in the district for managing soil acidity. Ozcal is a 2-6 mm lime granule produced from finely ground high purity limestone which breaks down rapidly in moisture.

Results

The pH measurement in H_2O was used because it is best suited to high organic matter soils (organosols).

While the Ozcal treatment did result in

- the greatest change in soil pH (see Table 4)
- the greatest increase in measured pasture length (see Table 5 and Figure 3) and
- the greatest increase in estimated kilograms of dry matter produced per hectare (Table 6)

compared to no treatment, **this needs to be weighed up against the cost of this amendment** (see Table 6).

Table 3 Trial plots and treatments

Treatment	Tonnes per hectare	Plot size (ha)	Total tonnes applied to plot
No treatment (control)	0	1.17	0
Lime sand lower rate	6	2.1	13
Lime sand higher rate	12	4.8	58
Ozcal	1	2.1	2.1

Table 4 Soil pH values of baseline and post-treatment samples

Treatment	Sampling date/pH [in H_2O]		change in pH [in H_2O]
	26 Feb (baseline)	23 Sep (after treatment)	
No treatment	5.47	5.51	0.04
Lime sand (6 t/ha)	5.22	5.42	0.20
Lime sand (12 t/ha)	5.55	5.99	0.44
Ozcal (1 t/ha)	5.18	5.92	0.74

Table 5 Effect of treatment on average sward length of pasture

Treatment	Sampling date/average sward length (cm)				increase in pasture production*
	20 Aug	1 Sep	16 Sep	23 Sep	23 Sep
No treatment	2.82	7.52	9.96	14.8	
Lime sand (6 t/ha)	4.92	10.2	17.2	21.4	44%
Lime sand (12 t/ha)	6.48	11.3	18.0	25.2	70%
Ozcal (1 t/ha)	7.22	14.6	23.5	27.8	88%

Note - blue cells indicate significant difference to no treatment
*compared to no treatment

no treatment

6 tonnes/ha lime sand

12 tonnes/ha lime sand

1 tonne/ha Ozcal

Figure 3 Pasture treaments at 23 September 2020

Table 6 Cost vs benefit of treatments

Treatment	increase in pasture production*	Cost per hectare ($)	Mean pasture length (cm) on 23 Sep	Estimated kg/DM/ha
No treatment		$ 0	14.5	1,800
Lime sand (6 t/ha)	44%	$ 320	21.4	2,400
Lime sand (12 t/ha)	70%	$ 440	25.2	3,000
Ozcal (1 t/ha)	88%	$ 1,200	27.8	3,200

*compared to no reatment as at 23 September

Even with a modest neutralising value of 30%, the locally sourced lime sand applied at 12 tonnes per hectare proved the most cost effective, producing almost as much estimated dry matter per hectare for around one third of the cost of the Ozcal treatment.

What do you need to consider?

- Is my soil too acid?
- What could be the best soil amendment?
- Is there an easily accessible lime sand source nearby?
- Would it be easier to apply a product like Ozcal yourself?

Conclusions

- Acidic soils can lock up nutrients essential for plant growth making them unavailable, and may result in other nutrients being available at levels which are toxic to plant growth.
- **Laboratory testing** of soil pH is crucial to calculate the type and volume of amendment to apply.
- **Testing soil pH is cost effective** – this 10-hectare site cost around $400 to evaluate through laboratory analysis which included micro and macro nutrient status as well as pH.
- In this production district, locally sourced lime sand proved to be the most cost-effective means of managing acidic soil pH and increasing dry matter production.
- **Failure to manage soil acidity can potentially result in significantly lower pasture production** (88%) and adversely affect the carrying capacity of a grazing enterprise on an organosol soil such as this demonstration trial site.
- The pasture is likely to have better nutritional value for the cattle due to the better balanced plant and soil nutrition.

Further resources

Check the CCNRM portal for more on protecting productive soils

The Soil Wealth and Integrated Crop Protection website also has a lot of useful information, including a factsheet on lime quality and application rates

Acknowledgements
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