Managing soil acidity in permanent pastures

Background

Subsurface (5-20 cm) soil acidity is considered a major constraint to production systems in the medium and high rainfall zones of central and southern NSW. Liming practices of recent decades have often been ineffective in managing soil acidity. Low lime rates and inadequate incorporation has increased pH in the 0-5 cm shallow surface soil layer, but the soil below continued to acidify, affecting plant performance. Field research conducted by NSW DPI has indicated that maintaining the 0-10 cm soil above pH_{Ca}>5.5 enables gradual removal of acidity in layers below 10 cm. Incorporation of the lime speeds up the rate and depth of the lime effect in the soil however, the challenge is that incorporation is not always achievable or preferred.

The 'Managing soil acidity in permanent pastures' Producer Demonstration Site (PDS), funded by Meat & Livestock Australia, aims to answer the following questions for producers:

1. What rate and frequency of top-dressed lime is required on established pastures to increase 0-10 cm pHCa above 5.5? (i.e., how do we achieve amelioration of subsurface acidity when lime is top-dressed?)
2. What is the benefit of updated approaches to acid soil management on productivity and composition of perennial pastures?

This will be achieved through several demonstration sites and field days to increase producers' knowledge in interpreting soil tests and assessing pastures to enable them to create an effective liming program for their unique soils and climate.

Mannus and Holbrook demonstration sites

The demonstration sites were established in February 2021 to monitor change in soil chemical properties to 0-30cm deep. Lime sourced from NSW crushers, with a neutralising value of 97 and fine particle size (96% passing through a 250 µm sieve) was applied using a direct drop lime spreader. Plot size was 50 m long by 3.6 m wide, with four replicates of four treatments (Table 1).

Table 1: Mannus and Holbrook demonstration site treatments and descriptions

Treatment pH target	Lime rate (t/ha)	Description
Control	0	Untreated soil
pH 5.2	3	Traditional approach. 3 t/ha targeting pH 5.2 in 0-10cm layer.
pH 5.5	5	5 t/ha targeting pH >5.5 in 0-10cm layer.
pH >6	7	Once-in-a-generation treatment. 7 t/ha targeting pH >6 in 0-10cm layer. Does this treatment: • ameliorate and prevent subsurface acidification in the long-term; and/or • induce nutrient deficiencies or toxicities?

Rosewood demonstration site

The demonstration site consists of multiple strips lime strips applied by the farmer since 2017 (Table 2). Lime sourced from NSW crushers was applied using a commercial spreader. Lime strips were 300-500 m long by 100-150 m wide.

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Table 2: Rosewood case study site lime strip descriptions

Paddock	Lime rate (t/ha)	Incorporation treatment
Elms West	Nov 2017 – 3 t/ha Mar 2018 – 2.5 t/ha Feb 2019 – 2.5 t/ha **Total – 8 t/ha**	Incorporated with offset discs (Feb 2019)
Elms East	Nov 2017 – 3 t/ha Feb 2019 – 2.5 t/ha **Total – 5.5 t/ha**	Incorporated with offset discs (Feb 2019)
Cattleyards (3 t/ha)	Feb 2019 – 3 t/ha **Total – 3 t/ha**	Not incorporated
Cattleyards (6 t/ha)	Feb 2019 – 3 t/ha July 2022 – 3 t/ha **Total – 6 t/ha**	Not incorporated
Cattleyards (9 t/ha)	Feb 2019 – 3 t/ha July 2022 – 6 t/ha **Total – 9 t/ha**	Not incorporated

Results and discussion

Soil

At the Mannus site, there was a significant increase in pH for all lime treatments compared to the control, to a depth of 15cm (Figure 1). Below 15cm there was a small but significant increase in pH for the 7 t/ha treatment only compared to the control. Similarly, there was a significant decrease in exchangeable aluminium percentage for all lime treatments compared to the control, to a depth of 20cm, and significant decrease for only the 7 t/ha treatment compared to the control, below 20cm.

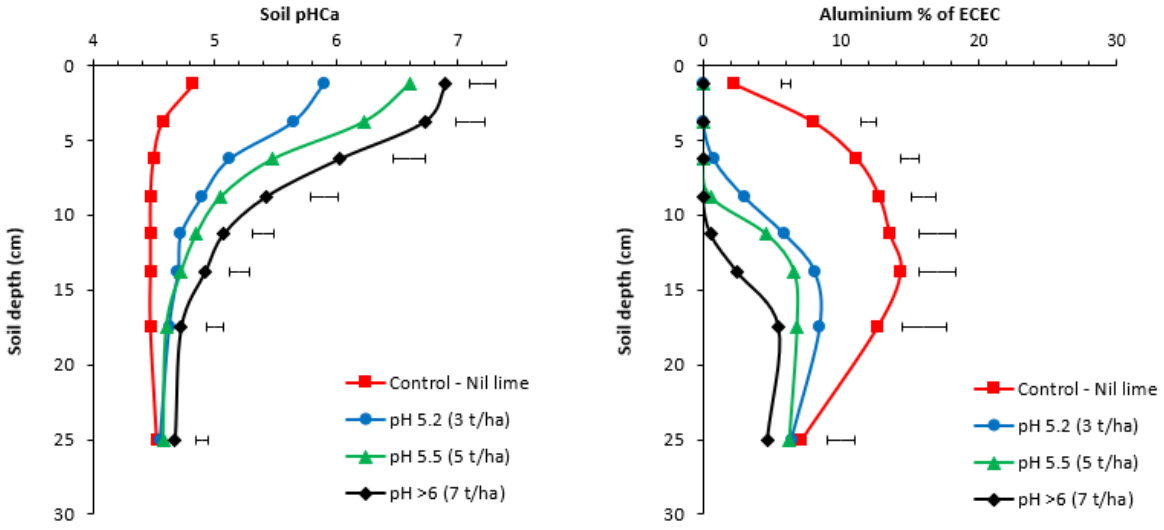

Figure 1. The soil profiles for pH_{Ca} and exchangeable aluminium percent at the Mannus PDS replicated demonstration site, sampled April 2023 (26 months post liming). Horizontal bars represent l.s.d. (P<0.05).

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At the Holbrook site, there was a significant increase in pH for all lime treatments compared to the control, to a depth of 30cm, although below 7.5cm, the increase was only slight (0.2-0.3 pH units) (Figure 2). There was also a significant decrease in exchangeable aluminium percentage for all lime treatments compared to the control to a depth of 30cm (except for the 5 t/ha lime rate).

The results are encouraging when compared to last year's results (14 months post-liming). Last year saw a significant increase in pH for all treatments compared to the control in the surface 2.5cm only, and a significant decrease in exchangeable aluminium percentage to a depth of 5cm.

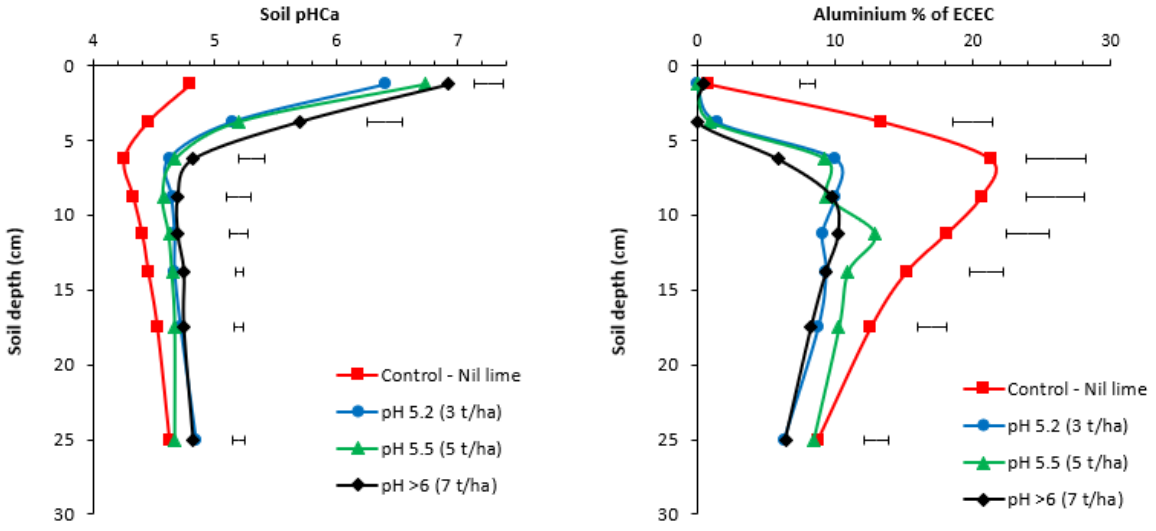

Figure 2. The soil profiles for pH_{Ca} and exchangeable aluminium percent at the Holbrook PDS replicated demonstration site, sampled April 2023 (26 months post liming). Horizontal bars represent l.s.d. ($P<0.05$).

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The Elms West strip at the Rosewood demonstration site was incorporated with offset discs after 3 applications of lime totalling 8 t/h and the Elms East strip was incorporated after 2 applications of lime totalling 5.5 t/ha (Table 2). At the Elms West strip, the pH in the surface 5 cm has decreased compared to last year, and the pH in the 5 to 12.5 cm depth layer has increased, indicating that alkali (lime) has moved down into these subsurface layers (Figure 3). At the Elms East strip (lower lime rate), the pH has decreased in the top 10cm compared to last year indicating that lime is being 'used up' in the surface.

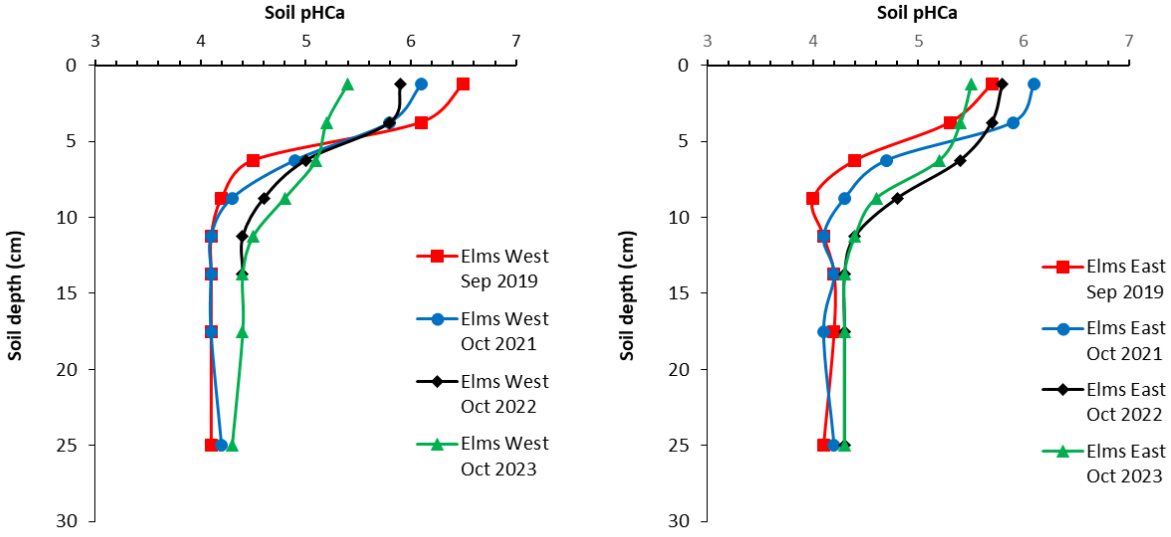

Figure 3. Soil profiles for pH_{Ca} at the Elms West and Elms East lime strips over four years.

At the Cattleyards paddock, all 3 treatments have increased subsurface pH to a depth of 20cm compared to 2019 levels. The surface pH in the 3 t/ha treatment (applied in 2019) has started to decrease, indicating that the lime is being 'used up'. It is not expected to increase subsurface pH much in the future. The higher lime rates of 6 t/ha and 9 t/ha (applied in July 2022) have an average 0-10cm pHCa of 5.8 and it is expected that these treatments will continue to increase subsurface pH in the future.

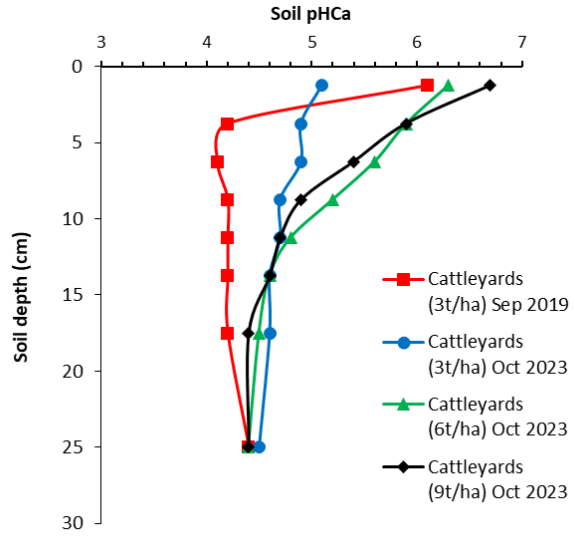

Figure 4. Soil profiles for pH_{Ca} at the Cattleyards lime strips over four years.

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Pasture

Pasture measurements including dry matter (DM) estimates, composition estimates and nodulation scores were collected at the Rosewood demonstration site on 8th November 2023. Cattle were grazing in all the paddocks at the time of sampling and the measured DM averaged between 800 and 1670 kgDM/ha across both paddocks. The results of the pasture measurements are summarised below (Note: these treatments are not replicated):

- Pasture DM at Elms West was made up of 27% subclover on average. Pasture DM at Elms East was made up of 16% subclover on average. The opposite was measured last year.
- Subclover composition decreased with increasing lime rates at the Cattleyards paddock.
- Subclover nodulation was similar between treatments in both paddocks. Elms West and Elms East had an average score of 4 (adequate). The Catttleyards strips had an average score of 3 (moderate).
- Pasture DM increased with lime application rate in both paddocks (Table 3)

Table 3: Pasture dry matter (DM) estimates at the Rosewood case study site

Paddock	Pasture dry matter (kgDM/ha)
Elms West	970
Elms East	800
Cattleyards (3 t/ha)	1330
Cattleyards (6 t/ha)	1560
Cattleyards (9 t/ha)	1670

Pasture measurements were collected at the Holbrook demonstration site on 9th October 2023. The paddock had been locked up for 24 days prior to measuring and there was sufficient dry matter in the paddock (3520-4720 kg DM/ha). For all measurements (DM, composition and nodulation) there was no significant difference between the treatments.

Pasture measurements were collected at the Mannus demonstration site on 7th November 2023. The paddock had been locked up for approximately 5 weeks prior to measuring and there was sufficient dry matter in the paddock (1810-3070 kg DM/ha). For all measurements (DM and composition) there was no significant difference between the treatments. However, there was a trend (P<0.1) of decreasing subclover and increasing phalaris composition with increasing lime application rate. This may explain the visual differences observed between treatments last year.

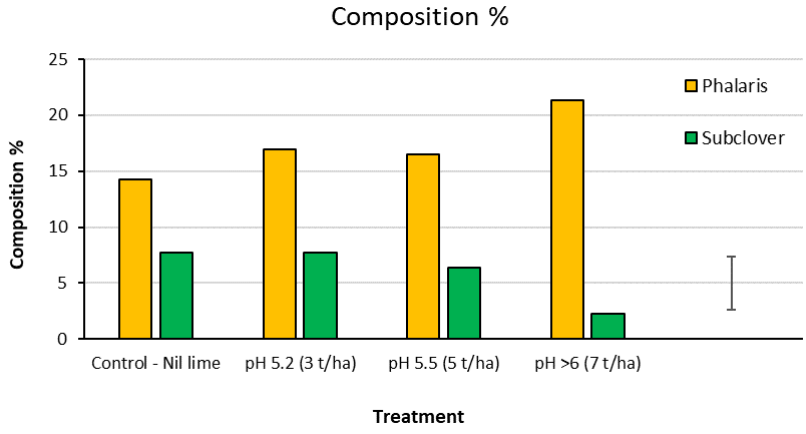

Figure 5. Phalaris and subclover composition at the Mannus demonstration site. Vertical bar indicates l.s.d. (P<0.1) for subclover composition.

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Summary

The 'Managing soil acidity in permanent pastures' PDS is in its second year and results are expected to increase with time as the recently applied lime reacts and influences soil chemistry and pasture characteristics. Findings to date include:

- Topdressed lime treatments at the Mannus demonstration site have significantly increased pH in the surface 15cm and significantly decreased exchangeable aluminium in the surface 20cm, 26 months post liming.
- Topdressed lime treatments at the Holbrook demonstration site have significantly increased pH and significantly decreased exchangeable aluminium percentage down to 30cm depth. Although below 7.5cm, the increase in pH was only slight (0.2-0.3 pH units).
- All 3 treatments in the Cattleyards paddock at Rosewood have increased subsurface pH to a depth of 20 cm compared to 2019 levels. The surface pH in the 3 t/ha treatment (applied in 2019) has started to decrease indicating that the lime is being 'used up'.
- Pasture DM increased with lime application rate in the Elms and Cattleyards paddocks at Rosewood.
- Subclover composition decreased with increasing lime rates at Mannus and the Cattleyards paddock.

Acknowledgements

This work is co-funded by Meat & Livestock Australia and Holbrook Landcare Network. The contribution of participating landowners hosting the demonstration sites is greatly appreciated.

The demonstration sites at Holbrook and Mannus were established with funding from a previous project 'New approaches to tackling and monitoring soil acidity', NLP-12074, started: 1.07.2019; completion date:31.03.2022. Lime spread at the Rosewood demonstration site was entirely funded by the landowner.

The technical support of Jason Condon of Charles Sturt University, and Helen Burns and Richard Hayes of NSW DPI and is greatly appreciated.

Further reading

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Conyers M and Li G (2006) MASTER – Soil acidity and lime responses. NSW DPI Primefact 32. Available at: https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/54374/MASTER-Soil_acidity_and_lime_responses_-_Primefact_32-final-1.pdf

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