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 (6 t/ha)	Feb 2019 – 3 t/ha July 2022 – 3 t/ha **Total – 6 t/ha**	Not incorporated
Cattleyards (3 t/ha)	Feb 2019 – 3 t/ha **Total – 3 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 treatments compared to the control, to a depth of 10cm, and a significant decrease in exchangeable aluminium percentage to a depth of 15 cm (Figure 1). It is expected that excessive lime is concentrated on the surface of the 7 t/ha treatment, as lime is less soluble as pH_{Ca} approaches 7. Therefore, there is expected to be limited difference in pH change between the 5 t/ha and the 7 t/ha treatments in the medium term.

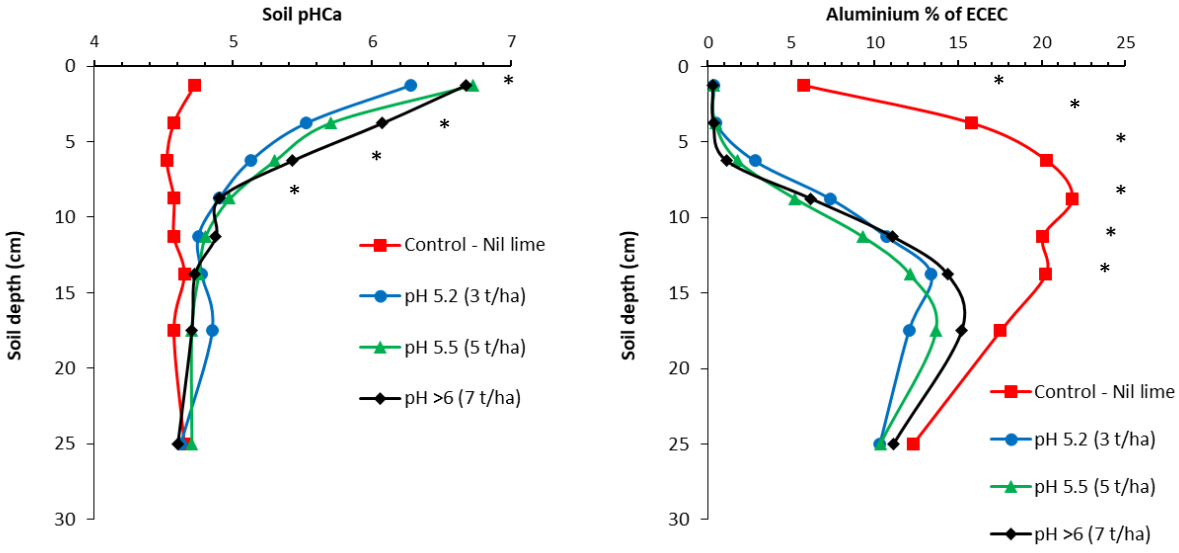

Figure 1. The soil profiles for pH_{Ca} and exchangeable aluminium percent at the Mannus PDS demonstration site, sampled March 2022 (13 months post liming). * Significantly different ($P<0.05$)

Lime movement has been vastly different at the Holbrook site compared to the Mannus site (Figure 2). This is potentially due to a difference in soil type, rainfall and/or organic matter levels between the two sites. There was

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a significant increase in pH for all treatments compared to the control in the surface 2.5 cm only, and a significant decrease in exchangeable aluminium percentage to a depth of 5 cm.

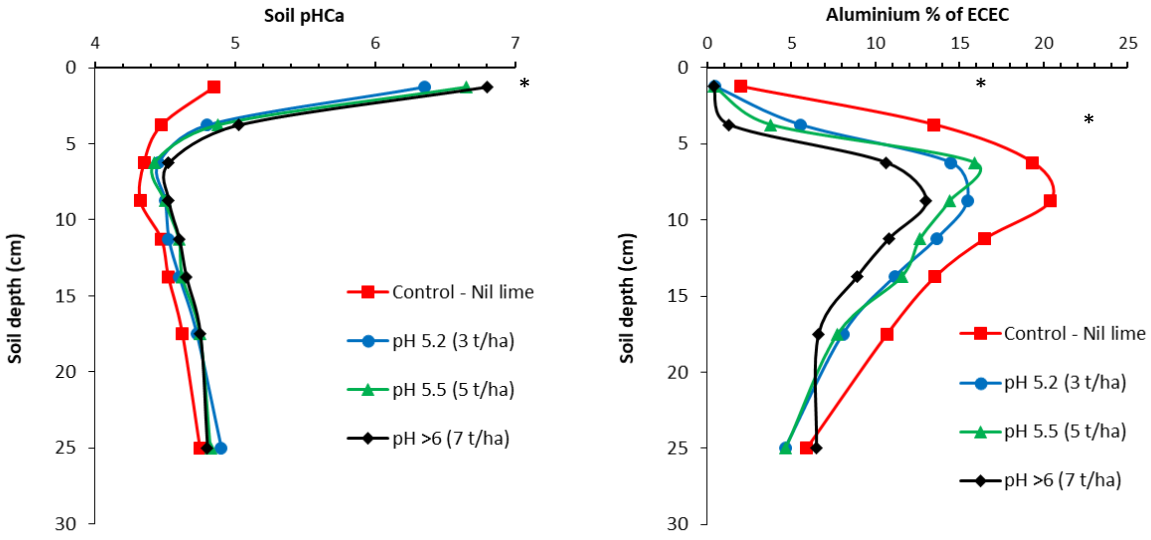

Figure 2. The soil profiles for pH_{Ca} and exchangeable aluminium percent at the Holbrook PDS demonstration site, sampled April 2022 (14 months post liming). * Significantly different (P<0.05)

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). The pH in the surface 5 cm in both strips has started to decrease indicating that the lime is being 'used up' in the surface. Interestingly, there was a big increase in pH below 7.5 cm at the Elms West strip and it's unsure whether this is 'real' or whether high subsoil moisture levels at the time of sampling caused an increase in soil pH via denitrification reactions. Future sampling will determine if this increase is real.

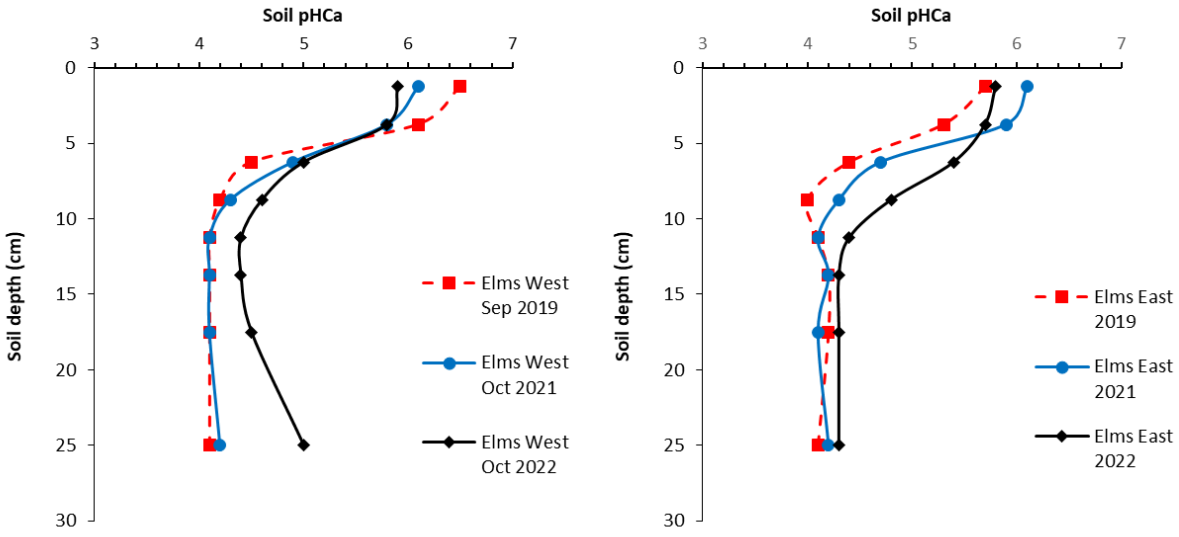

Figure 3. Soil profiles for pH_{Ca} at the Elms West and Elms East lime strips over three years.

At the Cattleyards strip where 2 applications of lime totalling 6 t/ha were surface applied, the pH has increased in the 7.5 cm to 12.5 cm depth layer and remained the same below 12.5cm.

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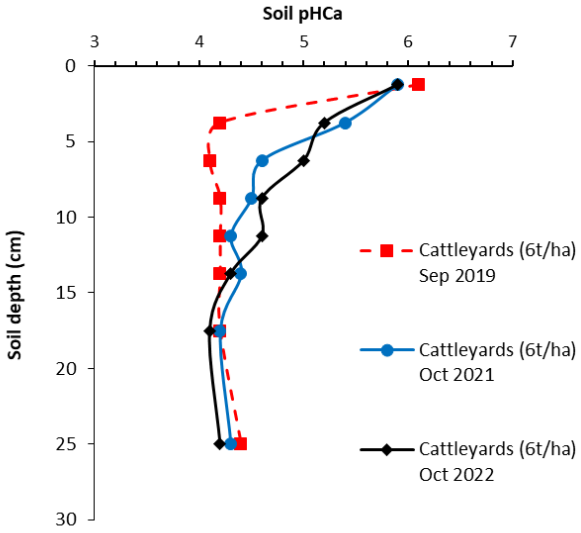

Figure 4. Soil profiles for pH_{Ca} at the Cattleyards (6 t/ha) lime strip over three years.

Pasture

Pasture measurements including dry matter (DM) estimates, composition estimates and nodulation scores were collected at the Rosewood demonstration site on 11th October 2022. Cattle were grazing in all the paddocks at the time of sampling and the measured DM averaged between 440 and 560 kgDM/ha across both paddocks . There was no measured difference in DM between strips in each of the paddocks as a result. In the future, pasture cages will be used to exclude stock in paddocks that are not being locked up for a period. The results of the pasture measurements are summarized:

- At Elms West the pasture DM was made up of 9% subclover on average. At Elms East the pasture DM was made up of 24% subclover on average.
- Better subclover nodulation was measured at Elms West with an average score of 4 (adequate). Elms East had an average score of 3 (moderate).
- In Cattleyards paddock there was no major difference in composition and nodulation score between the 3 strips.

Pasture measurements were collected at the Holbrook demonstration site on 10th October 2022. The paddock had been locked up for 10 days prior to measuring. For all measurements (DM, composition and nodulation) there was no significant difference between the treatments. This was expected as there has been minimal change in pH to depth at this site.

Pasture measurements were collected at the Mannus demonstration site on 15th November 2022. The paddock had been locked up for approximately 1 month prior to measuring and there was sufficient dry matter in the paddock (2200-7700 kg DM/ha). For all measurements (DM and composition) there was no significant difference between the treatments. Interestingly, the host farmer had noticed visual differences between treatments at different times throughout the year, and the control (nil lime) strips can be distinguished from the limed strips in a drone photo taken of the demonstration site at the time of sampling (see Figure 5). The brown colour of these control plots could potentially be representing reduced groundcover or plant vigour and the cause is expected to be determined as the project progresses.

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Figure 5. Nil lime (control) plots (labelled as T1) different in appearance compared to the limed treatment plots at the Mannus demonstration site.

Summary

The 'Managing soil acidity in permanent pastures' PDS is in its first 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 at the Mannus demonstration site has significantly increased pH in the surface 10cm and significantly decreased exchangeable aluminium in the surface 15cm, 13 months post liming.
- Topdressed lime at the Holbrook demonstration site has significantly increased pH in the surface 2.5cm and significantly decreased exchangeable aluminium in the surface 5cm, 14 months post liming.

Acknowledgements

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Further reading

Burns HM and Norton MR (2018). Legumes in acidic soils: maximising production potential in south eastern Australia. Grains Research Development Corporation, Canberra. Available at: https://grdc.com.au/legumes-in-acidic-soils

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