16

FarmLink Research Report 2019

Innovative approaches to managing subsoil acidity in the southern grains region

Report Author James Holding, FarmLink

Trial Site Location 'Yallambee', Douglas Gap Rd, Boorowa (Tim and Geoff Powell)

Introduction

Soil acidification is an ongoing issue that is unavoidable in productive farming systems. Acidification is a natural process caused mainly by the removal of alkaline plant biomass and the use of acidifying fertilisers. Soil acidity in the topsoil is easily ameliorated but it is the movement of this acidity down the profile and the development of subsoil acidity that is a threat to future agricultural productivity and sustainability.

Common farmer practice is to ameliorate soil acidity by spreading lime followed by incorporation, usually into the 0-10 cm layer. However, this management practice is largely ineffective at treating deeper acidity layers. Lime has low solubility and therefore moves slowly down the soil profile. Past research has shown that maintaining the topsoil layer at pH >5.5 will allow for lime movement down the profile at a rate of 1 cm per year (Li *et al*., 2019). This is a slow process and highlights the need for faster and more targeted management strategies to ameliorate deeper acidity in the soil profile.

This GRDC-funded project aims to evaluate the effectiveness of new and innovative treatments to overcome the adverse effects of subsoil acidity. The standard farmer practice of surface lime plus incorporation will be compared to deep ripping only, deep ripping plus lime and deep ripping plus organic amendment.

Project Partners

Department of Primary Industries (NSW Government), Charles Sturt University, RiverinePlains, CSIRO, La Trobe University, SFS, Holbrook Landcare Network, FarmLink

Funding Partner

GRDC Grains Research & Development Corporation

Project code - GRDC: DAN00206

Objectives

FarmLink's role in this project is to establish two paddock-scale replicated trials to:

1. Examine the effectiveness of several aggressive treatments to ameliorate and/or prevent subsoil acidity under field conditions.
2. Increase awareness of subsoil acidity and potential amelioration strategies

Method

Two paddock-scale field trial sites were identified by FarmLink in high rainfall areas (>500 mm) that had significant subsoil acidity issues. The first field trial was located at Binalong. This was a three-year trial that was completed in 2018 and featured in last year's research report. The second trial, at Boorowa, was established at the start of the 2019 season and will run for two years.

Trial sites were selected based on the following criteria:

- 0-10 cm depth: 4-4.5 pH ($CaCl_2$)
- 10-20 cm depth: < 4.3 pH ($CaCl_2$), exchangeable Aluminium > 20%
- 20-30 cm depth: < 4.6 pH ($CaCl_2$), exchangeable Aluminium > 10%

The Boorowa trial site has a long history of pasture and occasional surface-applied lime. The site was last surface limed at 2 t/ha in September 2018 before trial commencement. Baseline soil sampling was done in October 2018 at 10 cm intervals down to 1 m. The results of the pre-trial soil sampling for both Boorowa and Binalong can be seen below (Figure 1).

Treatments were applied to the trial site in February 2019. The trial consisted of 12 plots measuring 100 m x 12.5 m in a randomised block design with three replications. The treatments were: surface liming; deep ripping only; deep ripping plus lime; and deep ripping plus organic amendment (lucerne pellets) (Table 1). Deep ripping of the treatments was done using a dual depth delivery (3-D) ripping machine with 50 cm spaced tynes that was designed and fabricated by the NSW Department of Primary Industries. Crop sowing was offset to the ripping line by approximately 30 degrees and all crop management activities were done using farm-scale machinery.

Bimbil oats were sown on 19 April with 80 kg/ha MAP placed under the seed. Urea was top dressed across all plots at 65 kg/ha on 1 May. Crop growth was monitored throughout the season and standard agronomic measurements were recorded (establishment counts, biomass and yield data).

Soil sampling will be undertaken post trial to identify any soil pH changes and to evaluate the potential of the different treatment options. The soil pH and aluminium data for the completed Binalong trial are included in this report.

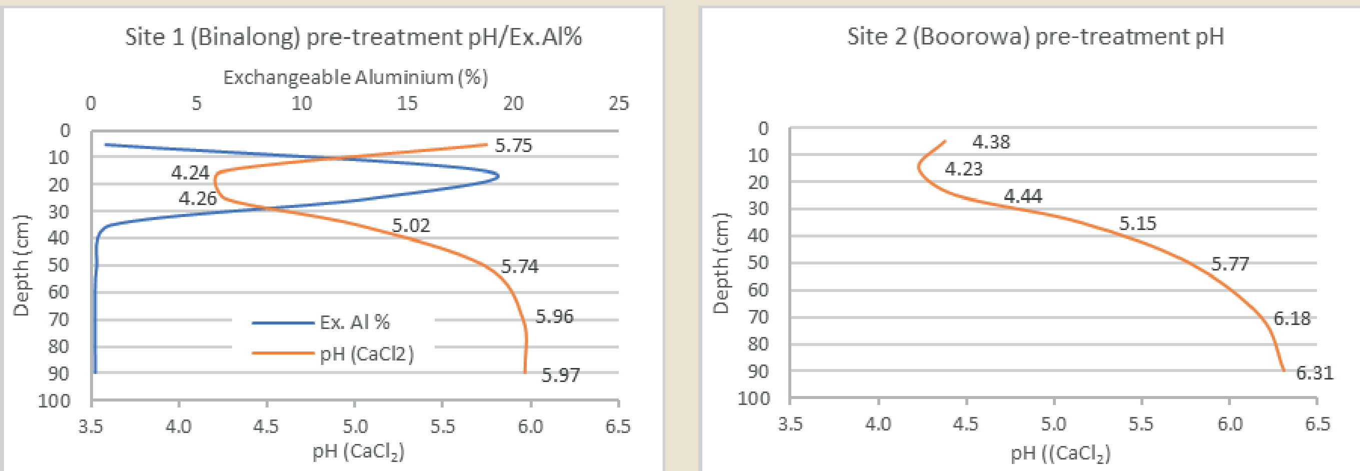

Figure 1. Segmented pre-trial soil analysis results at the Binalong and Boorowa sites

Table 1

	Treatment	Description
1	Surface liming	Surface liming 3.2 t/ha and incorporated 0-10 cm, target pH 5.5 ($CaCl_2$)
2	Deep ripping only	Surface liming 2.1 t/ha and incorporated 0-10 cm, target pH 5.0 Ripped to 30 cm depth
3	Deep ripping + lime	Surface liming 2.1 t/ha and incorporated 0-10 cm, target pH 5.0 Ripped to 30 cm depth + deep liming 3.1 t/ha at 10-30 cm, target pH 5.0
4	Deep ripping + organic amendment (lucerne pellets)	Surface liming 2.1 t/ha and incorporated 0-10 cm, target pH 5.0 Ripped to 30 cm depth + lucerne pellets 15 t/ha at 10-30 cm depth

*All lime rates were calculated based on preliminary soil test results and pH buffering capacity of soil

* Note: all treatments received surface liming

Results

The Boorowa site received 473.2 mm of rainfall for 2019, which was below the long-term average of 647 mm. Most of this rainfall fell early in the year and the crop became increasingly drought stressed from anthesis onwards. The increasing temperatures and continued dry conditions during spring significantly impacted crop yield potential. The effect of prolonged drought appeared to be the greatest limitation on plant growth rather than subsoil acidity.

Establishment was reasonably uniform across all treatments. There were marginally less established plants in the surface liming treatment (Figure 2). This was likely due to direct drilling seed into a hard-long term pasture paddock; however no statistical difference was recorded between treatments.

The trial had two grazing events on the 17 June and 5 August for a total grazing period of 57 days. The grazing involved 406 merino ewes grazing the combined trial and paddock area (25 ha total area). Isolation cages and quad cuts (1m^2 each) were used to estimate biomass removed by grazing. There was more dry matter removed in the deep lucerne pellets treatment than the other treatments, although no statistically significant difference was recorded (Figure 3). This was to be expected as visually there appeared to be more vegetative growth in the deep lucerne pellet treatments. Sheep were removed on 30 August and post grazing, all treatments had similar biomass remaining (2-2.5 t/ha dry matter, no statistical difference).

Anthesis cuts were taken on 15 October at approximately mid-flowering. The deep lucerne pellets treatment had the highest anthesis biomass (6376 kg/ha), however there was no statistically significant difference between treatments (Figure 4). Visually in the field all treatments were showing severe moisture stress.

Yield data was collected by taking harvest quad cuts (1m^2 each) on 21 November. The surface liming treatment was the highest yielding treatment (1889 kg/ha), followed by deep ripping + lime (1644 kg/ha), deep ripping (1582 kg/ha) and deep lucerne pellets (1113 kg/ha). There was no statistically significant difference between treatments.

The Binalong end-of-trial soil results are included (Figure 6) because the Boorowa trial is not yet completed. The Binalong site showed that deep ripping + lime resulted in increased pH and decreased exchangeable aluminium in the subsoil compared to the other treatments. At the amended depth (20-30 cm) the deep ripping + lime ended the three-year trial with pH 5.3, compared to all other treatments with pH 4.2-4.3. The increase in pH at the 20-30 cm depth was statistically significant. Exchangeable aluminium percentage was also greatly reduced in the deep ripping + lime treatment but this was not statistically significant (more replication would likely result in a statistically significant difference).

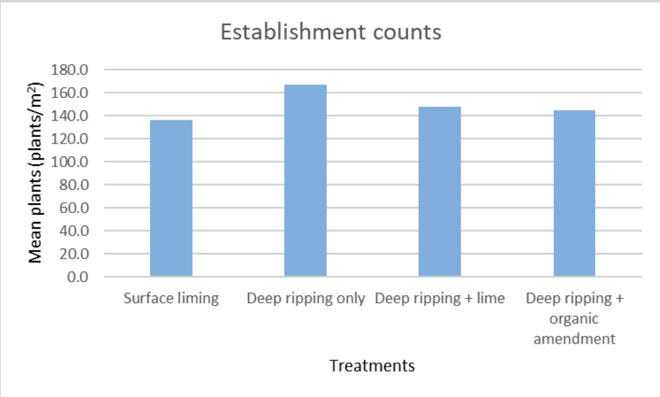

Figure 2. Crop establishment counts (no significant difference, p > 0.05)

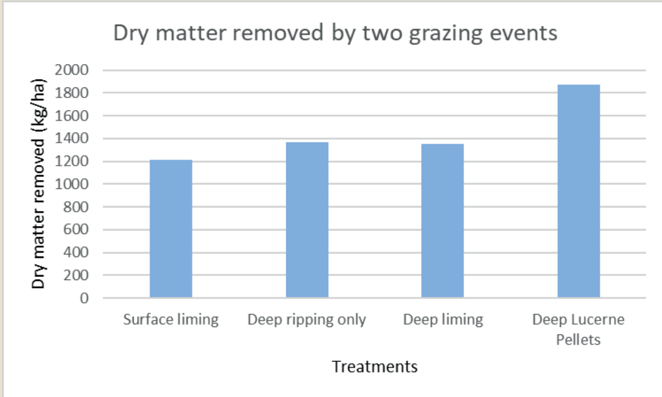

Figure 3. Total dry matter (kg/ha) removed by two grazing events (no significant difference, p > 0.05)

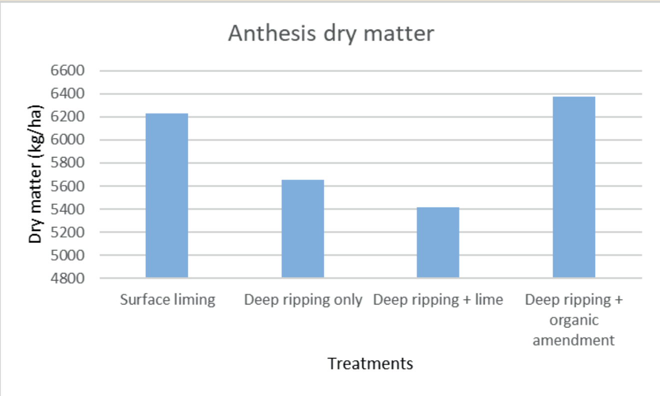

Figure 4. Anthesis dry matter (kg/ha, no significant difference, p > 0.05)

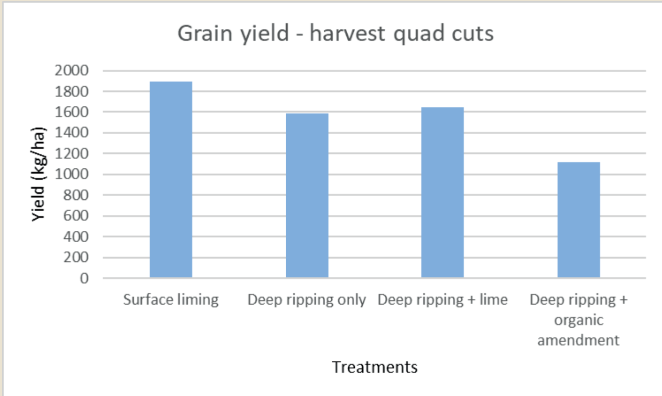

Figure 5. Harvest quad cut yield data (kg/ha, no significant difference, p > 0.05)

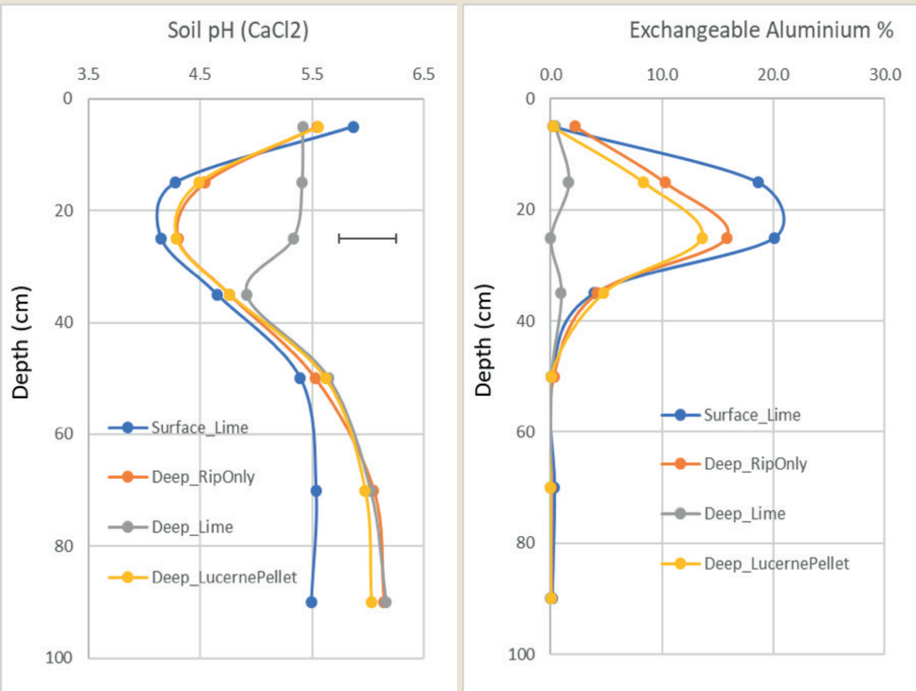

Figure 6. Soil pH and exchangeable Aluminium at Binalong (Binalong trial was completed in 2018). The bar represents LSD for soil pH data at the only depth increment where significant differences occurred (20-30 cm)

Discussion

Plant establishment at the Boorowa site in 2019 was relatively consistent across all treatments. There was no statistically significant difference and visually the establishment of all treatments appeared uniform.

Biomass measurements throughout the growing season showed consistently higher results for the deep lucerne pellets treatment. Total dry matter removed by grazing, and anthesis dry matter were both highest in the deep lucerne pellets treatment, however there was no statistically significant difference between treatments.

This result was supported by visual assessments, as it appeared that there was more vegetative growth in the lucerne pellets treatment compared to the others. It is likely that this extra biomass is a result of the higher nutritional benefit (nitrogen) of the lucerne pellets. Other research sites involved in this project have shown 70-100 kg/ha of extra mineral nitrogen being made available to plants in the first year of amendment (Li & Burns, 2017). Therefore, the nutritional benefit of lucerne pellets is significant and is likely causing increased crop biomass production.

Grain yield was below the long-term average at the Boorowa site due to the drought conditions, especially from anthesis onwards. Surface liming yielded the most, followed by the three deep ripping treatments. The deep ripping treatments potentially lost more soil moisture to evaporation early in the season and were therefore likely to be more moisture limited. The deep lucerne pellets treatment had the lowest yield, and this was likely due to extra vegetative growth early in the season resulting from the higher mineral nitrogen. This higher vegetative growth resulted in haying- off and therefore inefficient conversion of biomass into grain yield. In a higher rainfall year, this treatment would likely have the highest yield because of greater N nutrition. Soil testing at the completion of the Boorowa trial will be crucial in determining how much crop response can be attributed to soil pH changes and not just nitrogen interactions.

The end-of-trial soil results for the Binalong site (2016-2018) did show a soil pH change. At the completion of this trial, there was a statistically significant pH increase for the deep ripping + lime treatment at the amendment depth (20-30 cm). The deep ripping + lime resulted in pH of 5.3, compared to pH 4.2-4.3 for all other treatments. Aluminium was also greatly reduced in this deep ripping + lime treatment compared to the other treatments. The results for aluminium were not significantly different, but it is expected that increased replication would change this. Therefore, the conclusion from the Binalong trial is that deep ripping + applying lime directly to the acidic depth will increase subsoil pH and will likely reduce aluminium toxicity. This trial indicated that the benefit from this amendment will span more than one year and provide long-term results. However, on-farm adoption of this treatment strategy will require economic analysis to account for the increased costs associated with deep ripping.

Results at the Boorowa trial site were impacted by below-average rainfall during the first year (2019). It is expected that in a higher rainfall season, crop response will be determined more by soil acidity status rather than by limited soil moisture. Lime treatments will likely react more with the soil acidity as the trial progresses and produce more statistically significant results.

References

Li GD, Conyers MK, Heylar KR, Lisle CJ, Poile GJ and Cullis BR (2019). Long-term surface application of lime ameliorates subsurface soil acidity in the mixed farming zone of South-Eastern Australia. Geoderma 338, 236-246.

Li GD & Burns H (2017). Early measure of ameliorants to neutralise subsoil acidity. GRDC Groundcover, issue 129. Retrieved from https://grdc.com.au/resources-and-publications/groundcover/groundcovertm-129-july-august-2017/early-measure-of-ameliorants-to-neutralise-subsoil-acidity