Amelioration of subsoil acidity by subsurface placement of amendments in large-scale farm trials at Rutherglen and Bungeet

Cassandra Schefe, Jane McInnes
Riverine Plains Inc

Key points

- Large farm-scale trials provided useful practical information about applying soil amendments to relate back to small-scale and glasshouse-based experiments.
- Triticale showed a limited response to lime application at the Rutherglen site during 2019, most likely due to its tolerance to acid soils.
- During 2019, canola establishment at the Bungeet site was compromised by a lack of rainfall between deep ripping and sowing, followed by an intense rainfall event, leading to uneven germination.
- Assessment of subsoil amelioration techniques is difficult due to confounding factors, with several years of data collection required to allow for the physical effects of deep ripping to subside.

Introduction

As discussed in the article *Addressing soil acidity: subsurface amendments increasing pH and crop yield at Rutherglen* (page 46), acidity of subsurface soil is a major constraint to crop production in the high-rainfall cropping zone. The GRDC investment *Innovative approaches to managing subsoil acidity in the southern grain region* (DAN00206), led by NSW DPI, has evaluated a range of ameliorant options across a number of sites and years.

As part of this project, Riverine Plains Inc is conducting two large-scale field trials at Rutherglen and Bungeet to evaluate the effect of deep placement of lime, lucerne pellets and other products, compared with the surface application of lime.

The first site was established near Rutherglen during February 2018, while a site near Bungeet was established during February 2019. Baseline soil sampling was carried out before each site was established to confirm that pH values in the 0–30cm depth were highly acidic, with follow-up soil sampling to occur after the 2020 harvest.

A range of measurements have been undertaken for these large-scale field trials, focussing on the effect of the soil amendments on crop growth and yield.

After each site was established, the area reverted to farmer management with a commercial crop sown over the trial site. Plot boundaries were marked out using GPS to allow crop monitoring to occur for the remainder of the project term.

Both the Rutherglen and Bungeet sites will be monitored until after harvest 2020, at which time detailed deep soil cores will be taken to understand the effect of each amendment on subsoil pH and aluminium (Al) levels.

Aims

The aim of this research was to quantify the yield limitation caused by subsoil acidity and evaluate innovative soil amendments which act to ameliorate subsurface acidity.

Methods

The Rutherglen site was established during February 2018, while the Bungeet site was established during February 2019. The treatments for both sites are described in Table 1.

TABLE 1 Soil amendment treatments and rate of application for the trials established at Rutherglen during 2018 and Bungeet during 2019.

Location	Rutherglen treatments*	Bungeet treatments
Year trial established	2018	2019
Treatment	Surface lime (applied at 4t/ha)	Surface lime (applied at 0.8t/ha)
	Deep ripped (to approximately 30cm depth) + surface lime (applied at 2.5t/ha)	Deep ripped
	Deep placed lime (applied at 2.9t/ha) + surface lime (applied at 2.5t/ha)	Deep placed lime (applied at 2.8t/ha)
	Deep placed lucerne pellets (applied at 15t/ha) + surface lime (applied at 2.5t/ha)	Deep lucerne pellets (applied 15t/ha)
	Deep placed reactive rock phosphate (applied at 4t/ha) + surface lime (applied at 2.5t/ha)	-

* The Rutherglen site received an additional surface lime application (2t/ha) during 2019 as part of a whole-paddock amelioration program

At Rutherglen, the paddock received a blanket application of surface lime with all plot areas included in this application. This means the surface-lime-only treatment is considered the 'standard practice' control for this trial. All lime applications were calculated based on the lime requirement to raise the pH_{Ca} to 5.5 in the 0–10cm depth (for the surface lime treatment) and to pH 5.0 in the 10–30cm depth.

At the Bungeet site, the higher pH in the surface soil meant that only the 'surface lime treatment' received a surface lime application (to increase pH to 5.5), with no surface lime applied to any other treatments.

All deep ripping was done perpendicular to the sowing row, so the tynes did not run into the furrows. The deep amendments were placed approximately 10–30cm deep in the profile on a 50cm row spacing using the 3D ripper machine engineered by NSW DPI. A deep-ripped control, which had no deep amendments added, was included to determine if any plant growth benefit could be attributed to the deep ripping process itself. Plots were 100m long by 10m wide, with each treatment replicated three times.

Results

Rutherglen site, 2018

The site was sown to triticale (cv Astute) on 22 May 2018.

Establishment counts taken on the 19 June, 2018, showed significant differences in the number of plants/m^2 between treatments, with the surface applied lime treatment having significantly greater plants/m^2 compared with the deep ripped, deep lime, and deep rock phosphate treatments (Figure 1).

Visual differences were evident at the site during the season, with plants in the deep lucerne pellet treatment observed to be a deeper green for most of the season compared with the other treatments. Growth differences were also evident, with plants in the deep lucerne pellet treatment being visibly taller (Figure 2).

FIGURE 2 Drone footage taken 31 August, 2018, showing a section of the field site at Rutherglen, Victoria. (Image courtesy Jason Condon)

Note: The plots that received the deep lucerne pellet treatments are marked with a red outline. Treatments run perpendicular to the direction of sowing, with treatments running up the image (not all plots shown).

While there were visual differences in plant growth between the deep lucerne pellet treatments and the other plots, there were no significant differences in biomass production between treatments either at flowering or at harvest. Harvest dry matter (DM) results are shown in Figure 3.

The deep lucerne pellet treatment plots were observed to be more vigorous and a deeper green than all other plots during the season and were also visibly darker at harvest compared with the other plots (Figure 4). Plant samples were collected and assessed by a pathologist, who detected a higher presence of disease in the lucerne pellet plots compared with the other plots, none of which showed any disease-related blackening. The increased incidence of disease in the lucerne pellet treatment may be related to the earlier maturity and senescence of these plots compared with the other treatments. This, combined with a significant rain event prior to harvest, may have stimulated the onset of visible disease symptoms in the deep lucerne pellet treatment.

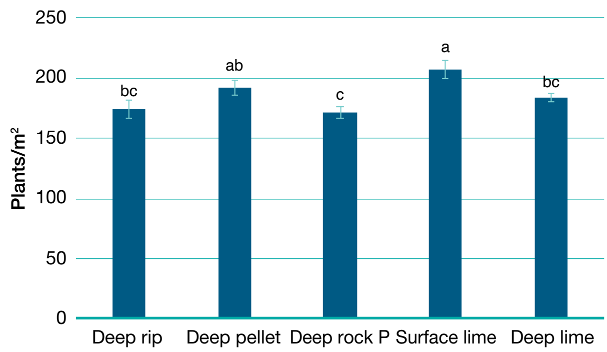

FIGURE 1 Establishment counts at the Rutherglen site, 19 June 2018

Bars are measures of standard error. Different letters denote significant differences between treatments.

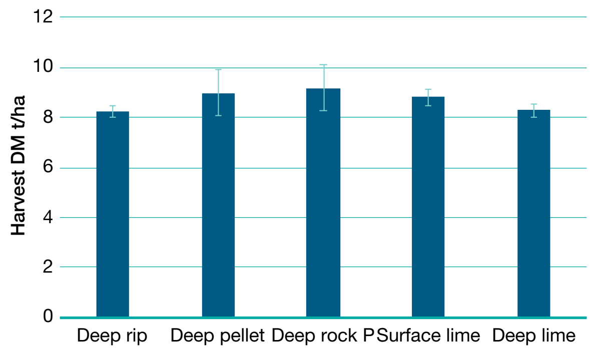

FIGURE 3 Harvest dry matter results for the Rutherglen site, 4 December, 2018

Bars are measures of standard error, with no significant differences between treatments.

FIGURE 4 Visual differences in plant colour at maturity observed in the deep lucerne pellet treatment Rutherglen, Victoria, 2018

The trial was harvested on 9 December 2018, with harvest yield data captured by the grain grower's yield monitor (Figure 5). The yield data showed a significant yield penalty for the lucerne pellet treatment compared with the other treatments, which was likely the combined result of early senescence, rain damage and an extended period from maturity until harvest (while waiting for the other plots to mature). There were no other differences between treatments.

Rutherglen site, 2019

During March 2019, a second 2t/ha application of lime was broadcast across the trial site as part of a whole-paddock amelioration program.

The site was again sown to triticale (cv Astute) on 31 May 2019. Plant counts taken on 26 June showed no differences in triticale emergence between any of the treatment plots (data not shown).

As was the case for the 2018 trial, visual differences in plant growth and greenness were again evident in the 2019 deep lucerne pellet treatment compared with the other plots (Figure 6). While this visual effect did not translate to any DM production differences at the flowering biomass assessment, there was a significant increase in harvest biomass for the deep lucerne pellet treatment ($p<0.05$), compared with all other treatments (Figure 7).

The trial was harvested on 17 December, 2019. Harvest yield data was again captured by the grower's yield monitor, with no significant differences in yield observed between any of the treatments (Figure 8).

As a legume, lucerne contains a high amount of nitrogen (N) and the deep placement of lucerne pellets (at a depth of 20–30cm) is likely to result in increased nitrogen supply to the crop throughout the season. While this is probably the reason for the increased early vigour and visual improvements in plant greenness observed in the lucerne pellet treatments, it is also likely to have caused haying off and early maturity in these plots. As the trial was harvested when all plots had reached maturity, the delay to harvest for the earlier-maturing lucerne-pellet plots likely resulted in a yield penalty for this treatment.

FIGURE 6 Drone footage taken 25 August, 2019 showing visual differences in plant growth for the deep lucerne pellet treatment at Bungeet, Victoria. (Image courtesy Jason Condon)
Note: The deep lucerne treatments are marked with a red outline. Not all plots are shown.

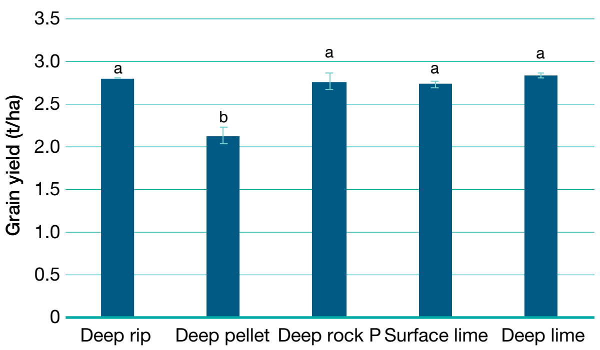

FIGURE 5 Rutherglen header yield data, 9 December 2018. Bars are measures of standard error
Different letters denote significant differences between treatments.

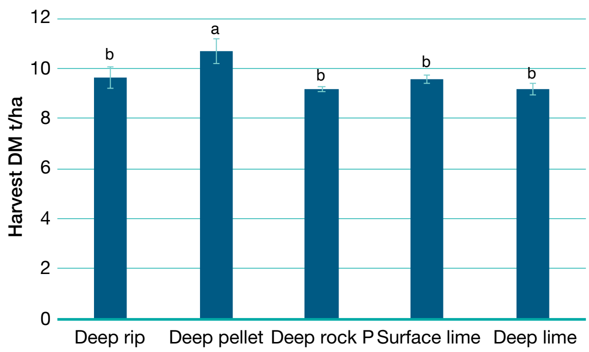

FIGURE 7 2019 Triticale harvest dry matter at the Rutherglen site. Bars are measures of standard error
Different letters denote significant differences between treatments.

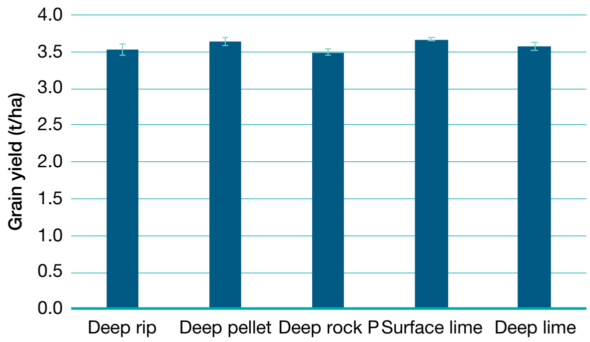

FIGURE 8 Header yield data at the Rutherglen site, harvested 17 December 2019
Bars are measures of standard error.

As a crop, triticale tolerates acid soils well and this might explain why there were no responses due to applied lime at depth compared with the surface-applied lime-only treatment. The lack of a nil-lime control means it is not possible to determine any specific plant growth response due to surface-applied lime.

Bungeet, 2019

The Bungeet site was established on 26 February 2019, with a range of soil amendments applied (Table 1). No significant rain events were received between the establishment of the trial and sowing on the 13 April, 2019, when the site was dry-sown to canola. The lack of rainfall, combined with the relatively short time frame between applying the soil amendments and sowing, meant the canola in the deep-ripped treatments was sown into a poor seedbed of highly fractured, cloddy soil. An intense rain event on 3 May, 2019, washed seed into the fractures and/or washed soil into the furrow and over the seeding row, which may have also caused some crusting. These actions meant the seed was buried at uneven depths, resulting in poor and variable germination. This can be clearly seen in Figure 9, where the most even canola growth can be observed in the surface-applied lime treatments, in the buffer strips between treatments, and in the surrounding crop.

FIGURE 9 Drone image taken 25 August 2019, at the Bungeet site, Victoria. (Image courtesy Jason Condon)
Note the visual differences in plant growth across the trial site (not all plots shown). The surface-applied lime treatments are marked with a red outline.

Given the challenging start to the season, plant establishment counts were low and variable. The surface-applied lime treatment showed a trend towards increased plant numbers, but this was not significant (Figure 10).

Variation in plant growth was evident throughout the season and flowering DM cuts also varied, however, there were no significant differences between treatments (Figure 11). A desiccant product was applied to the paddock before the harvest DM cuts could be scheduled, which meant these cuts could not proceed (walking through the crop would result in significant pod-shatter losses).

As was the case at the Rutherglen site during 2019, the canola in the deep placed lucerne pellet treatment was visually darker at harvest.

The canola plots were harvested on 30 November, 2019, with yield for each plot collected using field bins before being weighed in the paddock. There were no yield differences between treatments (Figure 12).

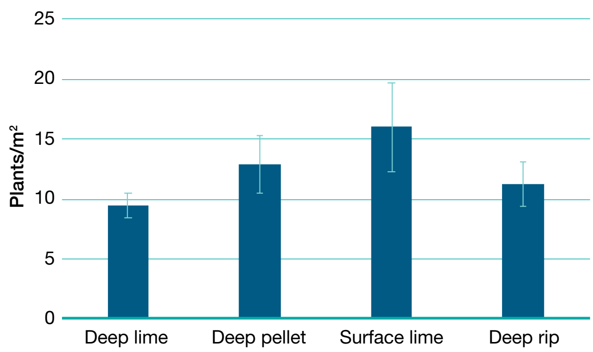

FIGURE 10 Plant establishment counts taken 18 June, 2019 at the Bungeet trial site, Victoria
Bars are measures of standard error.

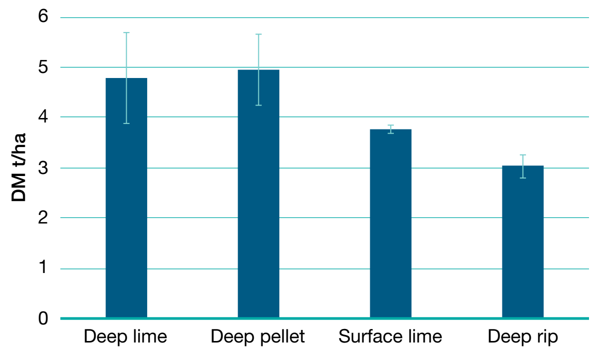

FIGURE 11 Flowering biomass cuts taken 30 August 2019, at the Bungeet site, Victoria
Bars are measures of standard error.

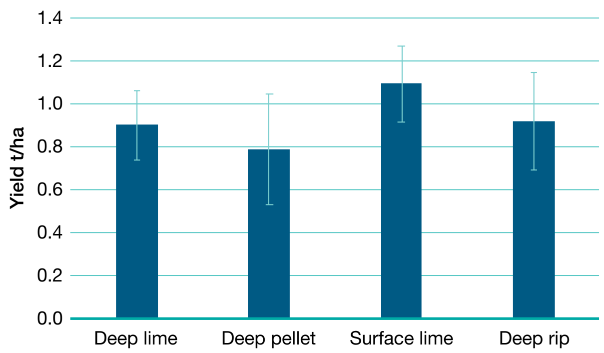

FIGURE 12 Canola harvest yields, 30 November, 2019, Bungeet, Victoria
Bars are measures of standard error.

The lack of plant response to any of the treatments applied at the Bungeet site is likely due to poor establishment caused when canola was sown into fractured, cloddy soil, which was then followed by an intense rainfall event.

The site has now received substantial rainfall, improving the condition of the soil, and it is hoped that treatment effects might be more clearly seen during the 2020 season.

The Rutherglen and Bungeet field sites will both continue to be monitored until the end of the 2020 season, when the project ends. Intensive soil sampling will be completed for each plot after the 2020 harvest; this will help identify how applying soil amendments may have altered soil pH values during the past two years at Bungeet and over three years at the Rutherglen site.

Observations and comments

The aggressive nature of the deep-ripping operation means both time and rainfall are required to resettle the soil and reduce the effect of deep ripping on crop establishment. If time and budget were not limiting, these sites would have benefited from being established one full year before monitoring commenced. This would have provided enough time for the confounding effects of soil disturbance on crop performance to be reduced. Moreover, the effect of soil disturbance has meant the yield limitation, or penalty, due to subsoil acidity could not be clearly defined. It is hoped any treatment effects become clearer after the 2020 season.

This project aimed to understand the effect of deep placement of amendments on subsoil acidity and crop performance. It did not aim to quantify the efficacy and practicality of this method on a large scale, due to its high cost. The learnings from this work will be used to further inform subsequent research, which would ideally move towards methods and practices more amenable to farmer adoption.

Further results will be available after the 2020 harvest is completed and when the post-2020 harvest soil testing results have been collated.

Acknowledgements

This work is part of the GRDC investment *Innovative approaches to managing subsoil acidity in the southern grain region* (DAN00206), led by NSW DPI.

Thank you to our farmer co-operators Lilliput Ag, Rutherglen and John Alexander, Bungeet.

Thank you also to BioAg for donating the reactive rock product. All other products were obtained through commercial suppliers.

Contact

Jane McInnes Riverine Plains Inc
P: (03) 5744 1713
E: jane@riverineplains.org.au