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FarmLink Research Report 2018

Innovative approaches to Managing Subsoil Acidity in the Southern Grain Region

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Introduction

Soil acidification is a natural process which is accelerated in areas of high agricultural productivity, high rainfall and on soils with low buffering capacities *(Conyers et al., 1996)*. In the eastern FarmLink region, where these characteristics are typical, surface liming has been used to combat soil acidification in the topsoil (0-10 cm). Due to the very slow movement of lime through the profile and consumption of alkalinity in the topsoil, this practice has limited potential to neutralise or prevent sub-soil acidification *(Tang et al., 2013)*.

The detrimental impacts of low pH soils include nutrient deficiencies and toxicities (particularly Aluminium toxicity, which adversely affects root growth), accelerated nutrient leaching, breakdown/loss of clay materials, a reduction in carbon sequestration and limitations to crop and pasture options within the rotation *(Ryan, 2018; Page et al., 2018)*.

To treat soil acidity in deeper layers of the profile, investigation of ameliorants and technologies capable of economically placing products at depth is required. This project brings together four research organisations and four farming system groups within the high rainfall area (500-800mm) of south-eastern Australia to analyse aggressive amelioration options for soil acidity at depths of 10-30cm. The standard farmer practice of surface liming will be compared to three intensive management options; deep ripping to 30cm, ripping plus lime at 10-30cm and ripping plus organic ameliorant at 10-30cm.

Project Partners

Funding Partner

Project code - GRDC: DAN00206

Objectives

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

Examine the effectiveness of a number of aggressive treatments to ameliorate and/or prevent subsoil acidity under field conditions

Increase awareness of subsoil acidity and potential amelioration strategies

Method

Two large-scale on-farm experiment sites have been identified by FarmLink in high rainfall areas (> 500 mm p.a.) in 2016 (Binalong) and 2018 (Boorowa).

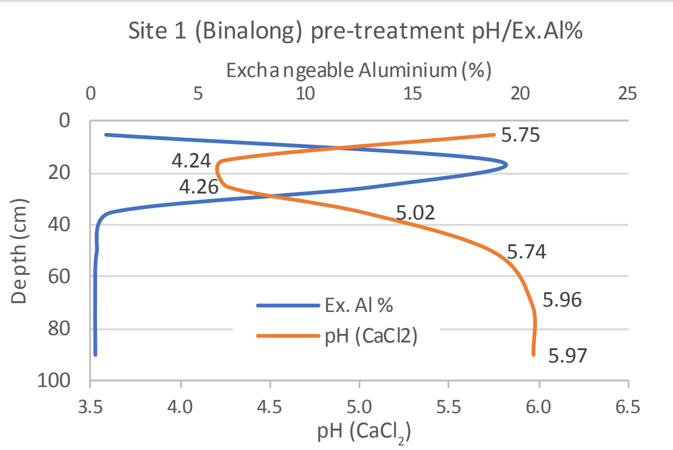
Selection criteria was based on the following:

- 0-10 cm: 4.0-4.5 pH ($CaCl_2$). If limed, preferring < 5.0

- 10-20 cm: < 4.3 pH ($CaCl_2$), exchangeable Aluminium >20%

- 20-30 cm: < 4.6 pH ($CaCl_2$), exchangeable Aluminium >10%

Site 1 is located at Binalong, NSW on a Yellow Chromosol which was limed in 2015 at 3.5t/ha. Pre-treatment soil sampling in February 2016 returned pH_{Ca} values of 5.75 (0-10cm), 4.24 (10-20cm) and 4.26cm (20-30cm). Site 2 is located at Boorowa, NSW and possessed pH_{Ca} values of 4.38 (0-10cm), 4.23 (10-20cm) and 4.44cm (20-30cm) as of October 2018 *(Figure 1)*.



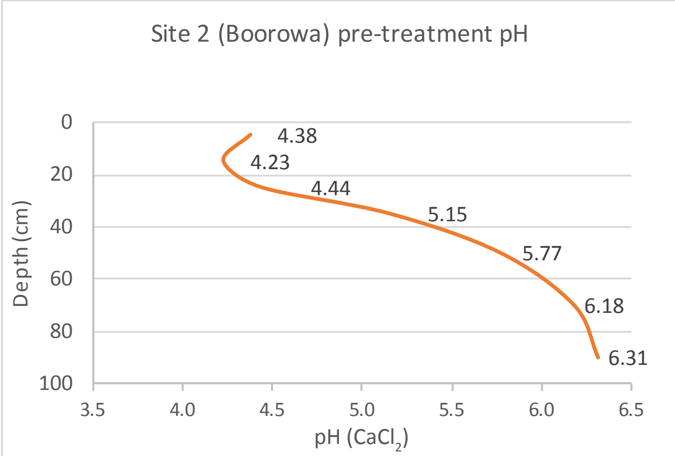


Figure 1: Segmented soil pH and exchangeable Aluminium at Binalong site (left) and 2019 Boorowa site (right).

Experimental treatments were executed at the Binalong site during February 2016. Treatments consisted of surface liming only, deep ripping, deep ripping plus lime and deep ripping plus organic ameliorant *(Table 1)*. Deep ripping was undertaken using a dual depth delivery (3-D) ripping machine with 50cm spaced tynes designed and fabricated by NSW Department of Primary Industries. Treatments were replicated three times in a block design for a total of twelve 100m x 12.5m strips orientated at roughly 30^0 to the direction of sowing. Site 2 will have a similar design, with treatments implemented in February 2019.

Table 1: Site 1 (Binalong) treatments.

	Treatment	Description
1	Surface liming only	Surface liming in 2015 at 3.5t/ha. No additional treatment in 2016.
2	Deep ripping	Ripping to 30 cm at 50 cm spacings.
3	Deep ripping + lime	Ripping + placement of 2.6t/ha of lime at 10-30cm depth.
4	Deep ripping + organic amendment	Ripping + placement of 10t/ha lucerne pellets at 10-30cm depth.
* All plots received 3.5t/ha surface lime in 2015		

Following the execution of treatments at the Binalong trial site, all actions have been as per standard farmer practice, summarised in *Table 2*:

Table 2: Site 1 (Binalong) cropping sequence

	2016	2017	2018
Crop	Canola	Wheat	Canola
Variety	Hyola 970CL	Spitfire	Hyola 970CL
Sowing rate	3kg/ha	70kg/ha	3kg/ha
Sowing date	14/03/2016	17/05/2017	20/03/2018
Harvest date	12/12/2016	18/12/2017	08/12/2018

Assessments undertaken throughout the season consisted of establishment counts, anthesis cuts, harvest dry matter cuts, header yield data and grain quality testing. Establishment counts and anthesis/harvest cuts all consisted of three observations per strip, bulked to return an average. Drying, weighing and threshing of samples was undertaken by FarmLink, while grain quality analysis was undertaken by NSW DPI. Final segmented soil sampling will be undertaken in February 2019 to assess for changes to soil chemical properties.

Results – Binalong

2018 was the third and final year of assessments at the Binalong site. The season was characterised by lower than average rainfall, with 361mm falling compared to the long-term average of 647mm.

Establishment counts were taken on 1 May 2018 at approximately 70% canopy cover, consisting of three counts averaged per plot. Plant populations ranged from 49 – 76 plants/m^2 across the 12 strips, with no significant difference observed across the four treatments in 2018 *(Figure 2)*. 2016 was the only year to record a significant difference in establishment, with the non-tilled treatment (surface lime only) displaying higher plant population numbers.

Grazing occurred during June/July of the 2018 growing season for approximately six weeks (250 ewes over the 18ha area). Isolation cages 1m^2 were used to gauge an estimate of the biomass removal from each treatment during this period. Post-grazing dry matter cuts were taken inside and outside cages placed in one replicate (i.e., four strips out of twelve). Dry matter production from the organic ameliorant plot (427g) was substantially greater than the deep liming (191 g), surface liming (199g) and deep ripped (188g) plots.

Anthesis dry matter cuts taken in mid-October showed a similar, however less pronounced trend. A significant difference between treatments was observed (p = 0.03) with the organic ameliorant (lucerne pellet) having the highest result (7.80t/ha), followed by the deep ripping (6.97t/ha), deep liming (6.95t/ha) and surface liming only treatments (6.84t/ha) *(Figure 3)*. This trend was also evident in 2016, however was not statistically significant due to variability across the replicates.

2018 anthesis DM cut results were further supported by qualitative analysis of in-season Normalised Difference Vegetation Index (NDVI)

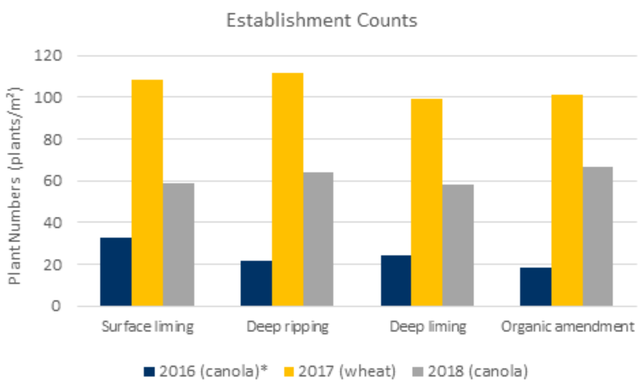


Figure 2: 2016-18 crop establishment results (plants/m^2). 2016 results (*) are significantly different (p = 0.004).

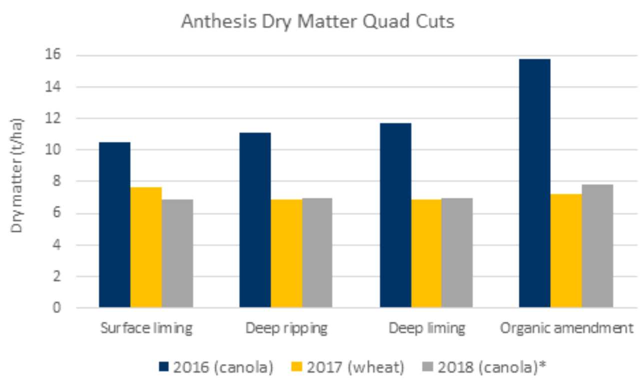


Figure 3: 2016-18 crop anthesis DM cut results (t/ha). 2018 results (*) are significantly different (p = 0.03).

imagery captured within September and October. Organic ameliorant (lucerne pellet) treated strips were spatially correlated with higher NDVI results, suggesting more vigorous and/or dense biomass in these treatments *(e.g. Figure 4; 30/09/18 capture)*. This was also supported by on-the-ground observations during this period.

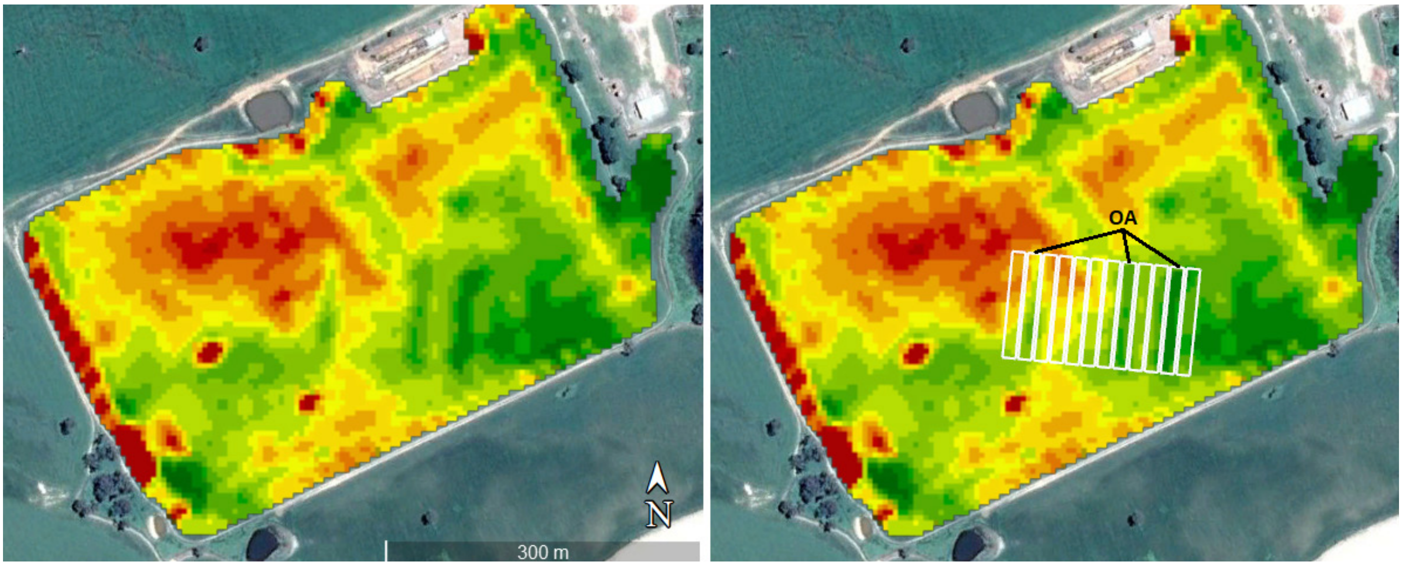


Figure 4: NDVI imagery 30/09/2018 captured by Sentinel 2. Range = 0.55 (red) – 0.83 (green). OA = Organic Ameliorant

Harvest data was captured by quad cuts taken just prior to windrowing in addition to weights recorded from each strip by the commercial harvester. Quad cut grain yields in 2018 ranged from 2.38t/ha to 3.91t/ha across the twelve strips, with the surface liming treatment yielding the lowest average (2.50t/ha) and the deep ripped treatment the highest (3.30t/ha). None of the harvest dry matter or grain yield results were significant in 2018, as was the case in 2017. This differed to 2016, where both harvest dry matter* and grain yield** results were significantly different across the four treatments in the order of surface lime < deep ripping < deep ripping + lime < deep ripping + organic amendment ($p < 0.001$* and $p = 0.003$**; *Figure 5)*.

Grain quality analysis of 2018 samples will be undertaken by NSW DPI within the coming months.

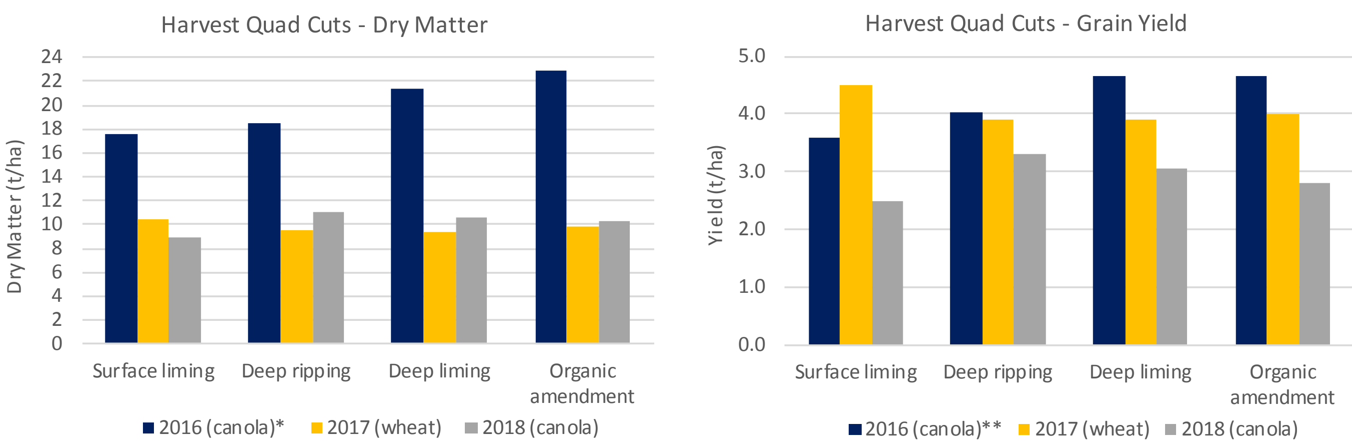


Figure 5: 2016-18 harvest quad cut dry matter and grain yields (t/ha). 2016 DM and grain results are significantly different (p < 0.001 and p = 0.003**).*

Discussion

Establishment success across the three year trial was influenced by both seasonal conditions and tillage effects. In 2016, plant populations in the deep ripped treatments were significantly lower than that of the surface lime only (non-tilled) treatment. This is most likely due to the loss of topsoil moisture and lower seed-soil contact achieved in the ripped plots. Plant populations were higher and more consistent in 2017 and 2018 across all treatments, most likely due to more favourable season breaks and the settling period elapsed since ripping. The lack of significant difference among treatments in 2017 and 2018 indicates that at this site, aggressive cultivation has not imparted any long-term impact on plant establishment success.

Biomass production across the treatments varied throughout the course of the trial, with significant differences observed between treatments in the 2016 harvest DM cuts and the 2018 anthesis DM cuts. In both instances, highest biomass production was recorded for the organic ameliorant (lucerne pellet) treatment and lowest production recorded for the surface liming treatment. This trend was also observed in the 2016 anthesis cuts, however results were variable due to the inconsistent establishment occurring in this season. Quantitative data was supported by on-the-ground observations and in-season NDVI imagery throughout the three seasons which suggested that the lucerne pellet treated plots were comparatively more vigorous than adjacent buffers and alternative treatments. It is likely that this effect is related to the additional nutritional (N) benefit of the lucerne pellets, however the response may also be through an increase in soil pH, the complexing of toxic Aluminium with organic acids or a combination of these factors. Final soil sampling results will be critical in teasing out the nutritional and soil chemical (particularly pH and Al^{3+}) effects imparted by the organic amendment.

2016 was the only year to record a statistical difference between grain yields of the four treatments, with the organic ameliorant and deep limed plots yielding approximately 1t/ha higher than the surface limed plots (4.66t/ha vs. 3.61t/ha respectively) despite the surface liming treatment having a significantly higher establishment count. In the subsequent two seasons, grain yield results were variable and no significant trends were observed. The slightly higher yield of the ripping only treatment in comparison to the surface lime only treatment suggests that at least some of the benefit observed in the deep lime and deep organic ameliorant plots in the first season may have been due to the ripping process itself. This may have been through improved moisture infiltration or incorporation of surface applied lime and/or other nutrients such as phosphorus.

The lack of significant results from the 2017 season (wheat) across any measurements suggests responsiveness may differ between crop types or in relation to rooting depth or growing season. Further work and/or interpretation of other trial site results will be required to investigate this further. The much smaller response in 2018 canola crop compared to 2016 canola crop also suggests that any positive benefit may be most substantial early on, with diminishing effect in subsequent seasons. This would follow if the benefit was primarily due to a nutritional effect or the alleviation of compaction (i.e. due to ripping). If the benefit is through an increase in soil pH however, we would expect a sustained response going forward, or an improvement over a number of seasons depending on the time required for soil pH neutralisation reactions to occur. Further interpretation of results will be possible following the completion of deep segmented soil sampling in early 2019.

References

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