Improving soil health by ameliorating subsoil compaction and subsoil acidity

Key Messages

- Ameliorating subsoil compaction and improving subsoil acidity improved barley grain yields by >1t/Ha at this trial site in 2019.
- Soil pH changes, in only 12 months, confirm Inclusion plates are effective at moving lime into the acidic subsoil.
- Results from the first 12 months confirm that high lime rates on the soil surface do not reduce subsoil acidity. Potential lime movement into the acidic subsoil is expected to take many years without tillage.
- Lime sourced on-farm performed equally to imported lime when adjusted for neutralising value percentage (NV%). Determining future value of on-farm lime sources may require different lime tests.
- The longer-term monitoring of this deep ripping site and other SCF Tillage sites will help estimate costs and benefits of applying controlled traffic farming (CTF) in our region.

Purpose

To evaluate if deep ripping with inclusion plates moves surface applied lime into the acidic sub-soil at a greater rate than lime spread on the soil surface. Secondary opportunity: To evaluate on-farm Lime source vs commercial Lime.

Summary

The aim for this trial was to evaluate if applying lime prior to deep ripping, with inclusion plates, was worthwhile economically for growers on the south coast of WA. It is expected that lime will move into the acidic subsoil much faster after ripping than surface applied lime and this could accelerate the payback for the ripping and lime costs through higher grain yields.

Some growers have been applying robust amounts of lime for the last two decades on the south coast. Deep ripping to remove compaction is a relatively new practice that farmers are starting to adopt on a wide-scale basis. Researchers hope to show that liming before deep ripping will alleviate acidic subsoils faster with minimal extra cost since deep ripping is already being completed in compacted soils. NB: Inclusion plates create extra 'drag' on the tractor which increases fuel usage as well being a wearing part themselves. The exact costs of running inclusion plates have not been analysed in this project.

Treatments

Treatment 1. Deep Rip + Inclusion plates with Nil Lime

Treatment 2. Deep Rip + Inclusion plates with 5t/Ha Boyanup Lime

Treatment 3. Deep Rip + Inclusion plates with 12t/Ha Willis (on-farm) Lime

Treatment 4. Lime – 5t/Ha Boyanup Lime without deep ripping

Treatment 5. CONTROL- Nil Ripping and Nil Lime

Site measurements

SOIL TYPE: site is deeper duplex sand over gravel/clay at >45cm to duplex layer. The trial area was grid sampled for sub soil compaction.

TABLE 1. Treatment average yields with two replicates and two measurements of yield. One set of yield data was collected using a weigh trailer. The second yield data set was obtained from the header yield monitor. *Figures followed by the same letter or symbol do not significantly differ (P=.05, LSD)*

Treatment	JD Yield Map (t/Ha)	Weigh Trailer plot Yield (t/Ha)	
Deep Rip with Nil Lime	4.93 t/Ha	4.92 t/Ha	ab
CONTROL Nil Rip & Nil Lime	4.40 t/Ha	4.29 t/Ha	a
Deep Rip + 12t/ha Willis Lime	5.23 t/Ha	5.33 t/Ha	b
Nil Rip + 5t/ha Boyanup Lime	4.29 t/Ha	4.20 t/Ha	a
Deep Rip + 5t/ha Boyanup Lime	5.49 t/Ha	5.44 t/Ha	b

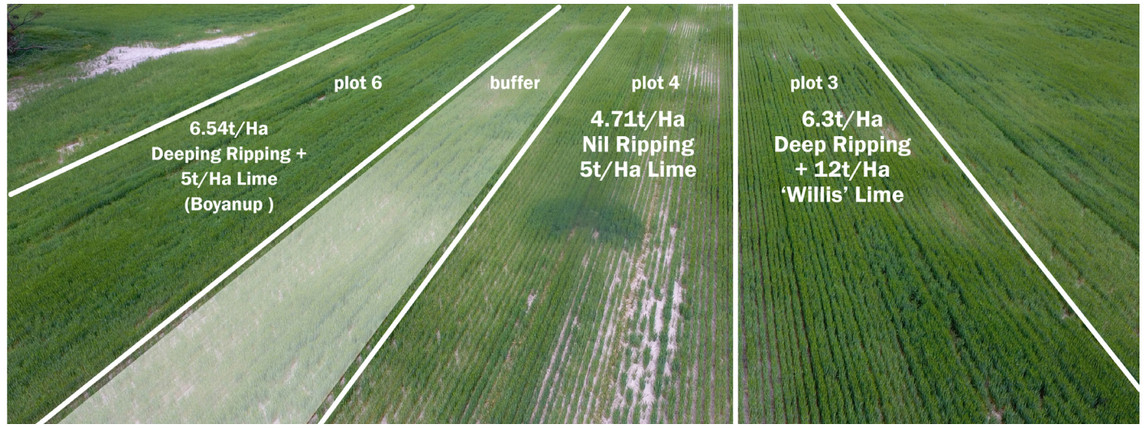

FIGURE 1. Displays the differences in biomass from four different treatments at the Willis trial site. Photo taken 19 September 2019.

2019 Results

Trial harvested 16 November 2019 and plot yields measured using both a weigh trailer and analysis of John Deere Yield map for the trial site. There was less than 4% variation between the two methods.

Without the aid of the yield map data the treatment differences were not significant at the P= 0.05 level but significant at the P= 0.1 level. Within plot analysis of the trial by Murdoch University shows treatment differences at P= 0.05. This is because in the sandy Duplex soil, the variation in depth to clay adds more variability in yields within replicates.

The trial is only 12 months old and SCF will monitor for at least two more seasons. With three years of yield data we will be able to complete a simple cost benefit analysis between the treatments.

Trial Site Subsoil Acidity

The trial site was intensively soil tested in February 2019. Results confirmed that soil pH was consistently lowest at 10-30cm soil depth with pH ranging from 3.8 to 4.27 (highly acidic).

TABLE 2. Summarises the soil pH ($CaCl_2$) for the five different treatments in December 2019, after the lime treatments were applied in March 2019.

Treatment	Soil Depth	pH CaCl2	Soil Depth	pH CaCl2
CONTROL- Nil Rip & Nil Lime	0-10cm	4.75	10-30cm	4.20
Deep Rip & Nil Lime	0-10cm	4.55	10-30cm	4.30
Deep Rip 12t/ha Willis Lime	0-10cm	6.15	10-30cm	5.25
5t/ha Boyanup Lime- Nil Rip	0-10cm	6.35	10-30cm	4.40
Deep Rip + 5t/ha Boyanup Lime	0-10cm	6.4	10-30cm	6.15

TABLE 3. Average soil pH pre-season (for whole site) and post-harvest for each of the treatments. Values in red denote very low pH levels that are suboptimal for crop growth

	Pre-season pH (CaCl2) Averages	Post-Harvest: Control plots pH	Post-Harvest: Deep ripped + Boyanup Lime 5t/Ha plots pH *Within rip lines*	Post-Harvest: Deep ripped + Boyanup Lime 5t/Ha plots pH: *Outside of Rip Lines*	Post-Harvest: Deep Ripped + Willis Lime 12t/Ha: *Within Rip Lines*	Post-Harvest: Deep Ripped + Willis Lime 12t/Ha *Outside of Rip Lines*
Topsoil 0-10cm	4.7	4.6	6.3	6.3	5.9	5.9
Subsoil 15-25cm	4.1	4.2	6.1	4.4	6.0	4.5

TABLE 4. Comparison of particle size distribution and neutralising value of imported Boyanup Lime and Willis's on-farm sourced lime.

		Particle Size Fractions (%) from dry* sieving					%NV
Sample	%Moist	>2mm	>1mm	>0.5mm	>0.25mm	<0.25mm	
Willis Average	16	28	12	18	24	18	35
Boyanup	5	0	1	33	52	14	86

Summer forage crop demonstration

Points to note

- Deep Ripping alone has given a 0.53t/ha yield advantage over the control (Nil Lime & Nil Rip) .
- Deep Ripping + 5t/ha Boyanup Lime has given an additional 0.56t/ha to ripping alone for a total of 1.09t/ha higher yield than the control.
- Deep Ripping + 12t/ha Willis Lime has given an extra 0.3t/ha yield advantage over ripping alone for a total of 0.83t/ha higher yield than the control.
- The yield differences between the ripping treatments and the different lime sources were not significantly different. (Remembering the liming rates (t/ha) were different but the effective neutralising value were the same).
- The increased grain yield from deep ripping was pleasing to see, although not unexpected because results were consistent with other research on similar soils.
- The lack of yield response from 5t/ha Boyanup lime applied to the soil surface was not surprising based on previous research.
- The differences in the top soil pH change in the topsoil (0-10cm) of 5t/ha Boyanup Lime treatment (Nil Rip) compared to the control (Nil Lime & Nil Rip) was significant, only 9 months after application.
- The pH of the control treatment in the 10-30cm is similar to the 5t/ha Boyanup Lime surface applied. This indicates little movement of lime into the acidic subsoil after only 10 months.

Why the two sources of Lime?

The imported Boyanup lime (screened) with high NV is a good comparison with Willis's own on-farm lime. High rates are used because the objective was to test different subsoil acidity treatment options while dealing with the sub soil compaction. For the two sources of lime, rates were adjusted for NV% in determining application rates.

The effectiveness of a lime source as an ameliorant for soil acidity depends not only on the neutralising value (%NV) but also on the particle size distribution. Lime particles less than 0.5 mm are most effective in neutralising soil acidity in the first year of application (Dr Craig Russell, UWA Albany Centre, pers comm).

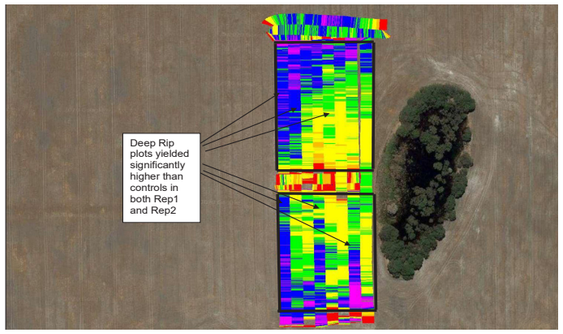

FIGURE 2. Yield map output for the Lime Ripping trial site at Clint Willis's property.

FIGURE 3. Soil profile at SCF Spring Field Day showing test dye color confirming lime at depth concentrated in rip lines > pH 5.5 (green) vs soil between rip lines < pH 4.2 (Yellow by color chart).

Discussion

The 2019 results clearly showed a yield advantage to ameliorating compaction and subsoil acidity through liming before deep ripping. We hypothesized there would be a yield improvement from the deep ripping, but it was surprising to see the liming + ripping having an additive effect on grain yield. Surprising because lime applied on the soil surface without incorporation rarely improves grain yield in year one, which is what we saw in this trial.

Results from a single year of data indicate growers should apply lime before deep ripping in sand plain soils when they have subsoil acidity. Amelioration of subsoil acidity was faster in this trial compared to surface applied lime. SCF researchers look forward to collecting yield results in the next two seasons to further evaluate yields and soil pH changes over time. It will be especially interesting to monitor the performance of the two different lime sources over the coming years. Initial estimates of lime costs are that the farm sourced lime applied at 12t/ha is cheaper than applying 5t/ha of commercial lime.

SCF would like to thank the Willis family for their cooperation in managing this trial for SCF and the funder: National Landcare Program.

Stirling to Coast Farmers (SCF) wanted to investigate the use of summer forage crops to take advantage of the summer rain that generally falls on the south coast as a potential cost-effective feed for livestock during the autumn period when feed is usually scarce.

A summer forage demonstration site was hosted by SCF member Jeremy Walker at Green Range in 2019/20. Jeremy grew Shirohie millet and Pallaton Raphano as alternate summer forage crops.

The site consisted of a 67ha paddock of Shirohie millet; 2000 lambs were put on the paddock to graze for a 37-day grazing period. The lambs were weighed into the paddock on November 28, 2019 at an average weight of 41.8kg, and weighed off on January 3, 2020 with an average weight of 46.2kg.

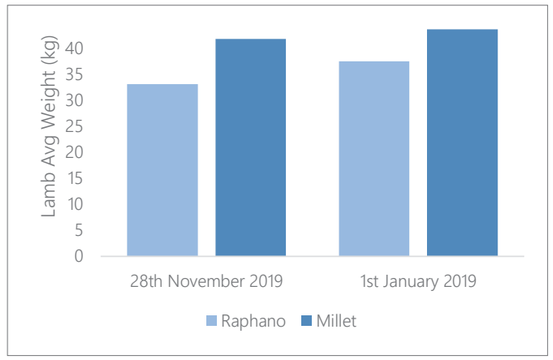

FIGURE 1. Crossbred lamb liveweight gains (kg) grazing Shirohie millet and Pallaton Raphano paddock over a 37-day period from November 28, 2019 to January 3, 2020. Average weight gain was 4.4kg per animal

The average weight gain per animal was 4.4kg over the 37 days. This gave an average daily weight gain of 118 grams. The average lamb liveweight gain across the 67ha was 3.5kg per hectare, per day (fig 1.)

The Pallaton Raphano demonstration trial had 300 lambs grazing a 12ha paddock over a 37-day grazing period. The lambs were weighed onto the paddock on November 28, 2019 with an average weight of 33.1kg and weighed off the paddock with an average weight of 37.5kg. This equated to a an average liveweight gain of 4.4kg. The average live weight gain across the 12-hectare paddock was 2.95kg per hectare.

FIGURE 2. Shirohie millet crop before grazing 28th November 2019 at Jeremy Walker's – Green Range

Visually there was more biomass in the millet paddock compared to the Raphano. Considering the dry period, where less than 10mm of rain fell between seeding (Oct 3, 2019) and January 3, 2019, Jeremy was happy with the liveweight gains off both forage crops.

With little rainfall over summer in 2019/20, the green feed grown in the demonstration paddocks was valuable for his mixed farming enterprise. The rainfall data shows there was 21.5mm in October 2019, 4.6mm in November, and 4.5mm in December. The cost of both the millet and Raphano seed was approx. $100/ha and $15/ha for fertiliser.

Growing summer crops means Jeremy can grow cost-effective feed, which will be available to livestock during the summer-autumn period when feed is normally scarce. Despite the recent summer being very dry, Jeremy was able to extract value from his summer cropping activities. SCF have recently obtained continued funding from MLA to continue measuring the feed value and liveweight gain from summer crops. We are interested in measuring these crops, and others, in a more average rainfall year when the south coast would receive higher rainfall than it did in the 2019/20 summer.

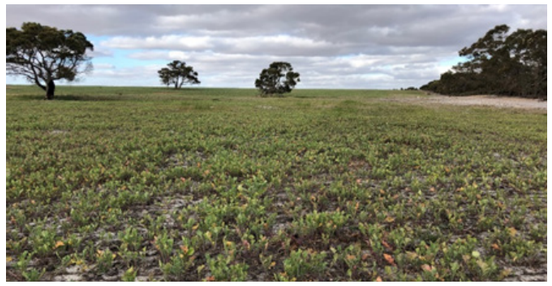

FIGURE 3. Pallaton Raphano crop before grazing 28th November 2019 at Jeremy Walker's – Green Range, WA.