Can incorporation of lime speed up yield response?

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KEY MESSAGES

- Incorporation of lime has not shown a yield response above that of surface applied lime in the first year with wheat or canola in a wet year.
- Acid layers exist within soils and are mainly confined within the topsoil on basalt soils and can extend deeper in other soil types.
- Sampling soil in 5 cm increments is useful for identifying exactly where acidity is the profile so that lime can be potentially incorporated within the acid area.
- Surface-applied lime takes time to move down the soil profile and ameliorate acidity.
- To minimise yield losses where acidity issues exist (pH less than 5.0), sow acid tolerant cereals (eg. wheat) following liming or look to incorporate lime.

Keywords: Soil acidity, lime

BACKGROUND

Many farmers apply surface lime in a no till system or perennial pasture. Follow up testing has shown that lime may not have addressed acidity below 5 cm depth after two or three years following application. Although yield responses have occurred with ameliorating acidity within the top 5 cm of soil, it is believed addressing deeper acidity could unlock further yield responses.

Acidity issues within basalt soils are frequently confined to the topsoil (A horizon) down to about 15 cm and then pH increases where the clay layer begins. In gradational soils or soils that are sedimentary, granitic or alluvial in origin, acidity can extend further into the profile. It is important to know the depth of the acidity so lime can be placed where it is most needed.

Lime was incorporated at two sites at Inverleigh and Drysdale to determine if this increased the speed of lime response in comparison to surface applied lime. It is known that surface applied lime can leach beyond 10 cm provided the topsoil is kept greater than pH 5.5, but the time for this to occur is commonly greater than 5 years and is dependent on leaching rainfall and lime fineness.

METHOD

Trials were established in April 2016 with four replicates and comparing two factors: incorporation method and lime rate. The incorporation methods were:

- Surface application
- Offset disc plough
- Ripping with SFS subsoil manuring prototype machine, with lime deposited at depth

Farmers at both sites had recently applied lime at a common rate:

- Drysdale – 2.0 t/ha in 2015
- Inverleigh – 2.5 t/ha in 2016

A further 2.5 t/ha of lime was added to some treatments resulting in a higher lime rate of 4.5 t/ha and 5.0 t/ha.

Lime was worked in with a disc plough to about 10 cm at Drysdale and 15 cm at Inverleigh to achieve good mixing but to avoid overworking the soil (figure 1). The ripping tynes were 75 cm apart and disturbed the soil to a depth of 25 cm. Lime was deposited in the rip line directly behind the tyne, to a depth of 10 to 20 cm.

Figure 4. Discing treatments in at the Drysdale site.

The soil pH of the soil profile at the start of the trial is presented (table 1).

Table 1. Soil pH(CaCl2) at the trial site in April 2016 immediately after lime application.

Depth (cm)	Inverleigh	Drysdale
0-5	4.8	4.9
5-Oct	4.6	4.4
Oct-15	5.2*	4.3
15-20	5.8	4.5
20-25	6.1	5.6
25-30	6.5	5.9

* = sample may be contaminated from surface applied lime, as previous testing at an adjacent trial suggest much lower pH (pH=4.2 10-15 cm)

As both trials had received surface applied lime recently, there was no Nil treatment. However, the Drysdale incorporation trial is located adjacent to a surface applied lime trial which was established in 2014 using treatments with or without 3.0 t/ha of surface applied lime. This offers a comparative Nil lime control. The starting pH at this nearby trial site was 4.2 at 0-10 cm.

RESULTS

The response to lime rate or incorporation method at the Inverleigh or Drysdale sites were not significant (figures 2 and 3). However the least responsive treatment was ripping without additional lime.

Significant yield differences were recorded at the adjacent surface applied Drysdale lime trial that was established in 2014 (and where the Nil treatment is no lime). Canola yield increased by 0.9 t/ha yield with the application of 3.0 t/ha of surface applied lime in 2014 (figure 4). Significant yield response also occurred with the poultry litter treatment (yield increase of 0.7 t/ha). Poultry litter is an alkaline product and applying it can raise the pH by about 0.2 pH units.

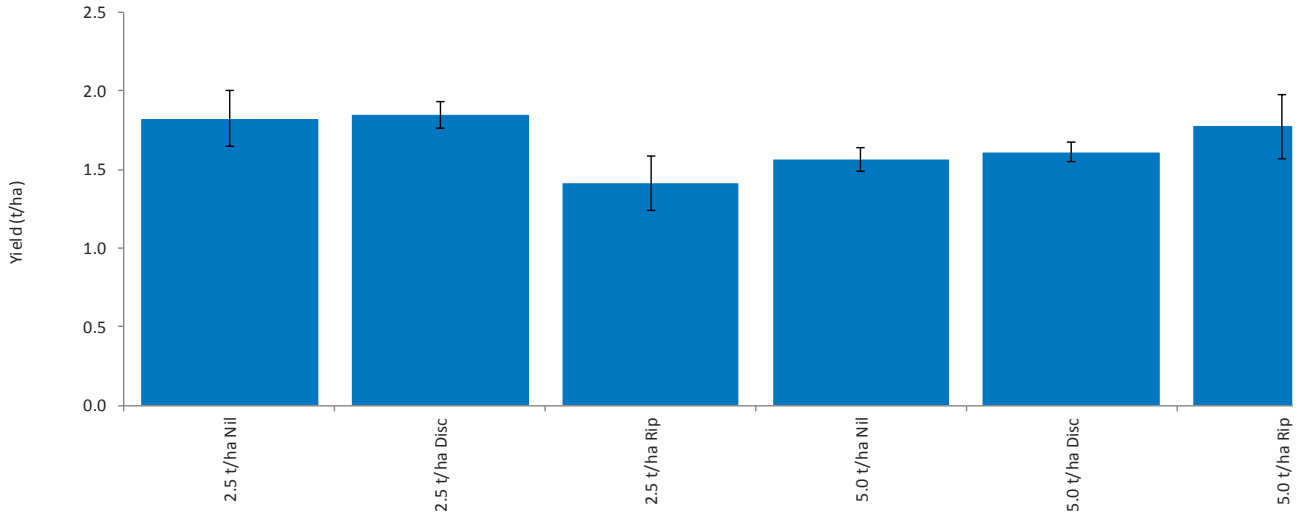

Figure 2. Mean canola yields in 2016 at the Inverleigh trial site.
Error bars represent the standard error of the mean. CoVar=15.8%

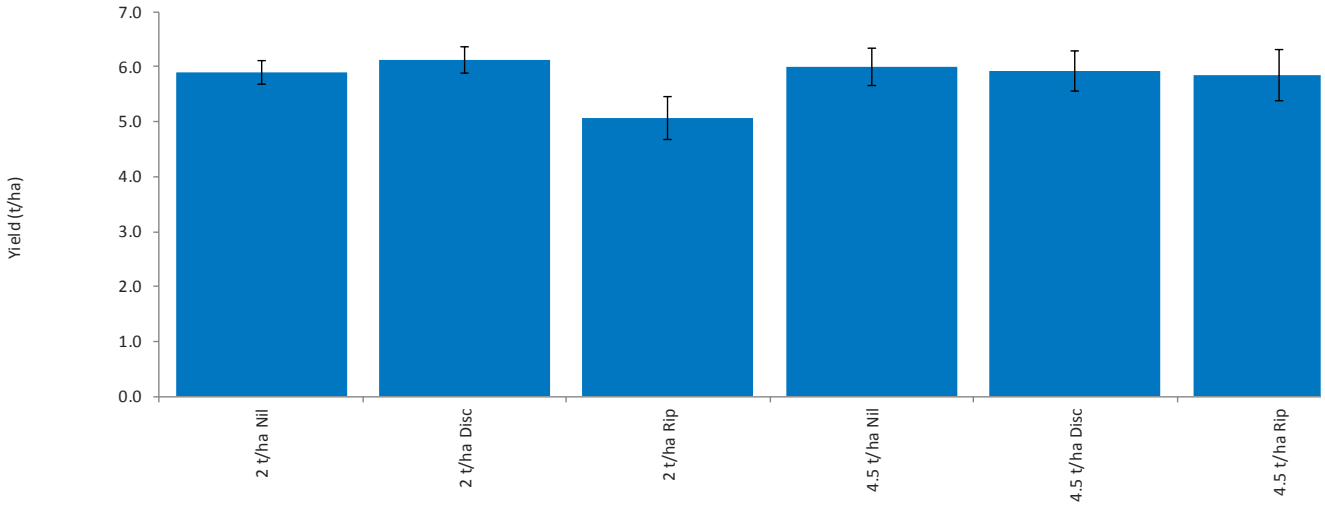

Figure 3. Mean wheat yields in 2016 at the Drysdale trial site
Error bars represent the standard error of the mean. CoVar=12.5%

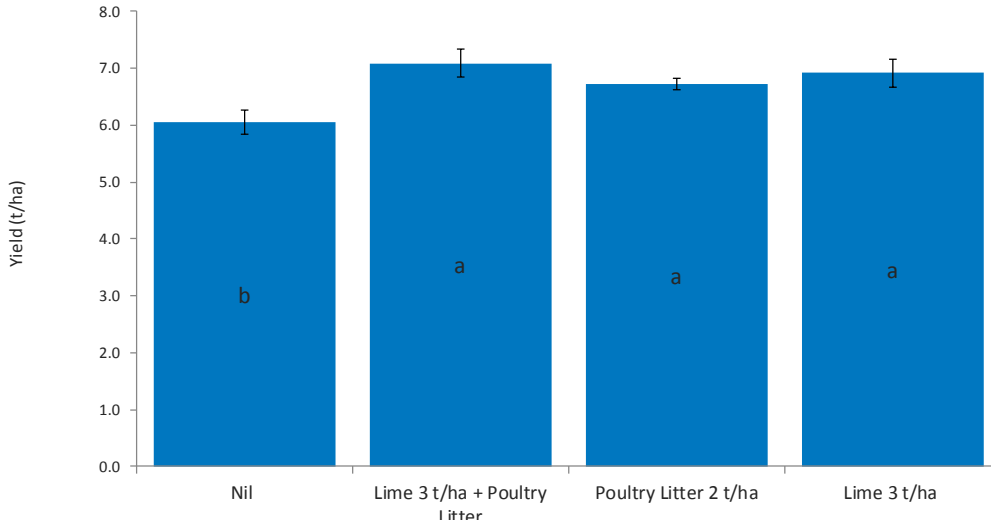

Figure 4. Mean wheat yields in 2016 at the Drysdale trial site from surface applied lime in 2014 and poultry litter in 2015 and 2016. LSD ($p<0.05$) =0.65 t/ha.
Error bars represent the standard error of the mean.

Comparison of yields from the 2014 established trial with the Nil treatment and the 2016 trial where lime had been applied at 2.5 t/ha in 2015 showed similar results. The Nil treatment wheat yielded 6.1 t/ha whilst the adjacent incorporation trial yielded 5.9 t/ha with surface application of 2 t/ha in 2015.

The tolerance of different crops to acidity (and aluminium) is evident at Drysdale. Statistical yield responses have occurred at this site with barley in 2014 and canola in 2015. Both species acid sensitive. However, there was no yield response to liming with the more acid tolerant wheat sown in 2016.

Soil testing from a range of other sites shows that surface applied lime does neutralise acidity down the soil profile, although this rate is often slow (table 2).

Table 2. Soil pH change at crop trial sites recorded in April 2016 of nil treatments and lime 2.5 t/ha surface applied in April 2014.

Depth	Modewarre		Rokewood north*		Westmere		Gatum		Yulecart		Rokewood west*	
	Nil	Lime	Nil	Lime	Nil	Lime	Nil	Lime	Nil	Lime	Nil	Lime
0- 5 cm	4.7	5.1	4.5	5.5	4.5	6.3	4.5	4.7	4.6	5	4.6	5.2
5-10 cm	4.4	4.5	4.4	4.8	4.2	4.4	4.2	4.4	4.4	4.4	4.7	4.8
10-15 cm	4.5	4.5	4.5	4.6	4.4	4.5	4.5	4.7	4.6	4.6	5.2	5.5
15-20 cm	4.7	4.7	4.7	4.6	4.9	4.8	4.8	5	5	5	6.5	6.4
0-10 cm	4.6	4.8			4.5	5.2	4.3	4.7	4.6	4.8		

*Lime following 3 years after application.

DISCUSSION

The jury is still out as to whether incorporation of lime can speed up lime response in our south west soils. There was no evidence in the first year that it improved yields above that of surface applied lime, although any response may have been masked by growing an acid tolerant species like wheat rather than a more sensitive crop like barley or canola. Likewise, there appeared to be no adverse effects on yield with soil disturbance treatments. The subsoil ripping machine did result in lower mean yields at both sites where no extra lime was applied but results were statistically non-significant. The subsoil manuring machine with ripping is likely to have placed lime in a layer and not provided good distribution throughout the soil. This treatment may have even redistributed the lower rate of lime away from the topsoil.

A surface applied lime response was observed from the nil treatment in the adjacent wheat trial at Drysdale after application of lime three years earlier. This tends to indicate that more time may be needed for acidity changing neutralising reactions to occur. It is generally thought that it takes about three years following lime application to see a yield response, although responses have occurred in the first year of lime application at the Drysdale site where barley, which is acid sensitive, was grown. Interestingly another incorporation trial established in 2016 at Chatsworth by DPI NSW also did not show yield responses with incorporation of lime where faba beans, which are acid sensitive, were sown.

Ideally you want good mixing if incorporating lime. You do not necessarily want pockets of lime even when it is fine because the pH can become too high for the neutralising reactions to occur and a proportion of the lime will sit there undissolved until the surrounding soil becomes more acid again.

We do know there are acid layers within our topsoil (table 2) even with paddocks with a lime history but we do not yet know how much they are impacting on yield. Roots are expected to find ways through by following less acidic pathways like old root channels to tap into moisture at depth. In the wet year of 2016, root access to deeper moisture was not an issue in South West Victoria. We also know that most of the soil microbiology is confined to the top 5 cm of soil and for nodulation of pulses we need good pH conditions down to about 15 cm to maximise potential nitrogen fixation. Currently pulse sowing depths of about 4 to 5 cm mean rhizobia-inoculated seeds are often placed into an acid soil layer which is likely to affect rhizobia survival and nodulation.

Due to the expense of lime incorporation it's not yet time to do away with surface application. Any incorporation of lime will generally need to be offset by addressing other soil constraints such as breaking up compaction layers, weed seed burial, reducing the soil fungal diseases or snail/slug populations and redistributing surface organic matter deeper in the profile. Lime also contains calcium which can help to remove excess sodium from the soil in sodic soils but is generally not used because its rate of movement through soil is slower than gypsum. Incorporation of lime will also come with costs of potentially losing soil carbon and structure, weed germination and the paddock may not be trafficable for some time. Incorporation of lime may be a one-off technique used to quickly address acid layers but then pH is maintained through surface application.

Further soil testing and monitoring of yields will continue at these sites. Testing of surface applied lime movement following the wet winter and spring in 2016 is also planned.

CONCLUSION

There is no clear evidence that incorporation of lime can speed up lime response after one year of testing.

ACKNOWLEDGEMENTS

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