4.1 YIELD RESPONSES TO DIFFERENT METHODS OF LIME APPLICATION IN 2020

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KEY MESSAGES

- Check for subsurface acidity at 10-20cm as it is commonly found in paddocks with poor liming history.
- Crop yield responses have occurred in the second year of trials compared to no lime but have not significantly increased yields compared to standard farmer surface application.
- Proactive liming to raise above pH 5.5 is encouraged to prevent subsurface acidity from forming and reducing yields.

Keywords: soil acidity, soil pH, lime, incorporation, tillage

BACKGROUND

This report will cover results from lime response trials:

- In their second year: Skipton, Mt Mercer, Bairnsdale, Rosedale, Stawell;
- Third year: Rokewood; and
- Sixth year: Westmere following lime application.

The results of these trials will be used in developing soil pH response curves, to help growers establish the economic return of maintaining good pH by liming. Trial results will also help inform when lime responses are most likely to occur, for example in the second year following liming or when subsurface acidity is addressed or under incorporation and under what treatments.

METHODOLOGY

Lime trials at Skipton, Mt Mercer, Bairnsdale and Rosedale were established in 2019 as part of the NLP project "Building Farmer Resilience." The methodology of Skipton and Mt Mercer is described in SFS trial results Victorian Edition 2019. Methodology was similar at the Gippsland sites (Bairnsdale and Rosedale), being randomised block designs with four replicates and plots 4 by 14m. However, local Buchan lime was used and included prilled lime applied at one third of the recommended Aglime rate as recommended by the supplier. Each of these sites include:

- Yield trial – testing the yield response of surface applied lime at different rates. Lime rates were calculated based on achieving different target pH levels to create response curves.
- Novel trial – testing methods of treating subsurface acidity (commonly 10cm to 20cm). Treatments included a standard farmer application of surface applied lime at 2.5t/ha, as well as a control (do nothing).

Two subsoil acidity trial sites have also been established in cropped paddocks near Rokewood and Stawell as part of a widespread GRDC project led by NSW DPI. These are randomised block design with three replicates, in 10 or 5m strips and 100 or 80m in length at Rokewood and Stawell respectively. Details of the Rokewood trial are described in the SFS trial results Victorian Edition 2018. These trials are primarily focused at evaluating the reduction of yield due to subsurface and subsoil acidity.

RESULTS

Skipton

There was no significant difference in canola yield between yield trial treatments, although yield was increasing with lime rate. In the adjacent novel trial, most lime treatments were significantly different from the control which may have been due to its lower pH (4.4). Although this difference is only 0.1 pH unit difference, because pH is measured logarithmically, even small changes can make large differences in the amount of hydrogen ions present. However, the novel lime treatments were not significantly different to the standard treatment. It was expected that incorporation of lime, would be ameliorating more of the soil acidity in the top 10cm and possibly even deeper and therefore resulted in higher yields but this effect was minimal, (0.1 t/ha). Applying lime to the surface and then deep ripping did not improve yields in comparison to standard farmer application treatment but this treatment was being impacted on by deep tractor marks (compaction and water pooling) that occurred in the winter following tillage.

Mt Mercer

Faba beans being acid sensitive responded well to lime. Soil acidity did not affect plant establishment numbers however plant stunting occurred and was observed in September. Recorded heights of plants within the control averaged 59 cm and was significantly different to the plants in the limed treatments of 70 to 75cm (p value 0.009) (results not shown). Yields were decreased by 1.3 to 1.6 t/ha compared to medium and high lime rates. However, again the incorporated lime had one of the highest yields but this was not a statistically significantly different in yield from incorporation of lime versus general surface application, despite a 0.3t/ha increase. The lime plus surface ripping reported the highest yield response and was significantly different from the rip control, indicating the increase in yield was not solely ripping related, but possibly enabling more lime to move deeper into the subsurface which had a pH of 4.5.

Bairnsdale

The Bairnsdale site developed an annual ryegrass problem which has affected results on both trials. Any potential gains by applying lime were removed by growing more annual ryegrass. All yields ranged from 0.9 to 1 t/ha, with no significance and high CV of 19 and 22%. Results are not presented. The soil pH results indicate this site to be strongly acidic down to 30 cm.

Table 1. *Soil acidity measured by pH(CaCl2) at three depths at different trial locations.*

Location	Trial name	Establishment year	0-10 cm	10-20 cm	20-30 cm
Mt Mercer	Yield	2019	4.4	4.6	5.1
	Novel		4.3	4.5	5.0
Skipton	Yield	2019	4.5	4.6	5.1
	Novel		4.4	4.5	5.1
Bairnsdale	Yield	2019	4.2	4.4	4.5
	Novel		4.3	4.4	4.5
Rosedale	Yield	2019	4.5	4.9	5.7
	Novel		4.5	5.0	5.7
Stawell	Subsoil	2019	4.4	4.5	5.3
Rokewood	Subsoil	2018	4.8	4.2	4.9
Westmere	Yield	2014	4.3	4.7	5.5

Table 2. *Skipton canola yield results in the novel and yield trial, 2020.*

Novel Trial		Yield Trial	
Treatment	**Yield (t/ha)**	**Treatment**	**Yield (t/ha)**
Control	1.89 b	**Control**	2.13
Standard farmer application 2.5 t/ha	2.36 a	**Lime 1 t/ha** *(target pH 4.7 0-10 cm)*	2.14
Lime surface 4.5 t/ha *(target pH 5.8 0-10 cm)*	2.28 ab	**Lime 2.6 t/ha** *(target pH 5.2 0-10 cm)*	2.22
Lime surface Inc. 3.8 t/ha *(target pH 5.2 0-20 cm)*	2.46 a	**Lime 4.5 t/ha** *(target pH 5.8 0-10 cm)*	2.30
Lime surface rip *(As above)*	2.04 ab		
Rip control	1.89 a		
LSD (p<0.05)	0.31		NS
CV	9.7		4.5

Means followed by the same letter do not significantly differ (LSD (p=0.05).

**LSD- Least Significant Difference*

† CV – Coefficient of Variation

Table 3. Mt Mercer faba bean yield results in the novel and yield trial, 2020.

Novel Trial		Yield Trial	
Treatment	**Yield (t/ha)**	**Treatment**	**Yield (t/ha)**
Control	3.23 c	**Control**	2.90 b
Standard farmer application 2.5 t/ha	4.50 ab	**Lime 1.6 t/ha** (target pH 4.7 0-10 cm)	3.75 a
Lime surface 6 t/ha (target pH 5.8 0-10 cm)	4.60 ab	**Lime 3.6 t/ha** (target pH 5.2 0-10 cm)	4.25 a
Lime surface Inc. 5 t/ha (target pH 5.2 0-20 cm)	4.83 ab	**Lime 6 t/ha** (target pH 5.8 0-10 cm)	4.50 a
Lime surface rip (As above)	5.40 a		
Rip control	3.83 bc		
LSD (p<0.05)	0.848		0.76
CV	12.8		12.3

Means followed by the same letter do not significantly differ (LSD (p=0.05).

Table 4. Rosedale canola yield results (t/ha) in the novel and yield trial, 2020.

Novel Trial		Yield Trial	
Treatment	**Yield (t/ha)**	**Treatment**	**Yield (t/ha)**
Control	2.71	**Control**	2.66
Standard farmer application 2.5 t/ha	2.92	**Lime 1.1 t/ha** (target pH 4.9 0-10 cm)	2.63
Prilled lime 0.8 t/ha (1/3 of 2.5 t/ha)	2.46	**Lime 2.5 t/ha** (target pH 5.3 0-10 cm)	2.62
Lime surface 4.2 t/ha (target pH 5.8 0-10 cm)	2.82	**Lime 4.2 t/ha** (target pH 5.8 0-10 cm)	2.47
Lime surface Inc. 4.9 t/ha (target pH 5.8 0-10cm, 5.2 10-20 cm)	3.30		
Lime surface 4.9 t/ha (target pH 5.8 0-10cm, 5.2 10-20 cm)	3.16		
LSD (p<0.05)	NS		NS
CV %	11.83		14.9

Table 5. Rokewood canola biomass and yield results, 2020.

Treatment	Biomass at Anthesis (kg/ha)	Yield (t/ha)
Lime surface Inc. 1.5 t/ha (target pH 5.5 0-10 cm)	6525	3.80 ab
Lime surface Inc. 1t/h + Deep Rip (target pH 5.0 0-10 cm)	6032	3.70 b
Lime surface Inc. 1t/h + Deep Rip Lime 1.5 t/ha (target pH 5.0 0-30 cm)	6188	3.97 ab
Lime surface Inc. 1 t/h + Deep Rip Lucerne Pellets 10 t/ha (target pH 5.0 0-10 cm)	7085	4.13 a
LSD (p<0.05)	NS	0.281
CV†	15.7	3.6

Rosedale

Results in both trials were non-significant. The Rosedale yield trial was more affected by waterlogging than the novel trial which may explain the higher CV% for the trial and lower yields. There was more variation between novel treatments. The incorporation of lime increased yield by 0.4 t/ha compared to the standard farmer application and prilled lime applied to the surface decreased yield by 0.5 t/ha and yielded lower than the control. Plots were hand harvested at Rosedale, in three randomly placed square metres.

Westmere

This lime trial was established in 2014, with additional lime being applied in 2020. There was a lack of lime response in this trial which was unexpected. Most treatments recorded wheat yields of 8 t/ha (CV 5.4%). There had been no observable differences between treatments throughout the year. It is possible that in a good year where plants were not stressed from moisture that soil acidity did not limit yield and urea addition compensated for any effects of increased soil mineralisation and release of nitrogen.

Rokewood

There was no significant difference recorded in biomass cuts at anthesis due to high variability. The deep placed lucerne pellets, show the crop still responding to nitrogen for the third year in a row. There is a slight yield difference (0.17 to 0.27 t/ha) from placing lime at depth (10-20 cm) where pH was 4.2. A 0.4 t/ha yield increase has been gained by adding lucerne pellets at depth. There were no gains in yield from the deep ripping treatment applied in 2018. Commonly deep ripping yield responses occur in the first year only following treatment.

Stawell

A visual difference in oat height and density were observed in late September with responses occurring to the increased nutrition from deep placed lucerne pellets (LP) at both 25 cm and 50 cm ripping spacing. This visual response was backed up by achieving higher biomass production in the deep placed lucerne pellets in ripping at 25 cm intervals. This higher biomass also supported greater yields with 5.1 t/ha recorded in the treatments with lucerne pellets at 25 cm. Both treatments also recorded the highest protein levels.

The no amendment control also yielded well (4.7 t/ha), which was unexpected and not easily explained. It had one of the lowest biomasses at anthesis and lowest protein levels. The lower biomass may have allowed it to support good grain fill with the nitrogen on offer. The limed treatments appear to have grown more biomass but possibly did not have enough nitrogen for grain fill.

It should be noted that the Surface Lime Inc. and Surface lime treatments had one replicate each that were visibly thinner than other plots, which appears to be a lighter soil type and so those treatments were excluded from analysis. Plant establishment differences were insignificant across plots, but a new seeder had been used and row spacing was variable across the site.

There is no clear evidence that placement of lime at depth has increased yields, only deep placed lucerne pellets.

DISCUSSION

Subsurface acidity is a common occurrence and affects all the trial sites except Rosedale. It is a reminder for growers to check pH at depth. Infrequent or low rates of lime will have contributed to increasing acidity in the subsurface and missed by soil testing only at 0-10 cm.

In the yield trials, the lime responses are to addressing acidity in the top 0-10 cm layer as we know that the alkalinity from lime is slow moving (1-3 cm/year) and therefore will not be impacting subsurface acidity.

The costs of acidity were evident at Skipton (0.6 t/ha of canola), Mt Mercer (1.3 t/ha of faba bean), Rosedale (0.6 t/ha of canola) but were not evident at Stawell (oats) or Westmere (wheat), where either crop tolerance of acidity has not limited production in the good rainfall year or the crop has run out of nitrogen for grain fill following increased crop biomass from liming.

The Rokewood trial indicated (although not statistically significant) the cost of acidity at 10-20 cm could possibly be 0.17 to 0.27 t/ha in lost canola yield in comparison to deep placed lime during ripping (Table 5). Scott *et al*, 1999 indicated the costs of subsurface acidity were worth addressing, with significant gains in wheat yields from amelioration. Condon et al, 2020 discusses indirect effects of subsurface acidity on plant productivity, reporting they are difficult to identify and quantify and could increase susceptibility of waterlogging, herbicide injury and soil borne diseases.

The novel trials indicated that incorporation of lime into the top 10-15 cm with high enough rates to bring soil pH to greater than 5.5 had highest yield responses but not significantly different from the standard farmer approach of surface applying lime at 2.5 t/ha. Two to three passes were used with tined implements to incorporate lime at Rokewood and Skipton sites, but Scott and Combes, 2006 reported the same mixing of soil can be achieved with one pass of offset discs.

Tillage creates more cost and has other downsides, but surface applied lime took four years to have the same effect on soil pH as lime incorporated by offset discs (Conyers et al, 2003). Change in soil pH of novel treatments occurred in 2020 and will be again tested in 2021 to demonstrate faster amelioration of pH from incorporation.

The trial treatments indicate that any rate of Aglime is showing favourable responses in the second year in the strongly acidic soils. However, the superfine prilled lime

Table 7. *Stawell oats biomass, yield and protein results, 2020.*

Treatment	Biomass (kg/ha)	Yield (t/ha)	Protein %
No amendment control	5918 b	4.7 ab	9.8 c
Surface Lime Inc. 2.6 t/ha *(target pH 5.5 0-10 cm)*	6906 b	4.0 a	11.3 abc
Surface Lime 2.6 t/ha *(target pH 5.5 0-10 cm)*	5964 b	4.4 ab	11.0 abc
Lime surface Inc. 1.8 t/ha + Deep Rip	6251 b	4.4 ab	10.8 abc
Surface Lime Inc. 1.8 t/ha + Deep Lime 1.9 t/ha, Rip 50 cm spacing *(Target pH 5.0 0-30 cm)*	6315 b	4.3 ab	10.5 bc
Surface Lime Inc. 1.8 t/ha + Deep Lime 1.9 t/ha, Rip 25 cm spacing *(Target pH 5.0 0-30 cm)*	6311 b	4.4 ab	10.6 bc
Surface Lime Inc.1.8 t/ha + Deep LP 10 t/ha, Rip 50 cm spacing	6471 b	4.8 ab	12.5 a
Surface Lime Inc. 1.8 t/ha + Deep LP 10 t/ha, Rip 25 cm spacing	8815 a	5.1 b	12.0 ab
LSD* (P<0.05)	1131	0.525	1.2
CV†	9.6	6.49	6.17

Means followed by the same letter do not significantly differ (LSD (p=0.05).

at Rosedale showed no increases in yield response. It is commonly marketed that less is needed because it works faster and therefore provides the same response. However, in broadacre application where pH is low (4.5), the more alkalinity applied through lime, the more reduction in acidity that will occur over time. Price *et al*, 2020 reports success of ameliorating subsurface acidity (4.3) within the sowing row through placement at 7.5 to 12 cm by a conventional seeder at a prill rate of 300 kg/ha at Wagga Wagga. Lime would still be needed to address acidity between sowing rows.

Davis *et al* (2019) reported that amelioration of deep soil acidity (>15 cm) using adequate rates of surface lime is slow and deep placement of ameliorant is expensive and has marginal effectiveness on yields over 3-5 years of most trials on soils of eastern Australia. Therefore, a proactive approach to soil acidity prevention is encouraged, which involves keeping soil pH above 5.5 to create enough alkalinity to address subsurface acidity.

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