Lime and liming – managing soil health

By Lisa Miller – Southern Farming Systems

Results at a glance…

- Liming to maintain good soil pH levels and avoiding yield losses is just as important as applying fertiliser.
- If growers let soil pH levels in the topsoil run-down (pH in CaCl2 < 5.0) they are at risk of creating soil acidity issues at depth which are harder and more expensive to treat.
- In general, not enough lime has been applied frequently enough to address acidification occurring within the whole soil profile, so soil test to depth and calculate lime requirements for 0–10 cm, 10–20 cm and 20–30 cm, not just the top 10 cm of soil.

Why do the trial?

SFS was fortunate to be involved in a soil acidity project in both crops and pastures which started in 2014 under a GRDC and federal government investment in South West Victoria.

We needed to improve our understanding of soil acidity management with particular regard to lime responses, soil acidity increases in the 10–20 cm layer, lime movement and lime quality.

From this research, better extension messages could be developed for local farmers and graziers.

What we found

Acidity affects plant and soil functions

Soil acidification is unavoidable in productive farming systems, and acidity eventually eats away profits, affecting chemical, biological and physical functions within soils and plants. This makes it difficult to diagnose acidity based on crop symptoms. But soil pH provides a good guide to which functions might be affected and the likely lime response as shown in Table 1.

Do not let soil pH run down

Our cars are serviced regularly so they run reliably and efficiently, and most people do not wait for their cars to break down and then have it fixed. The same applies to maintaining soils.

If topsoil pH is allowed to run down to less than 5.0 – which is common in grazing enterprises – significant production has probably been lost over the past five to eight years and possibly not noticed. More importantly, by letting the soil acidity form in the top 10 cm of soil, the acidity build-up results in leaching downwards of hydrogen ions and this allows soil acidity to increase at depths of 10 cm to 20 cm, where it becomes much more difficult and expensive to treat.

Lime is slowly soluble and often will not work straight away – it takes time to dissolve and move and so some ongoing yield losses will continue. If a subsoil acidity problem exists, lime with no

Table 1: Crop symptoms at different soil pH (measured in $CaCl_2$)

If the soil pH is:	
More than 5.5	There will be no problems from soil acidity affecting crop growth and yield, and there could be net movement of lime beyond 10 cm depth.
Less than 5.2	The effectiveness and numbers of rhizobia that fix nitrogen (N) on acid sensitive legumes (eg. lucerne and pulses, but not narrow-leafed lupin) are reduced. Liming increases the persistence and effectiveness of these rhizobia, and the amount of N fixed and grain produced of the sensitive legumes.
Less than 5.0	In addition to the effects above, there is a chance of molybdenum deficiency in legumes – check for local advice. Molybdenum is important in the synthesis of amino acids and proteins and a requirement for Rhizobium bacteria to fix atmospheric N.
Less than 4.8	In most soils, aluminium (Al) starts to precipitate from a harmless solid into a soluble form which is toxic to root growth. Aluminium tolerance among plant species varies. Reduced root growth means roots are unable to effectively explore soil for nutrients (particularly phosphorus and trace elements) and access stored subsoil water. Crop yield is reduced significantly. Reduction in root hairs occurs and so infection by rhizobia (nodulation of legumes) is severely affected.
Less than 4.5	The speed of N mineralisation processes (nitrification) slows significantly, resulting in decreased N supply. In most soils Al concentrations increase further and quickly become toxic to most pasture and crop species. There is a chance of molybdenum deficiency in cereals or canola, but check for local advice. The effectiveness of rhizobia in acid tolerant legumes, such as subclover, balansa and arrowleaf clover is reduced.
Less than 3.8	Soil can no longer buffer effectively against pH change and is overcome with acidity which breaks down clay minerals leaving only the sand component. Irreversible soil structural damage is done.

Source: Table adapted from Fenton, 2003.

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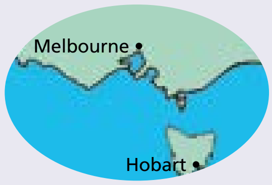
Region: Southern Farming Systems (SFS) was formed in 1995 by a group of farmers who came together to find ways of making farming in the higher rainfall zone (HRZ) more profitable. SFS has members in five branches; Geelong, Streatham, Hamilton, Gippsland and Tasmania. While SFS maintains strong partnerships with research and extension agencies and with agribusiness, the information provided to over 600 members, sponsors, supporters and students is highly valued for its quality and independence.



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Using good quality fine lime at the Rokewood site to ameliorate the acidity at 10 to 20 cm where the pH averaged 4.1.

incorporation will take five years or more to fix the acidity profile beyond 10 cm (depending upon soil type and rainfall), provided enough is applied to move downwards.

Maintaining good soil pH means yield responses to lime may not be immediately noticeable, but they will avoid ongoing acidification and yield declines. A soil pH increase will show that the lime is working and regular soil monitoring is recommended, particularly at 10–20 cm where there may be issues with subsurface acidity build-up.

Soil acidity eats away at yields

SFS replicated research trial data has been used to create lime response curves by calculating the percentage difference in yield of the control (un-limed plots) compared to limed plots for wheat and barley (see Figures 1 and 2). They show the yield reduction at different soil pH levels, especially in barley.

Most of the trial sites had acidity less than pH 4.5 in the topsoil plus acidity issues down to 15 cm or 20 cm. The moderate rates of lime applied and without any significant incorporation did not correct subsurface acidity at the sites and this probably reduced yield beyond what was measured.

NSW Agriculture broadcasting lime onto the soil surface at the Rokewood trial site.

Table 2: Rokewood subsoil acidity trial. Lupin response to liming treatments, 2018

Treatments	Treatment description	Lupin yield (t/ha)		Establishment counts (plants/m²)		Dry matter cuts at anthesis (kg DM/ha)	
Surface lime Incorporated	Surface liming 1.5t/ha incorporated into 0–10 cm with offset discs to bring pH to 5.5.	1.24	b	8.63	a	4084	b
Deep rip only	Surface liming 1 t/ha incorp. + deep rip. Ripped down to 30 cm, tines 50 cm apart.	1.36	b	6.73	b	4724	a
Deep lime	Surface liming 1 t/ha incorp. + deep rip + deep lime. Deep lime 1.5 t/ha placed between 8 to 25 cm (acid layer).	1.44	ab	9.07	a	4756	a
Lucerne pellet	Surface liming 1 t/ha incorp. and lucerne pellets 7.5 t/ha placed into acid band. (Rate based on providing the same amount of alkalinity). Contains 200 to 300 kg N/ha.	1.60	a	8.3	a	4983	a
LSD (P<0.05)		0.21		1.43		537	
CV (%)		7.46		8.72		5.8	

LSD – Least Significant Difference, CV – Coefficient of Variation

The responses are from surface applied South West soft rock lime [Neutralising Value (NV) 90 per cent, Effective Neutralising Value (ENV) 63 per cent] in 2014 with minimal tillage and incorporation.

These lime response curves will become even more robust with the collection of data points from 12 new trials SFS has set up in the high rainfall zone across Tasmania, south west Victoria, Gippsland and South Australia (supported by the National Landcare Program and GRDC).

We expect the responses to flatten out and become steady at pH levels above 5.0 for cereals and 5.5 for pulses.

With the collection of this additional data, lime response curves for canola and faba bean will also be generated.

Lime responses are difficult to predict

The lime responses can be variable as they are influenced by many factors such as:

Subsoil acidity

A trial at Rokewood is investigating subsoil acidity further including incorporating lime and organic amendment (lucerne pellets) to depth (see Table 2). The pH at this site was 5.1 at 0–10 cm, 4.1 at 10–20 cm and 4.7 at 20–30 cm. Relatively acid tolerant lupins were planted in the first year, but nonetheless it was apparent that the subsoil acidity resulted in a 672 kg per hectare reduction in biomass and a 200 kg per hectare yield loss (although yield difference was not significant).

Interestingly, the best response was with deep placement of lucerne pellets, producing an extra 399 kg per hectare biomass and 360 kg per hectare yield. Approximately a 20 per cent significant yield reduction in both wheat and barley was recorded at an acidity trial site near Cootamundra, NSW where the acidity constraint was at 10–30 cm depth.

Season

Acidity and aluminium toxicity reduce root growth which reduces the plant's ability to extract

Figure 1: Wheat yield responses to different soil pH levels, 2012–18

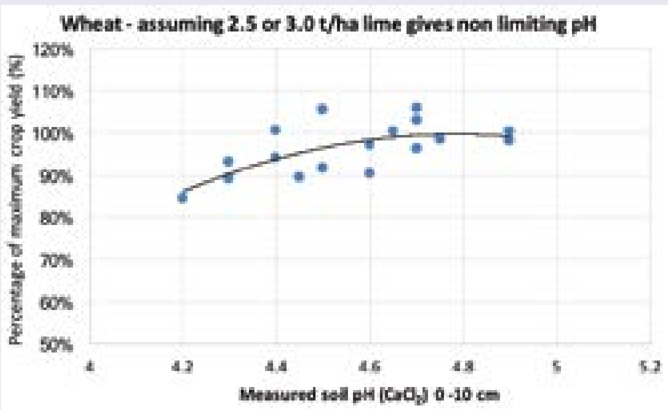

Figure 2: Barley yield responses to different soil pH levels, 2014–18