Better acid soil management critical for FutureSOILS

KEY POINTS

- Past liming practices have not stopped acid layers from forming in productive soils
- Check crops and pastures for poor growth
- Dig up any stressed plants and inspect the roots
- Poor vigour, stunted root growth and/or poor nodulation could indicate an acid soil constraint
- Use a soil pH test kit to check and compare soil pH profiles from areas of good and poor growth
- Collect soil samples in five-centimetre increments to a depth of at least 20cm if subsurface acidity is suspected
- Send the samples to an accredited laboratory for testing for pH, aluminium percentage and cation exchange capacity
- The test results will confirm the depth and severity of acidic layers
- Use the test results to develop a targeted acid soil management program
- Incorporate lime to the depth of acid layers, if possible
- Where acidity is deeper than the depth of lime incorporation or if incorporation is not possible, maintain a soil pH_{Ca} of more than 5.5 in soil overlying the acid subsurface layers
- If soil pH_{Ca} falls below 5.5 in the zero to 10cm layer, apply lime to move back to a pH_{Ca} of 5.8
- Lime will not move unless soil pH_{Ca} is above 5.5

Charles Sturt University (CSU) researcher Dr Jason Condon and NSW Department of Primary Industries (DPI) development officer Helen Burns are urging growers to act now to address acid soils.

The researchers are involved in a portfolio of work investigating effective acid soil management in collaboration with FarmLink, the Grasslands Society of NSW, Holbrook Landcare Network, Central West Farming Systems, K-Line Ag, Westlime and the Australian National University.

The research is collated in a National Landcare Program Smart Farming Partnership project, supported by the Australian Government, called FutureSOILS. It aims to update acid soil management practices based on evidence from field trials and historic data.

Dr Condon says the research is necessary because field surveys and paddock trials indicate that current liming practices are not alleviating acidity below the surface layer.

"Common practice is that paddocks are limed when soil pH_{Ca} drops below 4.8, with a pH_{Ca} target of about 5.2," he says.

"However, the five to 15-centimetre layer is commonly the most acidic of the soil profile. This is a real problem because people who are following the old acid soil management recipe are thinking they have addressed the problem, yet the production limiting acidity remains in the profile, often undetected."

Outdated advice

In the late 1980s when soil acidity was widely diagnosed in southern NSW, Dr Condon says interest rates were 17 to 18 per cent, while land cost on average about $300/hectare. Lime costs were about $60/tonne applied.

"At that time, the message was 'if you can increase pH_{Ca} in the surface zero to 10cm layer to more than 5.0 by adding lime, you eliminate aluminium toxicity and the roots are not affected'," he says. "Back then, the message was 'if you follow this recommendation, you won't have to lime for about 10 years and then about 2.5t/ha will move the pH_{Ca} back over 5.0'."

Dr Condon says there are several problems with this advice.

First, back then people incorporated lime before they sowed, resulting in mixing of lime through the soil, making it more effective within the topsoil.

Second, often lime was not applied until growers saw obvious symptoms of acid soil toxicity, so crops often suffered a yield penalty before lime was applied.

Third, when just enough lime is applied to increase soil pH_{Ca} above 5.0 and remove aluminium toxicity, the lime is consumed where it is placed.

Fourth, farming systems are much more productive than they were in the late 1980s.

"High grain yields, cutting crops for hay in droughts, farming systems with dual-purpose crops which remove product in stock and in grain, and which also demand more nitrogen fertiliser, all act to increase the acidification rate above those estimated in the 1980s," Dr Condon says.

"The old liming rates seem to be struggling to keep up with current acidification rates. Applying 2.5t/ha once every 10 years without incorporation means lime is consumed in the top 5cm of soil, and acidification continues unchecked in the deeper subsurface layers at five to 20cm."

Fifth, detailed soil surveys have shown that even in paddocks with a long lime history, under minimum-tillage systems where lime is surface-applied and only incorporated by sowing, a soil pH_{Ca} target of 5.0 has not increased pH below the zero to 7.5cm soil layer.

Dr Condon says some excellent fieldwork near Wagga Wagga in the late 1980s demonstrated that pH_{Ca} needed to be more than 5.5 for the lime effect to move below the depth of incorporation.

"However, that research was done on highly acidic soils (pH_{Ca} of just over 4.0). To achieve a pH_{Ca} of more than 5.5 required about 8t/ha of lime, which was not economical at that time," he says. "Accordingly, growers decided it was cheaper to buy more land than it was to lime any higher than pH_{Ca} 5.0."

Current research findings

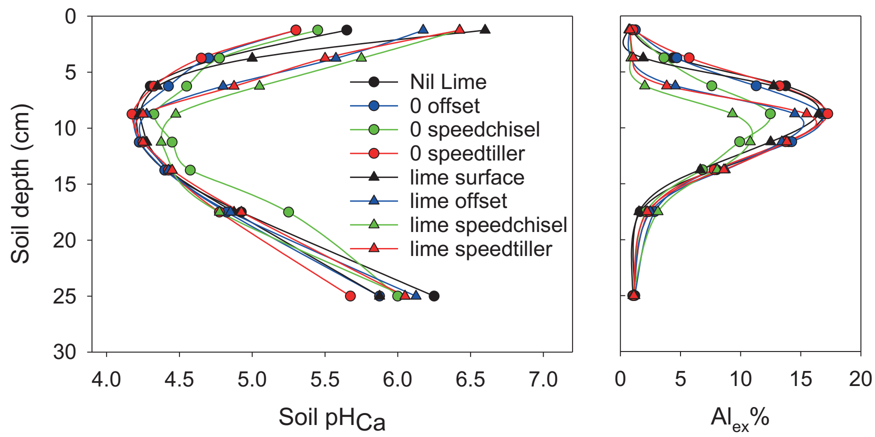

Figure 1: Soil pH_{Ca} at FarmLink's Grenfell, NSW, FutureSOILS trial site in 2021. Source: FarmLink and Charles Sturt University.

Dr Condon says several important findings have emerged from the FutureSOILS project.

"While pre-sowing incorporation is critical to mix lime through the soil profile, FutureSOILS research demonstrated that all machines tested did not mix lime to the depth of incorporation," he says.

By way of example, he points to the FarmLink-run FutureSOILS trial site near Grenfell, NSW, where, so far, there has been no yield response from applying 7t/ha of superfine, high-neutralising-value lime.

"The lack of agronomic response was explained when we sampled the soil and discovered the incorporated lime had not yet reached the acid soil band located 10 to 15cm beneath the surface.

"Our cultivation ripped through the acid layer but none of the machines sufficiently mixed the lime into the acid band (see Figure 1).

"The acid layer is still there, hence there is no agronomic difference yet, in terms of grain yield, between the treatments.

"A soil pH_{Ca} more than 5.5 should allow excess alkali to move down to remove the acidity in time and the incorporated treatment will have a good head start compared to the surface-applied lime that wasn't incorporated.

"There would still be unreacted lime in the profile 12 months after application, so we are waiting on the 2022 data to see what happened over the past year."

Dr Condon says Figure 2 shows that incorporation helps to increase pH_{Ca} to depth compared with the rate that was surface-applied.

"The highest lime rate, indicated by the green line, was most effective at changing pH_{Ca} one year after application. This treatment achieved a pH_{Ca} of 5.5 to a depth of 10cm and should continue to increase pH below this depth into the future," he says.

"By aiming to increase pH_{Ca} to more than 5.5 in the top 15cm, the intent is that excess alkali will move down to increase pH_{Ca} above 5.0 below 20cm in the next few years.

"Note also that the lower rate of 2.8t/ha has no effect below 5cm and has only increased pH_{Ca} above 5.5 in the zero to 2.5cm layer one year after application."

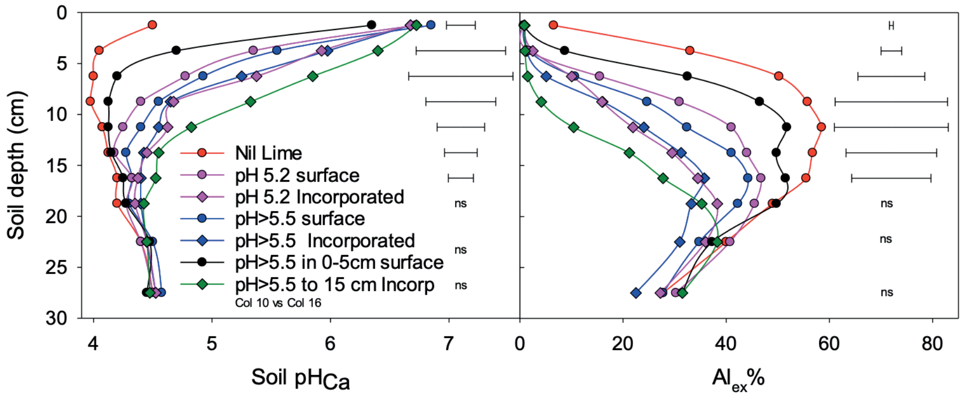

Figure 2: Soil pH_{Ca} and exchangeable aluminium percentage of the Lyndhurst, NSW field trial. Data are from the 2021 sampling. Trial established in 2020. Source: Helen Burns and Jason Condon.

Indicators of soil acidity

Dr Condon says variable or disappointing grain yields could indicate a possible acid throttle, which can be corrected with lime.

"Winter and early spring is an ideal time to pull up plants and look at root growth," he says.

"Using a Dig Stick and colourimetric pH_W test kit will indicate the depth and extent of acidity in the soil. Anywhere poor root growth coincides with yellow/green indicator colours is a signal that acidity is likely to be constraining crop growth.

"A Dig Stick allows you to easily check soil pH to a depth of 30cm during winter and early spring. You can compare areas of good and poor growth within a paddock.

"Using a garden fork at the same time to dig up plants and their roots allows you to see how plants are responding to the soil conditions."

In legumes and canola, Dr Condon says he often sees roots that are short and growing in a "j-shape". These roots are unlikely to extract moisture at depth in dry conditions.

He says a lack of nodules on legume roots is also a biological indicator that acidity could be a problem. "When acidity is suspected in the top 20cm of soil, and potentially acid-sensitive plants are to be grown in the next few years, it is worth sampling soil in 5cm intervals to a depth of 20cm and sending them to a lab for analysis of pH, cation exchange capacity and aluminium percentage.

"Sampling soil in 10cm intervals can hide the severity of an acid layer, especially where lime has been surface-applied.

"Taking samples in zero-to-10cm increments mixes all the soil in that layer, whereas, in reality, plants grow through soil layers with different pHs.

"Knowing the depth and severity of the acidic layers will inform the need for deeper incorporation and how much lime is needed to deal with the problem. For example, even a narrow acid band at 10 to 15cm will reduce the effectiveness of a legume plant and specific rhizobia in forming nodules and so limit nitrogen fixation potential.

"Trials have shown better plant growth during early winter when acidity has been removed. Early growth is important because it allows crops to outcompete in-crop weeds."

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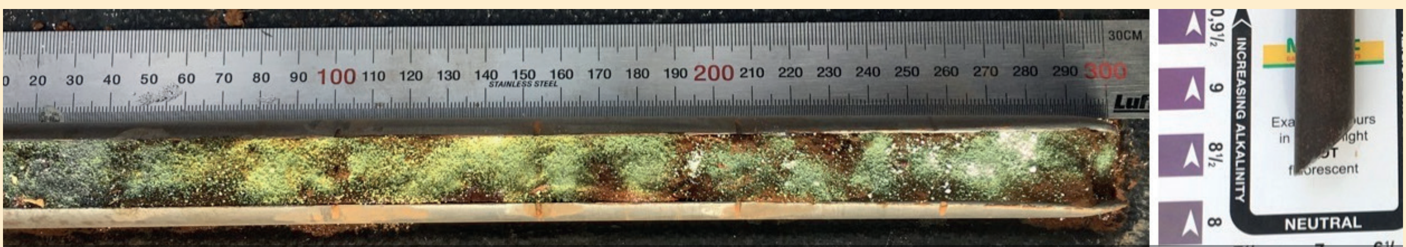

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Current recommendations

Dr Condon says soil testing every two to three years is the best way to determine if your management is effective or if acidity is still constraining yields.

Based on the latest research, he says, the new recommendation is to target a pH_{Ca} of 5.8 in the soil that sits over an acidic subsurface layer.

"Keeping pH_{Ca} over 5.5 in the top 10cm will ensure the alkali from the lime moves into the deeper acid soil layers," he says.

"The rate of movement will depend on soil type, rainfall and acidification rate, so predicting the rate of movement is difficult.

"Above a pH_{Ca} of 5.5, we can expect, over time, that the alkali will fix the acid layer beneath the depth of incorporation.

"History has shown us that if you have a pH_{Ca} of less than 5.5 in a layer, the alkali will not move.

"The message in the 1980s should have been 'fix the problem now!'

"With land now costing up to $20,000/ha, the relative price of lime is very low compared with the 1980s; people can't afford to buy more land but they can afford to fix the land they have."

Dr Condon says current FutureSOIL research will help to answer two questions:

- What is the most effective way to manage acid soils?
- What is the best method to achieve the target pH in certain soil layers?

He says the research will ultimately produce new tools to assist management.

Further reading

Burns, H. and Norton, M. (2018). *Legumes in acidic soils. Maximising production potential in southeastern Australia.* Grains Research and Development Corporation. Available at: https://grdc.com.au/legumes-in-acidic-soils

Condon, J. and Burns, H. (2021) Future proofing agricultural production through effective management of acidic soils. In: Southern NSW Research Results (NSW DPI) Available at: https://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/publications/southern-nsw-research-results

Condon, J., Burns, H., and Li, G. (2020). The extent, significance and amelioration of subsurface acidity in southern New South Wales, Australia. *Soil Research, 59* (1), 1-11. Available at: https://doi.org/10.1071/SR20079

Lime calculators

Dr Condon says the calculators currently used to determine how much lime to apply are out of date.

"They need updating, given our current farming systems," he says. "We are dealing with soils that have stratified pH_{Ca}, with variations in organic matter and aluminium with depth that can also change pH_{Ca}.

"Information currently used to determine lime rates is based on a table that has a maximum pH_{Ca} target of 5.5.

"Growers are asking for information above that target. The FutureSOILS project aims to create a system to provide that information to growers."

FutureSOILS research draws on 16 field experiments conducted using a range of funding sources and collaborators to better understand how much lime is needed for pH_{Ca} to reach 5.8 on different soil types and under varying climatic conditions. Researchers are also investigating the rate of lime movement and re-acidification.

"We are working to better understand the lime needed and the most effective way to manage its application to achieve a 5.8 pH_{Ca} in the top 10cm," Dr Condon says. "We will refine the models to predict pH_{Ca} change for different farming systems, climates and soil types."

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