

## MANAGING SUBSOIL ACIDITY (GRDC DAN00206)

# Key findings and recommendations

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<http://www.dpi.nsw.gov.au/agriculture/soils/acidity>

The most significant findings from this 5-year project were a) lime is the most effective ameliorant to increase soil pH and reduce aluminium toxicity; b) using organic amendments to ameliorate subsoil acidity is impractical in broadacre agriculture due to the large volumes required and high cost; and c) deep liming would take decades to recover the capital (lime) investment. Therefore, a proactive, preventative management of topsoil pH with lime addition remains the most cost-effective solution for growers.

## Introduction

A number of inorganic and organic amendments were evaluated over 5 years in 2015-2020 for their effectiveness in ameliorating subsoil acidity in controlled environment and field experiments across southern NSW and north-west Victoria. The aim of the project was to manage subsoil acidity through innovative amelioration methods that increase productivity, profitability and sustainability on farms.

## Experimentation

A scoping study was conducted to assess the role of genetics for improving the potential yield of Australia's major grain crops on acid soils.

An economic analysis was conducted to assess the economic impact and investment potential for innovative technologies that prevent or ameliorate subsoil acidification by considering their costs, yield benefits and residual values.

A series of experiments was conducted in controlled environment to test the efficacy of a range of inorganic and organic amendments in ameliorating soil acidity and to inform field activities.

Four research experiments and 8 large-scale on-farm field experiments were established and monitored over 2-4 growing seasons for changes in soil chemical properties and crop responses to soil amendments.

## Key findings

- Lime remains the most effective ameliorant to increase soil pH and reduce aluminium toxicity.
- Magnesium silicate is potentially more efficient in reducing Al toxicity than lime, but it may reduce grain yield and its cost is substantially higher compared with lime.
- Reactive phosphate rock can increase pH and release plant available phosphorus as it dissolves in acidic soil. However, the crop response to RPR in the field was variable.
- Nitrate-based nitrogen fertilisers can increase pH in the rhizosphere, which can be boosted by the addition of phosphorus. However, without root proliferation, it is unlikely to be effective in changing pH in bulk soil.
- Organic materials such as crop residues, animal wastes and garden composts, proved to have potential to increase pH either as an alkali source or by enabling alkaline reactions to occur during the decomposition of organic materials.
- The magnitude of any pH increase varies between plant residues and is dependent on their alkalinity content (organic anion content), and the rates applied.
- Deep placement of organic materials can increase soil pH in the short-term (up to 3 months), but subsequent nitrification could result in net acidification at deeper soil layers over a longer term.
- The large volumes of organic materials required to achieve a reduction in acidity, compared with lime, would be prohibitive in most instances.
- The exploration of genotypic variation of crop species could find more acid tolerant crop varieties to maintain productivity on acid soils, but the system will continue to acidify.
- Therefore, raising the target pH above 5.5 in CaCl<sub>2</sub> in the surface soil should be an urgent objective for the agricultural production systems.

## Recommendations

- The most cost-effective solution for growers to maintain productivity and sustainability is to manage topsoil pH with regular lime, proactively and preventatively.
- Amelioration of subsoil acidity is costly and would take many years to recover the capital (lime) investment.
- The opportunity cost of not liming is substantial. It would cost significantly more capital investment and take decades to recover soil fertility lost as pH declined.
- Novel materials, such as magnesium silicate, reactive phosphate rock and calcium nitrate have some potential to increase soil pH as alternatives to lime. However, their longevity and effectiveness need to be further evaluated in field experiments over a long term.
- Adding nutrients, such as nitrogen and/or phosphorus, without addressing acidity was not effective in raising pH and ensuring higher crop yields. Fertilisers are therefore not a substitute for lime.
- Growers should use caution when considering applying organic amendments at depth to address subsoil acidity. Addition of organic materials, particularly crop residues with low C/N ratios, such as lucerne hay pellets or poultry litters, would acidify soil in the longer term.
- Further research is warranted to examine the potential to use some organic amendments in conjunction with lime applied to the soil surface, to accelerate the movement of alkali material to deeper soil layers and reduce the time required for surface applied lime to raise pH in subsurface soil.
- More acid tolerant cultivars of most crop species exist, with opportunity to further develop particular species through screening and further breeding. However, use of acid tolerant crops are not a substitute for lime.
- Acid tolerant crops should be used in combination with a sound and ongoing liming program for sustainable grain production.
- The network of field sites established in this project needs to be maintained to closely monitor the rate of acidification at depth.

Without this resource farmers have no basis to inform their decision regarding the most appropriate and cost-effective strategy for their farm business.

- Extra care needs to be taken for representative soil samples when deep ripping is employed to overcome subsoil constraints, such as soil acidity, sodicity and compaction. Sampling on- and off-ripping lines biases soil test results.
- The multi-core soil sampler designed by NSW Department of Primary Industries is strongly recommended to be used for all future research dealing with deep tillage.
- Lack of commercial machinery is a real obstacle to prevent the adoption by growers of technology to address subsoil acidity.

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