Management strategies to overcome acidification of Mallee sandy soils

CASE STUDY 16

SNAPSHOT

Farmer name: Wade and Chad Nickolls
Location: Pinnaroo, SA
Farm size: 8000 ha
Enterprise: Cropping, hay and grazing
Average annual rainfall: 330 mm

KEY MESSAGES

- Alkaline subsoil can be mixed into acidic topsoil to improve overall soil pH.
- Test subsoil first to identify constraints, such as high salinity or boron toxicity. Adjust soil mixing depth to avoid bringing toxic soil to the surface.
- Incorporating lime or acidic subsoil into the acidic soil layer(s) is essential to rapidly treat soil acidity.

SANDY SOIL CONSTRAINTS

Area of land affected (ha): 2500 | Area of land affected (%): 20-30

Trialled

- Three lime rates (1.5, 3, 6 t/ha)
- Ripping and spading to incorporate lime
- Deep ripping

INTRODUCTION

Managed by brothers Wade and Chad since the late 1990s, the Nickoll's farm has been in the family for 80 years with their father Jeff, still a big part of the business.

Soils on the farm range from white water repellent sands to sandy loams over clay. The low productivity sandy soils cover 20-30% of the farm. Water repellence and acidity are the major issues, affecting about 2500 ha of the farm.

Acidity is a major concern and progressively getting worse, as no-till farming and disc seeding means lime is not incorporated. Acidity also means they need to 'patch' sow crops, such as sowing lupins and canola on the sand hills, and lentils on the flats. The family would like to ameliorate the soils to be able to have whole blocks sustain lentil production.

In a poor season, the sandy soils yield approximately 25% less than other soils. In a good year, the reduction is more noticeable increasing to approximately 50%.

The Nickoll's brothers have tried delving and clay spreading to treat water repellence, which has increased production by approximately 35%. Based on this success they bought a landplane to spread clay.

With alkaline soil close to the surface, they would prefer to treat acidity using this soil rather than lime if possible. "We're not keen on carting in thousands of tonnes of lime," said Wade. "We are already fixing water repellence with claying and delving. If that clay could also treat acidity, we could solve multiple issues in one go."

THE TRIAL

The trial was established on a duplex sandy soil near Pinnaroo, in the South Australian Mallee. The trial site topsoil is an acidic sand (pH of 4.8$CaCl_2$) from 0-10 cm, overlying an alkaline clay subsoil (pH 7.4–8.7$CaCl_2$). Acidification was therefore restricted to the top 10-15 cm of topsoil. The clay subsoil had high salinity levels (ECe>4 dS/m below 60 cm). Crop root growth is expected to be limited to this depth, especially for sensitive legume crops.

High subsoil salinity and sodicity are a known issue on the farm, with Wade saying, "We have to be careful with ripping as there are some areas with sodic clay, and bringing it up makes the paddock worse."

Despite the degree of water repellence across the farm, water repellence was not a constraint at this site.

The aim of this trial was to demonstrate management options to raise the pH of the topsoil to overcome acidification in Mallee sandy soils. Treatments were a combination of lime rates and soil disturbance, as outlined in Table 1. Lime treatments were spread prior to spading to ensure mixing through the topsoil.

Each treatment was implemented using large commercial scale strips which were 18 m wide and 200 m long. All treatments were implemented the season before the trial commenced to allow time for lime treatments to affect the soil pH. In 2023, the paddock was sown to a mixed species brown manure legume crop comprising of faba beans and vetch.

RESULTS

Soil acidity

All treatments increased soil pH relative to the untreated control (Figure 1). Surface applied lime did not improve soil pH below 5 cm depth.

Mixing the soil improved soil pH in the top 15 cm, by both incorporating the lime deeper into the soil and combining alkaline clay from the subsoil with the sandy topsoil. For example, spading without lime raised the pH of the top 15 cm of soil to around 6.5, while spading with lime gave a similar result (Figure 1). This was evident in the paddock. Wade observed, "The spading seemed to stand out, whether it was limed or not."

Dry matter production

Each treatment significantly increased the quantity of dry matter produced by the legume brown manure crop, relative to the untreated control (Figure 2). With no soil amelioration or lime applied, the faba bean/vetch mixed species crop produced just 1 t/ha of dry matter.

Table 1. Treatment combinations demonstrated at the site indicated by a ☑

Soil Amelioration Treatment	Lime Rate			
	Nil	1.5 t/ha	3 t/ha	6 t/ha
Nil	☑	☑	☑	☑
Deep Ripping (40 cm)	☑			
Spading (25 cm)	☑	☑	☑	☑
Deep Ripping + Spading	☑		☑	

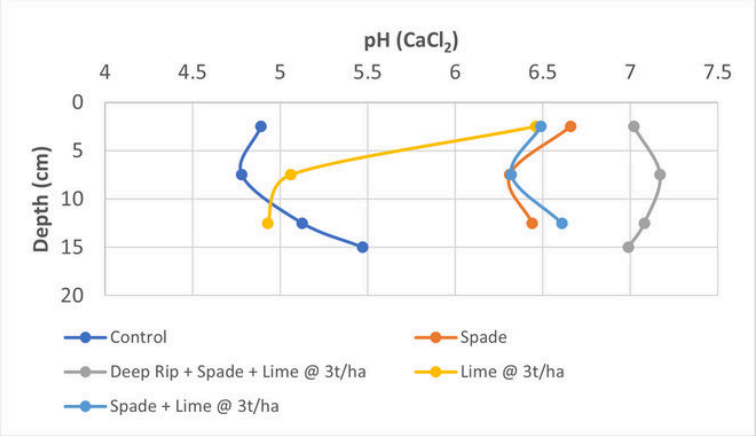

Figure 1. Effect of selected treatments on the pH ($CaCl^2$) of the sandy topsoil.

Visual assessments throughout the season indicated that plants in the control treatment were stunted and yellow with poor nodulation (Figure 3). Where lime was applied but not incorporated, an additional 0.5–1 t/ha of legume dry matter was produced above the control.

Ameliorating the soil with deep ripping, or spading, or both (no lime) increased biomass to approximately 2.5 t/ha.

The highest production came from treatments that included both soil amelioration and lime, with up to 3 t/ha of legume dry matter.

One of the challenges observed was the volume and quality of the subsoil clay brought up. "Some areas brought up just enough clay to do well, others too much to be a problem. Our biggest dilemma is working out where to and where not spade. Our subsoils are saline, sodic rubbish. You want to leave it buried if you can," said Wade.

RESULTS CONT...

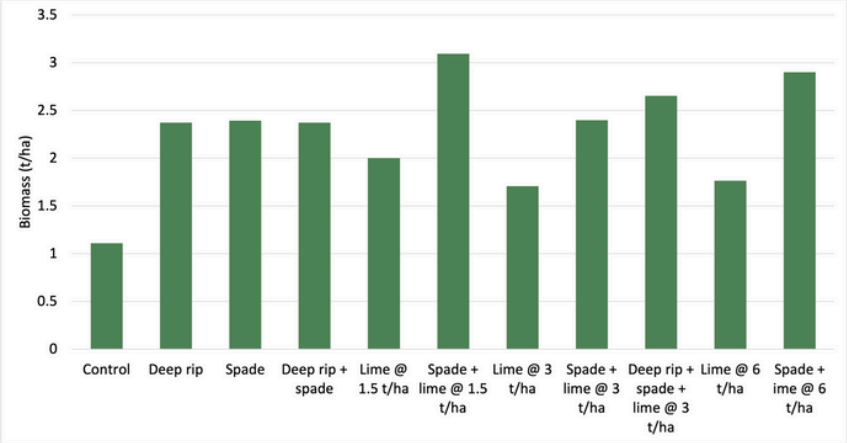

Figure 2. Legume dry matter produced for each treatment by the faba bean/vetch mixed species crop.

Figure 3. Faba bean plant from the Spade + Lime @ 6 t/ha treatment (Left) compared to a plant from the untreated control (Right).

NEXT STEPS

The trial has given the brothers confidence to do more delving and clay spreading. “I have bought a land planer to spread clay, but need to be careful with clay quality, particularly when delving,” Wade said.

Where possible they will address acidity and water repellence with clay spreading, spading and delving. “We’re hoping to overcome acidity with good clay in the soil profile, then it will change the acidity and fix water repellence in one go,” said Wade.

The challenge will be the time and labour require to delve and clay spread. The plan is to cover about 50 ha each year for the next 10-15 years. On areas where topsoil pH is very low, below around 4.5$CaCl_2$, they plan to lime and spade. Wade said, “The trial showed that liming is going to be beneficial. Where topsoil pH is OK we can use delving but in the bad areas, we are going to have to use lime.”

This project is being led by AIR EP and has been funded through the Australian Government’s Future Drought Fund and the Grains Research & Development Corporation (GRDC), and is supported by the South Australian Drought Resilience Adoption and Innovation Hub. Project delivery partners are Mallee Sustainable Farming (MSF), Northern Sustainable Soils (NSS), MacKillop Farm Management Group (MFMG) and the University of South Australia Agricultural Machinery Research & Design Centre (UniSA), with technical support provided by Primary Industries and Regions South Australia (PIRSA), CSIRO, Soil Function Consulting, Frontier Farming Systems and Trengove Consulting. Case studies compiled by Alluvio Pty Ltd.

RESOURCES

Soil Hub: https://soilhub.com.au/front-page/pinnaroo/
AgriKnow: https://www.agriknow.com.au/trial/43

PROJECT INFORMATION

Trial run by Michael Moodie, Frontier Farming Systems.

Thanks to Wade and Chad Nickolls who were the collaborating farmers for this trial site.
Thanks to Brian Hughes from SARDI for sampling undertaking soil sampling and analysis of treatments.

Building drought resilience by scaling out farming practices that will enhance the productive capacity of sandy soil landscapes.
Activity ID: 4-H6P3CX5

Produced April 2024