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Paddock Mapping Cost Effective Treatment of Soil Acidity on Lower Eyre Peninsula



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More than 150,000 hectares of soils on Lower Eyre Peninsula are susceptible to acidification that can negatively impact agricultural production. These are predominately ironstone soils south of Cummins and coarse shallow sands on clay near Ungarra/Cockaleechee. Soil acidification is a natural process but is accelerated with agricultural practices such as crop/hay removal and use of high nitrogen fertilisers.

This is one of two case studies, compiled under LEADA's National Landcare Program (NLP) funded project which documents the experience of two Lower Eyre Peninsula farmers in using 'real time' pH mapping to plan for cost effective management soil acidity on their properties.



Case Study 2
Luke and Belinda- Jane Moroney and Family

Location
Lawrence Road,
Kapinnie

Farm Enterprise
Continuous cropping

Average Annual Rainfall:
425 mm (350 GSR)

1 Property and Site Details

Luke and Belinda-Jane Moroneu and their family farm along with Luke's parents Greg and Deb, continuously crop 2, 700 ha of land that they own and lease on the Lawrence Road and Brimpton Lake Road north of Kapinnie.

1.1 Property Description and Rotations

Whilst much of the properties is dune-swale consisting of duplex sand over clay rises and alkaline red flats, areas of loamy ironstone soil which are prone to acidification also occur in many paddocks.

The Moroney's maintain a four year rotation consisting of a legume, cereal, oilseed, followed by a cereal. Lupins have been the traditional legume rotation. However, having successfully grown small areas of lentils in recent years Luke would like to grow more as a more profitable legume option and is keen to see which paddocks might be suitable to grow them in.



Figure 1. Luke Moroney's case study paddock #1.

1.2 Case Study Site Description

The case study site (Paddock #1) is a 57 ha paddock located due north of the house on Moroney's home farm. The paddock is gently undulating with a number of limestone ridges present.

Soil profiles vary considerably with a duplex sandy soil and shallow limestone ridge at the southern end of the paddock, and mixed soil types including alkaline red flats, alkaline sandy loams and acidic ironstone loamy soils scattered throughout the central and northern portions of the paddock.

Luke has only recently begun to investigate the impact of soil acidity on his property. Kapinnie is a district that has not traditionally been thought of as at risk of acidification. For the last 10 to 15 years the Moroney's have concentrated on improving the production of their non-wetting, low fertility duplex sands through soil modification practices such as delving and spading.

2 Identifying the Issue

Lupins have traditionally been used as a legume break crop on the property and have been well suited to the sandy soils. However, low prices and poor market access in recent years has resulted in poorer gross margins for lupin grain which has motivated Luke to look for alternatives. In consultation with his agronomist, Luke has been looking at the opportunities for growing lentils. However, recent soil test results from the property have shown that some areas of the property have low soil pH and might be unsuitable for growing lentils unless the pH is improved.

Luke observes that many crops germinate well but struggle when the roots hit the bleached A2 layer, which is often also acidic. He says that once the crop roots are able to grow beyond that layer into the B horizon clay they start to grow better. He had observed that the areas with low soil pH seem to correlate to the ironstone loamy soils, and are often associated with areas of poorer

crop production and increased weed competition, particularly from ryegrass. Luke has not yet applied lime on any areas of the property and would like to know the best course of action for addressing production constraints in the A2 layer.

3 Paddock Scale pH Mapping

3.1 Manually mapping the paddock

In 2016 Luke participated in the Natural Resources Eyre Peninsula 'Farming Acid Soils Champions' program which was delivered through LEADA and the Cockaleeche Landcare groups. The aim of this program was to provide landholders with the knowledge and skills to identify soil acidity on their property, develop an action plan for managing it and support them to champion cost effective management of low pH soils to their peers. This was achieved through a series of workshops and paddock exercises.

Participants were supplied with a field pH kit and aerial photograph of one paddock on their property and encouraged to determine the variability in the pH of surface soils across the paddock. This was done by marking different soil types/production zones on the aerial photo and then taking a series of soil samples and analysing soil pH using the field kit, marking the field pH for the location on the map (Figure 2).



Figure 2. Luke's manual pH map. Produced using field pH kit and aerial photo, March 2016.

3.2 VERIS “On-the-go” pH mapping

Under the ‘Farming Acid Soils Champions’ program Luke was given an opportunity to have a paddock mapped by an ‘on-the-go’ pH mapping machine. The site was mapped using a Veris ‘pH Manager’. Sampling was conducted at 36 m spacings, equating to around 10 sample locations per hectare. Validation of machine readings against laboratory results from a range of soil

The map produced by the pH mapping machine correlated well with the map produced manually by Luke, even though the map produced by Luke had a much lower sampling density (closer to 1 point every 2 ha rather than 10 points per ha).

Results from both Luke’s mapping and the Veris ‘on-the-go’ mapper clearly identified the alkaline limestone ridge in the southern third of the paddock as well as smaller ridges in the centre and the north-western corner. However, surprisingly the mapping showed that much more of the paddock was acidic than Luke had thought. It is recommended that soil pH is maintained above 5.5 (CaCl_2) at the surface to minimise the risk of acidification of subsurface layers. The results of the pH mapping showed that almost 80% of the paddock currently has surface soils with a pH below this target (Figure 4 and Table 1).

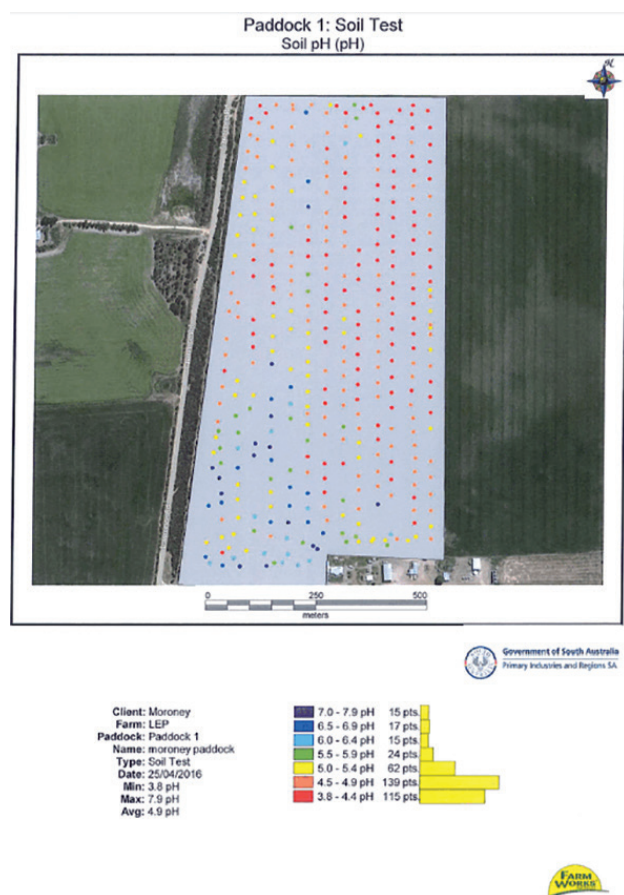


Figure 3. pH point data map (pH CaCl_2 adjusted)

types suggest that, in acidic soils the results from the Veris machine are in the order of 0.3 to 0.4 of a pH unit higher than pH (CaCl_2). Therefore 0.3 was subtracted from the Veris pH readings to bring them in line with pH (CaCl_2). Figure 3 shows the point data map. This map was interpolated using the ‘FarmWorks’ software program to create a pH map showing different zones (Figure 4).

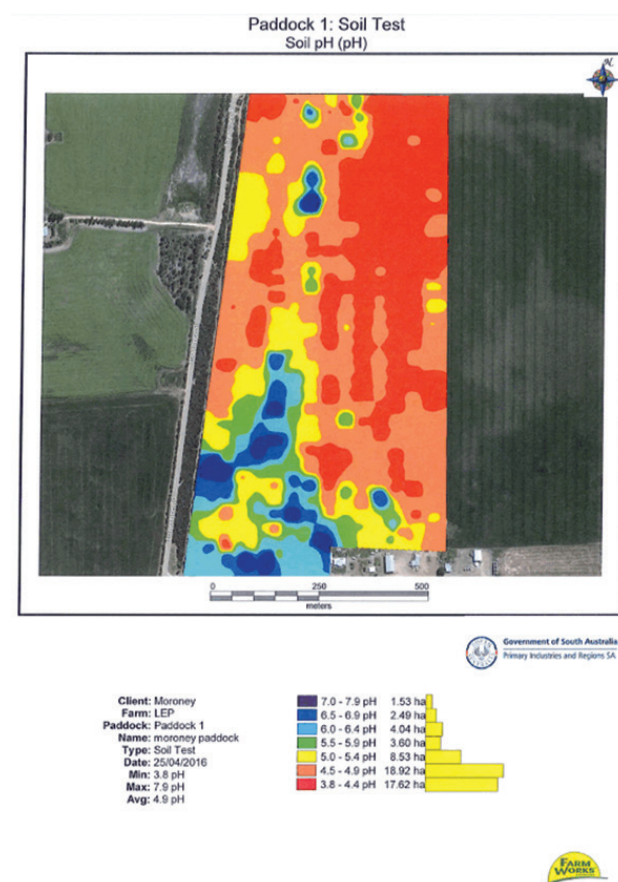


Figure 4. pH zone map (pH CaCl_2 adjusted)

| pH Range | Area (ha) | Area (%) |
|--------------|-----------|------------|
| <4.4 | 17.62 | 31 |
| 4.5 – 4.9 | 18.92 | 33 |
| 5.0 – 5.4 | 8.53 | 15 |
| 5.5 – 5.9 | 3.60 | 6 |
| 6.0 – 6.4 | 4.04 | 7 |
| 6.5 – 6.9 | 2.49 | 4 |
| >7.0 | 1.53 | 3 |
| Total | 57 | 100 |

Table 1. Area (Hectares) for different pH ranges on the site.

4 Lime Prescription Maps and Liming Recommendations

Surface applications of lime are the most cost effective way to increase the pH of surface soils. The pH zone maps were used to generate a lime prescription map (Figure 5).

The amount of lime required to increase pH varies according to the initial pH of the soil and the soil's buffering capacity; a function of soil texture and organic matter content. As soil texture varies considerably within paddocks, the lime prescription maps have been created using sandy loam as the default soil texture; requiring 2.5 to 3.5 t/ha to increase pH by one unit.

A total of 116 tonnes of limesand is required over an area of 51 hectares to address the areas with surface pH below the target of 5.5 CaCl₂. (Table 2). Most of the area requiring lime (61%) is very acidic and will require applications rates above 2 t/ha, with a further 22% of the area with acidic soil requiring lime applications of between 1.0 and 2.0 t/ha.

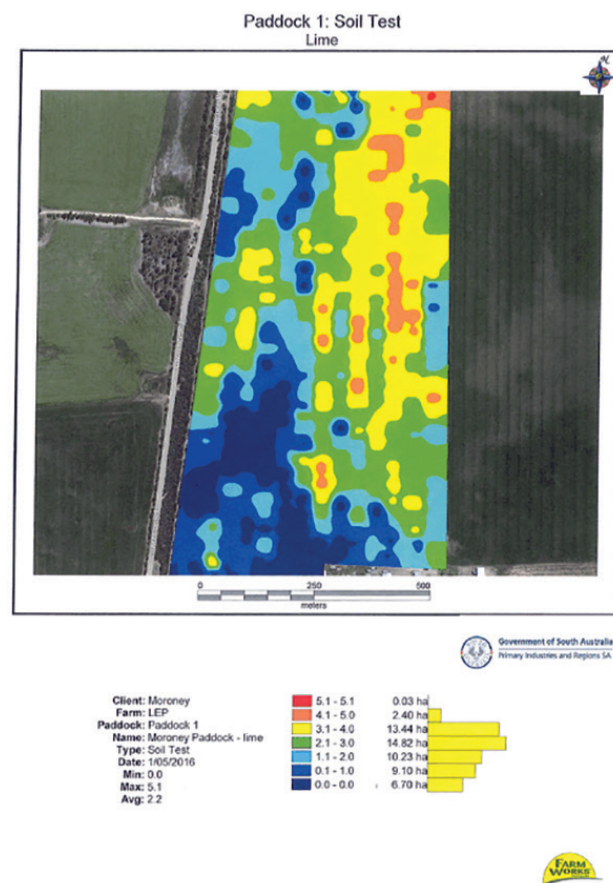


Figure 5. Lime rate prescription map

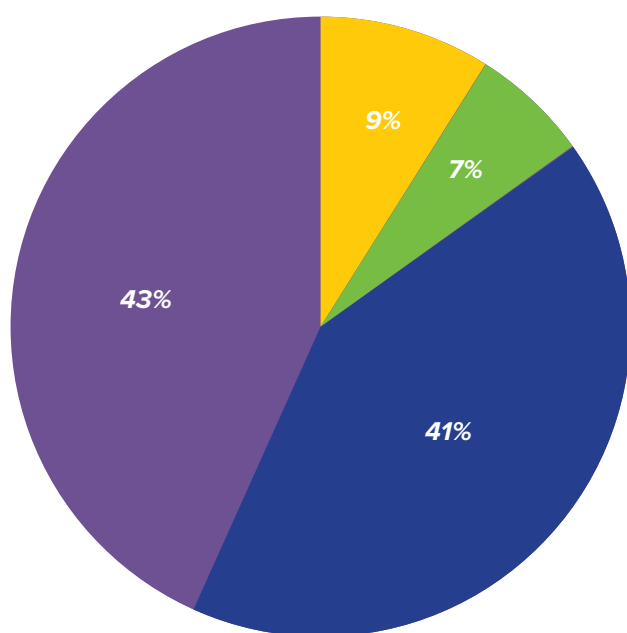
| Lime rate (t/ha) | Area (ha) | Tonnes Lime |
|---|-----------|-------------|
| 0 | 6.7 | 0 |
| 0 - 1 | 9.1 | 4.52 |
| 1 - 2 | 10.73 | 16.10 |
| 2 - 3 | 14.82 | 37.05 |
| 3 - 4 | 13.44 | 47.04 |
| 4 - 5 | 2.4 | 10.8 |
| > 5 | 0.03 | 0.15 |
| Total Area Requiring lime (hectares) | | 51 |
| Total Lime requirement (Tonnes) | | 116 |

Table 2. Lime requirement for paddock

5 Modelling Acidification Rate

Data on rainfall, production and fertiliser application rates on the paddock over the 7 years from 2009 to 2016 was entered into PIRSA's 'Lime maintenance rate' calculator. Using this data, it is estimated that the lime required to be applied to address acidification on this site under current farming practices is in the order of 308 kg/ha/year. This is much higher than the historical rules of thumb of around 150 kg/ha/year for cropping paddocks

Despite a legume crop being grown one year in four, this is still a very high nitrogen input, system with 84% of the total acidification at this site resulting from nitrogen fertiliser applications (Figure 6).



- Product removal (kg/ha)
- Legume fixed Nitrogen (kg/ha)
- Fertiliser 1 lime equivalent (kg/ha)
- Fertiliser 2 - lime equivalent (kg/ha)

Figure 6. Influence of Management Practice on Total Lime Requirement (2009-2016)

6 Cost Effectiveness of pH Mapping.

Luke has not yet applied any lime on the property. Typical surface application rates for the districts are in the order of 2.5 t/ha and have historically been applied as a uniform rate across the entire paddock. However, by pH mapping (either by manual sampling or using such technologies such as Veris 'On-the-Go' machine) and identifying zones of differing pH, there is an opportunity to either save money on the overall cost of the liming operation, or increase the cost effectiveness of the operation by applying lime at the right rates in the right areas.

If Luke were to apply a uniform rate of 2.5 t/ha across the whole 57 ha paddock 143 tonnes of lime would be required with a total supply and spreading cost of \$4578 (Table 3). However, using rates targeted to the 51 ha identified by the pH mapping, the total lime requirement is only 116 tonnes. Taking into account the cost of mapping this results in a total lime application cost for the mapped paddock of \$4389, which is a saving of \$189 for the paddock or a 4% saving compared to applying a 2.5 t/ha uniform rate over the whole paddock.

| | Uniform rate (2.5 t/ha) | Mapped paddock |
|--|----------------------------|-------------------|
| Area requiring lime (ha) | 57 | 51 |
| t/lime required | 143 | 116 |
| Cost lime (\$12/t) | 1717 | 1388 |
| Cost freight and spreading (\$20/t) | 2861 | 2314 |
| Cost of Mapping (\$12/ha) | 0 | 687 |
| Total cost | 4578 | 4389 |
| Saving (\$) | | \$189 |
| % saving on cost of lime operation compared to Uniform rate 2.5 t/ha | | 4% |

Table 3. Cost effectiveness of pH mapping

7 Discussion and Conclusions

The pH mapping of this site provides good data on current acidity levels on soils in a district that has not traditionally been considered at high risk of acidification. Luke was surprised that the proportion of acidic soil on his case study paddock was so high. Changes in farming practices over the last 15 to 20 years have resulted in rotations and fertiliser use that have increased the rate of acidification.

Because a high proportion of the paddock is acidic and requires high rates of lime to bring the pH up to the target, the potential cost savings from variable lime applications based on the pH map, when compared to a uniform application rate of 2.5 t/ha is relatively low (only 4% saving on the total cost of the liming operation).

Luke feels that although the cost saving on liming this paddock using the variable rates identified by pH mapping are not much different to applying a uniform rate of lime over the whole paddock, the effectiveness of the lime application rates is likely to be increased. He has increased confidence that by identifying pH variability across the paddock

and matching the lime rates to these zones he can now put the right amount of lime into the areas where it will have the greatest benefit, rather than over liming some areas and under liming others.

A suggested strategy for applying the lime at the variable rates detailed in the lime prescription map might be to apply 1.5 t/ha across all but the southern alkaline section, with a second pass at 1.5 t/ha on the green and yellow areas in the lime prescription map; thus achieving an application rate of 3.0 t/ha on those areas.

Because some areas of the paddock are so acidic they need relatively high rates of lime to bring the pH of the surface soil up to the target value of 5.5 CaCl₂. Where calculated lime application rates are above 3.0 t/ha on sandy soils it is recommended that the rate be split into two applications several years apart in order to avoid inducing nutrient deficiencies, providing favourable conditions for root disease or impacting the efficacy of herbicide applications.

8 Where to From Here?

Luke is looking to apply lime to address soil acidity on this paddock prior to cropping in 2018. He is also interested in mapping more of his paddocks to identify those areas of the paddocks which are currently acidic and those which might require liming in the future. He is also very keen to do some more sampling of subsurface and subsoil layers to find out where acidity at depth is limiting production, and then to further investigate methods for overcoming these constraints.

Acknowledgements

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Further Information

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