Lower Eyre Agricultural Development Association

LEADA

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

Australian Government
National Landcare Program

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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/ Cockaleechie. 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 1.
Dan and Lora Adams

Location
Chimina Hill Road, Cockaleechie

Farm Enterprise
Continuous cropping enterprise

Average Annual Rainfall:
415 mm (325 GSR)

1 Property and Site Details

Daniel and Lora Adams and their family, as well Dan's parents Bill and Anthea continuously crop around 900 ha on their Cockaleechie properties 'Beaumont' and 'Windilee'. The Adams' have a high intensity, three year rotation with canola or lentils followed by two cereals.

1.1 Property Description

Soils across the properties are highly variable and include alkaline red brown earths, acidic ironstone loamy soils and coarse acidic sands. Soil type and pH play an important role when deciding which break crop to grow, with the Adams' preferring to grow lentils due to their high value and contribution to soil nitrogen levels for following crops. Dan recognises soil acidity (low soil pH) as a major constraint to growing lentils in many areas of the property and is looking to address this issue in a cost effective manner wherever it is economical to do so.

Figure 1. Dan Adam's case study paddock (North-West)

1.2 Case Study Site Description

The case study site (Paddock North-West) is a 27ha paddock located on the western portion of Dan and Lora's property 'Windilee'. The paddock gently slopes toward the creek near the Cockaleechie Road on the southern boundary. Soil profiles vary across the paddock but consist of ironstone sandy loams and coarse quartzite sands, both of which have a low capacity to buffer pH change. Soil texture becomes heavier closer to the creek on the south-eastern side of the paddock

2 Identifying the Issue.

In the early 2000's Dan's father, Bill, recognised from paddock soil tests that soil acidity was an issue restricting production on some areas of the farm. He applied some lime to the areas of the paddock that he felt needed it. However, these lime applications were generally at low rates of around 1 t/ha, and were based on a single paddock soil test and Bill's observations of the way different areas in the paddock yielded, rather than utilising a zone approach to sampling for soil pH.

As Dan began to have more responsibility for management decisions regarding on farm operations, around 2009, he began a program of soil sampling based on production zones as reflected in the yield maps from his harvester.

From these maps he designated areas of low, medium and high production and took soil samples from within these separate zones, to try and determine why some parts of some paddocks were not performing as well as others and what management actions could be undertaken to address these production issues. Whilst the zone soil sampling was originally designed to try and identify nutrient deficiencies, he soon found that there was some correlation between the areas which traditionally had low productivity and low soil pH. Soil test results showed that the best performing areas had soil pH in the order of 7.0 to 7.5 ($CaCl_2$), whilst some of the poorest performing soils had pH as low as 4.3 ($CaCl_2$).

On the basis of these soil test results the Adams' limed the worst of the low productivity, low pH zones at rates of 2.0 to 2.5 t/ha between 2011 and 2013. From the results of his production zone testing, Dan applied limesand to fourteen hectares on the eastern side of the case study paddock (North-West) at a rate of 2.45 t/ha in 2013. (Figure 2)

As had been observed on other parts of the farm, the yield map from the 2013 season on the case study paddock reflected the correlation between soil pH and crop production. The yield map showed a distinct trend of poorer yield along the eastern and southern boundaries of the paddock (Figure 3), on which Dan had measured low pH values and applied lime earlier in the season (Figure 2). As lime can often take more than 12 months to effect pH change below the surface and the paddock was planted to barley (an acid sensitive species), improvements in crop production from the lime application were not expected in the first year.

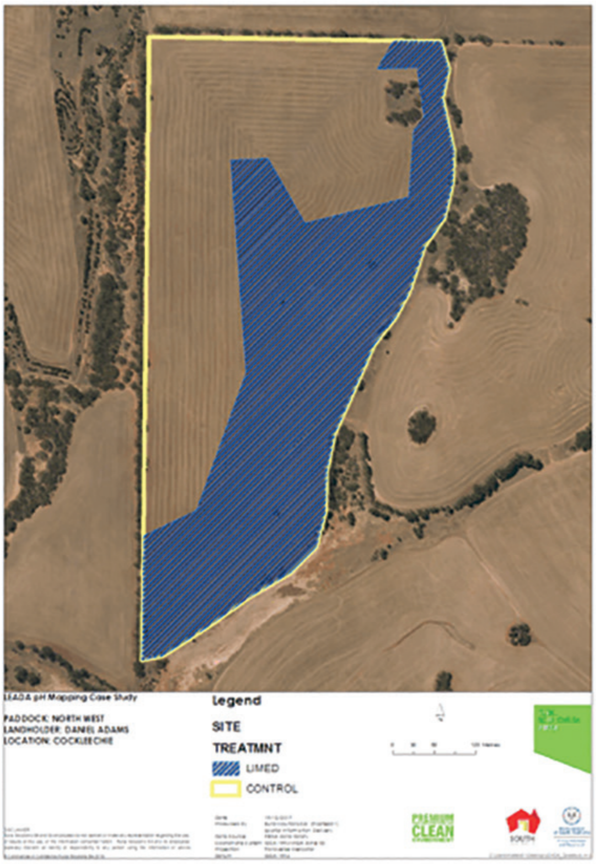

Figure 2. Area on eastern side of paddock limed in 2013

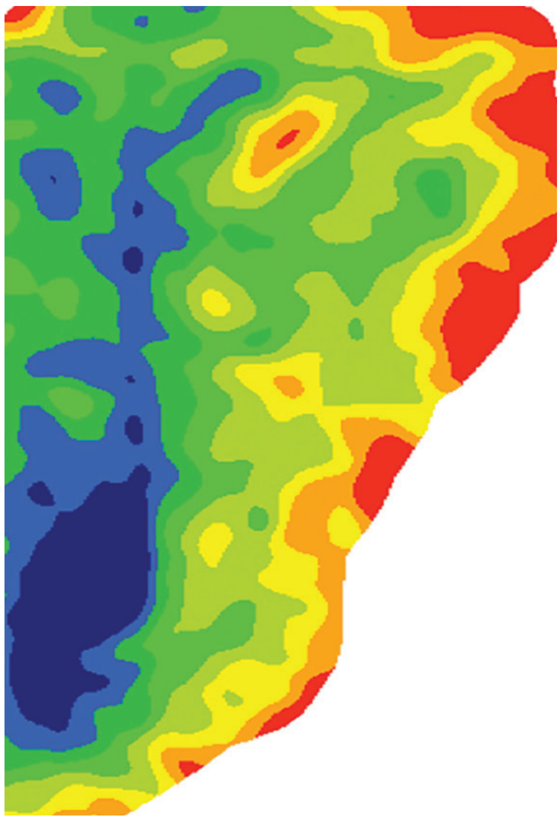

Figure 3. Northwest paddock grain (barley) yield map, 2013.

3 Paddock Scale pH Mapping

3.1 Manually mapping the paddock

In 2016 Dan participated in the Natural Resources Eyre Peninsula "Farming Acid Soils Champions" program which was delivered through LEADA and the Cockaleechie 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.

Dan took this simple mapping exercise a step further by geolocating his sampling points with GPS which allowed him to enter the pH data from his field analysis into his farm mapping software. He was then able to interpolate the point source pH data into a pH zone map. (Figure 4)

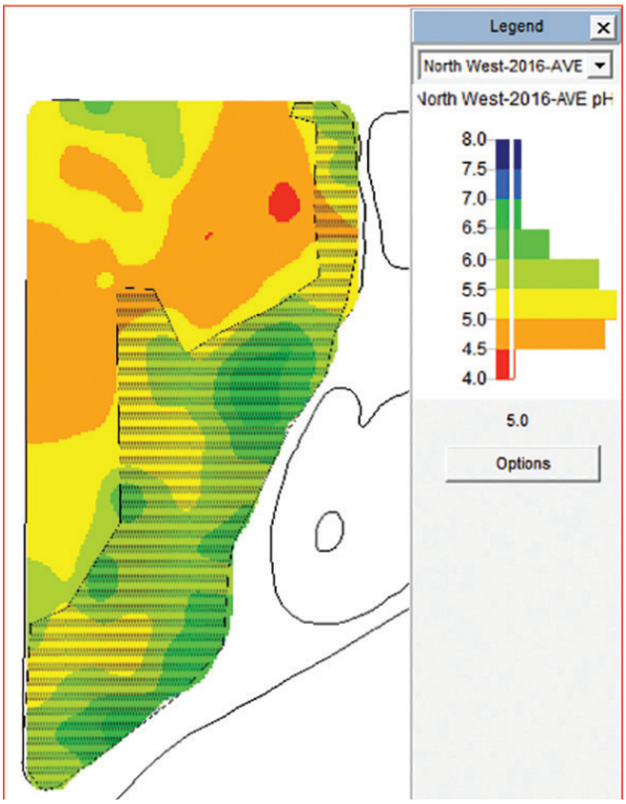

Figure 4. Field pH point data extrapolated to zone map.

From this map Dan could clearly identify the impact of the lime application from 2013 on soil pH. The map showed generally higher pH (field pH 5.5 to 7.0) in the areas where the lime was spread compared to pH values in the order of 4.5 to 5.5 (field pH) in those areas where lime had not been applied.

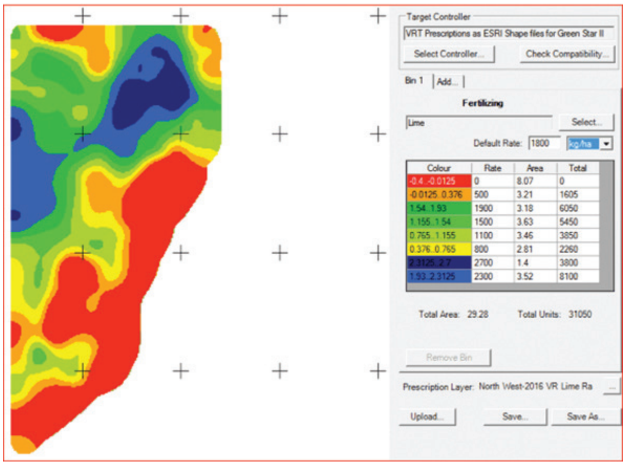

Figure 5 (above). Lime prescription map produced by Dan.

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. From this map Dan was able use his farm mapping software to develop a prescription map for variable rate lime applications to bring the surface pH above the target value (Figure 5). This map showed that about 28% of the paddock needed no further lime (red zone of prescription map) and 21% of the paddock (orange and yellow zones on the prescription map) only required a light rate of less than 1.0 t/ha to bring the surface pH in those zones above the target 5.5 ($CaCl_2$). Most of this area was in the zone that Dan had already limed in 2013, with a small alkaline rise in the northern part of the paddock. In the north-western part of the paddock where lime was not applied in 2013 (blue and light green zones on prescription map, comprising around 17% of the paddock) lime rates of above 2.0 t/ha are now required to bring the surface pH above the target.

3.2 VERIS 'On-the –Go'" pH mapping.

Under the 'Farming Acid Soils Champions' program Dan 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 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 6 shows the point data map. This map was interpolated using the 'FarmWorks' software program to create a pH map showing different zones (Figure 7).

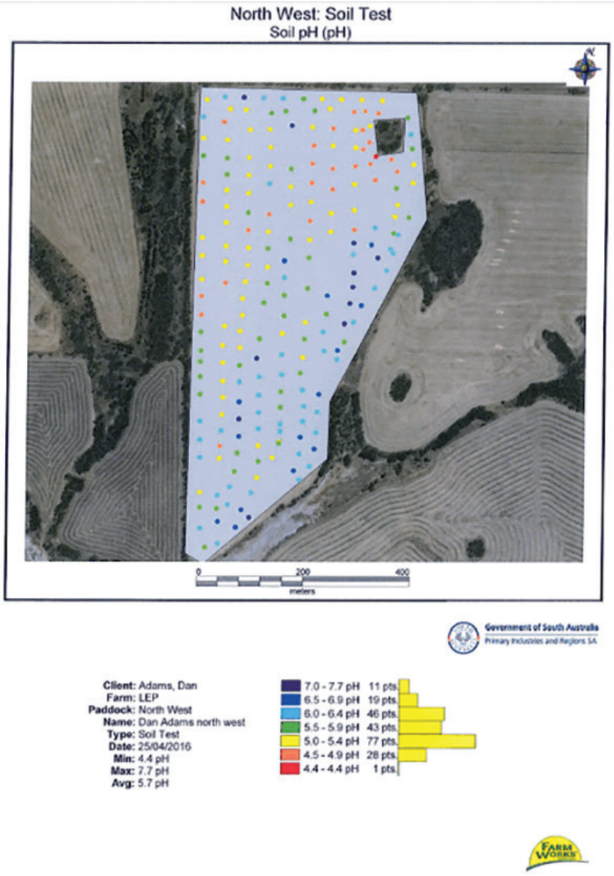

Figure 6. pH point data map (pH $CaCl_2$ adjusted)

The map produced by the pH mapping machine correlated well with the map produced by Dan, even though the map produced by Dan had a much lower sampling density (closer to 2 points per ha rather than 10-12 points per ha). The paddock area mapped by the Veris mapper was slightly less than that calculated by Dan's farm mapping software (27 ha compared to 29.3 ha). This is because the Veris machine was unable to map some rocky areas and close to scrub. Results from the on-the-go mapping, identified that 55% of the paddock was above the target pH of 5.5 ($CaCl_2$) at the surface with 12 % below the 5.0 ($CaCl_2$). (Figure 7 and Table 1)

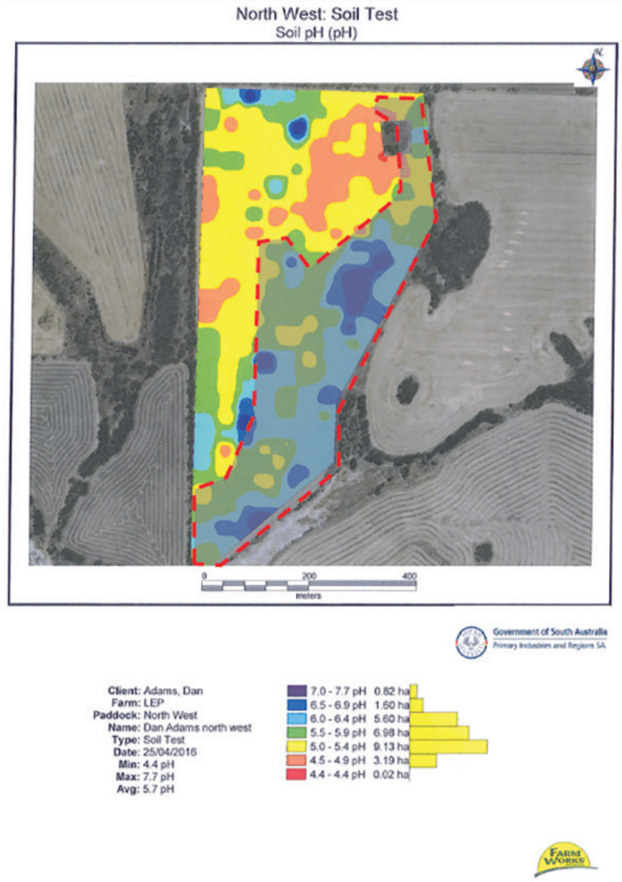

Figure 7. pH zone map (pH $CaCl_2$ adjusted)

This map also highlighted the higher pH values on the eastern site of the paddock, reflecting the impact of the 2013 lime application (Figure 7).

pH Range	Area (ha)	Area (%)
<4.4	0.02	0
4.5 – 4.9	3.19	12
5.0 – 5.4	9.13	33
5.5 – 5.9	6.98	26
6.0 – 6.4	5.6	20
6.5 – 6.9	1.6	6
>7.0	0.82	3
Total	**27**	**100**

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

4 Lime Prescription Map 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 8). 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 map was 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 15 tonnes of limesand is required over an area of 16 ha to address the areas of the paddock with surface soils below the target value of 5.5 ($CaCl_2$) (Table 2). Most of the area requiring treatment is located in the north western portion of the paddock where an application of 1.0 to 2.0 t/ha of lime will address the current soil acidity.

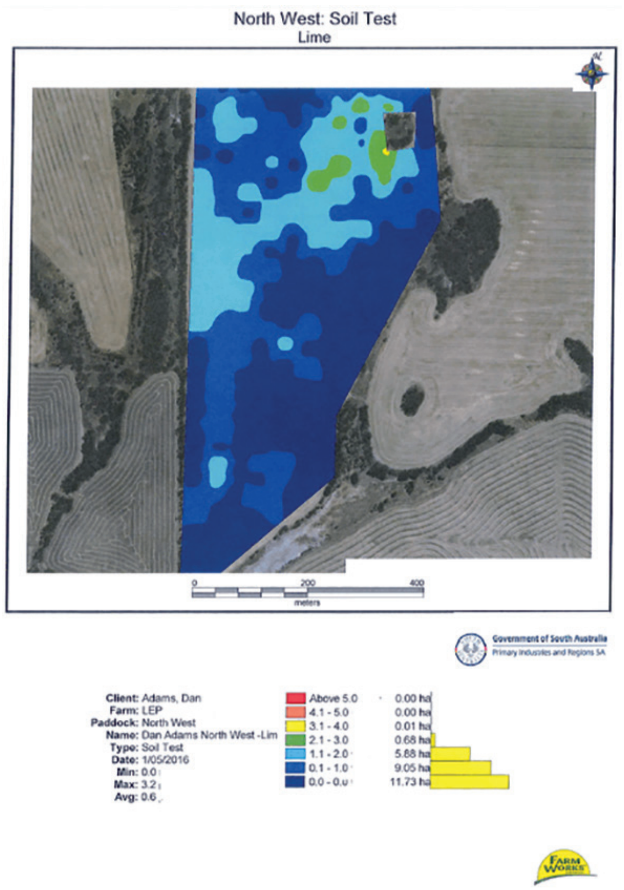

Figure 8. Lime rate prescription map

This data confirms previous data obtained from the site suggesting that changes to soil characteristics are persisting and that increases in carbon are not just residual carbon from previous applied organic matter.

Lime rate (t/ha)	Area (ha)	Tonnes Lime
0	11.73	0
0 - 1	9.03	4.52
1 - 2	5.88	8.82
2 - 3	0.68	1.7
3 - 4	0.01	0.04
4 - 5	0	0
> 5	0	0
Total Area Requiring lime (hectares)		**16**
Total Lime requirement (Tonnes)		**15**

Table 2. Lime requirement for Paddock

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 340 kg/ha/year. This is much higher than the historical rules of thumb of around 150 kg/ha/year for cropping paddocks.

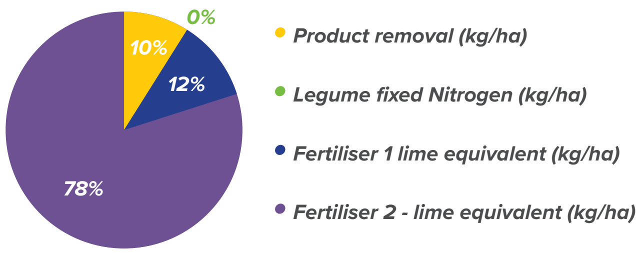

Figure 9. Influence of Management Practice on Total Lime Requirement (2009-2016)

This is the result of very high rates of applied nitrogen fertiliser (90% of the total acidification at this site is attributed to nitrogen fertiliser applications) (Figure 9). As there is no legume in this rotation all of the nitrogen for crop production is being applied in fertiliser and applications of lime are required to counteract the resulting acidification.

6 Cost Effectiveness of pH Mapping.

Having applied lime to a portion of the paddock in 2013 Dan was wondering what an appropriate rate for a follow up liming application on the paddocks would be. 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 Dan were to apply a uniform rate of 2.5 t/ha across the whole 27 ha paddock 68 tonnes of lime would be required with a total supply and spreading cost of $2168 (Table 3). However, using rates targeted to the 16 hectares identified by the pH mapping, the total lime requirement is only 15 tonnes. Taking into account the cost of mapping this results in a total lime application cost for the mapped paddock of $1302, which is a saving of $884 for the paddock or a 40% 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)	27	0
t/lime required	68	4.52
Cost lime ($12/t)	820	8.82
Cost freight and spreading ($20/t)	1367	1.7
Cost of Mapping ($12/ha)	0	0.04
Total cost	2186	1302
Saving ($)		**$884**
% saving on cost of lime operation compared to Uniform rate 2.5 t/ha		**40%**

Table 3. Cost effectiveness of pH mapping

7 Discussion and Conclusions

Determining the relationship between crop production and soil constraints has been the key driver for Dan to investigate soil pH across the property. As his enterprise is continuous cropping it is important to him to have profitable high value break crops in the rotation. Lentils offer the advantage of being high value and contributing large amounts of nitrogen for following crops through nitrogen fixation. However, lentils are very sensitive to low soil pH. Whilst the Adams' have had some understanding of soil acidity in the past and have taken some action to address it through the application of lime, these applications have tended to be ad-hoc and based more on 'gut-feel' than empirical soil pH data. By changing their soil testing methodology from a whole paddock transect to sampling within production zones, they were able to identify a correlation between productivity and low soil pH on their properties.

The 'Farming Acid Soils Champions' program provided Dan with the opportunity and tools to undertake some soil pH testing to identify the spatial variation of pH across a paddock. Through a combination of simple tools (including a field pH kit, GPS and printed aerial photograph) and on hand farm mapping software Dan was able to develop pH zone maps from which a plan for variable rate lime applications could be developed.

This mapping reflected historical lime applications that had occurred on the paddock and highlighted areas which required further liming. Follow up mapping using the Veris pH manager showed a good correlation between the Veris pH data and the maps produced by Dan through manual sampling and field analysis at a lower resolution.

Dan states that he can see the value in pH mapping on his property. The prescription pH map on his case study paddock revealed a potential cost saving of 40% on the total cost of the liming operation compared to a uniform lime application rate of 2.5 t/ha across the entire paddocks, even taking into account the cost of the mapping.

Dan feels that the biggest advantage of pH mapping would be on paddocks that have not been limed before where the pH mapper would be able to identify the variability in soil pH across the paddock. He feels that whilst any cost savings are good, the real benefit from mapping is knowing that you are putting the 'the right amount of lime to be applied in the right areas', which increases the overall effectiveness of the lime application and minimises the risk of adverse impacts from applying heavy rates of lime.

The information that Dan has gathered through this project has given him the confidence that his lime applications have had some effect on changing soil pH and has provided a starting point for him to devise management strategies for the site and other paddocks on the property. Dan also valued the opportunity to meet with his neighbours and peers to share and learn from their experiences of managing soil acidity in the region.

Whilst surface soil acidity can be effectively managed by spreading lime, many soils on the Adams' properties are also inherently prone to acidification of subsurface layers (i.e. coarse sand over clays and ironstone soils). Soil pH should be maintained above 5.5 ($CaCl_2$) at the surface in order to minimise the risk of acidification of subsurface layers.

8 Where to From Here?

Dan considers that he has a better understanding of the areas on his property that are prone to acidification and that the pH mapping is a useful tool for identifying the variability of pH within and between paddocks. He recognises that this doesn't need to be an expensive process but can effectively be achieved with basic tools and knowledge. He is confident that managing soil acidity is a key strategy in maintaining a robust, flexible continuous cropping enterprise and improving production on those areas which have struggled. One concern that Dan has is, the rate of acidification occurring on his properties due to the very high nitrogen fertiliser inputs associated with a canola and cereal rotation, however at present there are limited options for growing profitable legumes on acidic soils in the district with canola the only effective break crop currently available.

Dan is keen to continue using pH mapping as a means for fine-tuning his lime applications and plans to have all paddocks mapped using an 'on-the-go' mapper over the next 5-6 years to identify those areas which require maintenance lime applications. He believes that mapping at a finer resolution in the maintenance liming stage will continue to provide cost savings as well as improved effectiveness of liming operations by ensuring that the right amount of lime is applied to the right areas.

Acknowledgements

The author wishes to thank Daniel and Lora Adams for their willingness to share their information for this case study.

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Further Information

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