A lentil crop showing patches of poor stunted and yellowing growth, which can indicate soils are acidifying.

Credit PIRSA

Action on emerging soil acidity LOWER-NORTH

In recent years, farmers in the lower-north of South Australia have noticed poor performing patches in lentil and faba bean crops. Could increasing soil acidity be impacting the performance of crops with poor tolerance to acid soils?

To address this issue the Agricultural Bureau of SA Inc launched a project. 'Innovative and cost-effective methods to manage 'emerging' soil acidity to improve soil health, crop and pasture production'. The project was carried out with three Agricultural Bureau branches in the lower-north, i.e. Owen, Tarlee and Halbury-Whitwarta, in 2018 and 2019. As part of the project nine paddocks with mostly red loamy soils were pH mapped with PIRSA's Veris® machine. Seven of these paddocks had at least some acidic areas.

Farmers response to soil acidification

Michael Warnes

Owen, Lower-north, South Australia

Michael and Erin Warnes have been continuously cropping their property near Owen, since 2007. In that time, they have had a couple of hay crops in the rotation and legumes have been included since 1988. Their soils are mainly red brown earths and dark self-mulching clays. In the early 2000's Michael soil tested some of his paddocks, which confirmed that the red brown earths were slightly acidic.

On a 45 hectare paddock, Michael had noticed over time that legume crops, particularly lentils were not performing well in some parts of the paddock. This was shown in the biomass map (Figure 1) from July 2018 and the yield map from the same year (Figure 2). As part of the project, the

Mapping yield variation has shown Michael Warnes there is a strong relationship between lower production and soil acidification, with half of his test paddock needing lime (see Table 1).

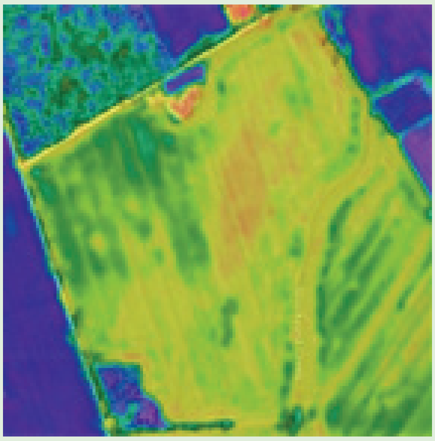
paddock was pH mapped using PIRSA's Veris® on-the-go machine. The soil pH map (Figure 3) shows that 28ha (62%) had a soil pH less than pH5.5($CaCl_2$) and the lowest pH areas correlated well with the low performing areas of the paddock. The soil pH map also quantified and located the extent of the acidification. This was not just confined to the areas that Michael had assumed to be acidic.

From the soil pH map a lime prescription map was prepared for the paddock (Figure 4). This was based on the soil pH, soil texture and lime quality (based on 100 % neutralising value) to raise the soil to pH5.5($CaCl_2$). Michael will use this map to apply lime to this paddock in autumn 2020.

Prior to pH mapping Michael would have only limed the areas where he thought it was required. Alternatively, he would have used a uniform rate of 2.5t/ha across the whole paddock.

Applying a variable rate of lime, to where it is required will improve production across the paddock. It will also result in a saving of $2,256 compared to a uniform rate of 2.5 t/ha, even when the cost of mapping is included (Table 1).

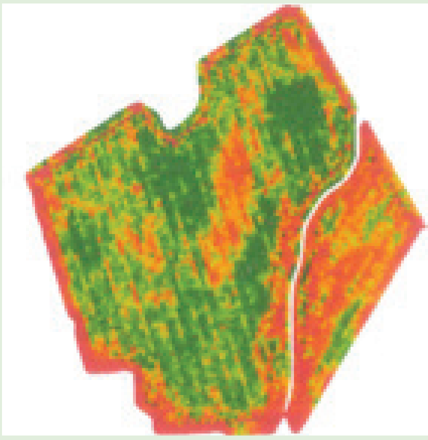
"This process and costings have given me the confidence to pH map other paddocks on the farm and start a program of variable rate liming."



Key: Biomass

Low — Medium — High

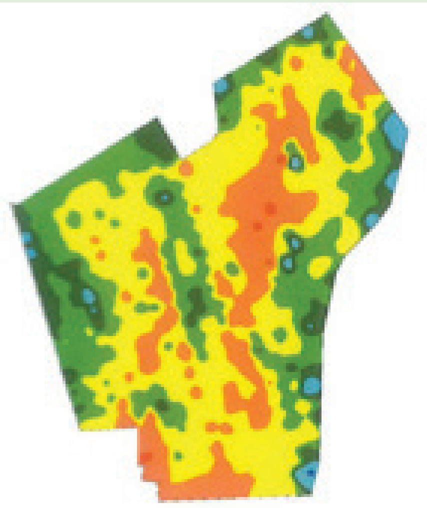
***Figure 1:** Lentil biomass, July 2018 (source Decipher).*



Key :Yield

Low — Medium — High

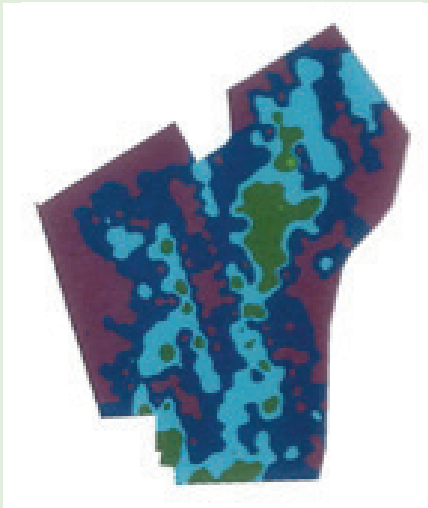
***Figure 2:** Lentil yield map, 2018.*



Key: pH Calcium Chloride ($CaCl_2$)

Above 7.4	0.00ha
7.0-7.4	0.02ha
6.5-6.9	0.95ha
6.0-6.4	4.18ha
5.5-5.9	12.20ha
5.0-5.4	19.12ha
4.5-4.9	8.65ha
4.3-4.4	0.16ha

***Figure 3:** Soil pH map, 2019.*



Key: Lime rates t/ha to increase the soil to pH5.5($CaCl_2$)

Above 4.099	0.00ha
3.100-4.099	0.03ha
2.100-3.099	3.79ha
1.100-2.099	10.19ha
0.100-1.099	18.66ha
0.000-0.099	12.60ha

***Figure 4:** Lime prescription map.*

Table 1: Cost saving between a uniform and targeted lime application.

	Uniform paddock rate 2.5t/ha	Lime applied at a variable rate where pH is less than pH5.5($CaCl_2$)
Area requiring lime	45ha	28ha
Tonnes lime required	112.5t	50.5t
Cost lime ($28/t)	$3,150	$1,414
Cost of freight and spreading ($20/t)	$2,250	$1,010
Cost of mapping ($16/ha)	-	$720
Total cost	**$5,400**	**$3,144**
SAVING	**$2,256 (42%)**	

Wind can be a problem when trying to evenly spread fine lime products. Mark Branson reduces this problem by spreading at night. Operations are made possible by using GPS guidance, autosteer and an ultraviolet light to help them see if the lime is meeting the required spread width.

Mark Branson

Stockport, Lower-north, South Australia

When Mark Branson saw the results of the first paddock he pH mapped in 2017, he had the shock of his life.

"My father and I had been applying lime to areas of red-brown earth soils for over 25 years, but the map showed all our soil types to be much more acidic than I had thought," said Mark.

Mark describes the soils across the farms as a mosaic of red brown earths and dark brown cracking clays, interspersed with some acid grey loams. Historically, the dark brown soils are alkaline and the red-brown earths mildly acidic.

"The pH map showed that the dark brown soils were now neutral, and the red soils were quite acidic with some areas as low as pH4.2 ($CaCl_2$). That means a significant amount of lime was still needed to achieve the desired pH level of 5.5($CaCl_2$)."

Historically, peas and faba beans were used in the rotation but lentils were introduced in 2015. The frequency of a pulse crop in the rotation has increased over the 35 years that Mark has been cropping. When he came home, the farm was 60:40 pasture to crops, now it is more like 20:80 with only small areas of permanent pastures.

Mark, now farming with son Sam, runs an 11 year rotation, although this changes depending on the level of ryegrass in a paddock. The base rotation is three years of pasture, followed by a year of canola, two years of wheat, followed by barley, another two years of wheat, a year of barley and another of a pulse or canola.

"Our farming practices and increasing yield have promoted soil acidification, especially on the red brown soils. This has resulted in more ryegrass, which is more acid tolerant than most of the crop species we grow."

As lentils and faba beans are both highly sensitive to low pH, they are good indicators of where acidification is occurring. In the past, Mark used the poor performing areas as well as soil colour to guide his soil sampling locations for soil pH and to create lime rate zones.

Since 2017, most of his property has been mapped with the Veris® machine. These maps are now used to create the lime rate zones, to raise soil to a target of pH5.5($CaCl_2$).

Using the Veris® pH map versus manually deciding where to spread has better matched rates to location. Compared to a uniform rate of 2.5t/ha Mark reports an average saving of $62/ha across the farm.

Where Mark has limed he has seen immediate results in crop yields in the areas where the soil was most acid. The economics Mark has done to date have only looked at the cost savings from the different application approaches, not at any difference in crop production post liming.

The Branson's have been early adopters of precision agriculture. They also run a controlled traffic system based on 3m wheel centres and tramlines every 13m. With the increased requirement for lime, Mark bought a new lime spreader that enabled him to control the application rates variably and to fit the controlled traffic system.

"We want to spread to 13m; the coarser the material the easier to reach this width but coarse material often is less effective than fine lime."

Mark uses a fine ground lime. To minimise the impact of wind he often spreads at night. This is possible with the use of GPS guidance, autosteer and an ultraviolet light to help them see if the lime is meeting the required spread width.

Lime is spread before seeding at one of three rates and incorporated with the seeding pass using knife points and press wheels. Where pH is less than pH5.0($CaCl_2$) the rate is 2.5t/ha, between pH5-6($CaCl_2$) the rate is 1.5t/ha and above pH 6 ($CaCl_2$) 1t/ha of lime is applied as a maintenance rate. On the very acid soils Mark will return with another 2.5t/ha of lime within five years.

Having seen that his production system is causing more rapid soil acidity than he had originally expected, Mark now plans to regularly monitor and manage soil pH to maintain production and profitability.

Credit Emma Leonard

On-the-go soil pH testing measures about 10 samples per hectare and displays the results as a map. The data can then be converted to a lime prescription map to target the right amount of lime to each area. In each paddock, Andrew Harding takes several samples to send to the laboratory for pH testing. The results are used to create a calibration for the on-the-go pH data collected in the paddock.

SOIL ACIDIFICATION

CAUSE

Soil acidification occurs naturally but is accelerated by more intensive and productive farming systems. Generally, soil acidity starts at the surface but moves down the profile. It is caused by the application of high rates of nitrogen fertiliser, nitrate leaching and the removal of produce such as hay or grain. Soil pH is measured in water (H_2O) or preferably in calcium chloride ($CaCl_2$). Readings in $CaCl_2$ are about 0.8 lower than in H_2O.

EFFECT

Plants prefer a pH of 6 to 8.5(H_2O), pH5.5 – 7.5($CaCl_2$). When soil pH falls below pH5.5 ($CaCl_2$) there are multiple effects. Crop yields start to decline; symptoms are more obvious in the more sensitive crops such as lentils, chickpeas and beans. Some nutrients become less available. Micro-organism survival is poor, including *Rhizobia* for legumes, so nodulation declines. The breakdown rate of some herbicides changes. Some nutrients, such as aluminium, can increase to toxic levels. Weeds with more tolerance to acid soils, eg ryegrass, increase.

ACTION

Soil test. This is important to identify if increased soil acidity is the cause and to monitor soil pH levels. Soil pH is offered as part of a soil nutrient test. Typically, about thirty soil cores from the 0-10cm layer were gathered randomly from across a paddock from the same soil type. These were mixed and a subsample sent for analysis. Some companies now offer a grid soil sampling option with a sample tested every one to two hectares.

The on-the-go Veris® pH sampling machine measures a soil sample every 30m. When driven on a 36m pass that results in eight to 10 samples per hectare, producing a high-resolution pH map (see Figure 3). This map can then be converted into a lime prescription map as shown in Figure 4.

Add lime. Spreading and incorporating crushed limestone or dolomite is the most efficient and cost-effective means of raising and maintaining soil pH. Gypsum does not change soil pH. The rate of lime is determined by the initial soil pH, soil texture and the fineness (>60% should be <300 micron) and neutralising value (>80%) of the lime.

Three calculators are available from PIRSA. **Lime Cheque** – to calculate the most cost effective sources of lime for your property. **Lime Maintenance** – how much lime your farming system needs every 10 years. **Acidity Cost** - The cost of acid soils on production.

Select more acid tolerant crops. It can take at least a year before the lime becomes effective. It is best to apply lime about two years before planting acid sensitive crops such as lentils.

***Acknowledgements** – This fact sheet was produced as part of the 'Innovative and cost-effective methods to manage 'emerging' soil acidity to improve soil health, crop and pasture project'.*
This was supported by:

Government of South Australia
Primary Industries and Regions SA

Agricultural Bureau of South Australia Inc.
PATHWAY TO IMPROVEMENT

Australian Government | National Landcare Programme

Thanks to the farmers of the Agricultural Bureau Groups; AgriKnowHow and Lightening Designs

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