Precision soil pH mapping

More than two million hectares of land in South Australia are susceptible to soil acidification, a process that degrades the soil and reduces crop and pasture growth. Many of the soils susceptible to acidification currently have a pH less than 5.0 ($CaCl_2$) in the 0-10 cm layer and soil acidity in the sub-surface (10-20 cm) layer is also becoming an issue. Soil pH often varies significantly down the soil profile and across paddocks.

Lime is the most effective and economical method for the treatment and prevention of acid soils. Previously, the amount of lime required for a paddock has generally been based on a single soil test with the lime applied as a uniform rate across the whole paddock. In recent years, the cost of lime and freight has significantly increased.

Precision soil pH mapping by machines is a new and innovative technology for measuring and mapping soil pH variation across the paddock. The maps identify soil pH zones within a paddock which allows appropriate rates of lime to be calculated for each zone. This not only results in better soil pH conditions for crop and pasture growth through targeted lime applications but in most cases can reduce the cost of lime applications.

This information note describes the pH machines and the benefits of mapping and managing pH zones.

Soil sampling machines

There are a number of soil sampling machines that are commercially available. This includes the Veris® machines and quad bikes or ATV with soil sampling units.

Veris® machines

Veris® Technologies Pty Ltd (USA) have developed two types of machines for soil pH mapping. They are the MSP-3 machine that can be mounted on the back of a tractor or towed by a 4WD or the U3 series that can be towed by an ATV.

As these machines are towed across the paddock they take a soil sample on-the-go, measure the soil pH from direct soil contact and record its geographic position.

The number of points sampled per hectare depends on the distance between runs. On controlled traffic tracks at 36 metres wide the machines sample about 8 -10 points per hectare and can cover about 120 hectares per day.

After sampling the data can then be downloaded to produce a pH map of the paddock. Calibration of the machines under controlled environmental conditions has shown that they are highly correlated with laboratory pH ($CaCl_2$) values.

Figure 1: *Veris® MSP-3*

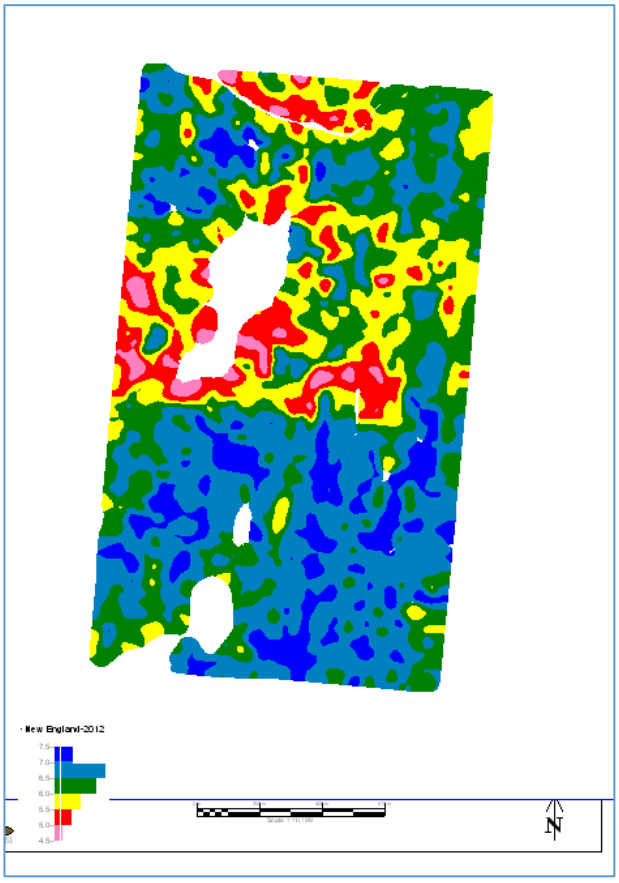
Due to an increased demand for the on-the-go soil pH mapping and to further develop this technology, Primary Industries and Regions SA (PIRSA) invested in a Veris® MSP-3 machine in 2015 (Figure 1). This machine is based at the Clare office and is available to undertake pH mapping work for projects or individual farmers on a cost-recovery basis.

Quad bikes or ATV with soil sampling units

Soil sampling units can be mounted onto quad bikes or ATV's to take soil samples. A number of organisations are now offering a soil service where soil samples are taken across the paddock (down to a depth of about 15 cm) on a pre-determined geo-referenced grid basis. All the work is done from the driver's seat. Due to cost–effectiveness sampling is generally done on a half to two hectare grid basis. The soils are then sent to a laboratory for a range of analyses including soil pH and the data is then used to produce maps.

Soil pH maps

Once the data has been downloaded then soil pH maps can be produced. Figure 2 shows the map from the *Veris® MSP-3* on a 200 hectare cropping paddock. The white areas in the maps are non-arable stony ridges. The map show a large spatial variability of soil pH and definite pH zones across the paddock. A rough line across the centre of the map indicates an old west-east fence line with the areas north and south of the line showing that the two paddocks have been managed differently in the past.



The maps produced by the *Veris®* machines can be quite detailed (8 -10 points per hectare) and will pick up small areas of low and high pH soils. The map from the soil sampling units (generally less than 2 points per hectare) will be less detailed but will pick up broader soil pH zones.

One of the constraints in using the *Veris® MSP-3* on-the-go machine is that it can block up with heavy soils and with stubbles or pasture residues. A camera mounted on the back of the pH machine with a monitor in the cabin of the tractor or 4WD allows the operator to see how the machine is performing.

pH mapping of long-term pasture paddocks can present a number of problems. Pasture paddocks are often compacted, and may make it difficult to sample the paddocks.

Figure 2: *pH map by the Veris® MSP-3*
(Blue and dark green– high soil pH; yellow, red and pink – low soil pH)

In addition, the decomposition of leaf litter and organic matter (thatch layer) can form a small alkaline layer (1 -2 cm) on top of the acid surface soil. Sampling with the soil sampling units will include the small alkaline layer in the test result whereas the *Veris® MSP-3* samples beneath this layer.

Lime application

The soil pH maps have shown that rather than applying a uniform rate of lime across the paddock, lime can be applied at variable rates to match the variability in soil pH. The area for liming and appropriate liming rate for each pH zone can be calculated more accurately. Figure 2 shows that only the pink, red and yellow areas in the top half of the paddock require lime. This map can be converted to a lime prescription map and then used with variable rate lime spreading.

The economics of liming and the cost savings are outlined in Table 1. In this case, the landholder only intended to lime the top half of the paddock that had a total of 113 hectares.

By mapping the paddock only 45 hectares (40% of the paddock) was found to require lime. Taking into account the cost of mapping there was a cost savings of $4,289 (43% cost savings).

Table 1: Economics of liming

Economics of liming	
Cost of lime	$20
Application	2 tonnes/ hectare
Freight $0.12/km/t Say 100km	$12/tonne
Spreading	$12/ tonne
Total cost /tonne	$44
Total cost /hectare	$88
Before mapping 113 hectares: $9,944	After mapping 45 hectares: $3,960
Cost of mapping say $15 x 113 ha $1,695	Savings $4,289

Case studies have shown that the cost savings of applying the appropriate amount of lime for different areas of the paddock compared to applying a uniform rate to the whole paddock can be in the order of about 30%. The highest cost savings were on those paddocks with a high degree of variability, particularly those with a large proportion of slightly acidic (not requiring lime) to alkaline soils.

In some cases more lime may be required in more highly acidic areas but the cost will be out-weighed by the improvement in productivity.

Figure 3: *Applying lime according to pH zones*

Summary

The use of soil pH precision mapping is increasing in SA. Soil pH mapping and the identification of pH zones will enable more accurate targeting of lime applications. This will not only help to save costs but also will result in improved soil pH conditions over the paddock that will result in an overall improvement of crop and pasture productivity.

Acknowledgments

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