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 prone 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 within 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 sheet describes the pH machines and the benefits of mapping and managing pH zones.

Soil pH machines

There are two types of soil pH machines that are commercially available. These have both been developed and marketed by Veris Technologies Pty Ltd based in the USA.

The *Veris pH detector*

*The Veris pH detector (*Figure 1) is a machine that can be mounted on the back of a quad bike or UTV and with this approximately 200 to 300 hectares can be mapped per day. Using this machine pH readings are generally taken from one point per hectare using a grid sampling pattern. At each point the operator pushes the electrode in to the soil and both the geographic position and soil pH are recorded. Paddock maps showing different pH zones are then produced from the field data. Veris no longer manufacture this machine as they are now promoting the *Veris pH Manager™*.

Veris pH Manager™

The *Veris pH Manager™* (Figure 2) is a machine that can be mounted on the back of a tractor or towed by a 4WD. It automatically takes a sample on the go, measures the soil pH from direct soil contact and records its geographic position while travelling across the paddock.

The number of points sampled per hectare depends on the distance between runs. On controlled traffic tracks at 36 metres wide the machine samples about 10-12 points per hectare and can cover about 200 to 250 hectares per day.

The *Veris pH Manager™* uses two electrodes. If the difference in the pH value between the two electrodes is less than 0.5 of a pH unit then an average of the two readings is stored. If the difference between the two readings is greater than 0.5 then that sampling point is discarded. Field

calibration of the machine has shown that only a small proportion of the sites are discarded. After field sampling the data can be used to produce a pH map of the paddock.

Calibration of the machines under controlled environmental conditions has shown that they are both highly correlated with laboratory pH ($CaCl_2$) values.

Figure 1: *Veris pH detector*

Figure 2: *Veris pH Manager™*

Due to an increased demand for the on-the-go soil pH mapping and to further develop this technology led Primary Industries and Regions SA (PIRSA) to invest in a Veris pH Manager™ machine in 2015. 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.

Soil pH maps

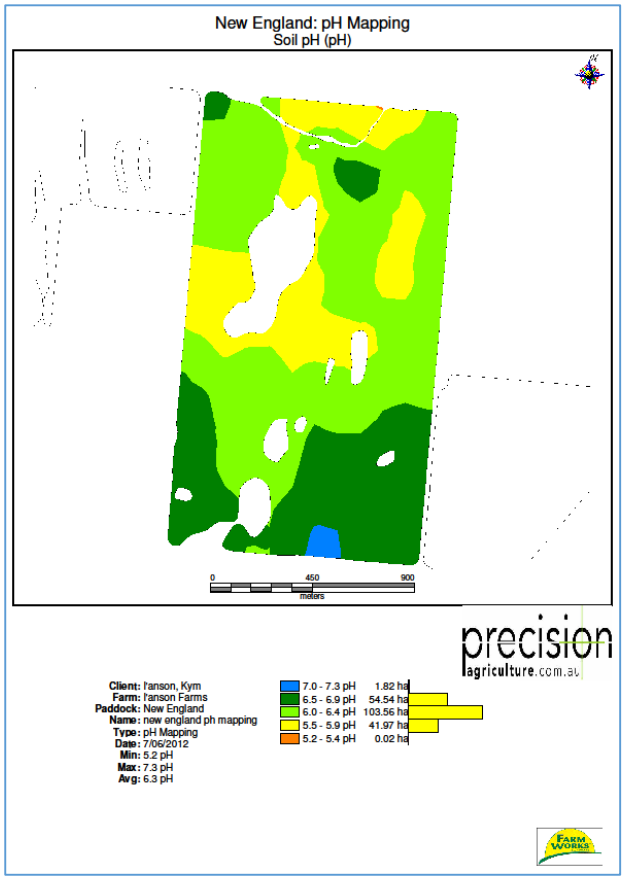
Figure 3 and 4 show the maps generated by the *Veris pH detector* and the *Veris pH Manager™* on the same 200 hectare cropping paddock. The white areas in the maps are non-arable stony ridges. The maps show a large spatial variability of soil pH and definite pH zones across the paddock. A rough line across the centre of the maps also 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 more intensive sampling of the *Veris pH Manager™* (10-12 points per hectare ~2,000 to 2,400 points per paddock) has produced a more detailed map picking up smaller areas of lower and higher pH soils, than the *Veris pH detector's* map (1 point per hectare – 200 points per paddock), however the pH zones for both maps are similar.

One of the significant constraints in using the mapping machines is that the soil must be moist to wet. In cropping paddocks this is often just before or after seeding. Also, the *Veris pH Manager*™ on-the-go machine 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 has presented a number of problems. Pasture paddocks are often compacted, making it difficult to push the electrode of the *Veris pH detector* into the full eight cm soil depth. In addition, the decomposition of leaf litter and organic matter can form a small

alkaline layer (1 -2 cm) on top of the acid surface soil that can interfere with the test results. Removing the thatch layer before testing has provided better results with this machine. The *Veris pH Manager*^{TM} has delivered better results than the *Veris pH detector* on long term pasture paddocks as this machine samples beneath the thatch layer.



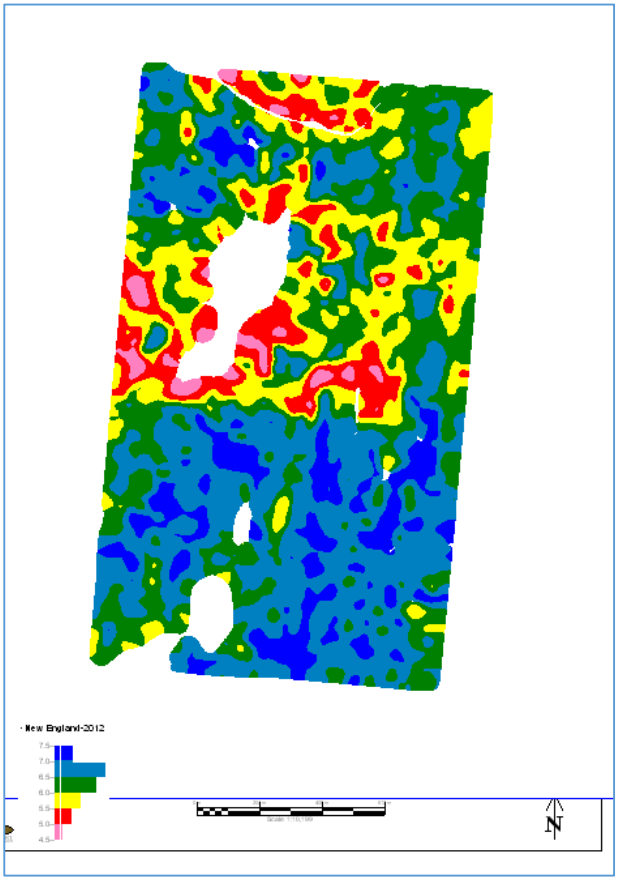


Figure 3: *pH map by the Veris pH detector* **Figure 4:** *pH map by the Veris pH Manager*^{TM}
(Blue and dark green– high soil pH; yellow, red and pink – low soil pH)

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. Figures 3 and 4 show 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 (Figure 5).

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. The cost of the pH mapping at the time was $10 per hectare. 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 $3,630 (46% cost savings). Since the initial field work the cost of lime has increased and the cost of pH mapping has also increased however, the mapping is still providing substantial savings.

Table 1: Economics of liming (2015)

Economics of liming	
Cost of lime	$15
Application	2 tonnes/ hectare
Freight $0.12/km/t Say 100km	$12/tonne
Spreading	$8/ tonne
Total cost /tonne	$35
Total cost /hectare	$70
Before mapping 113 hectares: $7,910	After mapping 45 hectares: $3,150
Cost of mapping say $10 x 113 ha $1,130	Savings $3,630

Other case studies from Precision Agriculture (Victoria) 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 range from 20 - 60% with an average saving of 30%. 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 5: *Applying lime according to the pH zones*

Summary

The use of pH testing machines in cropping paddocks is showing promising results for soils in SA. More testing and validation is required to build confidence in the performance of these machines, especially in long-term pasture paddocks. 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.

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