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 in this area have a pH less than 5.0 ($CaCl_2$) in the 0-10 cm layer and sub-surface (0-20 cm) soil acidity is also becoming an issue. There is often a significant variation in soil pH across paddocks and down the profile.

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 and the lime applied as as 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 and then appropriate rates of lime can be applied to those zones. This not only results in better soil pH conditions for crop and pasture growth across the paddock but in most cases can also help to save costs.

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 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. With this machine pH readings are generally taken on a 1 hectare grid sampling. At each point the operator pushes the electrode in to the soil and the pH reading is then recorded with geographic position data. After the field operation pH maps are then produced. This machine is now no longer manufactured by Veris and has been superseded by the *Veris pH Manager™.*

Veris pH ManagerTM

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. This machine can sample about 10-12 sites per hectare and can do about 200 to 250 hectares per day. The *Veris pH Manager™* uses two electrodes. If the reading between the two electrodes is less than 0.5 of a pH unit then the average value is stored. If the difference between the two readings is greater than 0.5 then that sampling point is discarded. From the field work only a small amount of the sites are discarded. After the field work a pH map can be produced.

Under controlled environmental conditions it has shown that both machines are highly correlated with laboratory data (pH $CaCl_2$).

Figure 1: *Veris pH detector*

Figure 2: *Veris pH Manager™*

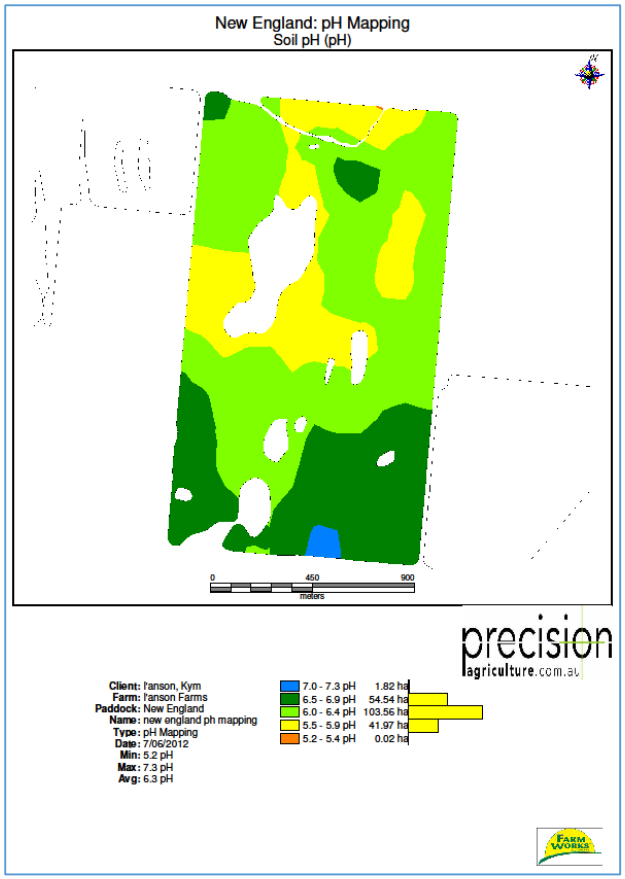
Due to an increased demand and to further develop this technology Primary Industries and Regions SA (PIRSA) invested in a Veris pH Manager™ machine in 2015. This machine is based at the Clare office and is available for project work or individual farmers on a cost-recovery basis.

Soil pH maps

Figure 3 and 4 show the maps generated by the *Veris pH detector* and the *Veris pH Manager™* over 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. There is also a rough line across the centre of the maps which is an indication of an old west-east fence line and the zones north and south of the line show that the two paddocks have been managed differently in the past. Due to the more intense sampling of the *Veris pH Manager™* (10-12 points per hectare ~2,000 to 2,400 points per paddock) its map shows more detail and picks up smaller areas of lower and higher pH soils than the *Veris pH detector's* map (1 point per hectare – 200 points per paddock) but the zones 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 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. Better results are being achieved with the *Veris pH Manager™* as this machine is sampling under the thatch layer.



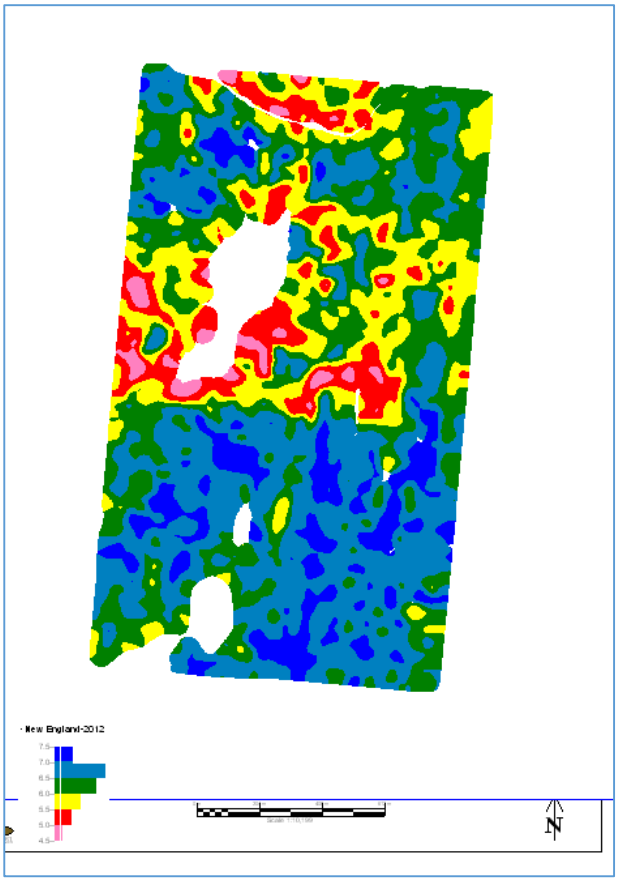


Figure 3: *pH map by the Veris pH detector* **Figure 4:** *pH map by the Veris pH Manager™*
(Blue and dark green– high soil pH; yellow, red and pink – low soil pH)

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 appropriate variable rates to match the variability in soil pH. The area of lime 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 with the pH detector at the time was $7.50. From the mapping it was found that only 45 hectares or 40% of the area required lime and taking into account the cost of the mapping there was a cost savings of $2,302. Since that time the cost of lime has increased and the cost of pH mapping has also increased to $10 - $15/ha (depending on the travel) but is still providing substantial cost savings.

Case studies by Precision Agriculture (Victoria) have shown that applying the appropriate amount of lime for different areas of the paddock compared to applying a uniform rate to the whole paddock can reduce the total amount of lime applied and that the cost savings can be in the order of 20 - 60% with an average saving of 30%. In some cases more lime may be required in more acidic areas but the cost will be out-weighed by the improvement in productivity.

Figure 5: *Applying lime according to the pH zones*

Table 1: Economics of liming (2015)

Economics of liming	
Cost of lime	$15
Application	2.0 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 $7.50 x 113 ha $848	Savings $3,912

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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