Soil acidity and treatment in the Northern and Yorke region

Soil acidity (low soil pH) is an increasing and significant issue throughout the Northern and Yorke landscape region, which is having an impact on crop and pasture productivity.

The extent, cause and treatment

Soil acidity is an increasing and significant issue throughout the Northern and Yorke landscape region. It is a natural process but is accelerated by more productive and intensive farming practices.

When soil pH falls below a pH of 5.5 ($CaCl_2$) then the productivity of crops and pastures starts to fall.

It is estimated that the area, currently acidic is approximately 503,000 hectares or 20% of the agricultural area (Figure 1).

It is estimated that a further 475,000 hectares of agricultural land in the area has the potential to become acidic over the next few decades assuming that the current farming practices continue and that soils are not adequately treated (Figure 1).

Lime and/or soil modifications such as ripping, delving, spading or clay spreading are options for the treatment of acid soils.

Current and potential soil acidity in Northern and Yorke

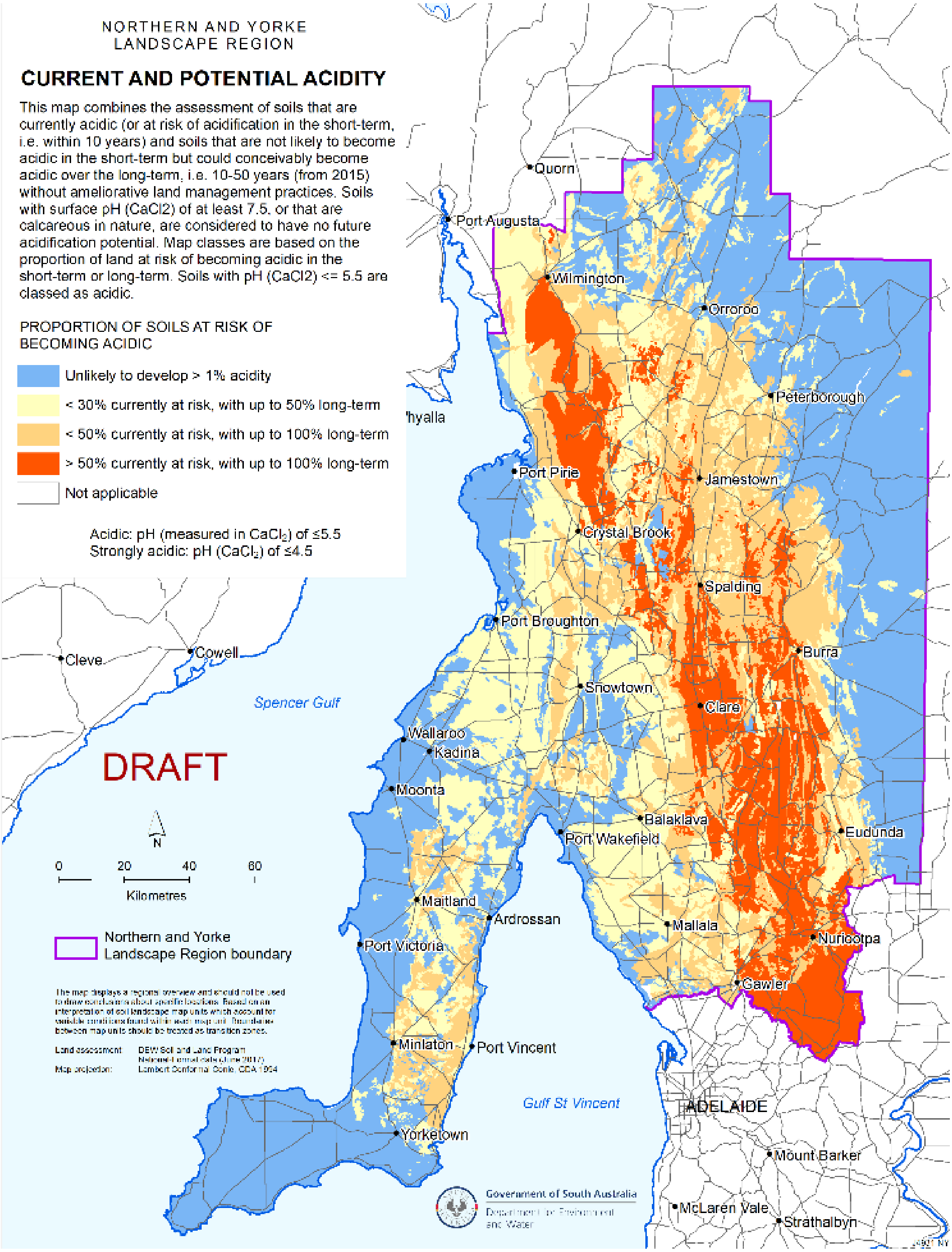

Figure 1: Current and potential soil acidity in the Northern and Yorke Landscape region.

Cause and effect of acid soils

Soil acidity is caused by a build-up of hydrogen ions throughout the soil due to:

- addition of ammonium-based nitrogen fertilisers;
- nitrate leaching and
- removal of alkaline nutrients in plant and animal products.

Soils can vary in pH down the profile. Acidic soils are usually more acidic near the surface and less acidic, or even alkaline at depth where higher quantities of alkaline clay or free lime (calcium carbonate) can neutralise the acidification.

Increased use of nitrogen fertilisers, higher yielding crops and more intensive cropping rotations have increased the rate of acidification throughout the Northern and Yorke Landscape Region and has extended the areas where soils were not previously affected. Soil acidity is now common such as along the plains (Mallala to Blyth) and on the Yorke Peninsula.

Nitrogen fertiliser applications accelerate soil acidification. Sulphate of ammonia (SOA) and mono-ammonium phosphate (MAP) are three times more acidifying than urea, and one-and-a half times more acidifying than diammonium phosphate (DAP) compared per unit of nitrogen.

Table 1 shows the acidifying effect from different farming systems. Approximately 250 kg/ha of lime is required in a continuous cropping system (high nitrogen inputs) to off-set soil acidification. In this case 2.5 tonnes of lime per hectare is required over a 10 year period to maintain the current pH level. If this farming system continues and not treated and if the soil texture was a sandy loam then it is possible that the soil pH could drop by 1 unit in 12 years.

Table 1: Farming systems: Lime equivalent kg/lime/ha/year

Land use	**Mean annual acidification rate (kg lime/ha/yr)**
Low intensity grazing	30
Medium intensity grazing (some hay cuts)	100
High intensity grazing	150
Cropping pasture rotation	100
Intensive cropping (some pasture, high N inputs)	200
Mostly continuous cropping (high N inputs)	250
Continuous cropping (high leaching years)	350

If soil acidity is not treated and when the soil pH falls below 5.5 ($CaCl_2$) nutrients such as phosphorus, potassium, calcium, magnesium and molybdenum become less available to plants.

Figure 2 shows the influence of pH on nutrient availability (pH water). The width of the bars indicates the availability of nutrients at different pH levels. The wider the bar the more available the nutrient is.

Soil acidity can also reduce microbial activity including *Rhizobia* which are important for the nodulation of legumes.

As the pH falls below pH 4.8 ($CaCl_2$) toxic amounts of aluminium can be released into the soil solution affecting root growth and plant development.

Aluminium toxicity is a problem when extractable aluminium levels are greater than 2 ppm.

Due to less availability of nutrients and toxic levels of aluminium then the productivity of crops and pastures start to decline, particularly for acid sensitive plants.

Lucerne, lentils, annual medic, faba beans, canola, vetch and barley are all sensitive to acid soils. As the soils become more acidic, less sensitive crops and pastures start to become affected. Table 2 shows the tolerance of crops and pastures to low soil pH.

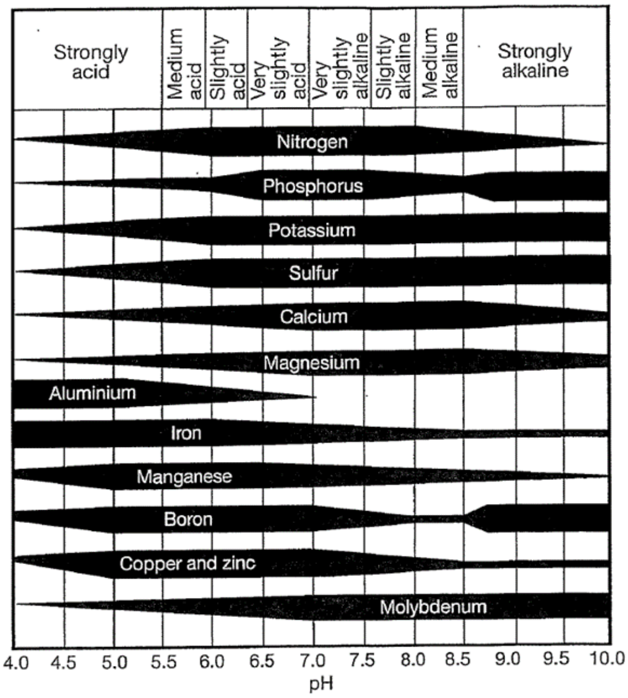

Figure 2: Influence of pH on nutrient availability (pH water) (Price, 2006)

Table 2: Tolerance of crops and pastures to soil acidity

Very sensitive	**Sensitive**	**Tolerant**	**Highly tolerant**
Lentils	Canola	Wheat*	Oats
Faba beans	Phalaris	Sub-clover	Triticale
Chickpeas	Barley	Rye-grass	Lupins
Lucerne	Peas		Couch grass
Annual medics			
Durum wheat			

** Some wheat varieties can be sensitive while others can be tolerant. Wheat varieties that have some tolerance include: Wyalkatchem, Mace and Scepter.*

Figure 3: Symptoms of low soil pH (pH 4.5 $CaCl_2$) on a lentil crop on the Yorke Peninsula

The symptoms of soil acidity show up as patchy un-even crop and pasture growth, yellowing of crops (Figure 3) poor nodulation of legumes and stunted root growth. If soil acidification is allowed to continue then it is likely that it will further decrease productivity and limit plant options to acid tolerant crops and pastures.

Acid tolerant weeds such as rye-grass and couch grass may dominant areas where soils are acidic.

If soil acidification continues then subsurface and subsoil layers can also be affected which are much more difficult and expensive to treat.

Where plants are affected there can also be reduced plant water use that can contribute to rising water tables and increased soil salinity. Where areas are left bare or partially bare then sandy areas can be prone to wind erosion.

The reduced amount of soil cover can also increase run-off and increase the risk of soil erosion and subsequent water pollution and deposition in streams.

Productive farming practices will continue to acidify the extent and severity of acidic land unless adequate on-going treatment such as liming and / or some form of soil modification is implemented.

Soil sampling and testing

Soil pH can be measured in the field or in the laboratory.

Field testing kits (Figure 4) that can be purchased from agricultural stores are a useful guide for measuring soil pH levels. However, the result is an approximation of pH measured in soil water.

For a more precise test, soil samples should be sent to a soil laboratory and tested for pH in calcium chloride ($CaCl_2$).

Figure 4: Field testing kits can provide a guide for measuring in-field soil pH levels (Image:: Belinda Cay, Ag Communicators).

Soil sampling was traditionally carried out by taking twenty or so soil samples at a depth of 0-10 cm in a transect across the paddock and then the soil samples were sent to a laboratory.

Many soils are often stratified where they have a thin alkaline layer with an acid layer below. By sampling soils at 10 cm deep, often the severity of soil acidity is missed.

When taking soil samples, it is now recommended to take depths at 0-5 cm increments to a depth of about 15 to 20 cm and then send these samples to a soil laboratory. When taking soil samples ensure that they are from a uniform area i.e. similar landscape and soil type.

On the laboratory test results you will notice that soil pH is measured by two methods i.e. in soil water or calcium chloride ($CaCl_2$) The optimum plant growth for pH (water) is between 6 and 8.5.

Soil pH ($CaCl_2$) is now the preferred method for testing soil pH as it gives a more accurate result in neutral to acid soils. However, it is about 0.8 pH units lower than pH (water). All lime recommendations are based on pH ($CaCl_2$).

For optimum crop and pasture production the soil pH ($CaCl_2$) in the top-soil should be 5.5 or greater.

Precision soil pH mapping

Precision soil pH mapping by machines is a relatively new technology for measuring and mapping the soil pH variation across paddocks.

A number of agents are now offering a soil sampling service where soil sampling units are mounted on quad bikes or ATV's. Soil sampling is carried out on a pre-determined geo-referenced grid basis and due to cost-effectiveness is generally only done on a one to two hectare grid. The soil is then sent to a laboratory for a range of soil analysis.

An alternative is the use of Veris® machines. As these machines are towed across the paddock they take a sample-on-the-go, measure the soil pH and record its geographic position. At a swath width of 36 metres wide

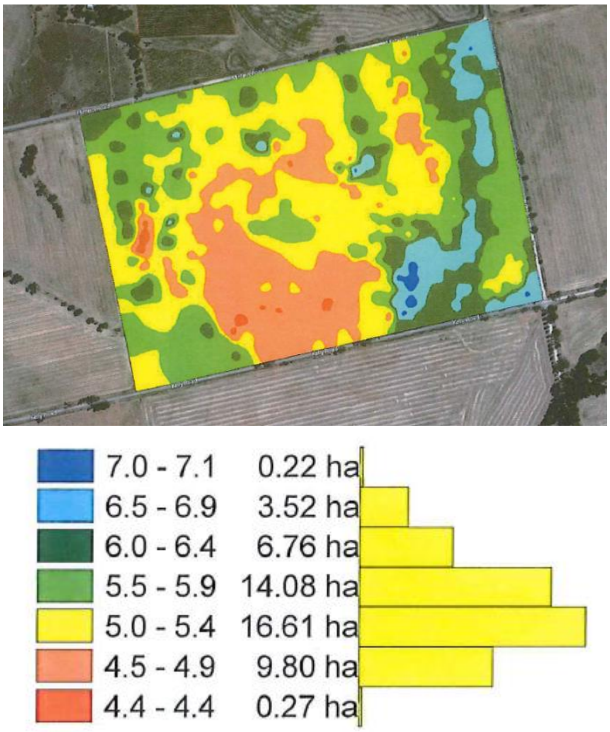

Figure 5: Soil pH Veris® map

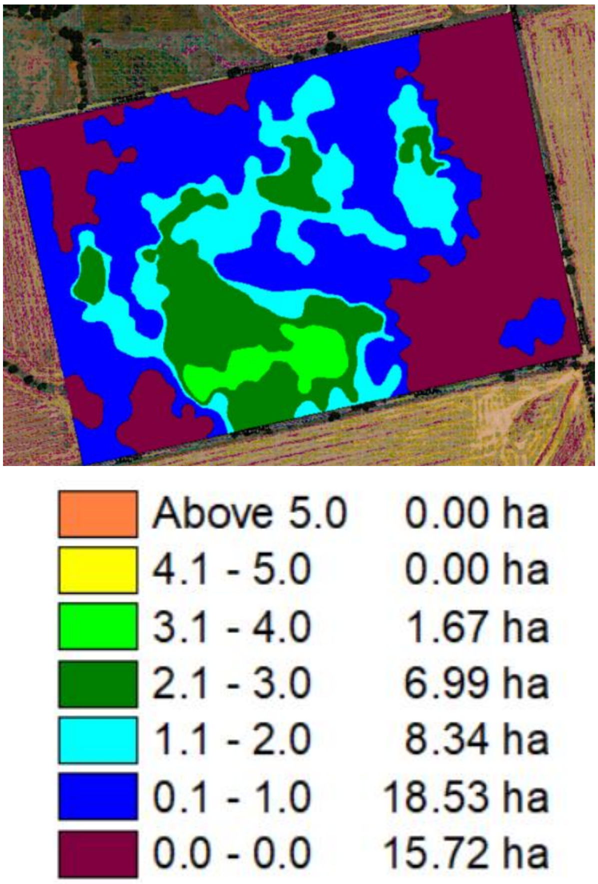

Figure 6: Lime (t/ha) prescription map

the Veris® machine takes about 8-10 points per hectare.

Once the data has been downloaded then soil pH maps can be produced. The maps show pH zones across paddocks and from this it shows where lime should be targeted, and appropriate liming rates can be calculated for each zone.

By applying lime only where it is needed rather than a 'blanket' application results not only in improved soil pH conditions across the paddock but also helps to save costs.

Figure 5 and 6 shows an example of a soil pH map and a lime prescription map in the Northern and Yorke Landscape Region.

The soil pH map shows the soil pH variation across the paddock. The lime prescription map shows where lime needs to be applied in the paddock and at the right rates to rise the soil pH to 5.5 ($CaCl_2$).

In this case, applying lime at a variable rate and taking into account the cost of soil pH mapping has reduced costs by 30% compared to a blanket application of 3t/ha.

Treatment of acid soils

Acid soils can be treated either with lime or in the sandy areas soil modifications such as ripping, delving, spading or clay spreading can be carried out provided that the underlying clay has a neutral or an alkaline soil pH.

Lime

Lime is used to neutralise soil acidification (Figure 7). The amount of lime required to treat acid soils depends on the initial soil pH, the target soil pH, soil texture and lime quality. For practical purposes, the aim is to keep the pH of the top-soil above 5.5 ($CaCl_2$).

The following equation gives a guide to the lime requirement:

Lime requirement (t/ha) = (Target pH – Current pH) x soil texture factor

Texture factor: Loam to clay loam 4; Sandy loam 3; Sand 2

For example: to raise a sandy loam of pH 4.8 ($CaCl_2$) to pH 5.5 ($CaCl_2$)

(5.5 - 4.8) x 3 = 2.1 tonnes of lime per hectare is required.

Reduce rates by 25% if organic matter is low.

Do not raise the soil pH any more than one unit at one time as this may induce trace element deficiencies such as manganese or zinc.

The lime requirement is based on a pure lime of 100% Neutralising Value. If the material is less than this then higher rates of lime can be used. For example, if you need to use 2 t/ha and the lime has NV of 80% then 100/80 x 2 then 2.5 t/ha could be used.

The finer the liming material, the quicker the lime will react in the soil. However, finer particles are often difficult to spread because they tend to block up the spreader and can drift.

A mixture of fine and coarse particles will overcome spreading difficulties, but the coarser particles will react more slowly. For the best effect 65% of the lime should have a particle size less than 0.3 mm. Lime with a high NV and small particle size will give the quickest response.

The Effective Neutralising Value (ENV) takes into account the NV and the particle size. For quickest response the ENV should be greater than 65%.

The cost of the lime per hectare depends on the lime quality (NV and particle size), freight costs, distance travelled from the lime source to the paddock and the application costs.

In the Northern and Yorke landscape region lime can be obtained from a number of sources.

A decision support tool for calculating lime application rates for acid soils and comparing the cost of lime from different lime suppliers

Figure 7: Spreading lime in the Northern and Yorke landscape region.

for your paddock taking into account the cost of lime, lime quality (NV or ENV), freight and distance has been developed by PIRSA. This is available from the web-site: https://acidsoilssa.com.au/.

In a no-till farming system, lime should be applied on the surface in the Autumn (several months before sowing crop or pastures) to allow time for the lime to react in the soil.

As lime does not move quickly through the soil, mixing lime within the top-soil with tillage will improve its effectiveness. Lime may take up to two to five years to be fully effective.

Once the top-soil has been raised to pH 5.5 ($CaCl_2$) a maintenance rate of lime would be required about every 10 years.

Liming trials have been established as part of a GRDC project in the Northern and Yorke Landscape region at Sandilands (Yorke Peninsula), Bute, Mallala, Wirrabara, Koonunga, Kapunda and Spalding to compare and evaluate lime sources and rates and determine increases in crop and pasture yields.

Further information can be sourced from https://acidsoilssa.com.au/.

Soil modification

Other options for the treatment of acid soils is ripping, delving or clay spreading by mixing neutral or alkaline clay throughout the top-soil. The pH of the subsoil clay should be checked before using these methods.

Summary

Soil acidity is an emerging and significant problem throughout the Northern and Yorke Landscape Region and is having an effect on soil health and the productivity of crops and pastures.

Both surface and subsurface soils should be monitored on a regular basis, at about every five years to determine soil pH.

Soil acidity can be prevented and treated through liming or in sand over clay areas soil modifications such as ripping, delving or clay spreading may be an option.

Reference

Price. G. (2006) *Australian Soil Fertility Manual (Third Edition).* Australian Fertiliser Federation and CSIRO**.**

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More information

Further information can be obtained from the website at: https://acidsoilssa.com.au/

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