Prepared for the Northern and Yorke NRM Board

Lime for Acid Soils

Sustainable Agriculture in the Northern and Yorke NRM Region.

Lime is the most effective method for the treatment of acid soils.

Within the Northern and Yorke Region there are more than 270,000 hectares of land susceptible to soil acidification that degrades the soil and reduces crop and pasture growth. Soil acidification tends to occur on the sands and sandy loams in the high rainfall areas, north of Kapunda through to Jamestown and from Crystal Brook through to Melrose with a smaller area around Redhill (Figure 1).

Soil acidification is caused by an accumulation of hydrogen ions in the soil through the build-up of organic matter; addition and leaching of nitrogen from fertilisers and legumes and the removal of alkaline nutrients in plant and animal products. As the amount of hydrogen ions increases then soil acidity increases.

When the soil falls below a soil pH of 5.0 ($CaCl_2$) the productivity of even tolerant crops and pastures starts to fall, toxic amounts of aluminium can be released into the soil, microbial activity starts to decline and nutrients such as phosphorus, magnesium, calcium and molybdenum become less available. Table 1 shows the tolerance of plant species to soil acidity.

Table 1: Tolerance of plants of soil acidity

Species	Tolerance
Canola, faba beans, lucerne, annual medic	Very Sensitive
Barley, wheat, peas, phalaris	Sensitive
Lupins, wheat, sub-clover, cocksfoot, vetch, fescue, perennial rye-grass	Tolerant
Triticale, oats, seradella	Very tolerant

Lime for acid soils

The use of lime will raise the soil pH and increase the productivity of crops and pastures.

The top-soil should be kept at soil pH above 5.0 ($CaCl_2$) but to allow for paddock, crop type and soil sampling variability it should preferably be at or above pH 5.5 ($CaCl_2$).

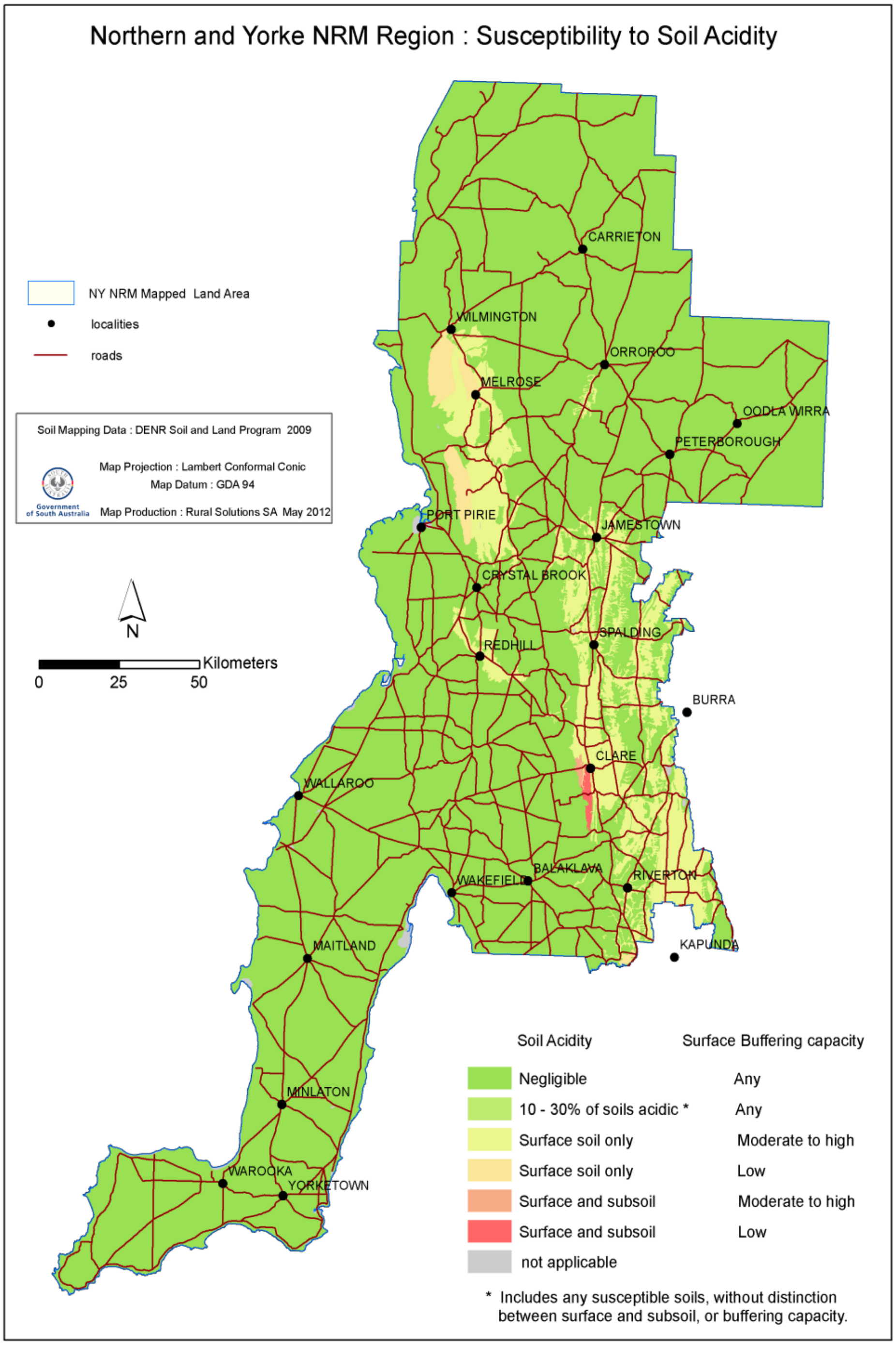

Figure 1: Area susceptible to soil acidity

Research work (Figure 2) in the Lower North has shown that liming acid soils can substantially increase crop yields. In this trial, lime was applied in the Autumn of 1999 and the results are from the harvest of 2000. The initial soil pH for both trials was 4.7 ($CaCl_2$) and the pH was measured at harvest in 2000 for each treatment.

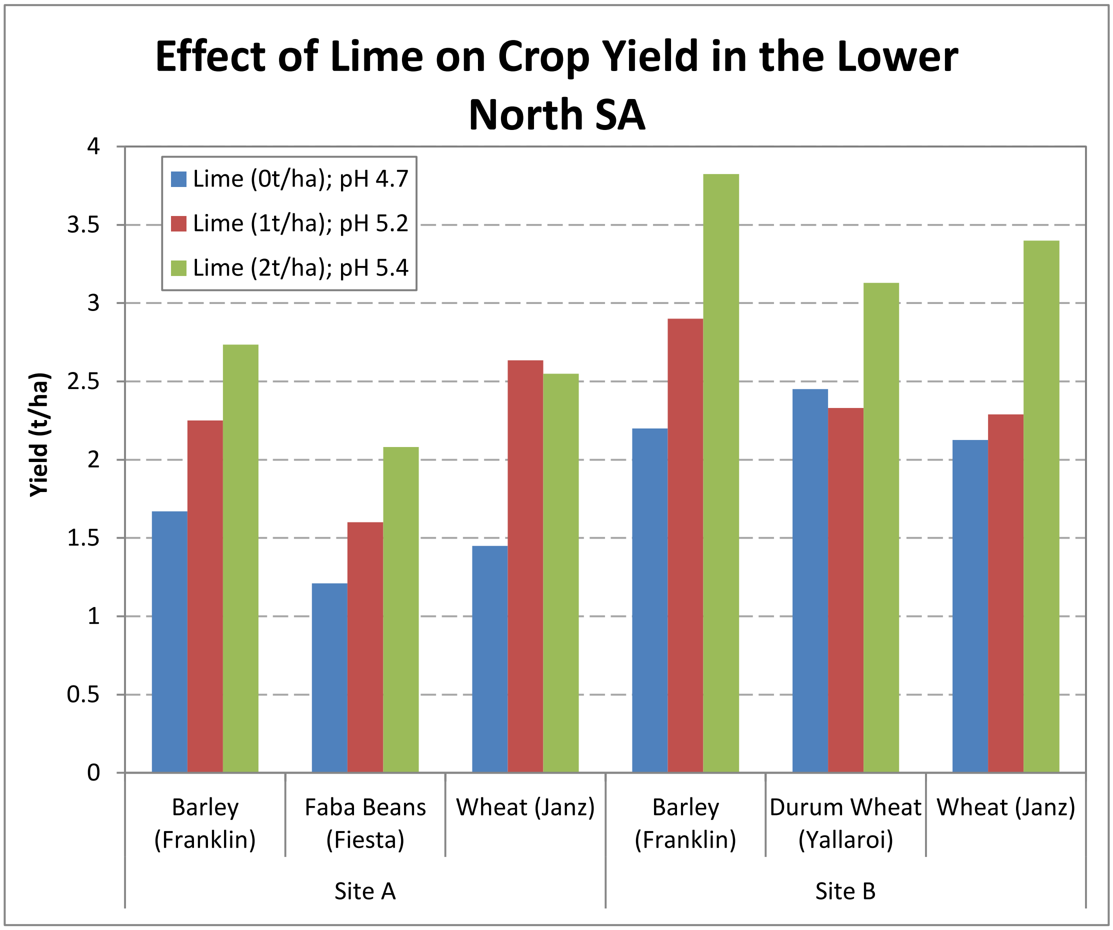

Figure 2: **Effect of lime on crop yield in the Lower North SA (Farhoodi, 2002)**

From site A there has been an increase in wheat yield by 1.15 tonnes. Based on a price of \$250/tonne this is an increase of gross income by \$287.

Lime Sources

Lime (calcium carbonate) and other liming sources such as dolomite (magnesium carbonate) reduces soil acidity by neutralizing acid reactions in the soil. The carbonate component reacts with hydrogen ions in the soil solution and in doing so raises the soil pH. There are a number of lime sources such as:

- Agricultural limestone: crushed and sieved limestone – mainly calcium carbonate;
- Lime sand: mined from natural deposits and mainly calcium carbonate;
- Dolomite: dolomite is often a mixture of magnesium and calcium carbonates;
- By-product of soda ash production: This contains mostly calcium carbonate with some calcium oxide and hydroxide.

Lime Quality

When using lime aspects of lime quality need to be considered. These include its Neutralising Value (NV) and particle size.

As carbonate is the key agent for neutralizing the acid in the soil, the amount of carbonate in the liming source is important. The NV is an indicator of this. The higher the NV the greater the capacity the liming source has to neutralize soil acidity. Good quality liming materials should have a NV of greater than 80%.

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 in the spreader and drift in the air. A mixture of fine and coarse particles will overcome spreading difficulties but the coarser particles will react more slowly. For the best effect lime particles should be no greater than 0.3mm. Lime with a high NV and small particle size will give the quickest response.

Agricultural lime suppliers are required to provide a laboratory analysis of the NV and particle size of their liming materials.

Application Rate

The amount of lime required to counteract soil acidity depends on a number of factors such as the existing soil pH; desired or target soil pH; soil texture and lime quality. For practical purposes the aim should be to keep the top-soil above pH 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 soil 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.

As can be seen from the texture factor more lime is required to raise the soil pH in clays than in sands so it is important to know the soil's texture. No more than 3 t/ha of lime should be applied at any one time as this can upset the soil nutrient supply. An even rate of spread is essential. If more than 3t/ha is required then split the application over several years. The lime requirement calculation is based on a lime NV of greater than 80%. If the NV is lower than this, higher rates of lime can be used.

Incorporation

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

As lime does not move readily through the soil, mixing it in the top-soil with tillage will improve its distribution in the soil. The ideal time to mix the lime into the soil is just before sowing a crop or before renovating pastures. The incorporation of lime into the soil will provide the quickest results.

Comparing lime sources

Factors in comparing lime sources are purchase price, freight, NV and particle size of the lime. A high proportion of the lime particles should be less than 0.3mm. Most of the lime sources in the Northern and Yorke region have a fine particle size, with more than 90% of the material having a particle size less than 0.3mm. To compare different lime sources, total costs need to be converted to 100% of the NV.

Table 2 show an example of two lime sources, one source has a NV of 96% while the other source has a NV of 60%. It shows that the effective costs ($/t for equivalent of 100% NV) of the two products are reasonably similar with a difference of $4.38 (Table 2). Table 3 shows examples of freight and spreading costs. The spreading costs are based on contractor costs. Using lower quality product means that you have to spread / freight more tonnes to get the equivalent NV. The further the lime needs to be transported the higher the NV needs to be.

Table 2: Effective costs of lime products

	Lime source 1: – NV 96%	**Lime source 2: - NV 60%**
Cost	$15 /tonne	$12 /tonne
Effective cost	100/96 x $15 =$15.62/t	100/60 x $12 = $20/t

Table 3: Freight and spreading costs

	Lime source 1: **100 km from farm**	**Lime source 2:** **50 km from farm**
Application rate required	2 t/ha	Equivalent rate 3.2t/ha
Freight costs per tonne ($0.10/km/t)	$10	$5
Spreading costs per tonne	$12	$12
Total costs per tonne	$37	$29
Cost per hectare	$74	$92.80

In this example the lime source with the highest NV but further away is the cheapest source to use per hectare.

Precision Agriculture

There is often a large variation in soil pH across a paddock. Often a lime application rate is based on a single soil test representing the whole paddock. Ideally it is best to take a number of soil samples in a grid system across the paddock for a better indication of the soil pH however, this is time consuming and expensive. Recently, some work has been done using pH precision mapping machines. These machines take pH readings from numerous points in a grid system across the paddock. Using this information paddocks can be mapped and liming zones determined. Rather than applying a 'blanket application' of lime across the paddock, lime can be applied at appropriate variable rates. Identifying the correct rates of lime for different areas of the paddock may reduce the total amount of lime applied compared to a blanket-rate (Table 4). Where more lime is required than the paddock rate the cost will be out-weighed by the improved yield potential.

Table 4 shows an example of the benefits of splitting a paddock into zones. Sixty three percent of this paddock required no lime. If the paddock had been sampled in zone 1 and the whole paddock limed based on the pH of that zone, then unnecessary costs would have been incurred. If zone 3 was sampled and no lime was applied then there would have been a potentially significant yield loss in Zone 1 and 2.

The cost of soil pH mapping using a pH precision mapping machine for a 40 hectare paddock is about $280 (excluding travel costs). In this example pH mapping and zoning saved $885 ($1,165 - $280) across a 40 hectare paddock or $22 / hectare.

Table 4: Soil pH results and liming costs for a sandy loam.

	Size (ha)	**Category top-soil pH ($CaCl_2$)**	**Lime (t/ha)**	**Total cost ($37/t)**	**$/ha**	**Cost of whole paddock treatment based on pH 5.0**
Zone 1	10	4.8 – 4.9	2.1	$777.00	$77.70	$555.00
Zone 2	5	5.0 - 5.4	1.5	$277.50	$55.50	$277.50
Zone 3	25	5.5 – 5.6	Monitor	$0.00	$0.00	$1,387.50
Total	40			$1054.50		$2,220.00

Cost/benefit

Research shows that the short term response to lime can be profitable and long term profitability ensured by maintenance of soil productivity (Figure 2). Economic responses have been achieved with most field crops and the cost of lime is often reimbursed in the first or second year. The benefits of liming will last for at least 5-6 years so the cost of applying lime (year 1) can be amortized over that period.

Summary

Liming is the most effective and economical way to improve the soil pH of soils, to improve soil health and maintain crop and pasture productivity. When using lime the lime source, quality, rate and areas of spread all need to be considered. The benefits of lime will last for at least 5-6 years. After this time the soil pH should be monitored and a maintenance application of lime may be required.