Choosing lime – what you need to know to make better decisions

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KEY MESSAGES

- Lime quality is affected mainly by its neutralising value and particle size and solubility plays a minor role affecting performance in the first 6 to 12 months
- A high quality lime has a NV above 90% and contains a high proportion of particle sizes less than 0.1 mm
- There are calculators available that can help growers compare the cost effectiveness of limes

BACKGROUND

The purchase of lime is a large upfront cost for growers and understandably they want to feel confident that their choice of lime is a good one and ameliorate any acidity. Lime quality is a major factor that affects the extent of pH change and the time frame in which pH is changed.

There are three factors which control lime performance:

- Chemical composition determines the quantity of base applied to the soil and is accounted for in neutralising value (NV).
- Particle size determines the surface area of lime exposed to the soil volume and its distribution throughout the soil.
- Solubility determines the tendency of the material to dissolve and hence the rate of the reaction of a given particle size in the first 6 to 12 months.

Lime Quality Indicators

NV is a measure of the lime's ability to neutralise acidity and is therefore the most important factor in selecting a lime. Pure calcium carbonate (or pure limestone) is taken as the standard with an NV of 100%. The higher the NV the more pure the product is. Lime products sold in Victoria commonly have an NV of 80 to 90%. Dolomite ($Ca_{0.5}$ $Mg_{0.5}$ CO_3) and burnt lime (CaO) can have a NV greater than 100 percent due to their lighter molecular weight compared to calcium carbonate.

Particle size determines the amount of soil contact and coverage and how fast this reaction will occur. For example Cregan et al, 1989 mathematically calculated the amount of lime needed at different sizes to give complete coverage over one hectare. Particle diameters of less than 0.15 mm achieved complete coverage at rates close to 2.5 t/ha but 18 t/ha would be needed if the lime is greater than 1 mm (see table 1).

Table 1. Total amount of surface applied lime required to cover 1 ha at different particle diameters (mm).

Particle Diameter (mm)	Amount of lime needed to cover 1 ha (t/ha)
1	18.1
0.5	9.1
0.25	4.4
0.15	2.7

The effect of fineness on the speed of pH change is demonstrated in figure 1. This is based on an experiment at Wagga Wagga Agricultural Institute where a hard calcitic lime was incorporated to a 10 cm depth. This study is currently unpublished but was used by the NSW Department of Primary Industries 'Limes and Lemons' extension programs in the nineties.

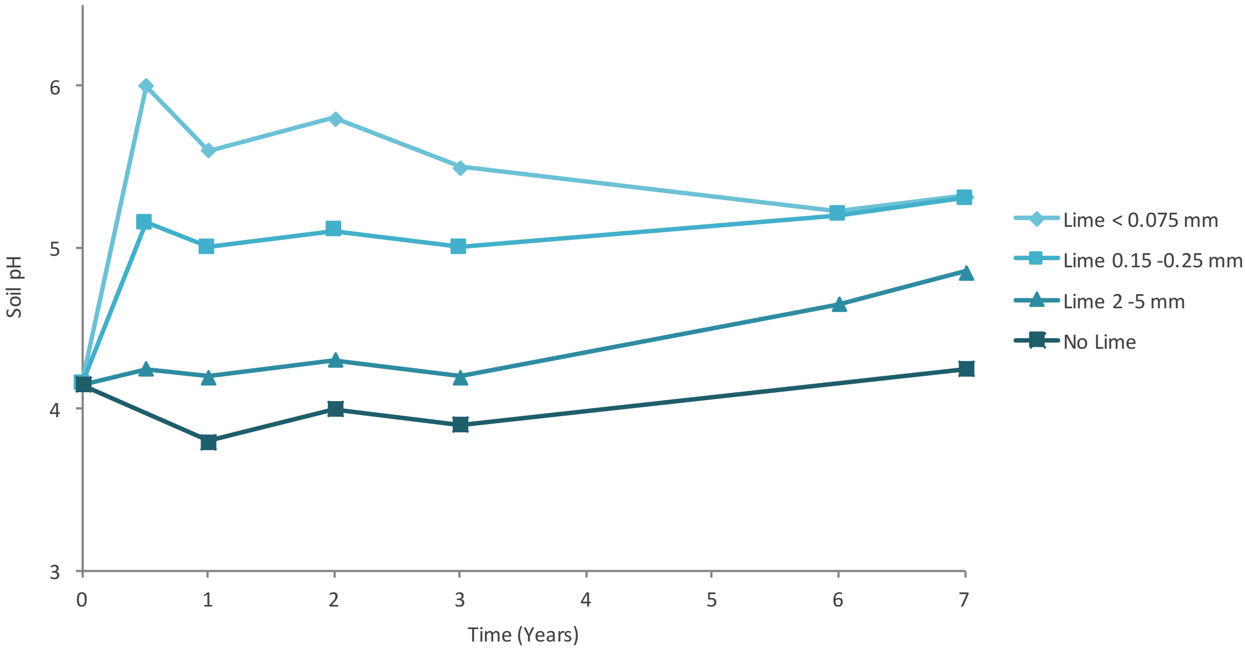

Figure 1. The change in pH over time using different lime particle sizes.

The diagram shows that the finer the lime the greater the increase in pH and that coarse lime (2-5 mm) did not achieve the same pH change after seven years. The bottom line is that coarse particles may never catch up. This is because the soil surrounding the lime particle reacts with the acidity and the pH becomes high and the lime ceases to dissolve, meanwhile the surrounding soil continues to acidify. Trials have also demonstrated that decreasing the particle size of lime will increase the rate of lime leaching which is important if trying to ameliorate subsurface acidity (Whitten, 2000). The implication is that the purchase of cheap coarse lime regardless of its NV may not be a good investment.

The emphasis on the importance of lime particle size has been lost over the years. Part of this reason is that the reporting of many quality factors including NV, particle fraction sizes and Effective Neutralising Value (ENV) was removed from mandatory reporting under the under the Victorian Fertiliser and Veterinary Regulations (Control of Use) in 2005. Now commonly only the proportions of particle sizes greater than 1 mm are reported. However, if you want a fast response to lime then a high percentage of the lime should be less than 0.1 mm. To make informed decisions on the purchase of lime, growers need to pay for the cost of a lime quality report by a NATA accredited testing laboratory which costs $75 to $100 per sample as there is currently very little information on particle size provided to growers by lime producers.

Solubility affects the lime's initial performance (first year) and for this reason is less important for consideration compared to NV and particle size which govern the limes overall performance. Solubility is linked to the type of liming material. NSW Agriculture field testing of 12 nationally available commercial limes including two from Victoria, found soft limes perform 20% more efficiently and dolomites 15% less efficiently than calcitic hard limes in the first 6 to 12 months after liming (Conyers et. al, 1995). By 12 to 24 months after application these differences disappeared. In the absence of information on different limestone solubilities, it was proposed that this information could be used as surrogates for the relative solubilities of these groups of liming materials.

This conclusion supports what is seen in field studies where soft limes have resulted in pH change down to about 5 cm after 12 months compared to rates quoted of 1 cm per year which presumably was based on findings using hard limes. However it could be that 1 cm per year is typical of lime movement after the first year.

Approximately 90% of liming products sold in Victoria are regarded as soft limes which are physically softer than harder limes. Examples of hard calcitic limes in Victoria are limes from Lilydale and Buchan and they are generally finer than soft limes as they undergo more processing. Dolomite is a naturally occurring blend of magnesium carbonate and calcium carbonate.

Tools to help growers compare limes

There are a number of tools that allow producers to make comparisons between different liming materials by accounting for both NV and particle size such as the ENV calculation shown below.

ENV = NV × [(% lime > 0.85mm × 0.1) + (% lime 0.3mm to 0.85mm × 0.6) + (% lime < 0.3mm × 1)]

Generally the tools are based on an NV multiplied by the percentage of lime contained in different sieved fractions which are rated by their effectiveness at changing pH. All of the states agree that the finer the lime the higher its effectiveness at changing pH but at what particle size to set the 100% effectiveness rating varies across states. A comparison of effectiveness ratings is shown in table 2.

An ENV calculation first originated in US (Adams, 1971) where 0.3 mm particle size was set at 100% effective because a 0.3 mm sieve was the finest used. The ENV method was studied in pot trials by the Victorian Department of Agriculture in 1987 for use for comparing limes in Victoria (Greenhill et al, 1987). They slightly changed the range of sieved particle fractions to fit their standard sieving practices. The calculators originating from WA use ratings modified from Cregan's DPI, NSW work in 1989 (Gazey, 2010). The NSW DPI calculator bases its effectiveness on field data from 1992 trials (Scott et al, 1992) and involved commercially available lime products. It best reflects that the finer the lime, the more effective it is. Its use is described in "Limes and Lemons".

Table 2. Effectiveness ratings of different particle sizes which are used in different calculations and calculators for lime quality comparisons.

Vic. ENV calculation	NSW DPI Lime comparison calculator, 2003	WA DAFF calculator & the Soil Quality online Lime Comparison Calculator
< 0.3 mm = 100% 0.3 to 0.85 mm = 60% >0.85 mm = 10%	< 0.075 mm = 100% 0.075 to 0.15 mm = 58% 0.15 to 0.25 mm = 42% 0.5 to 1 mm = 34% 1 to 2 mm = 22% > 2 mm = 12%	<0.125 mm =100% 0.125 to 0.25 mm =100% 0.25 to 0.5 mm = 100% 0.5 to 1 mm = 50% > 1mm = 20%

The cost effectiveness of different limes spread is commonly compared using the following formula:

Unit cost of ENV = Total cost per tonne spread ÷ ENV%

This is a simple calculation but it can be misleading as it does not take into account additional costs of having to purchase and spread lime which has a lower NV value. For example quality factors of two limes are shown in table 10. Lime A is slightly cheaper per unit cost of ENV and so would be considered more cost effective. However, if the grower decided to use Lime B then they need to purchase 19.1% more of it to have the same neutralising effect. That is for every 1 tonne of Lime A, they would need to purchase 1.27 t of Lime B.

Table 3. Quality and cost factors for two different lime products.

Quality and Cost Factors	Lime A	Lime B
Type	Soft earth lime	Soft earth lime
Neutralising Value %	90%	70.9%
Material > 5mm	0.5%	0%
Material 2mm – 5mm	3.4%	16.3%
Material 1mm – 2mm	8.7%	22%
Material 0.85mm –1mm	2.9%	10.3%
Material 0.3mm – 0.85mm	40.7%	28.5%
Material 0.075mm – 0.3mm	38.7%	17.3%
Material < 0.075mm	5.1%	5.7%
Effective Neutralising Factor	62.8	75.5
Cost $/t spread	$68/t	$35/t
Unit cost $ per ENV	$1.08	$1.10

Most lime calculators compute an ENV type sum that allows comparison between different limes, but also include an NV rate adjustment factor so that the limes can be compared fairly and the paddock costs ($/ha) calculated based on the rate of product to be used. What these calculators do not account for is the effects of solubility. Rules of thumb can be applied particularly if seeking a fast response, which is soft limes are 20% more effective and dolomite 15% less effective at changing pH than hard calcite limes in the first 6 to 12 months (Conyers et al, 1995).

Spreadsheets for calculators are available from SFS. New calculators are also under development. The soil quality lime comparison calculator can be found at the web address: http://www.soilquality.org.au/calculators/lime_comparison

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