Don't forget the lime!
By Tectra Regional Manager, Western North Island

Nitrogen use on hill country pastures has attracted a huge amount of interest in recent times. The concern that most commonly comes up in farmer discussion groups is that it will "acidify the soil and destroy it".

In fact it is not the nitrogen fertiliser that is doing the acidifying, but the increase in growth rate of the pasture, and the faster nutrient cycling rates as a result of improvements in soil health. This extra acidity is easily neutralised by the addition of a bit more lime.

Soils will always acidify over time.

It is a perfectly natural process that is the result of plants or soil organisms taking up positively charged nutrients (e.g. Calcium or Magnesium), or converting a positively charged nutrient to a negatively charged nutrient (e.g. Ammonium to Nitrate).

When a plant or soil organism absorbs positively charged ions, it has to balance its charge by excreting hydrogen ions, which are also positively charged. The more hydrogen ions there are in the soil, the lower the pH[1] (the more acid it is). Therefore any process or environmental condition that improves plant growth or soil health and thus increases the rate of nutrient uptake (higher fertility, better moisture levels, warmer temperatures, more sunlight) will result in faster soil acidification.

Lime has had a long history within agriculture since ancient farmers first noted how well pastures grew in soils derived from limestone. These soils were deemed to be "sweet" and poorer soils were "sour". By applying limestone to the "sour" paddocks they raised the pH of the soil, which started a cascade of effects that combined to result in healthier, faster growing pastures and healthier, better quality soils.

Lime consists mainly of calcium carbonate.

The calcium improves soil structure and aids both drainage and root penetration… better root penetration will improve the pasture's ability to access soil moisture in summer dry areas. Gypsum will also provide calcium to the soil, but will not affect pH. Gypsum is the main component (50%) of Superphosphate.

Carbonate is the part of lime that affects the pH of soil. This is negatively charged when dissolved in water. The carbonate binds with positively charged hydrogen found both in the soil solution and on soil particles, and produces carbon dioxide and water. By reducing the number of free hydrogen ions in the soil, the carbonate reduces the soil's acidity i.e. raises the pH.

Most plants grow best in a relatively narrow range of acidity, though the exact range will vary from species to species. Pasture plants grow best at a pH of between 5.8 and 6.2 (the exception is on peat soils which run at a much lower pH). The further you go away from this ideal range, the more the pasture will struggle to grow and the lower the production will be. Most hill country pastures run at a pH of 5.2 – 5.6, which is considerably lower than ideal[2].

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[1] pH is a measure of acidity and uses the scale 1 (very acid) to 14 (very alkaline) with 7 being neutral.
[2] Information supplied by Fert Research.

Acid soils also have higher levels of free aluminium ions and aluminium is toxic to roots, particularly clover roots. This results in clovers being effectively root pruned which leaves them vulnerable to dry spells and reduces their ability to compete with grasses for nutrients. Without clovers, hill country soils struggle to obtain enough nitrogen and potential pasture growth is substantially reduced.

Research funded by Fert Research which is soon to be published has shown that in dry hill country, on the southerly facing slopes where clover manages to survive, significant pasture growth responses to lime applications can be achieved. This is a combined result of both the action of calcium on soil structure and the effect of pH on the availability of aluminium, manganese and molybdenum. Adjusting the pH to create an environment more suitable for clover enhances the ability of clover to survive and thrive. Where there is more clover there is more nitrogen going into the nitrogen cycle and grasses perform better.

So how do we fix a low pH?

To raise pH by 0.1 of a unit – i.e. to go from 5.2 to 5.3 – you need approximately 1 tonne of good quality Lime per ha. More will be needed if using poorer quality lime (i.e. less carbonate). Most pastures will maintain a fairly stable pH if around 2.5 tonnes per ha of lime is applied every 3 – 4 years. To increase the pH you will need to either apply more lime per dressing, or apply more often.

As a rough rule of thumb, for every 1 kg of phosphorus applied in the form of Superphosphate, you will need to apply 0.8 kg's of lime at some stage to compensate for the increased growth rate that results[3]. Other practices such as nitrogen use, pasture renewal or improved pasture utilisation (which improves the nitrogen cycle) will also impact on lime requirements. It is perfectly realistic to add up your requirement for several years, and then apply several tonnes per ha of lime in one dressing.

Some fertilisers have a liming effect built in, for example Reactive Phosphate Rock (RPR). Phosphate rocks that are sufficiently soluble to apply directly to the soil (RPR) have a reasonable amount of calcium carbonate in their structure (calcium carbonate = lime). Added to this, the process of converting the phosphorus in RPR into the soluble form that is available for plant uptake consumes Hydrogen ions and this also reduces acidity. It is estimated that the liming value of 1 kg of phosphorus from RPR is roughly equivalent to 3.2 kg's of lime.

Lime is fairly insoluble and takes a very long time to fully dissolve into the soil. It will normally take 12 – 18 months to see a noticeable improvement in pH.

This delay in lime's effect on pH means that paddocks destined for a crop other than pasture may need lime applied up to 2 years prior to sowing. This is one reason why planning pasture renewal or crop rotations well ahead is so vital. Incorporating lime into the soil during cultivation and/or using a finer grade of lime will reduce the time taken to increase the pH.

Lime can be applied at any time of the year, though care should be taken when applying heavy rates (>5 tonnes/ha) in early spring. The extra calcium can interfere

[3] If you don't see a response to fertiliser application, either you don't need to apply any fertiliser for a while, or something else is limiting the pastures ability to increase growth e.g. deficiency's in other nutrients, trace element imbalances, lack of moisture, excessive compaction, poor drainage etc.

with magnesium uptake by both plants and animals in the short term, and may make magnesium deficiencies (e.g. grass/magnesium staggers) normally experienced at that time worse.

As with all fertilisers, avoid grazing immediately after application, ideally waiting until 25mm or more of rain has fallen to wash the fertiliser or lime from the pasture.

Element/Compound	**Common Name**	**Formula/Symbol**
Ammonium (ion)		NH_4^+
Calcium		Ca
Calcium (ion)		Ca^{2+}
Calcium Carbonate	Lime	$CaCO_3$
Calcium Sulphate	Gypsum	$CaSO_4$
Carbonate (ion)		CO_3^-
Hydrogen (ion)		H^+
Magnesium		Mg
Magnesium (ion)		Mg^{2+}
Magnesium Carbonate	Dolomite	$CaCO_4.MgCO_3$
Manganese		Mn
Molybdenum		Mo
Mono-calcium Phosphate	Superphosphate	$Ca(H_2PO_4)_2$
Nitrogen		N
Nitrate (ion)		NO_3^-
Phosphorus		P
Phosphate (ion)		PO_4^-
Reactive Phosphate Rock	RPR	$Ca_{10}(PO_4)_{6-}x(CO_3)_x(F_2OH)_{2+x}$