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Whole farm management of acid soils

Bruce Clements

NSW Agriculture, PO Box 1386, Bathurst NSW 2795

Abstract. In tablelands areas of NSW, the extreme variability of landscape features can often limit management options and responses to soil acidity. There are many factors at play that may close-up/exclude or limit options for treating or reducing soil acidification. Some of these factors include: topography and land class, sub soil acidity, soil depth, pasture type or species, other limits to pasture production, pasture growth patterns, poor utilisation of pastures, low stocking rates or carrying capacities, low livestock returns, cost of lime and re-sowing of pastures. Sensible management of soil acidity on a whole farm basis must take into account all these factors.

Soil acidity has long been recognised as a problem in the tablelands, as outlined in a review of acid soils research in the Southern Tablelands covering over 30 research papers from the 1940's to 1987 (Dann 1997). This is a very large topic to cover, and because my experience is in the Central Tablelands, I will limit my discussions and observations to the tablelands, and to pastures only. An alternative title to this paper could well have been, 'Landscapes, Lime and Livestock'.

Soil acidity is caused by a number of factors, including age of the soil, parent rock material, rainfall and organic matter levels. Some tablelands soils are naturally quite acidic, that is they have a low pH and soil acidity problems even in their natural timbered state. However, agricultural use and pasture improvement have led to an increase in the rate of acidification in some of our soils. This agriculturally induced acidity is mainly caused by nitrate leaching, increased organic matter accumulation and product removal. These factors have been described elsewhere in much more detail (Fenton *et al.* 1993).

Acid soil problems generally only start to occur when pH ($CaCl_2$ test) is less than 5.0 for acid sensitive species and 4.5 for more acid tolerant plants. An indication of soil acidity levels in the tablelands can be gained from some 1100 soil tests examined by G. Kelso, former district agronomist at Bathurst. Approximately half had pH <4.5, 35% were in the pH range 4.5 to 5.0 and only 16% had a pH>5.0.

Several specific soil chemical and biological problems have been identified in acid soils. However, it is often difficult to distinguish between them, as the symptoms can be similar and many factors interact. The more important problems are:

- Aluminium toxicity
- Manganese toxicity
- Molybdenum deficiency
- Legume nodulation failure
- Calcium and magnesium deficiency
- Increase in some plant diseases

However, aluminium toxicity and molybdenum deficiency are the most common problems identified for pastures on the tablelands.

The chemistry of soil acidity is very complex, and the more we learn, the more complex it seems to become. This complexity has tended to give rise to an over-simplification of responses by farmers, advisers and industry to the point where the message often sent out is, "*If it is acid, lime it*". However, this response takes no account of other factors that may restrict the use of lime or limit the level of responses obtained and, thus, the economics of lime use, particularly in tableland pasture situations.

Management of soil acidity on the tablelands

In tableland areas of NSW, the extreme variability of landscape features can often limit options and responses to soil acidity. There are many factors at play that may exclude or limit options for treating or reducing soil acidification. Some of these factors include topography and land class, subsoil acidity, soil depth, pasture type or species, other limits to pasture production, pasture growth patterns, poor utilisation of pastures, low stocking rates or carrying capacities, low livestock returns, and the costs of lime and re-sowing of pastures. The following is a discussion of how some of these landscape factors may affect decisions, actions, production levels and returns from acid soils on the tablelands.

Topography, land class and lime use

Topography

Two important topographic features on the tablelands affecting management of acid soils are trafficability and arability. Trafficability is the ability to drive over the land. It is affected by steepness of slope and the presence of obstacles such as rocks, gullies, logs, *etc.* Around 20-25% of the Central Tablelands could be described as non-trafficable. The technology for aerial lime application does not yet exist, so liming to correct acidity is not an option. This limits management to systems that minimise the rate of soil acidification (Fenton *et al.* 1993).

Arability is the ability to cultivate land. Steep slopes, rocky, shallow/skeletal soils and erosion prone soils all preclude cultivation. Up to 70% of the Central Tablelands (including non-trafficable areas) is regarded as non-arable (Kelso *et al.* 1997). On non-arable areas, options for dealing with soil acidity are limited to management to minimise soil acidification rates, together with the use of topdressed lime (*i.e.* lime cannot be soil incorporated).

Early research experiments and trials suggested topdressed lime was ineffective, producing lower crop and pasture responses. However, more recent trials are showing quite rapid movement of lime effects to useful soil depths (Kelso *et al.* 1997; Keys and Darby 1997) on a range of soil types on the tablelands of NSW. Topdressed lime may produce a slower response than incorporated lime, but it is applicable to a much larger area of the tablelands, can be applied to existing pastures negating the additional cost of re-establishing pastures, and could be applied to native pastures.

Land classes

NSW Agriculture's Land Classification system defines land capability, and in tablelands areas relies heavily on trafficability and arability (Simpson and Langford 1996). Land that is both arable and trafficable falls into Land Classes 1, 2 and 3 (mostly class 3 on the tablelands). These better land classes can be used for cropping, lime can be spread and incorporated and they are generally the more productive and higher carrying capacity areas.

High production, necessitating higher inputs (including lime) are options for these land classes. Many producers are using lime for acid soil problems on these areas, either through a cropping phase, for special use pastures or highly productive, high input pastures. Lime use for cropping has often been shown to be profitable, and lime is often necessary to establish highly productive sensitive species such as lucerne.

Land in Classes 4 and 5 is often of lower productivity, largely based on acid tolerant native pastures and with arability and trafficability limitations. Lime use for these land classes is probably not economic, even if it was possible. Even some Class 3 land, where there are high levels of natural acidity to depth or other limitations, may not be economic to lime.

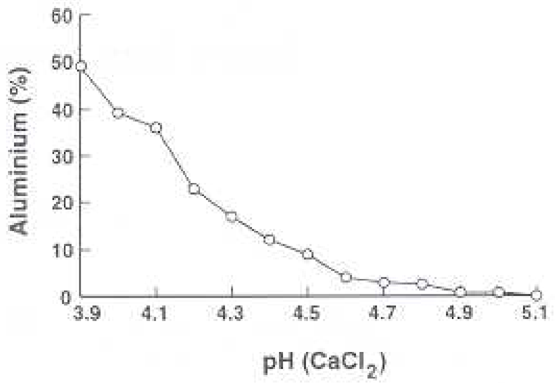

Figure 1. Relationship between aluminium (% of total cations) and pH for soil samples from the Bathurst district.

Factors that limit pasture responses to lime

pH, aluminium and plant tolerance

Most research and interest has centred on altering soil pH by using lime, and this is generally very successful (*i.e.* pH does change when soils are limed). However, what does this mean? A higher soil pH does not necessarily make more money.

Aluminium toxicity is the most common problem associated with tableland acid soils. Manganese toxicity is usually a lesser problem because many tableland soil types are low in manganese, and common pasture species are tolerant or highly tolerant of manganese. The relationship between soil pH and exchangeable aluminium percentage (aluminium as % of total cations) for the Bathurst area of the Central Tablelands is shown in Figure 1, and is virtually identical to previously published pH *versus* aluminium percentage relationships (Vimpany and Bradley 1986).

Information on plant tolerances to aluminium and exchangeable aluminium levels sufficient to cause a 10% production decline (Fenton *et al.* 1993), shows that most tableland pasture species (except lucerne) are unlikely to be affected until exchangeable aluminium level gets to around 8% or higher. Figure 1 shows that this roughly corresponds to a pH level below 4.6. Perhaps we could say from this that, on the tablelands, there is little or no pasture response likely from liming to raise soil pH to greater than 4.6. If this is the case, it is difficult to economically justify liming, especially where many tableland pastures are based on tolerant to highly tolerant species (*e.g.* sub clover, ryegrass, cocksfoot and native grasses (*Microlaena stipoides* and *Danthonia* spp.)

Soil depth

Tableland soils are often skeletal or shallow with very little topsoil, and often not much subsoil. Soil depth to bedrock may be only 30-100 cm (Kovack and Lawrie 1990). Many subsoils are also highly dispersible and act as barriers to root penetration. So, effective soil depth on the tablelands is often only 20-50 cm, and soils with greater than 1 m of effective root depth are not very common.

These shallow soils limit pasture growth through their low total water-holding capacity. Moisture stress is likely to reduce or limit pasture responses to lime and also any other nutrients. Using deep rooted perennial species, to utilise stored subsoil moisture and intercept leaching soil nitrates, must be questioned for more than 60% of the tablelands. Subsoil acidity is also common, and can be another factor that limits effective root depth of pastures (particularly for sensitive species).

Other nutrient deficiencies

Most tableland soils are generally regarded as being of only low to moderate fertility. Commonly these soils are deficient in phosphorus (P), sulphur (S) and sometimes potassium (K). Pasture growth, stocking rate, carrying capacity and profitability responses from correcting these deficiencies have in general been large, even where soils were quite acidic (Clements *et al.* 1998; Graham *et al.* 1998; Saul 1998).

Fertiliser use has declined on the tablelands, largely due to lower prices for products and relatively high fertiliser prices. Richardson (1998) estimated that only 30% of tableland farmers had maintained adequate P fertiliser programs over the last decade. Recent soil test results from the tablelands confirm this figure, with 70% or more regarded as deficient or extremely deficient for P (J. Laycock pers. comm.).

Reported pasture growth responses from fertilisers (P and S) have generally been much larger than responses obtained from lime (Bradley and Vimpany 1986; Dowling *et al.* 1997; Garden and Dann 1997), and where lime responses were recorded, they only occurred or were larger where adequate P was applied.

All this means that unless adequate fertiliser is being used, liming is not going to produce a response and is unlikely to be economic. Producers must also decide where best to invest what little money they have available. It is a worry that some producers are using lime and not fertilising their pastures.

Climate

One of the biggest limitations to stocking rates or livestock carrying capacities in the tablelands is the weather. Winter is the period of lowest pasture growth due to low temperatures and frost. Kemp and Liu (1992) demonstrated that pasture growth was severely restricted by temperatures <10°C and growth almost stopped at temperatures of <5°C, even where soil acidity and fertility were adequate. The higher the altitude in the tablelands, the more severely pasture growth is restricted by low temperature, and the longer the period of pasture growth restriction. An example of winter growth restriction due to cold can be gauged by the temperatures at Oberon, where for 3 months, the mean maximum temperature does not get above 10°C and mean minimum temperatures are <1°C.

Pasture growth curves for the Central Tablelands developed for the PROGRAZE manual show this period of very restricted winter growth (Figure 2). This reduces pasture production and limits carrying capacities. Since the temperature (and frost) effect will override any lime or fertility effect, it will further restrict potential economic responses to lime in the tablelands.

Factors that limit animal responses to lime

Pasture utilisation

In contrast to the winter growth of pasture on the tablelands, there is usually a large spring pasture growth flush (Figure 2). At this time of the year, any additional feed produced cannot really be utilised on most tableland properties, even with livestock breeding cycles matched to seasonal pasture production. Spring 1998 was a classic case, with utilisation rates for pastures often as low as 10-20%. Extra pasture production at this time of year from lime and/or fertilisers has to be greatly discounted in value. An extra 200 kg/ha of spring feed may produce no extra livestock production and, therefore, no additional income, whereas 200 kg/ha of additional feed going into winter or as green feed in summer could be quite valuable.

Pasture utilisation is also determined by stocking rate and type of livestock enterprise (*e.g.* breeding, fattening, woolgrowing). Many producers on the tablelands have fairly conservative stocking rates, and these low stocking rates can lead to very low pasture utilisation. Poor grazing management can also reduce or negate any pasture responses. This problem of utilisation and conversion of extra growth

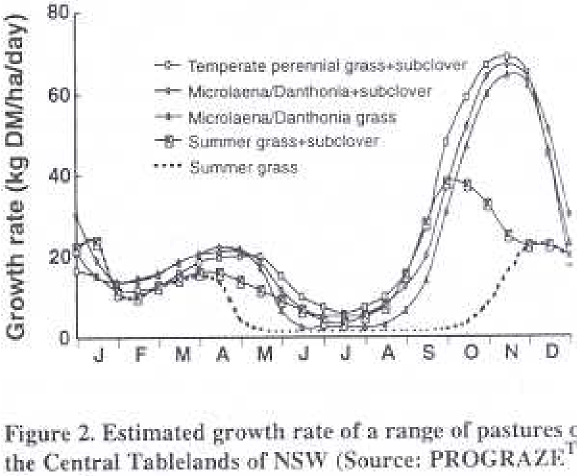

Figure 2. Estimated growth rate of a range of pastures on the Central Tablelands of NSW (Source: PROGRAZE™ Manual).

into a saleable animal product makes the economics of liming pastures a much more difficult proposition than demonstrating the economics of lime with crops. With crops, any extra production is harvested and then sold, but with livestock, it needs first to be consumed, then utilised or converted to some saleable product.

Non-profitable animal responses

Animal production responses are not always profitable or don't always result in higher prices or incomes. An example of this could be producing more but broader wool and thus lower wool returns. Other animal production responses can be recorded at certain times, but may have little effect when the product is actually sold. For example, a small extra liveweight gain in winter could be a large percentage increase in production, but may be masked or lost with time and compensatory weight gain through spring.

All these things can hinder/hide or reduce the economics of lime use on the tablelands. However, where lime is used for special pasture areas in a whole farm situation, such areas tend to have very high utilisation. Such special purpose pastures for, say, finishing, lambing, summer green feed, etc. also produce higher returns per ha than more general pasture areas.

Economics of lime use in tableland pastures

There is little or no information on the economics of lime use on the tablelands, and this is particularly so for grazing enterprises. What little information we do have for the tablelands is generally about pH and soil chemistry changes. Any pasture responses have generally been small. To investigate the full story on pastures, experiments must be grazed so that animal production responses can be measured. **We sell animal products not pH.** Animals may respond more or less than we can predict from pasture responses or pH changes.

We desperately need grazing experiments to investigate and demonstrate the economics of lime use with livestock enterprises. The current Acid Soil Action program (ASA) is going a long way towards addressing this situation. ASA now has many sites on the Central and Southern Tablelands where demonstrations or experiments will show the effects of liming acid soils, both from the sustainability and economic viewpoints. It is also hoped that this program can demonstrate acid soil management packages to tablelands producers to assist them to produce good responses and returns.

Many tablelands graziers, particularly wool producers, are currently facing an economic crisis, with low livestock returns and very low gross margins for all merino sheep enterprises (Webster 1998). These low gross margins, coupled with the often low carrying capacities of much of the tablelands, make it difficult to obtain responses from just about any on-farm spending. Consequently, producers are tightening their belts, spending less, and adopting low-input systems (Simpson and Langford 1996), especially where land class and other factors preclude cropping and limit carrying capacities and potential responses to low levels.

Conclusions

Management of acid soils on the tablelands on a whole farm basis will vary according to the characteristics of the individual farm, and needs to consider physical landscape features, climate, grazing enterprises, and economic response. The strategy used on many farms will include a whole range of approaches, including rectifying low soil pH by the use of lime, using tolerant native and introduced plant species, and adopting low input/output systems to reduce acidification, particularly on less productive areas of the farm.

There are many situations on the tablelands where lime is being used and quite large areas are being limed. For example, one Bathurst district contractor alone spreads 1500 to 2000 tonnes per month of N-Viro Soil ® (a liming product), equivalent to 300 to 400 ha being limed at 2.5 t/ha. There are several other spreading contractors also operating in the Bathurst district who spread lime, and in total, some 7,000 to 10,000 ha per year may be limed. Most of this area being limed is on better class land and is used for cropping, special purpose pastures (*e.g.* lucerne), and paddocks being re-sown to pasture. In tablelands districts, many producers have off-farm incomes and some derive most of their income as professionals (doctors, dentists, lawyers, *etc.*). A much larger proportion of these people are using lime. The main reason for this is not that they want to be more sustainable, but that they have the money to spend, and often derive big taxation benefits, making liming up to 48% cheaper for them than most full time graziers. Many graziers are not making enough profit to pay tax and may have better places to invest what money they have.

Farmers being farmers will look to improving their land and pastures as soon as there is some turnaround in their terms of trade. Liming acid soils will be a large part of this, as producers are mindful of issues such as long-term sustainability. Even now, more areas are being limed (much of it top-dressed) despite the lack of scientific or economic evidence to support this practice.

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