Chapter 3

Causes of Acidification

The major causes of the acidification process are many and varied but can be explained by examining the main causes of soil acidity.

- **Nitrogenous fertilisers**
- **Legumes in rotation**
- **Dry summer conditions**
- **Extent of perennial pastures**
- **Product removal**
- **Build up of organic matter**

These causes are summarised in Table 5 and dealt with in detail below.

Nitrogenous fertilisers

Australian soils are naturally deficient in nutrients such as nitrogen (N) and phosphorous (P), essential for the production of agricultural crops. Modern farming systems therefore require the addition of N fertiliser to crops to maintain yield, particularly where continuous cropping is practised and high value crops like canola are grown. Some forms of N fertiliser are more acidifying than others. Ammonium sulphate for example acidifies the soil as it is biologically transformed to nitrate. If any excess nitrate is not utilised by the plants, then it is available for leaching (Helyar 1990); (nitrate fertiliser applied directly and not used by plants also faces this same fate). This leaching of nitrate below the surface soil layers leads to a redistribution of cations in the soil profile, the end result being to leave more of the acidic hydrogen in the surface

layer and leaching nutrient cations such as Calcium (Ca), Magnesium (Mg) and Potassium (K) to lower soil layers or into waterways after lateral flow between the surface and subsurface layers.

Legumes in rotations

The use of leguminous plants capable of fixing their own nitrogen through the symbiotic relationship with Rhizobia bacteria in the soil, has markedly improved the nitrogen status of Australian soils (Helyar 1990, Coventry and Slattery 1991). At the same time this practice has increased the potential for increased nitrate leaching beyond that of native ecosystems. Nitrogen is an essential nutrient that is required by agricultural soils for continued crop production. The importance of nitrogen delivery (fertiliser or legumes), rate of application and the use of deep-rooted plants are all factors that will determine the ultimate rate of soil acidification.

Dry summer conditions

Hot environments where there are dry summer months, result in the build up of nitrate nitrogen due to the mineralisation of nitrogen in decomposing plant matter. When the season breaks in the autumn months, annual plants regenerating in crops and pasture systems have insufficient plant roots to capture all the nitrate in the soil before it leaches below the root zone; this results in increased acidification (Helyar 1990).

Extent of perennial pastures

The change in the landscape since clearing has decreased the perennial nature of the vegetation. Perennial root systems are capable of taking up more water and nutrients before they leach below the root zone (Helyar 1990, Ridley *et al*. 1990a) therefore, farm systems that contain fewer perennial pastures will acidify more quickly.

The need to increase the perenniality of our farming systems has been described by Ridley *et al.* (2002) as a useful means of reducing nitrate leaching and controlling water movement, ultimately leading to a reduction in the effects of salinisation.

Product removal

Removal of produce (grain, animal, pasture and trees) from a given area of land will take alkaline material with it, which if not replaced leads to soil acidification (Slattery *et al*. 1991, Moody and Aitken 1997, Noble *et al.* 1999). The most striking example here is if a lucerne pasture is cut for hay. Should 8t/ha of lucerne be removed in one year it requires 0.5 t/ha of lime, representing 20-30% of production costs, to replace the lost alkalinity in the surface soil (Slattery *et al*. 1991).

The removal of trees and shrubs over large areas of the landscape has made a significant contribution to product removal and thus accelerated acidification on many high rainfall soil types.

Build up in organic matter

Regular fertiliser use and improved pastures, particularly subterranean clover, has increased the amount of organic matter in the soil. While organic matter has many beneficial effects, the increasing amount of organic matter may make the soil more acid. However, organic matter will not build up indefinitely, and when equilibrium is reached the acidification process stops.

Table 5. Causes, effects and suggested remedial action for acidification processes.

Cause	Effect	Remedy
Legumes in rotation	Legumes contribute to a lowering of surface soil pH because the N is mineralised, which can be leached if excess rainfall carries it into the subsoil.	The use of deep-rooted perennial plants will assist in reducing leached nitrate in both cropping rotations and permanent pastures. Investigate alternative land management practices on land, which is uneconomic to use and plant to Al tolerant perennial species such as trees.
Application of fertiliser Nitrogen	Fertilisers improve crop and pasture growth leading to increased levels of nitrate production for legume crops and therefore increased nitrate leaching and a lowering of soil pH.	Apply only sufficient fertiliser to supply the needs of the plant. Identify amounts required with soil and plant tissue analysis.
Dry summer conditions	Nitrate nitrogen builds up over summer. Once it mineralises and breaks down to nitrate it can be leached during summer rainfall if plants are not present to take it up.	Provide soil cover during the summer months. Increase the amount of perennials in the farming system.
Change in vegetation	Changes in the use of the landscape and land clearing have led to a reduction in native perennial species (grasses, trees and shrubs) resulting in poorer capture of nitrate leaching down the soil profile, thus leading to faster rates of acidification.	Plant more perennial vegetation that is able to access nitrogen from deep in the soil profile. eg. lucerne in crop rotations.
Product removal	Most produce is alkaline leaving the soil more acidic following it's removal. Some produce is more alkaline than others eg. Lucerne hay is very alkaline.	Calculate and apply lime required to replace alkali from product removal and nitrate leaching. Feed hay back to stock rather than export it from the paddock. Lime frequently and at rates to replace lost alkali.