LEADA

Guidelines for managing soil acidity in dryland cropping systems

More than 186, 000 hectares of agricultural soils on the Eyre Peninsula are prone to acidification.

Soil acidity describes the condition of the soil where there is an excess of hydrogen ions. Severe soil acidity is reflected by very low soil pH.

Soils are generally most productive at pH($CaCl_2$) 5.5 to 6.5.

Strongly acid soils (<5.0 $CaCl_2$) limit crop and pasture production by;

- **Restricting root growth and reducing the efficiency of fertiliser uptake by plants**
- **Reducing the activity of micro-organisms**
- **Reducing the availability of many important nutrients, and;**
- **Increasing the availability of toxic elements.**

Species	Tolerance
Lentils, Faba Beans, Lucerne, Annual Medics	VERY SENSITIVE
Canola, Barley, Wheat (some varieties), Field Peas, Phalaris	SENSITIVE
Lupins, Wheat (some varieties). Sub-Clover, Cocksfoot, Vetch, Fescue, Perennial Ryegrass	TOLERANT
Triticale, Oats, Serradella, Lotus	VERY TOLERANT

Table 1. Species tolerance to soil acidity

Acidification of agricultural soils

Soils can be naturally acidic, however more intensive and productive farming systems can accelerate acidification. Crop and pasture plants take up alkaline cations as they grow, expelling acidic (hydrogen) ions to balance the soil charge.
The alkaline cations are often then permanently removed from the system as grain, hay or livestock.

Legume crops and pastures can contribute to acidification if the nitrogen produced is not efficiently used, as nitrate leaching also removes alkaline cations leading to soil acidity.

However, the biggest contributor to soil acidification in lower Eyre Peninsula farming systems is the application of nitrogen (N) in fertilisers. Both, the conversion of applied N fertiliser to plant available forms, and increased nitrate leaching from poor N use efficiency increase soil acidification. Modelling suggests that under high input canola/cereal production on lower Eyre Peninsula more than 90% of the total acidification can often be attributed to N fertiliser applications.

RULE OF THUMB:

On soils which are prone to acidification, to offset the acidification caused by nitrogen fertiliser applications; for every kilogram per hectare of applied fertiliser product approximately 1 kg of lime per hectare should also be applied*.

**Acidification per unit of N varies with different fertiliser products and the proportion of applied N that is leached. This rule of thumb approximates the amount of lime required to balance acidification from the application of 1 kg of N fertiliser product at around 50-65% leaching. In dry years or heavier soil types the lime requirement will be lower and in very wet years or on highly leaching soils can be much more*

Treating soil acidity

Lime can be applied to both;

- **CORRECT soil acidity where the surface soil pH has fallen below the target values of 5.5($CaCl_2$).**
- **Counteract annual soil acidification to MAINTAIN surface pH above 5.5($CaCl_2$).**

Whilst acid tolerant plant species and varieties may be used to manage the impact of soil acidity on crop and pasture production during amelioration (particularly as neutralisation of the soil acidity takes some time to occur following liming), surface applications of a liming product are the most cost effective way to neutralise soil acidity, increase pH and the long term production potential of cropping land (Figure 1).

Figure 1. Spreading limesand on acidic ironstone soil at Koppio.

Lime (calcium carbonate) and dolomite (calcium magnesium carbonate) are the two most cost effective liming products available to broadacre crop and pasture producers in South Australia. PIRSA's 'Lime Comparison tool' can help growers compare the cost effectiveness of different products in South Australia. In most cases the liming product which is of the highest quality and cheapest delivered on-farm will be the most cost effective product.

As lime and dolomite both perform the same acid neutralisation function, using dolomite only provides additional benefit if soil tests indicate low magnesium

The equivalent lime application required to annually counteract the acidification from production processes is referred to as the annual acidification rate and is expressed as kg lime/ha/year. This varies depending on the farming system, rotations, intensity of production and nitrogen fertiliser use (Table 2.)

Land use system	Typical acidification rate (kg lime/ha/year to balance acidity)
Low to medium intensity grazing	30 - 100
High intensity grazing – regular hay cuts	150
Low intensity crop-pasture rotation	100
Medium to high intensity crop-pasture rotation – Medium to high production and N input	150 – 200
Continuous cropping - high production/high N input.	≥ 250

Table 2. Farming system impact on annual acidification rates

GYPSUM CAN NOT BE USED TO NEUTRALISE SOIL ACIDITY!!

Gypsum (Calcium Sulphate) is a soil conditioner and a relatively cheap source of calcium and sulphur. Whilst it has been used in certain soil types with deep subsoil acidity to supply calcium for displacement and leaching of aluminium ions it does not neutralise acidic conditions. To neutralise soil acidity a liming product such as limesand, crushed limestone or dolomite is required.

Measuring soil acidity

Soil pH field kits are readily available at hardware and garden supplies stores and give a good indication of soil pH (Figure 2). However, a laboratory soil test should be undertaken to determine the precise pH value. Laboratories typically use two methods to measure pH. These are pH(water) and pH($CaCl_2$), which is more stable than pH(water) and is the preferred method for measuring pH.

Figure 2. Field kits give soil pH values which are approximate to pH(water).

> ***pH($CaCl_2$) values are usually 0.6 to 1.2 units lower than pH(water).***

Soil sampling to monitor acidity.

As soil acidity can vary greatly over a short distance, it is important that soil samples (15-30 cores) be taken from a consistent depth within a zone of similar soil type and paddock management history. These cores should be bulked together and thoroughly mixed to produce a representative sample of the management zone for analysis.

In cropping soils it is suggested that soil be taken from 0-10 cm in order to make appropriate management decisions. Be aware that stratification of pH can occur in low tillage farming systems, and the top few centimetres of the surface soil may have a much higher pH than at a depth of 10cm. This can be due to accumulation of alkaline plant residues at the surface or recent applications of lime.

Recent advancements in sensor technology and agricultural engineering have provided the opportunity for 'real-time' paddock scale monitoring of soil pH. These pH mapping machines are capable of rapidly testing soil pH at multiple points per hectare. The data is then extrapolated to produce a pH zone map for the paddock (Figure 3).

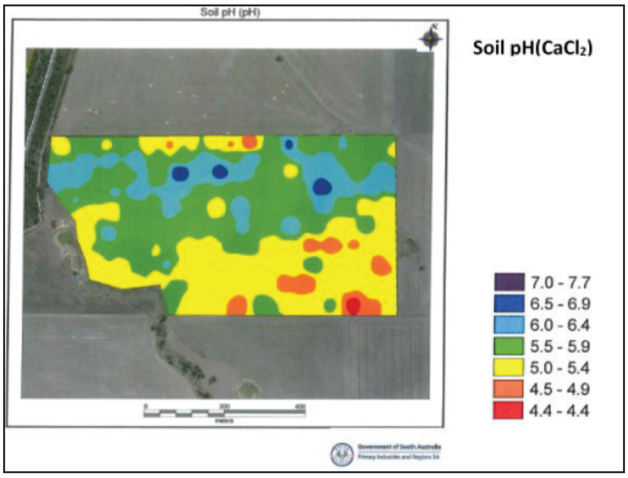

Figure 3. Paddock PH zone map.

These pH zones maps can then be used to formulate a prescription for applying variable rates of lime to different pH zones in the paddock. This has increased landholder confidence that the right amounts of lime are being applied on the right areas of the paddock, improving the effectiveness of their liming operations. In many cases, even when the cost of the mapping has been accounted for, it has resulted in cost savings.

> **Regular soil testing helps monitor soil acidification and provides information to guide decisions regarding lime and fertiliser applications.**

Lime quality and calculating lime rates.

Lime quality is a function of high nuetralising value (relating to the calcium carbonate percentage; a measure of product purity) and particle size. The combination of these parameters is expressed by Effective Nuetralising Value (ENV). High quality lime has a nuetralising value above 80% and should have a fine particle size, without being so fine that it blows offsite when spreading. When comparing different lime products for spreading, consider their cost effectiveness in terms of the tonnes of product required at equivalent to 100% nuetralising value by the cost per tonne of product delivered on farm.

The amount of lime required to increase soil pH varies according to the starting pH of the soil and the soil's buffering capacity (a function of soil texture and organic matter content) (Table 2).

Soil texture	Lime rate (t/ha)
Sand	2
Sandy loam	3
Loam to Clay loam	4

Table 3. Approximate lime rate required to increase pH one unit by texture class

Calculating lime requirement

To calculate the amount lime required to increase surface soil pH to the target value (5.5 $CaCl_2$ for cropping soils) the following formula can be used;

Lime requirement (t/ha) = (target pH – current pH) x soil texture factor *(from table 3).*

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.

Rates should be reduced by 25% where soil organic matter levels are very low.

Potential issues and crop rotations following liming

It is not recommended that any more than 2 t/ha of lime on sandy soils or 3 t/ha for sandy loams be applied at any one time. If the total rate required is more than this on these soil types consider splitting the application with 2-3 t/ha (depending on soil texture) applied now and the remainder in 3 to 4 years. This is to avoid issues which can result from having too much lime on the surface such as trace element tie up (particularly manganese) or reduced herbicide efficacy. The highly alkaline environment at the soil surface immediately following lime can also cause issues with increased infection from cereal root diseases such as Take-all (Haydie). This tends to only be an issue in paddocks which have had issues with this disease in the past.

Incorporating lime into the 0-10 cm layer using a disc or tyned implement can reduce the risk of these issues occurring and although it should not be an issue on soils with a good history of manganese applications, where deficiency symptoms occur foliar manganese applications can be used and are relatively cheap.

Many of these potential issues can be managed with rotations. As lupins and barley are susceptible to manganese deficiency it is not recommended that these are grown immediately after liming. If the paddock has a history of cereal root disease canola or a pulse should be grown in preference to wheat.

Subsurface acidity: An emerging Issue.

Whilst surface soil acidity can be effectively managed by spreading lime, many soils are also inherently prone to acidification of subsurface layers (i.e. coarse sand over clays and ironstone soils). Where this is an issue the surface pH must be maintained above 5.5 ($CaCl_2$) to prevent acidification of these layers. As surface applied lime is very slow to move deeper into the soil profile, where subsurface layers are already acidic, incorporation by disc or tined machines into these deeper layers may be required.

Three excel based decision making tools have been developed to help landholders more cost effectively manage soil acidity. These are available for download from https://agex.org.au/project/soil-acidity/

Refer to the LEADA case studies: Adams and Moroney for further information on cost effective management of soil acidity using pH mapping.

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