ACID SOIL MANAGEMENT IN LOW RAINFALL FARMING SYSTEMS OF CENTRAL WESTERN NEW SOUTH WALES

WHAT IS SOIL ACIDITY?

Soil acidification means an addition of acidity to the soil.

Acidification occurs naturally, but agricultural practices increase the rate of acid inputs to the soil.

Soil acidity is measured in pH units on a scale ranging from 0–14, with pH less than 7 being acidic and pH more than 7 being alkaline. pH of 7 is neutral (Fig. 1). Agricultural soils are usually in the range pH 4 to 8.

Note. In this publication, pH means pH($CaCl_2$)

Occurrence of soil acidity depends on

- the parent material of soil (granite-based soils are more prone to acidity than basalt-based soils)
- climate
- agricultural practices (Fig. 2)
  - product removal
  - leaching of nitrate below the root zone
  - excessive use of ammonium fertilisers
  - build up of organic matter.

The rate at which soil pH declines depends on the acidity inputs from farming practice as well as buffering capacity of the soil (i.e. the soil's ability to resist changes in the pH). Buffering capacity in turn depends on soil texture, soil organic matter and the occurrence of natural lime in the soil.

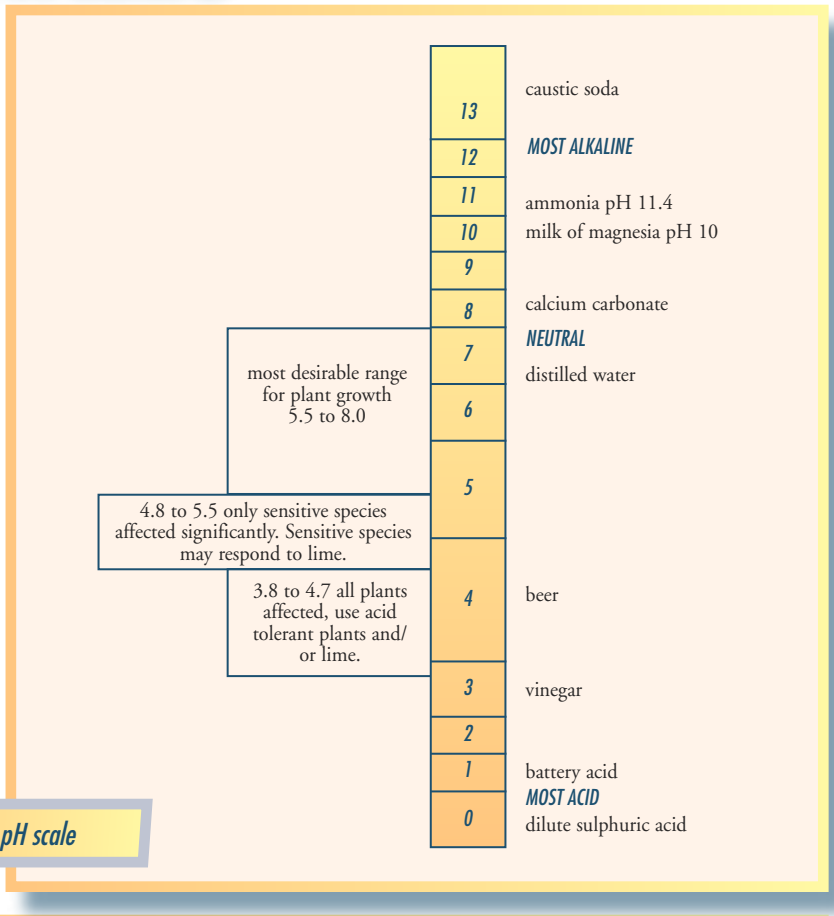


Figure 1: The pH scale

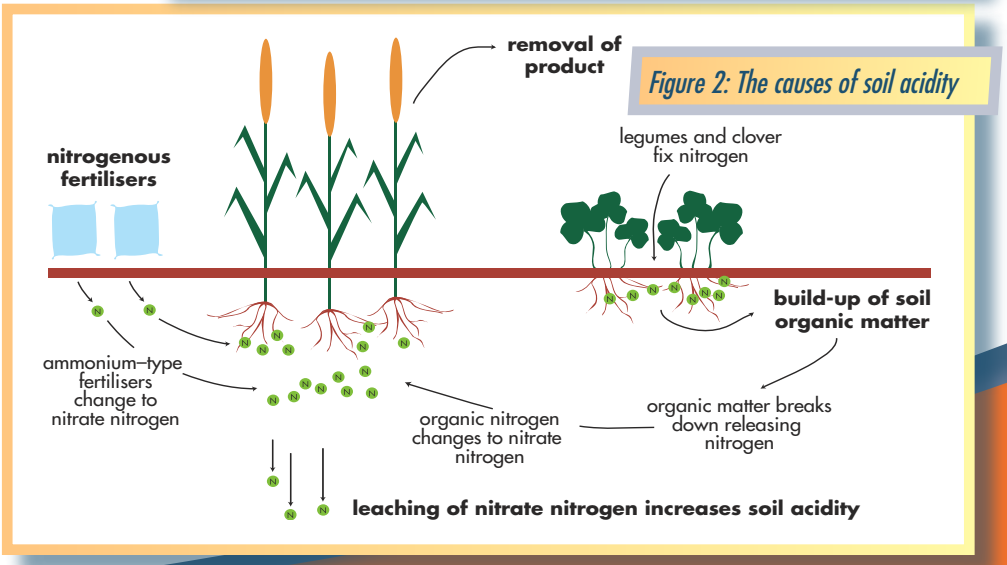


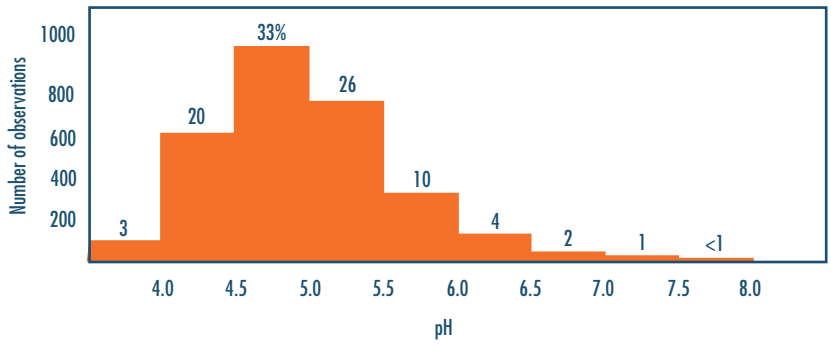
Figure 2: The causes of soil acidity

NSW Agriculture

In the low rainfall area surrounding Condobolin (100 km radius), soil acidity is seen mostly on the red earths and not the heavier grey clay soils, which acidify at a much slower rate.

In 2000, approximately 57% of the red soils in this area had a pH of less than 5.0. Of these, 24% have a pH less than 4.5 and 33% have a pH of 4.5 – 5.0 (Fig. 3).

Figure 3: Distribution of surface soil pH in central western NSW



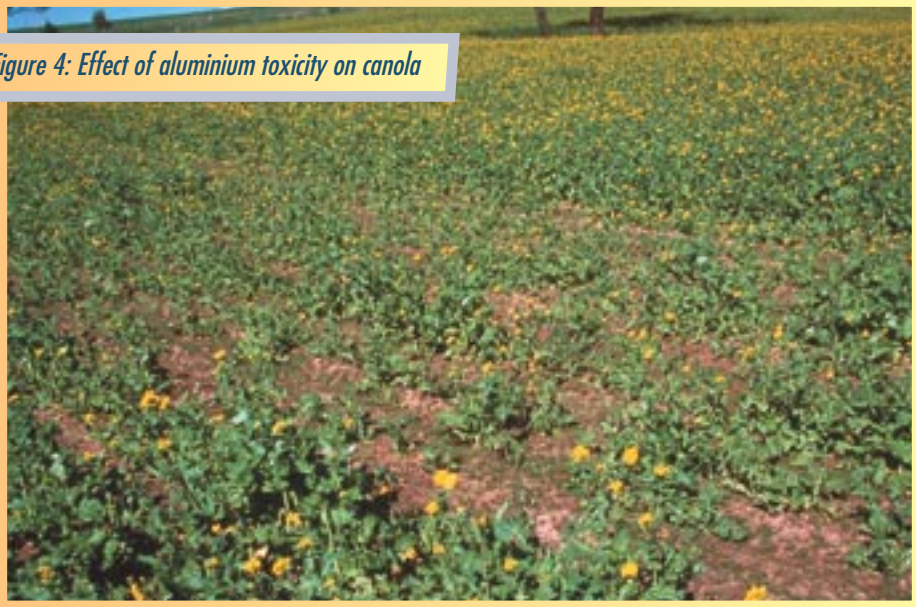
HOW SOIL ACIDITY MAY AFFECT PLANTS

In acid soils, there are increased levels of aluminium and manganese available to the plant, causing toxicity damage to sensitive plants. Simultaneously, the availability of some essential nutrients for plant growth (phosphorus, calcium, magnesium and molybdenum) are decreased. This may lead to

- Poor plant establishment and persistence; patchy or uneven growth in pasture or crop (Fig. 4)
- Reduced nodulation in legumes, and increased susceptibility of plants to diseases
- Invasion of pastures and crops by weeds
- Yellowing or necrotic (dead) tips on leaves of plants (Fig. 5)
- Short or stunted root growth (Fig. 6)
- Unexplained poor yields in pasture or crop production.

The problems lead to declines in yield and reductions in carrying capacity, with resultant poor production and income.

Figure 4: Effect of aluminium toxicity on canola



HOW DO I KNOW I HAVE SOIL ACIDITY?

- If you have seen any of the above effects of soil acidity on your property.
- If the soil is a red earth (sandy clay loam texture) and not a heavier grey clay.
- If you use high rates of nitrogenous fertiliser or remove large amounts of product from the paddocks (grain, hay or silage), you will need to apply lime to prevent your soil from becoming more acid.

  The most acidifying fertiliser is sulphate of ammonium followed in decreasing order by mono-ammonium phosphate (MAP), di-ammonium phosphate (DAP) and urea/ammonium nitrate/anhydrous ammonia.

- Soil tests are the key to identifying soil acidity problems.

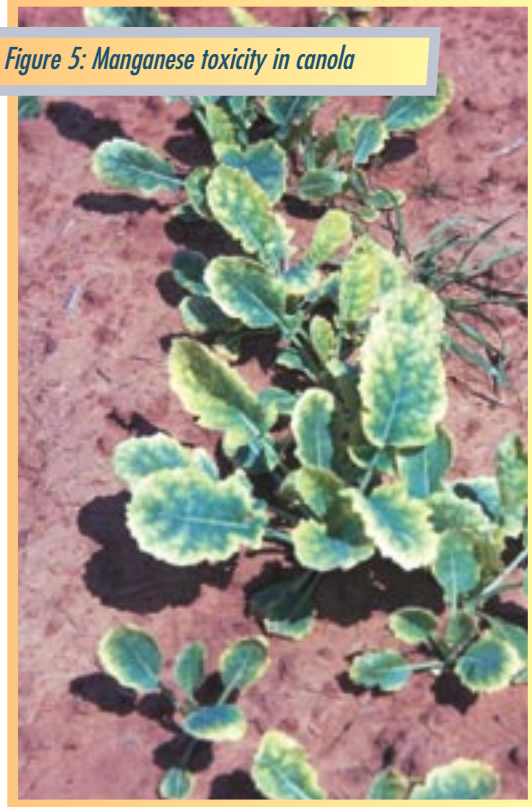
  — Collect 35 soil cores (0–10 cm) from around the paddock to be tested.

  — Avoid areas which are not representative of the paddock, such as gateways, headlands and sheep/cattle camps.

  — Mix the cores together and take a sub-sample from these weighing approximately 300 g.

  — Have them tested at an accredited Australian laboratory.

Figure 5: Manganese toxicity in canola



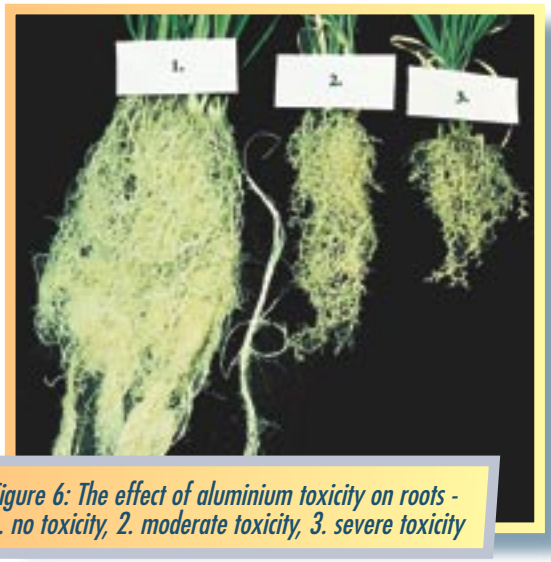


Figure 6: The effect of aluminium toxicity on roots - 1. no toxicity, 2. moderate toxicity, 3. severe toxicity

— Check the results against the local estimates and industry standards or see your local agronomist for an interpretation of the results (Table 1). Acidity may be a problem if the pH in the surface 0–10 cm is less than 5.0.

The comparative performance of species of plants growing in the area of interest can be a good indication of soil acidity.

— Tolerant plants include oats, triticale, cereal rye, narrowleaf lupins, vetch, some wheat varieties (Diamondbird, Wedgetail, Sunbrook, Sunstate), serradella, sub clover, ryegrass, cocksfoot, Rhodes grass, Premier digit grass, Consol love grass and tall fescue.

— Susceptible plants include canola, barley, some wheat varieties (Janz, Wylah), lucerne, red clover, annual medics (barrel, burr and strand) and tall wheat grass.

- Responses to lime test strips, such as increased growth and vigour of plants, increased root growth and general improvement in plant health and colour, may indicate acidification (Fig. 7).

Figure 7: Response to lime in subterranean clover

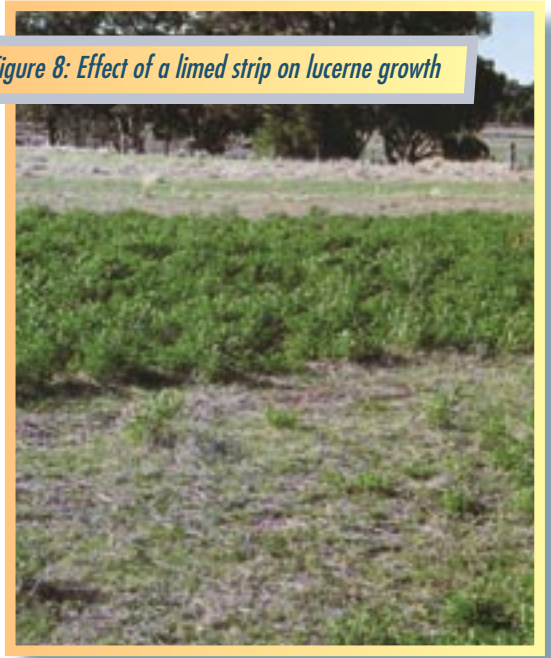


Figure 8: Effect of a limed strip on lucerne growth

— Apply the lime to an area which is representative of the paddock.

— Mark the area with pegs and identify it on a map so you can go back to it year after year.

— Leave an unlimed strip next to the limed strip

— Preferably apply in a paddock with an acid sensitive plant such as lucerne where the soil may be suspected of being acid (Fig. 8).

— Allow several years for a true response, however a response may be observed within the first 12 months.

— If possible, collect yield data from the limed and unlimed area in a crop or plant cuts from a pasture.

— As soil acidity varies across the paddock, the response to lime may also vary along the test strip.

TURNING THE TABLES ON SOIL ACIDITY

Identification of acidity

Correct identification of soil acidity is based on

- soil test
- comparative performance of species/ varieties of known tolerance
- consultation with agronomists.

Lime, lime and more lime

What lime does

- Raises soil pH.
- Decreases the level of available aluminium and manganese in the soil.
- Increases the availability of phosphorus, magnesium, calcium and molybdenum.
- Improves plant establishment and vigour.
- Improves nodulation in legumes.
- Improves the persistence of lucerne.

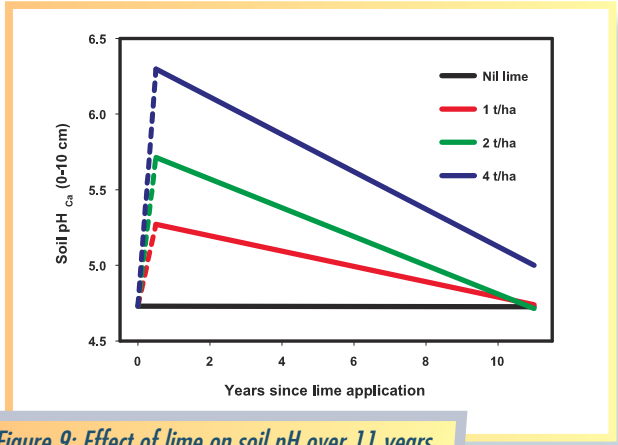


Figure 9: Effect of lime on soil pH over 11 years

Lime application

- Responses to applied lime will occur at rates ranging from 0.5 t/ha to 4 t/ha.
- Normal application rates of lime of 1–2 t/ha to a soil of pH 4.8 can raise the soil pH by 0.6 – 1.0 pH units. This pH will gradually decline over the next 10 years (Fig. 9).
- Applying lime at 3–4 t/ha can raise the pH from 4.8 to 6.3. This pH gradually declines over a 12 year period but the lime effect may still be present after this.
- Lime can be applied at any time of the year; best results are achieved if it is incorporated.
- Watch the pricing, as this fluctuates throughout the year.

The best quality lime for the job

- Lime quality is best described by fineness (particle size) and neutralising value.
- The finer the lime and the higher the neutralising value, the more effective the lime is at increasing the soil pH.
- How effective the lime is at increasing production on farm depends on

— the starting pH of the soil

— the level of aluminium and/or manganese in the soil

— the production system being used (crop and pasture variety choice)

— the fineness of the lime and its neutralising value

— the amount of rainfall received since lime application.

Lime verses dolomite

- Our soils are naturally high in magnesium, so limestone is preferred to dolomite as it contains less magnesium.

Plant tolerant species

- Planting tolerant species allows production to continue on the acidic soils but does not change the acidity. In many soils the best results are obtained from the combined use of tolerance and lime.

Improved nitrogen management

- Reduce acidification by improved nitrogen management in crops.
- Use nitrogenous fertilisers which are less acidifying.
- Use conservation farming techniques.
- Retain crop residues.
- Plant crops as soon as possible after rainfall in autumn to ensure that nitrate nitrogen is not leached from the plant root zone.

Perennial pastures minimise nitrate leaching

- Sow productive perennial pastures to minimise nitrate leaching.
- Avoid overgrazing.
- Keep a good balance of pasture species suited to the climate (acid tolerant and deep-rooted).

Table 1: Soil Interpretation Chart

Organic Carbon: Soils at Condobolin are commonly about 1%, although some levels are quite low and the range is around 0.5% – 2%. Try to keep the levels rising over the years by the introduction of a pasture phase.

pH Calcium Chloride ($CaCl_2$): A measure of soil acidity/alkalinity. Acid soils become a problem below pH$CaCl_2$ of 5.0. In the central west pH$CaCl_2$ can range from 4.5 – 9.

Exchangeable Cations: Measures positively charged elements such as calcium, magnesium, sodium, potassium, aluminium and manganese. These cations occupy the exchange sites on clay and organic matter in the soil.

Effective Cation Exchange Capacity (ECEC): This is the summation of all the cations (aluminium, calcium, magnesium, sodium and potassium). The values for the central west soils range from 5 to 11 cmol(+)/kg (meq/100g). The higher values will occur in soils with more clay content.

% Saturation of ECEC: Indicates the percentage of cation exchange sites occupied by a particular cation. For example 5% aluminium saturation of ECEC indicates that aluminium occupies only 5% of the ECEC and this can be toxic to sensitive plants.

Exchangeable Aluminium (Al): Aluminium becomes more readily available as the soil becomes more acidic. With soil below pH 4.6, exchangeable aluminium of >5% will affect plant growth of some sensitive species.

Further Information

Soil acidity and liming, Agfact AC.19
Lachlan Soil Management Guide
SOILpak for dryland farmers on the red soil of Central West NSW
Acid Soil Action leaflets
District Agronomists

Acknowledgments

Grains Research Development Corporation, Acid Soils Action and NSW Agriculture

Written and compiled by Georgina MacKinnon (NSW Agriculture), Catherine Evans (Central West Farming Systems) and Brendan Scott (NSW Agriculture).

NSW Agriculture

Acid Soil ACTION
An Initiative of NSW Government

GRDC
Grains Research & Development Corporation