SOIL ACIDITY—NEW SOUTH WALES

Key points

- Soil acidity is measured in pH units: the lower the pH of soil, the greater the acidity.
- pH should be maintained above 5.2 in the topsoil and 4.8 in the subsoil to maintain the soil resource and avoid production losses.

Background

More than half of the intensively used agricultural land in NSW is affected by soil acidity. In crop production, acidic soils cause significant yield penalties, and can prevent legumes capturing nitrogen. In pastures, production is reduced, deep-rooted species that increase water usage may not thrive, and some legumes may fail to persist. Reduced plant growth and groundcover can lead to increased run-off, erosion and water pollution, and also to nutrient leaching resulting in pollution of surface and ground waters.

Soil pH

Soil acidity is measured in pH units. Soil pH is a measure of the concentration of hydrogen (H^+) ions in the soil solution, measured on a logarithmic scale from 1 to 14, with 7 being neutral. The lower the pH the greater the acidity. A soil with a pH of 4 has 10 times more acid than a soil with a pH of 5, and 100 times more acid than a soil with a pH of 6.

The standard measurement of soil pH uses a mixture of one part soil to five parts 0.01 M $CaCl_2$ (calcium chloride). Measured in water, pH can read 0.6–1.2 pH units higher than in calcium chloride, and soils with low total salts show large seasonal variation if pH is measured in water. Field soil pH kits give results similar to water measurements and complement periodic laboratory testing.

Effects of soil acidity

Plant growth and most soil processes, including nutrient availability and microbial activity, are favoured by a soil pH range of 5.5–8.

Aluminium toxicity

When soil pH drops, aluminium becomes soluble (figure 1), retarding root growth, and restricting access to water and nutrients (figure 2). Poor crop and pasture growth, yield reduction and smaller grain size occur as a result of inadequate water and nutrition. The effects of aluminium toxicity are most noticeable in seasons with a dry finish as plants have restricted access to subsoil water for grain filling.

Nutrient availability

In very acid soils all the major, and some minor, plant nutrients may not be available in sufficient quantities despite adequate fertiliser application.

Microbial activity

Low pH in topsoils affects microbial activity, most notably decreasing legume nodulation. The resulting nitrogen deficiency may be indicated by yellowing and death of oldest leaves on grain legumes or reddening of stems and petioles on pasture legumes.

Weed Invasion

Poor crop or pasture growth leads to bare soil and reduced competition, favouring weed establishment.

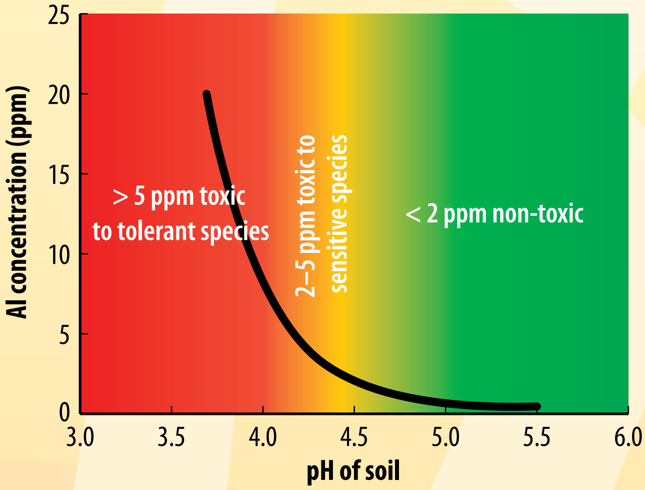

Figure 1: *A generalised relationship between soil pH and aluminium concentration with a rule-of thumb aluminium toxicity.*

Figure 2: *Roots of barley grown in acidic subsurface soil are shortened by aluminium toxicity..*

Chemistry

Causes of soil acidity

Soil acidification is a natural process accelerated by agriculture. The main driver of acidification in agricultural soils is inefficient use of nitrogen, followed by the export of alkalinity in produce.

Ammonium based fertilisers contribute to soil acidification, being readily converted to nitrate and hydrogen ions in the soil. If nitrate is not taken up by plants, it can leach from the root zone leaving behind hydrogen ions and increasing soil acidity.

Most plant material is slightly alkaline and removal by grazing or harvest leaves residual hydrogen ions, so soil acidifies with repeated plant removal. Cutting hay, especially lucerne hay, and legume crops, is a major contributor to soil acidity. Alkalinity removed in animal products is low, but concentration of dung in stock camps increases the variability of pH within paddocks. The soil becomes more alkaline around the camps and the remainder of the paddock becomes more acid.

Management of acidic soils

Soil testing

The best time to soil test is in autumn, two to ten days after good rain, Samples should not taken from overly wet or dry soils, at times of extreme high or low temperatures, within a few weeks of fertiliser applications, or within months of lime application. Sampling sites should take account of paddock variability and be recorded using GPS. Samples at the soil surface and subsurface will determine the soil pH profile and detect subsurface acidity. Sampling should be repeated at the same locations, same time of year and under similar conditions at least every three to four years to detect changes and allow adjustment of management practices.

Interpreting pH results

Surface pH above 5.2: If topsoil pH is above 5.2 and subsurface pH above 4.8, only maintenance levels of liming are required to counter on-going acidification caused by productive agriculture.

Surface pH below 5.2: If the topsoil pH is below 5.2, recovery liming is recommended. Keeping the topsoil above 5.2 will treat the on-going acidification due to farming and ensure sufficient alkalinity can move down and treat subsurface acidity. Untreated surface acidity becomes a problem in subsoils, which are more difficult and expensive to ameliorate.

Subsurface pH below 4.8: Liming is necessary if the subsurface pH is below 4.8, whether or not the topsoil is acidic. If the 10–20 cm layer is below 4.8 but the 20–30 cm layer above 4.8, liming is still required because the band of acidic soil will restrict root access to the soil below.

Liming acidic soil

Agricultural lime is applied to raise or maintain pH levels and is an economical method of ameliorating soil acidity. Carbonate in the liming material neutralises the acid in soil.

The rate of lime required depends on the soil pH profile, ECEC (Effective Cation Exchange Capacity) of the topsoil, and lime quality. ECEC tends to be higher in clay soils than sands, so clay soils need more lime per hectare to achieve an equivalent shift in pH. Lime quality is a factor of neutralising value expressed as a percentage of pure calcium carbonate and particle size. Lime with a higher proportion of small particles will react more quickly to neutralise acid in the soil. Lime with a higher neutralising value is more efficient because less lime can be used, or more area treated, for the same pH change.

Complementary strategies

- Using acid-tolerant species/varieties of crops and pasture reduces the impact of soil acidity, but is not a permanent solution because the soil will continue to acidify.
- Optimising nitrogen fertiliser inputs to match plant needs reduces nitrate leaching.
- Product export can be reduced by feeding hay back onto paddocks from where it has been cut.
- Increasing soil organic matter can have a beneficial effect by increasing the buffering capacity (the soil's capacity to resist pH change) of the soil.

Further reading and references

Lime Comparison Calculator, http://www.soilquality.org.au/calculators/lime_comparison.

The NSW DPI website has a range of useful information on soil acidity and its management in NSW, www.dpi.nsw.gov.au/agriculture.

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