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Acid soils

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Why worry about acid soils?

Soil acidity is a natural and induced chemical condition of soils that can:

- decrease the availability of essential nutrients
- increase the impact of toxic elements
- decrease plant production and water use
- affect essential soil biological functions like nitrogen fixation
- make soil more vulnerable to soil structure decline and erosion.

The process of soil acidification is a potentially serious land degradation issue. Without treatment, soil acidification will have a major impact on agricultural productivity and sustainable farming systems and acidification can also extend into subsoil layers posing serious problems for plant root development and remedial action.

In some regions, there has been a drop of one pH unit over the last 20 to 30 years. Already, some farming areas have lost the ability to grow preferred agricultural species such as phalaris and lucerne simply because, without lime, the soil is too acid.

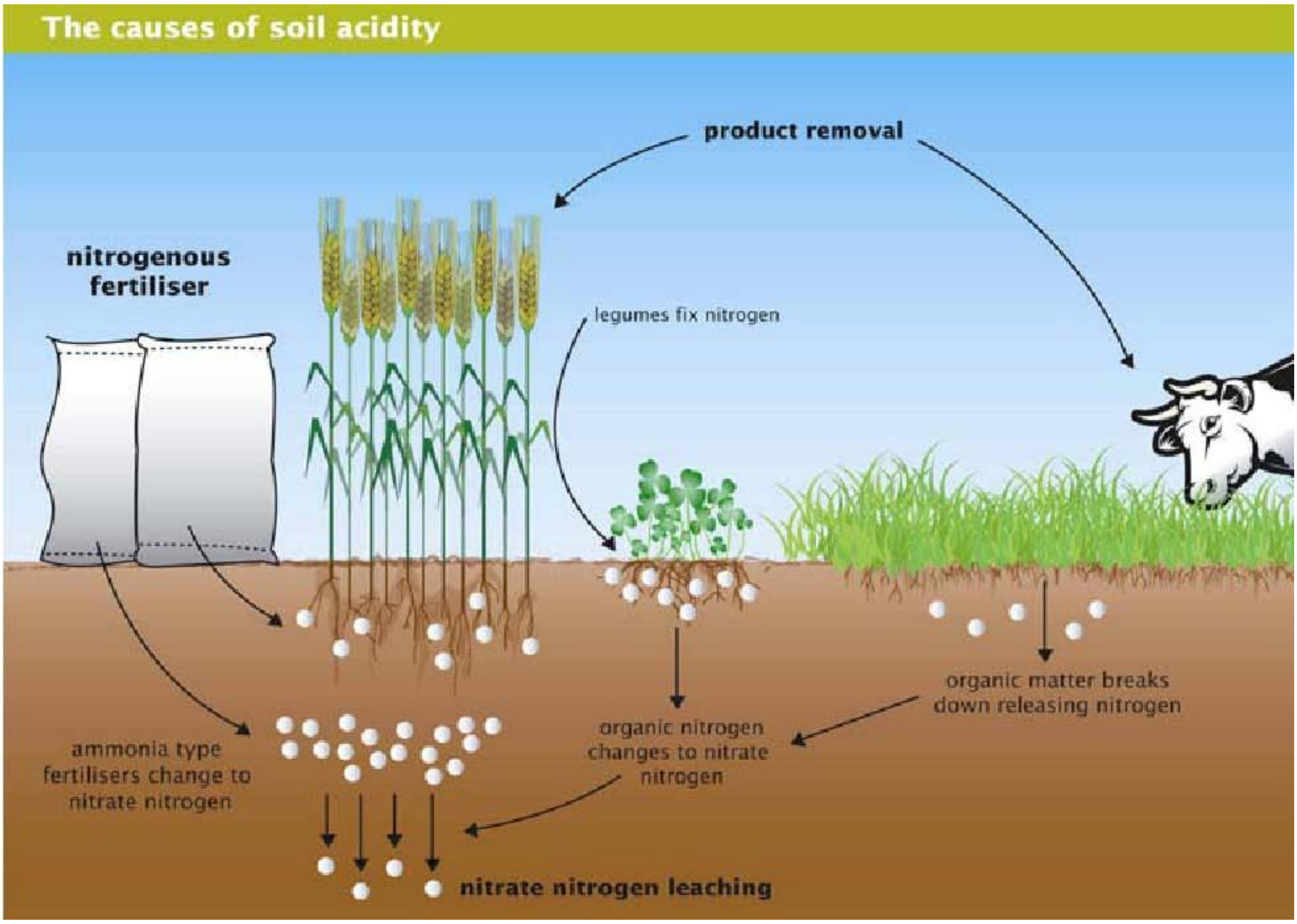

Figure 1: The causes of soil acidity

Understanding soil acidity

Soil acidity occurs naturally in higher rainfall areas and can vary according to the landscape geology, clay mineralogy, soil texture and buffering capacity. Soil acidification is a natural process, accelerated by some agricultural practices (Figure 1).

When plant material is removed from the paddock, alkalinity is also removed. This increases soil acidity. When grain, pasture and animal products are harvested from a paddock, the soil is left more acid. Hay removal is particularly acidifying because large amounts of product are removed.

More significantly, soil acidification is most often a result of nitrate leaching. Nitrogen is added to the soil in a number of ways:

- nitrogen fixed by legume-based plants
- as nitrogen based fertilisers
- from breakdown of organic matter
- dung and urine.

Acidification occurs in agricultural soils as a result of the:

- removal of plant and animal products
- leaching of excess nitrate
- addition of some nitrogen based fertilisers
- build-up in mostly plant-based organic matter.

Soil pH

Soil pH is a measure of acidity or alkalinity. A pH of 7 is neutral, above 7 is alkaline and below 7 is acid. Because pH is measured on a logarithimc scale, a pH of 6 is 10 times more acid than a pH of 7. Soil pH can be measured either in water (pH_w) or in calcium chloride (pH_{Ca}) and the pH will vary depending on the method used. As a general rule, pH measured in calcium chloride is 0.7 of a pH unit lower than pH measured in water (Figure 2).

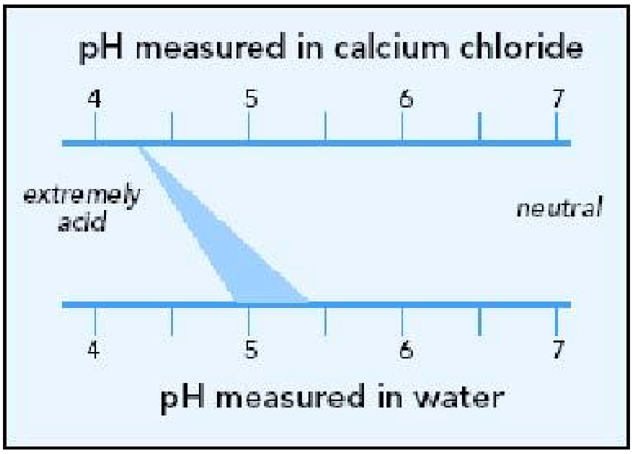

Figure 2: Relationship between pH measured in Calcium Chloride and Water.

When a laboratory measures your soil's pH it is important that they specify which method (water or calcium chloride) was used.

For most acid soils, the most practical management option is to add lime to maintain current soil pH status or increase surface soil pH.

The acid attack

Acidity itself is not responsible for restricting plant growth. The associated chemical changes in the soil can restrict the availability of essential plant nutrients (for example, phosphorus, molybdenum) and increase the availability of toxic elements (for example, aluminium, manganese). Essential plant nutrients can also be leached below the rooting zone. Biological processes favourable to plant growth may be affected adversely by acidity.

Bacterial populations generally prefer a slightly acid environment. However highly acidic soils can inhibit the survival of useful bacteria, for example the rhizobia bacteria that fix nitrogen for legumes. As the soil acidifies, the favorable environment for bacteria, earthworms and many other soil organisms is degraded. Acid soils have a major effect on plant productivity once the soil pH_{Ca} falls below 5:

- pH_{Ca} 6.5 - optimum for most plant growth; neutral soil conditions; some trace elements may become unavailable
- pH_{Ca} 5.5 - balance of major nutrients and trace elements available
- pH_{Ca} 5.0 - aluminium may become soluble in the soil depending on soil type; phosphorus combines with aluminium and may be less available to plants
- pH_{Ca} 4.5 - manganese becomes soluble and toxic to plants in some soils; molybdenum is less available; soil bacterial activity slows down; aluminium becomes soluble in toxic quantities
- pH_{Ca} 4.0 - soil structural damage begins to occur.

Soil pH will influence both the availability of soil nutrients to plants and how the nutrients react with each other. At a low pH many elements become less available to plants, while others such as iron, aluminium and manganese become toxic to plants and in addition, aluminium, iron and phosphorus combine to form insoluble compounds. In contrast, at high pH levels calcium ties up phosphorus, making it unavailable to plants, and molybdenum becomes toxic in some soils. Boron may also be toxic at high pH levels in some soils.

The relative availability of 12 essential plant nutrients in well-drained mineral soils in temperate regions in relation to soil pH is shown in Figure 3. A pH_{Ca} range between 5 and 6 (between heavy lines) is considered ideal for most plants.

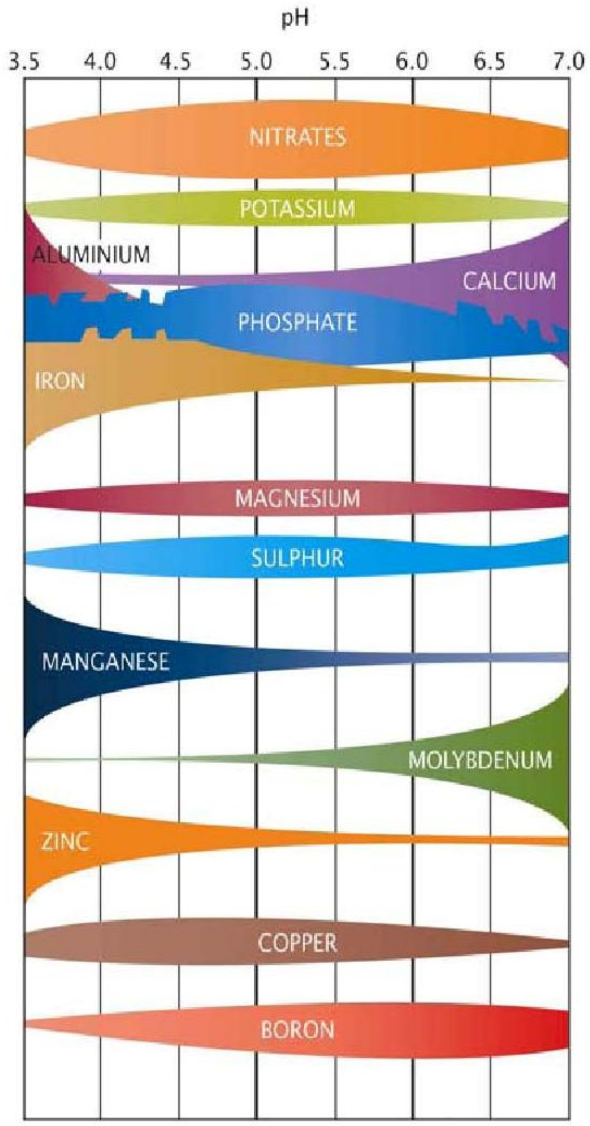

Figure 3: Effect of pH_{Ca} on the availability of plant elements

Understanding soil pH by testing

Soil pH is one of the most routinely measured soil parameters. It is used as a benchmark to interpret soil chemical processes and governs the availability of many essential or toxic elements for plant growth.

Soil pH is a common measure of the soil's acidity or alkalinity because:

- testing is relatively easy
- field equipment to measure pH is relatively inexpensive.

Field test kits are available that use colour to indicate pH levels. The kits are inexpensive, easy to use and will test a lot of samples but should not be relied on for decisions such as rates of lime application. Test kits will only tell you whether your soil is acid or alkaline.

A number of compact testing meters that can be used out in the paddock are available, most of which are capable of giving accurate results if used correctly. Professional soil analysis is recommended and sending soil samples to a recognised laboratory ensures the most accurate results.

Testing of both topsoil and subsoil is recommended. When interpreting plant responses based on soil pH, the surface (A horizon) and sub-surface (B horizon) need to be considered.

The soil pH_W is considered to be closer to the pH that the plant roots experience in the soil. But it is subject to large variation within the paddock because of seasonal changes in soil moisture and the ionic concentration of the soil solution that is related to the amount of total salts in the soil.

Research has shown that seasonal variation of pH_W can vary up to 0.6 of a pH unit in any one year. In comparison, the measurements of soil pH_{Ca} is less affected by seasons.

Farmers can take soil samples at different times during the year without affecting the final diagnosis or interpretation.

Soil pH_{Ca} measurements in Australia vary from pH_{Ca} 3.6 to pH_{Ca} 8 for a range of different soil textures (sandy loams to heavy clays). Soil pH_W values lie between pH_W 4 and pH_W 9.

Higher pH_W values to around 10 may be associated with alkali mineral soils containing sodium carbonates and bicarbonates.

Some useful tips……

- Soil pH is measured in either water or in calcium chloride. When measured in calcium chloride, the result is lower than pH measured in water.
- The pH_W may be higher by 0.6 to 1.2 in low salinity soils and higher by 0.1 to 0.5 in high salinity soils. Research has shown a difference of 0.7 for a wide range of soils.
- Soil testing will tell you the current acidity status of your paddock. If your soil pH_{Ca} is above 5.5 then there is little immediate risk of acidity.
- Lime can restore productivity in acid soils and should be considered once the pH drops below pH_{Ca} 5.0 if sensitive species are to be grown successfully.
- You are unlikely to get responses to lime if other nutrients are lacking. This should show up in a soil test or plant tissue analysis and should be corrected. Conversely, you may not get a response to some nutrients if the soils are too acid. A holistic balanced approached is necessary.
- Lime responses are generally seen in the first and second year for cropping systems, but can take up to five years depending on soil type, rainfall and lime quality for permanent pasture systems.
- It is necessary to re-lime your paddock about every 10 years, depending on the rate of re-acidification.

- If paddocks with an acidity problem are not limed, the soil pH will continue to fall and settle at pH_{Ca} 3.8 to 4.2.
- The amount of lime you need to apply varies according to soil type. Field experiments have shown that up to 5 tonnes a hectare on clay loams and 1.5 tonnes a hectare on sandy soils is needed to increase pH by one unit.
- Lime moves slowly (0.5 to 1 cm per year) through the soil profile via the soil macropore structure. Incorporation into the soil profile, where possible, will assist effective treatment.
- In permanent pasture situations, spreading the lime on the surface and allowing it to work its way into the soil is acceptable. Surface application is better than no application.

Further reading

The following Agnotes may assist landholders with field sampling procedures for soils:

Agnote AG0375: Sampling soils for growing pastures, field and fodder crops.

Agnote AG0376: How to sample soils used for flower, fruit, grape and vegetable production.

Agnote AG0889: Guidelines for sampling soils, fruits vegetables and grains for residue testing.

All Agnotes are located at: http//www.dpi.vic.gov.au
Search for 'Agnotes' and follow the prompts.

Testing of samples

This can be arranged at:

Department of Primary Industries - Werribee Centre

621 Sneydes Road Werribee VIC 3030

Telephone: (03) 9742 8755 Facsimile: (03) 9742 8700

Contact the relevant Section Leader - Inorganic Chemistry for soils testing and Organic Chemistry for residue testing for test specifications and pricing details, prior to sending samples.

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