

Lime acid soils to stay in business

HORTICULTURE



A Concise Technical Bulletin for Horticultural Farming Systems



Natural Heritage Trust



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Soil acidity – corrosion of soil health

Soil acidity is a natural phenomenon caused by accumulation of soil organic matter, nitrogen fixation, leaching of nitrate and removal of alkalinity in plant produce and animal products. All these processes leave an accumulation of acid hydrogen ions (H^+) in the soil.

Farming practices that increase the intensity of nutrient removal in produce and use high rates of acidifying fertilizers accelerate soil acidity.

Intensive horticulture – special risk

A dominant cause of soil acidification in horticulture is the use of high rates of ammonium forms of nitrogen fertilizers.

Ammonium-based fertilisers such as ammonium sulphate, urea and ammonium nitrate are converted in soil to nitrate in a chemical reaction that releases some acid hydrogen ions.

Irrigation, both dripper and sprinkler, increases nitrate leaching which can accelerate soil acidification within the wetted area. Fertigation with acidifying fertilisers can also acidify.

Sandy soils acidify faster than clay soils.

Horticulture crops established on existing acid soils are at immediate risk.

Diagnosing soil acidity

• Soil pH tests

Soil acidity tests measure the quantity of acid hydrogen ions that accumulate in soil. Acidity is measured on a pH scale of 0-14 where a pH less than 7 indicates acidity.

Laboratory soil-pH tests that are measured in calcium chloride (pH_{Ca}) are considered most reliable.

• Critical pH_{Ca} levels

Soil pH_{Ca} levels between 5.5-6.5 are optimum for many horticulture crops.

• Careful soil sampling is essential

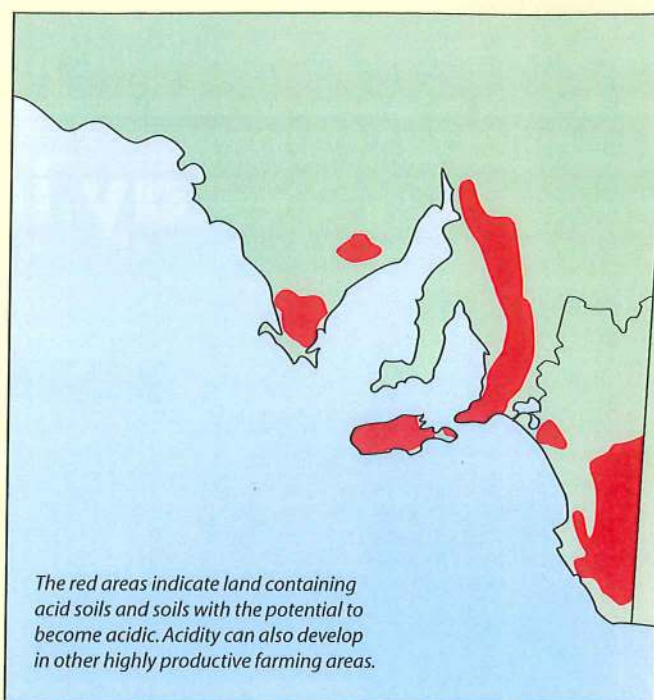
For samples to accurately reflect soil condition, careful collection is essential.

Take at least 20 samples to 15 cm deep from within a single soil type and combine these to make one sample. Samples collected from a depth of 15-30 cm are valuable to assess sub-soil acidity.

Mark sample collection points or transects for future sampling to monitor pH change.

Samples collected from patches of contrasting production performance can be useful to assess causes for the difference.

Complete soil analysis, including cations and trace elements, is recommended when planting horticultural crops under acid soil conditions.



Effects of soil acidity in horticulture

Soil acidity affects many aspects of soil and plant health causing gradual productivity decline.

Signs of acidity

Symptoms include:

- poor plant vigour,
- leaf symptoms – manganese toxicity; calcium, magnesium or molybdenum deficiency,
- nutrient imbalance,
- stunted root growth,
- increase in root disease,
- uneven crops, and
- plants which are un-competitive with weeds.

Soil toxicity

As soil pH_{Ca} falls below 5.0, toxic amounts of aluminium (Al) and manganese (Mn) can be released from clay minerals. Aluminium toxicity is indicated when Al levels in soil tests are >2ppm and exchangeable Al is >5%.

Tolerance of horticulture plants

Horticultural crops vary in their tolerance to acidity from extreme sensitivity to strong tolerance and some even have a requirement for acid conditions.

Productivity of sensitive plants is affected most. Plant varieties vary in their tolerance to acidity.

Tolerance	Crops
Sensitive:	Asparagus, broccoli, beet, spinach, cabbage, cauliflower, celery, lettuce, onion, pea, rockmelon.
Slightly tolerant:	Bean, carrot, capsicum, radish cucumber, tomato, turnip, apple, strawberry, rose, zucchini, grapes, cherries.
Tolerant or acid requirement:	Potato, watermelon, azalea, blueberry.

Acid soils – the outcomes

- **Nutrient loss** – in acid soils, potassium, magnesium and calcium levels are low.
- **Phosphorus inefficiency** – P combines with free aluminium (Al) and iron (Fe) to become less available to plants. Molybdenum (Mo) is also less available.
- **Reduced microbial activity** – soil biological health declines as microbes that decompose organic matter or fix nitrogen become less active.

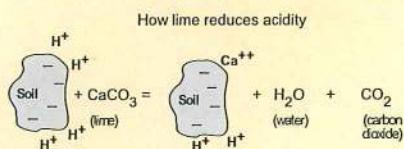
Off-farm effects

Nutrients leaching from acid soils contaminate streams and groundwater.

Neutralising effects of lime

Calcium carbonate (lime) and other liming materials reduce acidity by neutralising the acid reaction in soils.

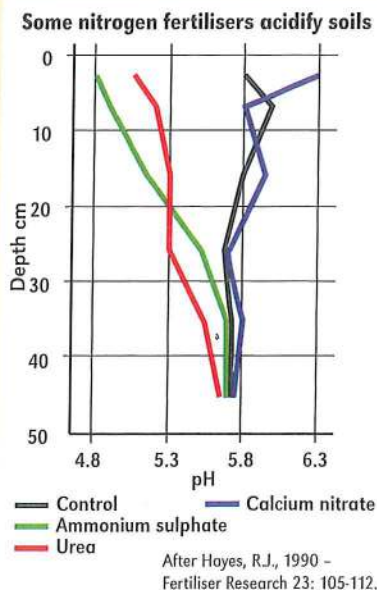
The toxic element aluminium also reacts with lime to precipitate as a harmless oxide.



Acidifying effects of N fertilisers

An application of 100 kg N/ha ammonium sulphate requires 540 kg lime/ha to neutralise the acidification.

For the same N rate, urea and ammonium nitrate require 180 kg lime/ha to balance acidity while, in contrast, calcium nitrate contributes the equivalent of 135 kg lime/ha and calcium ammonium nitrate has no net effect on soil acidification.



Lime to maintain soil health

Lime should be used to maintain soil pH_{Ca} at 5.5 or above for crops other than those that require acid conditions.

Incorporating lime into the surface 15 cm of soil before planting is a recommended strategy for horticultural crops.

For established perennial crops, surface lime applications are useful but act more slowly, moving into the soil profile at rates of 1-3 cm per year.

In these circumstances lime applications take many years to



affect acidic subsoils. **It is critical to prevent acidification or correct it before orchard establishment.**

Ideally, lime should be incorporated into acid sub-soils before perennial crops are planted. If ripping, apply lime first so that it can be incorporated to depth.

Lime is a capital investment

Liming to prevent soil acidification is an investment in the sustainability of the farm business.

It maintains soil health and productive capacity.

Benefits of 11 times the cost of liming have been recorded for some Australian horticultural crops.

Application rates – 'rules of thumb'

Lime required to raise soil pH by 1 unit depends on soil texture.

Soil	Lime required t/ha
Sand	2-3
Sandy loam	3.5-4.5
Loam/clay loam	5-6

(If organic matter is low, reduce rates by 25%.)

Target pH depends on the crop grown. For olives, grapes and apples aim for $\text{pH}_{\text{Ca}} > 5.5$.

For established perennial crops, surface applied lime at up to 4-5 t/ha on loams and 2-2.5 t/ha on sands in single applications repeated every 3-4 years is suggested until the desired soil pH is achieved.

For potatoes, lime is best applied after the crop to benefit following pastures or crops and to reduce potential for disease.

Caution – Nutrient imbalances

High rates of lime can induce nutrient deficiencies of zinc, manganese, iron and boron. Also fertiliser supplements may be needed on low fertility soils to support productivity increases stimulated by liming.

Liming materials

Commonly used materials in horticulture are agricultural lime (calcium carbonate) or dolomite (a mixture of calcium and magnesium carbonates) which is useful if soil magnesium is also low. Soil and plant tests which include calcium and magnesium can indicate levels of these nutrients.

Some irrigation waters can provide a useful source of lime input.

Products with fine particle size and high neutralizing value are most effective quickly.

Alkaline or neutral clays, when spread onto acid non-wetting sands, can adjust soil pH and also improve water and nutrient holding capacity.

Fertigation with calcium nitrate will also reduce acidification.

Monitor to make sure

It is essential to monitor changes in soil pH regularly – at least every five years.

Prevention of acidity and production decline is safer and more cost-effective than long and expensive remediation programs.



Regular applications of liming materials should be used as part of integrated paddock management programs.

The key points ...

- Acid soils can significantly reduce production and profitability before paddock symptoms are noticed.
- Soil acidification is inevitably accelerated in all productive farming systems as a result of product removal, increased use of ammonium-based fertilisers and leaching of nitrate, particularly under irrigation.
- Monitor changes in soil pH by regular soil testing.
- Dangerous levels of acidity are indicated for crops when soil pH_{Ca} is less than 5.5.
- Soil pH should be maintained in the optimum range for horticultural crops. Regular applications of liming materials should be used as part of integrated paddock management programs.
- **Establishing horticultural crops on acid soil is high risk. Lime should be incorporated before planting.**
- The aim is to prevent responses by liming before acidity reduces productivity.
- The most effective liming sources have high a neutralising value and have a high proportion of material with a particle size below 0.25 mm. Incorporation of lime into the soil speeds the effect.
- More lime is required to raise soil pH in clays than in sands.
- Liming can induce some trace element deficiencies where status is marginal. These risks can be managed by applying deficient nutrients.
- If acidity spreads to the subsoil, production losses will be much greater, correction will take longer and it will cost more.
- If severe acidity is allowed to develop, irreversible damage to the soil can occur.
- Acidity in horticulture can also be corrected by using alkaline forms of nitrogenous fertiliser e.g. $CaNO_3$ or alkaline irrigation water.
- It is important to determine soil cation (Ca, Mg, K) levels when correcting acid soils for horticulture.



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