



Grapevine nutrition 5: Soil acidification

Current titles in this Grapevine nutrition VitiNote series include:

1. Nitrogen fertilisation
2. Phosphorus fertilisation
3. Petiole analysis
4. Potassium fertilisation
5. Soil acidification
6. Liming
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8. Molybdenum

Acidic soil conditions ($\text{pH}_{\text{Ca}} < 5.5$) exist in some viticultural surface soils across Australia. This acidity is either naturally occurring or may have been induced (acidification) by the addition of acidifying nitrogen fertilisers (e.g. urea, ammonium nitrate) to the soil, particularly through drip irrigation systems, or the fixation of atmospheric nitrogen by legumes.

Knowledge of acidification is of vital importance to vineyards as the availability of nutrients is dependent upon soil pH. In acidic soils, the availability of some nutrients decreases (e.g. calcium, magnesium and molybdenum) whilst others may become more available (e.g. manganese, aluminium). In very acidic soils, some nutrients (e.g. manganese and aluminium) may even reach toxic levels.

An important impact of soil acidification is its effects on root growth. Field trials conducted in SA showed that root growth became depressed at $\text{pH}_{\text{Ca}} < 5.5$ and essentially ceased at $\text{pH}_{\text{Ca}} 4.5$ (Robinson 1992). In strongly acidic soil ($\text{pH} < 5$), aluminium and manganese become more soluble in most soils, such that their levels are toxic and stunt the growth of roots with obvious consequences for water and nutrient uptake, especially in dry conditions.

Increasing soil acidity may also increase the uptake of heavy metals such as copper and lead. This can be a problem in vineyards that have been planted on old apple or pear orchard soils where copper, lead and arsenic may have accumulated.

Soil acidification can also affect soil biology. Soil pH values below 5.5 can have a negative impact on overall numbers of bacteria, fungi and earthworms. This results in a reduction in breakdown of organic matter and consequently the release of nutrients from the organic matter. The effect of soil acidification can also have implications for conversion of the various forms of nitrogen applied in nitrogen-based fertilisers.

The susceptibility of a given soil to acidification is determined by its pH buffer capacity, i.e. its capacity to resist pH change. Soils with a high content of clay, organic matter, easily weatherable minerals or lime generally have higher buffering capacities.

The best way to detect and monitor soil acidity problems is to conduct regular soil tests. Measuring pH is probably the most common soil test used. In irrigated vineyards, care must be taken to sample the vineyard soil from areas and appropriate depths that will enable proper interpretation of the analysis results.

Separate test soils should be taken from areas that are in-row and mid-row, beneath drippers and mid way between drippers, and to depths of 0–15cm and 15–30cm so as to evaluate any changes that the fertigation practices may have caused (see *Grapevine Nutrition: Research to Practice™* notes for further information).

ACIDIFYING FERTILISERS

The management practice most likely to cause acidification of established vineyards is the use of acidifying fertilisers, i.e. those containing ammonium, urea or elemental sulphur (including some fungicides).

The acidifying effect of some commonly used fertilisers and the amount of lime required to neutralise the acidifying effect are shown in Table 1.

Different types of nitrogen fertilisers have different effects on the soil, e.g. ammonium-based fertilisers tend to be more acidifying, whereas nitrate-based fertilisers tend to raise the soil pH slightly as plant roots exchange alkali into the soil as they take up nitrates.

Urea causes soil acidification when it is broken down to form ammonium and the subsequent conversion of ammonium to nitrate, which is the predominant form of nitrogen taken up by vine roots. Severe acidification of the soil (pH in

calcium chloride <4.8) beneath drippers can occur in vineyards where urea fertiliser is distributed through the irrigation system.

Table 1. Some nitrogen sources, their N content and the amount of lime required to neutralise their acidifying effect on soils.

Nitrogen source	N content (%)	Lime requirement*
Ammonium sulphate	21	5.2
Anhydrous ammonia	82	1.8
Ammonium nitrate	34	1.8
Urea	46	1.8
UAN solution	28–32	1.8
MAP	10–11	5.0
DAP	18	3.1
CAN	26	0.3–0.7

*Amount of pure calcium carbonate (CaCO₃) required to either neutralise the acid-forming reactions of 1kg N or the amount of CaCO₃ required to equal the acid-reducing effects of 1kg N.

Source: Glendinning JS, (2000) *Australian Soil Fertility Manual*, CSIRO Publishing, Collingwood, Victoria.

Table 2. Acidification rates^A of some nitrate fertilisers at 0% or 100% leaching.

Fertiliser and acidification class		0% leached	100% leached
Most acidifying	• Ammonium sulphate	3.7	7.1
	• Mono-ammonium sulphate (MAP)		
Medium acidification	• Di-ammonium sulphate (DAP)	1.8	5.3
Low acidification	• Urea	0.0	3.6
	• Aqua ammonia		
	• Anhydrous ammonia		
Alkaline fertilisers	• Sodium nitrate	3.6	0.0
	• Calcium nitrate ^B		

^A Measured as the amount of lime in one kilogram of calcium carbonate (CaCO₃) to balance a kilogram of nitrogen applied as fertiliser.

^B Due to the manufacturing process, calcium nitrate contains up to 1.5% ammonium nitrate.

It is also important to remember that not all nitrogen applied as fertiliser is used by plants. Leaching of soluble nitrogen below the rootzone into the subsoil (and possibly the groundwater) can occur resulting in acidification of deeper soil layers. Deep rooted plants such as vines have the potential to increase subsoil pH therefore decreasing acidity, if they are able to take the nitrate from greater depths in the soil profile. In theory, this could occur at the expense of acidification of the upper soil layers, however it is unlikely as vine feeder roots (with root hairs for active nutrient uptake) are mostly restricted to the upper 30cm of soil.

EFFECT OF SOIL PH ON THE CONVERSION OF AMMONIUM AND UREA INTO NITRATE

The time required to convert ammonium (from ammonium fertilisers or urea as it is broken down) into nitrate increases dramatically as soil pH decreases (i.e. acidity increases), therefore fertiliser applied to improve vine nutrition may not be available to the vine when needed and this can affect grape quality. If nitrate only becomes available after leaf fall then leaching losses can occur as a result of winter rainfall.

As it can be difficult to predict the time it takes for these processes to occur, precisely timing urea or ammonium-based fertiliser application for effective uptake of nitrate by vines can be a problem. The uncertainty is reduced if the fertiliser already contains nitrate.

MANAGING ACIDIFICATION

There are a number of viticultural practices which can help avoid development or exacerbation of soil acidification, however they are generally restricted to the upper portions of the soil profile. If deeper layers are acidified, the problem may be too expensive to rectify or may be irreversible.

These practices include:

- Applying the correct amount of fertiliser for the vine size and crop load to avoid over-application. This can be determined by

plant and soil analysis and visual assessment of vine vigour and leaf colour.

- Reducing the amount of fertiliser applied in a single dose. This involves spreading applications over a number of irrigations if fertigation is used, or a number of weeks/months if a solid granular form of fertiliser is used.
- Applying nitrogen to correspond with periods of vine demand, spring and post harvest, so that maximum uptake and benefit will be obtained, and losses via leaching minimised.
- Applying nitrogen late in an irrigation cycle so that it is retained in the soil near the roots, thus optimising uptake by the vine rather than being washed past the root zone of the vines.
- Using less acidifying nitrogen sources, e.g. calcium nitrate.
- Maximising irrigation efficiency to avoid leaching and increase nutrient retention near the vine roots.

Growers should use regular soil tests to monitor vineyard soils to ensure that acidification caused by application of some forms of nitrogen is not occurring.

CORRECTING SOIL PH WITH LIME

Lime can be applied to ameliorate acidic soil conditions in many circumstances (see *VitiNote Grapevine nutrition 6: Liming*). The best time to apply lime is prior to vineyard establishment when it can be mixed into the soil by cultivation along the vine row as it can take a long time for the benefits of lime to take effect if it is applied to the soil surface.

When considering amelioration of acid soils with lime some factors to consider include:

- Soils with pH values less than 5.5 (measured in dilute calcium chloride) should be treated.
- The amount of lime needed will vary from one soil type to another.
- More lime is required to raise pH in clays than in sandy soils.

- Soils with subsoil acidity are more expensive and difficult to ameliorate, requiring slotting or deep ripping to place the lime where it is needed. This is because agricultural lime (the most common form of lime used) is not very soluble in water and consequently must be mixed through the soil profile by cultivation.

Strategies for mature vines

Careful monitoring of the soil under drippers is recommended. In low flow irrigation situations the vine roots are concentrated around irrigation outlets in the vine row. In high rainfall areas root activity will not be as confined.

Vines affected by soil acidity will grow less vigorously and yield less than unaffected vines. It can be difficult to treat soil acidity in existing vineyards as the soil around established vines is very difficult to mix or cultivate since traditional cultivation of the root area could cause considerable damage or plant death. Trellis structures also make it difficult to use machinery. In certain situations, more expensive but soluble forms of lime may be applied through the drippers.

Common amelioration practices include the surface application of lime along the vine row, followed by incorporation of lime into the soil of the mid row using different types of tillage implements. It is generally advisable to apply the lime in the autumn to allow winter rainfall to wash it into the profile. Soil sampling should not be carried out until the following autumn when the free lime has had a chance to react.

FURTHER READING

- Robinson JB, (1997) *Grapevine Nutrition*, in *Viticulture Vol 2 Practices*, Eds Coombe BG & Dry PR, reprinted 2001, Winetitles, Adelaide, pp. 178-208.
- *Grapevine Nutrition: Research to Practice™*, Cooperative Research Centre for Viticulture, Adelaide 2005.
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