viti-notes
[grapevine nutrition]

Research to Practice

Soil acidification

Viti-note Summary:

- Soil pH
- Soil acidification in vineyards
- Characteristics of acidic soils
- Acidifying fertilisers
- Effect of soil pH on rate of breakdown of ammonium to nitrate
- Management of acidification
- Correction of soil pH with lime
- Strategies for mature vines

Other topics in this Viti-Notes series include:

- Nitrogen fertilisation
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- Petiole analysis
- *Soil acidification*
- Liming
- Trace Elements

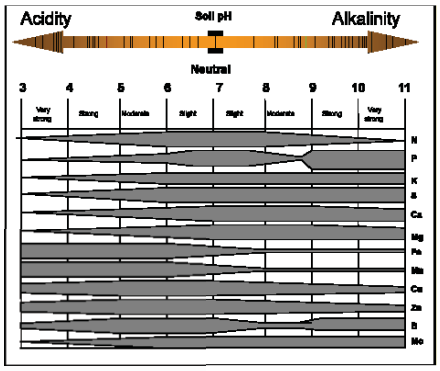

Figure 1. Effect of soil pH on availability of minerals

Soil pH

All plants and soil micro-organisms have preferences for soil within certain pH ranges, usually neutral to moderately acid or alkaline. Soil pH most suitable for grapevines is between 5.5 and 8.5. In this range, roots can acquire nutrients from the soil and grow to their potential. As soils become more acid or alkaline, grapevines become less productive. It is important to understand the impacts of soil pH in managing grapevine nutrition, because the mobility and availability of nutrients is influenced by pH (Figure 1).

Soil acidification in vineyards

Acidic soil conditions (pH < 5.5) exist in some viticultural surface soils across Australia. There are three particular situations in which acid soils are likely to present problems in vineyards:

- Planted on virgin soil which are naturally acidic, (often found in the higher rainfall areas of Australia);
- Established on old pastures which have become acidic as a result of long-term application of acidifying fertilisers, e.g. single superphosphate;
- On soils with a low capacity to resist changes in pH where acidifying nutrients have been applied.

Characteristics of acidic soils

Calcium and magnesium are displaced by aluminium (Al3+) and hydrogen (H+) and are leached out of the soil. Acidic soils below pH 6 often have reduced populations of micro-organisms. As microbial activity decreases, nitrogen availability to plants also decreases.

Sulfur availability to plants also depends on microbial activity so in acidic soils, where microbial activity is reduced, sulfur can become unavailable. (Sulfur deficiency is not usually a problem for vineyards as adequate sulfur can usually be accessed from sulfur applied as foliar fungicides).

- Phosphorus availability is reduced at low pH because it forms insoluble phosphate compounds with aluminium, iron and manganese.
- Molybdenum is seldom deficient in neutral to alkaline soils but can form insoluble compounds in acid soils.
- In strongly acidic soil (pH <5), aluminium may become freely available to plants in toxic levels. High aluminium levels stunt the growth of roots with detrimental effects on water and nutrient uptake, especially in dry conditions.
- Iron, manganese and zinc are more available in acid soils. In particular, manganese can reach toxic concentrations in acidic soils.
- Increasing soil acidity can 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.

Acidification affects soil biology and soil pH values below 5.5 may:

- Impact negatively on nitrogen and carbon turnover;
- Reduce earthworm numbers;
- Change the population dynamics and reduce overall numbers of useful bacteria and fungi. This prevents the breakdown of organic matter to release stored nutrients in forms more available to plants. This can have particular implications for conversion of the various forms of nitrogen applied in nitrogen-based fertilisers. Nitrogen and soil acidification.

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 (e.g. acidification of the soil beneath drippers to depths of 100cm or more can occur in vineyards where urea fertiliser is distributed through the irrigation system).
- Elemental sulfur (including some fungicides).

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 (Table 1).

Not all nitrogen applied as fertiliser is used by plants. Soluble nitrogen may leach below the rootzone into the subsoil (and possibly the groundwater) causing reduced pH levels at depth in the soil profile. Deep rooted plants such as vines have the potential to increase subsoil pH, and therefore decrease acidity, if they are able to extract 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 because vine feeder roots are mostly confined to the upper 30cm.

Effect of soil pH on rate of breakdown of ammonium to nitrate

As soil pH decreases, the time required to convert ammonium to nitrate increases. As a result, fertiliser applied to improve vine nutrition may not be available to the vine immediately. Precise timing is required for urea or ammonium-based fertiliser application to ensure effective uptake of nitrate by vines. The timing of application is made easier if the fertiliser contains nitrate.

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 and measuring pH is probably the most common soil test used. In irrigated

Table 1 Acidification rates^of some nitrate fertilisers at 0% and 100% leaching

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

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

* Due to the manufacturing process, calcium nitrate contains up to 1.5% ammonium nitrate

vineyards, care must be taken to sample the vineyard soil from areas and appropriate depths that will enable proper interpretation of the analysis results.

Management of acidification

There are a number of viticultural practices that can be used to prevent the development or exacerbation of soil acidification in the upper portions of the soil profile. If deeper layers are acidified, the problem may be expensive to rectify or in some cases irreversible. Management practices to avoid acidification include:

- Avoid over application of fertiliser. Apply the correct amount of fertiliser for the vine size and crop load. Correct amounts can be determined using petiole analysis and can be modified with ongoing monitoring and analysis;
- Reduce 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 is used;
- Apply nitrogen to correspond with periods of vine demand so that maximum uptake will occur and maximum benefit will be obtained;
- Apply nitrogen late in an irrigation cycle so that it is retained in the soil near the roots, thus optimising uptake by the vine;
- Using less acidifying nitrogen sources, e.g. calcium nitrate;
- Maximise irrigation efficiency to avoid leaching and increasing nutrient retention near the vine roots.

The use of some forms of fertiliser (particular nitrogen fertilisers) may lead to acidification of the soil. The acidifying effect of some commonly used fertilisers and the amount of lime required to neutralise the acidifying effect are shown in Table 2.

Table 2 Some nitrogen sources, their N content and the amount of lime required to neutralise their acidifying effect on soils.

Source: Glendinning (2000)

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

- Most of the acid-forming effects are due to the activities of soil bacteria during nitrification.

Correction of soil pH with lime

Lime can be applied to ameliorate acidic soil conditions in many circumstances. 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. Lime applied to the soil surface can take a long time for the benefits to take effect.

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.

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.

Acknowledgement

The Australian Wine Research Institute would like to acknowledge:

- Cooperative Research Centre for Viticulture (CRCV) and all involved in the VitiNotes series (1996 – 2006) particularly L. Chvyl and C. Williams.
- Mardi L. Longbottom for the update of this document.

Further information

Training
For regional specific training in grapevine nutrition management, the AWRI is running *Research to Practice: Managing grapevine nutrition in a changing environment.*

Contact
Marcel Essling: rtp@awri.com.au for more information.

Useful references:

Nicholas, P. 2004. *Soil, irrigation and nutrition.* Adelaide: Winetitles.

Articles about grapevine nutrition and viticulture in general are available to the Australian wine industry through the Australian Wine Research Institute library. Visit http://www.awri.com.au/information_services/jfml/ for details.

Product or service information is provided to inform the viticulture sector about available resources and should not be interpreted as an endorsement.

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