viti-notes
[grapevine nutrition]

Research to Practice

Nitrogen fertilisation

Viti-note Summary:

- The role of nitrogen in grapevine function
- Mobility and behaviour of nitrogen fertilisers
- Sources and losses of nitrogen
- Nitrogen management in the vineyard
- During vineyard establishment
- In mature vineyards
- Timing the application of nitrogen for efficient uptake
- Prior to budburst
- Between fruit set and veraison
- Post harvest
- Environmental and sustainability issues
- Eutrophication

Other topics in this Viti-Notes series include:

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

Figure 1. Nitrogen deficiency sypmptoms on grapevines. Initial symptoms include leaf chlorosis on older leaves, worsening to necrosis. (Photo courtesy of Mardi L. Longbottom)

The role of nitrogen in grapevine function

Nitrogen plays a major role in all grapevine processes and a significant amount of nitrogen is essential for normal vine growth. More than any other nutrient, a deficiency of nitrogen may affect key metabolic functions and retard shoot development and bunch formation.

With a few exceptions, nitrogen is only found in moderate to low quantities in the soils of Australian vineyards. However nitrogen fertiliser should be applied to vines carefully as excessive availability of nitrogen increases shoot growth at the cost of fruit development. Over supply of nitrogen can also delay fruit maturity and may result in poor bud fruitfulness in the following season.

Mobility and behaviour of nitrogen fertilisers

Fertilisers contain nitrogen as urea, ammonium or nitrate. It is important to understand the nitrogen cycle when applying nitrogenous fertilisers so that the fate of the nitrogen can be predicted.

Urea

Urea is mobile in the soil and can be actively taken up by vines. However, it is usually broken down into to the relatively immobile form ammonia which dissolves in the soil water to become ammonium.

Ammonium

Ammonium can be taken up by vines, however, it is toxic in high concentrations. Bacteria convert ammonium into nitrite (which is also toxic to plants).

Nitrate

Nitrite is quickly converted into nitrate. Nitrate is the form of nitrogen most readily used by vines. Nitrate is readily leached through the soil profile and may move out of the root zone rapidly in free-draining soils or after heavy rainfall or irrigation.

The accessibility of nitrogen by vines relies on the presence of sufficient soil water. Water movement into vine roots transports nitrate. If soil moisture is insufficient, uptake of nitrogen will be limited. A range of factors (e.g. soil type, irrigation and rainfall) affect how the various forms of nitrogen move through the soil profile.

Nitrogen is mobile within the grapevine, and can move from mature organs to areas of new growth. As such, deficiency symptoms appear first on older leaves. Symptomatic leaves may fall prematurely (see section 4.2.10 for more detail).

Nitrogen immobilisation and the carbon to nitrogen ratio (C:N)

Immobilisation (also known as 'draw down') is a state of temporary nitrogen deficiency in soil. Immobilisation occurs when organic mulches that are high in carbon and low in nitrogen (high C:N ratio), such as vine litter, dry slashed grass or straw from cereal cover crops, are incorporated into the soil. Micro-organisms and bacteria scavenge

nitrogen from the soil to fuel their own metabolism as they break down these materials. This can create a temporary nitrogen deficiency for vines. Immobilisation can be corrected by applying a base rate of nitrogen at the same time as the mulch. If materials with a high C:N ratio are left on the surface of the soil rather than being incorporated, they decompose slowly and have little impact on the soil nitrogen balance.

In contrast, when materials which are low in carbon but high in nitrogen (low C:N ratio) such as leguminous cover crops are incorporated in the soil, they decompose rapidly and release a large flush of available nitrogen for vines. If these low C:N ratio materials are left on the surface, breakdown will be slower but still quicker than the decomposition rates of most high C:N ratio materials. Examples of C:N for typical vineyard inputs are given in Table 1.

Table 1 C:N ratio for a range of viticultural inputs (adapted from Miller 1993)

Component	C:N Ratio	
Grass (dry weight)	40:1 to 80:1	High C:N
Mustard residues	20:1 to 30:1	
Legume residues	15:1 to 20:1	
Soil organic matter	10:1 to 12:1	
Microbes	4:1 to 9:1	Low C:N

Sources and losses of nitrogen

In addition to the processes discussed in the previous sections, nitrogen can also be sourced from:

- Fixation from the atmosphere by free-living bacteria and algae;
- Fixation to a 'plant ready' form in soil by bacteria living inside the root nodules of legumes;
- Decomposition of organic plant/animal matter in soil;
- Nitrogen in irrigation water;
- Applied nitrogenous fertilisers.

Nitrogen may be lost from the vineyard system via:

- Removal of bunches and prunings from vines;
- Removal of leguminous cover crops as opposed to mulching or turning them in;
- Leaching from the soil profile beyond the root zone;
- Removal of soil containing organic material and nitrogen by water runoff or erosion;
- Production of nitrogen gas by bacteria in poorly drained soils;
- Conversion of nitrogen to ammonia gas by high soil surface temperatures;
- Temporary immobilisation by turning in of high carbon content mulches such as dry grass/straw.

Nitrogen management in the vineyard

Nitrogen is available in a number of forms in both naturally occurring and commercial fertiliser products. These products have a variety of characteristics and can behave differently in different soil/water conditions (Table 2).

On sandy soils such as those in parts of the Riverland and Sunraysia, it may be necessary to apply greater quantities of actual nitrogen per hectare to compensate for potentially higher losses of nitrogen via leaching in these soils. Drip irrigated vines commonly experience leaching from the soil under drip emitters and thus require supplementary nitrogen application.

Nitrogen supplements may be necessary to compensate for poor vine vigour resulting from pest or disease attack, e.g. nematodes, or other debilitating factors. In some vineyards a leguminous cover crop grown over winter may provide sufficient nitrogen.

Maintenance of adequate nitrogen levels in the vineyard may mean annual or more frequent fertiliser application in some situations. There are a number of methods of fertiliser application, each with various factors to consider:

- Nitrogen fertiliser applied to the soil surface by broadcast or banding should be incorporated into the soil by irrigation, rain or tillage. Failure to incorporate the fertiliser may mean loss of nitrogen via conversion to ammonia gas (volatilisation);
- Foliar applications of nitrogen should only be used as a supplement to an appropriate seasonal soil fertiliser program;
- Fertigation offers better control of application, however high rates of urea or ammonium-based fertilisers applied through fertigation can result in ammonium toxicity and soil acidification;
- ONLY LOW BIURET UREA SHOULD BE APPLIED IN FOLIAR SPRAYS TO AVOID DAMAGE TO FOLIAGE.

During vineyard establishment

Young vines usually require about 2-5 g of actual N per vine per week (observe vine vigour and leaf colour to determine if this rate needs to be altered). Use calcium nitrate on acidic soils to avoid acidification. Urea and ammonium nitrate can be used on neutral to alkaline soils.

In mature vineyards

In warm regions apply 50-60 kg of actual N per hectare in spring or split applications between spring and post harvest is a good starting point. Observe vine vigour to determine an appropriate application rate. In cooler regions the application rate is likely to be approximately 20 kg of actual N per ha applied in spring or post harvest. In these areas inputs from rainfall, cover crop turnover, contaminated bore water etc. are sufficient to supply the needs of the vines without additional fertiliser.

Table 2 Characteristics of nitrogen-containing fertiliser products.

Urea
Very soluble in water;
Easily leached through the soil profile;
Requires microbial activity to transformation it to ammonium or nitrate before it is taken up by roots;
Lost as ammonia gas in moist alkaline soils;
Often the cheapest form of nitrogen;
Acidifying effect on soil.

Ammonium compounds
Usually soluble;
Absorbed onto clay particles in the soil making it less available to vines, but also less likely to be lost via leaching;
Generally transformed to nitrate before it is taken up by the roots, however ammonium can be actively taken up by vines;
Toxic to vines in high concentrations;
Lost as ammonia gas in moist alkaline soils;
Acidifying effect on soil. Sulphate of ammonia is very acidifying.

Nitrate compounds
Soluble;
Moves freely in the soil;
Taken up by plants in the transpiration stream;
Easily leached through the soil profile;
Non-acidifying, but expensive.

Complex organic molecules
Organic materials sourced from vines and weeds, animal and plant 'manures' and organic mulches;
Need to be extensively broken down and converted to ammonium or nitrate by soil organisms;
Also acts to improve soil structure;
Can harbour pathogens.

Timing the application of nitrogen for efficient uptake

The application of a mobile nutrient like nitrogen should follow periods of active root growth. These occur at two main times of the season:

- Around 4-6 weeks after budburst (dependent on soil temperature and moisture levels);
- Post harvest i.e. in the second flush of root growth (if there are no limiting factors, e.g. drought).

Timing of nitrogen application is much more efficient using fertigation because smaller amounts can be applied at regular intervals (bearing in mind the peak uptake periods). The amount applied can then be adjusted according to vine vigour and leaf colour.

If fertigation is not an option then split applications of nitrogen fertiliser are most effective:

- At least 4-6 weeks after budburst;
- Approximately 2 weeks after flowering.

Prior to budburst

The application of synthetic nitrogen fertilisers prior to budburst is futile as there is little or no root growth at this time to facilitate uptake. This early in the season vines are still using nitrogen stored from the previous season to support its growth. The probability of leaching is also high in many areas due to spring rainfall.

Between fruit set and veraison

Applications of nitrogen between fruit set and veraison can enhance amino acid concentration in berries. However, nitrogen application around veraison and during ripening requires caution to avoid prolonging or promoting excess shoot growth.

Post harvest

When the supply of available nitrogen is sufficient between harvest and leaf fall, grapevines store nitrogen over winter in the woody tissues for use the following spring. Nitrogen should be applied in the post harvest period if leaves are healthy. If the leaves have started to senesce or are in poor condition, uptake of nitrogen will be low and most will be lost to leaching through the soil profile.

Environmental and sustainability issues

There are a number of issues relating to both the sustainability of the nitrogen resource in a given vineyard and the use of nitrogenous fertilisers in the greater environment. These include:

- Leaching losses from the vineyard;
- Soil acidification;

Eutrophication

As discussed in previous sections, these issues are best managed by appropriate fertiliser selection and timing of application.

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Training

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

Contact

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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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