VitiNotes

Cooperative Research Centre for Viticulture

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Grapevine nutrition 7: Trace elements

Current titles in this Grapevine nutrition VitiNote series include:

Trace elements (also called micronutrients) are nutrients that are in very low concentrations in the grapevine but they play essential roles in vegetative and fruit development. The trace elements include copper (Cu), zinc (Zn), manganese (Mn), iron (Fe), boron (B), and molybdenum (Mo) (see separate VitiNotes for B and Mo).

While these elements, other than molybdenum, are more available at lower soil pHs, grapevines have developed mechanisms to obtain these trace elements at more neutral pHs. Boron is readily available at all pHs as well as in the lower pH range, while molybdenum is more available at moderate to high pHs (above 7). All of the trace elements are less available in leached sandy soils or are readily leached where the cation exchange capacity is low. Manganese and molybdenum have limited mobility within plants while copper, zinc and iron are immobile.

Since trace elements are required in such low concentrations, have limited mobility within the vine, and the metal cations of zinc, manganese and iron are readily fixed by most soils, foliar sprays are usually the most effective means of correcting trace element deficiencies in the current season.

Confirmation of a trace element deficiency or toxicity should be made with petiole analysis (see VitiNote *Petiole analysis*).

COPPER

Impacts

There are no direct effects of copper deficiency or excess reported on wine quality, however copper contamination of the must is undesirable, i.e. >20mg/L can exacerbate risk of wine oxidation, but these levels are rarely seen.

Symptoms of deficiency

Copper deficiency has been recorded at Gingin and elsewhere in Western Australia. Symptoms include unthrifty vines; short canes with shortened internodes; and small leaves with only slight indentations and pale in colour.

Nutrient management

Concentrations of 6–11mg/kg dried petiole at peak bloom are likely to be adequate for vine productivity.

The use of copper-based fungicide sprays generally provides vines with adequate copper.

Copper chelate or even copper sulphate sprays can be applied to vines at low concentrations, but the risk of leaf burn with fully soluble copper foliar sprays is extremely high. Also, care should be taken to avoid copper sprays at full bloom as copper may be toxic to open flowers and reduce fruit set.

Sustainability issues

Where copper has been used over many years, the level in the soil rises well above natural levels. In the very long term, it is possible that excessive levels could be reached which could lead to phytotoxicity and detrimental effects on soil microbes.

ZINC

Role in grapevine function

Zinc is involved in plant protein synthesis, the production of some plant hormones and in pollination and fruit set.

Impacts

As zinc is involved in the fruit setting process, zinc deficiency may cause a poor fruit set condition known as 'hen and chicken'. 'Hen and chicken' bunches have 'shot' berries which vary in size and rate of ripening.This poor fruit set may occur with or without leaf symptoms.

Excess use of zinc sprays can cause deformities in bunches.

Symptoms of deficiency

Vegetative deficiency symptoms include:

- Young leaves become characteristically mottled and, in severe cases, leaves become necrotic.
- The petiolar sinus opens wide so leaves do not have the typical shape expected.
- Shoots are stunted and may show a zigzag growth pattern.

Land with a history of high applications of superphosphate or animal manure may be more prone to zinc deficiency.

Influence of rootstock, variety and soil type

Some rootstocks are less well able to supply zinc than own-rooted vines. Varieties such as Muscat Gordo Blanco are more susceptible. Zinc deficiency may be more severe on alkaline soils or some sands.

'Looks like'

There is some similarity to the effect of herbicide damage such as caused by phenoxy acid and glyphosate and fanleaf virus, but neither symptom is quite the same as that of zinc deficiency.

Table 1. Characteristics of selected zinc-containing fertilisers*

Zinc sulphate Monohydrate 36% zinc Heptahydrate 23% zinc	Rapidly growing first or second year vines may benefit from the immediate availability of zinc sulphate.
Zinc-enriched superphosphate ('complete' fertiliser)	When applied to the soil, zinc in this form is rendered unavailable to vines, particularly in alkaline soils.
Zinc oxide 78% zinc	Less soluble than zinc sulphate and therefore releases zinc to vines more slowly. It is suitable for use on mature vines.
Zinc (EDTA) chelate	Chelates are expensive and as such may not always be an economic solution, although they may have advantages in tank mixes where oxides or sulphates are incompatible.

*Zinc-containing fungal protectants, e.g. ziram, can also be a source of zinc in vineyards.

Nutrient management

Petiole analysis results for zinc are generally reliable, however contamination of petioles is common and this may provide false results, so this possibility should be taken into consideration when interpreting tests. Concentrations of >26 mg/kg dried basal petioles at peak bloom are likely to be adequate for vine growth.

Fertiliser application

Zinc is generally applied as a foliar spray, however where zinc deficiency is noted and the soil is acidic, there may be benefit in applying zinc to the soil at the manufacturer's or adviser's recommended rates. Application to alkaline soils is usually unsuccessful.

Model zinc fertiliser requirements

For pre-planting and young vines

There is no requirement for treating soils with zinc prior to planting, however some advisers suggest applying zinc-enriched superphosphate at planting time.

With young, rapidly growing vines frequent treatment is required as zinc is not translocated from the treated leaves to the growing points. Growers should apply foliar sprays as needed each month or so to provide zinc for new growth.

Zinc sulphate heptahydrate sprays applied at 1kg/1000L of water, or the zinc contained in a number of commercial insecticides and fungicides, are generally sufficient to provide adequate zinc levels.

Where any symptoms of deficiency are noted, additional sprays can be applied.

In mature vineyards

As with young vines, adequate zinc may be supplied to mature vines through application of other products, and additional sprays can be applied where symptoms of deficiency are noted.

Additionally in mature vineyards consider applying a foliar spray containing zinc ten days or so before flowering, especially if the vineyard has a history of zinc deficiency.

This will maximise the cropping potential of vines by ensuring that there is no limitation on fruit set from zinc availability to flowers.

MANGANESE

Role in grapevine function

Manganese is involved in the synthesis of chlorophyll and in nitrogen metabolism.

Symptoms of deficiency and toxicity

Symptoms of deficiency are first seen on the older leaves and show as a yellowing between the main veins in broad bands. If the deficiency is severe, younger leaves may also be affected.

Manganese deficiency is most likely to occur in vines on calcareous (alklaline), sandy soils.

'Looks like'

Manganese deficiency symptoms can be confused with those caused by a deficiency of magnesium, zinc or iron, however deficiencies of these latter two nutrients tend to appear first on younger leaves.

Symptoms of toxicity

Symptoms of toxicity are rarely seen in grapevines. Manganese toxicity is seen as black spots on leaf blades, shoots and bunch stems.

It is only likely to occur in vines on waterlogged, acidic soils.

Nutrient management

Concentrations of 30 – 60 mg/kg dried basal petioles at peak bloom are likely to be adequate for vine growth. Be aware of potential high concentration if using mancozeb prior to sampling.

Fertiliser application

Fungicides containing mancozeb used in the spray program during the growing season usually provide sufficient Mn. If manganese is required, foliar nutrient sprays of manganese sulphate are normally used. Manganese is applied as needed as per petiole test results. Applications may be required each season.

Chelated forms (EDTA) of manganese are also used but are more expensive per unit of manganese.

Model manganese fertiliser requirements

For pre-planting and young vines
No manganese treatments are necessary prior to planting vines, however young vines may require supplementing.

> Zinc sulphate and manganese sulphate can be sprayed together if both elements are deficient.

In mature vineyards
When the fungicide mancozeb is used in the disease management program it appears to supply sufficient manganese as it breaks down, so that other specific manganese inputs may not be needed. If vines require supplementation, growers should apply manganese alone or with zinc sprays.

Routine application of manganese as a foliar spray in spring may provide a cheap form of 'insurance' against leaf chlorosis caused by manganese deficiency.

Sustainability issues

Current research indicates that mancozeb can have a detrimental effect on beneficial insect populations, so that the use of manganese sulphate is considered a 'safer' alternative than mancozeb, if manganese is required.

IRON

Role in grapevine function

Iron plays an important role in chlorophyll formation, energy trapping and transfer in photosynthesis and respiration, and cell strengthening.

Mobility and availability in soils and the vine

Soils that are truly deficient in iron are rare and are generally leached or wind-blown sands. Most soils contain adequate iron, but deficiency in vines can result from:

- A bicarbonate inhibition of uptake of iron ions at the root surface. High levels of bicarbonate are found in alkaline soils, due to free lime or sodicity, and are aggravated by poor aeration due to soil compaction and/or waterlogging. If soil alkalinity alone is inducing iron deficiency, the severity of symptoms will not change much during the season. Variations in tolerance will influence the usefulness of some of the rootstock cultivars (derived from less tolerant American Vitis species) in such conditions.
- In waterlogged soils, symptoms of iron deficiency often disappear if irrigation is withheld. Vines and weeds can gradually reduce the quantity of water in the root zone and improve aeration.
- Iron can also become more available as soils warm up later in the season. Iron is immobile within the vine.

Symptoms of deficiency

Iron deficiency results in general yellowing (chlorosis) of young leaves and new growth. In severe cases, total shoot chlorosis can occur making these tissues appear almost white. This total shoot chlorosis can then be followed by the development of necrotic spots between the veins.

When deficiency is not severe, veins retain their green colour. Iron deficiency is most likely to occur in vines on soils with an abnormally high pH.

'Looks like'

Iron and manganese deficiencies can be confused, however iron deficiency always shows up on the youngest parts of the shoots, whereas manganese deficiency is seen on older leaves. Symptoms similar to iron deficiency can also be caused by excessive uptake of the herbicide simazine.

Symptoms of iron toxicity are rarely seen in grapevines.

Nutrient management

Leaf analysis for iron is not a reliable indicator of iron status in the vines. Soil tests are also unreliable. Generally, the observation of deficiency symptoms on vines will provide the best estimate of iron status. Any test results should always be considered in conjunction with obvious symptoms and overall vigour of vines.

Fertiliser application

It is not possible to correct iron deficiency easily. Soil conditions that lead to iron deficiency usually quickly render soil-applied iron compounds insoluble.

Iron fertilisers are usually based on either a chelated or sulfate form of iron.

Only some chelated iron products contain a material that is able to protect the iron from bicarbonate-induced inhibition of uptake when applied to alkaline or high calcium soils. The best known is Fe-EDDHA.

EDTA based iron chelates are not suitable for use in calcareous soils.

A need for use for these products should be clearly established as they can be expensive. If deficiency is an issue, apply iron to vines immediately.

Foliar treatment with iron sulphate or iron chelates is only successful if good coverage is provided because iron does not move far from its point of entry to the vine, e.g. stomata, and re-greening of leaves can be patchy.

Excess concentrations of iron(>150g iron in 1000L spray) in foliar sprays can cause leaf burn.

Model iron fertiliser requirements

For pre-planting and young vines

The installation of a drainage system may be necessary if waterlogging is likely to be a problem in a planned vineyard development, because iron deficiency can be related to waterlogging.

If deficiency symptoms are severe growers should apply iron chelates.

In mature vineyards

Maintenance of appropriate soil pH and drainage are the best ways of ensuring adequate availability of iron (and other trace elements) to grapevines.

Irrigation control to limit waterlogging is the best preventative and corrective measure for iron deficiency if waterlogging is the cause.

Otherwise, or if symptoms are severe and deficiency clearly established, growers should apply iron chelates as per manufacturer's recommendations.

FURTHER INFORMATION

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

Further detail on trace element, nutrition, deficiency symptoms and management, and petiole testing can be found in the *Grapevine Nutrition: Research to Practice*™ training manual, Cooperative Research Centre for Viticulture, Adelaide 2005.

Useful references on these topics are:

- Robinson JB, (1997) Grapevine Nutrition, in Viticulture Vol 2 Practices, Eds Coombe BG & Dry PR, reprinted 2001, Winetitiles, Adelaide, pp178-208.
- Nicholas P, (Ed.) (2004) Soil, irrigation and nutrition, Grape Production Series 2, SARDI, Adelaide.
- Goldspink B, (1997) Liming of vineyard soils, in Fertilisers for winegrapes, Eds BH Goldspink et al, Agriculture Western Australia.

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