VitiNotes

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Grapevine nutrition 8: Molybdenum

ROLE IN GRAPEVINES

Molybdenum (Mo), is a micronutrient involved in the conversion of nitrate-nitrogen, taken up by the roots, into a form that the vine can use. It is also involved in enzymatic reactions essential for growth and reproduction in plants. Recent research indicated that molybdenum plays an important role in: grapevine fruit set; seed formation; berry formation and development; and bunch yield (Williams et al. 2004; 2007).

SYMPTOMS OF DEFICIENCY

Vegetative growth deficiency

Molybdenum deficiency may be involved in a growth disorder observed in Merlot (often called the "Merlot problem"), where newly planted vines, on their own roots, grow well initially and then exhibit symptoms including:

- Small leaves (size of a 50c coin or smaller);
- Leaf-edge burn, poor leaf colour, wood fails to mature;
- Rubbery feel to shoots, papery feel to leaves;
- Zig-zag or distorted growth habit of shoots.

Vines with these symptoms have excessive petiole nitrate-nitrogen concentrations and, it is thought, the lack of molybdenum impacts on the metabolism of nitrate-nitrogen in the vine, leading to a build up of nitrate-nitrogen (and protein deficiency).

Molybdenum deficiency associated with poor fruit set ('hen and chickens')

Merlot grapevines, in particular, have a critical need for adequate molybdenum concentrations during flowering and reproduction for seed formation and bunch yield (Williams et al., 2004). Wet and/or cold conditions leading up to flowering can also accentuate a temporary molybdenum deficiency, leading to:

- 'Hen and chickens' - a form of berry asynchrony or millerandage = seedless berries, where the bunch at harvest consists of a mixture of a few large, normal berries (hens) and many small berries (chickens) of uneven ripeness (Figure 1).

Figure 1. A Merlot bunch with 'hen and chickens' and shot berries

- 'Shot berry' formation - a form of berry asynchrony, where the bunch has excessive numbers of small (<5 mm diameter), green, seedless berries, that may or may not ripen at harvest.

Often there are no clear vegetative growth symptoms for molybdenum deficiency prior to flowering. After fruit set the only symptoms are 'hen and chickens' and 'shot berries'. Other indicators of possible/potential Mo deficiency for reproduction are: periods of cold, wet conditions between bud burst and fruit set, and vineyards with a history of fruit set disorders.

Merlot vines on own roots are more susceptible to Mo deficiency during flowering, hence its subsequent effects on fruit set and bunch yield. Other cultivars in Australia, including Cabernet Sauvignon, Chardonnay, Cabernet Franc, Ruby Cabernet and Sauvignon Blanc, are also susceptible, but are not as severely affected as Merlot.

NUTRIENT MANAGEMENT

Molybdenum deficiency that affects growth (vegetative deficiency) is rare in mature vineyards. Vineyard treatments should only be applied if petiole analysis shows excessive nitrate levels (e.g. 10,000 mg/kg nitrate nitrogen) and molybdenum deficiency symptoms are persistent.

However, molybdenum deficiency that is only temporary during flowering may be a major cause of poor fruit set, without any vegetative signs of deficiency. Other factors, such as periods of cold, wet conditions between bud burst and fruit set, and zinc or boron deficiency can also cause poor fruit set and should also be considered if fruit set is poor.

Interpreting plant tests for molybdenum

(a) Petiole tests and diagnostic standards for Mo at peak bloom

A suggested scheme to assist with the assessment of irrigated Merlot vines' Mo status (Williams et al. 2007):

Deficient: vines with petiole Mo concentrations at peak flowering less than 0.09 mg/kg (yield response to pre-flowering foliar Mo spray likely);

Marginal: vines with petiole Mo concentrations at peak flowering of 0.09-0.45 mg/kg (response to pre-flowering Mo sprays is uncertain);

Non-responsive: vines with petiole Mo concentrations at peak flowering greater than 0.45 mg/kg (response to pre-flowering foliar sprays unlikely).

The calibrated petiole test at peak flowering (standard time and tissue used for nutrient analysis in vines) can be used for diagnostic purposes, but will be too late for the most effective corrective measures to be taken in the current season. However, a scheme based on petiole sampling at flowering can still be used for troubleshooting (diagnostic testing), monitoring the vine Mo status on an annual basis (nutrient monitoring) and predictive testing.

A new Mo analysis procedure (using a mass spectrophotometer), which can accurately detect very low concentrations of Mo in grapevine tissues, is available in several states, including SA and WA, as a commercial service to industry (stimulated by the work of Williams et al. 2004; 2007). It will assist with monitoring the Mo status in grapevines, but must be specifically requested.

(b) Vineyard history

Vineyards with a history of berry asynchrony ('hen and chickens') are likely to be affected in certain growing seasons with inconsistent, recurrent, fruit set and berry asynchrony disorders. In other seasons, especially with warm, calm conditions leading up to flowering, no disorders are evident.

(c) Climatic factors

The onset of periods of climatic stress (e.g. periods of cold, wet conditions between budburst and flowering) is likely to increase the incidence of both Mo deficiency and fruit set problems.

(d) Acid soils

In acid soils there may be greater fixation of molybdate anions onto iron and aluminium compounds. The majority of Mo in these complexes may not be available for root uptake by plants in the current growing season. Hence, Mo deficiencies in plants are likely to be more common on acid compared with alkaline soils.

Note: In acid soils or soils low in molybdenum:

- Application of high rates of phosphorus fertilisers or lime increases molybdenum availability.
- Large applications of sulphate fertilisers (e.g. gypsum) may induce molybdenum deficiency.

ROOTSTOCK EFFECTS

Williams et al. (2007) demonstrated that increased bunch yield responses from Mo application to Mo deficient grapevines were greatest for Merlot on own roots (1.8 to 3.2 fold). They also showed significant, but smaller yield increases for Merlot on the rootstocks: SO4 (2.1- 3.6), 140 Ruggeri, Ramsey and Schwarzmann, (<1.8 fold). However, Merlot on 110 Richter did not respond, but produced high yields. These findings suggest that 110 Richter should be considered as a rootstock for new Merlot plantings in vineyards with a history of berry asynchrony and Mo deficiency, provided it meets other selection criteria such as resistance to nematodes, waterlogging etc.

MOLYBDENUM-CONTAINING FERTILISERS

Molybdenum, as a soluble fertiliser, is normally available as ammonium molybdate (54% Mo) or sodium molybdate (39% Mo).

FERTILISER APPLICATION

(a) For vegetative deficiency of Mo in young grapevines

As molybdenum is only required in a small quantity, one annual foliar spray of 500g ammonium or sodium molybdate per 1000L of water sprayed to the point of runoff should be adequate to overcome a vegetative growth deficiency where vegetative symptoms have been observed or petiole tests indicate high nitrate-nitrogen concentrations (Robinson and Burne 2000).

(b) Fruit set disorders and Mo deficiency in mature grapevines

When an effect on fruit set as a result of molybdenum deficiency is expected, growers can consider applying molybdenum foliar spray regimes (Williams et al. 2007) to improve fruit set and bunch yield as suggested below:

- Apply Mo before flowering at the growth stages in the (Coombe 1995) system, of E-L 12 to 18 (10 cm shoot length and 5 leaves, up to 50 cm shoot length with 14 leaves separating and first flower caps still in place),
- Apply 250 to 500mg of Mo per L of water (approximately 300g sodium molybdate per hectare of vineyard) to the point of canopy run-off,
- Apply one spray only, unless more than 2 mm of rainfall occurs within 48 hours. Then reapply the Mo spray during the next dry period of weather,
- Monitor petiole Mo in grapevines at peak bloom (to assess annual carryover in vines) and if Mo sprays have been used for 3 years, measure soil Mo reserves (see the caution note below).

SUSTAINABILITY ISSUES

Caution: Vineyard soils should be tested after 3 years of Mo spray regimes for total and extractable soil Mo, as Mo can accumulate in soils and has the potential to lead to surface runoff/leaching of

Mo to offsite water resources and/or molybdenosis toxicity in ruminants grazing inter-row cover crops. Such pasture plants can also be tested for Mo content (10-20 mg/kg of Mo in dried forage may pose a risk to ruminants, Johansen et al. 1997). If elevated levels of soil Mo are measured after 3 years of Mo sprays, consider no application of Mo for a few years, or use of ultra low rates of Mo.

Soil applications of Mo may not be an effective short-term measure to overcome Mo deficiency, for fruit set in the current season of application, as adequate proportions of soil applied Mo may not reach the fibrous roots, and/or conditions may not be suitable for uptake by the fibrous roots and transport to inflorescences before flowering. It may be a longer-term solution on soils low in iron and aluminium, with low capacity to 'fix' the molybdate anion.

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