Preliminary determination of nutrient uptake in grape vines

Pam Strange
SGS Australia Pty Ltd, PO Box 1102 Mildura Vic 3502.

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Summary

Foliar applied nutrients are available on the market as different formulations, ranging from sulphates to chelates and amino acids. Fertilizer companies make claims on the advantages of their formulation category. Murray Valley grape growers seek independent information on how quickly the different formulations are absorbed under local conditions and at what levels to improve the efficiency of foliar nutrient application in their vineyards.

Due to the lateness of a funding announcement, Murray Valley Winegrowers Inc (MVWI) contracted SGS to run a nutrient absorption trial on potted grape vines under shade cloth in a local nursery as a preliminary study, prior to a field study planned for next season. MVWI chose zinc as the element to test as zinc sulphate, zinc chelate and zinc oxide, applied as either a spray or as a dip.

An increase in zinc levels in the grape leaves was measured two days after the treatment. The highest level at this time was achieved by the Zinc Oxide treatment, but by Day 4 the zinc levels in the Zinc Oxide treated leaves were almost back to the untreated Control levels. Zinc levels in the Zinc Sulphate and Zinc Chelate treated plants remained higher than the Control plants for the duration of the trial. Inexplicably, red leaves, which had elevated zinc levels, started to appear by Week 2 and leaf zinc levels in the treated plants generally started to rise by Week 2 or 3.

A field trial next season will study nutrient absorption under local and commercial conditions and a number of recommendations have been made for the field trial.

Introduction

Scientific reviews have been written on the rates and pathways of absorption into the vine of different nutrients and the factors affecting absorption (Christensen, 2005). Foliar applied nutrients are available on the market as different formulations, ranging from sulphates to chelates and amino acids. Fertilizer companies make claims on the advantages of their formulation category. Agrichem has published on their web site (www.agrichem.au) a graph showing the uptake of different formulations of an unknown element (Figure 1). Murray Valley wine grape growers have the option to apply micro-nutrients as a foliar as part of a nutritional fertiliser program or to correct deficiencies, but they seek independent information on the timeframe for nutrient absorption under local conditions and at what levels for the purpose of seasonal nutrition planning and the correction of deficiencies in the vineyard.

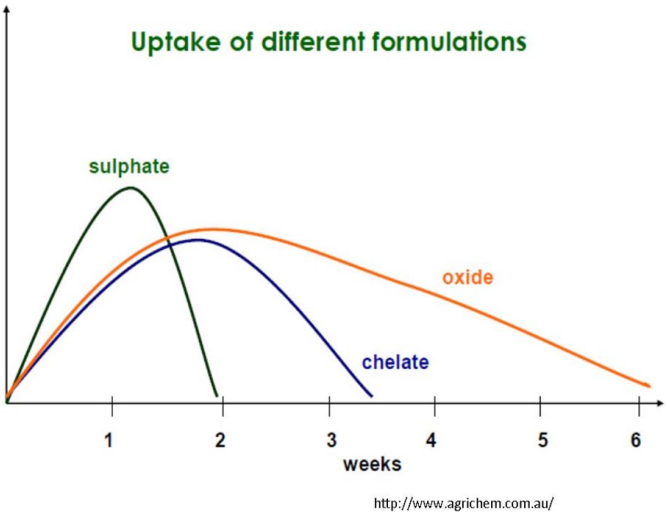

Figure 1 - Copy of the Agrichem graph indicating the uptake of different formulations of mineral nutrients applied as foliar fertilizer. Supplied by MVWI.

Murray Valley Winegrowers Inc. (MVWI) applied for funding from Grape and Wine Research and Development Corporation (GWRDC) to carry out a nutrient uptake trial to gain local independent information on the rate and level of uptake of a nutrient applied as a foliar fertilizer in different formulations. The trial sought to measure and track over time, the absorption of the nutrient into the vine and thus replicate the Agrichem graph. The funding announcement was too late for the work to be done in a commercial vineyard so SGS was contracted to run a preliminary study in a nursery on potted grape vines under shade cloth prior to the field study next season. MVWI selected zinc as the nutrient to trial and the formulations to be tested, which were sulphate, chelate and oxide.

Aim

This trial aimed to provide preliminary data of the absorption of three different formulations of an element over time in grape leaves to compare with the uptake data reported by Agrichem. The trial was done on potted nursery plants and zinc was chosen as the element to test, applied as the sulphate, chelate and oxide forms of the element.

Materials and Methods

Grape vines in 115 mm pots in a local nursery were used for the trial (Figure 2). Each treatment consisted of 105 pots in one replicate. The pots were moved from a glasshouse to a shade house for the trial. In the shade house, vines were not watered for 24 hours after treatment to allow the treatment to dry on the leaves and then watered with Lower Murray Water by over head sprinklers.

Figure 2 - Tagged potted vines in the shade house after treatment.

MVWI chose zinc as the element to work with as zinc is relatively immobile in the plant and zinc would not be expected to move out of the treated leaves into new growth (MVWI pers comm.).

Zinc, in the form of zinc sulphate, zinc oxide and zinc chelate, was mixed to the equivalent of 25g zinc in 10L water. Water to the nursery was supplied by Lower Murray Water and this was used to prepare the solutions. As well as the Control plants, treated with just water, the solutions were applied as either a 'Dip' or a 'Spray' application method. A 5 L hand held pressure pump sprayer was used to 'Spray' the treated plants to run off and a 20 L bucket was used to 'Dip' the foliage by covering the soil and holding the base of the plant by hand and inverting the foliage into the bucket of nutrient solution. MVWI received advice from a plant nutrition scientist that both spray and dip application methods be used.

Random vines were tagged at the top leaf to show which leaves were treated and to indicate new growth during the trial. A leaf sample was taken from vines in the glasshouse on Day 0 (20 February 2014) and then each treatment was sampled for laboratory analysis 2 days, 4 days, 1 week, 2 weeks, 3 weeks, 4 weeks and 5 weeks after treatment. Ten leaves were selected from each treatment block for a sample. This sample weighed approximately 7g and was sufficient for the laboratory to perform a zinc only analysis. For sampling after treatment, leaves were washed in a 1% hydrochloric acid solution and rinsed in tap water with brisk agitations then patted dry with paper towel (pers comm. SGS laboratory) before being sent to the laboratory express post. Leaf samples collected on Day 0, before treatment, were rinsed in distilled water and patted dry before sent to the laboratory express post.

Treatments

The products, zinc concentration and mixing rates for each treatment are listed in the following tables.

Product List

Product	Zinc concentration
Control	LMW water only
Zinc Sulfate Hepta	21.5% Zn as Zinc Sulphate
Twin Zn	70% Zn as Zinc Oxide
Biostim Zn	13% Zn as Zinc Chelate

Treatment List

Treatment	g or ml product per 10L (dip) or 5L (spray) of water
Dip Control	10L LMW water
Dip Zinc Sulphate	232g Zinc Sulfate Hepta
Dip Zinc Oxide	72ml Twin Zn
Dip Zinc Chelate	386ml Biostim Zn
Spray Control	5L LMW water
Spray Zinc Sulphate	58g Zinc Sulfate Hepta hy-
Spray Zinc Oxide	18ml Twin Zn
Spray Zinc Chelate	96.5ml Biostim Zn

Leaf sampling dates

Date	Days after treatment (DAT)
20 Feb 2014	0
22 Feb 2014	2
24 Feb 2014	4
27 Feb 2014	1 week
6 March 2014	2 weeks
12 March 2014	3 weeks
20 March 2014	4 weeks
27 March 2014	5 weeks

Results

An increase in the level of zinc in grape leaves was measured two days after treatment in both Sprayed and

Dipped plants and the highest level was achieved by the Zinc Oxide treatment at this time but the levels were similar for all of the Dip treated plants (Figures 4 & 5). The levels were higher in the Dipped plants than the Sprayed plants. By Day 4, however the level of zinc in the Zinc Oxide treated plants had dropped back and was similar to the untreated Control levels in both Dipped and Sprayed plants. The zinc levels in the Zinc Chelate and Zinc Sulphate treated plants stayed high relative to the Control plants throughout the study, at Day 2 or Day 4.

After seven to 14 DAT, zinc levels increased in some treatments, but not the Control. At the same time red leaves appeared in some of the treatments (Figure 3). More red leaves were seen in the Dip Zinc Sulphate and Dip Zinc Chelate plants but there were also some red leaves in the Spray Zinc Sulphate and Spray Zinc Chelate plants. Upon analysis at 3 weeks, it was found that the red leaves had very high levels of zinc (1100 mg/kg) which was twice the level in the Dip Zinc Sulphate leaves at that time.

Figure 3 - Red leaves in the Dip treated plants, three weeks

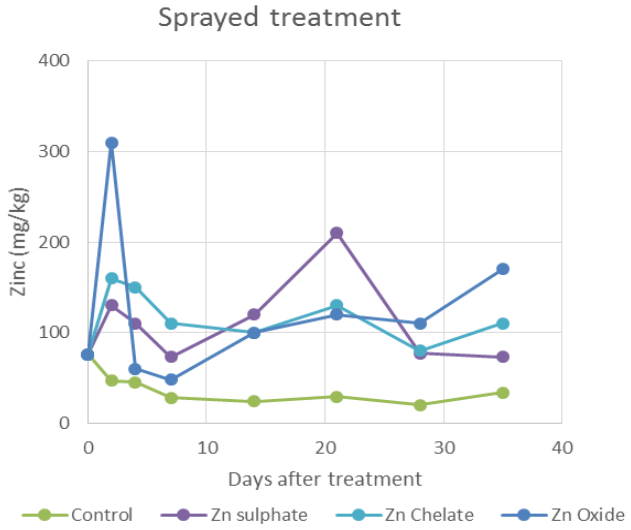

Figure 4 - Uptake of Zinc over time from the sprayed treatment.

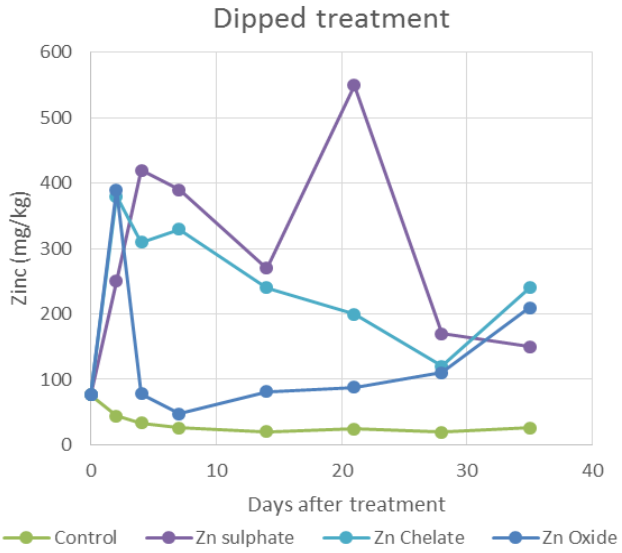

Figure 5 - Uptake of Zinc over time from the dipped treatment.

Discussion and Conclusions

Leaf zinc levels were shown to increase quickly after a foliar application of zinc fertilizer, regardless of the formulation. The large increase caused by Zinc Oxide however, appears to be short lived with levels dropping back by Day 4. The levels in the Zinc Chelate and Zinc Sulphate treated plants remained higher than the Control plants throughout the study.

A grapevine nutrition technical note (CRC for Viticulture, 2006) lists the characteristics of selected zinc-containing fertilisers as, 'Rapidly growing young vines may benefit from the immediate availability of zinc sulphate. zinc oxide is less soluble than zinc sulphate and thus releases zinc more slowly. This form of zinc is suitable for use on mature vines. zinc chelate is an expensive option but may have advantages in tank mixes where oxides and sulphates are incompatible'. Preliminary results from this trial do not support all of these claims. Zinc oxide was quickly and highly absorbed by the young potted plants in this nursery trial.

Dip treated plants reached higher zinc levels than the Spray treated plants but the trends were similar. In commercial grapes, the recommended adequate range for zinc in whole leaves at flowering is 25-100 ppm (Davenport & Horneck 2011). Many of the results in the treated leaves in this trial were much higher than this. Spray is the commercial application method which the field trial should follow.

Zinc, like many of the minor elements, moves to some extent from mature to immature tissue in the phloem (Clarkson, 1974) and, together with dilution due to growth, may explain the decreasing zinc levels in the Control plants. Zinc, though, is reported to be a relatively immobile element in the plant (CRC for Viticulture, 2000), especially under deficiency symptoms (Archer 1985). No deficiency symptoms were seen in this trial. While care was taken to sample treated leaves, there was an unexplained rise in zinc levels in the leaves after about 3 weeks and the presence of red leaves which had elevated zinc levels. The 'redness' can not simply be explained by the plants shutting down for autumn but maybe there has

been a toxic reaction by the young plants to the treatments. Reddening of leaves has been associated with zinc toxicity (Reichman 2002). The field trial should duplicate commercial application methods, rates and timing.

This trial aimed to sample treated leaves but the field trial may also sample new growth to investigate the absorption and mobility of different forms of an element to avoid deficiency in subsequent growth. Standardising the position of the leaf to sample after treatment i.e. opposite the bunch, may help identify treated leaves from new growth. Leaf sampling in the field trial should be done during active leaf and berry growth.

Given the limited availability of potted plants, only small leaf samples (10 leaves) were submitted to the laboratory for analysis from each treatment. This should not be the case in the field trial. The field trial should also replicate the treatments and sample each replicate separately.

It has proven difficult to gain any information about the Agrichem graph, and indeed even the authenticity of the graph. No information on which element or elements were tested or whether the element was a major or micro element. Thus I suggest that the field trial include two elements, one mobile (Mn for example) and one immobile (Zn, Fe, B or Mg for example, although Mg is a macronutrient). The use of foliar sprays with macronutrients is reported to show limited results due to a complete lack of response unless many applications were made (Christensen 2005). The results from this trial did not duplicate the Agrichem graph but zinc levels in Zinc Oxide sprayed leaves spiked higher and quicker than the Zinc Sulphate and Zinc Chelate sprayed plants but the Zinc Chelate and Zinc Sulphate treated leaves had higher zinc levels for longer. The field trial is needed to verify these preliminary results under local and commercial Murray Valley conditions.

Appendix 1 - Raw Data

Data is mg/kg zinc on a dry weight basis.

Days After Treatment	0	2	4	7	14	21	28	35
Control	76	47	45	28	24	29	20	34
Zn Sulphate	76	130	110	73	120	210	77	73
Zn Chelate	76	160	150	110	100	130	80	110
Zinc Oxide	76	310	60	48	100	120	110	170

Figure 6 - Raw data from the sprayed treatment.

Days After Treatment	0	2	4	7	14	21	28	35
Control	76	44	33	26	20	24	19	26
Zn Sulphate	76	250	420	390	270	550	170	150
Zn Chelate	76	380	310	330	240	200	120	240
Zinc Oxide	76	390	78	47	81	88	110	210

Figure 7 - Raw data from the dipped treatment.

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