GRAPEVINE RESPONSE TO CONCENTRATE AND TO DILUTE APPLICATION OF TWO ZINC COMPOUNDS

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ABSTRACT

Vineyard trials were conducted in 1975 and 1976 to compare the effectiveness of two zinc foliar spray compounds and two methods of application in correcting zinc deficiency. Zinc-EDTA chelate (14.2% Zn) and basic zinc sulfate (50% Zn) were compared with dilute (1169 liters/hectare) and concentrate (234 liters/hectare) spray applications in two Thompson Seedless vineyards.

Grapevine foliar uptake of and response to zinc applications were measured by shoot-tip analysis and berry size and degrees Brix measurements. Dilute application was more effective than concentrate application, regardless of the zinc compound used. This was shown in higher shoot-tip zinc levels 10 and 14 days after application and in higher berry weights and lower degrees Brix at harvest. The zinc chelate was more effective in foliar zinc uptake (10- and 14-day shoot-tip zinc levels) than basic zinc sulfate when compared at an equal application rate of elemental zinc per hectare. However, on a commercial recommended rate basis, basic zinc sulfate at 2.24 kg zinc/ha was more effective than the zinc chelate at .56 kg zinc/ha. It is concluded that zinc deficiency can be corrected most effectively with dilute (full-wetting) application of basic zinc sulfate if foliar sprays are used.

Zinc deficiency is the most widespread micronutrient deficiency of grapes in California, and ranks second to nitrogen deficiency in the number of acres involved (2).

Most vineyeard zinc deficiency studies have involved getting sufficient amounts of zinc into grapevines for correction (2,4,5,16). The daubing of fresh pruning cuts was an early development in this work; it is still a common method for treating spur pruned vines (2,5,9). Cane pruned vines are most commonly treated by foliar spraying (2,3,6,8). Soil applications are usually a last resort measure because of the high rates of zinc required and the limited duration of effectiveness; their usefulness is limited to localized, severe deficiencies and nursery sites (1,5,7).

Foliar spray application is increasing in popularity, even on spur pruned vines, because of convenience and cost. Daubing requires more supervision and labor. Such sprays most commonly utilize a neutralized or basic zinc sulfate or a chelated zinc compound and are applied as a prebloom dilute (full-wetting) spray. However, concentrate or low volume sprayers are gaining in popularity among vineyardists. Such sprayers usually operate in the range of 187-234 l/ha (20-25 gal/acre) for a prebloom spray and utilize an air stream to carry fine droplets onto the foliage. Dilute sprayers require about 935-1400 l (100-150 gals/acre) for a prebloom spray and utilize the driving force of spray droplets discharged under pressure, sometimes assisted by an air blower.

Concentrate sprayers have been shown to be equally effective in foliage coverage and deposit as dilute sprayers for the control of many grape pest and disease problems (10,11). Grapevine response to the growth regulators gibberellin and ethephon have also been effective with concentrate as well as dilute sprays; responses have been equivalent with either application method, using the same rates of technical gibberellin or ethephon per hectare (12,13). However, preliminary trials in 1971 (senior author's unpublished data) indicated possible differences in effectiveness between concentrate and dilute applications when used for zinc treatment of grapevines. This prompted a two-year study to compare the two methods of applica-

Table 1. Zinc spray treatments, 1975-1976.

Treatment no.	Application method	Zinc compound	Rate, Kg/hectare (lbs. per acre) of compound		of elemental zinc	
1	No treatment	None	—	—	—	—
2	Concentrate	Zinc chelate	3.9	(3.5)	.56	(0.5)(a)
3	Concentrate	Zinc chelate	7.8	(7.0)	1.12	(1.0)
4	Concentrate	Basic zinc	2.2	(2.0)	1.12	(1.0)
5	Concentrate	Basic zinc	4.4	(4.0)	2.24	(2.0)(a)
6	Dilute	Zinc chelate	3.9	(3.5)	.56	(0.5)(a)
7	Dilute	Zinc chelate	7.8	(7.0)	1.12	(1.0)
8	Dilute	Basic zinc	2.2	(2.0)	1.12	(1.0)
9	Dilute	Basic zinc	4.4	(4.0)	2.24	(2.0)(a)

(a) approximates maximum label recommended rates.

tion, using the most widely used zinc compounds, basic or neutralized zinc sulfate and zinc EDTA chelate.

MATERIALS AND METHODS

Similar trials were conducted in both 1975 and 1976, in mature, own-rooted Thompson Seedless vineyards. Both trial locations, a Monmouth district vineyard in 1975 and a Kingsburg district vineyard in 1976, were on soils classified as Delhi loamy sand — a deep, well drained, wind-deposited soil commonly found to be deficient in zinc. Both vineyards have a history of mild and fairly uniformly distributed zinc deficiency problems. Approximately 10% of the clusters in the Monmouth trial location had regularly shown the symptoms of reduced fruit set and the presence of "shot berries" typical of zinc deficiency. Mild foliar symptoms had also appeared on the same vines. The Kingsburg trial location had a zinc deficiency symptom incidence approximately twice that of the Monmouth vineyard.

Identical zinc treatments as shown in Table 1 were applied both years. The rates of the two zinc compounds were selected to be compared at equal rates of elemental zinc per hectare and at maximum label recommended rates. The basic zinc sulfate compound (Del Mo-Z®, Chevron Chemical Co.) is a zinc-sulfate hydroxide-calcium sulfate material containing 50% Zn, the chelated zinc (Geigy Chemical Co.) is an EDTA (disodium zinc ethylene diamine tetracetate dihydrate) compound containing 14.2% Zn.

A different concentrate sprayer was used each year, i.e. a Kinkelder model MV-250 in 1975 and an Ag Tech Sprayall 5003 in 1976 — each a tractor pull type, self-powered unit with a standard vineyard/orchard sprayhead. Both were operated at 234 l/ha (25 gal/acre) and a forward speed of 4.4 km/hr (2.75 mi/hr). Dilute sprays were applied with an inverted "U" over-the-row boom sprayer operated at 17.5 kg/sq.cm. (250 psi) and at 1169 l/ha (125 gal/acre). An adjuvant, Triton B-1956®, was added to all sprays at 15 ml/100 l (2 oz/100 gal). Sprays were applied 2 to 2½ weeks before "peak bloom" (60% calyptras off) so as to potentially influence fruit set. The sprayers were adjusted to cover the foliage and the flower clusters thoroughly.

Thirty-three-vine and 50-vine plots were used at the Monmouth and Kingsburg locations, respectively. Each treatment was replicated six times in a randomized complete block design.

Shoot tips, including the terminal 5 cm. (2 in.) with the small immature leaves and tendrils, were selected for zinc analysis to determine foliar uptake and translocation. Shoot tip sampling avoids surface contamination when enough new tissue has grown beyond the spray deposit. This technique, as described by Cook (8) and by Kessler (14), eliminates the necessity for washing the samples, or at least minimizes contamination. Twenty representative shoot tips were marked and tagged on the spray treatment dates and re-measured on the first post-treatment sampling date. This was to assure that actively growing shoot tips had grown more than 5 cm. beyond the spray deposit.

The first samples were taken before the spray treatments from each check, untreated plot, by sampling two shoot tips per vine. All plots were then sampled after treatment at 14 and 28 days in 1975 and 10, 20, and 30 days in 1976. Samples were dried at 49°C (120°F), ground and ashed. Zinc analysis of the sample extracts was performed with a Perkin-Elmer 303 atomic absorption unit.

A sample of 350 to 400 randomly selected berries was taken from each plot at harvest. They were weighed for berry weights, crushed in a food blender, and measured for °Brix of the clear juice with a temperature compensating refractometer. Grape yield measurements were not taken as planned because of harvest time difficulties in both years.

RESULTS

The shoot tip zinc level and berry sample analysis data for both years are given in Table 2. The zinc levels increased at the first post-treatment sampling and then decreased to the untreated vine levels by the second sampling. This limits treatment comparisons from zinc levels to the first post-treatment sampling data.

1975 Trial: Only the high rates of both zinc compounds gave significantly higher zinc levels, particularly so with dilute application. No differences are shown between the two zinc compounds at equal rates

Table 2. Effect of prebloom zinc treatments on post-treatment zinc foliar values, berry weight and soluble solids.

	Treatment		Kg elemental zinc	1975					1976					
				Shoot tip analysis, ppm Zn			Berry sample		Shoot tip analysis, ppm Zn				Berry sample	
	Application method	Zinc form	per hect.	Pre-treatment	Post-treatment 14 days	28 days	berry wt (g)	°Brix	Pre-treatment	Post-treatment 10 days	20 days	30 days	Berry wt (g)	°Brix
1	Check		0	74	63 b[1]	65 a	1.42 a	20.1 a	65	67 c	64 a	66 a	1.37 bc	17.7 bc
2	Concentrate	Chelate	.56	—	66 b	59 a	1.49 a	19.6 a	—	80 c	61 a	55 a	1.36 bc	18.1 c
3	Concentrate	Chelate	1.12	—	74 ab	52 a	1.54 a	19.2 a	—	91 c	62 a	67 a	1.35 bc	17.3 abc
4	Concentrate	Basic Zn	1.12	—	70 ab	59 a	1.48 a	20.4 a	—	78 c	64 a	64 a	1.44 ab	17.3 abc
5	Concentrate	Basic Zn	2.24	—	86 a	65 a	1.45 a	20.1 a	—	89 c	63 a	65 a	1.34 c	17.5 bc
6	Dilute	Chelate	.56	—	70 ab	64 a	1.44 a	18.5 a	—	126 b	63 a	62 a	1.33 c	16.8 ab
7	Dilute	Chelate	1.12	—	85 a	66 a	1.45 a	18.9 a	—	181 a	64 a	61 a	1.46 ab	16.5 a
8	Dilute	Basic Zn	1.12	—	75 ab	65 a	1.45 a	19.8 a	—	131 b	63 a	66 a	1.44 ab	16.9 ab
9	Dilute	Basic Zn	2.24	—	86 a	68 a	1.44 a	19.9 a	—	198 a	66 a	66 a	1.52 a	17.0 ab

[1] Mean separation by Duncan's Multiple Range test; 5% level.

of zinc/hectare. At label-recommended rates, only the basic zinc sulfate was better than no zinc treatment.

No treatment differences in berry weights or degrees Brix are shown.

1976 Trial: All of the dilute applications gave significantly higher post-treatment zinc levels, particularly at the highest rates of both compounds. When compared at equal rates of zinc/hectare, the zinc chelate gave the higher zinc levels. However, basic zinc sulfate was favored at the label recommended rate. Only dilute applications of the high rates of both compounds gave significant differences in berry weights and degrees Brix.

The 1976 data were further statistically analyzed by analysis of variance to evaluate the treatment comparisons of greatest interest in this study. This includes an overall comparison of concentrate vs. dilute, using data from both zinc compounds and rates; chelate vs. basic zinc was also compared at various rates/hectare with both methods of application.

This analysis (Table 3) shows significantly greater zinc uptake, larger berries, and lower degrees Brix readings from the dilute applications. The lower degrees Brix readings are the result of increased berry set and berry size from zinc treatment response, presumably from the delayed ripening of greater fresh fruit weights. A comparison of the two materials, at equal rates of zinc/hectare, favor the chelate in zinc uptake.

The last two analyses in Table 3 compare basic zinc sulfate at twice the rate of zinc/hectare over zinc chelate. It indicates that the zinc chelate was nearly comparable to basic zinc sulfate at one-half the rate of zinc/hectare as shown by shoot tip zinc levels.

DISCUSSION

The 1976 trial gave the greatest treatment differences in this two-year study. Aside from possible 1975 and 1976 seasonal differences in spraying conditions, this may be explained by the greater degree of existing zinc deficiency and the earlier post-treatment shoot tip sampling for zinc analysis in the 1976 trial vineyard.

Table 3. Treatment comparisons of dilute and concentrate zinc foliar applications and two forms of zinc at different rates.

Treatment comparisons	Rate elemental zinc Kg/hectare	Shoot tip Zn levels, 1st post-treatment sampling ppm Zn 1975	1976	Berry wt. gms 1976	°Brix 1976
Concentrate	all rates	74	84**	1.37	17.6
vs.		*		*	**
dilute		79	159	1.44	16.8
Chelate	1.12	79	136	1.40	16.9
vs.		*	**		
basic Zn	1.12	72	105	1.44	17.1
Chelate	.56	68	103	1.34	17.5
vs.	(a)	**	**		
basic Zn	2.24	86	144	1.43	17.3
Chelate	.56	68	103	1.34	17.5
vs.					
basic Zn	1.12	72	105	1.44	17.1
Chelate	1.12	79	136	1.40	16.9
vs.		*			
basic Zn	2.24	86	144	1.43	17.3

(a) maximum label recommended rates.
* Significant at 5% level.
** Significant at 1% level.

The 10-day post-treatment sampling interval in 1976 resulted in large treatment differences, but with no further differences in the 20-day sampling. The first post-treatment sampling (14 days) in 1975 showed intermediate treatment differences. This is in agreement with the shoot tip zinc levels reported by Cook et al. (8); it demonstrates the necessity of shoot tip sampling as soon as adequate post-treatment shoot growth is made, preferably before 14 days have elapsed. The vigorous shoot-growth "out-grew" the added foliar zinc supply in 20 days in 1976.

Method of application: The full-wetting, dilute foliar sprays improved zinc uptake over that of concentrate sprays, regardless of the material used. Whether this is a function of deposit onto and/or absorption into the leaves and flower clusters could not be shown in this study. Intentions to sample foliage for total zinc deposite analysis were prevented by late spring rains which washed off some of the spray deposit. Possible differences in spray deposit could result from the high air velocity of a concentrate sprayer moving more material past the limited foliage canopy in the spring. In comparison, the limited foliage when prebloom spraying enables thorough coverage with a dilute spray. A more detailed study on factors that favor foliar deposit and absorption of spray materials is needed. This study, however, demonstrates the performance of spraying methods under commercial vineyard conditions.

Materials: The 1976 data indicates that the zinc chelate is more effective than basic zinc sulfate at equal rates of zinc/hectare. A possible explanation is the difference in solubilities which may influence foliar absorption — the zinc chelate being fully soluble, while much of the zinc in basic zinc sulfate is insoluble and is applied as a suspension. The data suggest that the zinc chelate is approximately twice as effective as basic zinc sulfate when compared on a zinc/hectare basis. However, the basic zinc sulfate is superior when compared on a maximum label recommended basis — the much higher recommended rates more than offsetting the absorption differences at equal rates of zinc/hectare.

This study indicates that of the treatments studied here, a dilute application of basic zinc sulfate would be a grower's first consideration for maximum response.

Concentrate applications may be considered for lesser problems of deficiency. However, the low solubility of basic zinc sulfate requires close attention in concentrate sprayers to avoid its settling and plugging of lines. The fully soluble chelate avoids this problem in concentrate applications.

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