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Chemical thinning of grape clusters (Vitis vinifera L.)

by

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Introduction

An effective chemical means to thin grapes is needed. A loose cluster is less susceptible to bunch rot, and can withstand the effects of rainfall better than can a compact cluster. In addition, the packing of table grapes into boxes would be facilitated. Thinning is also a method for controlling the cropping of grape vines.

At present, gibberellin is used to a relatively small extent to thin compact-clustered wine cultivars (1, 2, 11) and is widely used to thin 'Thompson Seedless' for table use (2, 6). However, there is variability in results with wine grapes, and shot berries sometimes occur with seedless table grapes. As yet there is no acceptable thinning agent for seeded table grapes.

This report presents results of a study on the effectiveness of 12 potential chemical thinning agents tested over a range of concentrations at 4 specific physiological stages of vine development. Most compounds selected had previously shown promising results on grapes (12, 13), peach (3, 4, 5, 8), citrus (7), olives (10), or other crops.

Materials and Methods

The tests were conducted with mature vines in a University of California vineyard at Davis. 'Carignane' vines were head-trained and spur-pruned, and 'Thompson Seedless' vines were head-trained and cane-pruned, usually to four 15-bud canes (14).

The chemicals[1]) and concentrations used are listed in Table 1. Solutions of compounds dissolved in 50% ethanol also contained 0.1% (wt/v) Triton B-1956 for a wetting agent.

Treatments were made by momentarily immersing the clusters in the desired solution. Six replicate clusters were used in each treatment. Wings (large, elongated basal laterals), if present, were removed at time of treatment. About 4 weeks after fruit-set, the degree of thinning was evaluated by comparing the number of berries that had set per treated cluster to the number that had set per control cluster. Shot berries less than 5 mm in diameter were not counted.

Compounds were applied at prebloom, bloom, fruit-set, and 2 weeks post fruit-set. Prebloom treatments were made May 4, 11 days prior to beginning of bloom for 'Carignane' and about 10 days before 'Thompson Seedless' started to bloom. The longer shoots of both varieties were about 30 inches in length. Bloom treat-

[1]) The following abbreviations are used for chemical names in this paper, with the chemical name following in parentheses: ethephon (Ethrel) [(2-chloroethyl)phosphonic acid] furnished by Amchem Products, Inc.; 3-CPA (3-chlorophenoxy-α-propionamide), furnished by Amchem Products, Inc.; 4-CPA (4-chlorophenoxyacetic acid; Pennthin (dimethyl dodecylamine acetate), furnished by Pennwalt Corp.; Morphactin IT 5732 (2-chlorofluorenecarbonicacid-(9)-methyl ester), IT 4433 (2-chlor-9-hydroxyfluorenecarbonic acid-(9)-p-chlorophenoxyethyl ester), and IT 5733 (2, 7-Dichloro-9-hydroxy fluorenecarbonic acid-(9)-methyl ester), furnished by Chemagro Corp. KI (potassium iodide.).

Table 1

Number of berries set on 'Carignane' clusters after treatment with thinning compounds[1])

Compound tested	Stage of vine development	Concentration of compound (ppm)						
		0	0.1	1	10	100	1,000	4,000
1. Ethephon	Prebloom	204^{a}	182^{a}	198^{a}	219^{a}	193^{a}	0^{b}	—
	Bloom	231^{a}	205^{a}	177^{a}	127^{a,b}	17^{c}	27^{b,c}	—
	Fruit-set	208^{a}	189^{a}	198^{a}	186^{a}	123^{a}	0^{b}	—
	Post fruit-set	190^{a}	156^{a}	127^{a}	164^{a}	139^{a}	200^{a}	—
2. 3-CPA	Prebloom	178^{a}	—	176^{a}	202^{a}	27^{b}	0^{b}	—
	Bloom	179^{a}	—	165^{a}	88^{b}	7^{c}	2^{c}	—
	Fruit-set	181^{a}	—	187^{a}	127^{a}	7^{b}	4^{b}	—
	Post fruit-set	164^{a}	—	174^{a}	165^{a}	167^{a}	148^{a}	—
3. 4-CPA	Prebloom	173^{a}	—	117^{a}	96^{a}	0^{b}	1^{b}	—
	Bloom	145^{a}	—	145^{a}	134^{a}	127^{a}	0^{b}	—
	Fruit-set	213^{a}	—	211^{a}	175^{a}	164^{a}	0^{b}	—
	Post fruit-set	183^{a}	—	159^{a}	141^{a}	153^{a}	80^{a}	—
4. Pennthin	Prebloom	173^{a}	—	169^{a}	178^{a}	163^{a}	125^{a}	—
	Bloom	176^{a}	—	134^{a}	160^{a}	175^{a}	159^{a}	—
	Fruit-set	203^{a}	—	207^{a}	188^{a}	186^{a}	172^{a}	—
	Post fruit-set	176^{a}	—	132^{a}	158^{a}	160^{a}	141^{a}	—
5. IT 5732	Prebloom	190^{a,b}	28^{c,d}	120^{b,c}	170^{a,b}	243^{a}	0^{d}	—
	Bloom	201^{a}	192^{a}	161^{a}	194^{a}	0^{b}	0^{b}	—
	Fruit-set	185^{a}	193^{a}	231^{a}	157^{a}	1^{b}	31^{b}	—
	Post fruit-set	182^{a}	189^{a}	171^{a}	170^{a}	162^{a}	138^{a}	—
6. IT 4433	Prebloom	191^{a}	0^{b}	209^{a}	209^{a}	140^{a}	0^{b}	—
	Bloom	208^{a}	172^{a,b}	153^{a,b,c}	173^{a,b}	85^{a,b}	77^{c}	—
	Fruit-set	178^{a}	178^{a}	186^{a}	47^{b}	3^{b}	0^{b}	—
	Post fruit-set	168^{a}	138^{a}	160^{a}	151^{a}	140^{a}	126^{a}	—
7. IT 5733	Prebloom	177^{a,b}	117^{b}	201^{a,b}	232^{a}	151^{a,b}	97^{b}	—
	Bloom	193^{a}	140^{a,b}	167^{a,b}	126^{b}	144^{a,b}	61^{c}	—
	Fruit-set	202^{a}	222^{a}	182^{a}	199^{a}	163^{a}	9^{b}	—
	Post fruit-set	191^{a}	169^{a}	136^{a}	150^{a}	130^{a}	164^{a}	—
8. Salicylic acid	Prebloom	188^{a}	—	—	—	190^{a}	199^{a}	41^{b}
	Bloom	170^{a}	—	—	—	148^{a}	180^{a}	0^{b}
	Fruit-set	193^{a}	—	—	—	170^{a}	56^{b}	0^{b}
	Post fruit-set	138^{a}	—	—	—	183^{a}	195^{a}	0^{b}
9. Ascorbic acid	Prebloom	177^{a}	—	—	—	166^{a}	187^{a}	183^{a}
	Bloom	212^{a}	—	—	—	186^{a}	213^{a}	163^{a}
	Fruit-set	194^{a}	—	—	—	190^{a}	163^{a}	146^{a}
	Post fruit-set	218^{a}	—	—	—	147^{a}	161^{a}	176^{a}

(Continued from Table 1)

Compound tested	Stage of vine development	Concentration of compound (ppm) 0	0.1	1	10	100	1,000	4,000
10. Iso-ascorbic acid	Prebloom	183a	—	—	—	228a	219a	237a
	Bloom	203a	—	—	—	191a	204a	168a
	Fruit-set	217a	—	—	—	163a	160a	153a
	Post fruit-set	185a	—	—	—	138a	142a	144a
11. Iodoacetic acid	Prebloom	173a	—	—	—	144a	3b	0b
	Bloom	205a	—	—	—	158a	55b	0b
	Fruit-set	212a	—	—	—	132b	5c	0c
	Post fruit-set	191a	—	—	—	177a	5b	0b
12. KI	Prebloom	179a	—	—	—	123a	155a	16b
	Bloom	183a,b	—	—	—	212a	159a,b	88b
	Fruit-set	194a	—	—	—	216a	146a	178a
	Post fruit-set	194a	—	—	—	170a	117a	167a

1) Those values with different letters for a given chemical compound at given developmental stage are significantly different at the 5% level.

ments were made May 19, at which time about 50% of the calyptras (caps) had fallen from 'Carignane' clusters, and about 60% from 'Thompson Seedless' clusters. Clusters selected for dipping ranged from about 40 to 70% capfall. Applications at fruit-set stage were made May 29, when the average berry diameter for both cultivars was 4—6 mm. Post fruit-set applications were on June 23. At that time, berry diameter of 'Carignane' was 8—10 mm and that of 'Thompson Seedless' 6—8 mm.

A statistical analysis of variance followed by Duncan's Mutiple Range test was made.

Results

Ethephon

On 'Carignane', prebloom treatment at 100 ppm or less had no effect on berry set, but the compound at 1,000 ppm completely prevented set (Table 1). Bloom treatment at 10 ppm or lower had little effect, but 100 and 1,000 ppm essentially prevented set. The chemical did not induce uniform abscission of berries throughout the cluster. When applied at fruit-set, only 1,000 ppm was effective, but set was eliminated at that concentration. At post fruit set there were no significant effects at any concentration.

Ethephon at 10 ppm applied prebloom to 'Thompson Seedless' reduced berry set about one-half, and applications of 100 ppm or more resulted in no set (Table 2). With bloom application, the highest rate removed all flowers. When applied at fruit-set, there was no reduction in number of berries below 100 ppm, but at that concentration set was completely eliminated. At post fruit-set, 100 ppm failed to reduce number of berries, and berry size was reduced.

Table 2

Number of berries set on 'Thompson Seedless' clusters after treatment with abscission compounds[1])

Compound tested	Stage of vine developement	Concentration of compound (ppm)						
		0	0.1	1	10	100	1,000	4,000
1. Ethephon	Prebloom	307^{a}	$269^{a,b}$	$232^{a,b}$	165^{b}	0^{c}	0^{c}	—
	Bloom	264^{a}	229^{a}	258^{a}	238^{a}	160^{a}	0^{b}	—
	Fruit-set	262^{a}	304^{a}	326^{a}	237^{a}	0^{b}	0^{b}	—
	Post fruit-set	208^{a}	210^{a}	183^{a}	208^{a}	206^{a}	13^{b}	—
2. 3-CPA	Prebloom	246^{a}	—	269^{a}	206^{a}	0^{b}	0^{b}	—
	Bloom	272^{a}	—	$223^{a,b}$	$111^{b,c}$	0^{c}	0^{c}	—
	Fruit-set	288^{a}	—	291^{a}	175^{b}	8^{c}	0^{c}	—
	Post fruit-set	267^{a}	—	137^{b}	152^{b}	38^{c}	15^{c}	—
3. 4-CPA	Prebloom	227^{a}	—	185^{a}	201^{a}	1^{b}	0^{b}	—
	Bloom	266^{a}	—	174^{a}	$162^{a,b}$	$31^{b,c}$	0^{c}	—
	Fruit-set	265^{a}	—	256^{a}	257^{a}	166^{a}	4^{b}	—
	Post fruit-set	252^{a}	—	$184^{a,b}$	258^{a}	$89^{b,c}$	0^{c}	—
4. Pennthin	Prebloom	253^{a}	—	284^{a}	257^{a}	275^{a}	245^{a}	—
	Bloom	306^{a}	—	275^{a}	207^{a}	179^{a}	254^{a}	—
	Fruit-set	286^{a}	—	140^{b}	$187^{a,b}$	$197^{a,b}$	$169^{a,b}$	—
	Post fruit-set	234^{a}	—	155^{a}	266^{a}	229^{a}	188^{a}	—
5. IT 5732	Prebloom	244^{a}	264^{a}	221^{a}	209^{a}	271^{a}	0^{b}	—
	Bloom	245^{a}	221^{a}	241^{a}	102^{b}	0^{b}	0^{b}	—
	Fruit-set	268^{a}	293^{a}	216^{a}	31^{b}	3^{b}	0^{b}	—
	Post fruit-set	246^{a}	265^{a}	$225^{a,b}$	$182^{a,b}$	$170^{a,b}$	139^{b}	—
6. IT 4433	Prebloom	$207^{a,b}$	$107^{a,c}$	291^{b}	$230^{a,b}$	$212^{a,b}$	0^{c}	—
	Bloom	$280^{a,b}$	327^{a}	$310^{a,b}$	451^{a}	$156^{b,c}$	33^{c}	—
	Fruit-set	223^{a}	314^{a}	261^{a}	25^{b}	0^{b}	0^{b}	—
	Post fruit-set	270^{a}	206^{a}	$194^{a,b}$	$187^{a,b}$	80^{c}	$100^{b,c}$	—
7. IT 5733	Prebloom	281^{a}	253^{a}	243^{a}	265^{a}	246^{a}	60^{b}	—
	Bloom	233^{a}	268^{a}	279^{a}	262^{a}	300^{a}	16^{b}	—
	Fruit-set	$233^{a,b}$	320^{a}	$266^{a,b}$	186^{b}	59^{c}	0^{c}	—
	Post fruit-set	288^{a}	$172^{a,b}$	$184^{a,b}$	$196^{a,b}$	$200^{a,b}$	138^{b}	—
8. Salicylic acid	Prebloom	264^{a}	—	—	—	241^{a}	227^{a}	39^{b}
	Bloom	266^{a}	—	—	—	209^{a}	151^{a}	11^{b}
	Fruit-set	315^{a}	—	—	—	273^{a}	121^{b}	0^{c}
	Post fruit-set	223^{a}	—	—	—	191^{a}	136^{a}	0^{c}
9. Ascorbic acid	Prebloom	272^{a}	—	—	—	253^{a}	276^{a}	220^{a}
	Bloom	202^{a}	—	—	—	292^{a}	284^{a}	290^{a}
	Fruit-set	280^{a}	—	—	—	228^{a}	275^{a}	251^{a}
	Post fruit-set	253^{a}	—	—	—	186^{a}	202^{a}	205^{a}

(Continued from Table 2)

Compound tested	Stage of vine developement	Concentration of compound (ppm)						
		0	0.1	1	10	100	1,000	4,000
10. Iso-	Prebloom	275a	—	—	—	304a	309a	287a
ascorbic	Bloom	208a	—	—	—	238a	267a	247a
acid	Fruit-set	235a	—	—	—	222a	228a	252a
	Post fruit-set	270a	—	—	—	257a	187a	214a
11. Iodoacetic	Prebloom	266a	—	—	—	273a	50b	22b
acid	Bloom	207a	—	—	—	236a	0b	0b
	Fruit-set	265a	—	—	—	78b	2b	0b
	Post fruit-set	273a	—	—	—	216a	0b	0b
12. KI	Prebloom	273a	—	—	—	227a	250a	16b
	Bloom	224a	—	—	—	232a	204a	35b
	Fruit-set	248a	—	—	—	179a,b	245a,b	110b
	Post fruit-set	285a	—	—	—	195a	249a	203a

1) Those values with different letters for a given chemical compound at a given developmental stage are significantly different at the 5% level.

3-CPA

Prebloom application to 'Carignane' had no effeect on set at concentrations below 100 ppm (Table 1). At 100 ppm, set was reduced about 85%, and at 1,000 ppm no set occurred. At bloom, 'Carignane' grapes were more sensitive to 3-CPA than at prebloom, and set was reduced about 50% with 10 ppm. However, there was a large set of shot berries. Essentially no set occurred with 100 and 1,000 ppm, and the rachis died. Application at fruit-set also produced many shot berries at 10 ppm or higher. In fact, nearly 100% of the berries were shot berries as a result of applications at 100 and 1,000 ppm, but the clusters rachis did not die. Application of 3-CPA at post fruit-set did not reduce the number of berries, but at 1,000 ppm there appeared to be a delay in coloration.

Prebloom treatment with 3-CPA up to 10 ppm had little effect on 'Thompson Seedless', but at 100 and 1,000 ppm set was prevented (Table 2). 'Thompson Seedless' were most sensitive to bloom application, and 10 ppm reduced set about 60%, primarily by causing entire laterals to abscise. No set was obtained at higher concentrations. At fruit-set, 3-CPA at 10 ppm induced some shot berry development, but less than when applied at bloom. With 100 and 1000 ppm, there was little set. At 1,000 ppm some cracking and callusing of the rachis, and especially of the peduncle, occurred. All levels of 3-CPA at post fruit-set stage reduced number of berries and caused some callusing of the rachis. At 100 and 1,000 ppm, the compound greatly reduced number of berries and caused extensive callusing of the rachis.

4-CPA

Prebloom application to 'Carignane' eliminated all set at 100 and 1,000 ppm. At bloom, treatment with 100 ppm reduced average berry size (Table 1), but only

1,000 ppm reduced set. The rachises did not dry, but only shot berries formed. Results from application at fruit-set were similar to those from bloom application, whereas post fruit-set application failed to reduce number of berries. However, much callusing of the rachis resulted from 4-CPA at 100 and 1,000 ppm applied at post fruit-set stage.

On 'Thompson Seedless', prebloom treatment with 4-CPA reduced set only at 100 and 1,000 ppm. The 100-ppm treatment caused extensive callus formation, and in the 1,000-ppm treatment the rachises were dead. At bloom, 10 and 100 ppm reduced set of normal berries, but caused formation of about 20% and 80% shot berries, respectively. There was no set of normal berries with 1,000 ppm applied at fruit-set stage, but much callusing developed on the rachis. Applications at 10 and 100 ppm increased variability of berry size, and at 1,000 ppm there was cluster necrosis. Post fruit-set applications did not markedly reduce number of berries except at 100 and 1,000 ppm. However, extensive twisting and callusing of the rachis occurred at 100 and 1,000 ppm. Although many berries appeared normal in the 100-ppm treatment, the rachis was dead or dying; and at 1,000 ppm the rachis and berries had dried.

Pennthin

Pennthin did not reduce berry set on either cultivar, except with 1 ppm applied to 'Thompson Seedless' at fruit-set (Tables 1, 2). Treatment with 100 and 1,000 ppm at post fruit-set caused rings or "halo"-type scars on both cultivars.

IT 5732

Prebloom application at 0.1 ppm greatly reduced set on 'Carignane'. A concentration of 1,000 ppm killed the clusters. The clusters were most sensitive to the higher concentrations at bloom, when application of 100 ppm caused necrosis. Applications of 100 and 1,000 ppm at fruit-set also resulted in a decrease in number of berries. At post fruit-set there was some reduction in number of berries, although it was not significant, and the thinning was uniform throughout the cluster.

With 'Thompson Seedless', applications of IT 5732 at prebloom caused the least, and applications at fruit-set the most, reduction in number of berries. Application of 1,000 ppm at fruit-set resulted in some browning of the epidermis.

IT 4433

The 'Carignane' clusters were not as sensitive to IT 4433 as to IT 5732. At prebloom, 1,000 ppm IT 4433 caused complete thinning, and at 0.1 ppm unexplainably also resulted in no fruit-set.

At bloom, very loose clusters were produced with 100 and 1,000 ppm. At fruit-set, even 10 ppm reduced number of berries, but at post fruit-set there were no significant effects at any concentration.

'Thompson Seedless' was most sensitive at fruit-set stage, with concentrations as low as 10 ppm markedly reducing berry number. Applications of 100 and 1,000 ppm at post fruit-set also reduced the berry number.

IT 5733

On 'Carignane', bloom application caused the most reduction in set, but even at 1,000 ppm there was considerable set. At fruit-set stage only 1,000 ppm reduced number of berries, and treatment at post fruit-set had no effect.

On 'Thompson Seedless', 100 ppm at fruit-set reduced berry number to about 25% of that of the control. Application of 1,000 ppm IT 5733 at post fruit-set also was effective.

Salicylic Acid

Application of 100 or 1,000 ppm to 'Carignane' at prebloom or bloom had no effect, but at both stages 4,000 ppm markedly reduced set (Table 1). At fruit-set, there was marked reduction in number of berries with 1,000 ppm. The thinning was relatively uniform throughout the clusters, but many of the berries that developed had ring scars. Application of 1,000 ppm at post fruit-set caused ring scars, and tissue necrosis within the area of the ring.

On 'Thompson Seedless', 4,000 ppm almost eliminated set at the last three stages tested (Table 2). As with 'Carignane', levels of salicylic acid effective in thinning produced some ring scarring and necrosis of berries.

Ascorbic Acid

No treatment significantly reduced set on 'Carignane' or 'Thompson Seedless' (Tables 1, 2).

Iso-ascorbic Acid

Iso-ascorbic acid had no significant effect on fruit-set of either cultivar (Tables 1, 2).

Iodoacetic Acid

Applications of 4,000 ppm killed the 'Carignane' clusters at all stages of growth; and 1,000 ppm essentially killed the clusters except at bloom, when set was about 25% of normal (Table 1). All concentrations reduced berry number at fruit-set stage.

On 'Thompson Seedless', 1,000 and 4,000 ppm caused a marked reduction in set (Table 2). Applications of 100 ppm at post fruit-set caused the berries to turn brown. Phytotoxic responses were also evident on berries treated with 100 ppm at fruit-set; but at the first two stages of application, the 100-ppm level had no effect on berry set or development.

KI

'Carignane' clusters were more sensitive to bloom or prebloom application than to later ones (Table 1). On 'Thompson Seedless', KI at 4,000 ppm reduced set except when applied at the last stage. The thinning response induced by 4,000 ppm at fruit-set resulted in uniformly loose clusters. At prebloom and bloom stages the material was too toxic at 4,000 ppm, and 1,000 ppm did not reduce set (Table 2).

Discussion

In some situations complete removal of a crop is desirable. For example, in training young vines and in the production of nursery stock, the depressing effect of fruits on vegetative vigor should be avoided. Complete crop removal from a weak vineyard might allow rapid recovery of vigor. The optimum time to thin for complete crop removal is at the pre-bloom stage. Hale and Weaver (9) have shown that the clusters do not become major utilizers of photosynthate until after anthesis. Thus, removal of the clusters before bloom ensures that all of the carbohydrate production by the vine will go into the vegetative parts

Prebloom thinning is also desirable for cultivars which tend to have poor fruit-set, such as 'Cardinal' and 'Muscat of Alexandria'. With these, the aim is not to remove all the fruit, but to eliminate whole clusters so as to reduce the potential crop. The reduced crop makes more nutrients available to the retained clusters, and improved set and berry size result. Even in situations in which complete fruit removal is to be avoided, it might be possible to utilize compounds which completely eliminate fruit-set, by using selectively directed sprays.

Among the morphactins tested, IT 5733 is most suitable for further testing on 'Thompson Seedless' because the compound had the widest range of activity on this cultivar.

It is desirable to thin at fruit-set or post fruit-set stages, as by then the amount of crop that has set can be estimated, and the proper amount of thinning agent to be applied can be determined. Earlier treatment might result in too much thinning in a year when the natural set is low.

We found that chemical thinning of individual clusters is more difficult than removal of entire clusters. This is often a narrow range between no activity and complete elimination of flowers or fruits. It is possible that intermediate concentrations not tested in this study may achieve satisfactory thinning.

Summary

Twelve thinning compounds were tested at 0.1 to 4,000 ppm on 'Carignane' and 'Thompson Seedless' clusters at 4 developmental stages (prebloom, bloom, fruit-set, and 2 weeks after fruit-set). Clusters were usually least sensitive to the compounds at post fruit-set and, in general, 'Thompson Seedless' was more sensitive than 'Carignane'. On 'Thompson Seedless' the morphactin IT 5733 had a wider activity range than IT 5732 or IT 4433. Potassium iodide reduced set when applied at prebloom or bloom. Ethephon was usually effective at some concentration at all growth stages. Ascorbic acid, iso-ascorbic acid, and Pennthin usually were not significantly effective in thinning either cultivar.

The 3-CPA had a wide range of activity on both cultivars at most stages of growth, and this compound at 10 ppm reduced number of berries at bloom and fruit set for 'Carignane' and 'Thompson Seedless', respectively. Iodoacetic acid at 1,000 ppm was effective in reducing number of berries in both cultivars at all growth stages. The 4-CPA at 100 ppm was effective at prebloom stage on 'Carignane', and at bloom on 'Thompson Seedless'. Salicylic acid at 1,000 ppm effectively reduced number of berries of each cultivar when applied at fruit-set stage.

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