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Experiments on Thinning Grapes with Alpha-naphthaleneacetic Acid and Dinitro-sec-butylphenol

by

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Introduction

Since hand thinning of grapes is very expensive, several studies have been made to develop chemical methods for thinning. In 1958 Samish and Lavee (2) reviewed the literature on this subject.

The results of preliminary experiments with 17 growth regulators, defoliants, or thinning agents showed promise that certain chemicals could be used as thinning agents for grapes (3). Therefore, further experiments were performed using the two most promising of these compounds. One objective was to study the effects of various concentrations of the compounds, applied at different stages of development, on fruit thinning. Other studies dealt with feasibility of eliminating entire clusters by chemical means.

Materials and Methods

Five-year-old Zinfandel and Muscat of Alexandria (Muscat) vines in an irrigated University of California vineyard at Davis were used as the experimental plants. All vines were head-trained and spur-pruned. Except for the spray treatments, vineyard care was routine.

Alpha-naphthaleneacetic acid (NAA) solution was prepared by adding ammonium hydroxide to an aqueous suspension of the acid. DN-289 (dinitro-sec-butylphenol) was obtained as a 36% solution of the triethanolamine salt of dinitro-sec-butylphenol. Sufficient Dreft was added to the solutions for a wetting agent.

Solutions were applied with 2½ gallon hand sprayers. Clusters and foliage in the cluster region were sprayed thoroughly, but no effort was made to spray the apical two thirds of the shoots. In flower cluster and cluster thinning, an attempt was made to spray only the clusters to be killed. The terms flower cluster and cluster thinning are used according to the definitions given by Winkler (4).

At harvest about 30 lb of fruit were taken from vines in each treatment and the degrees Balling and percentage of total acid were determined (1). The degree to which a cluster had been loosened was considered as the visual estimate of that part of the total volume of a cluster not occupied by berries. This estimate is referred to as the "looseness" percentage. Controls were assumed to have zero per cent unoccupied space.

Experimentation and Results

Applications of NAA to Zinfandel at Various Developmental Stages

In the following experiments, conducted in 1954, 1955, and 1956, an attempt was made to find the optimum concentration of NAA and the proper developmental stage of flowers at which to apply it, for most effective thinning of Zinfandel grapes.

1954. Vines were sprayed with NAA at 50, 75, 100, 200, 300, or 500 ppm at one of four different stages of flower and fruit development. There were three vines per treatment, except in the fourth stage when only two vines per treatment were used. The vines were treated on May 17 when about 20% of calyptras had fallen. A second series of vines was sprayed on May 22 at 50% capfall. In this series the 500 ppm concentration was omitted. A third series was treated on May 28, at which time all calyptras had fallen and berries were 3 to 4 mm in diameter. The fourth series of vines was sprayed on June 11, after the shatter of berries had occurred. The larger berries were 8 to 10 mm in diameter.

Two days after spraying on May 17, the rachises and lateral branches of clusters sprayed with 50 ppm were bent, and the folding of some leaves gave the vine a wilted appearance. These symptoms were progressively more pronounced as the concentration was increased. By May 26 blooming was past on unsprayed vines. At this date some leaves of vines sprayed at 50 ppm showed crumpling and the rachis of some clusters still showed slight bending. Only about 25% of the total number of calyptras had not fallen. These were split along the sides, but were attached at the base.

On June 15 vines sprayed with NAA at 50 ppm on May 17 still had a few wrinkled leaves, but overall damage to foliage was negligible. The foliage on vines sprayed with NAA at 500 ppm was yellowing, but the leaves showed no abnormal venation or other formative effects.

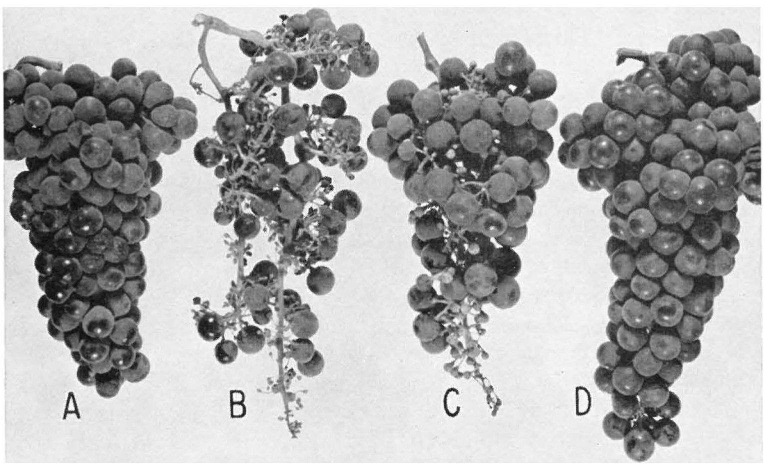

Fig. 1: Zinfandel grapes sprayed on May 17 (B), May 28 (C), and June 11 (D) with 200 ppm of NAA. Control, A.

Note that the earlier the spray the greater the thinning. Cluster sprayed on June 11 (D) is like the control (A). Note that persistent calyptras still adhere to over half the stunted, green berries on clusters sprayed on May 17 (B). At spraying on May 28 green berries are considerably larger. (Photographed October 5, 1954).

The second spraying resulted in essentially the same injury to clusters and foliage as did the first. The third spraying produced much less injury to the foliage. For example, 200 ppm NAA were required to cause folding of leaves, and foliage

Table 1

Looseness percentage of Zinfandel grapes at harvest (October 11, 1954) after spraying vines with NAA at one of four developmental stages

Concentration of NAA ppm	Looseness Percentage Date of Spraying May 17	May 22	May 28	June 11
0	0	0	0	0
50	35	30	25	0
75	35	30	25	0
100	55	50	40	0
200	85	80	45	0
300	85	85	65	5
500	90	—	85	5

did not yellow as a result of sprays at 500 ppm. The fourth spraying caused little damage to clusters; injury to foliage was negligible (Fig. 1, Table 1).

Observations at harvest showed that spraying at the three bloom stages, especially the first two, resulted in the greatest amount of thinning (Table 1). The lowest concentration used, 50 ppm, was too high for proper thinning at the first three stages. Clusters with a looseness percentage of 3 to 10% were sufficiently thinned. As a result of the first spraying calyptras were still on some of the small undeveloped berries. None of these small berries had shattered. Some berries in the third treatment were present that were the same size they were at spraying time.

1955. The treatments in 1954 resulted in too much injury, so they were repeated using lower concentrations of NAA. On May 27, when about 20% of the calyptras had fallen, vines were sprayed with 0, 5, 10, 20, 40 or 100 ppm, four vines per treatment. A second series of vines was sprayed on June 2 at 90% capfall, and a third series on June 10, after the shatter of berries following bloom. All the second-crop clusters were removed on July 14 so that they would not be confused with the treated primary clusters.

Three days after the spraying on May 27, vines treated with 5 ppm showed some twisting of clusters; some of the shorter shoots on vines treated with 20 ppm exhibited curvatures. At 40 ppm some of the larger leaves were folded, and at 100 ppm all vines had a very wilted appearance. By July 14, foliage on vines treated with 40 ppm was severely injured; at 100 ppm some shoot apices were killed. At harvest, on October 4, 10 ppm resulted in about 3 to 5% looseness percentage, which is considered a suitable degree of loosening (Table 2). However, 40 ppm resulted in many berries that were small and green. A number of berries had persistent calyptras.

The effect of the second spraying was about the same as the first although slightly more thinning occurred. NAA at 5 or 10 ppm applied on June 2 resulted in about the proper amount of thinning (Table 2, Fig. 2). The third spraying was least effective (Table 2, Fig. 3).

All sprayings of NAA reduced crop yields. The controls had the lowest degrees Balling and highest total acidity, probably as a result of larger crops than those of the sprayed vines.

1956. Since early sprays caused considerable foliage injury, treatment was delayed until after shatter in 1956. Four vines each were sprayed with NAA at 0, 5, 10, 15 or 20 ppm on June 7 when berries were 6 to 8 mm in diameter. The second-crop clusters were just appearing. A second series of vines was sprayed on June 20 when clusters were

Table 2

Effect of sprays of NAA applied at each of three developmental stages on weight of crop, looseness percentage, degrees Balling, and total acid of Zinfandel grapes[1])

Concentration of NAA ppm	Wt. crop[2]) per vine lb	Looseness percentage	Balling Degrees	Total acid g. tart./100 ml.
		Sprayed May 27		
0, Controls	34.6	0	18.5	0.79
5 ppm	21.8	0	20.3	0.74
10 ppm	16.8	3—5	21.7	0.75
20 ppm	15.4	15	20.2	0.62
40 ppm	10.1	30	21.0	0.62
100 ppm	6.0	50	25.1	0.60
		Sprayed June 2		
0, Controls	34.6	0	18.5	0.79
5 ppm	25.6	5	20.2	0.72
10 ppm	17.2	10	21.9	0.74
20 ppm	14.1	25—30	20.3	0.62
40 ppm	12.3	50	18.3	0.64
100 ppm	6.2	50	19.1	0.70
		Sprayed June 10		
0, Controls	34.6	0	18.5	0.79
5 ppm	16.7	0	21.6	0.70
10 ppm	14.6	0	21.1	0.75
20 ppm	25.1	5—10	21.3	0.64
40 ppm	11.7	10—15	20.4	0.65
100 ppm	7.7	15	21.3	0.64

[1]) Harvested October 4, 1955.

[2]) $d_{.05}$ between concentrations on a given spraying date is 10.1 lb.
$d_{.05}$ between spraying dates at a given concentration is 5.3 lb.

already becoming compact, and when the second-crop clusters were in full bloom. The third and final spraying was on July 16 when berries on primary clusters were about 13 mm in diameter and those on second crop about 8 mm in diameter. The degrees Balling readings of primary and secondary clusters were 5.6 and 3.8, respectively.

None of the sprays caused foliage damage in this experiment. On July 5, clusters of second crop sprayed with NAA at 15 or 20 ppm at the first two spraying dates were straggly; only six to ten berries per cluster had enlarged.

Fruit was harvested on September 29, 1956. Two clusters from each vine were taken for laboratory analyses (Table 3). NAA applied at 10 or 20 ppm at the first spraying resulted in small, green ovaries or berries in the clusters, which gave a desired thinning effect. At the second and third treatments such berries were absent.

Use of NAA to Remove Second Crop

The second-crop clusters arise on lateral branches of the main shoots. Therefore these clusters are much younger than the primary clusters arising from the main

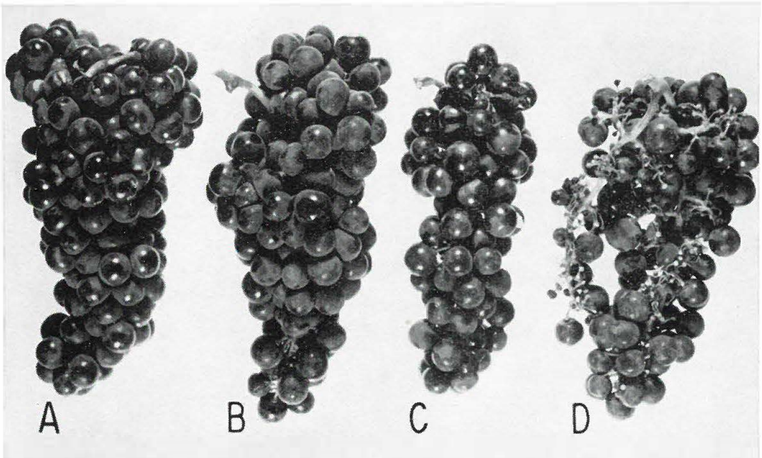

Fig. 2: Zinfandel clusters at harvest after spraying on June 2 with NAA at 0 (A), 10 (B), 20 (C), or 40 (D) ppm.
Note that proper thinning occurred with NAA at 10 ppm, but too much occurred as a result of 40 ppm. (Photographed October 5, 1955)

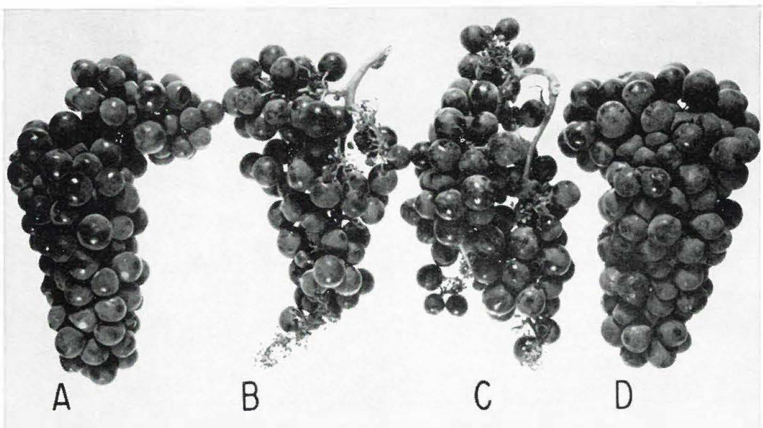

Fig. 3: Zinfandel clusters at harvest (October 4, 1955) after spraying with NAA at 100 ppm on May 27 (B), June 2 (C), on June 10 (D). A, control.
Note that severe thinning occurred at the first and second treatments, but little at the third. (Photographed October 5, 1955)

shoot. Since younger clusters are much more sensitive to plant regulators than are older ones, it was believed that second-crop clusters could be killed at a sensitive stage without injury to primary-crop clusters. The objective of the following experiments with Zinfandel and Muscat of Alexandria was to test this hypothesis.

Zinfandel, 1955. Vines were sprayed on June 27 with NAA at 0, 50, 100, or 300 ppm, five vines per treatment. On one group of vines the secondary crop was removed by hand. There were about 40 small second-crop clusters per vine at time of spraying. The shatter of berries following flowering was almost complete for the se-

Table 3

Influence of sprays of NAA at varying concentrations on crop weight, degrees Balling, and total acid of Zinfandel grapes[1])

Date of Spraying	Concentration of NAA ppm	Wt. crop [2]) vine lb	Balling Degrees	Total acid g. tart./100 ml.
	0	45.6	11.7	0.92
	5	39.8	14.6	0.84
June 7	10	34.0	13.5	0.82
	15	20.5	16.4	0.73
	20	26.6	14.3	0.74
	0	37.3	15.2	0.87
	5	21.8	15.9	0.78
June 20	10	26.9	15.8	0.75
	15	43.4	14.4	0.84
	20	25.7	15.4	0.78
	0	28.3	14.8	0.79
	5	38.0	11.8	0.79
July 16	10	30.2	13.0	0.89
	15	22.4	13.5	0.83
	20	36.2	11.1	0.82

[1]) Harvested September 29, 1956.
[2]) $d_{.05}$ between concentrations on a given spraying date is N.S.
$d_{.05}$ between spraying dates at a given concentration is N.S.

Table 4

Effect of method of thinning on crop weight, degrees Balling and total acidity of Zinfandel grapes*)

Treatment	Crop weight per vine lb			Balling Degrees		Total acid g. tart./100 ml.	
	Primary	Secondary	Total	Primary crop	Secondary crop	Primary crop	Secondary crop
Controls	35.3	5.3	40.6	16.1	14.1	0.90	1.34
Hand thinned	28.4	1.1	29.5	17.2	17.0	0.81	1.19
NAA, 50 ppm	34.6	2.2	36.8	15.1	14.5	0.86	1.28
NAA, 100 ppm	27.3	0.6	27.9	18.1	15.2	0.86	1.12
NAA, 300 ppm	25.1	0.2	25.3	15.8	17.4	0.81	1.08
$d_{.05}$	N. S.	1.6	—	0.8	—	0.05	—

*) Harvested on October 3, 1955.

cond-crop clusters, but there was much variation among clusters. The berries of primary clusters were 9 to 10 mm in diameter.

Fruit was harvested on October 3 (Table 4). About 13% of the total yield in the controls was second crop. When hand thinning was used, 3.8% of the total was second crop. Evidently some new second-crop clusters developed after the hand

Fig. 4: Second-crop Zinfandel clusters from vines sprayed with NAA at 50 ppm (lower). Corresponding clusters from checks (upper).

Note that berries of many sprayed clusters are still small and green. (Photographed October 5, 1955)

thinning. NAA at 50 ppm produced many straggly second-crop clusters (Fig. 4). The compound at 100 ppm killed most of the second-crop clusters, and at 300 ppm damage to the vine occurred. Secondary clusters remaining on vines sprayed with 100 ppm were very straggly.

Zinfandel, 1956. Vines were sprayed with NAA at 0, 25, 50, or 100 ppm on June 20. There were four vines per treatment. Berries of primary clusters were about 10 mm in diameter; secondary clusters were in full bloom. The grapes were harvested on September 29 (Table 5).

Table 5

Effect of spray applications of NAA on weight of crop, degrees Balling, and total acid of Zinfandel grapes*)

Concentration NAA ppm	Crop weight per vine lb			Balling Degrees		Total acid g. tart./100 ml.	
	Primary	Secondary	Total	Primary crop	Secondary crop	Primary crop	Secondary crop
0	29.8	4.8	34.6	14.8	16.8	0.80	0.93
25	27.5	1.7	29.2	13.8	16.6	0.86	1.03
50	37.1	3.0	40.1	13.0	14.8	0.83	1.13
100	30.5	2.4	32.9	15.2	15.8	0.79	1.12
$d_{.05}$	3.3	1.8	4.4	N. S.	N. S.	N. S.	0.12

*) Harvested September 29, 1956.

Table 6

Effect of spray applications of NAA on crop weight, degrees Balling, and total acid of Muscat of Alexandria grapes*)

Concentration NAA ppm	Crop weight per vine lb			Balling Degrees		Total acid g. tart./100 ml.	
	Primary	Secondary	Total	Primary crop	Secondary crop	Primary crop	Secondary crop
0	46.2	6.4	52.6	17.2	13.6	0.65	1.34
25	40.1	3.2	43.3	18.8	13.5	0.60	1.40
50	42.1	1.9	44.1	17.5	12.6	0.64	1.23
100	42.3	1.2	43.4	16.7	15.4	0.63	1.16
$d_{.05}$	N. S.	1.7	N. S.	N. S.	1.8	N. S.	N. S.

*) Harvested September 29, 1956.

The treatments usually reduced the weight of the second crop by 50% or more. The decrease was less than occurred in the 1955 experiment, probably because the sprays were applied to vines at an earlier stage of development in 1956 than in 1955, and a greater number of secondary clusters developed subsequent to spraying. Berry weight on primary clusters used as controls and on primary clusters from vines sprayed at 100 ppm were 2.48 and 1.94 gm, respectively. Corresponding figures for secondary clusters were 2.03 and 0.78 gm.

Muscat of Alexandria, 1956. Early in the season it was evident that there would be only a light secondary crop. Hence, on June 4 all growing tips were pinched to stimulate growth of lateral shoots so that size of clusters of the second crop would be increased. Vines were sprayed on June 20 with NAA at 0, 25, 50, or 100 ppm, five vines per treatment. The secondary crop was in full bloom and the berries of primary clusters were 8 to 10 mm in diameter.

NAA at 100 ppm caused more injury to Muscat than it did to Zinfandel. On June 25 it was noted that 25 ppm had caused a slight twisting of secondary clusters; this condition was progressively more evident at higher concentrations. Concentrations of NAA at 50 and 100 ppm had produced some browning of shoot apices. Fruit was harvested on September 29 (Table 6). In general, primary clusters in all treatments were in good condition at harvest, although a few berries at the apex of clusters sprayed with 100 ppm were small and hard. There were many normal mature berries in second-crop clusters, but these clusters were small with tough stems. Total crop weight was not reduced by NAA sprays although second-crop was significantly reduced. Degrees Balling was higher in the primary crop and total acid was higher in the secondary crop.

Thinning Experiments with DN-289

Flower-cluster thinning of Muscat, 1954. The objective was to determine the proper concentration of DN-289 necessary to thin flower clusters on Muscat efficiently. Vines were sprayed on May 17 at full bloom with solutions of 0.001, 0.005, 0.01, 0.05, 0.1, 0.2, or 0.3%. Dreft at 0.2% by weight was used as a wetting agent. Nine days after treatment about 20% of the berries were dead on clusters sprayed with DN-289 at 0.01%, but there was only very slight burning of the leaf margins. At 0.05% concentration, from 3 to 5% of the leaf surface showed burning, and 95%

of the clusters were dead. Foliage sprayed with DN-289 at 0.1, 0.2, or 0.3%, was 40, 75, and 95% dead, respectively. All clusters thus treated, also were dead.

Final observations were made on October 4. Clusters sprayed with DN-289 in the range of 0.001 to 0.01% were normal; at 0.05% most clusters were dead; from 0.1 to 0.3% all clusters were dead. These results show that the proper amount of thinning might be obtained with DN-289 somewhere between 0.01% to 0.05%.

Zinfandel, 1955. On June 11, one vine each at the fruit-set stage was sprayed with 0.001, 0.005, 0.01, 0.05, 0.1, 0.2, or 0.3% DN-289. Fruit was harvested on October 4. Clusters sprayed in the range of 0.001 to 0.01% were normal; those sprayed with 0.05% had a looseness percentage of 95%. At higher concentrations all clusters were dead.

Discussion

There are two disadvantages in spraying at prebloom instead of the fruit set stage. In the first place it is easy to overthin at the early stages, and secondly the foliage at the earlier stage is more susceptible to injury. However, lower concentrations of NAA are required at the earlier stages than after fruit set. The data show that under our experimental conditions NAA at 5 to 10 ppm produces proper thinning at the bloom stages, and 10 ppm at the set stage.

Samish and Lavee (2), working in Israel with Queen of the Vineyards and Shalas Doré, two compact-clustered table varieties, obtained results which were generally similar to those reported here. It is interesting that these investigators found that water sprays to which no NAA had been added also produced the desired amount of thinning when applied at bloom.

In 1955 the crop weight of Zinfandel was decreased by application of NAA at the bloom or at the set period. In 1956 crop weights were not reduced significantly as a result of post-bloom sprays. The fact that the degrees Balling usually were higher and the percentage of acid lower in sprayed than unsprayed samples probably was due in many instances to the decreased yield in the sprayed vines.

In wine grapes it is desirable to have little secondary crop. It is best that the vine use its energy to produce a large primary crop. If there is both a primary and secondary crop there is a temptation to pick the fruit after the primary crop has passed its optimum quality but while the second crop is still too green. The result may be an inferior wine.

In our experiments in which the second crop was partially removed by hand thinning or sprays of NAA, the degrees Balling of the second crop was often almost as high or higher than that of the primary crop. These results can probably be explained by the small amounts of second crop in both the untreated and treated plots.

Our results show that the amount of second crop of Zinfandel and Muscat of Alexandria grapes can be reduced greatly by sprays of NAA from 25 to 50 ppm, sometimes without significantly reducing the weight of total crop. The principle is to spray when the second crop is in full bloom and more sensitive to the growth regulator than is the primary crop.

Thinning experiments with DN-289 indicated it is difficult to obtain the correct amount of thinning with this compound. The margin for error between underthinning and overthinning is probably relatively narrow.

Samish and Lavee (2) reported NAA sprays hastened maturation without reducing yield. Our results show that hastened maturation from NAA often was associated with a yield reduction. However, in some instances ripening possibly may have been hastened without an accompanying reduction in crop weight.

Summary

1. Zinfandel vines at various stages of flower and fruit development were sprayed in the years 1954, 1955, and 1956 with NAA in the range from 0 to 500 ppm. NAA at 5 to 10 ppm applied at bloom stage or 10 ppm NAA applied at fruit-set stage resulted in suitable loosening of clusters.
2. In order to destroy the second-crop clusters, Zinfandel and Muscat of Alexandria vines were sprayed with NAA in a range from 0 to 300 ppm. Spraying was done when the second crop was in full-bloom or fruit-set stage, and the berries on primary clusters were larger and less susceptible to injury. NAA at 25 to 50 ppm sharply reduced the secondary crop without injury to the primary crop.
3. DN-289 (dinitro-sec-butylphenol) in a range from 0.001% to 0.3% was applied to Muscat of Alexandria vines at bloom and Zinfandel vines at fruit-set stage to determine its value in flower cluster and cluster thinning. DN-289 at 0.05% killed 95% of the clusters in both varieties; in Muscat only 3 to 5% of the leaves showed injury.

Acknowledgements

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