THE EFFECTS OF SUCCINIC ACID 2,2,-DIMETHYL HYDRAZIDE ON CONCORD GRAPES, VITIS LABRUSCA L.

by 2285

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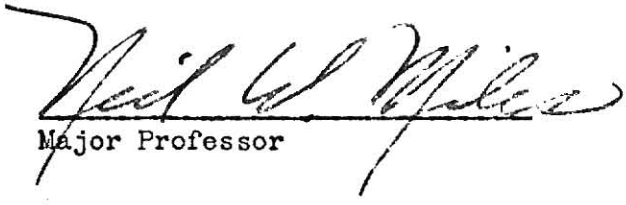

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I. INTRODUCTION

The Concord grape originated in 1843 and was introduced commercially in 1852. Concord is the most extensively grown American variety throughout the United States. It possesses many qualities that make it superior to other varieties for Kansas but it is not free from undesirable characteristics such as, uneven ripeness, poor fruit set in some years, and susceptibility to 2,4-D injury.

Alar (Succinic acid, 2,2-dimethyl hydrazide)* is a synthetic growth regulator according to the definition of the American Society of Plant Physiologists: "organic compounds other than nutrients, which in small amounts promote, inhibit or otherwise modify any physiological process in plants." (47)

Several workers (4, 8, 10, 36) have investigated and reported the response of horticultural crops to alar. It has increased the number of blossoms in the succeeding years (3, 4), reduced the fruit size (4, 41, 43, 44), inhibited shoot elongation (4, 14, 19, 21, 24, 30, 47), and corrected or prevented certain physiological disorders on some apple cultivars (27, 43).

Recently, alar was registered for use on Concord grapes. In 1965 and 1966, Tukey and Fleming (45) conducted studies to determine the varietal response of Concord grapes to this compound.

The work reported herein was conducted in the field and in the greenhouse to investigate the effects of alar on fruit set and quality of berries of Concord grapes in Kansas, and also to determine the reaction of Concord plants to alar in the presence of 2,4-D.

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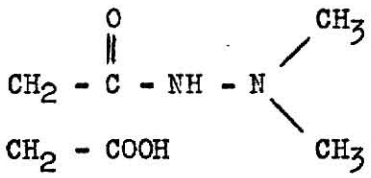
*A product of Uniroyal Chemical Company, Division of Uniroyal, Inc., Naugatuck, Connecticut.

II. REVIEW OF LITERATURE

A. Growth Retardants

The literature on growth retardants was reviewed in 1964 by Cathy (10). He defined growth retardants as, "all chemicals that slow cell division and cell elongation in shoot tissues and regulate plant height physiologically without formative effects." Retarding chemicals are subclassified under six families of compounds according to their chemical structure: nicotiniums, quaternary ammonium carbamates, hydrazines, phosphoniums, substituted cholines and succinamic acids.

Succinic acid, 2,2,-dimethyl hydrazide, also designated as B-995 (Alar), is unique in its chemical structure as a growth retardant. Unlike other growth retardants, it does not contain a benzene ring, quaternary ammonium or phosphonium cation, or substituents that are of small size, nucleophilic and nonionizable (36). Alar is a free, ionizable acid with the C-C-N-N system found in B-hydroxyethyl hydrazine ($HOCH_2\ CH_2\ NH\ NH_2$) and malic hydrazine (10). The structural formula of alar is presented below.



Succinic acid, 2,2,dimethyl hydrazide (alar)

Donald (12) reported that the growth-retarding action of B-995 (alar) is attributed to the formation of 1,1-dimethylhydrazine *in vivo*. This hydrazine strongly inhibited tryptamine oxidation by pea epicotyl homogenates.

Martin *et al.* (31) employed a method of ^{14}C alar uptake through the petiole, severed stem, or a single root of apple seedling. Autoradiographs

showed the compound to be mobile and comparable to many inorganic ions in the speed of movement. The majority of the previously injected ^{14}C labeled alar remained intact after long periods of metabolism.

Martin and Williams (32) found that labeled alar moved freely into all areas of the apple plant and passed into the soil through roots. The major extractable radio-activity was $^{14}CO_2$ as alar slowly degraded throughout the growing period.

Edgerton (15) determined the distribution of ^{14}C labeled alar in the apple fruit. Within 24 hours after spraying alar on the surface of the fruit, radio-activity was reduced by nearly one half and considerable activity was found in flesh and seeds. The distribution of the compound in various tissues of treated branches was measured in the dormant season. The compound accumulated first in flower buds, then in vegetative buds, cluster bases, one-year old bark, and one-year old xylem.

B. Effects of Alar on Vegetative Growth

Batjer et al. (4) reported that alar spray applied to apple, pear, and sweet cherry foliage retarded shoot growth. The degree of growth reduction was related but not proportional to the concentration of the chemical.

Griggs et al. (19) found that shoot growth in Bartlett pear was reduced by spray applications of 1000, 2000, and 5000 ppm alar but not significantly. Pears on sprayed trees had shorter, thicker pedicels.

Hapiton et al. (21) reported that two alar spray applications of 5000 ppm significantly retarded new shoot elongation of Collins and Bluecrop highbush blueberries.

Edgerton and Hoffman (14) found that 5000 ppm of alar as a pre-bloom spray to Delicious apple trees reduced vegetative growth. Luckwill and Weaver (30)

found that shoot growth of ten-year old dwarf apple trees was reduced with spray applications of 200 ppm, 500 ppm, 1000 ppm, and 2000 ppm alar but 2000 ppm alar was most effective when applied two weeks after full-bloom.

Unrath et al. (48) found that 1000 ppm to 8000 ppm of alar sprayed at two weeks after full-bloom decreased sour cherry terminal growth by reducing internode length.

Jaffe and Isenberg (24) found that alar applied to seedlings of tomatoes, petunias, and cucumbers retarded their early growth proportional to the spray concentration. Cucumber plants treated with high concentration of alar showed a marked retardation of internode length.

Knavel (25) applied alar and cycocel to young tomato plants grown in soils of different fertility levels. Alar effectively reduced plant height. Plants treated with either chemical were more drought resistant and had a darker green color. Alar-treated plants contained more chlorophyll and their leaves had more palisade cells than plants of the control.

Andrews (2) found that alar-treated land cress plants were greener, shorter and more compact than non-treated plants.

Singh (42) working with strawberry studied the effects of 2500 ppm, 5000 ppm, and 7500 ppm alar on the growth of field-grown Surecrop and Midland strawberry plants. Significant reductions were found in the number of runners and daughter plants, dry weight and root length of alar-treated plants.

C. Effects of Alar on Flowering

Griggs et al. (19) found that 1000 ppm, 2000 ppm, and 5000 ppm of alar provided a graded, effective, and safe means of delaying bloom in Bartlett pears. Loss of bloom due to late spring frosts was avoided. The delay in bloom resulted in increased fruit set over and above frost protuction.

Batjer et al. (4) reported that apples, pears, and sweet cherries treated with 500 ppm to 2000 ppm alar after full-bloom showed a marked increase in amount of bloom the following spring. Blooming of apple trees was delayed the spring following treatment.

Jaffe and Isenberg (24) found that tomato, petunia, and cucumber flower numbers were not affected by a 5000 ppm alar treatment.

Bukovac et al. (8) reported that Concord grape flower initiation and differentiation was not suppressed by alar treatment. Since the nodal regions were not affected, the flowering potential of canes would be increased as a result of the increased number of nodes per unit length.

Hapiton et al. (21) found that the number of flower buds per unit length of new growth of high bush blueberry was increased by application of 5000 ppm alar.

D. Effects of Alar on Fruits

Williams et al. (49) found that alar applied to apple trees several days after full-bloom largely prevented the development of storage scald and significantly extended the shelf-life of the fruit after removal from the storage. Treated apples remained firmer in storage and softened at a slower rate when ripened than the checks. The alar treatment resulted in less water soluble pectin and slightly more total pectin in the fruit after storage.

Tukey et al. (46) applied 500 ppm to 2250 ppm of alar as foliar spray to grape vines. They found that lower concentrations most effectively increased berry size. Applications at flowering stage were better than at pre-bloom stage, post-bloom applications had little or no effect. Concentration of alar did not significantly affect the percentage of total soluble solids in the fruit. Alar treatments increased the weight per 100 bunches but reduced the

average weight per berry.

Hull (22) found that fruit set of Concord grapes was markedly increased by alar at 2500 ppm either at pre-bloom, full-bloom, or after full-bloom. The soluble solids content of the fruit was not affected by alar.

Tukey and Fleming (45) found that alar on Concord grapes increased the set of berries and caused a more compact and attractive grape cluster.

Batjer et al. (4) found that alar treatments on apples, pears, and sweet cherries reduced fruit size, shortened fruit stems and advanced maturity of sweet cherry fruits.

Hapiton et al. (21) found that foliar applications of 2000 ppm of alar significantly increased fruit color of sour cherries. The force required to separate the fruit harvested early in the season from its pedicel was reduced. Fruit firmness and resistance to softening when mechanically harvested were significantly increased. Alar also caused fruit to be of a more uniform size. Fruit acidity and respiration were significantly reduced.

Andrews (2) found that land cress seeds of 5000 ppm alar-treated plants were delayed in maturity, were smaller, and had a much lower percentage of germination than check plants.

Blanpied et al. (6) reported the following effects of alar on the apple fruits: increased firmness, delayed harvest date, increased red color, delayed onset of respiratory climacteric in storage, frequently decreased the incidence of storage scald, and increased core browning in common storage.

Ryugo (38) concluded that sweet cherry trees sprayed with 2000 ppm alar after full-bloom produced fruit that had a marked increase in anthocyanino content, but the soluble solids content and harvest size was not changed when concentrations of 2000 ppm alar were sprayed after full-bloom.

Gambrell et al. (18) reported that peaches from trees sprayed with alar

matured five days earlier than fruit of check trees. No differences were observed in fruit yield, size and shape. The color, soluble solids, titrated acidity, and sugar/acid ratio of peaches from alar-treated trees were equal to or higher than fruit from non-treated trees.

Batjer and Williams (5) found that alar, when applied to Delicious and Winesap apple trees, delayed the development of water core in the fruit and effectively reduced pre-harvest fruit drop. Treated fruits were firmer and somewhat lower in soluble solids than check fruits, suggesting retardation of maturity.

Looney et al. (26) found that alar significantly increased the amount of bloom and number of apple fruits the following season, but fruit size was reduced.

Lord et al. (27) showed that alar, at rates of 2000 ppm and 5000 ppm to Delicious apple trees improved fruit flesh firmness prior to harvest, and the firmness generally persisted throughout the storage season. Alar delayed the development of water core, reduced the occurrence of internal breakdown following harvest, but had no effect on storage scald.

E. Effects of 2,4-D on Concord Grape

1. Mode of action

The hormone-like effects of 2,4-D was determined by Zimmerman and Hitchcock (50) on garden peas, snap bean, potato, tomato, and cucumber plants. Measurable cell elongation in tomato was produced by using .0007 percent in lanolin paste. Higher rates modified the shape by the new organs, leaf venation, formation of adventitious root, and production of seedless fruits.

Marth and Mitchell (33) studied the volatility of various forms of 2,4-D by using tomato and bean plants as biological indicators. After exposure under

bell jars, methyl, ethyl, and butyl esters produced epinastic effects. With the acid, sodium salts, ammonium salts, amide, and triethanolamine salt forms showed no epinastic effects.

Tukey et al. (44) studied histological changes in bindweed and sow thistle following application of 2,4-D acid. Four possible modes of actions were suggested: 1 - Chlorophyll-depletion in the leaves diminishing stored food. 2 - Increased respiration activity resulting in depletion of food supply. 3 - Rupture and disorganization of rhizomes and root cortex leading to invasion by soil pathogens and decay organization. 4 - Proliferation of the phloem in the vascular bundles interferring with translocation.

Rasmussen (35) found that reducing sugar contents in the roots of dandelion showed a rapid increase following 2,4-D application. After treatment the sucrose content of the roots decreased slowly, and the levulin dextrin contents declined rapidly. Sell et al. (40) found that protein and amino acids accumulated in the stem of red kidney bean plants treated with 2,4-D acid. Reducing and non-reducing sugars were depleted in the treated plants. This indicated that a large portion of the carbohydrates were utilized in protein synthesis.

Humphreys and Dugger (23) postulated that respiration rate of eliotated pea seedlings increased after 2,4-D treatment.

2. Response of some plants to 2,4-D

Caryle and Thorpe (9) reported that germination, growth, and nodulation of bean, pea, red clover, and alfalfa were restricted with 0.5 ppm of 2,4-D in the soil.

Luckwill and Lloyd-Jones (28 and 29) reported that high rates of decarboxylation of the applied 2,4-D were found in resistant varieties of

strawberries. Similarly resistant varieties of apple decarboxylated about 60% of the applied 2,4-D in four days; whereas, susceptible varieties decarboxylated only 2%.

Clore and Bruns (11) reported the typical symptoms of injury from the application of 2,4-D at 0.0001 to 512 µg/plant on Concord grapes as follows: "lethal injury to tissues in the treated areas; inhibition of development and growth; varying degree of leaf dwarfing; fan-shaped leaves with anastomosed veins developing finger-like projections; inward curling of treated immature leaves; and leaves flaccid, pendulant, crinkled, and twisted with veins appearing wider, more prominent, and chlorotic and the interveinal tissues becoming rough and pebbly when treated at the nearly mature stage."

Scholz (39) observed that ripening of Concord grapes will be retarded by direct treatment of 2,4-D but did not effect flowering or fruit set. Carry-over effect was found at high concentration.

Abmeyer (1) considered Concord grape plants grown under Northeastern Kansas conditions moderately susceptible to atmospheric contaminations of 2,4-D.

III. MATERIALS AND METHODS

A. Field Experiment

The Concord grape vines grown at the Kansas State University Horticulture Farm near Manhattan, Kansas, were used. Well established vines of uniform size and vigor were selected for experimentation.

A randomized complete block (RCB) with three replicates was used as the experimental design. All plots consisted of four vines. Data were taken on September 9-11 and September 18-20.

B. Treatments

Five alar treatments including the check were set up as follows:

Treatment 1	Check
Treatment 2	1000 ppm pre-bloom
Treatment 3	1000 ppm post-bloom
Treatment 4	2000 ppm pre-bloom
Treatment 5	2000 ppm post-bloom

Applications were made as a dilute aqueous foliar spray of 1000 ppm and 2000 ppm alar applied to the drip point with a three gallon single nozzle compressed air sprayer. Pre-bloom applications were applied on May 19, nine days before full-bloom. Post-bloom applications were applied on June 5, eight days after full-bloom. Full bloom (May 28) was defined as the time when 50% of the flower caps had fallen.

Prior to the first harvest (September 9 to 11) the second cluster from the base of the upper and lower southern shoot was selected to observe the coloration development of Concord grape berries by counting the number of green, starting to color, and colored berries (full blue) every second day for six dates (August 27 to September 6).

C. Data Collected

At harvest time (September 9-11 and 18-20) the effect of alar on Concord grape clusters was determined by obtaining the following data from the plot sample vine:

1. The total yield of fruits in kilograms
2. Total number of clusters
3. Average cluster weight in grams = $\frac{\text{Total yield of fruits}}{\text{Total number of clusters}}$
4. Four basal clusters selected at random from four shoots from the plot sample vine were collected for the following measurements:
   a) Number of berries per cluster
   b) Berry weight of Concord grapes in grams = $\frac{\text{Total weight of four clusters}}{\text{Total number of berries in four clusters}}$
   c) pH: Ten berries selected at random from the four cluster sample were macerated and a juice sample was read with a Metrion IV pH Meter Model 28 C.
   d) Total soluble solids (TSS). The total soluble solids content was determined with a hand refractometer on juice which was hand squeezed from ten berries selected at random.

D. Greenhouse Experiment

Rooted cuttings of Vitis labrusca L. cv. Concord obtained from Interstate Nursery, Hamburg, Iowa, were potted in 7" pots on May 24. This study was conducted in the greenhouse of the Horticulture Farm at Kansas State University under natural photoperiod during the summer of 1969. When vegetative growth reached 10-12", eighteen plants well established and uniform in size and vigor were selected at random from about 120 plants. Applications of aqueous foliar sprays of 2,4-D at 100 ppm, 1 ppm, 0.01 ppm, 0.0001 ppm, 0.000001 ppm and check were applied to establish the minimum sensitivity of Concord vegetative growth to 2,4-D. Plants were sprayed on June 19 outside the greenhouse and the pots

were left there overnight to minimize contamination of other grape plants.

Because of the severe 2,4-D injury found on plants treated with 1 ppm and 100 ppm, and no visible symptoms was observed on that treated with 0.01 ppm of 2,4-D, this concentration (0.01 ppm) was considered the minimum sensitive concentration to Concord grape vegetative growth.

The following treatments were applied to a single plant from each replication:

1. Alar, 2000 ppm on 7/11
2. 2,4-D, 0.01 ppm on 7/12
3. Alar, 2000 ppm plus 2,4-D, 0.01 ppm applied immediately after alar application on 7/12
4. Alar, 2000 ppm plus 2,4-D, 0.01 ppm applied seven days after alar application on 7/11

Applications were made as a dilute aqueous foliar spray of alar and 2,4-D to plants outside the greenhouse and the plants remained there overnight as before. Materials were applied with separate compressed air sprayers. The entire plant was completely wetted.

On July 31, the internode length was measured in centimeters. The main shoots were dried in an oven at 65° C for 24 hours and dry weight was determined.

E. Statistical Analysis

All data were treated statistically. Variances were determined by the appropriate two way analysis of varia nce for randomized complete block design. The Fisher's least significant difference (LSD) test was used to determine the significance among means at 5% level (17).

IV. RESULTS

A. Field Experiment

The effects of pre-and post-bloom applications of alar at 1000 ppm and 2000 ppm on the fruit of *V. labrusca* L. cv. Concord grape under field conditions are summarized in Tables 1 to 7. The parameters studied included: yield of fruits, cluster weight, number of berries per cluster, berry weight, pH, total soluble solids, and response of Concord berry coloration to alar treatment.

1. Yield of fruit

Table 1 shows the effect of pre-and post-bloom application of alar at 1000 ppm and 2000 ppm on the total yield of Concord grapes. Vines treated with alar at 1000 ppm and 2000 ppm post-bloom, and 1000 ppm pre-bloom produced more fruits than check vines. However analysis of variance indicated no significant differences among data.

2. Cluster weight

The influence of pre-and post-bloom application of alar at 1000 ppm and 2000 ppm on fruit cluster weight is shown in Table 2. There are no significant differences amongst data; although, the weight of fruit clusters from vines treated with 1000 ppm of alar pre-and post-bloom was slightly greater than that of check vines.

3. Number of berries per cluster

Table 3 shows the effect of alar applications on the number of berries per cluster of Concord grapes.

No significant differences among the means of alar treatments were observed.

Clusters harvested on September 9-11 had significantly more berries per cluster than those harvested on September 18-20. The interaction between

Table 1. Effect of pre-and post-bloom application of alar at 1000 ppm and 2000 ppm on the yield of Concord grapes.

Alar Treatment	Date of Application	Yield of Fruit[1,2] Harvested Sept. 9-11	Harvested Sept. 18-20	Total
		Kg	Kg	Kg
1000 ppm pre-bloom	May 19	5.13	4.06	9.19
1000 ppm post-bloom	June 5	4.50	4.83	9.33
2000 ppm pre-bloom	May 19	4.50	1.60	6.1
2000 ppm post-bloom	June 5	3.26	7.43	10.69
Check	---	2.96	4.56	7.52
Average		4.07	4.19	

[1]Treatment, harvest date, TXD, LSD .05 = NS

[2]Average of one vine from each of three blocks.

Table 2. Effect of pre-and post-bloom application of alar at 1000 ppm and 2000 ppm on the fruit cluster weight of Concord grapes.

Alar Treatment	Date of Application	Fruit Cluster Weight[1,2] Harvested Sept. 9-11	Harvested Sept. 18-20	Average
		gm	gm	gm
1000 ppm pre-bloom	May 19	91.3	86.0	88.6
1000 ppm post-bloom	June 5	95.2	83.2	89.2
2000 ppm pre-bloom	May 19	88.6	64.0	76.3
2000 ppm post-bloom	June 5	62.5	83.8	73.2
Check	---	69.4	86.0	77.7
Average		81.4	80.6	

[1]Treatment, harvest date, TXD, LSD .05 = NS

[2]Fruit cluster weight = $\frac{\text{Total yield of fruit}}{\text{Total number of clusters}}$

Table 3. Effect of pre-and post-bloom application of alar at 1000 ppm and 2000 ppm on the number of berries per cluster of Concord grapes.

Alar Treatment	Date of Application	Number of Berries[1] Harvested Sept. 9-11	Harvested Sept. 18-20	Average
1000 ppm pre-bloom	May 19	170a[2]	106c	138
1000 ppm post-bloom	June 5	164a	105c	135
2000 ppm pre-bloom	May 19	144ab	118bc	131
2000 ppm post-bloom	June 5	102c	158a	130
Check		111bc	105c	108
Average		138a	118b	

Treatment LSD .05 = NS
Harvest data LSD .05 = 14.86
Treatment x Harvest Date LSD .05 = 33.6

[1]Average derived from four clusters from one vine in each of three blocks.

[2]Means not having a letter in common are significantly different at the 5% level.

treatment and harvest data was significant. Within the first harvest date (September 9-11) the numbers of berries per cluster treated with 1000 ppm pre- and post-bloom were significantly greater than check. Within the second harvest date the number of berries treated with 2000 ppm post-bloom was significantly greater than the check and all other alar treatments. The number of berries per cluster treated with 1000 ppm alar pre- or post-bloom at the first harvest date (September 9-11) was significantly more than those at the second harvest date (September 18-20). The number of berries treated with 2000 ppm alar at the second harvest date (September 18-20) was significantly more than that at the first. The number of berries per cluster harvested from check vines on September 9-11 was not significantly different from those harvested September 18-20. There was a distinct tendency for alar treatments to increase berry set (berries per cluster).

4. Berry weight

Table 4 shows the effect of pre-and post-bloom applications of alar at 1000 ppm and 2000 ppm on the berry weight of Concord grapes. The berry weight of the alar treated vines was significantly smaller than that of check berries. There were no significant differences among the alar treatments but there was a tendency of an inverse relationship between concentration and berry weight.

5. Acidity of fruit juice

Table 5 shows the effect of pre-and post-bloom application of alar at 1000 ppm and 2000 ppm on the pH of the juice of Concord grape berries. The pH of Concord grape berry juice increased from the first to the second harvest date. Alar treatments affected pH of ripe berries significantly. Berries treated with alar post-bloom had the lowest acidity (highest pH). Pre-bloom applications at 2000 ppm did not differ from the check but 1000 ppm pre-bloom

Table 4. Effect of pre-and post-bloom applications of alar at 1000 ppm and 2000 ppm on the berry weight of Concord grapes.

Alar Treatment	Date of Application	Berry Weight[1] Harvested Sept. 9-11	Harvested Sept. 18-20	Average
		gm	gm	gm
1000 ppm pre-bloom	May 19	3.8	3.8	3.8b[2]
1000 ppm post-bloom	June 5	3.9	3.6	3.8b
2000 ppm pre-bloom	May 19	3.7	3.5	3.6b
2000 ppm post-bloom	June 5	3.3	3.8	3.5b
Check	---	3.9	4.5	4.2a
Average		3.7	3.8	

Treatment LSD .05 = 0.39 D, TXD, LSD .05 = NS

[1]Berry weight in grams = $\frac{\text{Total weight of four clusters}}{\text{Total number of berries in four clusters}}$

[2]Means not having a letter in common are significantly different at 5% level.

Table 5. Effect of pre-and post-bloom application of alar at 1000 ppm and 2000 ppm on the pH of juice of Concord grapes.

Alar Treatment	Date of Application	pH of Juice		
		Harvested Sept. 9-11	Harvested Sept. 18-20	Average
1000 ppm pre-bloom	May 19	3.5	3.6	3.5c[1]
1000 ppm post-bloom	June 5	3.6	3.8	3.7a
2000 ppm pre-bloom	May 19	3.5	3.8	3.6b
2000 ppm post-bloom	June 5	3.5	3.8	3.7a
Check	---	3.4	3.7	3.6b
Average		3.5a	3.7b	

Treatment LSD .05 = 0.03
Harvest Date LSD .05 = 0.02 TXD, LSD .05 = NS

[1]Means not having a letter in common are significantly different at the 5% level.

treatment produced berries with the most acidic juices.

6. Total soluble solids

The effect of pre-and post-bloom applications of alar at 1000 ppm and 2000 ppm on the total soluble solids of Concord grape is shown in Table 6. The total soluble solids of berries harvested on the first date (September 9-11) was significantly more than that of the second harvest date (September 18-20). The total soluble solids of berries treated with 2000 ppm alar pre-bloom was reduced significantly below the check and berries treated with 1000 ppm alar pre-and post-bloom.

7. Berry coloration

Figure 1 and Table 7 shows the effect of 1000 ppm and 2000 ppm pre- and post-bloom applications of alar on the percentage of berries of Concord grape clusters that were green, starting to color, and colored. One thousand ppm alar applied at pre-bloom enhanced coloration of treated Concord berries as compared to the check. Other treatments did not enhance coloration and alar at 2000 ppm post-bloom tended to delay coloration.

B. Greenhouse Experiment

Table 8 shows the effect of alar and 2,4-D applied alone and in combination on the internode length of Concord grapes grown in the greenhouse.

The internode length of Concord grape plants treated with either 2,4-D immediately after alar application or 2,4-D applied seven days after alar application was significantly shorter than check or 2,4-D treated plants. The internode length of alar treated plants was significantly shorter than 2,4-D treated plants but not significantly shorter than check plants.

Total dry matter of treated plants, Table 9, was not significantly different than that of non-treated plants.

Table 6. Effect of pre-and post-bloom application of alar at 1000 ppm and 2000 ppm on the total soluble solids of Concord grapes.

Alar Treatment	Date of Application	Total Soluble Solids		
		Harvested Sept. 9-11	Harvested Sept. 18-20	Average
		B.U[1]	B.U[1]	B.U[1]
1000 ppm pre-bloom	May 19	15.5	14.6	15.0a[2]
1000 ppm post-bloom	June 5	15.1	15.0	15.0a
2000 ppm pre-bloom	May 19	14.5	13.2	13.8b
2000 ppm post-bloom	June 5	14.8	13.7	14.2ab
Check	---	14.7	14.7	14.7a
Average		14.9a	14.2b	

Treatment LSD .05 = 0.80
Harvest date LSD .05 = 0.12 TXD, LSD .05 = NS

[1]Bolling units as measured with a hand refractometer.

[2]Means not having a letter in common are significantly different at the 5% level.

Figure 1. The effect of 1000 ppm and 2000 ppm pre-and post-bloom applications of alar on the average percentage of berries of Concord grape clusters that were green, starting to color, and colored.

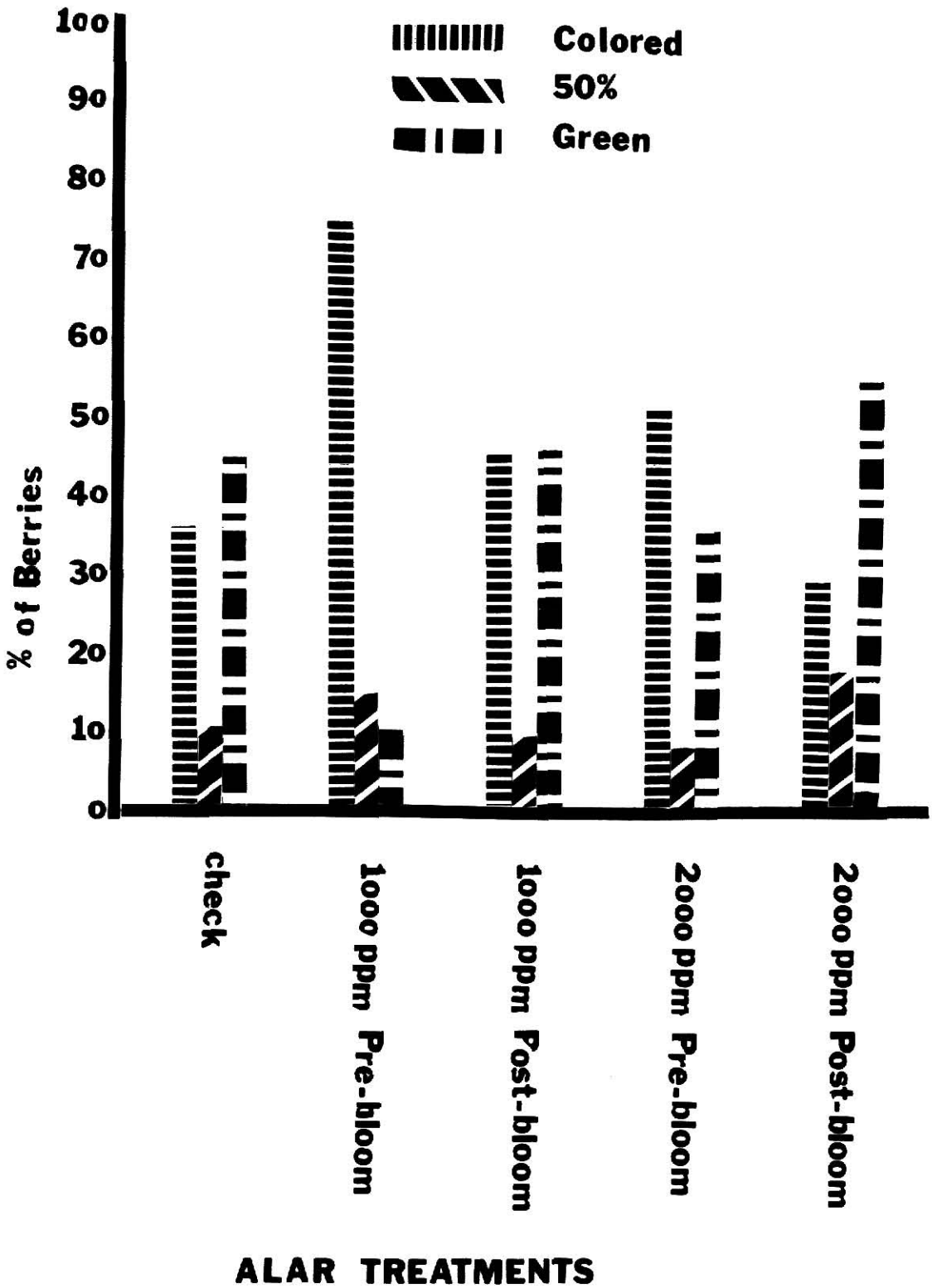

100
90
80
70
60
50
40
30
20
10
0
% of Berries
Colored
50%
Green
check
1000 ppm Pre-bloom
1000 ppm Post-bloom
2000 ppm Pre-bloom
2000 ppm Post-bloom
ALAR TREATMENTS

Table 7. The effect of 1000 ppm and 2000 ppm pre-and post-bloom application of alar on the percentage of berries of Concord grape clusters that were green, starting to color and colored on dates test clusters were examined.

Date	Check			1000 ppm pre-bloom			1000 ppm post-bloom		
	Colored	50%	Green	Colored	50%	Green	Colored	50%	Green
	%	%	%	%	%	%	%	%	%
8/27	17.2	10.3	72.4	60.7	3.5	35.7	25.7	7.8	71.4
8/29	24.0	10.3	65.5	64.2	14.2	21.4	31.4	14.2	54.2
8/31	41.3	6.0	51.7	71.4	17.8	10.7	37.1	11.4	51.4
9/2	44.8	13.7	41.3	75.0	25.0	0.0	51.4	11.4	37.1
9/4	65.5	13.7	20.6	85.7	14.2	0.0	57.1	14.2	38.5
9/6	75.8	10.3	13.7	92.8	7.1	0.0	65.7	20.0	14.2
Ave.	36.9	10.7	44.2	74.9	13.6	11.3	44.7	9.3	44.5

Table 7. (Contd.)

Date	2000 ppm pre-bloom			2000 ppm post-bloom		
	Colored	50%	Green	Colored	50%	Green
	%	%	%	%	%	%
8/27	25.0	5.5	69.4	8.8	5.8	85.2
8/29	38.8	8.3	52.7	14.7	14.7	70.6
8/31	50.0	8.3	13.8	20.5	17.6	61.7
9/2	58.3	8.3	33.3	26.4	20.5	52.9
9/4	63.8	8.3	27.7	47.0	17.6	35.2
9/6	69.4	5.5	25.0	52.9	23.5	23.5
Ave.	50.9	7.3	36.9	28.4	16.6	54.8

Table 8. Effect of alar and 2,4-D applied alone and in combination on the internode length of Concord grapes grown in the greenhouse.

Treatment	Rate of Application	Means of Internode Length
		cm
Alar	2000 ppm	4.1bc[3]
2,4-D	0.01 ppm	4.9a
[1]Alar plus 2,4-D	2000 ppm + 0.01 ppm	4.0c
[2]Alar plus delayed 2,4-d	2000 ppm + 0.01 ppm	4.0c
Check	---	4.8ab

Treatment LSD .05 = 0.75

[1]2,4-D applied immediately after alar application.

[2]2,4-D applied seven days after alar application.

[3]Means not having a letter in common are significantly different at 5% level.

Table 9. Effect of alar and 2,4-D applied alone and in combination on the total dry matter of Concord grapes grown in the greenhouse.[1]

Treatment	Date of Application	Total Dry Matter[2]
		gm
Alar	2000 ppm	4.36
2,4-D	0.01 ppm	4.80
[3]Alar plus 2,4-D	2000 ppm + 0.01 ppm	4.55
[4]Alar plus delayed 2,4-D	2000 ppm + 0.01 ppm	5.09
Check	---	5.09

[1]No significnat difference amongst data at the 5% level.

[2]Average of one shoot from the one plant in each of eight replicates.

[3]2,4-D applied immediately after alar application.

[4]2,4-D applied seven days after alar application.

V. DISCUSSION

The effects of alar in these experiments were not dramatic. Yield of fruit and cluster weight were not significantly affected by alar. The following discussion concerns the significant effects of alar treatments on the number of berries, weight of berry, fruit acidity, and total soluble solids.

Cluster weight of alar treated vines did not respond significantly (Table 2). This result was partly in agreement with that of Tukey and Fleming (45). They reported a slight but not significant difference in cluster weight of alar treated and non-treated vines.

The number of berries was significantly more at the first harvest date than the second (Table 3). At the first date berries were stuck firmly to their pedicles and there was a lower population of fruit insects. Both factors could cause considerable loss of ripe berries. At the first harvest date the number of berries per cluster from vines treated with the low concentration and 2000 ppm of alar pre-bloom were significantly more than the check also significantly more than that treated with low concentration at second harvest date. Since these alar treatments did not affect berry numbers at the second harvest date, the decrease in number of berries per cluster from the first to second harvest date was due to shattering of berries. The shattering of berries may have been influenced directly or indirectly by alar. Post-bloom application of alar at 2000 ppm was opposite in effect. Maturity of these clusters was delayed. Delaying of maturity may have reduced shattering because the insect damage was less or berries were held tightly to the pedicles. Although alar treatments did not significantly increase the number of berries per cluster, there was a definite trend in that direction. The interaction table supports that conclusion since significance was always towards increased numbers. Tukey

and Fleming (45) found that alar significantly increased the number of berries per cluster.

All alar treatments reduced berry size. Since the number of berries was little affected by alar treatment, the reduction in size of berries was due most likely to the direct effect of alar. This result coincides, in part, with the work of Tukey and Fleming (45) where the average weight of Concord berries was reduced when alar was applied at full-bloom or earlier. Fisher and Looney (16) reported that the size of Golden Delicious apples decreased with increasing concentration of alar applied at full-bloom time (500 ppm and 2000 ppm). Batjer et al. (4) reported that the fruit size of Delicious apples and Bartlett pears was reduced when 2000 ppm of alar was applied 16 days after full-bloom.

Alar induced changes in pH were statistically significant, but these differences ranged from 3.5 to 3.7 a difference only 0.2. It is questionable that these differences are biologically important. If important then a reduction of fruit acidity is a change associated with advancing maturity of grapes. Maturation is controlled by numerous factors such as genetical, environmental, yield density (45), presence or absence of 2,4-D injury (39), and others. Table 5 shows that alar at 1000 ppm and 2000 ppm post-bloom reduced acidity of berries and vines treated with 1000 ppm pre-bloom were more acidic than those from check vines. It was observed in the field that alar at 1000 ppm pre-bloom enhanced the coloration development of berries (Fig. 1). Color development occurred independently from berry maturation. The alar treatment inducing the most rapid coloration in effect delayed maturation. Rygo (38) found that 2000 ppm alar applied 25 days before harvest enhanced pigmentation of sweet cherry fruit. He concluded that alar did not advance the fruit maturation but only induced early development of pigments. Fisher and Looney (16) found no significant effect on titratable acid in Delicious apples

treated with 1000 ppm and 2000 ppm alar, but Golden Delicious apples showed a significant increase in titratable acid. Winesap and McIntosh apples showed a slight but continuous reduction in acid with increasing concentration of alar. Williams et al. (48) reported no significant differences in the pH and titratable acid of Red Delicious apples due to alar application from 2 to 5 weeks after full-bloom.

The reduction in total soluble solids from the first to second harvest date (Table 6) was due to the relatively high number of immature berries in the samples taken on the second date. It was observed in the field that the alar treatment (2000 ppm pre-bloom) that reduced total soluble solids also had a larger number of immature fruits in the harvest samples of both dates. Alar treatment that affected pH of ripe berries did not affect total soluble solids when compared to the check. Fisher and Looney (16) indicated that total soluble solids was less uniform among apple cultivars treated with 500 ppm, 1000 ppm, and 2000 ppm applied after full-bloom. Batjer and Williams (5) reported lower soluble solids of apples from Winesap trees treated with 1000 ppm and 2000 ppm applied 14 to 20 days after full-bloom, with similar but non-significant trend in Delicious apples.

Clusters treated with 2000 ppm alar post-bloom developed their ripe color at a later date than other alar treatments and the check (Fig. 1 and Table 7). It was also noted that a large proportion of the fruit from this treatment was harvested at the later date (Table 1). This suggests that the delay of coloration of fruit could be contributed to a more uniform maturity of the clusters. It was observed at harvest time that these clusters were, in fact, more uniform in ripeness and coloration.

No concentration of alar was effective enough to be recommended commercially. Concord vines treated with 2000 ppm post-bloom exerted some commercially

desirable responses. Yield was increased but not significantly; acidity of juice was low; and a possible improved uniformity of ripeness amongst berries of the cluster.

The greenhouse study showed that alar in the presence of 2,4-D significantly reduced internode length of Concord grapes. This treatment differed very slightly from alar alone. This supports the conclusion that the 2,4-D concentration used in the experiment (0.01 ppm) did not alter the alar mode of action of inhibition of shoot elongation.

The Concord vines used for field experimentation were visibly injured with atmospheric contamination of 2,4-D. Evidence from the greenhouse study would suggest that alar treatments were not appreciably affected by the 2,4-D contamination.

VI. SUMMARY AND CONCLUSIONS

The results of this experiment gives the following conclusions:

1. Number of berries per cluster of Concord grape was increased when harvested on September 9-11. It was greater at vines treated with 1000 ppm either pre-or post-bloom.
2. Berry weight was reduced with alar treatments regardless of concentration or timing.
3. Berry juice acidity was reduced with post-bloom application of alar. Berries harvested on September 18-20 had low acidity.
4. Total soluble solids content of Concord grape berries was not affected by alar at 1000 ppm pre-or post-bloom and 2000 ppm post-bloom. Total soluble solids of harvested berries on September 9-11 were higher at the later date.
5. Coloration enhancement of berries in the field was induced with 1000 ppm of alar pre-bloom but not correlated with maturity.
6. No concentration of alar was effective enough to be recommended commercially. Alar at 2000 ppm post-bloom exhibited some desirable responses.
7. The presence of 2,4-D in the plants did not influence the alar response on Concord grapes.

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THE EFFECTS OF SUCCINIC ACID 2,2,-DIMETHYL HYDRAZIDE ON CONCORD GRAPES, *VITIS LABRUSCA* L.

by

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Field and greenhouse experiments were conducted at the Kansas State University Horticulture Farm at Manhattan, Kansas, in spring and summer of 1969 to investigate the effects of Succinic acid 2,2-dimethyl hydrazide (alar) on Concord grapes Vitis labrusca L. In the field measurements were made on yield of fruit, cluster weight, number of berries per cluster, berry weight, fruit acicity, total soluble solids, and berry coloration to determine the influence of alar on fruit set and berry quality.

Alar was applied at 1000 ppm pre-bloom, 1000 ppm post-bloom, 2000 ppm pre-bloom and 2000 ppm post-bloom. Pre-bloom application was nine days before full-bloom (May 27) and post-bloom application was eight days after full-bloom.

In the greenhouse, to determine the reaction of Concord plant to alar (2000 ppm) in the presence of 2,4-D (0.01 ppm), internode length and total dry matter were determined.

Alar treatments did not significantly influence the fruit yield or the cluster weight of Concord grapes.

Clusters harvested on September 9-11 had significantly more berries per cluster than those harvested on September 18-20. The interaction between treatments and harvest date was significant. Within the first harvest date (September 9-11) the number of berries of clusters treated with 1000 ppm pre- and post-bloom were significantly greater than check and those at the second harvest date (September 18-20). Within the second harvest date the number of berries treated with 2000 ppm post-bloom was significantly greater than the check, all other alar treatments, and those at the first harvest date.

Alar significantly reduced berry weight. No significance was found within alar treatments but there was a tendency of an inverse relationship between concentration and berry size.

Acidity of Concord berry juice was significantly reduced below the check

with 1000 ppm and 2000 ppm applied post-bloom. One thousand ppm pre-bloom berries were more acidic than check berries. Fruit acidity of berries harvested on September 18-20 was significantly lower than September 9-11.

Total soluble solids (TSS) of Concord berries was not influenced by alar treatments except 2000 ppm pre-bloom reduced TSS. TSS of berries harvested on September 9-11 was higher than on September 18-20.

Prior to harvest it was observed that 1000 ppm alar applied at pre-bloom enhanced berry coloration but this was not associated with fruit maturity. Alar at 2000 ppm post-bloom tended to delay coloration.

No alar treatment used was effective enough to be recommended commercially. Alar at 2000 ppm post-bloom induced the most desirable response.

In the greenhouse the internode length of Concord grape plants treated with alar (2000 ppm) plus 2,4-D (0.01 ppm), either immediately after alar application or seven days later, were significantly shorter than check or 2,4-D treated plants. These treatments differed only slightly from alar alone. This concentration of 2,4-D did not alter the alar mode of action of inhibition of shoot elongation.