The direct relationship between berry size and seed number agrees with Darrow's (2) and Eaton's (3) findings that there is a strong positive correlation between seed number and berry size in the blueberry fruit within a variety. Apparently some factor required for large berry size is lacking in the parthenocarpic fruit. The factors responsible for the higher percentage of large berries from the control and uncaged GA-treated bushes are likely to be due to more or different growth substances produced by the seed. The possibility also exists that the presence of seeds results in the fruits becoming stronger mobilization centers. The slightly later ripening of the fruit from the caked GA treatments may be caused by factors similar to those responsible for the lower percentage of large berries.

The lack of firmness and poor keeping quality characteristics of parthenocarpic tomatoes was not evident in the seedless blueberries produced in this experiment. The lower refractive index of the fruit from the higher levels of GA treatment may be due to the slower rate of maturation associated with this fruit. Since a longer time was required for such fruit to turn blue, the physiological changes associated with maturation were undoubtedly occurring at slower rates. Perhaps, if the seedless berries were allowed to remain on the bush somewhat longer after they became blue, the refractive index readings would have been the same as those found in the seeded fruit.

Although the GA-treated berries tended to be slightly smaller and later ripening, these disadvantages would be more than offset by the increased yield affected by GA application in years when internal set was low. Further investigation is needed to determine whether the greater pull required to separate the GA-treated berries from the bush will hinder mechanical harvesting.

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Chemical Thinning of Apple Trees Using Concentrate Sprays[1]

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Abstract. Sevin was used in thinning sprays in dilute—1×—and concentrate form—ranging from 3× to 33×—over a 4-year period on mature 'Rome Beauty' apple trees. Although treatments were not the same in each year, all sprays applied significantly thinned in 3 out of 4 years. There was some evidence that concentrate sprays thinned less than dilute sprays, but usually not significantly so. When using 33× concentrates, significant thinning was achieved in 1 year when Sevin was used at full strength—33 lb./100 gal. Approximately the same degree of thinning was obtained when the rate was reduced by one-half. Adding pesticides commonly used in petal-fall sprays to Sevin—all concentrated to the same extent—did not alter significantly the thinning obtained with Sevin alone.

Results on 'Jonathan' apples in a 1-year experiment revealed significant thinning with NAD and Sevin in a dilute spray, as well as Sevin at 3× and 6× concentrates. In a 1-year experiment on 'Golden Delicious', NAA thinned significantly as a dilute spray, and at 3× and 6× concentrates. The dilute spray was more effective.

Introduction

DILUTE spray-thinning of apples is well established, and several comprehensive reports have been published (1, 2, 8). For various reasons there has been little research on concentrate sprays for thinning. Years of work on concentrate applications of pesticides in Maryland (7) have led to widespread use of this technique in the state, and have raised the question of feasibility of concentrating the thinning spray. Experiments were conducted from 1963 through 1967 to investigate concentrating chemical thinning sprays, ranging from dilute to 33×. Frost ruined the 1963 experiment: results of the other 4 years are reported.

Materials and Methods

All experiments were performed in commercial orchards in the vicinity of Hancock, Maryland on heavily-blooming trees approximately 20 to 25 years old. Dilute sprays were applied with hand guns operated from high-pressure sprayers. Sprays of 3× and 6× concentrates were applied with a John Bean 200 TR air-blast sprayer. At a tractor speed of 2.5 MPH, spray delivery from 1 side only was approximately 7 and 3.5 gal per 100 ft of travel for 3× and 6× applications, respectively. Sprays of 33× concentrate were applied with an Econ-O-Mist air-blast sprayer, with a delivery rate of approximately 2.5 pints per 100 ft of travel, spraying from 1 side only at a speed of 2.5 MPH. All sprays were applied in the period between 15 and 21 days after full bloom, with the exception of 1967, when they were applied about 30 days after full bloom because of a long, cool period following blossoming. The number of trees ranged from 6 to 10 per treatment.

'Rome Beauty' was the main variety used, 'Jonathan' and 'Golden Delicious' to a lesser extent. The principal thinning agent used was 1-naphthyl N-methylcarbamate (Sevin) and is reported in pounds of the 50% wettable powder. 'Rome Beauty' is classed as difficult to thin (2); however, successful results have been reported with the use of Sevin (6). Naphthaleneacetic acid (NAA) plus Tween-20 was used on 'Golden Delicious' only. Naphthaleneacetamide (NAD) was used in 1964 only, as recommended for commercial application, for comparison with results obtained with Sevin. In 1965, pesticides normally used in petal-fall sprays were added to the concentrate thinning spray, all concentrated to the same degree. They were based on dilute rates of the commer-

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Table 1. Results of dilute thinning spray of NAD compared with Sevin in dilute and concentrate thinning sprays on Rome Beauty and Jonathan apples in 1964.

Material and concentration	Concentrate used	Fruit set (no./100 blossoming spurs)	Yield (bu/tree)	Fruit size (no./35 lb.)	Return bloom in 1965 (%)
		Rome Beauty			
Check	—	87	15.7	162	27
NAD 50 ppm	1× (dilute)	57	12.3	138	73
Sevin 1 lb./100	1× (dilute)	50	17.0	102	86
Sevin 3 lb./100	3×	59	14.5	115	87
Sevin 6 lb./100	6×	52	17.3	105	83
	LSD 5%	13.5	NS	16.6	16.2
	LSD 1%	18.7		22.6	22.1
		Jonathan			
Check	—	57	—	—	88
NAD 50 ppm	1× (dilute)	40	—	—	94
Sevin 1 lb./100	1× (dilute)	42	—	—	93
Sevin 3 lb./100	3×	36	—	—	95
Sevin 6 lb./100	6×	41	—	—	92
	LSD 5%	12.4			4.3
	LSD 1%	16.8			5.8

cial formulations per 100 gal as follows: Captan 50% WP, 2 lb.; lead arsenate 1.5 lb.; and azinphosmethyl (Guthion) 25% WP, 0.5 lb.

Fruit set was recorded as the number of fruits per 100 blossoming clusters, according to the method described by Harley et al. (4). Hand-thinning was employed on 'Golden Delicious' in 1967. At harvest, fruit side was determined by weight, except in 1967, when circumference of 25 fruits, selected at random from each tree, was measured just prior to harvest. These values were converted to volume—assuming the fruits to be a sphere—and are reported as cc per fruit. Return bloom was recorded as an estimate of the percentage of spurs blooming.

Results and Discussion

In 1964, Sevin dilute (1×), 3×, and 6× concentrate thinned 'Rome Beauty' to a significant degree, and no significant differences in fruit set were found between dilute and concentrate sprays (Table 1). Trees sprayed with NAD were thinned to about the same extent as those sprayed with Sevin. While yields were not influenced significantly, fruit size on sprayed trees was much larger than on unsprayed trees. Both NAD and Sevin thinned significantly, but fruit from the NAD-sprayed trees was significantly smaller than fruit from the Sevin-sprayed trees. The smaller fruit from the trees sprayed with NAD might be attributed to the tendency of this material to cause "pygmy" fruits on certain varieties, whereas Sevin has not been reported to have this effect. The season was extremely dry and the heavy set on the unsprayed trees was reflected the following year in the small amount of return bloom. 'Rome Beauty' is not strongly biennial in bearing habit, and has not received as much attention in chemical thinning experiments as certain biennial varieties. During the years 1965 to 1967 many 'Rome Beauty' trees were observed to be quite biennial, presumably due to several consecutive years of severe drouth.

Significant thinning was achieved on 'Jonathan' trees in 1964 by NAD at 50 ppm, and by Sevin at 1×, 3× and 6× applications (Table 1). The following year all sprayed trees had an excellent return bloom, the check trees somewhat less.

Since concentrate sprays of Sevin at 3× and 6× performed well in 1964, work on 'Rome Beauty' trees was expanded in 1965 to higher concentrates with and without normal petal-fall pesticides included (Table 2). Unsprayed trees set a lighter crop of fruit in 1965 than in the 1964 experiment, but all sprays accomplished a highly significant degree of thinning. The inclusion of formulated pesticides with any adjuvants contained therein did not result in increased or decreased thinning. Dilute sprays of Sevin as a commercial application to the same variety in the same orchard were observed to be quite effective, and it was concluded that the concentrate sprays probably were as efficient as the dilute spray under these conditions. Yields were reduced in all spray treatments, though not significantly. Fruit size from all spray treatments was significantly larger than that from unsprayed trees. In the following year, sprayed trees had from 96 to 99% return bloom, while the check trees had 68%.

The effectiveness obtained with Sevin in 1964 and 1965, whether dilute or concentrated or with pesticides added, led to the experiment in 1966 when dilute Sevin spray was compared with Sevin sprays delivered at 33× volume, but with Sevin added at full, one-half, and one-quarter strength (Table 3). No significant reduction in fruit set was caused by any of the spray treatments, the only year in 4 reported here in which Sevin failed to thin the 'Rome Beauty' variety. Fruit set on unsprayed check trees was low, even lower than the set on all the sprayed trees in the 1964 and 1967 experiments (Tables 1, 4).

Table 3. Results with Sevin as a dilute spray compared with concentrate sprays delivered at 33× volume, but with rates ranging from full- to quarter-strength, on Rome Beauty apples in 1966.

Concentration (lb./100 gal)	Concentrate used	Fruit set (no./100 blossoming spurs)	Return bloom in 1967 (%)
Check	—	40	37
1	1× (dilute)	30	41
33	33×	31	32
16	33×	24	33
8	33×	33	33
	LSD 5%	NS	NS

Post-bloom weather in 1967 was unusually rainy and cool. Cold or cool temperatures—even though above 32° F—during this period, have resulted in increased thinning action and even severe overthinning with NAA at standard concentrations (5, 9). Reduced concentration under these conditions thinned effectively, and adequate thinning was achieved for a somewhat longer period (9). For these reasons, the dilute NAA plus Tween-20 on 'Golden Delicious' in 1967 was only half the standard concentration, and timing was delayed to about 30 days. Although less is known about the effect of post-bloom temperatures on the thinning action of Sevin, its

Table 2. Effect of concentrate thinning sprays of Sevin, with and without regular petal-fall pesticides, on Rome Beauty apple trees in 1965.

Material and concentration[a]	Concentrate used	Fruit set (no./100 blossoming spurs)	Yield (bu/tree)	Fruit size (no./35 lb.)	Return bloom in 1966 (%)
Check	—	53	17.4	115	68
Sevin	6×	19	10.7	81	99
Sevin + pesticides	6×	17	13.4	73	99
Sevin	33×	21	13.1	80	96
Sevin + pesticides	33×	18	13.5	77	99
	LSD 5%	8.5	NS	16.1	7.4
	LSD 1%	11.6		22.0	10.1

[a]Sevin based on dilute rate of 1 lb. per 100 gal. Pesticides based on dilute rates of commercial formulations as follows: Captan 50% WP, 2 lb.; lead arsenate, 1.5 lb.; and azinphosmethyl (Guthion) 25% WP, 0.5 lb.

application to 'Rome Beauty' was likewise delayed. All Sevin sprays on 'Rome Beauty' significantly reduced the number of fruits per 100 blossoming spurs, as compared to unsprayed trees (Table 4). Observations at harvest indicated that the dilute-sprayed trees were thinned adequately, whereas concentrate-sprayed trees had an excessive crop load. Sevin at 33× concentrate was equally effective in fruit removal at either full-strength or half-strength. Unsprayed trees had such a heavy load of fruit that considerable limb breakage occurred, whereas very little was sustained on sprayed trees. Fruit measurements on October 5, just prior to harvest, revealed that fruit size on dilute-sprayed trees was 36% larger than that on unsprayed trees. Size increase was less, as was thinning, in the concentrate treatments. Return bloom the following year was light on unsprayed trees, whereas all sprayed trees had satisfactory bloom.

Table 4. Effects of dilute and concentrate thinning sprays of NAA on Golden Delicious, and of Sevin on 'Rome Beauty' apple trees in 1967.

Material and concentration	Concentrate used	Fruit set (no./100 blossoming spurs)	Fruit size (volume/fruit in cc)		Return bloom in 1968 (%)
		Rome Beauty			
			July 19	*Oct. 5*	
Check	—	78	62.6	181	18
Sevin, 1 lb./100	1× (dilute)	44	78.2	246	76
Sevin, 6 lb./100	6×	51	75.8	234	67
Sevin, 33 lb./100	33×	61	70.4	211	48
Sevin, 16 lb./100	33×	57	70.5	213	71
	LSD 5%	13.8	6.50	19.7	17.1
	LSD 1%	18.7	8.80	26.6	27.9
		Golden Delicious			
			June 30	*Sept. 14*	
Check	—	79	32.0	168	1
NAA[a] 5 ppm	1× (dilute)	48	38.5	200	63
NAA[a] 15 ppm	3×	55	37.6	192	29
NAA[a] 30 ppm	6×	58	36.2	184	32
	LSD 5%	9.2	2.82	13.3	8.3
	LSD 1%	12.5	3.84	18.1	11.2

[a]Tween 20 added at rate of ½ pt/100 gal.

'Golden Delicious' apple trees were thinned significantly in 1967 by dilute NAA sprays and by 3× and 6× concentrates (Table 4). The amount of thinning tended to decrease as concentrates were increased. At harvest time average fruit volume, based on a sample of 25 apples, was significantly larger on NAA-sprayed trees than on unsprayed check trees. Trees which received the dilute spray were ideal in crop load and fruit spacing. Unsprayed trees had practically no bloom the following spring. All sprayed trees had some bloom, but the dilute-sprayed trees had highly significantly more.

Significant thinning in commercial orchards often cannot be ascertained visually even though representative control trees are retained, and frequently growers conclude erroneously that no thinning was accomplished. Fruit measurements on both 'Rome Beauty' and 'Golden Delicious' fruits in mid-summer in the 1967 experiment revealed that a significant size increase had already been established (Table 4). That these early measurements were a sensitive indication of thinning response was evident, for approximately the same relative size difference between treatments still existed at harvest.

The trend toward closer planting of trees and the use of hedgerow systems makes it difficult for a commercial grower to thin parts of a tree chemically, or even individual trees. Consequently, chemical thinning sprays will have to be applied to a basic unit regardless of the bloom and set on limbs or individual trees. This procedure is not as dangerous as it may seem, for trees with light bloom are more resistant to chemical thinners than are comparable trees with heavy bloom. Furthermore, if block spraying is practical for thinning purposes, results presented here indicate that a cover spray and a Sevin thinning spray when applicable, may be combined safely into one application.

Thorough spraying usually has been employed when applying chemical thinning sprays in dilute form, with concentration being the variable factor. Concentration is determined after consideration is given to all factors which might affect results to be expected, such as variety, weather, tree vigor, etc. Even after the best possible evaluation has been made, results are still somewhat unpredictable. The use of concentrate sprays is more subject to error in mixing of sprays and calibration of spray equipment, as pointed out by Forshey and Hoffman (3). They stated also that practical experience has shown that a concentrate not exceeding 2× will give more consistent results. In this experiment, the use of Sevin at concentrates up to 33× on 'Rome Beauty' apples produced fairly consistent results. In 1967, however, Sevin at 33× thinned significantly less than the dilute spray. It is not known if the cool post-bloom temperatures interacted in some way to render the high concentrates less effective.

A factor which probably contributed largely to the favorable results with Sevin in concentrate form is its uniform performance in thinning action when used as a dilute spray at from 0.75 lb./100 gal to 4 lb./100 gal. Furthermore, it is relatively insoluble and a saturated solution is produced by the lower of these rates, according to Forshey and Hoffman (3), who reported that "absorption by the foliage is limited to the material in true solution....." Successful thinning with concentrate sprays of Sevin, far beyond the level of its solubility, raises the question of how absorption was accomplished. The amount of spray applied per tree in the 33× concentrate was approximately 1¼ pt, a volume so low that leaves showed no evidence of dampness immediately after the application. It appears that more needs to be done to develop a knowledge of absorption of chemicals from concentrate applications.

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