insensitivity of citrus seedlings to low concn of Amo-1618 has been reported by Monselise and Halevy (5), who found, however, that these same low concn increased peroxidase activity in 6-month-old sweet-lime seedlings.

The growth-retarding effect of single spray applications of 5,000- and 10,000-ppm Amo-1618 persisted for 45 days or more after treatment; whereas, 1,000-ppm sprays started to lose their effect after 20 to 30 days, and 500 ppm after about 15 days. The period of effectiveness for the lower concn could be extended by repeated weekly or biweekly applications. This procedure helped to maintain a certain level of effect and also increased the overall effect without any smyptoms of phytotoxicity or chemical burn on the leaves (Table 2).

On the basis of 10 ml of 1,000 ppm Amo-1618 per seedling, the foliage-drench application, which includes some chemical runoff into the soil, was 25% more effective than spraying the foliage without allowing the runoff to penetrate the soil, and 46% more effective than pouring the 10 ml into the soil. Soil application of Amo-1618 can be very effective if sufficient quantities of the chemical are used. For example, Marth and Mitchell (4) reported that Amo-1618 mixed in a sandy loam at the rate of 11.21 kg/ha (10 lb./acre) was still effective after 9 years, and the chemical was not herbicidal to bean plants, even at high rates of 112 kg/ha (100 lb./acre).

Table 2. Effect of repeated 1,000 ppm spray application[z] of Amo-1618 on the growth of citrus seedlings.

	% of control							
	Stem elongation after[y] (days)					Stem internode	Leaf[x]	
Cultivar	6	18	25	39	46	length[x]	Width	Length
Mott grapefruit	42	41	39	28	27	43	76	63
Pineapple orange	52	45	31	26	24	26	77	73
Rough lemon	–	–	–	–	–	25	83	67

[z]Sprays applied at 0-, 6-, 18-, 25-, and 39-day intervals.

[y]From initial spray date.

[x]After 46 days from initial spray date.

Regardless of such disadvantages as high cost and apparent ineffectiveness at low concn, Amo-1618 is considered useful as a standard for comparing effects of other growth retardants on citrus.

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NAA and Sevin on Composition, Development, and Abscission of Apple Fruit[1]

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Abstract. **Naphthaleneacetic acid (NAA) applied as a spray to apple trees on May 7 reduced fruit set, number of seed per fruit, percent and amount of reducing sugar in flesh of young fruits but did not affect protein level or fruit size. Fruit from trees sprayed with NAA on May 18 had more seed and less reducing sugar than the checks. The late NAA spray also reduced fruit size and set but did not affect the protein level of flesh or seed. Sprays of 1-naphthyl methylcarbamate (Sevin) applied on the same dates reduced fruit set but did not affect other factors measured. We propose that the reduced metabolite supply (reducing sugar) in the young fruit is the primary reason for reduced fruit set on trees sprayed with NAA and that effect on seed number is not related to this change in composition.**

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Most studies of chemical fruit thinning have evaluated only the effect on fruit set without regard to reason for the observed effect. Nitsch (9) reported that seeds serve the important role of metabolic sink (probably due to high auxin levels) which enable developing fruit to successfully compete for the metabolites necessary for fruit set and growth. Bollard (2) defined a metabolic sink as a region of tissue or organ into which nutrients, either inorganic or organic metabolites, appear to move preferentially and suggested this is a role of growth substances in seeds of developing fruit.

The objective of this study was to determine if chemicals that effect fruit set, such as NAA and Sevin, also affect the metabolite level in developing apples.

NAA at 25 ppm or Sevin (50%) at 0.91 kg/38 dekaliter (2 lb./100 gal) was applied as sprays to five 10-year-old 'Golden Delicious' trees on 'M 7' rootstocks on May 7 (petal fall + 7 days) or May 18 (petal fall + 18 days). Untreated trees served as checks. Trees were selected for uniformity of bloom and tree condition.

Fruit on 3 branches per tree were counted June 11 after the June drop to determine the no. of fruit per 100 flowering points. Fruit samples were collected from the check and early-treated trees 2, 3, 4, 6, 8, 12, 18 and 20 days after treatment and from the check and late-treated trees 1, 2, 3, 4, 6, 8, 12 and 18 days after treatment. The fruitlets, with the pedicel removed, were immediately placed on dry ice in the field and later held at -20°C for analysis. A minimum of 300 fruit were harvested on each collection date. All fruit in random clusters, regardless of size were included in the sample. Data on fruit set and seed no. were collected after the June drop. The other data represent treatment means including all collection dates. Thus the check means of the 2 treatment dates are different (Table 1). The data from each collection date were used as a replicate in the statistical analysis.

The fruit was permitted to partially thaw so the developing ovules, which

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Table 1. Effect of NAA and Sevin on apple fruit set, seed no. and size and composition of flesh and seeds.[z]

Measurement	Applied May 7			Applied May 18		
	NAA[y]	Sevin[x]	Check	NAA[y]	Sevin[x]	Check
Fruits/100 clusters	29.8b	28.3b	–	27.0b	34.5b	69.3a
No. seeds/fruit	4.78a	7.20b	–	8.54c	7.0b	7.24b
Dry wt (g) of flesh/fruit	0.47a	0.49a	0.50a	1.0a	1.2ab	1.3b
Dry wt (mg)/seed	3.0a	3.1a	3.0a	4.7a	5.2b	5.3b
Protein						
% in flesh	5.3a	5.4a	5.0a	4.3a	4.2a	3.9a
mg in flesh/fruit	19.5a	19.3a	17.7a	27.9a	30.9a	30.7a
% in seed	7.0a	6.8a	7.9a	6.2a	5.7a	5.6a
mg in seeds/fruit	1.4a	1.3a	1.1a	1.7a	1.4b	1.6a
Reducing Sugar						
% in flesh	11.3a	12.3ab	12.9b	17.7a	18.2a	18.1a
mg in flesh/fruit	77.5a	83.4ab	96.8b	143.9a	169.6ab	173.5b
% in seed				7.3a	8.3b	8.6b
mg in seed/fruit				2.2a	2.1a	2.5a

[z]Mean separation within rows by Duncan's multiple range test, 5% level.

[y]25 ppm

[x]Sevin (50%) at 0.91 kg/38 decaliter (2 lb./100 gal)

will be called seed, could be removed. The flesh and seed were then refrozen on dry ice and lyophilized prior to analysis. Analyses of both total and reducing sugars were made according to a modification of the method of Hoffman (5) as described by Lasheen et al. (6). The protein determinations were made according to the method of Lowry et al. (7).

Both NAA and Sevin reduced fruit set without excessive thinning (Table 1). Neither application of Sevin affected no. of seed per fruit. The early NAA application reduced the no. of viable seed, whereas fruit on the trees receiving the late NAA application had more seeds than the fruit from check trees; yet the effect on fruit set was similar. This larger no. of seed per fruit was probably due to selective thinning of fruit with few seeds. Thus, in this test the effect of NAA and Sevin sprays (both early and late) on fruit set is independent of their effect on seed no.

Our data agree with previous reports (8, 10) that Sevin had little effect on fruit size. They are not in complete accord with their report that NAA resulted in slower growth of the young fruit for the early application did not affect the size of young fruit. However, the late NAA application caused a reduction in growth of young fruit even though seed no. per fruit was greater than in the check.

Neither application of NAA or Sevin consistently affected % protein or amount of protein per fruit in the flesh or seed. There was no correlation between fruit set, fruit size, seed no. and % protein or amount of protein in flesh or seed. Thus, the data indicate that fruit or seed protein is not affected by treatments that reduced fruit set or by no. of seed per fruit. Thus, the thinning action of NAA and Sevin must not be due to an effect on the protein level of young fruit or their ability to accumulate or assimilate proteins and it appears that seed have little metabolic sink role in accumulating protein in young fruit on trees sprayed with NAA or Sevin.

The alcohol sugars such as sorbitol were not detected by the methods used to determine total and reducing sugar of flesh and seed. Almost all the sugar found was reducing sugar. The % reducing sugar and wt of reducing sugar per fruit was significantly lower in fruit from the early NAA-treated trees than in fruit from the check trees. The late application of NAA did not affect % reducing sugar in the flesh but it was reduced in the seed. As in the early NAA-sprayed fruit, the wt of reducing sugar per fruit was significantly lowered by the late NAA spray. The early and late NAA sprays did reduce the amount of reducing sugar per fruit but this was not correlated with seed no. per fruit. Thus in this test no. of seed was not a controlling factor in reducing sugar accumulation.

Bollard (2) and Nitsch (9) attributed the metabolic sink role to seed. However, Cranes (4) conclusion that endogenous growth substances may be supplied by some structure other than the seed is more in agreement with our data which indicates that some structure or factor other than the seed must have an important effect on accumulation of reducing sugar in fruit on NAA-sprayed apple trees. Booth et al. (3) reported that indoleacetic acid applied to leaves stimulated movement of nutrient reserves to treated areas. Their finding suggests the possibility that the NAA spray reported herein stimulated active metabolite uptake and accumulation in the leaves thereby reducing metabolites available to the young developing fruit.

Since total reducing sugar per fruit was reduced by each NAA treatment (Table 1) and since a high metabolite level is required for fruit set and growth (1), it seems likely that the thinning effect of NAA is directly or indirectly due to its effect on the amount of reducing sugar available to or present in the young developing fruit. It is also concluded that the thinning action of NAA and Sevin are due to different physiological effects of the 2 chemicals; both reduced set but Sevin did not affect the amount of reducing sugar in young fruit.

Since application of Sevin (early or late) did not affect protein or reducing sugar levels in young apple fruit, one must assume that the thinning action of Sevin is not due to its effect on metabolite (reducing sugar or protein) translocation to the developing fruit as suggested by Williams and Batjer (11).

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