Some Effects of CCC and Alar on Fruit Set and Fruit Quality of Apple[1]

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Abstract. The growth retardants, CCC and Alar, were compared for their effects on fruit set and fruit quality of apple. Early season sprays were applied to 'Golden Delicious' and midsummer applications were made on 'Idared'. Pre-bloom sprays of Alar increased fruit set on 'Golden Delicious'. Pre-bloom applications of CCC and post-bloom applications of Alar tended to reduce set. Neither chemical influenced fruit size, flesh firmness or percent soluble solids of 'Golden Delicious' at the concentration used in this study. Pre-bloom sprays of both retardants increased the severity of fruit russet on this cultivar; post-bloom sprays did not affect russet. On 'Idared', Alar reduced fruit size and increased red color; it also increased flesh firmness at harvest but not after storage to March. CCC did not affect any measured characteristic of 'Idared' apples.

A number of reports indicate that application of 2-chloroethyl trimethylammonium chloride (CCC)[3] inhibits shoot growth of apple (1,2,7,). The influence of this chemical on fruit quality, however, has not been investigated. The effects of succinic acid 2,2- dimethylhydrazide (Alar)[3] on fruiting and fruit quality are well documented. These retardants were compared for their effects on fruit set and fruit quality of 2 apple cultivars during the 1967 season. Early season sprays were applied to 'Golden Delicious' and mid-season applications were made on 'Idared'. The experimental trees were 6 years old on EM VII rootstock.

'Golden Delicious'. A comparison was made of CCC and Alar sprays at different concentrations and times of application. The 9 treatments are enumerated in Table 1. Pre- and post-bloom sprays were applied 9 days before and 21 days after full bloom, respectively. There were 4 single tree replicates in a randomized complete block design.

The total number of blossom clusters was counted on each replicate before bloom. Post-bloom counts were made of the total number of fruit per tree and of the number of clusters with more than one fruit. All trees were hand-thinned to one fruit per cluster, 45 days after full bloom.

'Idared'. The effects of midsummer sprays of CCC and Alar on fruit quality were evaluated. The treatments were applied on July 22, 56 days after full bloom. There were 4 single tree replicates in a randomized complete block design.

The CCC was a 50% liquid formulation and the Alar was technical grade. The CCC preparation contained an adjuvant and no further wetting agent was added. 'Tween 20' at 0.1% was added to the Alar sprays and was applied to the controls in both trials. Spray solutions were applied to run-off with a high pressure sprayer.

The 'Golden Delicious' apples were harvested on October 20 and 'Idared' on November 4. Data on fruit number and fruit weight were obtained on all treatments. Percent drop and russet were measured on 'Golden Delicious' only and color on 'Idared' only. At harvest, flesh firmness and percent soluble solids were measured on random samples of 15 apples per replicate of both cultivars. Twenty 'Idared' fruits per tree were stored at 32°F and evaluated for flesh firmness and soluble solids content on March 21, 1968. Flesh firmness was measured with a Magness-Taylor pressure tester and percent soluble solids with a portable refractometer.

None of the treatments significantly affected the percent fruit set of 'Golden Delicious' (Table 1). The pre- and post-bloom applications of Alar at 500 ppm and of CCC at 5,000 ppm tended to increase and reduce fruit set, respectively. Alar, when applied pre- and post-bloom at 500 ppm, increased fruit number per tree; this was due to an increase in the number of fruit per cluster. Conversely, the post-bloom spray of Alar (1,000 ppm) reduced fruit numbers by reducing the number of fruit per cluster; CCC, when applied pre- and post-bloom at 5,000 ppm had a similar effect.

The combined pre- and post-bloom treatment of CCC at 5,000 ppm reduced the number of fruit harvested due to a reduction in fruit set (Table 2). None of the treatments affected fruit weight, flesh firmness, or percent soluble solids.

Severity of fruit russet on 'Golden Delicious' was evaluated according to the classification in Fig. 1. The results are presented in Fig. 2 as percentages of the total fruit number per tree. Pre-bloom sprays and combined pre- and post-bloom treatments of both CCC and Alar increased the proportion of severely russeted apples and reduced that of slightly russeted fruit.

Table 1. Effects of time of application and concentration of CCC and Alar on fruit set of 'Golden Delicious.'

Treatment	Conc. (ppm)	Bloom stage pre	Bloom stage post	Fruit set %	No. fruit per tree	No. clusters with more than one fruit
Control				83	158	41
CCC	5,000	x		52	119	29
CCC	500	x	x	73	132	32
CCC	5,000	x	x	53	102*	23
Alar	500	x	x	98	213*	84*
CCC	1,000		x	66	136	31
CCC	5,000		x	75	132	37
CCC	10,000		x	73	127	32
Alar	1,000		x	81	103*	23
DSD 5%				NS	50	28

*Significantly different from control by Dunnett's test.

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[3]CCC and Alar were supplied by American Cyanamid Co., and UniRoyal, Inc., respectively.

Table 2. Effects of CCC and Alar on some harvest characteristics of 'Golden Delicious' apples.

Treatment	Conc. (ppm)	Bloom stage pre	Bloom stage post	Fruit count	Fruit weight (g per apple)	Flesh firmness lbs	Soluble solids %
Control				107	165	14.8	15.2
CCC	5,000	x	x	65*	173	15.3	15.2
Alar	500	x	x	133	157	14.8	14.4
CCC	10,000		x	89	162	14.4	15.5
Alar	1,000		x	77	173	14.7	15.1
DSD 5%				37	17	NS	NS

*Significantly different from control by Dunnett's test.

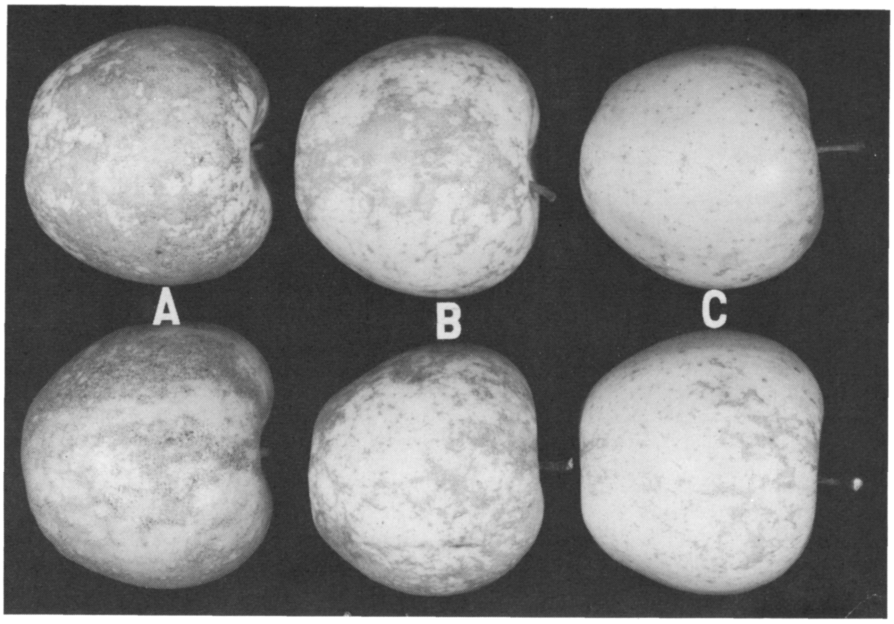

Fig. 1. Russet categories of 'Golden Delicious' apples A - severe; B - moderate; C - slight.

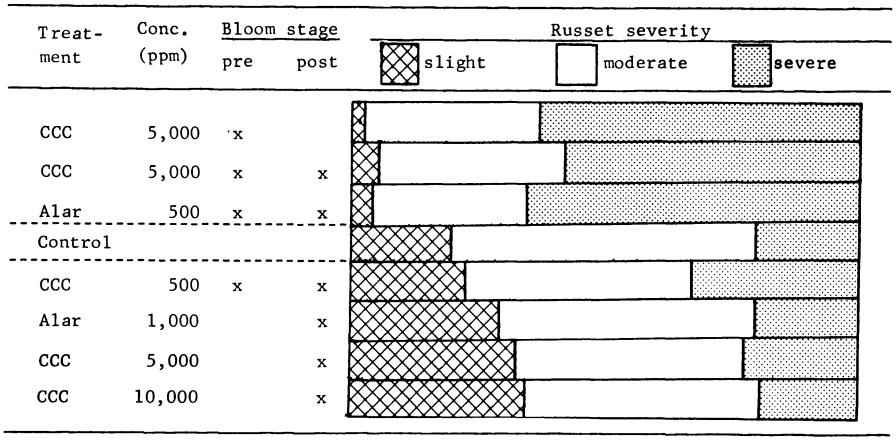

Fig. 2. Effects of CCC and Alar treatments on russet severity of 'Golden Delicious' apples.

Post-bloom treatments alone had no effect on the severity of the russet. Russet severity of the exceptionally low CCC treatment (500 ppm) did not differ from the control, probably due to the low level of effectiveness.

The results for 'Idared' are presented in Table 3. Alar at 1,000 ppm significantly reduced fruit size. This effect was not due to crop load; fruit size was similar in the CCC treatments despite large differences in fruit number per tree. Flesh firmness was increased by Alar at harvest but not after storage to March. Application of CCC at 1,000 or 5,000 ppm did not influence fruit size or flesh firmness. The soluble solids content was not affected by any treatment.

All 'Idared' apples were graded into 3 categories of red color. Results are shown in Fig. 3 as percentage of the total fruit number per tree. Alar at 1,000 ppm more than doubled the proportion of well colored apples and reduced that of medium and poorly colored fruit. CCC had no effect on fruit color.

The fruit set data indicate that pre-bloom sprays of Alar increased the number of fruit per cluster on 'Golden Delicious' while post-bloom sprays reduced it. Reports on fruit set have been apparently contradictory, even within cultivars. For example, Edgerton *et al* (4) noted that post-bloom sprays of Alar reduced fruit set on 'Golden Delicious'. Subsequently, the same treatment increased set on this cultivar (6). Effects on fruit set may be associated with an interaction of Alar with environmental and other factors rather than a direct effect of the chemical.

Russet severity was increased on 'Golden Delicious' by CCC and Alar when applied pre-bloom. Post-bloom application did not affect russet. Fisher and Looney (5) noted that two sprays of Alar at 2,000 ppm increased russet on this cultivar.

The second and third week after bloom may be the critical period for russet initiation on 'Golden Delicious'; low temperatures at this time predispose the fruit towards russeting (8). Low temperatures (0.5-2.0°C) occured during the third and fourth week after bloom in this trial.

The harvest quality of 'Golden Delicious' apples was not affected by Alar. In another trial (5), this chemical decreased fruit size and increased flesh firmness of 'Golden Delicious'. The absence of effect in this trial was probably due to the light crop and to the low levels of retardant applied. CCC did not affect the fruit quality of 'Golden Delicious' despite the high concentrations applied.

Midsummer applications of Alar reduced fruit size and increased red

color and flesh firmness of 'Idared' apples. The effect of Alar in this regard is well known on many cultivars (3). In contrast, CCC did not affect these fruit characteristics despite higher levels of application.

These results indicate that CCC does not directly influence any fruit characteristics; its effects are confined to a retardation of vegetative growth and possibly a promotion of fruit bud formation (1,2,7). Further trials on these and other cultivars are necessary to confirm or contradict this trend.

Table 3. Effects of midsummer applications of CCC and Alar on the harvest and storage quality of 'Idared' apples.

Treatment	Conc. (ppm)	Fruit count	Fruit weight (g per apple)	Flesh firmness (lbs) 11/4/67	Flesh firmness (lbs) 3/21/68	Soluble solids (%) 11/4/67	Soluble solids (%) 3/21/68
Control		134	201	16.1	12.1	13.8	13.3
Alar	1,000	151	182*	17.3*	11.9	14.1	13.5
CCC	1,000	139	195	15.9	12.2	13.5	13.0
CCC	5,000	176	195	16.1	11.4	13.7	12.9
DSD 5%		NS	12	1.1	NS	NS	NS

*Significantly different from control by Dunnett's test.

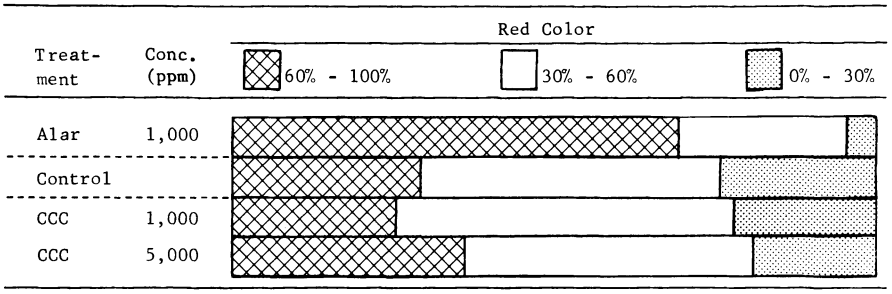

Fig. 3. Effects of midsummer applications of CCC and Alar on red color of 'Idared' apples.

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Effects of Succinic Acid 2, 2-Dimethylhydrazide (Alar) on Bloom Delay and Fruit Development of Delicious Apples[1]

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Abstract. Alar applied at the rate of 4000 ppm to 'Delicious' apple trees in the fall delayed bloom the following spring four to five days and increased fruit set. At harvest, the fruits were smaller, less elongated, had more advanced ground color and expressible juice. Fruit diameter, over color, flesh color, soluble solids, and respiration rate were not affected.

In apple areas subject to late spring frosts, orchard heating is a necessary and expensive orchard practice. Limited reports indicate that succinic acid 2, 2-dimethylhydrazide (Alar) may be useful in retarding bloom (1, 5). Although only a few days' bloom delay has been reported, this may reduce the need for orchard heating. The purpose of this experiment was to determine bloom delay of 'Richared Delicious' apples and the subsequent development of fruits following fall application of Alar.

Eight 21-year-old 'Richared Delicious' trees at New Mexico State Agricultural Experiment Station were selected for treatment in the fall of 1967. Six branches in each tree were tagged and Alar was applied at the rate of 4000 ppm to three of the branches on September 18.

Bloom delay was determined by recording, on March 25, March 30, April 4, and April 9, the number of spurs in which the majority of buds were in the green tip, pink, full bloom, and petal fall stages. Each branch contained at least 150 flowering spurs with an average of 250. Fruit length and diameter and fruit set were determined on June 16. All trees had a very heavy set and were hand-thinned following fruit set counts.

On August 27, all of the apples from each branch were harvested and sized according to the following criteria: less than 2½", 2½" to 2¾", and greater than 2¾". Because of the small number of apples in the largest size group, fruit characteristics were determined on only the two smaller sizes.

The results indicate that Alar applied in the fall delayed bloom the following spring four to five days (Table 1). Between March 30 and April 9, buds on Alar-treated branches were in a more

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