densities of pubescence. Two replicates (4 FS's with a single fruit per replicate) of each selection were placed in each of 2 wooden screen cages (47 × 47 × 47 cm), held in growth chambers maintained as in Test 2, and 25 mated pairs of CM per cage were released. Adults were removed after 4 days, and the number of eggs and their location on the leaf and fruit were determined. Larval entries were counted three days later and the site of entry into the fruit sections noted as designated in Fig. 2. The data were analyzed using ANOVA, and the means were separated using the Duncan's multiple range test. Student's paired *t* test was used to test significance of differences between the mean numbers of larval entries (location means) into the designated sections of the fruit. Data from the mid-section were not compared with the other sections because its surface area differed from the others.

In all selections, except 673-20 where the numbers were almost equal, more eggs were deposited on the upper leaf surface than the lower (Table 2). The lowest number of eggs was deposited on both leaf surfaces of selection 1689-110, and these were significantly different from those for the upper surface of selections 1569-100 and 1686-1 and the lower surface for 673-20 and 1225-100 (Table 2). Differences between egg numbers on the upper and lower leaf surfaces were significant ($P<.0.05$) for selections 1569-110, 1589-110, and 1686-1. When the mean number of eggs deposited on the lower leaf surface of all low pubescent selections (673-20, 1569-100, 1225-100) and those of the highly pubescent selections (1689-110, 1686-1) were calculated and compared (*t* test), the differences were significant at $P=0.01$, suggesting a distinct preference by ovipositing CM for the low pubescent surfaces. Although a significantly ($P=0.05$) greater number of eggs were found in the middle part of the fruit as compared to the calyx or stem ends, the differences in the total number of eggs deposited on the fruit among selections were not significant. In selections 673-20, 1225-100, 1686-1 and 1569-100, a higher percentage of oviposition (range 59.9% to 57.6%) occurred on the leaf than on the fruit (range 32.4% to 43.0%), whereas on selection 1689-110, the reverse was true.

Our findings in the caged pairs test agreed with those of Test 2. The number of larval entries was lowest at the calyx end of the fruit and highest in the mid-section of the fruit (Table 3). Although the differences between selections in larval entries were nonsignificant, there were more entries on the upper fruit surface than from the lower fruit surface. Differences in mean larval entries between location of entries, i.e., calyx vs. calyx end, stem vs. stem end, and upper vs. lower leaf surface, were all significant ($P=0.05$).

The overall data from Test 2 generally indicate that larvae reached the fruit from either leaf surface in spite of being placed on the most pubescent (midrib) part of the leaf. The survival of larvae on pubescent surfaces and the oviposition preference of females for glabrous surfaces suggests that leaf pubescence was probably an oviposition rather than a larval barrier.

The factors that determine resistance to CM are poorly understood and may include chemical, physical, and environmental factors. Leaf pubescence, as indicated in this study of a single stage in apple development under controlled environmental conditions, was a factor in the success of CM larvae reaching the fruit.

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Effect of Chemical Thinners on 'Delicious' Apple Trees Previously Sprayed with GA_{4+7} + BA

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Abstract. **Fruit thinning by a postbloom spray of 1-naphthyl n-methycarbamate (carbaryl) or naphthaleneacetic acid (NAA) was not increased by a previous full bloom spray of gibberellin A_{4+7} (GA_{4+7}) plus 6-benzylamino purine (BA). Chemical thinning generally increased return bloom but not fruit size. GA_{4+7} + BA consistently increased the fruit L/D ratio, showed no effect on fruit size or seed number, and these responses were not altered by the chemical thinners. Overall responses were similar for trees treated either one or 2 consecutive years with GA_{4+7} + BA and chemical thinners. Response to treatment was similar among strain of 'Delicious' and did not vary with tree age.**

'Delicious' apples produced in many areas of the United States are less elongated than those grown in the northwestern part of the country. Thus, the proprietary formulation of GA_{4+7} + BA (Promalin; Abbott Laboratories, North Chicago, IL 60064) frequently is applied in the northeastern and midwestern United States to elongate 'Delicious' fruit in order to facilitate marketing. Fruit set of 'Delicious' in these areas is frequently light (2), and the cultivar is considered easy to thin (16). It is known that GA_{4+7} + BA can thin apples (13, 14) and that effects of chemical thinners may be additive, especially when thinners belong to different classes of compounds (1, 15).

This experiment was designed to determine if a previous application of GA_{4+7} + BA on 'Delicious' trees at full bloom (FB) would enhance thinning by a postbloom application of a chemical thinner, and to determine if the fruit responses to GA_{4+7} + BA are altered by chemical thinners. All trees used in this investigation were growing at the Horticultural Research Center, Belchertown, Mass.

Trials with mature 'Richard Delicious'. Four limbs, 12–15 cm in circumference, per tree on Malling 7a rootstock were tagged, and bloom was counted prior to full bloom. Eight trees were selected in 1979 and 10 in 1980. One day after FB, 2 of the 4 limbs/trees received a dilute application of 25 ppm GA_{4+7} and BA (as the proprietary formulation Promalin; Abbott Laboratories, North Chicago, IL 60064) in 0.125% Glyodin. A dilute spray of carbaryl was applied in 1979 and 1980 at 1200 ppm 22 days after FB on

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Table 1. Effects of GA_{4+7} + BA or carbaryl on fruit set, fruit characteristics and return bloom of mature 'Richared Delicious' apple trees.

Year and treatments[z] (ppm)	Blossom clusters/ cm limb circum. prior to treatments	Fruit per cm limb circum.	Fruit per 100 blossom clusters	Fruit wt (g)	Fruit L/D ratio	Seeds/fruit	Repeat bloom: Blossom clusters/cm limb circum.
1979							
Check	12.6 a[y]	8.1 a	70 a	170 ab	0.93 b	5.0 a	12.7 b
BA + GA_{4+7} 25, 25	12.9 a	3.7 b	31 b	185 a	1.03 a	4.8 a	19.0 a
BA + GA_{4+7} 25, 25 + carbaryl 1200	12.4 a	3.6 b	31 b	146 c	1.03 a	2.5 b	16.0 ab
Carbaryl 1200	12.8 a	6.6 a	52 a	156 bc	0.94 b	2.7 b	13.5 b
1980							
Check	10.5 a	7.2 a	70 a	141 a	0.89 b	5.5 a	12.2 b
BA + GA_{4+7} 25,25	10.9 a	4.9 a	44 b	143 a	0.95 a	5.2 a	15.0 a
BA + GA_{4+7} 25, 25 + carbaryl 1200	10.9 a	6.9 a	72 a	143 a	0.95 a	4.0 b	16.1 a
Carbaryl 1200	10.5 a	6.3 a	61 ab	142 a	0.90 b	3.8 b	13.4 ab

[z]Eight trees treated in 1979 and 10 different trees in 1980.
[y]Mean separation in columns for each year by Duncan's multiple range test, 5% level.

Table 2. Effects of GA_{4+7} + BA or carbaryl or NAA on fruit set, fruit characteristics, and yield of young bearing 'Richared Delicious' apple trees in 1982 and repeat bloom in 1983.

Treatments (ppm)	Blossom clusters/ cm limb circum. prior to treatments	Fruit per cm limb circum.	Fruit per 100 blossom clusters	Fruit wt (g)	Fruit L/D ratio	Seeds/ fruit	Yield kg/tree	Repeat bloom: Blossom clusters/cm limb circum.
Check	10.1 a[z]	7.6 ab	75.7 b	169 a	0.96 b	6.3 a	220 a	11.8 a
BA + GA_{4+7} 25, 25	10.1 a	5.1 c	56.3 bc	179 a	1.04 a	5.6 b	178 b	11.8 a
BA + GA_{4+7} 25, 25 + carbaryl 1200	9.9 a	4.1 c	40.3 c	176 a	1.04 a	4.5 c	122 c	13.3 a
BA + GA_{4+7} 25, 25 + NAA 6	9.6 a	6.3 bc	66.9 b	123 b	1.03 a	1.7 d	144 bc	7.5 b
Carbaryl 1200	9.0 a	4.7 c	55.0 bc	176 a	0.96 b	4.0 c	130 c	12.0 a
NAA 6	9.6 a	9.1 a	100.7 a	122 b	0.93 c	1.9 d	136 bc	10.5 ab

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

1 untreated limb and on 1 limb that was previously sprayed with GA_{4+7} and BA. One limb was unsprayed and served as a control. At the completion of "June drop" the fruit set on all tagged limbs was counted. At the normal harvest time, 30 fruit/limb were picked, weighed, the length to diameter ratio determined, and the seed numbers counted. Prior to bloom the following year, the number of blossom clusters on each tagged limb were counted.

Trials with young, bearing 'Red Prince' and 'Richared Delicious'. A block of 42 'Red Prince Delicious' on M 26 rootstock in their 9th leaf and a block of 42 'Richared Red Delicious' on MM106 rootstock in their 8th leaf were selected. Both blocks of trees were separated into 7 groups of 6 trees each. Two limbs/tree were selected, tagged, and all blossom clusters counted prior to FB. Three trees in each block were sprayed one day prior to FB with a dilute application of 25 ppm GA_{4+7} plus BA in 0.125% Glyodin. Carbaryl at 1200 ppm or naphthaleneacetic acid at 6 ppm were applied 16–17 days after FB on 1 tree previously receiving GA_{4+7} + BA, and on 1 tree that was previously unsprayed. One tree in each block was untreated and served as a check. At the normal harvest time 30 fruit/tree were harvested and examined as described for the mature 'Richard Delicious' trees. Return bloom was determined on the tagged limbs the following year. Treatments on 'Red Prince Delicious' were repeated a 2nd year. Trees the 2nd year received the same treatments at the same timing as they did the 1st year.

GA_{4+7} + BA thinned fruit in 3 experiments (Tables 1, 2, 3) had a marginal effect in one experiment (Table 1) and caused no thinning in one experiment (Table 3). When GA_{4+7} + BA is applied at the rate recommended by the manufacturer (20–40 g/ha), thinning is unlikely (14). In our studies, glyodin, which acted as a surfactant (4), an overdosage may have been responsible for the thinning action of GA_{4+7} + BA (Tables 1, 2). NAA did not thin (Tables 2, 3), and the response to carbaryl was inconsistent (Tables 1, 2, 3).The thinning capabilities of carbaryl and NAA are well documented (16) as well as their lack of consistency (1, 6, 11). The rates and timing of carbaryl and NAA used generally were within commercial recommendations, and the light thinning activity due to a lack of absorption seems unlikely. The reduction in seed number (Tables 2, 3) seems to support this argument, since it has been reported (15) that rates of carbaryl known to give good thinning activity reduce seed number, especially in 'Delicious' (16).

Stress on trees can influence the extent of thinning activity (15). Since weather conditions, especially temperatures during the years of this investigation did not induce a stress, we believe its absence may explain the light thinning activity of the chemical thinners.

In no instance, in the 5 experiments conducted over 4 years, did the use of a chemical thinner following a GA_{4+7} + BA application increase the thinning response on either young or mature trees (Tables 1, 2, 3). This lack of difference is of particular interest because young trees are more easily thinned than old trees (17), and the commercial grower is concerned about excessive thinning of 'Delicious'.

It cannot be stated definitely that spraying GA_{4+7} + BA-treated trees with a chemical thinner will not cause additional thinning, since the lowest fruit set was frequently determined on trees or limbs treated with the combination spray (Tables 2, 3). Lack of statistical significance may be due to tree variability or an insufficient number of replications to achieve statistical significance. However, one can definitely state that if a

Table 3. Effects of 2 consecutive annual applications of GA_{4+7} + BA, carbaryl, or NAA on fruit set, fruit characteristics, and return bloom of 'Red Prince Delicious' apple trees.

Year and treatments (ppm)	Blossom clusters cm limb circum. prior to treatments	Fruit per cm limb circum.	Fruit per 100 blossom clusters	Fruit wt. (g)	Fruit L/D ratio	Seeds/ fruit	Yield kg/tree	Repeat bloom: Blossom clusters/cm limb circum.
1981								
Check	11.4 a[z]	4.3 a	40 a	203 b	0.92 c	4.9 a	96 ab	11.2 a
BA + GA_{4+7} 25, 25	11.1 a	4.1 a	39 a	203 b	0.98 a	4.5 abc	84 ab	13.4 a
BA + GA_{4+7} 25, 25 + carbaryl 1200	11.5 a	2.1 b	19 b	214 ab	0.98 a	3.7 d	54 c	12.6 a
BA + GA_{4+7} 25, 25 + NAA 6	11.7 a	2.9 ab	25 ab	211 ab	0.97 b	4.1 bc	88 ab	13.6 a
Carbaryl 1200	11.1 a	3.6 ab	31 ab	217 a	0.92 c	3.9 cd	78 bc	14.5 a
NAA 6	11.6 a	3.5 ab	31 ab	222 a	0.92 c	4.7 ab	94 a	13.3 a
1982								
Check	11.2 a	6.4 a	56.4 a	173 b	0.94 b	6.5 a	148 a	10.7 c
BA + GA_{4+7} 25,25	13.4 a	3.8 b	28.6 cd	183 ab	1.02 a	6.3 ab	102 b	16.2 a
GA + GA_{4+7} 25, 25 + carbaryl 1200	12.6 a	2.9 b	20.3 d	192 a	1.02 a	5.4 c	100 b	13.8 ab
BA + GA_{4+7} 25, 25 + NAA 6	13.6 a	3.6 b	28.0 cd	182 ab	1.02 a	5.4 c	110 b	11.7 bc
Carbaryl 1200	14.5 a	5.8 a	39.6 bc	190 a	0.94 b	5.5 bc	140 a	11.7 bc
NAA 6	13.3 a	6.1 a	45.1 ab	181 ab	0.93 b	5.3 c	142 a	10.6 c

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

chemical thinner is used following GA_{4+7} + BA application, it is unlikely that excessive additional thinning will occur. Chemical thinning sprays on GA_{4+7} + BA-treated trees have resulted in adequate thinning and increased return bloom (11).

All fruit that received GA_{4+7} + BA had an increased L/D ratio (Tables 1, 2, 3). No chemical thinning treatment influenced the shape induced by GA_{4+7} + BA.

The thinning response was usually, but not always, followed by a corresponding increase in bloom the following year (Tables 1, 2, 3). In instances where increased bloom did not occur (Tables 1, 3) untreated trees returned with a heavy bloom (above 11.0 blossom clusters/cm limb circumference). The gibberellins in the GA_{4+7} + BA combination can inhibit flowering (8). Flowering was not inhibited in this study because relatively low rates of GA_{4+7} were used, and it is known that BA can reverse the inhibitory effects of GA_{4+7} on flowering (9). If GA_{4+7} + BA does thin when used under commercial conditions, it appears that adequate return bloom can be expected.

Fruit thinning rarely increased fruit size (Tables 1, 2, 3), probably due to the absence of excessive fruit set and/or lack of a moisture stress on the vigorous trees selected for the studies. Increased fruit size in the absence of thinning has been shown in some areas following GA_{4+7} + BA application (10, 13), but not in the Northeast (3).

NAA application on 'Richared Delicious' caused no thinning, but reduction in fruit size occurred (Table 2). This was primarily due to a large increase in the number of seedless 'pygmy' fruit (data not shown), as reported by Luckwill (7) when excessive rates are used. Excessive rates of NAA spray were not used in this investigation, but the spray was followed by over 24 hr of slow drying which probably increased foliar penetration (5). This effect points out the potential danger of using NAA as a thinner for 'Delicious', as observed by Southwick (12).

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