Preharvest applications of dicamba at rates of 10 to 30 mg·liter⁻¹ appear equal, or superior, to NAA for delaying fruit abscission without advancing maturity of the major fall apple cultivars. Although additional information concerning optimal timing and possible combination with NAA would be useful, our data indicate that dicamba effectively reduces preharvest fruit drop of apple and is worthy of serious consideration for U.S. Environmental Protection Agency registration.

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**Thinning Activity of Benzyladenine on Several Apple Cultivars**

Duane W. Greene and Wesley R. Autio  
Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003

**Paul Miller**  
Victorian Department of Agriculture, Horticultural Research Institute, Knoxfield, Victoria 3180, Australia

*Additional index words.* Malus domestica, BA, fruit set, flowering, return bloom, carbaryl, NAA, ethephon, bioregulator

**Abstract.** Postbloom sprays of BA thinned ‘McIntosh’, ‘Delicious’, ‘Golden Delicious’, ‘Mutsu’, ‘Empire’, and ‘Abas’ apples. BA at 75 to 100 mg·liter⁻¹ was equal to NAA at 6 to 7.5 mg·liter⁻¹ or carbaryl at 600 to 800 mg·liter⁻¹. BA increased fruit size, flesh firmness, and soluble solids concentration (SSC) on all cultivars evaluated. Since BA is applied during the time when cell division is occurring, it is concluded that the increased fruit size and flesh firmness were due to Increased cell numbers. Increased SSC was not due solely to increased leaf : fruit ratio. Thinning with BA was additive with other chemical thinners and no interactions were found on fruit abscission. In most cases, BA increased return bloom. Chemical names used: N-phenyl-1H-purine-6-amine [benzyladenine (BA)]; 1-naphthaleneacetic acid (NAA); 1-naphthalenyl methylcarbamate (carbaryl); butanedioic acid mono(2,2-dimethylhydrazide (daminozide); (2-chloroethyl)phosphonic acid (ethephon).

Chemical thinning is one of the most important yet one of the most difficult plant growth regulator practices to perform in modern apple production (Looney, 1986). Cost of chemical thinning materials and their application are relatively low, yet the cost is perilously high if over-thinning or under-thinning occurs.

The chance of over-thinning with carbaryl is not great, since carbaryl is not a potent thinner and, at the concentrations generally used, its response is not concentration dependent (Forsey, 1987). Frequently, carbaryl may not thin adequately. This has been true in recent years when there is an increasing demand for larger fruit (Greene and Autio, 1988). NM and ethephon...
are more potent thinners, but they also may over-thin, especially when applied during high temperatures (Williams and Edgerton, 1981).

No chemical thinning agents have been registered recently for use in the United States. McLaughlin and Greene (1984) suggested that BA may be used as an effective chemical thinner on apples. Greene and Autio (1989) recently reported that BA effectively thinned ‘McIntosh’ apples. BA at 50 mg-liter\(^{-1}\) was more effective than NAA at 5 mg-liter\(^{-1}\). BA and NAA thinned more effectively when each was combined with carbauyl.

This investigation was initiated to evaluate BA as a chemical thinner on several apple cultivars and to evaluate the thinning potential of BA when used in combination with other commercially used chemical thinning agents.

**Materials and Methods**

Several experiments were conducted over 6 years when BA and other chemical thinners or growth retardants were applied as dilute sprays to whole apple trees either in production or just coming into production.

**Bearing trees**

*Experiment 1.* ‘Empire’/MM.106, Belchertown, Mass. Before bloom, two limbs, 10 to 15 cm in circumference, per tree were tagged, the circumference recorded, and all blossom clusters counted. At full bloom (FB) + 14 days, whole trees were sprayed to the drip point with BA at 0, 100, or 200 mg-liter\(^{-1}\) or carbauyl at 0 or 600 mg-liter\(^{-1}\) alone or in combination.

Experimental design was a randomized complete block with seven replications. At the end of the June drop period, all fruit on tagged limbs were counted. At commercial harvest time, a 30- apple sample was randomly harvested from each tree and weighed. Ten representative fruit from each bag were selected and the flesh firmness determined with a Magness-Taylor pen- etrometer (tip diameter 11 mm) on two sides of each fruit. Juice was collected during the firmness test and soluble solids concentration (SSC) was determined by use of a hand refractometer on a composite juice sample. The total length (L.) and diameter (D.) of 30 fruit was measured and the L : D ratio calculated.

Yield for each tree was calculated by adding the number of hand-picked fruits and dropped fruit. Return bloom the following year was determined on the tagged limbs.

*Experiment 2.* ‘McIntosh’/M.7, Belchertown, Mass. BA (0 or 75 mg-liter\(^{-1}\)), NAA (0 or 6 mg-liter\(^{-1}\)), and carbauyl (0 or 600 mg-liter\(^{-1}\)) were applied as whole-tree sprays at FB + 20 days in a factorial randomized complete-block design with six replications. Bloom, fruit set, and fruit quality measurements were determined as described in Expt. 1. In addition, 30 apples per tree were individually rated to the nearest 10% for the percentage red surface; we also judged whether the degree of redness of each of these fruits was sufficiently intense to be graded U.S. Extra Fancy.

*Experiment 3.* ‘Hi Early Delicious’/seedling, Harcourt, Victoria, Australia. BA (0, 100, or 200 mg-liter\(^{-1}\)), ethephon (0 or 100 mg-liter\(^{-1}\)), and carbauyl (0 or 800 mg-liter\(^{-1}\)) were applied in a factorial randomized complete block, with eight replications. The experimental procedures were similar to those described in Expt. 1. In addition, fruit symmetry was rated and the seed number counted on a 30-apple sample from each tree.

*Experiment 4.* ‘Abas’/seedling, Knoxfield, Victoria, Australia. In a factorial experiment, BA (0 or 100 mg-liter\(^{-1}\)), ethephon (0 or 150 mg-liter\(^{-1}\)), and daminozide (0 or 1500 mg-liter\(^{-1}\)) were applied to whole trees in a randomized complete-block design with nine replications. Ethephon was applied at FB + 4 days, BA at FB + 13 and 23 days, and daminozide at FB + 23 days. Data collection was similar to that described for Expt. 1.

*Experiment 5.* Cultivar evaluation, Belchertown, Mass. Six trees each of ‘Golden Delicious’, ‘Starkrimson Delicious’, ‘Starking Delicious’, and ‘McIntosh’ on M.7 rootstock and ‘Empire’/MM.106 were selected before bloom, and four limbs, 10 to 15 cm in circumference, per tree were tagged. All blossom clusters were counted on each limb. When fruit diameter was = 10 mm, between FB + 16 to 19 days, BA at 100 mg-liter\(^{-1}\) was applied to two of the four limbs per tree. Two limbs per tree were untreated and served as the control. Fruit set and fruit evaluation was similar to that described for Expt. 1.

**Trees just coming into production**

*Experiment 6.* ‘Mutsu’/M.7, Brookfield, Mass. A block of 6- year-old ‘Mutsu’ trees was partitioned into seven blocks (replications) of eight trees each. Twelve days after full bloom, when terminal growth was = 10 to 15 cm, seven trees in each block were sprayed to the drip point with daminozide at 1500 mg-liter\(^{-1}\). For six of the daminozide-treated trees, BA was included at 50, 100, or 200 mg-liter\(^{-1}\) (two trees treated per level). One tree was not sprayed and served as the control. Three weeks after the first application, one of the two BA-treated trees at each level in each block received a second spray of BA. Fruit were evaluated at harvest as in Expt. 1.

*Experiment 7.* ‘Redspur Delicious’/M.7, Belchertown, Mass. Four-year-old trees were blocked into seven groups (replications) of eight trees each. Thirteen days after full bloom, four trees in each block were sprayed to the drip point with 1500 mg daminozide/liter. One tree sprayed with daminozide and one unsprayed tree in each block were treated with 0, 75, 150, or 300 mg BA/liter. Fruit set was determined on three limbs per tree after June drop. Return bloom and yield were determined the following year.

*Experiment 8.* ‘Redspur Delicious’/MM.111. Five-year-old trees were partitioned into seven blocks (replications) of six trees each. Ten days after full bloom, three trees in each block were sprayed to the drip point with 1500 mg daminozide/liter. One tree sprayed with daminozide and one tree not previously sprayed were then treated with BA at 0, 150, or 300 mg-liter\(^{-1}\). Fruit were evaluated as in Expt. 1.

All data were subjected to analysis of variance. Where interactions were nonsignificant, only main effect means are presented. Those means were separated by F test or single-degree-of-freedom orthogonal comparisons, depending on the number of levels in the experiment. In Expt. 6, single-degree-of-freedom linear comparisons were also used to separate means.

**Results**

BA and carbauyl significantly reduced crop load on ‘Empire’ (Table 1). The thinning response to BA was linear, with excessive thinning occurring at the highest BA rate. A full bloom + 14 days BA spray increased fruit weight, flesh firmness, SSC, and L : D ratio. Return bloom was increased by both BA and carbauyl, but neither increased yield the 2nd year. There were no interactions.

BA at 75 mg-liter\(^{-1}\) thinned ‘McIntosh’ comparably to NAA at 6 mg-liter\(^{-1}\), while carbauyl at 600 mg-liter\(^{-1}\) was ineffective (Table 2). Although NAA and BA thinned comparably, only
Table 1. Effect of BA and carbaryl combination sprays on fruit set, fruit quality, fruit characteristics, and return bloom on 'Empire'/MM.106 apples. Expt. 1.

| Treatment (mg-liter⁻¹) | Fruit/cm limb circumf.* | Yield/° (kg/tree) | Fruit wt° (g) | Flesh firmness%', (N) | Soluble solids concn° (%) | L : D ratio° | Blossom cluster/cm limb circumf.* | Fruit/cm limb circumf.* |
|-----------------------|-------------------------|------------------|--------------|------------------------|--------------------------|-------------|---------------------------------|-------------------------|
| BA                    |                         |                  |              |                        |                          |             |                                 |                         |
| 0                     | 7.6                     | 98.2             | 139          | 78.0                   | 11.0                     | 0.85        | 10.2                            | 3.3                     |
| 100                   | 4.8                     | 64.8             | 174          | 79.3                   | 11.4                     | 0.87        | 13.0                            | 4.1                     |
| 200                   | 2.9                     | 53.6             | 190          | 79.3                   | 11.3                     | 0.86        | 12.5                            | 3.5                     |
| **Significance**       |                         |                  |              |                        |                          |             |                                 |                         |
| Carbaryl              |                         |                  |              |                        |                          |             |                                 |                         |
| 0                     | 5.9                     | 81.6             | 163          | 78.9                   | 11.2                     | 0.86        | 10.5                            | 3.6                     |
| 600                   | 4.3                     | 62.6             | 173          | 78.4                   | 11.2                     | 0.86        | 13.3                            | 3.7                     |
| **Significance**       |                         |                  |              |                        |                          |             |                                 |                         |

*Means of 28 (BA) or 42 (carbaryl) observations.

yMeans of 14 (BA) or 21 (carbaryl) observations.

xMeans of 280 (BA) or 410 (carbaryl) observations.

wThe response was linear (l) or quadratic (q).

The response was linear (l) or quadratic (q).

*NSSignificant within columns at P = 0.05, 0.01, or 0.001, or nonsignificant, respectively.

Table 2. Effects of NAA, carbaryl, and BA at 6, 600, and 75 mg-liter⁻¹, respectively, used alone and in combination on fruit set, yield, and fruit quality of 25-year-old 'McIntosh'/M.7. Expt. 2.

| Treatment | Fruit/cm limb circumf.* | Yield/° (kg/tree) | Fruit wt° (g) | Flesh firmness%', (N) | Soluble solids concn° (%) | Red color° (%) | U.S. Extra Fancy° (%) |
|-----------|-------------------------|------------------|--------------|------------------------|--------------------------|---------------|-----------------------|
| Control   |                         |                  |              |                        |                          |               |                       |
| 9.3       | 302                     | 135              | 66.5         | 10.1                   | 59                       | 81            |
| NAA       | 7.1                     | 308              | 143          | 67.9                   | 10.0                     | 62            | 86                    |
| Carbaryl  | 8.6                     | 270              | 139          | 67.9                   | 10.2                     | 60            | 77                    |
| BA        | 7.3                     | 296              | 153          | 67.4                   | 10.4                     | 61            | 79                    |
| BA + NAA  | 5.0                     | 274              | 162          | 68.3                   | 10.4                     | 56            | 74                    |
| NAA + carbaryl | 4.7                   | 206              | 153          | 74.3                   | 10.5                     | 53            | 61                    |
| BA + NAA + carbaryl | 5.2                   | 236              | 150          | 68.8                   | 10.2                     | 57            | 75                    |
| **Significance** |                         |                  |              |                        |                          |               |                       |
| NAA -     | 7.5**                   | 286              | 147**        | 14.7**                  | 10.2**                   | 59**          | 78**                  |
| +         | 5.4                     | 244              | 150          | 15.3                   | 10.3                     | 57            | 73                    |
| Carbaryl - | 7.1**                   | 278              | 146**        | 15.0**                  | 10.2**                   | 59**          | 77**                  |
| +         | 5.8                     | 252              | 152          | 15.0                   | 10.3                     | 58            | 75                    |
| BA -      | 7.5**                   | 278              | 142**        | 14.8*                   | 10.1***                  | 59**          | 80**                  |
| +         | 5.4                     | 250              | 156          | 15.2                   | 10.4                     | 57            | 72                    |

*Means of 12 observations with individual treatments (T1-T8) and 24 observations within pooled chemical thinner means.

xMeans of six observations with individual treatments (T1-T8) and 24 observations within pooled chemical thinner means.

wMeans of 120 observations with individual treatments (T1-T8) and 480 observations within pooled chemical thinner means.

vMeans of 180 observations with individual treatments (T1-T8) and 720 observations within pooled chemical thinner means.

**NSSignificant within columns at P = 0.05, 0.01; or 0.001, or nonsignificant, respectively.

BA increased fruit weight. BA also increased flesh firmness and SSC. No thinning treatment altered development of redness or fruit that graded into the U.S. Extra Fancy category because of color intensity. There was a significant BA × NAA interaction on yield. BA alone did not significantly reduce yield. However, when NAA was included with BA, the yield per tree was reduced (data not shown).

Carbaryl and BA thinned 'Hi Early Delicious', while ethephon was ineffective (Table 3). Only BA increased fruit size at harvest. Both carbaryl and BA reduced seed number. BA increased flesh firmness, SSC, L : D ratio, and the number of fruit with asymmetric, shape. All treatments increased return bloom, although subsequent fruit set was not influenced. There were no interactions between BA and the other growth regulators.

Both BA and ethephon reduced fruit set and increased fruit weight on 'Abas' (Table 4). BA and daminozide increased flesh firmness. Ethephon and BA increased fruit SSC, while dami-
Table 3. Effects of ethephon, carbaryl, and BA on fruit set, fruit quality, fruit characteristics, and return bloom of ‘Hi Early Delicious’ seedling apples. Expt. 3.

| Treatment (mg·liter⁻¹) | Fruit/cm limb circm. | Fruit wt* (g) | Flesh firmness* (N) | Soluble solids concn* (%) | L : D ratio | Seeded fruit* (%) | Seedless fruit* (%) | Asymmetric fruit (%) | Blossom clusters/cm limb circm.¹ | Fruit/cm limb circm. | Fruit/100 bloom clusters |
|------------------------|----------------------|---------------|---------------------|---------------------------|-------------|------------------|-------------------|--------------------|------------------------|----------------------|-------------------------|
| Control                | 2.9 a                | 225 a         | 77.5 a              | 11.0 b                    | 0.95 a      | 4.0 a           | 70.0 b            | 22 a                | 8.8 b                  | 3.8 ab               | 52 a                    |
| Ethephon 100           | 2.6 a                | 223 a         | 78.9 a              | 11.4 a                    | 0.93 a      | 4.3 a           | 13.8 b            | 18 a                | 11.7 a                 | 4.2 a                | 40 b                    |
| Carbaryl 600           | 1.6 b                | 249 a         | 80.3 a              | 11.6 a                    | 0.96 a      | 2.8 b           | 37.7 a            | 23 a                | 10.7 a                 | 3.3 b                | 33 b                    |
| BA 0                   | 4.3                  | 190           | 73.4                | 11.0                      | 0.93 a      | 4.7 a           | 8.3 a             | 7.2                 | 7.2 a                  | 3.6                  | 34 a                    |
| BA 100                 | 2.0                  | 245           | 79.3                | 11.6                      | 0.95 a      | 4.0 a           | 19.1 a            | 20 a                | 10.7 a                 | 4.1                  | 41 a                    |
| BA 200                 | 0.8                  | 271           | 83.9                | 11.5                      | 0.96 a      | 2.5 a           | 44.0 a            | 27 a                | 13.2 a                 | 3.6                  | 30 a                    |
| Significance*          | ![***, q*, ***]      | ![***, q**, ***] | ![***, q**, ***] | ![***, q**, ***] | ![***, q**, ***] | ![***, q**, ***] | ![***, q**, ***] | ![***, q**, ***] | ![***, q**, ***] | ![***, q**, ***] | ![***, q**, ***] |

¹Mean separation within columns, Duncan's multiple range test, P = 0.05.
²Means of 48 observations.
³Means of 24 observations.
⁴Means of 480 observations.
⁵The response was linear (1) or quadratic (q).
⁶Main effects within columns significant at P = 0.05, 0.01, or 0.001, or nonsignificant, respectively.

Table 4. Effects of BA, ethephon, and daminozide on fruit set, fruit quality, fruit characteristics, and return bloom of ‘Abas’ seedling apple. Expt. 4.

| Treatment (mg·liter⁻¹) | Fruit/cm limb circm.* | Yield* (kg/tree) | Fruit wt* (g) | Flesh firmness* (N) | Soluble solids concn* (%) | Seed/fruit* | Return bloom | Blossom clusters/cm limb circm.* |
|------------------------|-----------------------|------------------|---------------|---------------------|---------------------------|-------------|--------------|-------------------------------|
| BA 0                   | 7.8 NS                | 33.0             | 89            | 83.9                | 13.2                      | 6.6         | 1.0          | NS                            |
| 100                    | 6.7 **                | 33.0             | 103           | 89.4                | 13.8                      | 7.1         | 1.5          | NS                            |
| Ethephon 0             | 8.1 NS                | 36.4             | 89            | 87.1                | 13.2                      | 7.0         | 0.7          | NS                            |
| 150                    | 6.3 NS                | 29.9             | 103           | 85.8                | 13.7                      | 6.7         | 1.8          | NS                            |
| Daminozide 0           | 7.4 NS                | 34.2             | 98            | 87.5                | 13.7                      | 7.1         | 0.4          | NS                            |
| 1500                   | 7.1 NS                | 32.2             | 94            | 90.8                | 13.2                      | 6.6         | 2.0          | NS                            |

¹Means of 64 observations.
²Means of 32 observations.
³Means of 640 observations.
⁴Means of 960 observations.
⁵Main effects within columns significant at P = 0.05, 0.01, or 0.001, or nonsignificant, respectively.

nozide reduced it. BA increased seed number, daminozide reduced it, and ethephon had no effect. No treatment influenced return bloom. There were no growth regulator interactions.

BA at 100 mg·liter⁻¹ significantly thinned and increased fruit weight of ‘McIntosh’, ‘Bisbee Delicious’, ‘Starking Delicious’, ‘Golden Delicious’, and ‘Empire’ (Table 5). Soluble solids concentration was increased in ‘Bisbee Delicious’, ‘Starking Delicious’, and ‘Golden Delicious’. BA did not alter seed number in any cultivar.

BA thinned young ‘Mutsu’ (Table 6) and ‘Redspur Delicious’ (Tables 7 and 8) trees at concentrations up to 300 mg·liter⁻¹. Two applications of BA increased fruit weight and SSC more than one application (Table 6). Daminozide increased flesh firmness. Return bloom was increased when daminozide was included with either one or two sprays of BA, although fruit set the year after application was increased only when BA was applied twice. There were no growth regulator interactions.

Daminozide did not influence fruit set, yield, or return bloom of ‘Redspur Delicious’ (Tables 7 and 8), although flesh firmness and SSC were increased and fruit weight was reduced (Table 8). BA increased return bloom and fruit set on ‘Redspur Delicious’ in 1984 but not in 1983. BA increased fruit weight, flesh firmness, SSC, and the number of “pygmy” fruit (Table 8).

Discussion

The thinning capability of BA on ‘McIntosh’ reported by Greene and Autio (1989) has been confirmed in this investiga-
Table 5. Effects of BA, applied as a fruit thinning spray, on fruit set, fruit size, and fruit characteristics of several apple cultivars. Expt. 5.

| Cultivar         | BA (mg·liter⁻¹) | Blossom clusters/cm limb circumf. | Fruit/cm limb circumf. | Fruit wt (g) | Flesh firmness¹ | Soluble solids concn² (%) | Seed no.* |
|------------------|-----------------|----------------------------------|------------------------|--------------|-----------------|---------------------------|-----------|
| McIntosh         | 0               | **                               | **                     | 119          | 83.5            | 9.5                       | 7.1       |
|                  | 100             | NS                               | **                     | 142          | 83.9            | NS                        | NS        |
| Bisbee Delicious | 0               | 13.3                             | 8.0                    | 131          | 86.7            | 9.3                       | 5.5       |
|                  | 100             | 13.0                             | NS                     | 154          | 87.1            | *                         | NS        |
| Starking Delicious | 0             | 12.3                             | 6.6                    | 157          | 84.8            | 9.7                       | 5.8       |
|                  | 100             | 12.0                             | NS                     | 203          | 85.3            | NS                        | NS        |
| Golden Delicious | 0               | 15.8                             | 13.5                   | 114          | 83.5            | 11.7                      | 7.5       |
|                  | 100             | 15.9                             | NS                     | 142          | 83.0            | 12.5                      | 7.6       |
| Empire           | 0               | 13.8                             | 18.2                   | 116          | 71.1            | 10.6                      | 6.1       |
|                  | 100             | 13.5                             | NS                     | 154          | 73.4            | NS                        | NS        |

BA was applied when fruit were ≈ 10 mm in diameter. ‘McIntosh’ and ‘Empire’ were sprayed 26 May; ‘Bisbee Delicious’, ‘Starking Delicious’, and ‘Golden Delicious’ were sprayed 29 May.

Means of 12 observations.

Means of six observations.

Means of 128 observations.

Means of 180 observations.

*Significant within columns within cultivars at P = 0.05 or 0.01 or nonsignificant, respectively.

Table 6. Effects of daminozide (D) at 1500 mg·liter⁻¹ and combined with BA on fruit set, fruit quality, and return bloom of ‘Mutsu’ apples. Expt. 6.

| Treatment (mg·liter⁻¹) | No. of BA applications | Fruit/cm limb circumf. | Fruit wt (g) | Flesh firmness¹ | Soluble solids concn² (%) | Blossom clusters/cm limb circumf. | Fruit/cm limb circumf. | Fruit100 blossom clusters* |
|-----------------------|------------------------|------------------------|--------------|-----------------|---------------------------|-----------------------------------|------------------------|-----------------------------|
| Control               |                        | 2.7                    | 188          | 81.6            | 11.1                      | 7.0                               | 1.6                    | 21                          |
| D                     |                        | 2.4                    | 178          | 89.6            | 11.1                      | 9.9                               | 1.5                    | 14                          |
| + BA 50               | 1                      | 1.8                    | 197          | 89.9            | 11.0                      | 12.0                              | 1.6                    | 14                          |
| + BA 100              | 1                      | 1.7                    | 204          | 91.3            | 11.0                      | 10.9                              | 2.4                    | 20                          |
| + BA 200              | 1                      | 1.1                    | 235          | 95.8            | 11.5                      | 12.3                              | 3.5                    | 27                          |
| + BA 50               | 2                      | 1.7                    | 201          | 91.3            | 11.6                      | 14.0                              | 3.1                    | 21                          |
| + BA 100              | 2                      | 1.5                    | 221          | 92.6            | 11.5                      | 12.5                              | 2.6                    | 19                          |
| + BA 200              | 2                      | 0.9                    | 266          | 94.9            | 11.8                      | 12.7                              | 4.0                    | 32                          |

Significance

D + BA

Linear

***

NS

NS

NS

NS

NS

NS

NS

D + BA

Linear

***

NS

NS

NS

NS

NS

NS

NS

Quadratic

NS

NS

NS

NS

NS

NS

NS

NS

BA 1× vs. BA 2×

NS

NS

NS

NS

NS

NS

NS

NS

BA 1× vs. control

***

NS

NS

NS

NS

NS

NS

NS

BA 2× vs. control

***

NS

NS

NS

NS

NS

NS

NS

D vs. control

NS

NS

NS

NS

NS

NS

NS

NS

BA 1× vs. BA 2×

(same amount BA)

NS

NS

NS

* NS

NS

NS

NS

*Significant within columns at P = 0.05, 0.01, or 0.001 or nonsignificant, respectively.
Table 7. Effects of daminozide and BA on fruit set, yield, and return bloom of ‘Redspur Delicious’/M.7. Expt. 7.

| Treatment (mg-liter\(^-1\)) | 1982 | 1983 |
|-----------------------------|------|------|
|                             | Fruit/cm limb circuit.\(^a\) | Blossom clusters/cm limb circuit.\(^a\) | Fruit/cm limb circuit.\(^a\) | Fruit/100 blossom clusters | Yield\(^b\) (kg/tree) |
| Daminozide                  |      |      |      |      |      |
| 0                           | 0.30 | NS   | 9.5  | 10.2 | 40   | 48  | 49.8 |
| 1500                        | 0.30 | NS   | 10.2 | NS   | 40   | NS  | 49.8 |
| BA                          |      |      |      |      |      |
| 0                           | 0.90 | NS   | 8.9  | 10.4 | 40   | 48  | 47.0 |
| 75                          | 0.20 | 10.0 | 3.6  | 9.3  | 40   | 46.8 |
| 150                         | 0.03 | 10.4 | 4.0  | 40   | 51.6 |
| 300                         | 0.05 | 9.8  | 4.3  | 45   | 57.0 |
| Significance\(^c\)          | NS   | NS   | q**  | NS   | NS   |

\(^a\)Means of 56 (daminozide) or 25 (BA) observations.
\(^b\)Means of 28 (daminozide) or 14 (BA) observations.
\(^c\)The response was linear (l) or quadratic (q).
\(^*\)Main effects within columns significant at \(P = 0.05, 0.01, \) or nonsignificant, respectively.

The response was linear (l) or quadratic (q).

Table 8. Effects of daminozide and BA on fruit set, fruit quality, and fruit characteristics of ‘Redspur Delicious’/MM.111. Expt. 8.

| Treatment (mg-liter\(^-1\)) | 1983 | 1984 |
|-----------------------------|------|------|
|                             | Fruit/cm limb circuit.\(^a\) | Yield\(^b\) (kg/tree) | Fruit weight\(^b\) (g) | Flesh firmness\(^c\) (N) | Soluble solids concen\(^d\) (%) | L : D ratio\(^e\) | Pygmy fruit\(^f\) (%) | Blossom clusters/cm limb circuit.\(^a\) | Fruit/cm limb circuit.\(^a\) | Fruit/100 blossom clusters\(^g\) |
| Daminozide                  |      |      |      |      |      |      |      |      |      |      |      |
| 0                           | 2.8  | 43.2 | 171  | 75.7 | 10.4 | 0.99 | 11.5 | 2.8  | 1.3  | 67   |
| 1500                        | 3.2  | 47.0 | 158  | 79.8 | 9.8  | 0.98 | 8.3  | 3.5  | 1.7  | 54   |
| BA                          |      |      |      |      |      |      |      |      |      |      |      |
| 0                           | 3.7  | 45.2 | 148  | 74.3 | 9.8  | 0.99 | 0.5  | 2.1  | 1.2  | 81   |
| 150                         | 2.9  | 43.2 | 165  | 75.9 | 10.1 | 0.99 | 8.1  | 3.5  | 1.6  | 54   |
| 300                         | 2.4  | 46.8 | 180  | 82.7 | 10.4 | 0.99 | 21.1 | 3.8  | 1.7  | 47   |
| Significance\(^c\)          | NS   | NS   | q**  | NS   | NS   | NS   | NS   | NS   | NS   | NS   |

\(^a\)Means of 42 (daminozide) or 28 (BA) observations.
\(^b\)Means of 21 (daminozide) or 14 (BA) observations.
\(^c\)Means of 420 (daminozide) or 280 (BA) observations.
\(^d\)The response was linear (l) or quadratic (q).
\(^*\)Main effects within columns significant at \(P = 0.05, 0.01, \) or nonsignificant, respectively.

In all instances, BA increased flesh firmness while also increasing fruit size. This result is contrary to that normally observed, since flesh firmness generally declines as fruit size increases. BA is a cytokinin and it is well documented that cytokinins increase cell division (Letham, 1969). Cell division is still occurring during the time (14 to 18 days after bloom) BA is applied as a thinner (Denne, 1963). Increased cell numbers following BA application undoubtedly contributed to increased fruit size. Further, increased cell numbers per volume of fruit could explain the increase in flesh firmness in this investigation and that reported earlier by McLaughlin and Greene (1984) and Greene and Autio (1989).

BA increased SSC in all experiments. It could be argued that the thinning activity of BA changed the leaf : fruit ratio so that there were more leaves to support fruit growth. However, this explanation may be only a partial one, since BA and NAA reduced crop load to a comparable level on ‘McIntosh’, yet SSC was increased only in BA-treated fruit.

BA is a component in the proprietary mixture containing GA\(_{4+7}\) and BA (Promalin) that is applied to elongate apples (Unrath, 1974). This product is generally applied at bloom for maximum response, but later applications may have some thinning effect (Unrath, 1974). The L : D ratio was increased in some experiments in this investigation, indicating that, in some years, increased fruit elongation may be one of the responses noted if BA is used as a chemical thinner.

Foliar sprays of BA increase flower bud formation in apple (McLaughlin and Greene, 1984; Greene and Autio, 1989). In most cases, the flower bud-promoting capability of BA was confirmed in this investigation. BA did not increase repeat bloom.
on ‘Abas’, but this cultivar is one that is noted for its extreme biennial-bearing characteristics. Ethephon also had no influence on return bloom of ‘Abas’. BA did not increase flowering in one experiment with ‘Redspur Delicious’, but crop load the previous year was so low that even control trees returned with a heavy bloom.

**Literature Cited**

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Yeager, 1916). The influence of light levels, spur age, and canopy position have been studied, especially on older spur-type trees (Barritt et al., 1987). Growth regulators may also influence spur vigor. Foliar sprays of aminoethoxyvinylglycine (AVG) increased bud size and leaf area on young ‘Delicious’ trees (Greene, 1983). BA application increased flower number and survival of king flowers following a frost on ‘Golden Delicious’ trees (McLaughlin and Greene, 1984).

This study was undertaken to determine the growth and spur quality responses following application of BA or BA-growth regulator combinations on bearing apple trees or trees that were just starting to come into production.

**Materials and Methods**

**Bearing trees**

Experiment 1. ‘Empire’/MM.106, Belchertown, Mass. A block of mature ‘Empire’ trees were selected, and whole trees were treated with BA at 0, 100, or 200 mg·liter

1, alone or in combination. The experimental de-