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# Response of Rabbiteye Blueberries to Chemical Thinning Agents

*Frank B. Matta, Jose R. Cartagena, and James M. Spiers*

## ABSTRACT

The thinning potential of various chemicals sprayed on 'Tifblue' rabbiteye blueberry was examined under field conditions in 1991 and 1992. Chemicals used were 7-benzylamino purine (BA), gibberellic acid ($GA_3$), 2-naphaleneacetic acid (NAA), 1-naphthyl N-methylcarbamate (carbaryl). BA at 75 mg/L and the combination of carbaryl at 400 mg/L and BA at 25 mg/L reduced fruit set in 1991 and 1992. Combinations of carbaryl and $GA_3$ reduced fruit set, but the response depended on $GA_3$ concentration and varied from year to year. $GA_3$, NAA, and carbaryl also reduced fruit set, but results were inconsistent. In 1991, greater thinning occurred when treatments were sprayed 10 days after corolla drop (ACD). BA at 25 mg/L increased fruit diameter at first harvest in 1991, and carbaryl at 400 mg/L increased fruit diameter in 1991 and 1992. Fruit diameter was increased in the presence and absence of thinning, depending on year and application time. Yield and return bloom were not influenced by any of the treatments.

## INTRODUCTION

Chemical fruit thinning may be a viable method for regulating blueberry crop load. Maintaining a balance between vegetative and reproductive growth is needed to optimize blueberry yield and quality. However, no research has been reported on the use of chemical thinning for blueberries. The potential of BA as a thinning agent has been demonstrated by Kondo and Mizuno (1989), who showed that BA sprays increased ethylene evolution from apples, followed by increased fruit abscission. Gibberellins enhanced abscission of citrus (Lewis and Bakhshi, 1968) and other plants (Chatterje and Leopold, 1964). $GA_3$ stimulated abscission of peach (Young and Edgerton, 1979) but did affect berry set in grapes (Looney and Wood, 1977). Thinning capabilities of NAA in apples are well documented (Williams, 1979). Fruit thinning has been associated with increased fruit size in peach (Byers, 1989), apples (Forshey and Elfving, 1977), and grapes (Reynolds et al., 1986). Fruit size of rabbiteye blueberries has been increased by pruning or selective cane removal (Austin and Brightwell, 1984). Mature highbush blueberries must be pruned annually to reduce overbearing (Galletta and Himelrick, 1990). The objective of this study was to determine the effects of BA, $GA_3$, NAA, and carbaryl on blueberry thinning, yield, return bloom, and fruit size.

Matta is a professor and Cartagena is a former graduate student in the Mississippi State University Department of Plant and Soil Sciences, and Spiers is director of the U.S. Department of Agriculture Agricultural Research Service Small Fruit Research Station in Poplarville, Mississippi. This research report was published by the MSU Office of Agricultural Communications, a unit of the Division of Agriculture Forestry and Veterinary Medicine.

Experiment Station
Vance H. Watson, Director
Mississippi Agricultural & Forestry Experiment Station
J. Charles Lee, President • Mississippi State University • Vance H. Watson, Vice President

## MATERIALS AND METHODS

Two similar experiments were conducted using an 8-year-old 'Tifblue' rabbiteye blueberry research orchard at the USDA Small Fruit Research Station in Poplarville, Mississippi. (30°30´N, 89°87´W), during 1991 (April 12 to July 11) and 1992 (April 14 to June 13). Plants were 2 m high and uniform in size and vigor. Plants were spaced and the orchard was managed according to commercial recommendations for Mississippi (Spiers et el., 1985). Concentrations of chemical thinners that showed a selective thinning of 30% to 69% in a greenhouse experiment were selected (data not shown). All solutions, including the distilled water control, contained the surfactant Tween 20 at 0.1%. Foliar sprays were applied with an electrical pressure sprayer to runoff (2.11 kg/cm$^2$) to individual plants between 11 a.m. and 3 p.m. (Central Standard Time). Four branches on each plant were randomly selected to determine fruit thinning. In 1991, plants were sprayed either on April 12, 10 days ACD when the average fruit diameter was 5.2 mm and air temperature was 26°C, or April 23, 20 days ACD when the average fruit diameter was 8.5 mm and air temperature was 24°C. In 1992, applications were made either on April 14, 10 days ACD when the average fruit diameter was 5.4 mm and air temperature was 29°C, or on April 23, 19 days ACD when average fruit diameter was 8.6 mm and air temperature was 26°C. Spray dates were calm and either partly cloudy (1991) or sunny (1992), and drift to non-treated plants was avoided by shielding individual plants with a tarp.

Thinning response was based on fruit counts of the first three terminal clusters on individual tagged limbs after fruit drop had ceased; it was expressed as percentage fruit set, with the initial count being 100%. Fruit set percentages for both experiments were adjusted using arcsin transformation before analysis. Completely randomized designs were used in both years. All experimental units were single plants, and treatments were replicated four times. A factorial analysis of variance was performed, where chemical concentrations and application dates were factors considered. Treatment means were compared using the *t* test under SAS's LS means option.

In 1991 and 1992, to measure fruit diameter, a random ripe (blue) 500-g berry sample from the whole plant was harvested at two dates. To measure return bloom in 1992, the number of flower buds on new year's growth of three randomly selected limbs was counted. Yield was based on total berry weight per plant, and the plants were harvested twice.

## RESULTS

The factorial analysis showed no interaction between chemicals and application dates; therefore, only main effect means for each year were considered (Table 1). BA at 75 mg/L reduced fruit set in 1991 and 1992. BA at 25 mg/L also reduced fruit set in 1992. The combination of carbaryl at 400 mg/L and BA at 25 mg/L reduced fruit set in 1991 and 1992. The consistent reduction in fruit set with BA and lack of response to carbaryl in 1991 suggest that BA was primarily responsible for reduced fruit set. The combination of carbaryl and $GA_3$ reduced fruit set; however, its effectiveness depended on $GA_3$ concentration and varied from year to year. $GA_3$, NAA, and carbaryl did not influence fruit set in 1991; however, in 1992, these chemicals reduced fruit set; $GA_3$ was effective at 25 mg/L, NAA was effective at 15 mg/L, and cabaryl was effective at both concentrations. The lack of consistent response to $GA_3$, NAA, and carbaryl from year to year makes the role of these compounds in blueberry thinning difficult to interpret. Rogers and Thompson (1983) raised the possibility that this erratic response may be due to biological and meteorological variations. Analysis of variance also

**Table 1. Fruit set percentage of 'Tifblue' blueberry plants as affected by various thinning chemicals applied 10 or 20 days after corolla drop (ACD), 1991 and 1992.[1]**

| Chemical | Concentration | Fruit set | |
|---|---|---|---|
| | | 1991 | 1992 |
| | *mg/L* | *%* | *%* |
| Control | — | 76 d | 96.6 gf |
| BA | 25 | 64.9 bcd | 86.6 cd |
| | 75 | 38.7 a | 77.1 ba |
| $GA_3$ | 25 | 74.2 d | 78.0 ba |
| | 50 | 73.1 cd | 95.5 fg |
| NAA | 7.5 | 68.7 bcd | 97.2 gf |
| | 15.0 | 69.6 bcd | 90.8 ed |
| Carbaryl | 400 | 68.8 bcd | 92.4 ed |
| | 600 | 66.1 bcd | 90.3 decd |
| Carbaryl + BA | 400 + 25 | 54.7 abc | 87.4 dcbe |
| | 400 + 75 | 63.9 bcd | 96.3 gf |
| Carbaryl + $GA_3$ | 400 + 25 | 71.2 cd | 92.9 ed |
| | 400 + 50 | 51.7 b | 98.0 gf |

[1]Mean separation within columns were compared using the *t* test under SAS's least squared means option. Means in columns with the same letter do not differ at $P = 0.05$.

indicated that application date was significant in 1991, showing greater thinning when the treatments were sprayed 10 days ACD. However, in 1992, application date was not significant. In addition, fruit set was greater in 1992. Lack of absorption due to chemical volatility or plant vigor may have been factors.

Yield in 1991 and 1992 and return bloom in 1992 were not influenced by thinning treatments (data not shown). BA has enhanced flower bud formation in apple, especially when applied soon after bloom (McLaughlin and Greene, 1984). In this study, BA and $GA_3$ did not increase return bloom. However, increased return bloom on apples is due to elimination of fruit that are a source of gibberellings early in the season. Return bloom on blueberries is associated with shoot vigor (Gough and Shutak, 1978) and thickness of 1-year-old wood (Gough and Shutak, 1978), both of which are secondary effects influenced by crop load.

**Table 2. Fruit diameter at first harvest of 'Tifblue' blueberry plants as affected by chemical thinners and application date, 10 or 20 days after corolla drop (ACD), 1991 and 1992.[1]**

| Chemical | Concentration | Fruit diameter | | | |
|---|---|---|---|---|---|
| | | 1991 | | 1992 | |
| | | 10 ACD | 20 ACD | 10 ACD | 20 ACD |
| | *mg/L* | *mm* | *mm* | *mm* | *mm* |
| Control | — | 14.1 Ade | 14.9 Aabc | 16.3 Abcd | 16.0 Abc |
| BA | 25 | 15.6 Aab | 14.2 Bbc | 16.2 Bcd | 16.6 Aabc |
| | 75 | 14.4 Acde | 14.5 Aabc | 15.9 Bd | 17.0 Aa |
| $GA_3$ | 25 | 14.4 Acde | 14.1 Abc | 16.7 Aa-d | 16.3 Aabc |
| | 50 | 14.7 Ab-e | 14.4 Aabc | 16.4 Ba-d | 16.9 Aab |
| NAA | 7.5 | 14.8 Ab-e | 15.3 Aab | 16.6 Aa-d | 16.8 Aabc |
| | 15 | 15.1 Aa-d | 15.2 Aabc | 16.4 Aa-d | 16.1 Aabc |
| Carbaryl | 400 | 15.3 Aabc | 15.1 Aabc | 17.1 Aa | 16.0 Bc |
| | 600 | 15.9 Aa | 13.9 Bc | 16.7 Aabc | 16.3 Aabc |
| Carbaryl + BA | 400 + 25 | 13.9 Be | 14.7 Aabc | 16.6 Aa-d | 16.8 Aabc |
| | 400 + 75 | 14.6 Bcde | 15.5 Aa | 16.2 Acd | 16.4 Aabc |
| Carbaryl + $GA_3$ | 400 + 25 | 14.5 Acde | 14.5 Aabc | 16.3 Bbcd | 16.8 Aabc |
| | 400 + 50 | 14.2 Ade | 14.8 Aabc | 17.0 Aab | 16.5 Babc |

[1]Mean separation within columns and rows compared using the *t* test under SAS's least squares means option. Means in columns with the same small letter and means in rows with the same capital letter do not differ at *P*=0.05. Means represent average diameter of 10 blueberries.

Thinning results with $GA_3$ in 1992 agree with Looney (1981), who reported grape thinning using $GA_3$. However, $GA_3$ is sold specifically for increasing fruit set in blueberries. The recommended GA application time is when most flowers are elongated but not yet open. In this study, $GA_3$ was applied postbloom when the ovaries were 5.2 mm.

Analysis of variance for fruit diameter indicated that chemical concentrations and application date were significant and that there was an interaction of these factors in both years (Table 2). In 1991, application date made no difference in fruit diameter at first harvest except for BA at 25 mg/L and carbaryl at 600 mg/L, which resulted in larger fruit when applied 10 days ACD; conversely, plants treated with carbaryl plus BA at both levels had larger fruit with the 20 ACD application date. In 1992, at first harvest, greater fruit diameter was obtained with carbaryl at 400 mg/L when applied 10 vs. 20 days ACD and with BA at both concentrations. GA at 50 mg/L increased fruit diameter when applied 20 vs10 days ACD. In addition, the combination of carbaryl and $GA_3$ at 25 mg/L increased fruit diameter when applied 20 days ACD. However, carbaryl plus GA at 50 mg/L increased fruit diameter when applied 10 days ACD (Table 2). At second harvest in 1992, BA at 75 mg/L, $GA_3$ at 25 mg/L, and NAA at 7.5 mg/L increased fruit diameter when applied 20 days ACD, and the combination of carbaryl and $GA_3$ at 50 mg/L increased fruit diameter when applied 10 days ACD (Table 3).

In 1991, fruit diameter at first harvest was increased by BA at 25 mg/L and carbaryl at both concentrations when applied 10 days ACD but not 20 days. These treatments did not reduce fruit set in 1991; therefore, the increase in fruit size was not due to thinning. Apparently, BA and carbaryl directly influenced fruit diameter. Greene and Lord (1985) found an increase in apple size in the absence of thinning when $GA_{4+7}$ plus BA was used. Fruit diameter was not influenced by any of the treatments when applied 20 days ACD in 1991 compared with the control. In 1992, only carbaryl at 400 mg/L and BA at 75 mg/L increased fruit diameter when applied 10 and 20 days ACD, respectively. Since BA and carbaryl reduced fruit set in 1992, the increase in fruit diameter in 1992 may be attributed to thinning. It is evident that, in both years, carbaryl at 400 mg/L increased fruit diameter at first harvest when treatments were applied 10 days ACD (Table 2).

In 1992, at second harvest, only the combination of carbaryl at 400 mg/L and $GA_3$ at 50 mg/L, which did not reduce fruit set in 1992, increased fruit diameter when applied 10 days ACD but not 20 days. Therefore, the increase in fruit size cannot be attributed to increased thinning (reduced fruit set). When the treatments were

applied 20 days ACD in 1992, BA at all concentrations, $GA_3$ at 25 mg/L, and NAA at 7.5 mg/L increased fruit diameter. The continued increase in fruit size with BA and $GA_3$ at second harvest in 1992 may be attributed to fruit thinning, since BA and $GA_3$ reduced fruit set in 1992. However, increased fruit diameter by NAA at 7.5 mg/L at second harvest in 1992 cannot be attributed to fruit thinning, since NAA at 7.5 mg/L did not reduce fruit set in 1992. NAA has increased fruit size in the absence of thinning (Rogers and Thompson, 1983). Blueberry fruit size has been correlated with shoot vigor. Generally, more vigorous shoots produce larger berries (Galletta and Himelrick, 1990). Treatments in this experiment would not be expected to influence plant vigor and thus not influence fruit size. Also, Shutak et al. (1980) reported that blueberry fruit enlargement follows a double sigmoid growth curve. In Stage I, the fruit undergoes rapid pericarp development with cell division and accelerated endosperm growth. It is possible that BA and carbaryl directly influenced cell division. Apparently, the treatments that resulted in fruit thinning did not influence berry cell division or mesocarp enlargement, which occur in Stage III.

Results from this study indicate that BA alone or combined with carbaryl consistently thinned 'Tifblue' rabbiteye blueberries. Fruit diameter increase by BA and carbaryl seemed to influence berry growth directly, although fruit diameter was also increased in the presence of thinning. $GA_3$, NAA, and carbaryl gave inconsistent thinning results. Increased fruit diameter by NAA and the combination of carbaryl and $GA_3$ occurred only in 1992 in the absence of thinning. There was a concentration-by-application date interaction, indicating that fruit diameter depended on concentration and application date. In both years, however, carbaryl at 400 mg/L increased fruit diameter when applied 10 days ACD but decreased fruit set only in 1992. Yield and return bloom were not influenced by any of the chemical thinners. Further research on blueberry chemical fruit thinning is needed to determine cultivar differences and the influence of environmental conditions, application method, and multiple applications of thinners. The influence of such thinners on fruit size must be investigated.

**Table 3. Fruit diameter at second harvest of 'Tifblue' blueberry plants as affected by chemical thinners and application date, 10, or 20 days after corolla drop (ACD), 1992.[1]**

| Chemical | Concentration | Fruit diameter | |
|---|---|---|---|
| | | 10 ACD | 20 ACD |
| | *mg/L* | *mm* | *mm* |
| Control | — | 14.4 Ab | 14.1 Ad |
| BA | 25 | 14.8 Aab | 15.5 Aab |
| | 75 | 14.3 Bb | 15.4 Aabc |
| $GA_3$ | 25 | 14.3 Bb | 15.5 Aab |
| | 50 | 15.3 Aab | 15.1 Aa-d |
| NAA | 7.5 | 14.9 Bab | 15.8 Aa |
| | 15 | 15.0 Aab | 14.3 Acd |
| Carbaryl | 400 | 15.3 Aabc | 14.8 Aad |
| | 600 | 15.1 Aab | 14.8 Aad |
| Carbaryl + BA | 400 + 25 | 15.0 Aab | 14.7 Aad |
| | 400 + 75 | 14.8 Aab | 14.4 A bcd |
| Carbaryl + $GA_3$ | 400 + 25 | 15.3 Aab | 15.0 Aad |
| | 400 + 50 | 15.6 Aa | 14.3 Bbcd |

[1]Mean separation within columns and rows compared using the *t* test under SAS's least squares means option. Means in columns with the same small letter and means in rows with the same capital letter do not differ at *P*=0.05. Means represent average diameter of 10 blueberries.

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Mississippi State University

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