Fruiting Response of the Highbush Blueberry to Gibberellic Acid under Field Conditions[1]

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Abstract. Gibberellic acid (GA) at 0, 50, 100, 250 and 500 ppm was applied to the highbush blueberry var. 'Coville' at bloom for 2 consecutive seasons in the field. Percentage fruit set was increased by all GA treatments in 1966. In 1967 yields were increased by the 100, 500 and 500 ppm caged treatments. GA-treated plants produced smaller berries that required a longer maturation period but were still of fresh market quality. The smallest and latest maturing fruit were seedless and were produced from caged plants receiving GA. No differences in mold incidence and percentage weight loss in storage were apparent between treated fruit and the control. Only fruit from caged plants receiving 500 ppm GA had refractive index values less than those of the control berries. The GA treatments did not reduce the number of flower buds formed in 1966 or 1967.

Introduction

BOTH highbush (4) and lowbush (1) blueberry flowers have been induced to set and develop parthenocarpic fruit with the application of gibberellin at 500 and 20 ppm GA, respectively. Barker and Collins (1) report that the parthenocarpic lowbush fruits resulting from gibberellin treatment were similar to seeded berries; however, the flavor was described as being flat. Under field conditions the gibberellin treatment did not successfully increase set or yield. In addition to producing seedless fruit, GA was found to delay maturity (7). Smith (6) reported a threefold increase in yield of fruit per plant of the 'Coville' variety in response to 100 ppm potassium gibberellate. However, set was only increased from about 10 to 30%, which is still too low for a commercially acceptable yield.

This study was undertaken to determine whether gibberellin applied to 'Coville' blueberry plants under field conditions will increase set and yield, and to evaluate GA effect on berry size, time of ripening, berry quality, and flower bud formation.

Materials and Methods

Thirty-six, 5-year-old 'Coville' variety blueberry plants growing at the Blueberry-Cranberry Research Center were selected for uniformity. On May 22, 1966, before bloom, 6 bushes were covered with 16 by 16 threads-per-inch cotton screen supported on a steel frame to exclude pollinating insects. Flowers were counted on May 29, and treatments of 0, 50, 100, 250 and 500 ppm gibberellic acid (GA_3) were applied to the uncaged bushes and 500 ppm to the caged bushes in a randomized block design with 6 individual bush replications for each treatment. The bushes were sprayed until drip occurred (about 150 gal per acre) with a sprayer (100 psi). Wetting was increased by adding 0.05% Tween "20" to the GA solutions. The cages were removed on June 15 when petal fall was complete. Ripe berries were picked on August 1, 11, 22 and 31. Remaining berries were weighed, counted and divided into 3 size categories. Sizing was accomplished by shaking the berries on ¾- and ½-inch mesh screens. Seeds were counted in 10 medium sized berries (½ to ¾ inches in diameter) from each treated bush on each harvest date. Flower buds were counted on December 2, 1966. In February, 1967 the plants were pruned.

The treatments were repeated with some modification in 1967. The same bushes received the 0, 50, 100, 250, 500 and the caged 500 ppm GA_3 treatments. In 1967 additional bushes were selected, caged, and given a 375 ppm GA_3 treatment, also the 250 ppm treated plants were caged. The cages were erected May 18, and the flowers were counted on May 29, 1967, followed by treatment application. Ripe berries were picked on July 25, August 2, 8, 15, and 24. Green berries remaining on August 24, were also picked. Measurements of berry weight, number, and size were conducted just as in 1966. Seeds were counted in berries from each of the 3 size categories for each treatment and for each picking date. Each value reported represents 20 medium sized berries (½ to ¾ inches in diameter), or at least 2 large berries (over ¾ inches) or 10 small berries (under ½ inch). Fruit quality determinations were made on berries from the second picking. Following picking, the berries were placed immediately in refrigerated ice chests. After the berries were weighed, sized counted and samples taken for seed count, 25 medium sized fruits from each bush were weighed and placed in open quart boxes in a room at about 60°F. Ten days later the berries were examined for mold development and reweighed. The remaining berries from each treated bush in replication 1 were combined with the correspondingly treated berries from replication 2. Replications 3 and 4, and 5 and 6 were also combined and the juice was extracted. Juice pH, refractive index, and titratable acidity were measured. Flower buds were counted November 27, 1967.

Results

Fruit set. In 1966 all GA treatments caused a significant increase in fruit set (Table 1). The control plants set 78.2% of the blossoms while all GA treatments with the exception of the 100 ppm treated plants set over 90% of the blossoms.

Table 1. Per cent fruit set and yield of GA-treated 'Coville' blueberry in the field.

Treatments ppm GA	Per cent fruit set[z]		Yield (g per bush)[z]	
	1966	1967	1966	1967
Control	78.2 a	69.1 a	783.0 a	834.7 a
50	93.1 b	73.2 a	805.6 a	1196.2 ab
100	89.0 b	71.2 a	1031.0 a	1273.4 b
250[x]	92.5 b	80.3 a	866.0 a	1213.2 ab
500	92.8 b	81.5 a	766.7 a	1379.6 b
375 caged[y]	—	79.5 a	—	1138.3 ab
500 caged	91.1 b	81.0 a	739.0 a	1526.1 b

[x]Bushes caged in 1967.
[y]Treatment begun in 1967.
[z]Mean values within a column are statistically different at the 5% level if they do not have a common letter after the value.

Yield. The weight of fruit harvested per bush was not increased by the GA treatments in 1966 (Table 1). In 1967 the 100, 500 and 500 ppm caged treatments yielded a greater weight of fruit than the control. The increases were as great as 83% for the 500 ppm caged treatment.

Period of maturation. Although a trend towards delayed ripening occurred in all GA treatments in both 1966 and 1967, only the caged plants receiving 500 ppm GA experienced a significant delay in fruit maturation. In 1967 75% of the control fruit was harvested in the first two pickings as compared to only 50% in the 500 ppm caged treatment.

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Table 2. Distribution of GA-treated 'Coville' blueberries according to size in 1966.

Treatments ppm	Berry size (in) distribution (% of total no. berries)[x]											
	1st picking			2nd picking			3rd picking			4th picking		
	>¾	½-¾	<½:	>¾	½-¾	<½:	>¾	½-¾	<½:	½-¾	>½	Green
Control	10.8a	86.9a	2.3a	1.4a	83.0ab	15.6ab	0.0a	59.8a	40.2a	14.4a	52.0a	33.6a
50	11.6a	87.4a	1.0a	2.0a	89.1a	8.9c	0.5a	62.4ac	37.1ab	6.9a	29.3b	63.8b
100	9.2a	87.9a	2.9a	2.2a	86.2ab	11.6abc	0.1a	76.2bc	23.7bc	16.9a	27.9b	55.2b
250	8.0a	90.6a	1.4a	2.1a	88.8a	9.1bc	0.6a	68.6abc	30.8abc	6.6a	28.0b	65.4b
500	8.0a	90.0a	2.0a	4.5b	88.5a	7.0c	0.0a	81.6b	18.4c	19.1a	27.7b	53.2b
500 Caged	2.2b	90.7a	7.1b	0.6a	81.9b	17.5a	0.1a	63.8ac	36.1ab	18.6a	27.8b	53.6b

[x]Mean values within a column are statistically different at the 5% level if they do not have a common letter after the value.

Table 3. Distribution of GA-treated 'Coville' blueberries according to size in 1967.

Treatments ppm GA	Berry size (in.) distribution (% of total no. berries)[x]											
	1st picking			2nd picking			3rd picking		4th picking		5th picking	
	>¾	½-¾	>½:	>¾	½-¾	<½:	½-¾	<½:	½-¾	<½:	½-¾	<½: Green
Control	9.3a	87.0a	3.7a	1.6a	86.4a	12.0a	72.6a	27.4a	45.4a	54.6a	12.9a	77.7a 9.4b
50	5.7ab	92.5a	1.8a	1.6a	91.7a	6.7a	84.1a	15.9a	57.3a	42.7a	16.0a	57.8a 26.2a
100	5.5bc	91.6a	2.9a	1.3a	89.4a	9.3a	79.4a	20.6a	56.6a	43.4a	23.8abc	59.3a 16.9a
500	2.9bc	92.2a	4.9a	1.3a	87.4a	11.3a	83.0a	17.0a	62.5a	37.5a	42.8bc	43.0a 14.2b
250 Caged	1.3c	94.6a	4.1a	0.4a	90.4a	9.2a	75.9a	24.1a	42.0a	58.0a	20.9ab	63.4a 15.7b
375 Caged	1.4c	96.3a	2.3a	0.8a	87.2a	12.0a	74.3a	25.7a	45.8a	54.2a	28.6bcd	60.1a 11.3b
500 Caged	0.4c	90.9a	8.7a	0.3a	86.7a	13.0a	81.8a	18.2a	70.5a	29.5a	44.8c	41.7a 13.5b

[x]Mean values within a column are statistically different at the 5% level if they do not have a common letter after the value.

Berry size distribution. GA applied to caged plants at 500 ppm resulted in a significant reduction in berry size in both the first and second pickings of 1966 (Table 2). Also in 1966 a larger percentage of green berries remained on the GA treatments than on the control at the final harvest. In 1967, GA treatments greater than 50 ppm were associated with the production of smaller fruit in the first picking than were produced on the control plants. Berry size differences between treatments did not occur after the first picking in 1967 (Table 3).

Seed number. Medium-sized blueberries produced by the 500 ppm GA-treated caged plants averaged less than one seed per berry in 1966 for all 4 pickings (Table 4). The caged plants receiving the 500 ppm level of GA produced fewer seeds per berry than any of the other treatments in the first 3 pickings. In 1967 the caged plants receiving the GA treatments produced fewer seeds per berry in every size class at all the pickings than were found in the control berries (Table 5).

Storage quality and composition. No differences in percentage mold, percentage weight loss, juice pH, or titratable acidity were found between control fruit and GA-treated fruit. The lowest refractive index values occurred in fruit from the caged 500 ppm treatment, however, all GA-treated berries had refractive index readings lower than the control.

Flower bud. There were no statistical differences in the number of flower buds formed in 1966 or 1967 between treatments. In 1967 the average number of flower buds per bush ranged from 843 in the control plants to 594 in the 500 ppm caged plants.

Table 4. Average number of seeds per medium sized 'Coville' blueberry (½-¾ in.) treated with GA in 1966.

Treatments ppm GA	Seed number per medium sized berry[x]			
	1st picking	2nd picking	3rd picking	4th picking
Control	5.28 a	3.70 a	1.98 a	0.45 ab
50	6.58 a	3.90 a	2.15 a	0.57 ab
100	5.80 a	3.75 a	2.45 a	1.52 ab
250	5.42 a	3.68 a	3.08 a	1.56 ab
500	7.05 a	2.67 a	2.25 a	1.68 a
500 Caged	0.60 b	0.28 b	0.02 b	0.16 b

[x]Mean values within a column are statistically different at the 5% level if they do not have a common letter after the value.

Table 5. Average number of seeds per large, medium, and small-sized 'Coville' blueberry treated with GA in 1967.

Treatments ppm GA	Seed number according to berry size (in.)[x]												
	1st picking			2nd picking			3rd picking			4th picking		5th picking	
	>¾	½-¾	<½:	>¾	½-¾	<½:	>¾	½-¾	<½:	½-¾	<½:	½-¾	<½
Control	21.8a	13.6bc	2.8a	13.7a	5.4a	1.4bc	—	4.6a	1.6a	2.8a	1.4a	2.0b	0.9ab
50	23.4a	15.7c	2.1a	11.7a	4.5a	0.9bc	12.5a	4.0a	1.0ab	3.1a	1.1a	2.3b	1.1a
100	25.1a	9.1b	5.8a	13.3a	4.9a	2.0c	8.3a	6.6a	0.8b	3.6a	1.5a	6.3a	0.7ab
500	15.9b	8.0b	1.6a	10.6b	3.3a	0.6ab	7.0a	3.6a	0.6b	2.2a	1.0a	2.5b	0.4bc
250 Caged	3.0c	0.1a	0.0a	0.0c	0.2b	0.0a	—	0.0b	0.0c	0.0b	0.0b	0.0c	0.1d
375 Caged	2.6c	0.2a	0.0a	0.5c	0.0b	0.0a	0.0a	0.0b	0.0c	0.0b	0.0b	0.0c	0.0d
500 Caged	3.7c	0.3a	0.0a	4.4b	0.1b	0.0a	0.0a	0.0b	0.0c	0.0b	0.2b	0.0c	0.0d

[x]Mean values within a column are statistically different at the 5% level if they do not have a common letter after the value.

Other observations. In 1967 slightly more vigorous shoot growth was observed on the bushes treated with 375 and 500 ppm GA. In both 1966 and 1967 it seemed that more force was required to pull the ripe GA-treated berries from the bush than was required for the control berries. No attempt was made to measure differences mechanically in pull required to separate the berry from the bush.

Discussion

The relatively high percentage fruit set of the control bushes in 1966 and 1967 can be attributed to ideal conditions for pollination occurring on the 'Coville' bushes used in this experiment, including good pollination weather and a high concentration of bumblebees. Marucci (5) has observed that bumblebees will work Coville blossoms as readily as other varieties, but domestic honeybees work other blueberry varieties in preference to 'Coville'.

The effectiveness of the GA treatment in increasing fruit set is indicated in the response of the caged plants to GA. Since the 'Coville' blueberry does not have a tendency to produce natural parthenocarpic fruit, caged bushes would not be expected to yield any appreciable amount of fruit. GA treatments produced normal but seedless fruit in the plants, indicating that GA is capable of inducing parthenocarpic fruit in the 'Coville' blueberry. These results substantiate earlier data obtained under greenhouse conditions by the authors (4).

Failure to increase yield in 1966 by GA treatment can be attributed to the smaller berries produced. In 1967 the situation was reversed, increases in yield resulted from the GA treatments without a corresponding increase in per cent fruit set. Since fruit size reduction was also experienced in 1967 as the result of GA treatment, the discrepancy between per cent set and yield may be attributed to the method used for determining per cent set. The blossoms were counted when the bushes were near full bloom, but there were still many small unopened flowers that were difficult to count. These small, late flowers tended to drop from the control plants but set and matured on the bushes treated with the higher levels of GA. The failure to make an accurate flower count resulted in more than 100 per cent fruit set on some of the higher GA treated bushes. This experimental error may have contributed to the failure to show fruit set differences in 1967.

The direct relationship between berry size and seed number agrees with Darrow's (2) and Eaton's (3) findings that there is a strong positive correlation between seed number and berry size in the blueberry fruit within a variety. Apparently some factor required for large berry size is lacking in the parthenocarpic fruit. The factors responsible for the higher percentage of large berries from the control and uncaged GA-treated bushes are likely to be due to more or different growth substances produced by the seed. The possibility also exists that the presence of seeds results in the fruits becoming stronger mobilization centers. The slightly later ripening of the fruit from the caked GA treatments may be caused by factors similar to those responsible for the lower percentage of large berries.

The lack of firmness and poor keeping quality characteristics of parthenocarpic tomatoes was not evident in the seedless blueberries produced in this experiment. The lower refractive index of the fruit from the higher levels of GA treatment may be due to the slower rate of maturation associated with this fruit. Since a longer time was required for such fruit to turn blue, the physiological changes associated with maturation were undoubtedly occurring at slower rates. Perhaps, if the seedless berries were allowed to remain on the bush somewhat longer after they became blue, the refractive index readings would have been the same as those found in the seeded fruit.

Although the GA-treated berries tended to be slightly smaller and later ripening, these disadvantages would be more than offset by the increased yield affected by GA application in years when internal set was low. Further investigation is needed to determine whether the greater pull required to separate the GA-treated berries from the bush will hinder mechanical harvesting.

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Chemical Thinning of Apple Trees Using Concentrate Sprays[1]

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Abstract. Sevin was used in thinning sprays in dilute—1×—and concentrate form—ranging from 3× to 33×—over a 4-year period on mature 'Rome Beauty' apple trees. Although treatments were not the same in each year, all sprays applied significantly thinned in 3 out of 4 years. There was some evidence that concentrate sprays thinned less than dilute sprays, but usually not significantly so. When using 33× concentrates, significant thinning was achieved in 1 year when Sevin was used at full strength—33 lb./100 gal. Approximately the same degree of thinning was obtained when the rate was reduced by one-half. Adding pesticides commonly used in petal-fall sprays to Sevin—all concentrated to the same extent—did not alter significantly the thinning obtained with Sevin alone.

Results on 'Jonathan' apples in a 1-year experiment revealed significant thinning with NAD and Sevin in a dilute spray, as well as Sevin at 3× and 6× concentrates. In a 1-year experiment on 'Golden Delicious', NAA thinned significantly as a dilute spray, and at 3× and 6× concentrates. The dilute spray was more effective.

Introduction

DILUTE spray-thinning of apples is well established, and several comprehensive reports have been published (1, 2, 8). For various reasons there has been little research on concentrate sprays for thinning. Years of work on concentrate applications of pesticides in Maryland (7) have led to widespread use of this technique in the state, and have raised the question of feasibility of concentrating the thinning spray. Experiments were conducted from 1963 through 1967 to investigate concentrating chemical thinning sprays, ranging from dilute to 33×. Frost ruined the 1963 experiment: results of the other 4 years are reported.

Materials and Methods

All experiments were performed in commercial orchards in the vicinity of Hancock, Maryland on heavily-blooming trees approximately 20 to 25 years old. Dilute sprays were applied with hand guns operated from high-pressure sprayers. Sprays of 3× and 6× concentrates were applied with a John Bean 200 TR air-blast sprayer. At a tractor speed of 2.5 MPH, spray delivery from 1 side only was approximately 7 and 3.5 gal per 100 ft of travel for 3× and 6× applications, respectively. Sprays of 33× concentrate were applied with an Econ-O-Mist air-blast sprayer, with a delivery rate of approximately 2.5 pints per 100 ft of travel, spraying from 1 side only at a speed of 2.5 MPH. All sprays were applied in the period between 15 and 21 days after full bloom, with the exception of 1967, when they were applied about 30 days after full bloom because of a long, cool period following blossoming. The number of trees ranged from 6 to 10 per treatment.

'Rome Beauty' was the main variety used, 'Jonathan' and 'Golden Delicious' to a lesser extent. The principal thinning agent used was 1-naphthyl N-methylcarbamate (Sevin) and is reported in pounds of the 50% wettable powder. 'Rome Beauty' is classed as difficult to thin (2); however, successful results have been reported with the use of Sevin (6). Naphthaleneacetic acid (NAA) plus Tween-20 was used on 'Golden Delicious' only. Naphthaleneacetamide (NAD) was used in 1964 only, as recommended for commercial application, for comparison with results obtained with Sevin. In 1965, pesticides normally used in petal-fall sprays were added to the concentrate thinning spray, all concentrated to the same degree. They were based on dilute rates of the commer-

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