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Flower Bud Stage and Chill Hours Influence the Activity of GA_3 Applied to Rabbiteye Blueberry

D.S. NeSmith
Department of Horticulture, Georgia Experiment Station, Griffin, GA 30223-1797

Gerard Krewer
Rural Development Center, P. O. Box 1709, Tifton, GA 31793

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Abstract. **Individual flower clusters of 'Tifblue' rabbiteye blueberry *(Vaccinium ashei* Reade) were treated with 300 ppm GA_3 at several flower bud stages to determine the activity of the growth regulator in promoting fruit set. Applications were made one time only at a specified stage of flower development, or once followed by a second application. A single application of GA_3 when flower buds had elongated but corollas had not expanded (stage 5) led to the largest increase in fruit set. Two applications of GA_3, 10 to 18 days apart, increased fruit set compared with a single application at flower developmental stages other than stage 5. Fruit set promoted by a single spray of GA_3 imposed on fully expanded corollas (stage 6) decreased with increasing number of chill hours (350, 520, 760, or 1150). Chemical names used: gibberellic acid (GA_3).**

The rabbiteye blueberry is an important fruit crop in the southeastern United States; however, there are inherent problems in production associated with year-to-year variation in fruit set (Lyrene and Crocker, 1983; Mainland, 1985). 'Tifblue' comprises more than one-half of the rabbiteye blueberry area in Georgia (Hubbard and Purcell, 1985), and it is also one that has inferior fruit set (Davies, 1986; Lyrene and Goldy, 1983). Several growth regulators have been explored for their potential to improve blueberry fruit set (Collins et al., 1966; Davies, 1986; Doughty and Scheer, 1975; Mainland and Eck, 1968), and the most promising compound to date has been GA_3.

Improvement of blueberry fruit set and subsequent yield with GA_3 has been variable. Mainland and Eck (1969a, 1969b) observed a significant increase in fruit set and yield of highbush blueberries *(Vaccinium corymbosum* L.) treated with GA_3, and they concluded that the growth regulator should

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Table 1. Effects of chilling on rabbiteye blueberry fruit set in response to a single application of either GA_3 (300 ppm) plus Tween or Tween only at flower bud stage 6.

	Fruit set/cluster (%)	
Chill hours[z]	GA^3 + Tween	Tween only
350	100.0	18.9
520	99.0	10.3
760	73.1	0.0
1150	41.2	0.0
Significance	L**	L**

[z]Number of hours plants were below 7C.
**Linear (L) at $P = 0.01$.

Table 2. Effect of a single GA_3 application (300 ppm) at different stages of flower bud development on fruit set of rabbiteye blueberries.

Flower bud stage[z]	Fruit set/cluster (%)
3	7.0 c[y]
4	33.3 b
5	66.4 a
6	41.2 b
7	49.5 b
1 week past stage 7	7.3 c

[z]Flower bud stages are after Spiers (1978).
[y]Mean separation by LSD, $P = 0.05$.

be applied directly to flowers to obtain best results. Rabbiteye blueberries exhibited increased fruit set with additions of GA_3 in some instances; however, the response has been observed to be cultivar dependent, and yields have not always been improved (Austin, 1979; Davies, 1986; Davies and Buchanan, 1979; Mainland et al., 1979). Davies and Buchanan (1979) suggested that GA_3 concentrations of ≥200 ppm or multiple sprays may be necessary to increase fruit set. Additionally, Davies (1986) postulated that differences in the degree of chilling achieved may have an effect on the activity of growth regulators applied to rabbiteye blueberries.

The application of GA_3 in the various experiments described above was timed to coincide with a predetermined percent bloom, but the same criteria were not used in the different tests. Pharis and King (1985) noted that levels of endogenous GA_3 in flowers differ depending on the stage of flower development. They further suggested that exogenous GA_3 applications may trigger the endogenous GA_3 cycle to provide the growth regulator in the absence of seeds in unpollinated fruit. Thus, some of the variation reported for fruit set response of rabbiteye blueberry to GA_3 maybe because the plants are at a less than optimum developmental stage in terms of receptivity to the exogenous material.

The objective of this research was to determine the fruit set-promoting activity of GA_3 applied to rabbiteye blueberries at various stages of flower bud development and in response to chill-hour exposure.

Three experiments were conducted with 2-year-old potted 'Tifblue' blueberry plants. For all experiments, plants were defoliated by hand on 14 Nov. 1990, before any chilling temperatures (< 7C) occurred, and were placed in a dark cooler at constant 3 to 4C. After the required number of chill hours had been accumulated, plants were transferred to a greenhouse with a natural photoperiod and average day/night cycles of 24/19C to force budbreak. Bee and other insect activity in the greenhouse was monitored carefully, and none was observed. Gibberellic acid was applied to three to five individual flower clusters of plants (20 to 30 flowers per plant) when the flowers were at the desired stage of development. Bud development was monitored based on the stage descriptions of Spiers (1978): 1 = no visible swelling; 2 = visible swelling, bud scales separating; 3 = scales separated, apices of flowers visible; 4 = individual flowers distinguishable, bud scales abscised; 5 = individual flowers distinctly separated, corollas unexpanded; 6 = corollas completely expanded; 7 = corollas dropped. No attempt was made to standardize the position of buds that were treated (i.e., terminal buds vs. others) nor the type of wood from which the buds developed (i.e., twiggy growth vs. older wood). We used 300 ppm GA_3 (Pro Gibb 4%, Abbott Laboratories, North Chicago) with 0.25% surfactant (Tween 20). This concentration of GA_3 was selected because it was >200 ppm, as suggested by Davies and Buchanan (1979), and it was a concentration currently being used by commercial blueberry producers under field conditions. Control spray solutions consisted of water and surfactant only. Individual flower clusters were sprayed by means of a small hand-held spray bottle with solutions to the point of runoff. Before spraying, flower clusters were tagged and the number of flowers per cluster was recorded. Only the tagged flowers were sprayed on each plant. Fruit set was determined by counting fruit 4 to 6 weeks after petal fall to insure that the major period of fruit abortion was past (Davies, 1986). After a substantial number of berries had ripened on all treatments, mature fruit were harvested from flower clusters to determine their fresh weight and soluble solids concentration (SSC). Fruit set percentage data were subjected to arcsin transformation before analyses, and all data were analyzed using appropriate analysis of variance and regression procedures.

Chill hours (Expt. 1). This experiment was designed to discern the possible influence of chill hours on fruit set in response to a single application of GA_3 (350, 520, 760, or 1150 below 7C). Ten plants of each chilling treatment were removed from the cooler and placed in the greenhouse under forcing conditions. Five plants for each chilling regime were treated with the growth regulator solution, and five were treated with the control solution. Flowers were treated at stage 6 for all chilling regimes. This flower stage was selected because it was nearest to full bloom.

Flower bud stage–single application of GA_3 (Expt. 2). This experiment was intended to explore the effects of a single application of GA_3 at various flower bud stages on subsequent fruit set. All plants in this experiment received 1150 chill hours. Treatments consisted of spraying the flower clusters of plants that were at stages 3, 4, 5, 6, or 7, and 1 week past stage 7. Eight plants at each stage were sprayed with the GA_3, and eight plants at stage 6 only were sprayed with the control solution. Stage 3 was selected as the starting point because it was the first stage readily discernable.

Flower bud stage–two applications of GA_3 (Expt. 3). In this experiment fruit set response to two separate applications of GA_3 at several stages of flower bud development was elucidated. All plants in this experiment received 1150 chill hours. Treatments included spraying once at stage 4 and again at stage 6; spraying once at stage 5 and again at stage 7; spraying once at stage 6 and again 10 days later; spraying once at stage 6 and again 18 days later. There were eight plants for each treatment.

Experiment 1. There was a decreased response of fruit set with increasing number of chill hours using GA_3, although all GA_3 plants set more fruit than their respective controls (Table 1). Floral budbreak of plants receiving low chill hours was slow and erratic, as reported by other investigators (Austin et al., 1982; Darnell and Davies, 1990; Spiers, 1976; Spiers and Draper, 1974). Possible reasons for the inversely proportional relationship between fruit set and chilling are 1) large temperature differences at the time of fruit set, 2) altered floral physiology due to chilling, 3) fewer flowers per cluster, and 4) different sink loads among chilling treatments. The first possibility is unlikely because temperatures were not drastically different over the course of the experiment. The second possibility can be discounted based on work by Darnell and Davies (1990) that revealed chilling does not alter flower physiology such

Table 3. Effect of a single or two separate GA_3 applications at different stages of flower bud development on fruit set of rabbiteye blueberries. The concentration of each GA_3 application was 300 ppm.

Single applications		Two applications	
Flower bud stage[z]	Fruit set/cluster (%)	Flower bud stage	Fruit set/cluster (%)
4	33.3 d[y]	4 & 6	56.0 bc
5	66.4 ab	5 & 7	72.2 ab
6	41.2 cd	Stage 6 & 10 days later	79.2 a
		Stage 6 & 18 days later	79.5 a

[z]Flower bud stages are after Spiers (1978).
[y]Mean separation by LSD, $P = 0.05$.

that fruit set potential is diminished. The third option was not a factor because flower count was similar among treatments, and similar to the 6.1 flowers per cluster reported for 'Tifblue' by Lyrene and Goldy (1983). The fourth possibility is the most plausible because the number of actively growing flower and leaf buds was proportional to the number of chill hours (data not presented). The result was that the higher chilling treatments had more sink competition for available assimilates, which could have lessened fruit set.

Experiment 2. The activity of a single application of GA_3 in promoting fruit set differed depending on stage of flower bud development when plants received 1150 chill hours (Table 2). The highest fruit set occurred when the growth regulator was applied at stage 5. Flowers treated at lower or higher developmental stages resulted in significantly less fruit set. Differences in GA_3 activity at assorted flower developmental stages may explain, in part, variable results of other experiments.

Experiment 3. Compared with a single application only, a subsequent application increased percent fruit set in all cases except when the initial treatment was at stage 5 (Table 3). In fact, fruit set resulting from a single application of GA_3 at stage 5 was not significantly different from the best fruit set achieved with multiple GA_3 applications. The generally increased response of fruit set to the second application of GA_3 suggests that the extra exogenous supply of the growth regulator replaced the naturally produced GA_3 totally, or enhanced some endogenous growth regulator cycle, which in the absence of seeds in the unpollinated fruit stimulated the plant to maintain fruit.

Fresh fruit weight (mean 1.45 g) and SSC (mean 11.2%) were not significantly affected by the various treatments in any of the experiments. There was considerable variability in these data due to differences in fruit load and berry age.

Results from this series of experiments conducted with single flower clusters under controlled conditions suggest some important practical implications for growers. The target developmental stage for applying GA_3 appears to be when most of the flowers are at stage 5, which is before full bloom. This presents a dilemma if the growth regulator will be used only in the absence of adequate natural pollination and fruit set, which would be best evaluated at full bloom. In the case where a grower would only consider using GA_3 when pollination was poor, it would be best to evaluate pollen synchronization and pollinating insect activity as soon as possible once stage 6 has been reached, and then make an application if needed. This application should be followed by a second one 10 to 14 days later.

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