

Project Report: Prohexadione calcium for canopy management in cranberries
Phase 2 (2022)

Principal investigator: Charitha Jayasinghege (Agriculture and Agri-Food Canada, Agassiz, BC)

Research assistants: Carine Bineng, Izzy Nicholson, and Julia Klossok

Collaborators:

Miranda Elsby

Markus Clodius (Minor Use Pesticides Program, Agriculture and Agri-Food Canada)

Rishi R Burlakoti (Plant Pathologist, Agriculture and Agri-Food Canada)

Introduction

Proper canopy management is essential for achieving maximum yield potential and maintaining the long-term health and vigor of cranberry vines. Particularly, controlling canopy growth can optimize photoassimilate partitioning for shoot, root, and reproductive development, as well as improve nutrient utilization efficiency. The plant hormone gibberellin (GA) plays a crucial role in the development of shoots in plants, primarily by stimulating cell elongation. Therefore, it is a primary target for managing vegetative growth. However, many compounds that can act as GA inhibitors are not suitable for use in agriculture due to their unreliable effectiveness or undesirable toxicological and ecological effects.

Prohexadione-calcium (Pro-Ca) is a relatively new inhibitor of GA biosynthesis that has been used for controlling vegetative growth in pome fruit trees since the early 2000s. It is available under the trade names Apogee® and Kudos® in Canada. Pro-Ca has a shorter half-life of 10-14 days in plants and less than a day in microbiologically active soil, making it a safer option than many other GA inhibitors in terms of toxicological and ecotoxicological effects. Pro-Ca is easily absorbed by plant leaves and once inside, prohexadione translocates in the xylem, inhibiting GA biosynthesis and reducing longitudinal shoot growth. Since phloem acts as the main supply route for developing fruits, and prohexadione has low stability, no detectable levels

of prohexadione accumulate in the fruits. Additionally, the low stability of this compound eliminates the chances of prohexadione carrying over to the next growing season. These qualities make Pro-Ca an ideal option for controlling GA action in fruit and berry crops (Rademacher et al., 2006).

In 2021, we conducted a study to evaluate the effectiveness of using Apogee growth regulator (Pro-Ca) for managing canopy growth in cranberries. The study took place at the Cranberry Research Farm in Delta, BC, on a Stevens bed. Three different concentrations of the growth regulator were tested: 450 mg/L, 900 mg/L, and 1350 mg/L (representing roughly 0.5mM, 1mM, and 1.5mM of Pro-Ca, respectively). Two or three rounds of applications were done at each rate with 14-day intervals between each application. The results indicated that two applications of Apogee at a rate of 450 mg/L during the early stages of runner growth effectively reduce runner length and density without negatively impacting yield or fruit quality. Increasing the concentration or number of applications did not improve canopy growth control and instead increased the risk of yield loss.

Our findings indicate that the Apogee growth regulator could be an effective option for managing cranberry canopy growth, especially in cases where excessive runner growth is a concern. However, to confirm the reproducibility of these results, it is necessary to conduct additional studies. Also, given that the lowest rate produced the best results, it would be beneficial to further evaluate lower rates and expanded application timing to determine the optimum rates and application timings. Additionally, it is important to monitor canopy growth and yield data in the following year to ensure that our treatments do not have any long-term negative impacts. Therefore, our aim in the phase 2 of this study was to optimize treatment application timings, rates and to evaluate long term impacts of the growth regulator treatments.

Objectives

1. To determine the optimal Pro-Ca (Apogee) treatment rates and application timing for improved canopy management
2. To evaluate the impact of previous year's Apogee treatments on canopy growth parameters in the following year.
3. To study the effects of Apogee growth regulator on cranberry fruit yield and fruit quality attributes.

Materials and Methods

Plot Design and Growth Regulator Treatments

The studies were conducted at the Cranberry Research Farm in Delta, BC. The research plots were set up in the Stevens (field-4) and Mullica Queen® (field-3) beds.

In the Stevens study, a randomized complete block design with four replications was used. Each plot measured 2m x 1m with a 0.75m buffer zone between them. There were eight different treatments: (1) two applications of Apogee at a rate of 450mg/L at 2 week intervals, (2) two applications of Apogee at a rate of 450mg/L at 3 week intervals (3) three applications of Apogee at a rate of 450mg/L at 3 week intervals, (4) two applications of Apogee at a rate of 300mg/L at 2 week intervals, (5) two applications of Apogee at a rate of 300mg/L at 3 week intervals, (6) three applications of Apogee at a rate of 300mg/L at 3 week intervals, (7) three applications of Apogee at a rate of 450mg/L at 3 week intervals with the third application after 11 weeks (mid-August), and (8) two applications of water at 2 week intervals as a control treatment. Treatments were initiated in early June when approximately 80% of buds were at the bud elongation stage (determined by visual estimation)

In the Mullica Queen study, a completely randomized design with 3 replications was used. Each plot measured 2m x 2m with a 0.75m buffer between them. There were three different treatments: (1) two applications of Apogee at a rate of 450mg/L with 3 week intervals, (2) three applications of Apogee at a rate of 450mg/L with 3 week intervals, and (3) two applications of water with 3 week intervals as a control. First sprays were done in mid-May when most of the plants were at the bud break and elongation stages. All the treatments were applied with Agral® 90 surfactant at a rate of 0.5ml/L.

Canopy growth and yield analysis

The growth rate of runners in Stevens was evaluated during the growing season by studying four separate, untreated plots within the same blocks used for the Apogee study. To conduct the analysis, eight runners showing strong growth were randomly chosen from each plot, labeled, and their length from the point of origin of the current growing season growth was

recorded in early July. The length of these runners was then measured at various intervals until the end of the growing season in mid-November. The growth rate was calculated as a percentage of their initial length.

In the Stevens and Mullica Queen studies conducted in 2022, in order to ensure that the disturbance to the plant canopy would not affect the yield data, canopy growth measurements were conducted on half of the plots, while the other half were used for yield data collection. A 30 cm x 30 cm square quadrat was randomly placed within a designated portion of the plots, and measurements of runner and upright growth for the current growing season were taken from the point of origin of the current growing season growth, identified by the terminal bud scar. For runner growth measurements, 10 runners displaying vigorous growth were randomly chosen. In cases where there were fewer than 10 runners present, all runners within the quadrant were included in the measurements. To measure vegetative upright growth, 15 uprights with no flowers or fruits that were at least three years old (as determined by the terminal bud scars; Elle 1996) were randomly selected. The upright growth measurements taken after harvesting in November included both vegetative and reproductive uprights, as reproductive uprights could not be excluded by visual inspection alone. The measurements were taken once a month from July to November during the first two weeks of each month. Additionally, the height of 15 reproductive uprights was also measured in September in the Stevens study, and in July and October in the Mullica queen study.

The effect of the Apogee treatment on canopy growth in the following year was assessed in an adjacent Stevens cranberry plot treated in 2021. This plot included a randomized complete block design with four replications. There were three different Apogee treatment concentrations recognized as low (450 mg/L), medium (900 mg/L) and high (1350 mg/L), a water-treated control, and an undisturbed control, where no sprays were applied and plants were not disturbed for data collection until harvesting. The Apogee treatments were applied as two or three repeated applications with 2-week intervals between treatment. The canopy growth data of these plots was collected as described above in early August, 2022.

The effect of growth regulator treatments on reproductive development was determined by counting the number of reproductive uprights that had at least one fruit from July to October in the Stevens study sprayed in 2022 and in August in the Stevens study sprayed in 2021. The percentage of reproductive uprights to total uprights was assessed in August and September for

the Stevens 2021 and 2022 studies, respectively. Fruit yield was assessed in mid-October when the fruits were fully mature, using the following methods: For the Stevens 2022 study, berries were harvested within four 30cm x 30 cm quadrants per plot, and the average was taken. For the Mullica Queen study and the Stevens study sprayed in 2021, fruits were harvested within two 30cm x 30 cm quadrants and the average was taken. Any berries showing fruit rot symptoms or small brownish berries (which appeared to be early-aborted berries that were not abscised) were collected separately as diseased berries, but were not included in the yield or fruit quality analysis.

Fruit Quality Analysis

For fruit quality analysis, approximately 80g of berries per plot were ground with a hand blender. The percentage of total soluble solids (TSS; °Brix) in the ground fruit sample was measured using an Atago PR-32 Alpha refractometer (Atago Co. Ltd., Japan). For titratable acidity (TA), 5 g of ground fruit samples were homogenized with approximately 100 mL of water, and titrated with 0.1 N NaOH to an endpoint of pH 8.1 using a Titroline Easy titrator (Schott Instruments, Germany), and expressed as milliequivalents of citric acid (Vorsa and Johnson-Cicalese, 2012; Tyl and Sadler, 2017). The total anthocyanin content was determined using the pH-differential method, adapted from Wrolstad (1976), Giusti and Wrolstad, (2001), and Borowska et al. (2009). Briefly, 6g of ground cranberries were homogenized, and anthocyanins were extracted using 80 mL of extraction solution containing 80% methanol and 0.1% HCL (MeOH:H₂O:HCl 80:20:0.1; V:V:V). 1 mL of the extract was mixed with 4 mL (or 9 mL if the absorbance at pH 1 and 530 nm was out of the range of 0.4-0.6) of potassium chloride buffer (pH 1.0) or sodium acetate buffer (pH 4.5), and the absorbance was measured at 530 and 700 nm. The anthocyanin mass fraction was estimated as equivalents of cyanidin-3-galactoside.

Results

Pro-Ca treatment suppress runner development in Stevens

The Stevens cranberry bed used in this study exhibited excessive vegetative growth with fast-growing runners. To determine the duration of this growth, the length of selected runners

was measured from early July to mid-November. These measurements show that the runners elongate rapidly until around mid-September, and have a minimal growth from that point until the end of evaluation in November (Fig. 1).

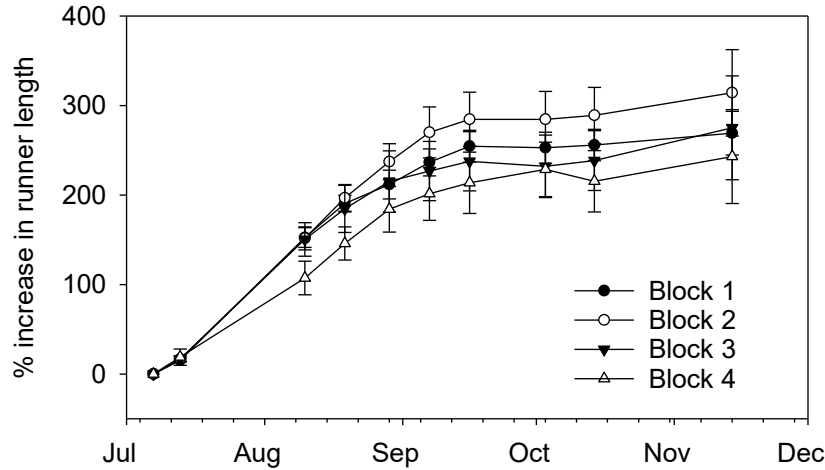


Figure 1. Length increase of runners in the cultivar Stevens during 2022 growing season.

Data was collected from selected runners in four independent blocks between July and November, with the increase in runner length assessed as a percentage of the length measured in early July. Data are means \pm SE (n=5-8)

Treatment with the Apogee growth regulator resulted in a reduction in runner growth in Stevens when compared to non-treated controls from July to November (Fig. 2A). The rate of the growth regulator or the timing of its application did not have a significant impact on the suppression of runner growth observed. Measurements taken from September to November, when runner expansion had mostly stabilized, showed a reduction of approximately 30-60% in runner length in comparison to controls. Additionally, runner density also decreased in response to Apogee treatments, with all treatments resulting in significantly fewer runner numbers compared to the water-treated control in October. However, measurements in November only showed significant effects in response to two or three applications of Apogee at a rate of 450mg/L, with 3-week intervals (Fig. 2B).

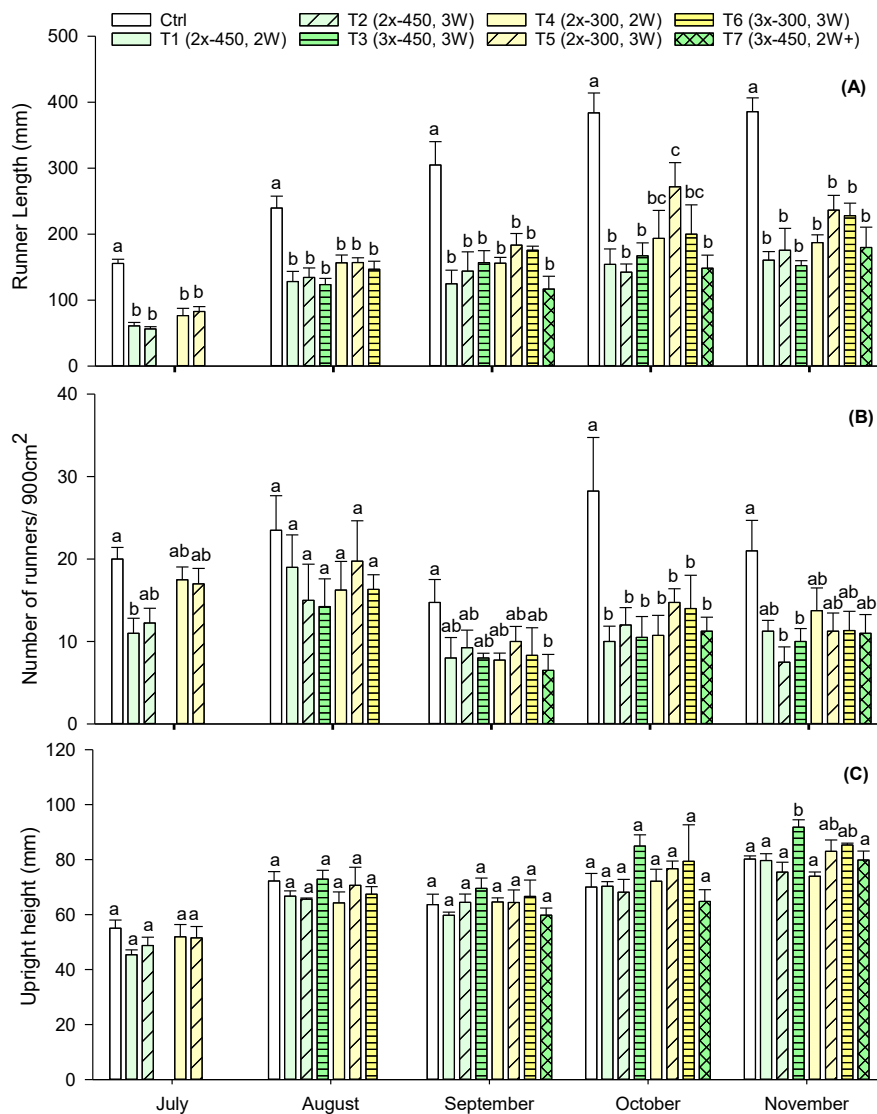


Figure 2. Effects of Apogee treatment on cranberry runner length (A), runner density (B), and vegetative upright height (C) in the cultivar Stevens over the growing season. The Apogee growth regulator was applied two or three times at a rate of 300mg/L or 450mg/L with 2 or 3 week (2W, 3W) interval between treatments, except for T7 where the third treatment was applied 11 weeks after the second treatment. The upright height data in November may include both vegetative and reproductive uprights as measurements were taken after harvesting. Different letters denote significant differences within a time point (Two-way ANOVA with Holm-Sidak post hoc test, $P < 0.05$). Data are means \pm SE ($n=4$, with the exception of T6, where $n=3$).

In contrast to the growth suppression observed in runners, the length of the vegetative uprights did not change in response to any of the treatments throughout the growing season (Fig.2C). The analysis of the reproductive upright height in September also revealed no impact of treatment, except for a slight reduction in height in response to two applications of 450mg/L at two-week intervals, and three applications at the same rate with an August treatment (Fig. 3).

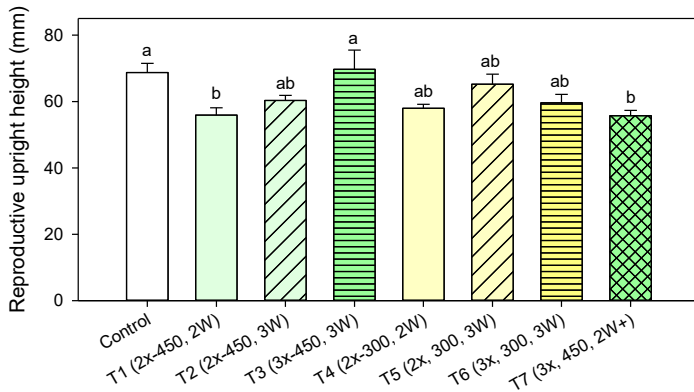


Figure 3. Height of reproductive uprights of the cultivar Stevens treated with Apogee growth regulator. Apogee growth regulator was applied at rates of 300mg/L and 450mg/L at 2-week (2W) or 3-week (3W) intervals between treatments, except for T7, where the third treatment was applied 11 weeks after the second treatment. Different letters indicate significant differences (determined by two-way ANOVA with Holm-Sidak post-hoc test, $P < 0.05$). Data represent mean \pm SE ($n = 4$, except for T6, where $n = 3$)

In the Mullica Queen study, there were no runners in most plots, including in the controls, within the 900 cm² area of the quadrant. As a result, only the upright growth was assessed. The analysis of vegetative upright heights from July to October and reproductive upright height in July and October showed no significant impact of the growth regulator treatments on growth (Fig. 4).

Impact of Apogee treatments on fruit yield and qualities

The effect of growth regulator treatments on reproductive upright density was assessed in the Stevens study from July to October, and no difference in response was found when compared to the water-treated controls. The only exception was an increased upright density following two

applications of Apogee at a rate of 450 mg/L at a 2-week interval in September data. However, even this treatment did not differ from the others at any other time point (Fig. 5A). We also assessed fruit yield, average fruit weight, and the percentage of reproductive uprights to total uprights and found no treatment effect (Figure 5C-D). The fruit quality parameters, titratable acidity, total anthocyanin content, and total soluble solids (% Brix) were also not affected (Table 1).

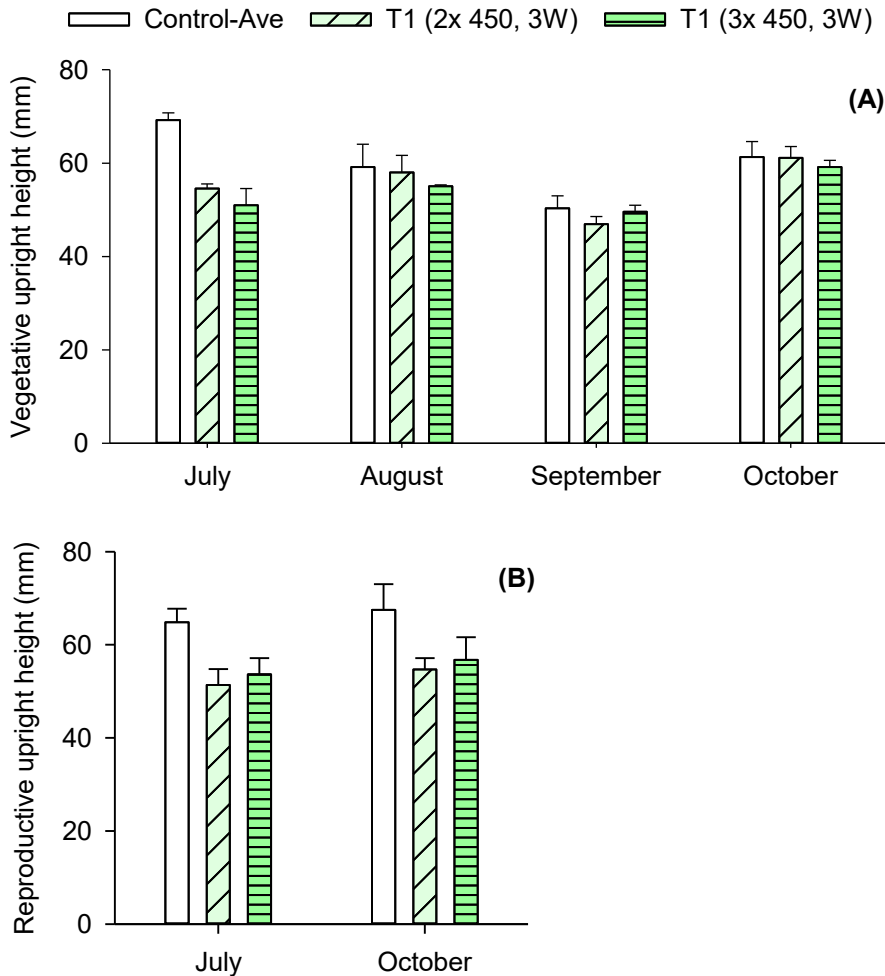


Figure 4. Effects of Apogee treatment on the vegetative (A) and reproductive (B) upright heights in the cultivar Mullica Queen. The Apogee growth regulator was applied two (2x) or three (3x) times at a rate of 450mg/L with 3 week intervals between treatments. There were no significant differences in upright heights at any time point (One-way ANOVA with Holm-Sidak post hoc test, $P < 0.05$). Data are means \pm SE (n=3).

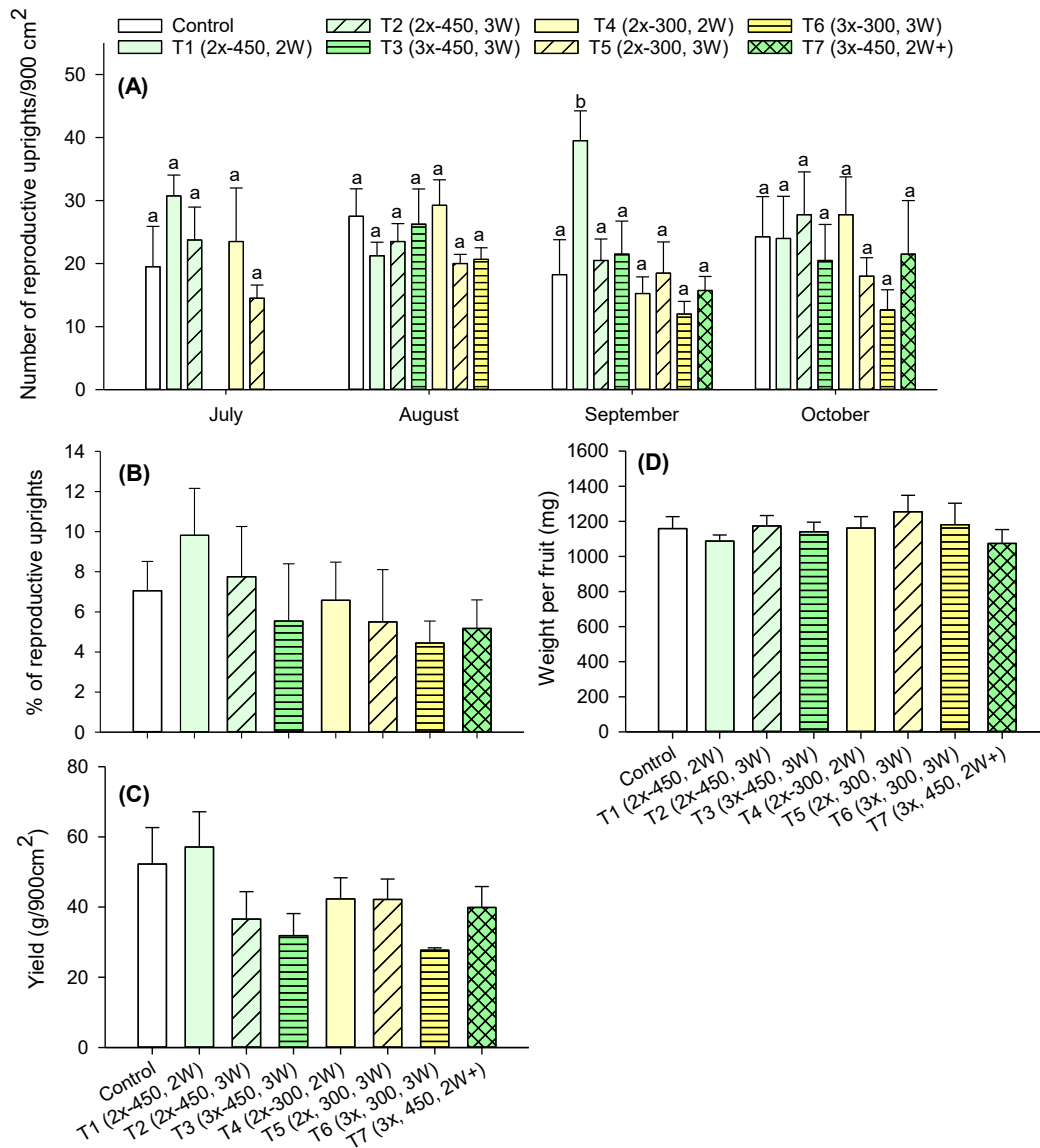


Figure 5. Effects of Apogee treatment on reproductive development. Reproductive upright density (A), percentage of reproductive uprights to total uprights (B), fruit yield (C), and average weight per fruit (D) in the cultivar Stevens were assessed in response to Apogee growth regulator treatments. The treatments were applied two or three times at a rate of 300mg/L or 450mg/L with 2 or 3-week (2W, 3W) intervals between treatments, except for T7, where the third treatment was applied 11 weeks after the second treatment. Different letters denote significant differences within a time point (Two-way ANOVA with Holm-Sidak post-hoc test, $P < 0.05$). No significant differences were seen between treatments in B, C and D. Data are means \pm SE ($n = 4$, with the exception of T6 where $n = 3$).

Additionally, a few fruits that were either well-developed but wrinkled and mushy or smaller and brownish, which may have aborted early in their development, were collected and categorized as diseased berries. There was no difference in the number of diseased berries with respect to growth regulator treatments. Similar results were also observed in the Mullica Queen study, where Apogee treatments had no effect on fruit yield and average fruit weight (Fig. 6), and there were approximately 16 diseased berries in average per 900 cm², but the numbers were not affected by treatment.

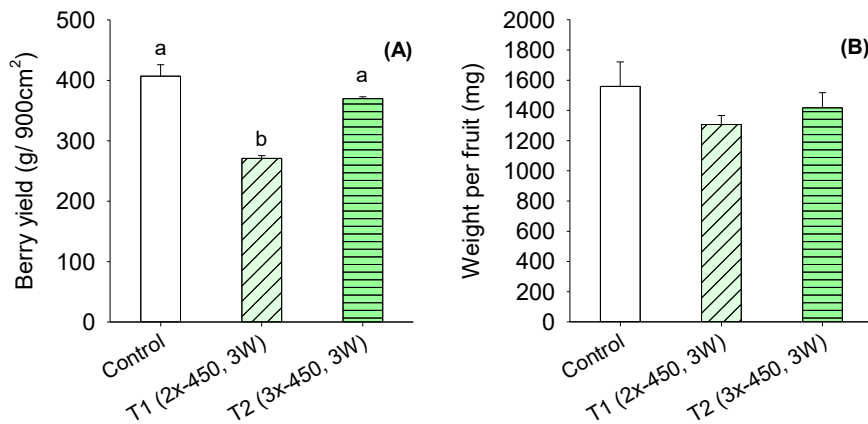


Figure 6. Fruit yield and average weight per fruit of the cultivar Mullica Queen treated with Apogee growth regulator. Two (2x) or three (3x) applications were applied at a rate of 450mg/L with three-week intervals between treatments. different letters denoting significant differences (one-way ANOVA with Holm-Sidak post-hoc test, $P < 0.05$). Data are presented as means \pm SE (n=3).

Impacts of Apogee treatments on vine growth and production in the following year

The carryover effects of Apogee treatments applied in 2021 were investigated by measuring vegetative and reproductive growth parameters in 2022. Results showed no impact of previous year treatments on runner length (Figure 7A), vegetative upright height (Figure 7C) and vegetative upright density (Figure 8A). However, the number of runners was lower in vines treated with medium and high rates of the growth regulator (Figure 7B). The reproductive upright density and percentage of reproductive uprights to total uprights measured in late August

indicated that 3 applications of high rate of Apogee may also reduce the development of reproductive uprights in the following growing season (Figure 8B and C). Similar trends were also seen in reproductive upright density data collected in mid-August, although the differences were not significant (Figure 7D). Fruit quality parameters, such as average weight per fruit, anthocyanin content, total soluble solids, and diseased fruits present in a given area, showed no difference in response to treatments (Table 2). Interestingly, titratable acidity showed significant but minor increases in all growth regulator treatments that included three rounds of Apogee treatments or two applications of Apogee at 900mg/L. However, none of these treatments showed significant deviations from the fruit samples collected in undisturbed vines, which also received no growth regulator treatment. Therefore, it is likely that the observed differences are not in response to Apogee treatments.

Table 1. Effect of 2022 Apogee treatment on anthocyanin content, total soluble solids (TSS), titratable acidity (TA), and fruit rot incidences in the cultivar Stevens

Treatment*	Anthocyanin (mg/100 g fresh fruits)[‡]	TSS (°Brix)	TA (%)[¶]	Fruit rot (fruits/3600 cm²)
T1 (2x-450, 2W)	46.1±1.7	9.3±0.1	2.63±0.02	10.3±4.9
T2 (2x-450, 3W)	38.6±2.7	9.0±0.2	2.73±0.02	3.5±0.9
T3 (3x-450, 3W)	35.4±3.9	8.9±0.2	2.68±0.06	4.8±1.7
T4 (2x-300, 2W)	43.5±4.3	9.1±0.2	2.65±0.04	3.8±1.9
T5 (2x, 300, 3W)	35.0±2.9	9.4±0.1	2.68±0.06	6.0±0.4
T6 (3x, 300, 3W)	32.7±4.1	9.0±0.3	2.69±0.13	3.7±1.5
T7 (3x, 450, 2W+)	41.5±2.7	9.2±0.1	2.77±0.04	2.8±1.1
Control	37.0±2.0	8.9±0.2	2.73±0.02	4.0±1.2

*The treatments were applied at a rate of 300mg/L or 450mg/L with 2 or 3 week (2W, 3W) interval between treatments, except for T7 where the third treatment was applied 11 weeks after the second treatment. No significant differences could be seen between treatments for TSS, TA and fruit rot incidences (Two-way ANOVA with Holm-Sidak post hoc test, $P < 0.05$). Data are means ±SE (n=4, except for T6 where n=3).

[‡]Expressed as cyanidin-3-galactoside equivalent

[¶]Expressed as citric acid equivalent

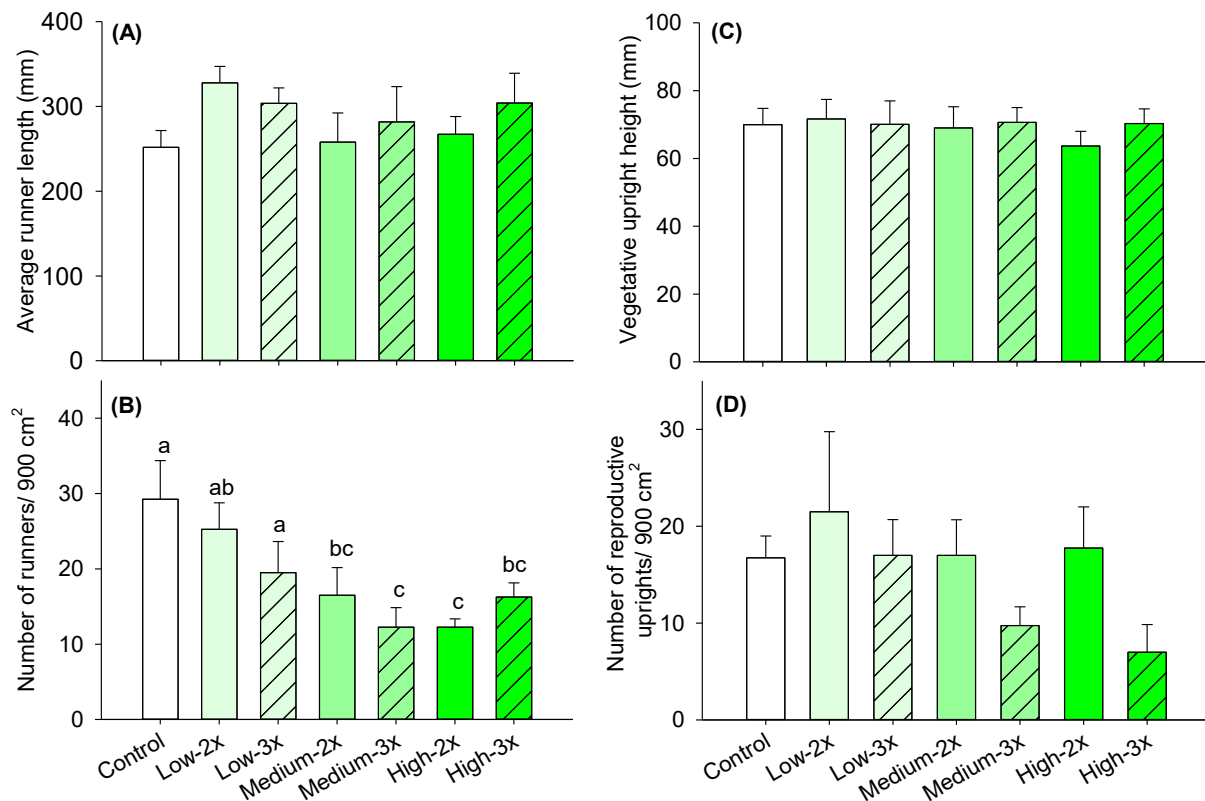


Figure 7. The impact of previous year's Apogee treatments on canopy growth parameters in the Stevens cultivar of cranberries. Treatments consisted of 450 mg/L (low), 900 mg/L (medium), or 1350 mg/L (high) doses of Apogee growth regulator applied in two or three rounds with two-week intervals during the 2021 growing season. Controls were treated with water. Runner length (A), runner density (B), vegetative upright height (C), and reproductive upright density (D), were assessed in mid-August 2022. Significant differences are denoted by different letters (Two-way ANOVA with Holm-Sidak post-hoc test, $P < 0.05$). Data are presented as means \pm SE ($n=4$).

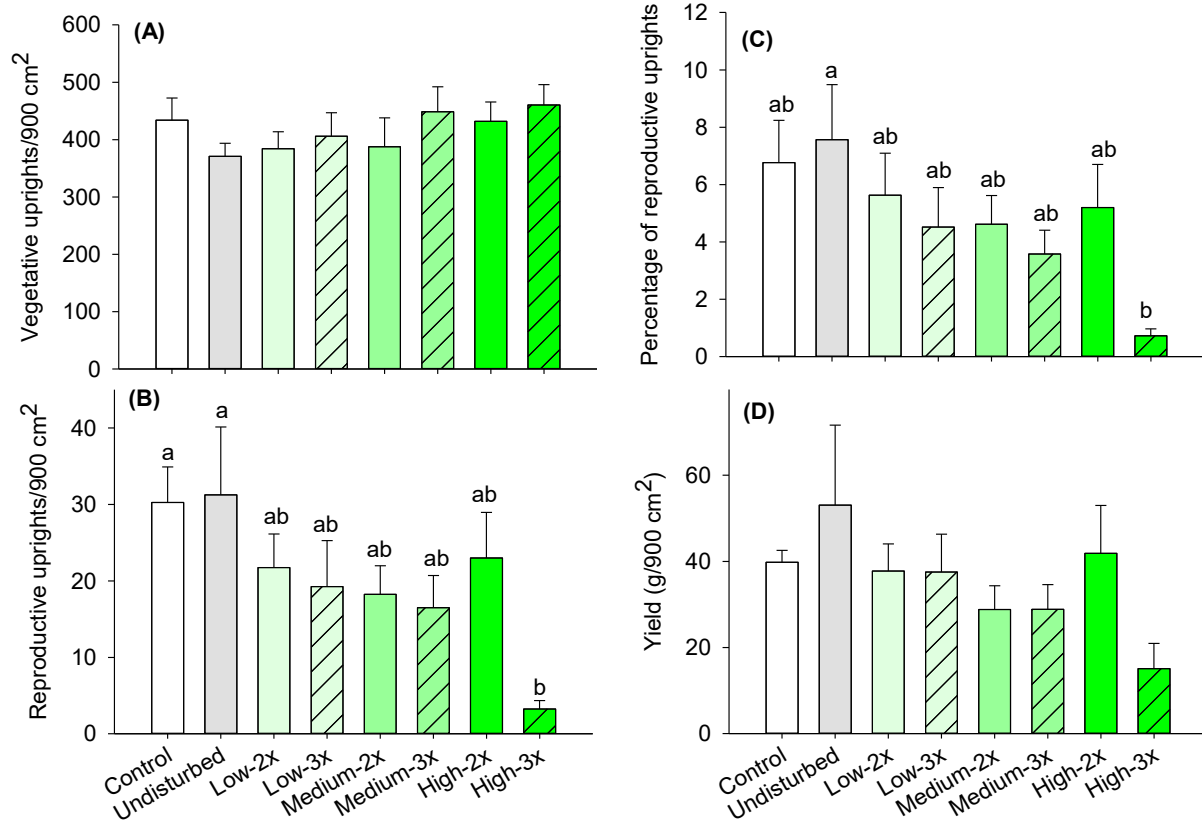


Figure 8. The effect of previous year Apogee treatment on upright density in the cultivar Stevens. Cranberry vines were treated with 450 mg/L (low), 900 mg/L (medium), or 1350 mg/L (high) rates of Apogee growth regulator for two (2x) or three (3x) times with two-week intervals between treatments in the 2021 growing season. Control treatments were applied with water, and no treatment was applied to undisturbed controls which were not used for any canopy growth data collection. Density of vegetative (A) and reproductive (B) uprights, as well as the percentage of reproductive uprights to total uprights (C), were assessed in late August 2022. Yield was assessed in October 2022. Different letters denote significant differences (determined using a Two-way ANOVA with Holm-Sidak post-hoc test, $P < 0.05$). Data are presented as means \pm SE ($n=4$)

Table 2. Effect of previous year Apogee treatment on, average fruit weight, anthocyanin content, total soluble solids (TSS), titratable acidity (TA), and fruit rot incidences

Treatment	Average weight/fruit (mg)	Anthocyanin (mg/100 g fresh fruits)*	TSS (°Brix)	TA (%) [¶]	Fruit rot (fruits/1800 cm ²)
Undisturbed	1246±47	30±3	9.3±0.2	2.66±0.01 ^{ab}	2.5±0.3
Control	968±81	31±4	9.4±0.2	2.54±0.04 ^a	1.5±1.0
2X_Low	1314±50	30±2	9.2±0.1	2.66±0.02 ^{ab}	1.25±0.5
2X_Medium	1110±46	28±1	9.4±0.1	2.72±0.02 ^b	1.5±0.6
2X_High	972±54	31±2	9.4±0.2	2.66±0.03 ^{ab}	2±1.7
3X_Low	1050±39	25±2	9.2±0.2	2.7±0.02 ^b	0.75±0.5
3X_Medium	1308±69	32±2	9.4±0.2	2.68±0.02 ^b	0.25±0.3
3X_High	1049±58	30±1	10.0±0.3	2.71±0.03 ^b	0.5±0.5

Different letters denote significant differences. No significant differences could be seen between treatments for any of the traits except for TA (Two-way ANOVA with Holm-Sidak post hoc test, $P < 0.05$). Data are means \pm SE (n=4).

*Expressed as cyanidin-3-galactoside equivalent

[¶] Expressed as citric acid equivalent

Discussion

In the first phase of this study, which was conducted in 2021, we found that the Apogee growth regulator effectively suppresses runner growth and runner numbers in the Stevens cultivar. The results of the 2022 treatments confirm these findings, with a significant reduction in the length of fast-growing runners throughout the growing season, even at lower Apogee rates than those used in 2021. By November, when the plants were preparing for or entering winter dormancy, even the lowest rate of Apogee treatment (two applications at 300mg/L) continued to maintain more than 30% reduction in runner length. The 2021 study also showed consistently lower runner numbers throughout the growing season. In the present study, we observed a

significant reduction in runner numbers in response to all treatments in the growth measurements taken in October, and in response to selected treatment at 450mg/L rate in November.

In contrast to the reduction in runner growth, we did not see a significant impact of Apogee treatments on the upright heights. This is consistent with observations made in 2021, where upright height remained unaffected even in response to Apogee rates as high as 1350mg/L. The only exception was a smaller but significant reduction of reproductive upright heights in response to two of the 450mg/L rates with 2-week intervals between the first two applications. Since cranberries produce fruits on the uprights produced in the same growing season, a lack of strong inhibition of upright growth may even be desirable, as it may help avoid any potential interference on reproductive development.

In the Mullica Queen cultivar, we found extremely low numbers of runners, making it impossible to assess the impact of Apogee treatment on runner development. In agreement with observations made in the Stevens, growth of both vegetative and reproductive uprights in Mullica Queen were also not affected by Apogee treatments. It is possible that the comparatively small increase in upright height compared to that of the runners, and the variability of upright heights, mask the treatment effects. If this is the case, we may still be able to see a reduction in total upright height if the treatments were repeated over several growing seasons. On the other hand, it is important to assess the contribution of upright growth in the overall increase of canopy thickness in a given cultivar to determine the potential benefit of growth regulator treatments. For the cultivar Stevens, where runner growth represents a major portion of vegetative growth of vines, a reduced runner growth achieved with Apogee may be sufficient to maintain the canopy growth when used in combination with other canopy management approaches such as mowing and sanding. The benefit of Apogee treatment on managing canopy growth in a cultivar such as Mullica Queen, which does not show vigorous runner growth, is unclear at this stage and may require repeated applications over multiple growing seasons to determine.

Growth regulator treatments applied to maintain canopy growth are not beneficial to growers if they negatively affect fruit yield or quality. In our 2021 study, we noticed potential phytotoxicity causing reduced yield in Stevens cranberries treated with high rates of Apogee growth regulator. However, no such effects were observed in response to treatments at a rate of 450mg/L. In agreement with the lack of negative impacts of lower Apogee rates on cranberry

yield, we observed no significant reduction in fruit yield or quality in response to Apogee treatments both in Stevens and Mullica Queen cultivars in the present study.

During the initial phase of this study, it was uncertain whether reduced canopy growth seen in response to Apogee treatment could lead to a growth stimulation in the next growing season, resulting in stronger growth in the treated vines. However, our data supports that vines do not respond to suppressed growth in the previous year with stronger growth in the following year. Our assessment of fruit yield in the plots treated in 2021 also shows that Apogee at a rate of 450mg/L has no impact on yield in the next growing season. However, higher rates can have an impact on both vegetative and reproductive development in the following season. Given the low stability of the active ingredient prohexadione calcium, the effects observed with higher rates are not likely due to residual activity of the growth regulator. Instead, these are likely due to phytotoxic effects caused by the high rates during the treatment year, impacting plant growth and reproductive development.

Based on the Apogee product label, the recommended rate of Apogee for canopy management in strawberries, cherries, and apples can be generalized as 450 mg/L (Pest Control Products Act. Registration No. 28042). However, unlike most temperate fruit crops, cranberries retain their leaves from the previous growing season. These leaves have a thick cuticle, which reduces the potential for spray absorption, potentially lowering the plant response to treatments (Workmaster et al., 1999). Nevertheless, our results show that an Apogee rate of 300-450 mg/L is sufficient to reduce the growth and density of cranberry runners in the cultivar Stevens. Rates higher than 450mg/L had minimal to no added effect on runner growth or density.

According to the Apogee product label, up to two, three, and four applications of the growth regulator at 14 to 21-day intervals are recommended for cherries, strawberries, and apples, respectively. In our study on cranberries, we did not observe a significant difference in runner growth between two and three applications, regardless of whether the third application was applied after three weeks of the second application or after 11 weeks. In general, Pro-Ca (Apogee) has been shown to be most effective when applied at the beginning of shoot growth. Application at later stages of growth may not be as effective or even enhance growth in some cases, as Pro-Ca treatment can also block the activity of GA inactivation enzymes (Rademacher et al., 2006). However, in our study, we did not see any growth stimulatory effect when a third Apogee treatment was applied in mid-August, which could be due to the already suppressed

growth from the initial two applications. The treatment window of two weeks or three weeks between applications also appears to have no clear impact, allowing for treatment application flexibility based on other requirements such as weather conditions.

Our findings indicate that applying Apogee growth regulator at a concentration of 300-450 mg/L twice during the early growing season effectively suppresses runner growth in cranberries and can aid in managing canopy growth in cultivars such as Stevens where excessive runner growth is an issue. While we expected that suppressing vegetative growth would lead to better fruit yield through more efficient resource allocation for reproductive development, we did not see any positive effects. The present study offers valuable insights on appropriate application rates, timing, and responsive cultivars, enabling future studies to be conducted on larger plots over multiple years, which will provide a more comprehensive understanding of the effects of this canopy management approach on canopy structure and fruit yield.

Summary

This study, conducted over two growing seasons, found that the Pro-Ca (Apogee) plant growth regulator can effectively suppress runner development in cranberries when applied at a rate of 300-450 mg/L in two to three applications. Our results suggest that Apogee can be a useful tool for managing canopy growth in cranberry cultivars such as Stevens, where fast-growing runners are a significant portion of vegetative development. However, this growth regulator is likely to have minimal effects on upright growth and therefore, a single year treatment may not significantly reduce canopy growth in cultivars such as Mullica Queen where runner growth is minimal. Further research, conducted over multiple years on a larger scale, is necessary to fully understand the effects of Apogee on upright growth and reproductive development.

Next steps

We plan to continue collecting data from the plots treated in 2022 to evaluate the impacts of growth regulator treatments on vine growth and reproductive development during the upcoming growing season.

Acknowledgments

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