Thinning Response of Ambrosia and Gala Apple Trees to Petal Fall and Late Applications of Accede®, with and without Sevin XLR

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Introduction

Thinning the apple crop early by pruning, blossom thinning or fruitlet thinning is beneficial to reduce fruit set, crop load, and the high labour costs associated with hand thinning. In addition, thinning early to improve fruit size and return bloom, particularly of biennial bearing cultivars such as Honeycrisp, is important.

As part of a multi-year study investigating the efficacy of 1-aminocyclopropane carboxylic acid (ACC), formulated as Accede® (PCP 34861, Valent BioSciences), a experiment was conducted in 2025 on Ambrosia and Gala with the aim of measuring the thinning effectiveness of a petal fall and "late" spray of ACC, and comparing these with hand-thinned and trees left un-thinned. In several of our past studies since 2017, we have found ACC to be a mild thinner and have often obtained inconsistent thinning even when applied at the highest label rate of 400 ppm. Therefore, combining carbaryl (Sevin XLR) with ACC was another objective of this study.

Materials and Methods

In 2025 a block of 'Ambrosia'/Bud 9 trees planted in 2021 spaced 1.1 m x 3.8 m (2424 trees/ha; 981 tress/acre) and a block 'Gala cv. Crimson'/M.9T337 spaced of 1 x 4 m (2500 trees/ha; 1012 trees/acre), both trained to a spindle hedgerow orchard system, were used for this study. Trees were located at the University of Guelph Horticultural Experiment Station, Simcoe, ON was used for this study.

Commercial products used in this study:

- Carbaryl: Sevin XLR (contains 466 g/L carbaryl, Tessenderlo Kerley Inc)
- 6-BA: Maxcel (contains 1.9% 6-benzyladenine, Valent BioSciences)
- ACC: Accede SG ® (contains 40% (w/w) 1-aminocyclopropanecarboxylic acid, Valent BioSciences)
- Non-ionic surfactant: Agral 90 (contains 92% nonylphenoxy polyethoxy ethanol, Syngenta Canada)

A randomized complete block with six replications and seven treatments was used as the experimental design. Treatments were applied according to Table 1. Both Ambrosia and Gala trees were in full bloom on 13 May 2025.

Treatments were applied using a commercial air blast sprayer (Slimline Manufacturing, Model MP3T19P with 19-60SS tower, Penticton, Canada) at 758 kPa (109 PSI). Sprays were applied dilute based on tree row volume (577 L/ha) (Sutton and Unrath, 1988). The sprayer was equipped with 9 nozzles (Four Teejet TXR AITXA8001VK nozzles (top) and five TXR8001VK nozzles (bottom)) per boom (side) and a large axial fan to move the spray into the canopy. To minimize treatment interference caused by spray drift, experimental units were separated by at least one guard tree. Applications were made at a ground speed

Table 1. List of thinning treatments

Treatment	Timing	Days after full bloom (date)
1. Untreated control	-	-
2. Hand thinned control[1]	After "June" drop	37 (June 19)
3. 400 ppm ACC[2]	5 mm (petal fall)	7 (May 20)
4. Carbaryl[3] + 75 ppm 6-BA (Maxcel)[2] ("grower standard")	6-8 mm	13 (May 26)
5. 400 ppm ACC [2]	19-20 mm	29 (June 11)
6. 400 ppm ACC tank mixed with Carbaryl[2,3]	19-20 mm	29 (June 11)

[1] Fruit clusters were singled and fruit were spaced approx. 10 cm apart
[2] All spray treatments included 0.05% Agral 90 non-ionic spray adjuvant
[3] 3.2L Sevin XLR/1000 L water

of 2.9 km/hr (1.8 m/hr). All spray treatments included 0.05% Regulaid® non-ionic spray adjuvant.

The petal fall sprays were applied on 20-May (7 days after bloom) when king fruitlets of Ambrosia were 5.5 mm and Gala were 6.1 mm. The grower standard sprays of carbaryl and 6-BA were applied on 26-May (13 days after bloom) when king fruitlets were 6.4 mm and 7.8 mm for Ambrosia and Gala, respectively. The "late" sprays of ACC and ACC tank mixed with carbaryl were applied on 11-June (29 days after bloom) when king fruitlets were 18.9 mm and 20.6 mm for Ambrosia and Gala, respectively.

The hand-thinned control trees were thinned on 19 June by removing all but one fruit per cluster and spacing fruit ~10 cm apart. Average number and weight of fruit removed by the hand-thinned trees (n=12) was 65 fruitlets for Ambrosia and 32 fruitlets for Gala. Municipal ground water with an average pH of 7.5 to 8.0 and hardness of 281 mg/L to 295 mg/L (Kristin Pressey, Personal Communications) was used as the source water for the spray mixture.

Horticultural Measurements

The following measurements were recorded:

- Weather conditions
- Fruit set (not presented)
- Yield parameters (total yield, marketable yield, number of fruit/tree, average fruit weight)
- Fruitlet diameters during early fruit set
- Tree circumference 20 cm about the ground (to calculate trunk cross-sectional area (TCSA))

Ambrosia fruit were harvested on 1-Oct 2025 and Gala on 11-Sept 2025. During harvest, the total number and weight of fruit was recorded. The number of unmarketable fruit (undersize, poor colour, pre-harvest dropped fruit) were also counted and weighed. Mean fruit size was estimated by dividing the total mass of marketable fruit by the number of fruit in the sample. A random sample of 30 fruit per tree was taken from each experimental unit (60 total fruit) and placed in cold storage (~2°C) for subsequent grading on a commercial colour sorting and sizing grading line in November of 2025.

Results

Weather and Environmental Conditions

Environmental conditions were good for pollination on May 13 and the following four days, then a 15- day period of very unusual cool weather followed from 18-May to 10 June, with daily high temperature below 20°C (Figure 1). This resulted in the traditional chemical thinning window inconducive for chemical thinners, especially the hormonal products NAA, 6-BA and ACC based on product labels. Notwithstanding, to test the efficacy of "early" petal fall sprays of ACC, ACC was applied during this period on May 20, when air temperatures ranged from 3.5-15.6°C on the day of application. In addition, the grower standard spray of 6-BA and carbaryl was applied 26-May when temperatures ranged from 6.2-19.2°C the day of application. This treatment was applied 2-3 days earlier than the target timing of 8-10 mm, but with two days or rain, cool and windy weather forecasted, we proceeded when king fruitlets were 6-8 mm. Late sprays of ACC and ACC tank mixed with carbaryl were applied on 11-June, when temperatures ranged from 13.7-26.2°C the day of application, followed by more seasonably warm weather.

Number of Fruit Per Tree

Treatments had a significant effect on the number of Ambrosia ($P<0.0001$) and Gala ($P=0.0045$) fruit per tree. For Ambrosia (Figure 2), trees treated with the hand thinned control, grower standard of CB+6-BA at 6.4 mm and, ACC combined with carbaryl at 19 mm had less fruit/tree than the untreated control. ACC applied alone at PF and 19 mm had no effect on the number of fruit/tree compared with the untreated control. For Gala (Figure 3), trees treated with the grower standard of CB+6-BA at 7.8 mm and, ACC tanked mixed with carbaryl at 20 mm had fewer fruit/tree compared with the untreated control, but a similar amount as the hand thinned trees. Trees that were hand thinned or treated with ACC applied alone at PF and 19 mm had no effect on the number of fruit/tree compared with the untreated control. Overall, untreated control trees had 103 Ambrosia fruit and 66 Gala fruit/tree when the target numbers were ~66 Ambrosia and ~70 Gala fruit per tree based on a crop load of 7 fruit/cm^2 TCSA.

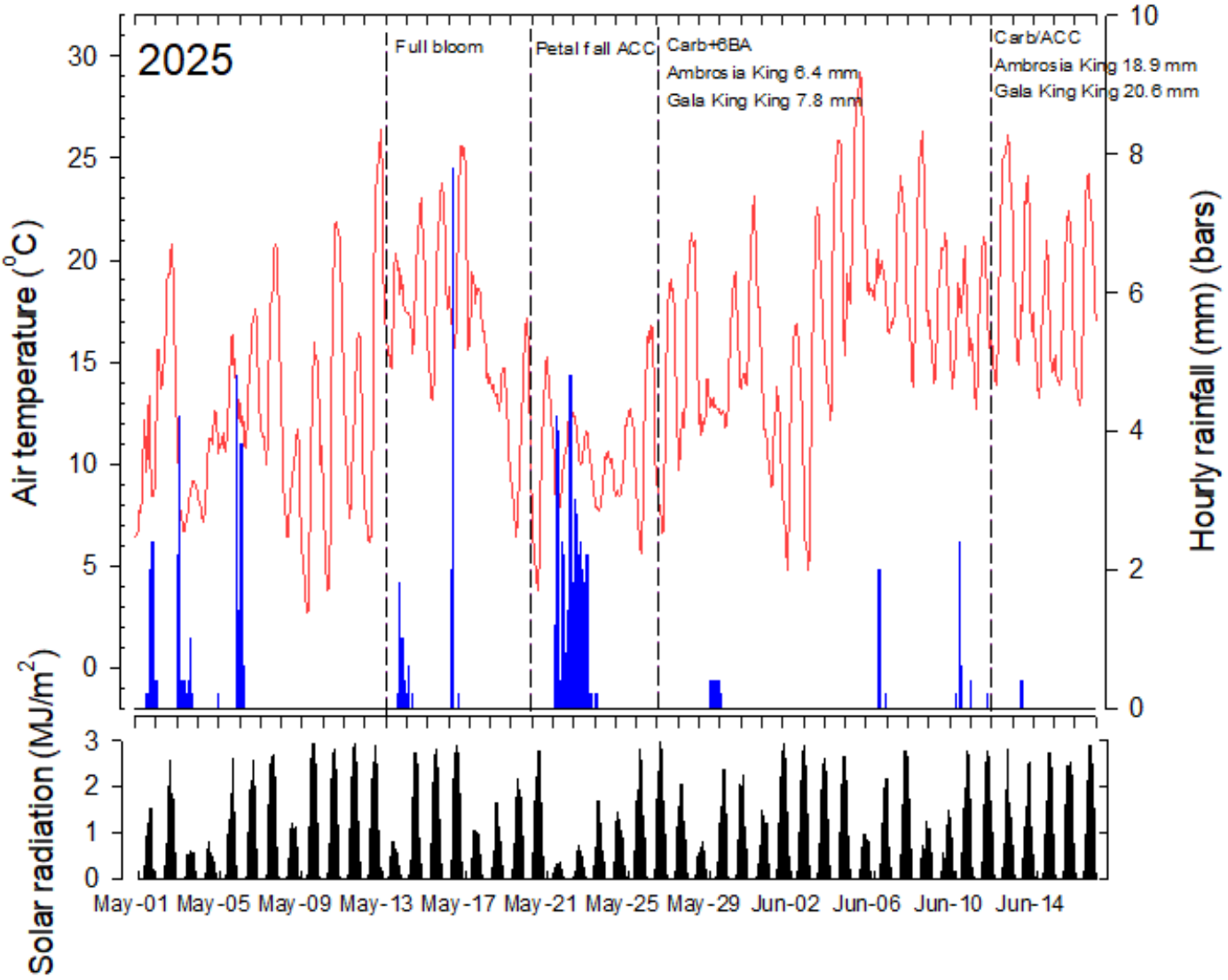

Figure 1. *Air temperature (red line), precipitation (bars), and solar radiation (lower graph) from 1-May to 16-June 2026 at the Horticultural Research Station – Simcoe. Vertical lines indicate date of full bloom and dates sprays were applied with corresponding king fruitlet diameter.*

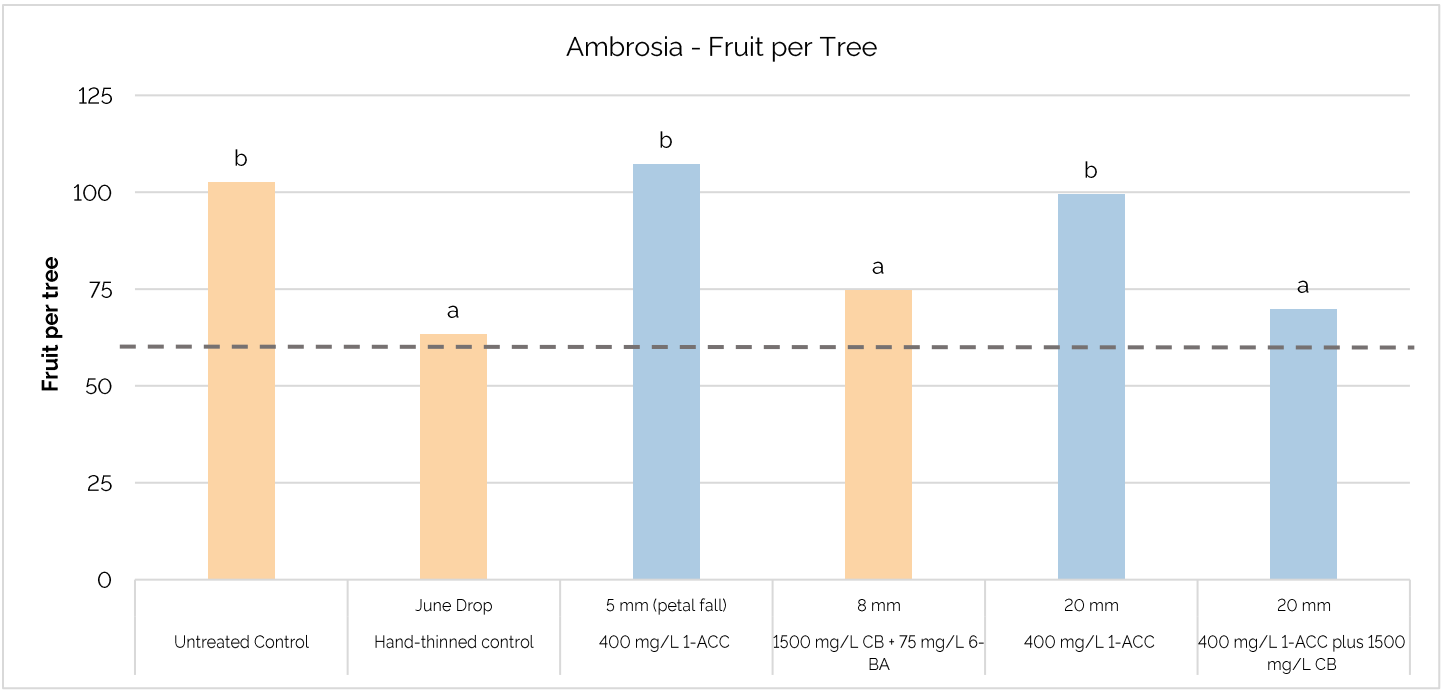

***Figure 2**. Influence of ACC (blue bars), carbaryl (CB), 6-benzyladenine (6-BA applied at petal fall, 6.4 mm and 19 mm fruitlet diameters on number of fruit per tree of 'Gala' trees in 2025. Treatments were applied at: a) petal fall, 5.5 mm fruitlet diameter on 20-May 2025 (7 days after bloom), b) 6.4 mm on 26-May (13 days after bloom), and c) at 19 mm on 11-June (29 days after bloom). Trees were hand thinned on 19-June (37 days after bloom). The horizontal line indicates the target number of fruit per tree. Mean values (bars) with the same letters are not significantly different according to Tukey's HSD test at P=0.05.*

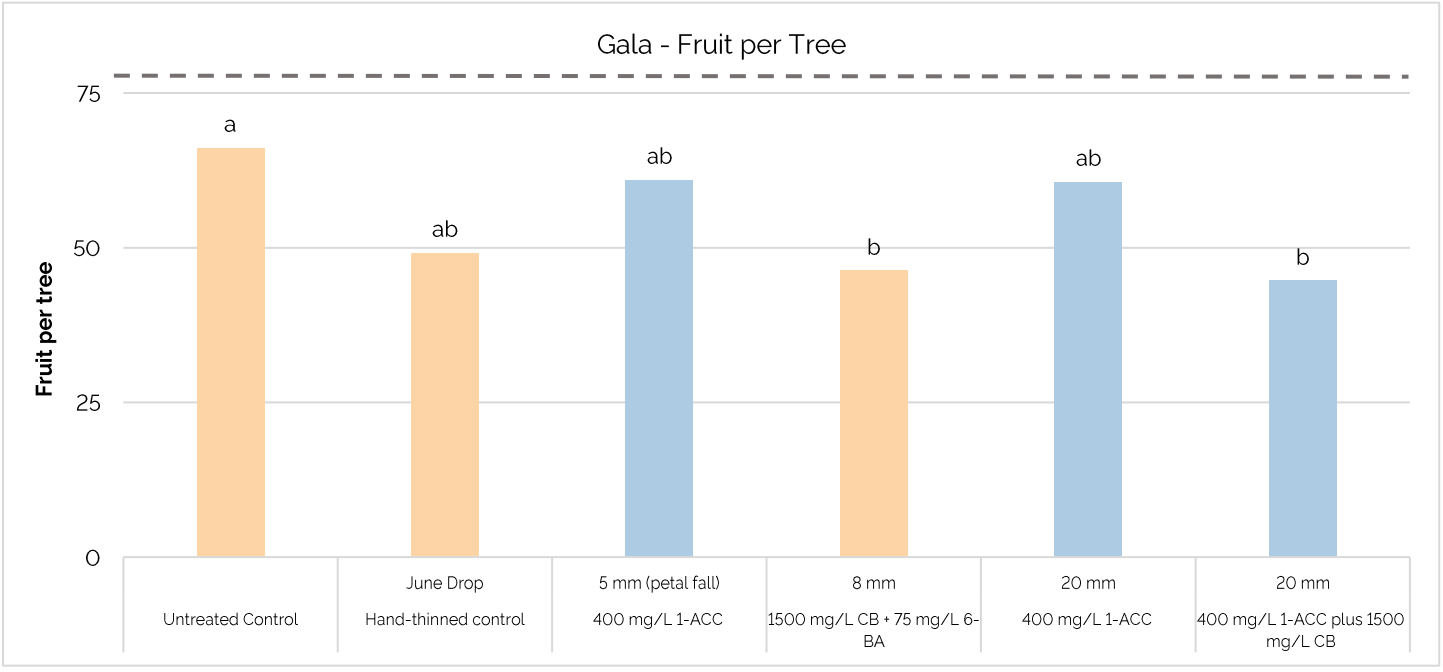

***Figure 3.** Influence of ACC (blue bars), carbaryl (CB), 6-benzyladenine (6-BA applied at petal fall, 7.8 mm and 20 mm fruitlet diameters on number of fruit per tree of 'Gala' trees in 2025. Treatments were applied at: a) petal fall, 6.1 mm fruitlet diameter on 20-May 2025 (7 days after bloom), b) 7.8 mm on 26-May (13 days after bloom), and c) at 20 mm on 11-June (29 days after bloom). Trees were hand thinned on 19-June (37 days after bloom). The horizontal line indicates the target number of fruit per tree. Mean values (bars) with the same letters are not significantly different according to Tukey's HSD test at P=0.05.*

Crop Load

Crop load, which adjusts for slight differences in trees size and is a calculation of the number of fruit divided by the trunk cross-section area, followed a similar pattern as number of fruit per tree. Treatments had a significant effect on crop load of Ambrosia ($P<0.0001$) but not Gala ($P=0.0518$) trees. For Ambrosia (Figure 4), trees treated with the hand thinned control, grower standard of CB+6-BA at 6.4 mm and, ACC tank mixed with carbaryl at 19 mm had lower crop loads than the untreated control. ACC applied alone at PF and 19 mm had no effect on crop load compared with the untreated control. For Gala (Figure 5), crop load was statistically similar for all treatments, but numerically trees treated with the grower standard of CB+6-BA at 7.8 mm, and ACC tanked mixed with carbaryl at 20 mm had lower crop loads compared with the untreated control, but similar as the hand thinned trees. Numerically, trees that were hand thinned or treated with ACC applied alone at PF and 19 mm had no effect on crop load compared with the untreated control.

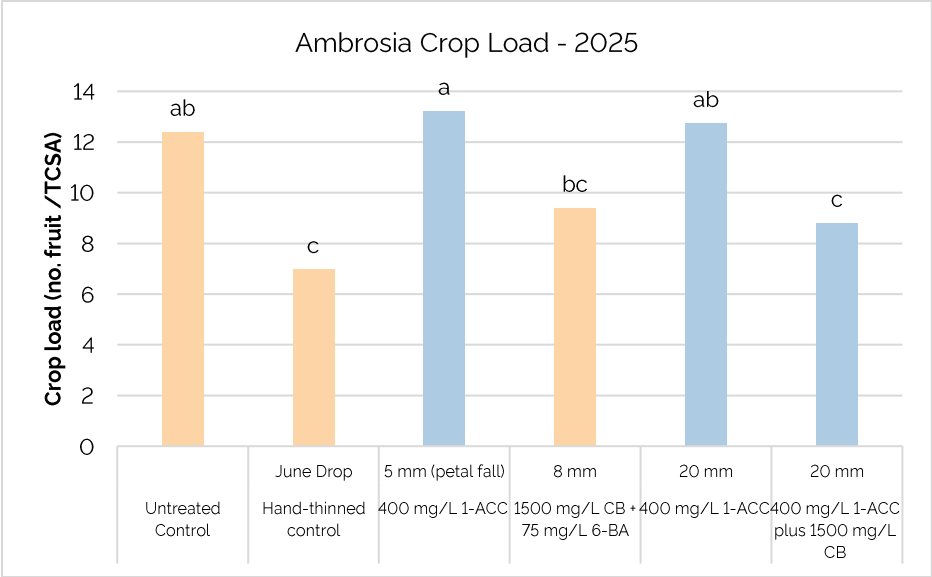

Figure 4. *Influence of ACC (blue bars), carbaryl (CB), 6-benzyladenine (6-BA applied at petal fall, 6.4 mm and 19 mm fruitlet diameters on crop load of 'Ambrosia' trees in 2025. Treatments were applied at: a) petal fall, 5.5 mm fruitlet diameter on 20-May 2025 (7 days after bloom), b) 6.4 mm on 26-May (13 days after bloom), and c) at 19 mm on 11-June (29 days after bloom). Trees were hand thinned on 19-June (37 days after bloom). Mean values (bars) with the same letters are not significantly different according to Tukey's HSD test at P=0.05.*

Fruit Weight

Treatments had a significant effect on the average fruit weight of Ambrosia ($P<0.0001$) but not Gala ($P=0.0592$) fruit (average based on all harvested fruit). For Ambrosia (Figure 6), trees that were hand thinned, or treated with the grower standard of CB+6-BA at 6.4 mm, and ACC+carbaryl at 19 mm, had 27%, 18% and 19% greater fruit weight than the untreated control, respectively. ACC applied alone at PF and 19 mm had no effect on fruit weight compared with the untreated control ($P=0.0592$). For Gala (Figure 7), fruit weights were statistically similar for all treatments ($P=0.0596$).

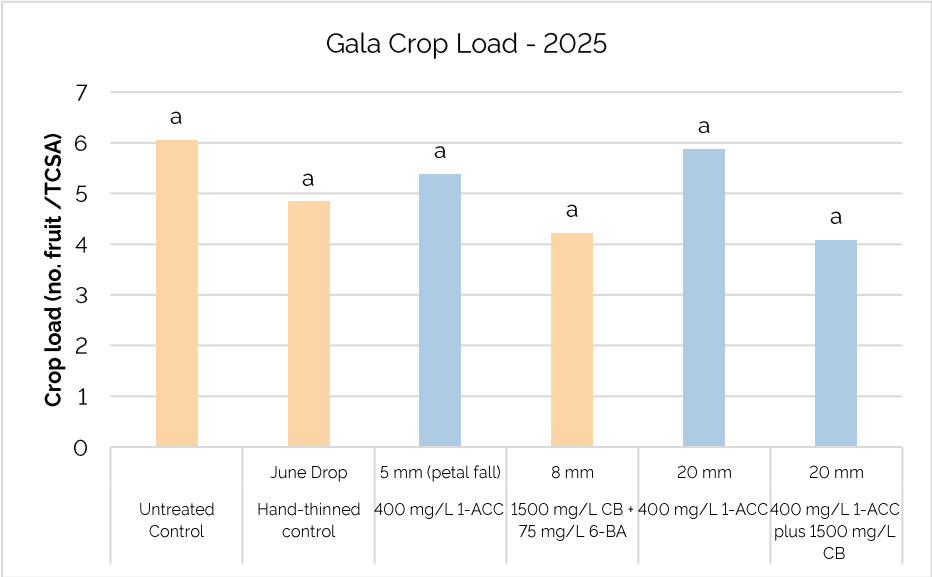

Figure 5. *Influence of ACC (blue bars), carbaryl (CB), 6-benzyladenine (6-BA applied at petal fall, 7.8 mm and 20 mm fruitlet diameters on crop load of 'Gala' trees in 2025. Treatments were applied at: a) petal fall, 6.1 mm fruitlet diameter on 20-May 2025 (7 days after bloom), b) 7.8 mm on 26-May (13 days after bloom), and c) at 20 mm on 11-June (29 days after bloom). Trees were hand thinned on 19-June (37 days after bloom). Mean values (bars) with the same letters are not significantly different according to Tukey's HSD test at P=0.05.*

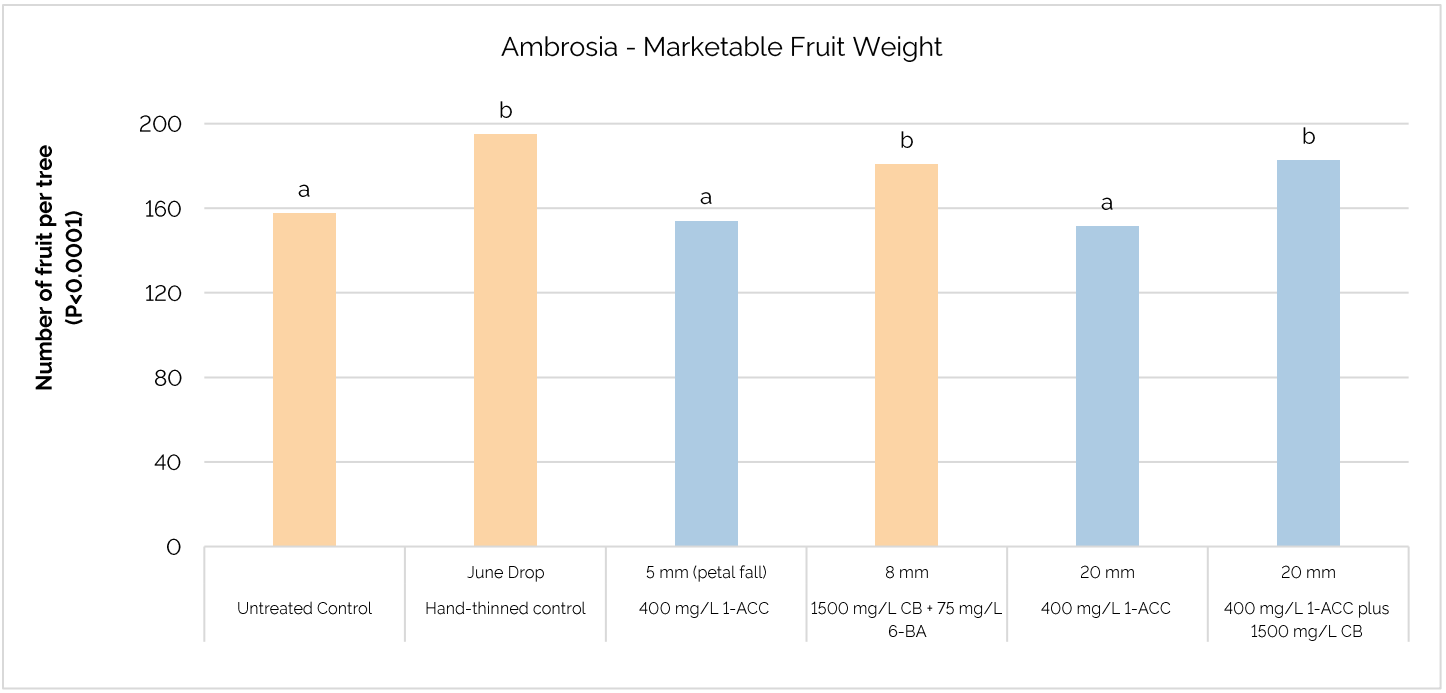

Figure 6. *Influence of ACC (green bars), carbaryl (CB), 6-benzyladenine (6-BA applied at petal fall, 6.4 mm and 19 mm fruitlet diameters on average fruit weight of 'Ambrosia' in 2025. Treatments were applied at: a) petal fall, 5.5 mm fruitlet diameter on 20-May 2025 (7 days after bloom), b) 6.4 mm on 26-May (13 days after bloom), and c) at 19 mm on 11-June (29 days after bloom). Trees were hand thinned on 19-June (37 days after bloom). Mean values (bars) with the same letters are not significantly different according to Tukey's HSD test at P=0.05.*

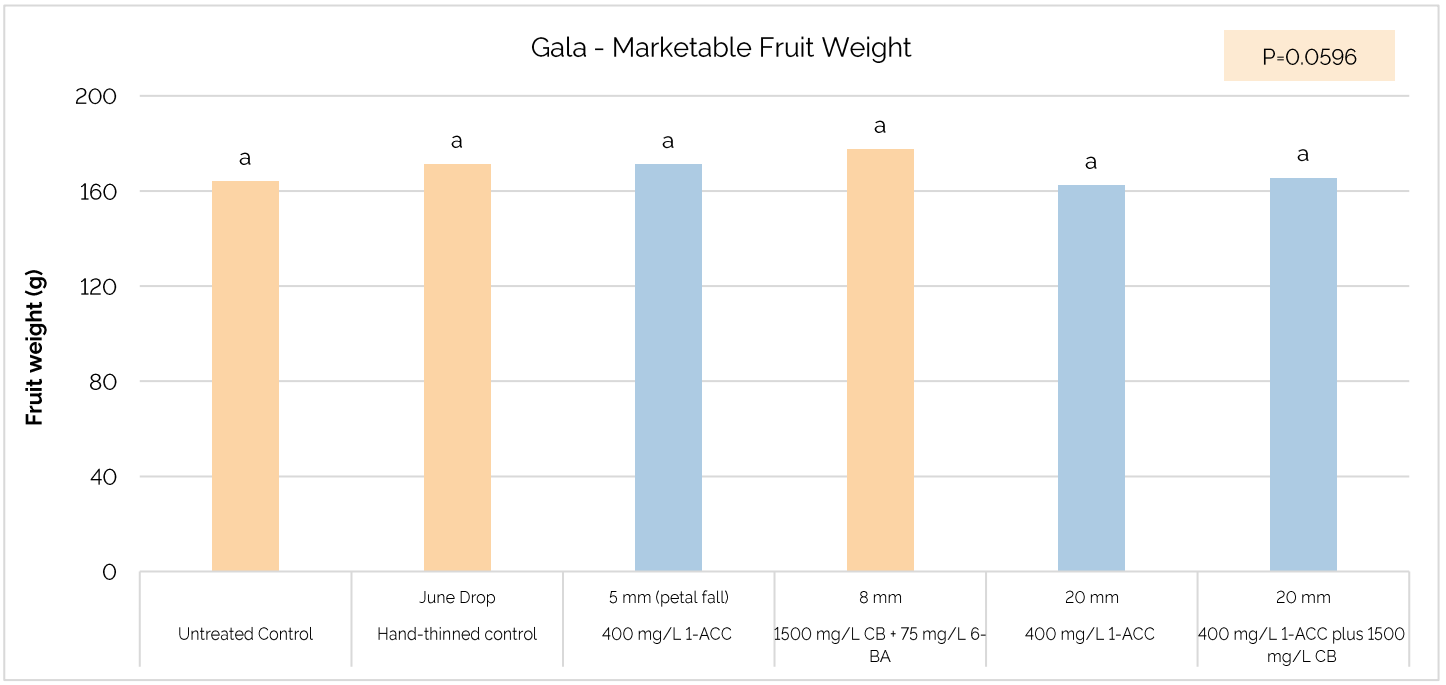

Figure 7. *Influence of ACC (green bars), carbaryl (CB), 6-benzyladenine (6-BA applied at petal fall, 7.8 mm and 20 mm fruitlet diameters on average fruit weight of 'Gala' trees in 2025. Treatments were applied at: a) petal fall, 6.1 mm fruitlet diameter on 20-May 2025 (7 days after bloom), b) 7.8 mm on 26-May (13 days after bloom), and c) at 20 mm on 11-June (29 days after bloom). Trees were hand thinned on 19-June (37 days after bloom). Mean values (bars) with the same letters are not significantly different according to Tukey's HSD test at P=0.05.*

Discussion and Conclusions

Weather conditions during early fruit development were unusually cool for a protracted period following bloom, making fruitlet chemical decision difficult. When more consistent warmer temperatures arrived on 2-June, king fruits were approximately 13 mm in diameter and approaching the outer limits of the ideal 8-15 mm fruitlet diameter thinning window. For this reason, it was a good year to evaluate a "late" timing of Accede®, a product that is promoted for "late" or "rescue" thinning. Unfortunately, there was no thinning response to ACC when applied at petal fall or 19-20 mm. Cool conditions were experienced during and following the PF application, but temperatures were ideal when ACC and ACC tank mixed with carbaryl were applied to 19-20 mm fruit on 11-June.

The reason for the lack of thinning with ACC is not fully understood but is consistent with several previous studies when we began evaluating ACC beginning in 2017. Culemann et al. (2025) suggest that ACC has poor mobility into apple leaves and even less into fruit relative to 6-BA and NAA. Increasing ACC uptake by the addition of salts such as calcium chloride or surfactants that increase the hydration of the spray deposit may increase the horticultural performance under field conditions.

Despite less-than-ideal environmental conditions when the grower standard tank mix of carbaryl and 6-BA was applied at 6-7 mm, this treatment proved effective at reducing fruit number and crop load on Ambrosia trees, but less so on Gala trees.

Ambrosia trees were likely more responsive because of the higher natural fruit set, while Gala trees had a natural fruit set of 6 fruit per cm^2 TCA, which resulted in fruit numbers less than the target crop of ~75 fruit per tree.

A surprising result of this study was to learn the effectiveness of the 'late' spray of carbaryl tank mixed with ACC when fruit were 19-20 mm in diameter (29 days after bloom). This slightly exceeded the allowable timing of XLR up to 25 days after bloom, but in a more typical year when fruit would grow faster under warmer temperatures during early fruit growth, staying with the 25-day limit would not likely be problematic. However, one consideration when using 'late' thinning sprays of Sevin XLR is that it has a 14-day REI for hand thinning (which in this was 25-June), and this may be too restrictive for growers who wish to start hand thinning earlier.

Overall, Sevin XLR appears to be an effective late thinner that has not previously been typically considered in our regional thinning programs. This study will be repeated in 2026 and further ways to explore methods to improve ACC may be investigated.

Acknowledgements

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Disclosures

Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the University of Guelph of the products named and does not imply criticism of similar ones not mentioned.

Literature Cited

Culemann, E., Brinkmann, T. & Knoche, M. (2025). Factors affecting penetration of 1-aminocyclopropane-1-carboxylic Acid (ACC) into apple fruit and leaves. J. Plant Growth Regul. https://doi.org/10.1007/s00344-025-11990-3