Potential Strategies for Thinning Apples without Carbaryl

John Cline
University of Guelph, Simcoe
Horticultural Experiment Station, Simcoe
14 ha of research orchards
Research focus: rootstocks, tree physiology, irrigation, soil management, nutrition, fruit quality, hard cider
Thinning is a common practice that improves fruit quality and ensures return bloom.

- Small fruit
- Damage to tree limbs
- Biennial bearing

† Resources for fruit
† Economic value
† Harvest efficiency

Over-cropping: 5 fruit cluster

Hand thinning = labour-intensive

(McArtney et al., 1996; Link, 2000; Dennis, 2000)
Factors Affecting Fruitlet Thinning
- After Williams and Edgerton, 1981

Cultural – cultivar, tree age, spur type

Chemical – product, concentration, uptake, surfactant

Tree Physiology – health, tree age, previous crop, biennial bearing, stress level, fruit cuticle

Weather – solar radiation, air temperatures (day/night),
Hand Thinning – Least Desirable

- Least effective on return bloom and final fruit size at harvest
- Labour is costly
What is the impetus for developing better thinning methods

- Thinning apple requires ~40 hrs/acre labour
- Hand thinning is done ~45 DAFB, resulting in an enormous ‘waste’ in photosynthetic energy
- Harvest efficiency – proportional to number of fruit per tree

Ontario minimum wage (1965-2018)

Source: Gov’t Canada
Natural Fruit Abscission

- June drop

Plant Bioregulators

- Plant bioregulators, influence plant metabolism, augment fruitlet thinning, cultivar-specific
- Registered: Carbaryl, cytokinin, auxin
- Not registered (alternatives): Ethylene precursor (ACC), abscisic acid, ethephon

Challenges

- Carbaryl no longer used in Europe
- Greater restrictions placed on Carbaryl in Canada
- Thinning window = Petal fall to 15 mm
• 1-2 applications per season
• 10-14 day re-entry for hand thinning
• Apply between late petal fall (after bees have been removed) to 25 days later

Sevin XLR Label

### Revised Restricted-Entry Intervals (REIs)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Activity</th>
<th>REI (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>apples (orchards that have transitioned to high density trellis production)</td>
<td>Hand harvest</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Hand thinning, hand-line irrigation</td>
<td>14</td>
</tr>
<tr>
<td>Max. application rate: 1.5 kg a.i./ha (chemical thinning application)</td>
<td>Hand pruning, scouting, pinching, tying, training</td>
<td>4</td>
</tr>
<tr>
<td>apples (orchards that have not transitioned to high density trellis production)</td>
<td>Hand harvest</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Hand thinning, hand-line irrigation</td>
<td>10</td>
</tr>
<tr>
<td>Max. application rate: 1.0 kg a.i./ha (chemical thinning application)</td>
<td>Hand pruning, scouting, pinching, tying, training</td>
<td>0.5</td>
</tr>
</tbody>
</table>
Timing

✓ NAD - Amidthin (King Bloom petal fall)

✓ 6-BA  8 to 12 mm

✓ Carbaryl (Sevin XLR) – late petal fall to 25 days after full bloom.

✓ NAA - Bloom to  12 mm

(later applications tend to reduce fruit size)
Table 1. Primary apple fruitlet thinners used for apples in Canada and their associated rates and estimated costs.

<table>
<thead>
<tr>
<th>Product</th>
<th>Active Ingredient</th>
<th>Units</th>
<th>Typical</th>
<th>PBR cost (cents/lb) apple produced (based on 30 bins/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruitone N</td>
<td>NAA</td>
<td>mg/L</td>
<td>10</td>
<td>$ 0.35</td>
</tr>
<tr>
<td>Fruitone L</td>
<td>NAA</td>
<td>mg/L</td>
<td>312</td>
<td>$ 0.35</td>
</tr>
<tr>
<td>Maxcel</td>
<td>6-BA</td>
<td>mg/L</td>
<td>100</td>
<td>$ 2.18</td>
</tr>
<tr>
<td>Cilis Plus</td>
<td>6-BA</td>
<td>mg/L</td>
<td>100</td>
<td>$ 2.18</td>
</tr>
<tr>
<td>Sevin XLR Plus</td>
<td>Carbaryl</td>
<td>Litre</td>
<td>1.0</td>
<td>$ 0.07</td>
</tr>
<tr>
<td>Sylgard 309</td>
<td>Siloxylated Polyether</td>
<td>% (v/v)</td>
<td>0.05%</td>
<td>$ 0.04</td>
</tr>
<tr>
<td>Agral 90</td>
<td>Nonylphenoxy polyethoxy ethanol</td>
<td>% (v/v)</td>
<td>0.05%</td>
<td>$ 0.03</td>
</tr>
</tbody>
</table>

1 - based on 1000 Litres of water per hectare (Tree row volume) University of Guelph
2 - based on 2010 grower price
3 - assuming 30 bins/acre (22,660 lbs/acre)
• Greater restrictions have been placed on Carbaryl.
• Fruitlet are most responsive the thinners when applied between 8-15 mm in diameter.
• Later fruitlet chemical thinning ‐ it would be beneficial if the thinning window were expanded beyond 15 mm to the 20-25 mm diameter stage.
• Fruit drop response takes 7+ days.
• Often, repeat sprays of 6-BA, carbaryl, or NAA following initial spraying is desired, but the effect of these second sprays are unpredictable with concern about over-thinning.
Objectives:

- Investigation of new fruitlet thinners s-ABA and 1-ACC
- Use NAA and 6-BA alone or in combination
Experiment 1: Materials and methods (2015-2106)

Eleven Treatments

Unthinned control

Hand thinned control (1 frt/spur, spaced 15-20 cm)

Carbaryl + 6-BA (standard)

75 mg/L 6-BA (Cytokinin) + *Auxin

75 mg/L -6-BA + *Abscisic acid

*Ethylene precursor (ACC)

*Chemical Thinners

Carbaryl = 1-naphthyl methylcarbamate (Sevin XLR Plus) 1000 mg/L

Cytokinin = 6-benzyladenine (6-BA) (Maxcel, Cilis Plus) 75 mg/L

Auxin = Naphthaleneacetic acid (Fruitone - NAA) 5, 10, 15 mg/L

Ethylene precursor = 1-aminocyclopropane-1-carboxylic acid (ACC) 5,10, 15 mg/L

Low, med, high ABA,ACC) = 150, 300, 450 mg/L
Materials and methods: Guard trees and a randomized complete block design

Experimental Design

• ‘Gala’
• Guard trees, replications in RCBD
• 2014 (9 mm): Simcoe Research Station
• 2015 (17 mm): Blenheim
Materials and methods: Efficacy of treatments, negative effects, and fruit quality

**Thinning Efficacy**
- Fruit set - before and after
- Crop load
- Yield
- Return bloom

**Treatment Effects**
- Phytotoxicity
- ‘Pygmy’ fruit

**Quality at Harvest**
- Firmness
- Appearance
- Taste
Results: Cytokinin + abscisic acid, and ethylene precursor promote thinning

**2014 at 9 mm**

**Fruit Set**
**Effective:** Cytokinin + auxin, cytokinin + abscisic acid

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**2015 at 17 mm**

**Fruit Set**
‘Pygmy’ fruit: Cytokinin + auxin
**Effective:** Cytokinin + abscisic acid, ethylene precursor

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*Percentage of fruit retained on tree relative to initial fruit count*
Results 2015: Some treatments matched the crop load of the carbaryl control

Harvest 2015:

**Crop Load** (Figure)
- Low and med rates of cytokinin + abscisic acid effective
- Low rate of ethylene precursor was effective
- Crop loads were naturally low both years

**Yield**
- High concentrations = low marketable

**Quality**
- Similar to carbaryl control
- Similar return bloom as control
Discussion: Cytokinin + abscisic acid and ethylene precursor consistent with previous research

Chemical Thinners

- Consistent
- Pygmy fruit = inconsistent, previous reports minor incidence in ‘Gala’

Concentration

- High over thinning = inconsistent, no over thinning ‘Golden Delicious’

Quality

- Consistent = No direct effects of chemical thinners

Differences between Years

1. Stage of development
2. Weather and cultural differences

(Bukovac et al., 2008; McArtney and Obermiller, 2012; Robinson, 2006; Schupp et al., 2012; Wertheim, 2000; Westwood and Batjer, 1958)
Conclusions: Cytokinin + abscisic acid and ethylene precursor are alternatives to carbaryl

Commercially Acceptable

• i. Low rates of cytokinin (6-BA) + abscisic acid
  ii. ethylene precursor (1-ACC) at (17 mm)

• Interpret with caution - naturally low crop load both years

• ABA and 1-ACC may be alternatives for fruitlet thinning ‘Gala’ if carbaryl is withdrawn from registration

Further Investigation is required

• Response of other cultivars to 1-ACC and s-ABA

• Reliability/consistency

• Research in the photosynthetic inhibitor metamitron (Brevis®)

(Wertheim, 2000; Westwood and Batjer, 1958)
Blossom thinning – is a (less preferred) option

Effective, but…

• None selective

• Requires a uniform, narrow hedge-row canopy to reach flowers

• Can spread fireblight

• Greater risk of frost injury compared with fruitlet thinning
Research Objectives:

- Investigate the pattern of fruitlet drop/abscission
- Determine the optimal concentration of plant bioregulators for thinning "Gala" fruitlets during the fruit set period (9 and 17 mm fruitlet diameter)
- How is thinning affected by a second spray of chemical thinner?
- What thinners work best?
- What was the final crop load, yield and fruit size response?
Experiment 2: Materials and methods (2013-2014)

- 12-yr old Gala trees on Bud.9 rootstocks
- 11 treatments, 6 single tree reps
- Randomized complete block design
- Commercial airblast sprayer – 800 L/ha TRV 1X
- Guard trees between treatment trees

### Treatments

<table>
<thead>
<tr>
<th>May 31 2013 1st Spray (8 mm)</th>
<th>June 7 2013 2nd Spray (+ 7 days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Unthinned control</td>
<td></td>
</tr>
<tr>
<td>2 Hand Thinned at June Drop</td>
<td></td>
</tr>
<tr>
<td>3 Carbaryl (1000 mg/L)</td>
<td>6-BA (75 mg/L)</td>
</tr>
<tr>
<td>4 Carbaryl (1000 mg/L)</td>
<td>Carbaryl (1000 mg/L)</td>
</tr>
<tr>
<td>5 Carbaryl (1000 mg/L)</td>
<td></td>
</tr>
<tr>
<td>6 6-BA (100 mg/L)</td>
<td>6-BA (75 mg/L)</td>
</tr>
<tr>
<td>7 6-BA (100 mg/L)</td>
<td>Carbaryl (1000 mg/L)</td>
</tr>
<tr>
<td>8 6-BA (100 mg/L)</td>
<td></td>
</tr>
<tr>
<td>9 6-BA (100 mg/L) + Carbaryl (1000 mg/L)</td>
<td></td>
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<td>10 6-BA (100 mg/L) + Carbaryl (1000 mg/L)</td>
<td>6-BA (75 mg/L)</td>
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<tr>
<td>11 6-BA (100 mg/L) + Carbaryl (1000 mg/L)</td>
<td>Carbaryl (1000 mg/L)</td>
</tr>
</tbody>
</table>
Effect of one or two applications of carbaryl (CB) and 6-benzyladenine (6-BA) applied alone or tank mixed in 2014 on cumulative fruitlet drop. The first application occurred on 4 June and the second application occurred on 12 June.
Experiment 2: Materials and methods (2013-2014)

Fruit set (2013-2014)
Crop load (2013-2014)

Crop load (no. fruit/TCSA)
Fruit weight (2013-2014)
Yield (2013-2014)

Total fruit yield (kg/tree)
Summary

- 12-14 days was required from the time of 1st spray for thinners to initiate fruit drop
- Single application of thinners applied at 8 mm advanced fruit drop
- A tank mix of 6-BA and Carbaryl applied ~8 mm followed by Carbaryl 14-15 mm was the most effective thinning treatment
- 6-BA applied at 8-9 mm followed by Carbaryl at 14-15 mm was also very effective
- When 6-BA was applied as a second spray, it was not effective in promoting fruit drop
- Combination sprays of 6-BA and Carbaryl, tank mixed or applied separately, were more effective than repeat sprays of the same product
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