Some Practical Advice from 30 Years of Chemical Thinning Research

Steve McArtney
Valent BioSciences LLC

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Topics to be covered...

Chemical thinning
- Benefits and importance
- Some underlying physiology that will help you make better decisions
- A unifying hypothesis – carbohydrate balance in the fruit is key
- Why product formulation is so important
- Life without carbaryl
- Putting it all together in a program
- ACC – something new for the future

Promalin
- Programs for fruit size enhancement
- An effective frost rescue treatment
The triple benefits of a successful thinning program

Benefit #1: Increased fruit size and crop value

Fruit size potential is determined within 40-50 days of bloom

A small apple at the end of the cell division phase is going to be a small apple at harvest

The earlier that you can establish the final crop load the larger fruit size will be at harvest
The triple benefits of a successful thinning program

Benefit #2: Reduced hand thinning costs

Hand thinning will normally occur after the cell division phase is finished

“You can make a big apple small but you can’t make a small apple big!”
The triple benefits of a successful thinning program

Benefit #3: Reduced risk of triggering a biennial bearing cycle

- Initial fruit set
- Initial seed set
- Summer NAA and Ethrel programs
- Success of chemical thinning program
- Other factors:
  - Nutrition
  - Tree vigor
  - ???
Why is light (and heat) important for fruit set?

During the period when thinners are applied, the carbohydrate supply from current photosynthesis is in balance with the demand from the different organs (roots, young shoots, fruit, wood), with the daily balance depending on the amount of sunlight and the temperatures experienced for that day.

A shortage of carbohydrates results in competition between fruit and shoots.

Fruit are weaker sinks than shoots at this time.
CARBOHYDRATE STRESS IN THE FRUIT INTEGRATES THE EFFECTS OF ENVIRONMENT AND CHEMICAL THINNERS ON FRUIT SET
• The fruit cuticle is 2-3 micrometers thick at bloom

• Thickness increases to around 15 micrometers at harvest

Source: Martin Goffinet
Dried droplet residue

Target (leaf or fruit)

active ingredient

cuticular matrix

Droplet contact area, drying time and penetrants will influence uptake
WATER-BASED FORMULATIONS CAN HAVE SOLUBILITY PROBLEMS

- Poorly formulated 6-BA product results in crystallization in solution
- Photograph shows 6-BA crystals in a solution of 150ppm
## Efficacy of different 6-BA products (PC FRUIT)

### Peer: Conference

<table>
<thead>
<tr>
<th>Product</th>
<th>Bloemknoppen</th>
<th>Vruchten</th>
<th>Vruchten/100 clusters</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controle</td>
<td>148</td>
<td>131</td>
<td>89</td>
<td>100</td>
</tr>
<tr>
<td>Globaryll 2 l/ha</td>
<td>154</td>
<td>108</td>
<td>71</td>
<td>80</td>
</tr>
<tr>
<td>MaxCel 10 l/ha</td>
<td>152</td>
<td>89</td>
<td>53</td>
<td>59</td>
</tr>
<tr>
<td>Exilis 10 l/ha</td>
<td>150</td>
<td>125</td>
<td>86</td>
<td>97</td>
</tr>
</tbody>
</table>

### Appel: Rockit

<table>
<thead>
<tr>
<th>Product</th>
<th>Bloemknoppen</th>
<th>Vruchten</th>
<th>Vruchten/100 clusters</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controle</td>
<td>131</td>
<td>180</td>
<td>137</td>
<td>100</td>
</tr>
<tr>
<td>Globaryll 1,5 l/ha</td>
<td>123</td>
<td>160</td>
<td>130</td>
<td>95</td>
</tr>
<tr>
<td>MaxCel 7,5 l/ha</td>
<td>111</td>
<td>122</td>
<td>111</td>
<td>81</td>
</tr>
<tr>
<td>Exilis 7,5 l/ha</td>
<td>109</td>
<td>141</td>
<td>130</td>
<td>95</td>
</tr>
</tbody>
</table>

*Bron: Pcfruit*
Different Sources and Concentrations of 6-BA in Chemical Thinning of Post-flowering in Apple Trees

Gentil Carneiro Gabardo\(^1\), José Luiz Petri\(^2\), Aike Anneliese Kretschmar\(^1\), Mariuccia Schlichting de Martín\(^2\), André Amarildo Sezerino\(^2\) and Willian Coser\(^1\)

\(^1\)Santa Catarina State University, Agroveterinary Sciences Center, Lages, Brazil.
\(^2\)EPAGRI/Caçador Experimental Station, Caçador, Brazil.

BA is efficient in fruit thinning in 'Fuji Suprema' apple trees, being the reduction of fruiting, and increase of fruit size, proportional to the applied concentration. There may be differentiated efficiency of the product by its formulation, even though they have concentrations of active ingredient equivalent. Exilis® was efficient in thinning of apple "Fuji Supreme", when applied to fruit 5 to 10 mm in diameter reduced the need for manual thinning, without causing toxicity. BA can
MaxCel® Use Rates by Variety and Thinning Difficulty

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Product Rate per Ha (in 1000 L)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 ppm</td>
<td>2.5 L / ha</td>
<td>Use for <em>size enhancement</em>. Make 2-4 apps at 3-10 day intervals starting at PF.</td>
</tr>
<tr>
<td>75 ppm</td>
<td>3.7 L / ha</td>
<td>Use for <em>moderate thinning</em> on varieties such as McIntosh, Paulared, Spartan, and Gingergold</td>
</tr>
<tr>
<td>100 ppm</td>
<td>5 L / ha</td>
<td>Use for <em>most thinning situations</em>. This rate has worked well on Gala, Empire, Golden Delicious and Red Delicious</td>
</tr>
<tr>
<td>150 ppm</td>
<td>7.5 L / ha</td>
<td>Use in orchards that have <em>very difficult</em> to thin cultivars such as Fuji or have a history of being difficult to thin.</td>
</tr>
</tbody>
</table>
MAXCEL® IN AN APPLE THINNING PROGRAM

<table>
<thead>
<tr>
<th>E</th>
<th>F1</th>
<th>F2</th>
<th>G</th>
<th>H</th>
<th>7 mm</th>
<th>15 mm</th>
<th>25 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethéphon</td>
<td>ATS</td>
<td>Mechanical</td>
<td>NAD</td>
<td>NAA</td>
<td>6BA</td>
<td>metamitron</td>
<td>Ethéphon</td>
</tr>
<tr>
<td>PRM 12® RP</td>
<td>Amid Thin® W</td>
<td>Rhodofix®</td>
<td>Fixor®</td>
<td>MaxCel®</td>
<td>Brevis®</td>
<td>PRM 12® RP</td>
<td></td>
</tr>
</tbody>
</table>
CARBOHYDRATE STRESS IN THE FRUIT INTEGRATES THE EFFECTS OF ENVIRONMENT AND CHEMICAL THINNERS ON FRUIT SET
Table 2-10. Suggested Rates of MaxCel or Cilis Plus to Use With or Without Sevin XLR

<table>
<thead>
<tr>
<th>Desired response(^1)</th>
<th>Concentration of 6-BA (ppm)(^2)</th>
<th>Concentration of Carbaryl (ppm)(^3)</th>
<th>Number of Applications</th>
<th>Amount of MaxCel (L/1,000 L water/ha)</th>
<th>Cilis Plus (L/1,000 L water/ha)</th>
<th>Amount of Sevin XLR (L/1,000 L water/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhance size only(^4)</td>
<td>10–50</td>
<td>—</td>
<td>2 to 4</td>
<td>0.5–2.65</td>
<td>0.5–2.5</td>
<td>—</td>
</tr>
<tr>
<td>Mild thinning (^5)</td>
<td>25–75</td>
<td>—</td>
<td>1 to 2</td>
<td>0.4–2.65</td>
<td>0.5–2.5</td>
<td>—</td>
</tr>
<tr>
<td>Moderate thinning</td>
<td>50–75</td>
<td>—</td>
<td>2 to 4</td>
<td>0.4–2.65</td>
<td>0.5–2.5</td>
<td>—</td>
</tr>
</tbody>
</table>

\(^1\) There are several levels of thinning intensity, ranging from very light to very aggressive.
\(^2\) 1 ppm is equal to 6-BA.
\(^3\) Mild thinning does not require Carbaryl use.
\(^4\) While 6-BA is spray concentrated, Carbaryl is not.

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**Precautions**

Do not apply MaxCel or Cilis Plus in combination with the hormone thinner, NAA (naphthaleneacetic acid), either as a tank-mix or separate sprays during the same growing season. Doing so may result in pygmy fruit.
Can NAA replace Carbaryl in 6-BA mixes?

As a rule of thumb 7.5ppm NAA can replace:

1 pint Carbaryl/100 gal ≈ 7.5 ppm NAA (3oz Fruitone L)

1 L Carbaryl /1000L ≈ 7.5 ppm NAA (200 ml/1000L Fruitone L)

in moderate to hard-to-thin varieties

However, this does not apply for varieties such as Fuji and Red Delicious as pygmy fruit may result.
EXCITING FUTURE FOR PGR’s FROM VBC

1-Aminocyclopropane carboxylic acid (ACC)

- Naturally occurring amino acid.
- Present in all major land plants (fruit, vegetables, grains, nuts, etc.).
- Immediate precursor of the plant hormone ethylene
- VBC holds numerous patents
- VBC has been studying ACC for a variety of commercial applications.
ACC IS A VERY EFFECTIVE LATE APPLE THINNER

3 days after applying ACC to ‘Cameo’ at 19 mm
POSITIONING ACC IN AN APPLE THINNING PROGRAM

<table>
<thead>
<tr>
<th>Days after full bloom</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

Full Bloom

ACC

maxCel™

Other thinning agents

Hand Thinning

Hand Thinning

Hand Thinning

Hand Thinning

Hand Thinning

Hand Thinning

Hand Thinning
ACC THINS STONE FRUIT

Trial #3  App A  600 ppm 7 DAT March 15th on Black Beaut Plums.-Visalia, CA
- **Gibberellins A4+7**
  - Promotes cell expansion - increase fruit size
  - Apples
    - Improves fruit shape
    - Increase size
    - Sets parthenocarpic fruit after a frost

- **6-Benzyladenine**
  - Promotes cell division
  - Increased fruit size
  - Stimulates branching
PROMALIN® FROST RESCUE TREATMENT (APPLE)
PROMALIN® FROST RESCUE TREATMENT (APPLE)

Arrows indicate when Promalin® was sprayed.
APPLE FLOWERS ARE MOST SENSITIVE TO LOW TEMPERATURE DURING BLOOM

Question: How Much Damage will -4.5°C cause at Full Bloom?

Answer: > 90% flowers dead after 30 minutes exposure
PROMALIN® FROST RESCUE TREATMENT (APPLE)

- Promalin 1.2L/Ha
- Untreated
- Parthenocarpic fruit
VALUE TO THE FARMER OF PROMALIN® FROST RESCUE TREATMENT (APPLE)

Table 1. Effects of gibberellin A<sub>4</sub> + A<sub>7</sub> and 6-benzyladenine (GA<sub>4+7</sub> plus 6-BA) treatments after freezes during full bloom on 12 and 13 Apr. 2012 on fruit set, total yield, fruit number per tree, and mean fruit weight of ‘Taylor Spur Rome’/‘M.7’ apple in Henderson County, NC.

<table>
<thead>
<tr>
<th>Treatment*</th>
<th>Fruit set (fruit/100 clusters)</th>
<th>Yield (kg/tree)&lt;sup&gt;+&lt;/sup&gt;</th>
<th>Yield (bu/acre)&lt;sup&gt;+&lt;/sup&gt;</th>
<th>Fruit (no./tree)</th>
<th>Mean fruit wt (g)&lt;sup&gt;+&lt;/sup&gt;</th>
<th>Crop value ($/acre)&lt;sup&gt;+&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated control</td>
<td>2.6 a&lt;sup&gt;+&lt;/sup&gt;</td>
<td>11.7 a</td>
<td>94 a</td>
<td>58 a</td>
<td>198</td>
<td>1965</td>
</tr>
<tr>
<td>GA&lt;sub&gt;4+7&lt;/sub&gt; plus 6-BA (25 mg·L&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>17.7 b</td>
<td>36.8 b</td>
<td>296 b</td>
<td>195 b</td>
<td>185</td>
<td>5807</td>
</tr>
<tr>
<td>GA&lt;sub&gt;4+7&lt;/sub&gt; plus 6-BA (50 mg·L&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>14.9 b</td>
<td>33.9 b</td>
<td>273 b</td>
<td>185 b</td>
<td>182</td>
<td>5328</td>
</tr>
</tbody>
</table>

Significance: **NS***

<sup>+</sup>Calculated assuming cull fruit had a value of $0.20/lb ($0.441/kg) and fresh fruit had a value of $0.57/lb ($1.257/kg); $1/acre = $2,471/ha.

Values in a column with different letters are statistically different by Duncan’s multiple range test at P ≤ 0.05.

NS, **, ***Nonsignificant or significant at P ≤ 0.01 or 0.001, respectively, based on analysis of variance.

Source: McArtney et al., 2014
# VALUE TO THE FARMER OF PROMALIN® FROST RESCUE TREATMENT (APPLE)

Table 4. Effect of 50 mg·L$^{-1}$ (ppm) gibberellin A$_4$ + A$_7$ and 6-benzyladenine (GA$_{4+7}$ plus 6-BA) sprays after a series of frost/freeze events during pink bud and full bloom on fruit set, yield, crop load, mean fruit weight, seed number per fruit, and crop value of ‘Ginger Gold’, ‘Gala’, and ‘Jonagold’ apple trees on ‘M.9’ rootstock in Geneva, NY.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Treatment</th>
<th>Fruit set (fruit/100 clusters)</th>
<th>Fruit (no./tree)</th>
<th>Yield (kg/tree)$^a$</th>
<th>Yield (bu/acre)$^a$</th>
<th>Crop load (% full crop)</th>
<th>Mean fruit wt (g)$^b$</th>
<th>Seeds (no./fruit)</th>
<th>Crop value ($/acre)$^c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ginger</td>
<td>Control</td>
<td>8.5</td>
<td>9</td>
<td>1.6</td>
<td>50</td>
<td>4</td>
<td>207</td>
<td>5.5</td>
<td>967</td>
</tr>
<tr>
<td>Gold</td>
<td>GA$_{4+7}$ plus 6-BA</td>
<td>25.4</td>
<td>24</td>
<td>4.6</td>
<td>141</td>
<td>12</td>
<td>198</td>
<td>1.6</td>
<td>1944</td>
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<tr>
<td></td>
<td>Significance$^3$</td>
<td>NS</td>
<td>NS</td>
<td>**</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>**</td>
</tr>
<tr>
<td>Gala</td>
<td>Control</td>
<td>39.9</td>
<td>168</td>
<td>21.6</td>
<td>664</td>
<td>55</td>
<td>133</td>
<td>—</td>
<td>5057</td>
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<tr>
<td></td>
<td>GA$_{4+7}$ plus 6-BA</td>
<td>49.4</td>
<td>200</td>
<td>25.9</td>
<td>797</td>
<td>66</td>
<td>132</td>
<td>—</td>
<td>5988</td>
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<td>Significance</td>
<td>NS</td>
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<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td>Jonagold</td>
<td>Control</td>
<td>18.3</td>
<td>20</td>
<td>4.8</td>
<td>148</td>
<td>11</td>
<td>268</td>
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<td>2238</td>
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<tr>
<td></td>
<td>GA$_{4+7}$ plus 6-BA</td>
<td>45.6</td>
<td>71</td>
<td>17.9</td>
<td>550</td>
<td>39</td>
<td>257</td>
<td>—</td>
<td>8456</td>
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<tr>
<td></td>
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<td>**</td>
<td>**</td>
<td>**</td>
<td>NS</td>
<td>**</td>
<td>NS</td>
<td>**</td>
<td>**</td>
</tr>
</tbody>
</table>

$^1$1 kg = 2.2046 lb, 1 42-lb (19.1 kg) bushel (bu) per acre = 47.0757 kg·ha$^{-1}$, 1 g = 0.0353 oz.

$^a$Long-term average fruit prices were assigned to the yield in each packout size to calculate a gross crop value excluding packing, storage, and sales charges; $1/acre = $2.4711/ha.

$^b$Ns, **Nonsignificant or significant at $P \leq 0.01$, respectively, based on analysis of variance.

Source: McArtney et al., 2014

- **GINGER GOLD**: +5 TON/Ha
- **GALA**: +7.3 TON/Ha
- **JONAGOLD**: +22 TON/Ha

**+US$2,400/Ha**

**+US$15,500/Ha**
PROMALIN® CAN BE SPRAYED SIX DAYS AFTER A FROST (APPLE)

Frost in 2014

<table>
<thead>
<tr>
<th>Date</th>
<th>Start</th>
<th>Finish</th>
<th>Duration</th>
<th>Low Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-Apr</td>
<td>20:54</td>
<td>8:34</td>
<td>9.5 hr</td>
<td>26.6</td>
</tr>
<tr>
<td>17-Apr</td>
<td>4:24</td>
<td>8:04</td>
<td>3.5 hr</td>
<td>27.5</td>
</tr>
</tbody>
</table>

Promalin Application (days after frost) | Fruit set (%) | Significance
--- | --- | ---
Control | 11.7 a | 0.002
1 day | 20.2 bc |
2 days | 21.9 bc |
3 days | 16.1 ab |
5 days | 18.9 bc |
6 days | 24.1 c |

Brookfield Gala/M.7
Unpubl. data from North Carolina (2014)
Thank You