Some Uses of Plant Growth Regulators in Modern Apple Production Systems

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Some Uses of PGR’s

- Crop load management
- Control of russet
- Breaking a biennial bearing cycle
- Reducing preharvest fruit drop
Light is important for fruit set.
The carbohydrates required for initial growth of leaves and flowers comes from reserves in the trunk and roots.

The reserves run out about the time of bloom.

After bloom the leaves have to supply all of the carbohydrates required for growth of fruits and shoots.
Fruit are Weak Sinks

Some fruit are weaker sinks than other fruit. Why?

• Differences in seed number?

Stress resulting from **cloudy weather** or **chemical thinners** or **high temperatures** will slow down the fruit growth rate

• Smaller fruit are the first to show reduced growth rates during stress
Chemical thinners can ...

- trigger a burst of ethylene
- slow down the rate of fruit growth

This reduction can be measured within the first week after application

http://www.umass.edu/fruitadvisor/2008/predictthinprocedure.pdf
The MaluSim Carbon Balance Model for predicting chemical thinner response

Photosynthesis sub-model
Photosynthesis Sub-model

To run the model...

- Julian day of bud break
- Daily max. temperature
- Daily min. temperature
- Daily total solar radiation
Daily Carbohydrate Balance
(MaluSim Model Output, run by Terence Robinson)

North Carolina 2010

Full Bloom

Petal fall thinners applied
Fruit thinners applied

deficit

Days after Bud Break

Carbohydrate Balance (g/day)
Chemical thinning recommendations based on short-term averages (3 days ahead) of the predicted daily carbon balance (thinning index)

<table>
<thead>
<tr>
<th>Thinning Index</th>
<th>Recommendation</th>
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<tbody>
<tr>
<td>positive</td>
<td>Expect little or no response to normal rates of chemical thinners. You will need to thin more aggressively than normal</td>
</tr>
<tr>
<td>0 to -20 g/day</td>
<td>Expect normal thinning responses to standard rates of chemical thinners</td>
</tr>
<tr>
<td>-20 to -40 g/day</td>
<td>Expect normal to slightly aggressive responses to standard rates of chemical thinners</td>
</tr>
<tr>
<td>-40 to -60 g/day</td>
<td>Expect aggressive responses to standard rates of chemical thinners. Consider reducing rates to avoid over thinning</td>
</tr>
<tr>
<td>-60 to -80 g/day</td>
<td>Expect very aggressive responses to standard rates of chemical thinners. Reduce rates to avoid over thinning</td>
</tr>
<tr>
<td>&lt; -80 g/day</td>
<td>Standard rates of thinners will result in severe over-thinning. Reduce rates by at least 50 percent.</td>
</tr>
</tbody>
</table>
Carbohydrate Stress in the Fruit Integrates the Effects of Environment and Chemical Thinners on Fruit Set
Control of russet
Epicuticular waxes protect the fruit from desiccation, insect and physical damage, pathogen attack (?)
epidermis

phellogen

filling tissue
Lenticels develop early, causing a break in the epicuticular waxes, Exposure of hypodermal cells to air stimulates a wound response – phellogen activation results in cork cell formation (russet)
Rapid relative fruit expansion rates during the first few weeks after bloom can generate stress-fractures in areas where the cuticle is weak.
Application of ‘caustic’ chemicals when the cuticle has been breached like this can increase russet incidence
Environmental Conditions and Chemical Sprays Have Additive Effects on Russet

3 Applications of 2% Lime Sulfur as a bloom thinning spray

![Graph showing the effects of lime sulfur applications on russet defects in apples.](image)

Reject line
Provide + Apogee
meristem apex flat means it is vegetative
meristem apex domed means it is floral
Once doming occurs floral differentiation proceeds rapidly.

The central (king) bloom is the last to initiate.

Courtesy Toshi Foster.
Immature seeds produce gibberellins that diffuse to the developing bud to inhibit flower formation.
The Biennial Bearing Cycle

Williams and Edgerton, 1981

Increase flower bud formation in the on year

chemical thinning
Ethrel
NAA
NAA Programs for Return Bloom

Summer NAA

Four bi-weekly applications of 5 ppm NAA beginning in mid-June

Preharvest NAA

Four, weekly applications of 5 ppm NAA beginning one month prior to anticipated harvest. Primarily applied for stop drop control.
Preharvest NAA sprays are applied after doming is over???

Buds were sampled from non-flowering spurs on two year old or older wood.
Ethrel and NAA treatments for Return Bloom

(‘Golden Delicious’, 2006)

Return bloom (% floral spurs)

Control  Summer NAA  Preharvest NAA  Ethrel

a  c  c  b
Comparison of NAA and Ethrel programs for return bloom

<table>
<thead>
<tr>
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<th>Summer NAA</th>
<th>Ethrel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Timing:</strong></td>
<td>Start program in late June.</td>
<td>Make one application 5-6 weeks after bloom when the thinning window is over.</td>
</tr>
<tr>
<td><strong>Frequency:</strong></td>
<td>Four bi-weekly applications.</td>
<td>Usually only one application is needed.</td>
</tr>
<tr>
<td><strong>Rate:</strong></td>
<td>5 ppm NAA (Fruitone L) for all varieties.</td>
<td>Rate is variety dependent.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16-24 oz/acre: Gala, Rome, Red Delicious</td>
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<td></td>
<td></td>
<td>24-48 oz/acre: Golden Delicious</td>
</tr>
<tr>
<td></td>
<td></td>
<td>48-72 oz/acre: Fuji, Cameo</td>
</tr>
<tr>
<td><strong>Notes:</strong></td>
<td>Can be included with cover sprays.</td>
<td>Not recommended on early season varieties prone to pre harvest drop eg. Honeycrisp.</td>
</tr>
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</table>
“The controlling system of a process is as complex as the process itself”
Ashby’s Law of Requisite Variety

There is no such thing as a silver bullet

Initial Fruit Set
Success of Thinners

Summer NAA and Ethrel programs

Other factors:
• Nutrition
• Tree vigor
• ???
Natural fruit drop varies from year to year

Long-Term Drop Study

• Yearly drop records from 1991-2001

• ‘Red Delicious’ orchard in Henderson Co.

• Fruit drop recorded weekly for six weeks starting from the normal harvest date each year
The Role of Ethylene in Fruit Ripening

- SAM
- ACC
- Ethylene
  - fruit softening
  - starch breakdown
  - stem loosening
  - red color development
Effects of **ReTain** on Fruit Ripening

- **SAM**
  - \( \text{MdACS1} \downarrow \)
  - \( \text{ACC} \)
  - \( \text{MdACO1} \downarrow \)

- **Ethylene**
  - \( \text{MdPG1} \downarrow \)
  - \( \text{MdPG2, MdEG1} \downarrow \)

- **fruit softening**
- **starch breakdown**
- **red color development**
- **stem loosening**
Effects of NAA on Fruit Ripening

SAM → ACC

MdACS1

ACC → Ethylene

MdACO1

Ethylene →

fruit softening

MdPG1

starch breakdown

MdPG2, MdEG1

stem loosening

red color development
Mixing ReTain and NAA

Why bother?

**ReTain** inhibits ethylene formation, but is **slow** to act
- Delays softening, starch breakdown, red color, stem loosening

**NAA** only delays stem loosening, is **quick** to act, but is not persistent

Maybe the effects of combining and ReTain and NAA are additive?
- don’t see negative effects of NAA (softening) when combined?

Maybe you can reduce the rate of ReTain without losing efficacy?

<table>
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| -4 | -3 | -2 | -1 | Harvest | 1 | 2 | 3 | 4 |

Weeks from Harvest
“I despise using ReTain on Gala because of what it does to color”
ReTain and NAA Combinations on Red Color of ‘Scarlet Gala’ – Harvest 1

Tree 1 | Tree 2 | Tree 3 | Tree 4

- Control
- ReTain Full
- 4 WBH
- 10 ppm NAA
- 2 WBH
- ReTain Full + 10 ppm NAA
- 2 WBH
- ReTain Half + 10 ppm NAA
- 2 WBH
# ReTain and NAA Combinations on Red Color of ‘Scarlet Gala’ – Harvest 4

<table>
<thead>
<tr>
<th>Tree 1</th>
<th>Tree 2</th>
<th>Tree 3</th>
<th>Tree 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Control" /></td>
<td><img src="image2" alt="Control" /></td>
<td><img src="image3" alt="Control" /></td>
<td><img src="image4" alt="Control" /></td>
</tr>
<tr>
<td><img src="image5" alt="ReTain Full" /></td>
<td><img src="image6" alt="ReTain Full" /></td>
<td><img src="image7" alt="ReTain Full + 10 ppm NAA" /></td>
<td><img src="image8" alt="ReTain Full + 10 ppm NAA" /></td>
</tr>
<tr>
<td><img src="image9" alt="4 WBH" /></td>
<td><img src="image10" alt="4 WBH" /></td>
<td><img src="image11" alt="2 WBH" /></td>
<td><img src="image12" alt="2 WBH" /></td>
</tr>
<tr>
<td><img src="image13" alt="10 ppm NAA" /></td>
<td><img src="image14" alt="10 ppm NAA" /></td>
<td><img src="image15" alt="10 ppm NAA" /></td>
<td><img src="image16" alt="10 ppm NAA" /></td>
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