IMPROVE TREE PERFORMANCE USING PLANT GROWTH REGULATORS

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KEYWORDS
Growth control, Plant growth regulators, Prohexadione-calcium, chemical thinning, branching, ethylene inhibitors, Apogee, Kudos, AVG, harvest delay.

ABSTRACT
Plant growth regulators (PGRs) are compounds that regulate or direct specific physiological processes in the plant that improve fruit quality while helping to optimize production. It must be emphasized that PGRs can only be used effectively and profitably when applied to properly designed trees in a well-managed orchard. While they may help troubled orchards they are most effectively used in amplifying the value of fruit harvested in well managed orchards.

Growth Control
Effective growth control is extremely important in today’s well managed orchard. Prohexadione-calcium (Pro-Ca) has emerged as being the most important growth PGR in used in the orchard today. There are two formulations available (Apogee and Kudos) and these appear to perform comparably. Although Pro-Ca has been in use for many years we are still learning about how to use this most effectively. It requires 10 to 14 days after application for Pro-Ca to function fully as a growth retardant. Since trees in northern climates start to grow early and the most rapid growth is early, it is important to apply Pro-Ca as early as possible or when sufficient tissue has emerged to absorb it. When applied early repeat application(s) are generally necessary. The amount applied and the frequency of application depends on the amount initially applied and the propensity for the trees to grow. Pro-Ca can increase fruit set. This can be considered a positive effect when used on trees that will or have been blossom thinned. Generally, Pro-Ca treated orchards required a more aggressive thinning program to compensate for its tendency to reduced June drop.

Delay in harvest and drop control
Many commercial varieties suffer from moderate to severe preharvest drop. Consequently, controlling this malady as well as retarding ripening account for a very large portion of the total PGR use. While drop is less of an issue in Washington these same drop control products, ReTain and Harvista can be used to delay ripening. ReTain appears to be used much more frequently than is Harvista due in large part to the ability of the grower to apply what is needed at the proper time compared with application of Harvista which in most cases is done or directed by the company using
special application techniques or equipment. Response to ReTain is linear; the more you apply the greater the response. We generally use the maximum rate allowed per application on difficult varieties such as McIntosh. We use a third to half that amount on low ethylene producing varieties such as Honeycrisp and Gala. Although ripening is delayed as assessed by the starch test, treated fruit still lose firmness, so firmness must be monitored.

Branching
There has been an increase in the interest in increasing branching on trees in the orchard especially on trees grown as a tall spindle. The use of BA as the formulation MaxCel is the usual product used because of its effectiveness and the absence of GA to inhibit flower bud formation. Notching is also used to increase branching. When done together, prior to bloom a large percent of the treated bud break and develop into functional lateral shoots.

Chemical thinning
Crop load adjustment is one of the most important things and orchardist must do and it can influence the bottom line more than almost any other management decision. The use of PRGs is critical. Fruit may be thinned over at least a 3 week period. During this time a fruit is goes through changes that dictate the type of chemical approach that must be used. Initially at bloom caustic products or products that influence pollen germination of pollen tube growth are most useful. Hormone-type thinners such as NAA, Amid-Thin MaxCel or carbaryl may be used at petal fall but the mode of action as thinners at this time is unclear. As a fruit grows and develops it becomes a sink for photosynthates thus making them vulnerable to thinners that cause a stress in the trees by limiting available carbohydrate. It is at this stage that hormonal thinners are most effective.
PGRs in Tree Manipulation

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Good Horticulture Comes First

• PGRs are an indispensable tool to achieving the highest performance in a block
• While the use of PGRs can mask a few problems they are no substitute for good management and horticulture.
• PGRs augment the value of fruit harvested from a well planned and managed orchard
• They do not undo a multitude of sins
Don’t Expect Miracles

• You can’t turn a sows ear into silk purse.
• PGRs can’t transform poor quality fruit on poorly managed trees into quality fruit.
• PGRs do enhance the value of fruit in well managed blocks, often significantly so.
PGRs Used in Many Areas

- Growth Control
- Improved branching
- Chemical Thinning
- Delay maturity and drop control
- Advance fruit maturity
- Improve fruit finish and shape
- Increase flowering and return bloom
Growth Control Techniques

• Growth control can be achieved in many ways
  – Rootstock
  – Crop load management
  – Training system and pruning
  – Horticulture growth control tool box
  – Root pruning

• Plant growth regulators
  – Can be used at almost any time and the results may be achieved rapidly.
PGR Advantages

- Extremely convenient
- Very versatile
- Can be started and stopped as needed
- The use is not irreversible such as a rootstock selection or a training system selection.
Gibberellins

• Gibberellins are the major group of hormones responsible for stimulating vegetative growth.
• Controlling the production of this hormone in the tree is a very convenient and effective way to regulate growth.
• There are several gibberellin biosynthesis inhibitors known but Prohexadione-Ca is the only GA synthesis inhibitor cleared for use in apple orchards in the US.
• Many have been tested.
Growth Control

• The primary growth control PGR in use today is Prohexadione-calcium.
• It was put on the fast track to regulatory approval a number of years ago (1997)
• Little research has been done (supported) on this compound in recent years.
• Most progress has been through grower trials and observations.
Gibberellin Inhibition

- Gibberellins are the dominant group of hormones that promote vegetative growth.
- Therefore, controlling the synthesis of this hormone is an effective way to limit growth in a tree.
- Pro-Ca inhibits GA biosynthesis late in the synthetic pathway thus the predominant effect is on GA synthesis.
- There are relatively few side effects.
Gibberellins (GA) stimulate vegetative growth.

Inhibition of GA synthesis or action is a good way to regulate plant (tree) growth.
Prohexadione-calcium

- There are now two formulations registered for use by apple growers in the US.
  - Apogee
  - Kudos
  - Both are 27.5% formulations
- Both formulations appear to have similar growth control capability.
- Regalis 10% is available in other locations where Pro-Ca is registered.
Apogee vs Kudos
Keys to Successful Use

- A water conditioner or Mg sulfate equal in weight to the amount of Apogee used is recommended.
- If pH too high Apogee may be inactivated.
- A surfactant
- Antifoam agent may be useful
- No calcium-containing compounds should be in the same tank.
Time of Application

• Apply as early in the growing season as there is sufficient leaf area for absorption.
• To achieve the maximum amount of growth control, early application (in the season) is necessary.
• Official Apogee literature does not encourage early application but I think that this is an error, especially in the northern tier of states in the US.
Influence of location on growth rate and duration
There is a lag time

- APogee does not immediately stop growth once application has been made.
- It requires at least 10 to 14 days from the time Pro-Ca is applied for the growth control to be seen.
- During this time terminal shoots are growing very rapidly.
- Growth retardation is lost if the first application is made after shoot growth starts.
Cortland Untreated Control
Cortland- Pink
Cortland- Start of Petal Fall
Amount to Apply?

• The amount to apply per application and the number of applications is somewhat vigor dependent.

• In the East we have tended to use lower initial rates and more applications to avoid:
  – Increased fruit set
  – Difficulties achieving satisfactory thinning.
  – This conclusion was arrived at by logic and interpreting a foggy crystal ball Guessing), not experimentation.
<table>
<thead>
<tr>
<th>Treatment (Mg/L)</th>
<th>Fruit set Fruit/cm LCSA</th>
<th>Return bloom Bloom/cm LCSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.3</td>
<td>8.4</td>
</tr>
<tr>
<td>125</td>
<td>6.2</td>
<td>6.1</td>
</tr>
<tr>
<td>250</td>
<td>8.2</td>
<td>4.1</td>
</tr>
<tr>
<td>375</td>
<td>9.8</td>
<td>3.3</td>
</tr>
<tr>
<td>Significance</td>
<td>***</td>
<td>***</td>
</tr>
</tbody>
</table>
Thinning Recommendations

• Our thinning recommendations include suggestions for more aggressive thinning on blocks of trees treated with Apogee.

• We have been operating under the assumption that if low rates are used initially, this will reduce the effect of increasing fruit set.

• This may not be the case.

• More frequent application of lower rates helps counter the reduced rates.
All rates of Apogee increased fruit sets on Fuji

![Graph showing fruit per cm LCSA over different dates and treatments]

- **Date Set Taken**: 5-28, 6-6, 6-16, 7-25
- **Fruit per cm LCSA**: 5, 10, 15, 20, 25
- **Treatments**:
  - Control
  - Pro-Ca 3
  - Pro-Ca 6
  - Pro-Ca 9
  - Pro-Ca 12

The graph illustrates the increase in fruit per cm LCSA over different treatments and dates.
The 3 oz Apogee rates started to grow
Fuji Untreated Control
Apogee 9 oz/100 gal One Application
Suggestions for Maximum Growth Control Using Apogee

• For maximum growth control, apply as early as there is tissue to absorb the Apogee.
• Apply at rates of at least 9 oz per 100 gal
• Repeat application at least once 2.5 to 3 week intervals.
• Apply additional Apogee if needed at a lower rate
• Thin aggressively.
How Much is Needed?

- The jury is still out on how much is needed.
- Much depends on the growth potential of the trees and the weather.
- We can not turn off the rain in the East so that is an unregulatable variable that you do not have here.
Apogee- Fire Blight Control

• Fire blight has emerged as one of the most damaging diseases on apple trees.
• Apogee is one of the most used defenses against shoot blight.
• Strep is commonly used for blossom blight but not for shoot blight- resistance strategy
• The amount required for effective or maximum control is in debate. but generally the higher amount is more effective.
Apogee- Fire Blight Control

• Dilemma on young trees.
• Generally, we try to fill the space in young plantings as soon as possible.
• Growth retardation seems counter productive, but loosing trees is a poor alternative.
• It is often used in situations where there is a high risk for fire blight.
Ethrel (ethephon)

- Ethrel is one of the oldest and most effective growth retardants available.
- Its use is very limited since it is also an effective thinner.
- Rates that are effective at reducing terminal growth also may thin severely.
- It was used quite extensively 30 to 35 years ago to increase flowering and regulate growth of young trees on semidwarf rootstocks.
- More dwarfing and precocious rootstocks are now used reducing the need for ethephon to enhance flowering.
Increase Branching on Young Trees

• Tall spindle is the dominant tree form being plated in Eastern US
• Frequently there are large areas of the main axis that do not have feathers.
• It would be useful to improve cropping potential by increasing the number of branches
Increase Branching on Tall Spindle Trees

• 25 years ago I did work in the US and Australia to try increase branching on young trees using:
  – Notching
  – BA sprays

• Frequently, the combination of both increased branching much more.

• However, lateral shoots were only 10 to 15 cm in length, much shorter than we were looking for to serve as permanent scaffold branches.

• Stephen McArtney revisited this approach and recently published this work in HortTechnology Vol.25, April 2015.
Notching Process

• Notching is done by removing a 4 mm piece of bark about 1/3 of the way around a shoot immediately 3 mm above a lateral bud.
• This was done with two hack saw blades.
• This process is not time consuming (5 seconds per bud) and no longer than 40 seconds per tree.
Branching Treatments

• The primary branching sprays were:
  – BA (MaxCel)
  – BA + GA4+7 (Promalin)

• Sprays were applied directly to the bud and notched area above the bud.

• Trees treated Fuji and Granny Smith
Granny Smith 2 year old

Influence of Notching on Budbreak

Time after Budbreak (weeks)

-2 0 2 4 6 8

Budbreak (%)

0

20

40

60

Budbreak- Shoots

Budbreak- Spurs

Influence of Notching on Budbreak

Budbreak (%)

Time after Budbreak (weeks)

-2 0 2 4 6 8

Budbreak- Shoots

Budbreak- Spurs
Influence of Notching, 6-BA and 6-BA + GA on budbreak and shoot length of Granny Smith apples

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Budbreak (%)</th>
<th>Shoot length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0 a</td>
<td>---</td>
</tr>
<tr>
<td>Notching (N)</td>
<td>59 b</td>
<td>0.8 a</td>
</tr>
<tr>
<td>6-BA 1.5 g·L⁻¹</td>
<td>0 a</td>
<td>---</td>
</tr>
<tr>
<td>N + 6-BA</td>
<td>95 c</td>
<td>7.9 ab</td>
</tr>
<tr>
<td>N + 6-BA + 0.25 g·6-BA + GA₄+₇</td>
<td>90 c</td>
<td>15.5b</td>
</tr>
</tbody>
</table>

Effect of notching and 6-BA on budbreak and shoot length of Fuji apples

<table>
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<tr>
<th>Treatment</th>
<th>Budbreak (%)</th>
<th>Shoot length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1.5 a</td>
<td>0.1 a</td>
</tr>
<tr>
<td>Notching (N)</td>
<td>56.7 b</td>
<td>11.0 b</td>
</tr>
<tr>
<td>6-BA 0.75 g·L⁻¹</td>
<td>8.2 a</td>
<td>0.3 a</td>
</tr>
<tr>
<td>N+ 6-BA 0.75 g·L⁻¹</td>
<td>67.6 b</td>
<td>14.7 b</td>
</tr>
</tbody>
</table>

Notching Conclusions

- Notching is most effective when done at bud break or soon thereafter.
- When applied alone early BA is not very effective at causing bud break.
- Notching will cause buds to break but BA may be necessary to get adequate shoot growth.
- Area notched provides an avenue for BA to enter the bud thus stimulating growth.
- Branching response to notching and BA appears to be cultivar depending
Conclusions

• Growth control using PGRs is a critical tool that growers should have at their disposal to use when necessary or economically advantageous.
• Apogee is the primary PGR used during the growing season to control growth.
• Even though this is not a new PGR there is still much we need to learn to take full advantage of it.
• Notching and BA are useful PGRs to increase branching on young trees.
Chemical Thinning

• Over the chemical thinning period flowers/fruit undergo many physiological changes.

• Identification of vulnerability at each of these periods may provide new opportunities to thin, as yet unknown.
  – Bloom
  – Petal fall to 5 mm
  – 7 to 15 mm
  – 18 to 25 mm
Chemical Thinning Periods

Fruit Growth

Days after Petal Fall

Fruit Size (mm)
Chemical Thinning

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  – Bloom
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Opportunities

- Bloom