EFFECTS OF PREHARVEST PLANT GROWTH REGULATORS ON PREHARVEST FRUIT DROP, ON-TREE MATURATION, AND STORABILITY IN PEARS (PYRUS COMMUNIS)

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ABSTRACT
The objective of this presentation is to introduce the behind physiology and commercial applications of the registered preharvest plant growth regulators (PGR): 1-naphthaleneacetic acid (NAA), aminoethoxyvinylglycine (AVG), and 1-methylcyclopropene (1-MCP) for controlling preharvest fruit drop, on-tree maturation, and storability in pears. NAA, the active ingredient (ai) in ‘Fruit Fix’, is a synthesized auxin-type hormone. AVG (ai in ReTain®) and 1-MCP (ai in Harvista™) are inhibitors for ethylene biosynthesis and action, respectively.

Preharvest fruit drop, a significant concern in summer and winter pears, results directly from expression of genes and activity of enzymes (i.e., cellulose and polygalacturonase) associated with cell wall degradation in the abscission zone. The expression of genes for cell wall degradation enzymes is triggered by a reduction in auxin plus an increase in ethylene synthesis. Importantly, auxin must fall below a certain threshold in the abscission zone to be sensitive to ethylene and the resultant abscission. As a consequence, fruit drop can be reduced or delayed by NAA (increasing auxin) and/or AVG/1-MCP (inhibiting ethylene synthesis/action). Our research showed the efficacies of NAA, AVG, and 1-MCP differ in pears for pre-harvest drop control. The combo of NAA and AVG is more efficient than NAA, NAA more efficient than AVG, and 1-MCP may have a similar efficiency with AVG. However, auxin-type PGRs generally increase ethylene production in fruit, therefore application timing and rate are important for reducing NAA’s negative effect on ripening pear fruit.

It is sometimes a challenge to harvest a large portion of pear fruit in a short period of time resulting from faster maturation by stresses (i.e., hot season) or shortage of labor. AVG or 1-MCP can delay fruit on-tree maturation. Our research indicated that AVG extends 5-7 d harvest window during fruit maturation between 19 to17 lb in ‘Bartlett’ pears. Preharvest applications of AVG or 1-MCP may increase storability of pears.
Our research indicated that preharvest AVG extends ‘Bartlett’ storage life by reducing senescence disorders such as pink-end, senescent scald, and core breakdown, however, application rate, timing and harvest maturity are critical for AVG efficacy. Our research also showed that postharvest application of 1-MCP (ai in SmartFresh) is more efficient than preharvest application of 1-MCP (Harvesta) for controlling disorders and extending packing seasons in ‘Bartlett’, ‘Starkrimson’, ‘Bosc’, and ‘Anjou’ pears. More research is warranted for adequately recovering ripening capacity of 1-MCP treated pear fruit after cold storage and a consistent efficacy of SmartFresh at commercial application.

In summary, the preharvest PGRs: NAA, AVG, and 1-MCP are efficient tools for controlling preharvest fruit drop, extending harvest window, and increasing storability in pears. Application timing, rate, and fruit harvest maturity are critical for efficacy and reducing the possible negative effects of the PGRs on pears. Compared to apples (Malus × domestica), pears may respond differently to NAA, AVG, and 1-MCP, since pears produce little ethylene than apples, especially during maturation on-trees.
Pre-harvest Plant Growth Regulators in Pears

Focusing on physiology & applications of NAA, AVG, 1-MCP for:

1. **Controlling pre-harvest fruit drop**
2. **Extending harvest window**
3. **Increasing storability**

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WSU Fruit School, Nov. 17-18, 2015
Commercially registered pre-harvest PGRs in pears

- **NAA (1-Naphthaleneacetic Acid):** *Fruit Fix*
  
  *Function:*
  Reducing/delaying pre-harvest fruit drop

- **AVG (Aminoethoxyvinylglycine):** *ReTain®*
  
  *Functions:*
  1. Delaying on-tree maturation
  2. Reducing/delaying pre-harvest fruit drop

- **1-MCP (1-Methylcyclopropene):** *Harvista™*
  
  *Functions:*
  1. Delaying on-tree maturation
  2. Reducing/delaying pre-harvest fruit drop
I. Control Pre-harvest Fruit Drop

Bartlett

Bosc

Anjou
Physiology behind fruit drop

- Fruit drop directly results from expression of genes and activity of enzymes associated with cell wall degradation in the abscission zone (AZ)
  - Cellulose and polygalacturonase

- Expression of the genes is triggered by the interplay between **auxin** and **ethylene**

- **Auxin** must fall below a certain threshold in the AZ to be sensitive to **ethylene**

- Therefore, pre-harvest fruit drop is actually a result of **reduced auxin + increased ethylene** in AZ
Physiology behind fruit drop control by PGRs

- **NAA** – a synthetic auxin
- **AVG** – an inhibitor of ethylene biosynthesis
- **1-MCP** – an inhibitor of ethylene action

Therefore,
- Applications of NAA/AVG/1-MCP can balance auxin/ethylene in AZ and therefore reduce/delay abscission
**Efficacies of NAA, AVG, 1-MCP on pear pre-harvest drop**

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**Our research indicated that**

- **NAA > AVG ≈ 1-MCP**?
- **NAA+AVG > NAA**
- Results on pears may not be the same on apples
  - Pears produce less ethylene on-trees
NAA & pear storability

Physiologically, auxin-type PGRs generally increase ethylene production and ripening of tree fruit

Our research indicated that

• NAA may reduce storability in pears

  NAA at 33ppm (label rate)
  – 3 WBAH: No effect on ethylene
  – 2 WBAH: Increase ethylene production

  NAA at 15ppm
  – 2 WBAH: No effect on ethylene
  – 1 WBAH: Increase ethylene production

The increased ethylene production reduced storability
To reduce negative effects of NAA on storability without reducing its efficacy on stop-drop in European pears

1. Application rate
   - 20ppm on Bosc and Anjou
   - 15ppm on Bartlett

2. Application timing
   - Do not apply NAA less than 2 weeks before harvest
   - NAA becomes effective in 2-3d after application and controls drop for 2 weeks

3. Combo of NAA + AVG
   - Increases efficacy on stop-drop
   - Counteracts the negative effect of NAA on storability
II. Extend Harvest Window

• Harvest maturity is the single most important pre-harvest factor affecting pear storage potential, postharvest loss, and quality at consumption.
  – Bartlett: 19-17 lb
  – Anjou: 15-13 lb
  – Bosc: 15-13 lb
  – Comice: 13-11 lb

• However, it is sometimes a challenge to harvest a large portion of pear fruit in a short period of time as a result of faster maturation (i.e., 2015) or shortage of labor.
Our research on Bartlett indicated that

Applied AVG 1wbah/FF=20-21lb

- AVG did not affect fruit maturation reaching FF=19lb

- AVG slowed on-tree maturation from FF=19-17lb

- Therefore, AVG extends harvest window for ~5d (2013, 2014)

- A reduced efficacy if applied >2wbah1

![Graphs showing the effects of AVG on fruit and chlorophyll levels over time in 2013 and 2014.](image-url)
Some commercial field trials on **Bartlett**

Pearson, T. and Y. Wang. 2015
1-MCP delayed on-tree firmness reduction of Bartlett

Efficacy may not be consistent

Villalobos-Acuña et al., 2010. HortScience 45:610-616
III. Increase Storability of Summer Pears

Significant storage/export losses due to senescent disorders in ‘Bartlett’ and ‘Starkrimson’ each year

- **Bartlett**
  1. Pink end
  2. Senescent scald
  3. Senescent core breakdown (SCB)
  4. Yellowing

- **Starkrimson**
  1. Senescent core breakdown (SCB)
  2. Increased susceptibility to $\text{O}_2$/CO$_2$ injuries
**ReTain & Bartlett storage**

Our research indicated that

- **AVG inhibits ethylene production, therefore reduces senescence disorders and extends storage life of Bartlett**
  - *Pink-send, senescent scald, core breakdown*

- **The keys for being efficient**
  - **Timing:** **1 WBH1** (H1=19lb)
    Application closer to harvest results in higher efficacy, however, PHI = 7d
  - **Rate:** **60-120ppm** (0.5-1 pouch/acre)
  - **Harvest at 19lb**
ReTain & Starkrimson storage

Our research indicated that

- **AVG inhibits ethylene production, therefore reduces senescence disorders, decays, and extends storage life**

- The keys for being efficient
  
  - **Timing:** 1 WBH1
  
  - **Rate:** 60-120ppm (0.5-1 pouch/acre)
  
  - **Harvest at 15-14lb**
Harvista & Bartlett storage

- No effect on color
- Little effect on firmness
- **Reduced senescence disorders**

Villalobos-Acuña et al., 2010. HortScience 45:610-616
Compared to pre-harvest Harvista or ReTain, **postharvest SmartFresh** is more efficient on increasing storability of European pears.
SmartFresh & Bartlett

Benefits of 1-MCP at 300ppb
• Maintain green color, reduce senescence disorders
• Recover ripening capacity after 4 months

Challenge
• Non-consistent efficacy in commercial application

We identified the following factors:
• Harvest maturity
• Production elevation,
• Time elapsed between harvest and treatment
• Exogenous ethylene in the treating room
SmartFresh & Starkrimson

- 1-MCP at 300ppb extends Starkrimson storage life to 4 months at 30°F
- However, it takes 2 weeks at 68°F to ripen following cold storage >2 months
SmartFresh & Bosc

- 1-MCP inhibited ethylene production
- Retained FF, SSC, TA, greener color, higher eating quality by sensory panelists
- Reduced decay: *Bull’s eye rot, Phacidiopycnis rot, Cladosporium rot*
SmartFresh & Anjou

Benefits
• Postharvest 1-MCP at 150-200ppb
  – Shuts down ethylene synthesis
  – Controls superficial scald
  – Extends storage life

Challenge
• Recovering ripening capacity following cold storage

We have identified:
• Elevated storage temperature + CA
• Simultaneous of 1-MCP + ethylene
• Post-storage ethylene conditioning
Long-term storage 8 months

Ethoxyquin + low $O_2$:
6% scald
6% speckling + PBC
3% decay

1-MCP + Ethoxyquin + low $O_2$:
0% scald
0% speckling + PBC
0% decay
Ripened by PSEC
SmartFresh & Anjou (commercial application at 100ppb)
Summary

• Controlling pre-harvest fruit drop
  – NAA+AVG > NAA > AVG ≈ 1-MCP
  – NAA may have negative effects on storability
    • Application rate and timing are critical
    • AVG counteracts NAA’s negative effect

• Extending harvest window
  – ReTain (= Harvista?), ~5d for summer pears
  – Winter pears: under research

• Increasing pear storability
  – ReTain and Harvista may increase storability of summer pears
    • ReTain: Application timing and harvest maturity are important to be efficient
    • Winter pears: under research
  – Postharvest SmartFresh
    • Postharvest smartfresh >> preharvest Harvista
    • Rate, timing, and fruit maturity are important for consistent efficacy
Thank you for your attention and research support!

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- NW Pear Research Commission
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- Stadelman Fruit
- Underwood Fruit
- Stemilt Growers
- Blue Bird
- Blue Star Growers