Effects of calcium sprays and AVG on fruit quality at harvest and after storage

Chuck Ingels, Beth Mitcham (UCD), Bill Biasi (UCD), Michelle Leinfelder-Miles

Grower Cooperators
Matt Hemly and Topper Van Loben Sels
Many physiological disorders in fruits are associated with Ca deficiency

Ca foliar sprays have been shown to reduce fruit diseases and physiological disorders in apples

Fruits with a high level of Ca have lower respiration rate and longer potential storage life than fruits containing low Ca
Ca Problem in Delta Orchards

- OK by UC guidelines (decades old, unknown criteria), but longer storage sometimes needed
- 2009 – $1M fruit bad (Argentina dumping)
- Growers use 200 lbs. CaNO₃ May & June in part to add Ca, thought to improve quality
- Many growers include Ca in blight sprays
- There appears to be a rate effect
Ethylene biosynthesis inhibitor

- May enhance fruit color and size by allowing fruit to remain on the trees longer, extending harvest
- More consistent effects on apple than pear
- May extend pear storage life
Ca and ReTain Cost

- **Vigor-Cal** = $22/gal., **Agro-K 9-24-3** = $16 gal.
- 2 qts./acre each → $19/application
- 4 tank-mixed applications = $76 total, no application cost

- ReTain applied at 11.7 oz./acre (1 bag) = $265
- Could be tank mixed with NAA, but timing might not be ideal
Objectives

1. Evaluate effects of foliar Ca sprays and ReTain on Bartlett fruit size and quality

2. Compare effects on postharvest fruit quality after storage and ripening
Leaf Nutrient Content
Apr. 22, 2013

VigorCal + 9-24-3 (2 qts. vs. 4 qts.)

Adequate = 1-8%

- N
- P
- K
- Ca

- Untreated
- 2 Qts.
- 4 Qts.
Total Soluble Solids
2013

%  

15
14
13
12
11
10

1st Pick 1st Pick 2nd Pick + 7 days

Untreated
2 Qts.
4 Qts.
ReTain
4 Qts. + ReT
Experimental Protocol
2014

- Bartlett orchard on Merritt Island
- Some black end present
- Randomized complete block design
- 6 treatments, 9 single-tree replicates
- Trees separated by guard tree and full row
- 100 gal./acre, mist blower backpack sprayer
# Treatments 2014

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate/Acre</th>
<th>Application Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Vigor-Cal + 9-24-3</td>
<td>4 qts. each</td>
<td>3/19, 3/24, 4/2, 4/8, 4/15, 4/22, 5/13, 6/3</td>
</tr>
<tr>
<td>2 ReTain + NuFilm 17</td>
<td>11.7 oz.</td>
<td>6/26</td>
</tr>
<tr>
<td>3 # 1 and #2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Ca chloride (CaCl₂)</td>
<td>1.8 lbs.</td>
<td>4/29, 5/13, 5/20</td>
</tr>
<tr>
<td>5 Soluble gypsum</td>
<td>8 lbs.</td>
<td>4/2, 4/8, 4/15, 4/22, 4/29, 5/13, 6/3</td>
</tr>
<tr>
<td>6 Untreated</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>
Vigorous Black End Tree
## Nutrients in Leaves
### July 2014

<table>
<thead>
<tr>
<th>Treatment</th>
<th>% N</th>
<th>% P</th>
<th>% K</th>
<th>% Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vigor-Cal + 9-24-3</td>
<td>1.77</td>
<td>0.24</td>
<td>1.51</td>
<td>1.23</td>
</tr>
<tr>
<td>ReTain</td>
<td>1.88</td>
<td>0.25</td>
<td>1.62</td>
<td>1.32</td>
</tr>
<tr>
<td>#1 + #2</td>
<td>1.85</td>
<td>0.24</td>
<td>1.66</td>
<td>1.27</td>
</tr>
<tr>
<td>CaCl$_2$</td>
<td>1.93</td>
<td>0.24</td>
<td>1.66</td>
<td>1.54</td>
</tr>
<tr>
<td>Gypsum</td>
<td>1.94</td>
<td>0.24</td>
<td>1.52</td>
<td>1.30</td>
</tr>
<tr>
<td>Untreated</td>
<td>1.88</td>
<td>0.29</td>
<td>1.76</td>
<td>1.30</td>
</tr>
<tr>
<td>Black end trees</td>
<td>2.05</td>
<td>0.19</td>
<td>1.46</td>
<td>1.30</td>
</tr>
</tbody>
</table>
## Nutrients in Fruit (Wedges)
### July 2014

<table>
<thead>
<tr>
<th>Treatment</th>
<th>% N</th>
<th>% P</th>
<th>% K</th>
<th>% Ca</th>
<th>% Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vigor-Cal + 9-24-3</td>
<td>0.20</td>
<td>0.068</td>
<td>0.69</td>
<td>0.031</td>
<td>0.040</td>
</tr>
<tr>
<td>ReTain</td>
<td>0.23</td>
<td>0.073</td>
<td>0.75</td>
<td>0.033</td>
<td>0.041</td>
</tr>
<tr>
<td>#1 + #2</td>
<td>0.23</td>
<td>0.074</td>
<td>0.77</td>
<td>0.032</td>
<td>0.043</td>
</tr>
<tr>
<td>CaCl₂</td>
<td>0.22</td>
<td>0.072</td>
<td>0.76</td>
<td>0.033</td>
<td>0.042</td>
</tr>
<tr>
<td>Gypsum</td>
<td>0.22</td>
<td>0.073</td>
<td>0.73</td>
<td>0.028</td>
<td>0.039</td>
</tr>
<tr>
<td>Untreated</td>
<td>0.25</td>
<td>0.080</td>
<td>0.79</td>
<td>0.035</td>
<td>0.044</td>
</tr>
<tr>
<td>Black end trees</td>
<td>0.37</td>
<td>0.090</td>
<td>0.90</td>
<td>0.042</td>
<td>0.053</td>
</tr>
</tbody>
</table>
Evaluation of 1st Pick Fruit
At Harvest

- Fruit quality evaluations at 1st or 2nd pick (both picked to 2¾”)
  - Few or no differences in fruit weight, firmness, soluble solids, or color
Storage Disorders

Superficial scald

Senescent scald

Internal breakdown
Evaluation of 2nd Pick Fruit
3.5 months, no ripening

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Firmness (psi)</th>
<th>Color Rating (a*[C])</th>
<th>% of Fruit with Scald</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vigor-Cal + 9-24-3</td>
<td>13.5 a</td>
<td>-8.46 ab</td>
<td>0.0 b</td>
</tr>
<tr>
<td>ReTain</td>
<td>13.8 a</td>
<td>-9.32 a</td>
<td>0.0 b</td>
</tr>
<tr>
<td>#1 + #2</td>
<td>13.7 a</td>
<td>-8.91 a</td>
<td>0.0 b</td>
</tr>
<tr>
<td>CaCl₂</td>
<td>14.3 a</td>
<td>-7.28 bc</td>
<td>0.0 b</td>
</tr>
<tr>
<td>Gypsum</td>
<td>11.6 b</td>
<td>-6.56 c</td>
<td>35.8 a</td>
</tr>
<tr>
<td>Untreated</td>
<td>9.7 c</td>
<td>-5.20 d</td>
<td>28.6 a</td>
</tr>
</tbody>
</table>
## Evaluation of 2\textsuperscript{nd} Pick Fruit

3.5 months + ripening

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Firmness (psi)</th>
<th>% of Fruit w/ Scald</th>
<th>IB Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vigor-Cal + 9-24-3</td>
<td>2.19 b</td>
<td>10.8 b</td>
<td>0.0 b</td>
</tr>
<tr>
<td>ReTain</td>
<td>2.32 b</td>
<td>7.8 b</td>
<td>0.0 b</td>
</tr>
<tr>
<td>#1 + #2</td>
<td>2.07 b</td>
<td>10.1 b</td>
<td>0.0 b</td>
</tr>
<tr>
<td>CaCl\textsubscript{2}</td>
<td>2.13 b</td>
<td>4.8 b</td>
<td>0.0 b</td>
</tr>
<tr>
<td>Gypsum</td>
<td>3.29 a</td>
<td>61.0 a</td>
<td>0.60 a</td>
</tr>
<tr>
<td>Untreated</td>
<td>3.70 a</td>
<td>47.0 a</td>
<td>0.98 a</td>
</tr>
</tbody>
</table>
Selected Replicates
3.5 months, no ripening

CaCl₂, rep 1
Gypsum, rep 6

Gypsum, rep 1
Untreated, rep 6
Black End Spray Trial
VLS Home Orchard, Twin Cities Rd.

- Rosired trees with black end (B.E.)
  - 9 trees sprayed with CaCl$_2$
  - 9 trees untreated
- 2 lbs./acre in 100 gal./acre water
  - Backpack mist sprayer
- 5 sprays applied 4/29, 5/7, 5/13, 5/20, 6/3
- Preharvest evaluation:
  - Sprayed trees: Avg. 15 B.E./50 fruit (30%)
  - Unsprayed trees: Avg. 17 B.E./50 fruit (34%)
Black End Sampling
VLS Home Orchard, Twin Cities Rd.

- 2 trees each of Rosired and Red Sensation with and without black end
  - Good fruit from one side of orchard (near levee)
  - Bad fruit from other side (away from levee)
- Sampled 50 leaves & 10 fruit each analyzed for nutrient content
- Soil samples taken from under each tree
## Soil Nutrients (0-12”)
Good trees and black end (B.E.) trees

<table>
<thead>
<tr>
<th>Variety</th>
<th>NO3-N (ppm)</th>
<th>Olsen-P (ppm)</th>
<th>X¹-K (meq/100g)</th>
<th>X-Ca</th>
<th>X-Mg</th>
<th>CEC</th>
<th>OM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rosired (good)</td>
<td>10.7</td>
<td>27.3</td>
<td>0.56</td>
<td>16.5</td>
<td>9.2</td>
<td>26.6</td>
<td>3.4</td>
</tr>
<tr>
<td>Rosired (B.E.)</td>
<td>6.2</td>
<td>44.5</td>
<td>0.69</td>
<td>21.0</td>
<td>13.9</td>
<td>36.2</td>
<td>4.8</td>
</tr>
<tr>
<td>R. Sens. (good)</td>
<td>5.2</td>
<td>22.3</td>
<td>0.64</td>
<td>13.5</td>
<td>8.5</td>
<td>22.9</td>
<td>3.1</td>
</tr>
<tr>
<td>R. Sens. (B.E.)</td>
<td>7.5</td>
<td>38.1</td>
<td>0.70</td>
<td>22.2</td>
<td>12.6</td>
<td>35.9</td>
<td>4.6</td>
</tr>
</tbody>
</table>
# Nutrient Analyses of Good and Black End (B.E.) Leaves and Fruit

<table>
<thead>
<tr>
<th>Variety</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(%)</td>
<td>(%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaves</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rosired (good)</td>
<td>2.40</td>
<td>0.146</td>
<td>0.79</td>
<td>1.12</td>
<td>0.358</td>
</tr>
<tr>
<td>Rosired (B.E.)</td>
<td>2.32</td>
<td>0.179</td>
<td>1.12</td>
<td>1.51</td>
<td>0.363</td>
</tr>
<tr>
<td>R. Sens. (good)</td>
<td>2.25</td>
<td>0.140</td>
<td>1.15</td>
<td>1.57</td>
<td>0.372</td>
</tr>
<tr>
<td>R. Sens. (B.E.)</td>
<td>2.26</td>
<td>0.158</td>
<td>0.95</td>
<td>1.59</td>
<td>0.323</td>
</tr>
<tr>
<td>Fruit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rosired (good)</td>
<td>0.36</td>
<td>0.058</td>
<td>0.59</td>
<td>0.028</td>
<td>0.035</td>
</tr>
<tr>
<td>Rosired (B.E.)</td>
<td>0.54</td>
<td>0.094</td>
<td>0.83</td>
<td>0.045</td>
<td>0.050</td>
</tr>
<tr>
<td>R. Sens. (good)</td>
<td>0.41</td>
<td>0.065</td>
<td>0.71</td>
<td>0.031</td>
<td>0.038</td>
</tr>
<tr>
<td>R. Sens. (B.E.)</td>
<td>0.52</td>
<td>0.088</td>
<td>0.81</td>
<td>0.042</td>
<td>0.047</td>
</tr>
</tbody>
</table>
Conclusions

- Little effect of sprays on fruit quality at harvest
- Little effect of sprays on leaf or fruit nutrients
  » CaCl₂ increased leaf Ca but not fruit Ca
- Most Ca sprays improved long-term storage
  » Gypsum did not
- Black end trees at Merritt Island more vigorous
  » Trees at both sites had higher leaf nutrient values
- CaCl₂ did not reduce black end
Thanks to Matt Hemly and Topper Van Loben Sels for participating in these studies
Evaluation of Pear Tissue Sampling Protocols for Improving Nutrient Management

Chuck Ingels, Michelle Leinfelder-Miles, Patrick Brown, and Kitren Glozer

Grower Cooperator

Chris Frieders

University of California Cooperative Extension
Current Leaf Sampling Recommendations in Calif.

- Non-bearing spur leaves in mid-summer
  - Leaves 3 months old, not strong nutrient sink
  - Static in nutrient mobilization

- Shoot or bearing spur leaves are a better indicator of nutrient status
  - Real-time status of nutrient mobilization

- Shoot leaves used throughout world
  - Also in Calif. before 1983
Spring Sampling

• With spring sampling, can make in-season fert. adjustments based on crop load
  – Reduce vigor potential
  – Anticipate fruit quality problems from nutrient imbalances
Leaf Sampling

- No benefit has ever been documented from N application when July leaf N > 2.2%
- Leaves not always indicative of fruit nutrient status, especially Ca
  - Fruit sampling may be more indicative
Objectives

• Compare nutrient levels & ratios from different tissues and timings
• Determine if a better sampling protocol can improve nutrient management
• Lead-in to possible FREP project
• Possibly revise UC recommendations for sampling & nutrient management
Sampling
(in 4 alternating drive rows)

• Late April (after early fruit drop)
  – Fruits and leaves

• July
  – Mid-shoot and non-bearing spur leaves
  – Fruit just before first pick
  – Soil
Three Bartlett Blocks

- **Block A** – Very productive, loam soil
- **Block F** – Struggled for years, low production, drainage problems, loam soil
- **Block O** – Organic transition, younger, highly uniform, higher density but one with lower production, clay soil
- No foliar nutrients applied
## Soil Sampling Results

<table>
<thead>
<tr>
<th>Block</th>
<th>NO$_3$-N</th>
<th>Olsen-P</th>
<th>X-K</th>
<th>X-Ca</th>
<th>X-Mg</th>
<th>CEC</th>
<th>OM</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5.3</td>
<td>54.3</td>
<td>1.5</td>
<td>7.4</td>
<td>3.5</td>
<td>12.5</td>
<td>2.0</td>
<td>6.1</td>
</tr>
<tr>
<td>F</td>
<td>10.7</td>
<td>40.9</td>
<td>1.8</td>
<td>17.6</td>
<td>6.2</td>
<td>26.7</td>
<td>3.5</td>
<td>6.9</td>
</tr>
<tr>
<td>O</td>
<td>19.8</td>
<td>46.5</td>
<td>1.3</td>
<td>21.7</td>
<td>9.5</td>
<td>33.0</td>
<td>4.9</td>
<td>6.6</td>
</tr>
</tbody>
</table>
• Yields highest in A, intermed. in F, lowest in O
• Fruit size: A & F = 0.41 lb., block O = 0.47 lb.
# Leaf Sampling Results N & K

<table>
<thead>
<tr>
<th>Block</th>
<th>N (%)</th>
<th>K (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>April Mid-Shoot</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>2.86</td>
<td>b</td>
</tr>
<tr>
<td>F</td>
<td>3.14</td>
<td>a</td>
</tr>
<tr>
<td>O</td>
<td>2.95</td>
<td>b</td>
</tr>
<tr>
<td><strong>July Mid-Shoot</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>2.43</td>
<td>ab</td>
</tr>
<tr>
<td>F</td>
<td>2.52</td>
<td>a</td>
</tr>
<tr>
<td>O</td>
<td>2.40</td>
<td>b</td>
</tr>
<tr>
<td><strong>July N-B Spur</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>1.98</td>
<td>ns</td>
</tr>
<tr>
<td>F</td>
<td>1.95</td>
<td>ns</td>
</tr>
<tr>
<td>O</td>
<td>2.03</td>
<td>ns</td>
</tr>
</tbody>
</table>
Fruit Sampling

• No relation:
  – Leaf vs. fruit analyses
  – Fruit analyses in April vs. July
July Leaf Prediction Model
Nonpareil Almond

• Sample all leaves of 5-8 non-fruiting spurs/tree 6 weeks after full bloom when reach full size (mid-April)
• Collect leaves from 18–28 trees /orchard, place in a single bag
  – EACH SAMPLED TREE AT LEAST 30 YARDS APART
  – 100 leaves/sample bag
• Send to lab, ask for a FULL NUTRIENT ANALYSIS
  – N, P, K, B, Ca, Zn, Cu, Fe, Mg, Mn, S
## July Leaf Prediction Model – Almond Pear Leaf Samples 2014 (mid-shoot leaves)

Enter the tissue nutrient values for leaves collected in spring

<table>
<thead>
<tr>
<th>N (%)</th>
<th>P (%)</th>
<th>K (%)</th>
<th>S (ppm)</th>
<th>B (ppm)</th>
<th>Ca (%)</th>
<th>Mg (%)</th>
<th>Zn (ppm)</th>
<th>Mn (ppm)</th>
<th>Fe (ppm)</th>
<th>Cu (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (%)</td>
<td>P (%)</td>
<td>K (%)</td>
<td>S (ppm)</td>
<td>B (ppm)</td>
<td>Ca (%)</td>
<td>Mg (%)</td>
<td>Zn (ppm)</td>
<td>Mn (ppm)</td>
<td>Fe (ppm)</td>
<td>Cu (ppm)</td>
</tr>
</tbody>
</table>

### Predicted Values

<table>
<thead>
<tr>
<th>Block</th>
<th>July % N Predicted (N-F Spur)</th>
<th>Predicted % of Trees above C.V.</th>
<th>July % N Actual (Mid-Shoot)</th>
<th>July % N Actual (N-F Spur)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2.41</td>
<td>94.7%</td>
<td>2.43</td>
<td>1.98</td>
</tr>
<tr>
<td>F</td>
<td>2.45</td>
<td>97.1%</td>
<td>2.52</td>
<td>1.95</td>
</tr>
<tr>
<td>O</td>
<td>2.44</td>
<td>96.6%</td>
<td>2.40</td>
<td>2.03</td>
</tr>
</tbody>
</table>
Conclusions

• Little to no relationship in nutrient values of leaves or fruit between April and July sampling dates
• Mid-shoot leaves higher in N, lower in K
• Little relationship between soil, leaf nutrients
• Strong fit of April leaf levels with predicted July leaf levels
• Would knowledge of July N levels in April affect pre-harvest N fertilization?
Thanks to Chris Frieders
for participating in this study
Pear Variety Evaluation in the Sacramento River District

Pear Research Meeting
Feb. 4, 2015

Chuck Ingels
UC Cooperative Extension, Sacramento County
Blake’s Pride

- Created through breeding 1965
- Blight resistant, consistent yield
- Fruit shaped like Bartlett, skin golden, light tan russetting; very russetted in North Coast
- Requires pollination
- Ripens 2 weeks after Bartlett in the Pacific Northwest but closer to Bartlett in California
Blake’s Pride
Mod. size, sweet, and ugly
Sunrise

- USDA-ARS variety
- Blight resistant
- Early season, ripens before Bartlett, close to Starkrimson
- Yellow skin, slight pink blush, little russetting
- Sweet pleasant flavor
- Excellent overall consumer acceptance
Sunrise
Good yields/size, red blush
Cinnamon

- Discovered as limb mutation in a Bartlett tree near Hood River in 1979, but is a winter pear
- Late-harvested variety that fully russetted in North Coast trial and in Sacramento Delta
- Ranked high in taste tests, scoring as well as Bartlett
Carmen

- The most widely sold new variety in Italy
- Consistent bearer, flowers with Bartlett but ripens much earlier
- Attractive yellow & red color that is accentuated during refrigeration
- Long shelf life, very tolerant of handling
- Rattails and blight
Carmen Rattail Blooms!
Avg. % of Tree Remaining
2014 Fire Blight Damage

% of Tree Remaining
No. of Fruit per Tree
2014

Bar chart showing the number of fruits per tree in 2014 for different varieties.

- **Bartlett**
- **Blake's Pr.**
- **Cinnamon**
- **Norma**
- **Sunrise**
- **Tosca**
- **Turandot**

Varieties are compared using bars, with green indicating 'OHxF 87' and pink indicating 'W. Nelis.'

The chart shows that 'Tosca' has the highest number of fruits per tree, followed by 'Turandot.'
Weight per Fruit
2014

Fruit Weight (lb.)

- Bartlett
- Blake's Pr.
- Cinnamon
- Norma
- Sunrise
- Tosca
- Turandot

Colors:
- OHxF 87
- W. Nelis
Yield per Tree
2014

Yield/Tree (lbs.)

Bartlett
Blake's Pr.
Cinnamon
Norma
Sunrise
Tosca
Turandot

OHxF 87
W. Nelis
New Blight-Resistant Varieties (R. Bell)
Growth Increase, 2013-14

Planted April 2013

% Increase over 2013

- XB21
- XB22
- XB23
- XB24
- XB25
- Bartlett
Varieties and Prospects
Likely not acceptable

Promising except for blight:
- Santa Maria – removed 2012 due to blight
- Carmen – Big trees, big fruit, early, bad blight
- Bartlett – Promising new variety but major blight

Poor performers:
- Tosca – Large number of fruits but very small
- Norma – Excess vigor, low yields
- Andy – Large trees, little blight, low yields
- Turandot – Large trees, little blight, low yields
Varieties and Prospects
Delicious with little blight, but some flaws

- Blake’s Pride – Mod. vigor, good fruit size, delicious, but russetted and ugly
- Cinnamon – Low-mod. vigor, low-mod. fruit numbers early, but consistently large fruit, very late
- Sunrise – Mod. vigor, good yields, good size, partial red blush
Thanks to Daniel Wilson

for participating in this study
Questions?