CLM Outline

1. Light management (Elfving)
2. Pruning (Hornblow)
3. Floral initiation (Hirst)
4. Pollen dynamics (Yoder/Combs)
5. Chemical programs (WTFRC)
6. Mechanized thinning (Lewis)
Growers are from Mars

Trees are from Venus

Don C. Elfving
WSU-TFREC
Wenatchee, WA
1. Production vs. light

Lakso et al., 1997
EFFECT OF LEAVES ON LIGHT MOVEMENT IN FRUIT TREES

100% SUN

1% LIGHT TRANSMITTED

10% LIGHT TRANSMITTED

90% INCIDENT LIGHT ABSORBED OR REFLECTED

90% INCIDENT LIGHT ABSORBED OR REFLECTED

1% LIGHT TRANSMITTED
“... the limiting factor in the performance of an apple tree is the shade the tree casts upon itself”.

(Forshey, Elfving & Stebbins, 1992)
Pruning Strategies to Manage Cropping

WSHA December 2009

Presented by

Craig Hornblow
AgFirst Consultants
4 dimensional
Complex system
need high degree of skill (4th D)
Wide range of size quality

3 dimensional
Simpler
Improved quality
Apply existing technology

2 dimensional
Simplest
Ability to be market specific
New and existing technologies
Bud Counting

Yield /acres $\rightarrow$ Yield/ tree

Buds/ branch $\leftarrow$ Yield/ branch
Specific pruning targets

Buds required per tree

just as we would for fruit per tree for green fruit thinning
Variety Variations

*These ratios are built up over a number of years experience and are specific to NZ*

<table>
<thead>
<tr>
<th>Variety</th>
<th>Winter bud Ratio (winter buds per fruit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gala</td>
<td>1 : 1</td>
</tr>
<tr>
<td>Braeburn</td>
<td>1.6-2 : 1</td>
</tr>
<tr>
<td>Pink Lady</td>
<td>1.5 : 1</td>
</tr>
<tr>
<td>Jazz</td>
<td>1.2 : 1</td>
</tr>
</tbody>
</table>
Can simpler systems achieve top production?

Target **8 miles/acre** fruiting wood @ **1 fruit every 3 inches**

= **80 bins per acre**

| 4.8-8.5 miles | 6.2-9.5 miles | 8 miles | 10.3 miles |
5 row rule
Apple flower initiation:
looking into the black box

Peter Hirst
The development of an apple fruit

1. Perception of floral induction signal
2. Doming of apex
3. Differentiation of floral apex
4. Flowering
5. Cell division
6. Cell expansion
7. FINAL FRUIT SIZE
What the text book says...

1. Gibberellins cause biennial bearing
2. Thinning $\rightarrow$ less gibberellins $\rightarrow$ better return bloom
3. Earlier thinning = better return bloom
4. Earlier thinning = better fruit size
5. Resting spurs are essential for return bloom
Gala - regular bearing
- small fruit size

Fuji - biennial bearing
- larger fruit size
Effects of fruiting

Does fruiting affect spur development?
(are resting spurs necessary?)

vegetative

flowering but not fruiting

fruiting
Take home messages

1. Floral/fruiting status had no effect on future floral formation
2. Floral/fruiting status had no effect on the quality of flowers for the following year
3. Localized effects within a spur may be secondary to overall tree crop load
4. Fuji buds had fewer appendages than those of Gala, but no difference in bud or flower diameter
5. No relationship between bud diameter and king flower diameter
Effect of bourse length on return bloom
Spencer Seedless, 1996

Neilsen, 1998
Apple fruiting spur
Effect of temperature on apple pollen tube growth: Implications for bloom thinning

Summary of WTFRC Projects
2005-2009

Keith Yoder
with
Leon Combs and Rongcai Yuan

VA Tech Ag. Research and Extension Center
Winchester, VA

Sponsored by
Washington Tree Fruit Research Commission
Some Snowdrift pollen tubes reached the base of some styles in <48 hours in 65/40ºlt/dk and 75/45ºlt/dk tests.
Based on predicted fertilization, in-orchard 2% LLS+CFO apps. effectively prevented fruit set at 24 hr but not at 48 hr.
VARIETAL AND POLLINIZER DIFFERENCES

Varietal effect on in-orchard growth of Snowdrift pollen tubes in 7 cultivars after 24 hours, Winchester, VA.
Varietal and pollinizer differences

PINK LADY STIGMA RECEPTIVITY AND POLLEN TUBE GROWTH OF POLLINIZERS APPLIED AT FULL BLOOM IN GREENHOUSE AND EVALUATED 40 HOURS AFTER POLLINATION (2009)

AVERAGE NUMBER OF POLLEN TUBES GROWING TO END OF STYLES

<table>
<thead>
<tr>
<th>Pollinizer</th>
<th>Average Number of Pollen Tubes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snowdrift</td>
<td>13.1</td>
</tr>
<tr>
<td>Manchurian</td>
<td>4.1</td>
</tr>
<tr>
<td>Gala</td>
<td>0.8</td>
</tr>
<tr>
<td>Golden Delicious</td>
<td>10.1</td>
</tr>
<tr>
<td>Fuji</td>
<td>8.1</td>
</tr>
</tbody>
</table>

AVERAGE NUMBER OF POLLEN TUBES REACHING END OF STYLES
Pollen tube growth decreased by 50% in older flowers pollinated 3-5 days after opening vs. those pollinated 1-2 days after first open.
Apple bloom phenology & fruit growth modeling project

- WTFRC & WSU Extension
- Phenology: 11 Red Delicious, 11 Gala, 9 Cripps Pink
- Fruit growth: 9 Red Delicious, 9 Gala, 7 Cripps Pink
- Available on DAS in 2012?
WTFRC chemical thinning studies
APPLE CHEMICAL THINNING TRIALS
WTFRC 1999-2009

CULTIVAR
Gala
Fuji
Red Delicious
Golden Delicious
Granny Smith
Braeburn
Pink Lady
Honeycrisp
Cameo
Jonagold
Pacific Rose
Jazz

ROOTSTOCK
M9
M26
M7
M106
Seedling
Bud9
Nic29
M111
Phenological points for crop load management

- **VOE**
- **Caustics**
- **BA, NAA, NAD, GA carbaryl, Ethrel**
- **Hand thinning**
- **NAA, Ethrel**
- **THE GOAL**
WTFRC Internal Program
Apple bloom thinning agents evaluated 1998-2007
(# of formulations tested in parentheses)

- ATS (3)
- Dormex
- Wilthin
- Water
- NC99 (2)
- Lime sulfur (2)
- Aliette
- ThinRite
- Cal Plex 12
- Sodium chloride
- Ju VOE
- New Zealand soap (3)
- Crocker’s Fish Oil
- TetraSul
- Kaligreen
- Molasses
- Vinegar
- Tergitol
- Urea
- Ethrel
- Raynox
- Corn oil
- Canola oil
- Soybean oil
- NAA
- GenThin
- Clove oil
- Potassium metabisulfite
- Potassium sulfate
- Matran
- Salicylic acid
- MaxCel
- Exilis Plus
WTFRC Internal Program
(# of formulations tested in parentheses)

<table>
<thead>
<tr>
<th>OILS</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crocker’s Fish Oil</td>
<td>Hi Crop Liquid Fish</td>
</tr>
<tr>
<td>VOE (Ju formulation)</td>
<td>Kelly Green Fish Emulsion</td>
</tr>
<tr>
<td>Saf – T – Side Oil</td>
<td>Pacific Natural Fish Emulsion</td>
</tr>
<tr>
<td>JMS Stylet Oil</td>
<td>Latron</td>
</tr>
<tr>
<td>Wilbur Ellis Supreme Oil</td>
<td>Regulaid (3)</td>
</tr>
<tr>
<td>Omni Supreme Oil</td>
<td>Silwett</td>
</tr>
<tr>
<td>Orcal Freedom Oil (4)</td>
<td>Silgard</td>
</tr>
<tr>
<td>Corn oil</td>
<td>Exit</td>
</tr>
<tr>
<td>Soybean oil</td>
<td></td>
</tr>
<tr>
<td>Canola oil</td>
<td></td>
</tr>
</tbody>
</table>
## WTFRC blossom thinning programs

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>AMOUNT/100 gal/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium thiosulfate (ATS)</td>
<td>3.4 gal (1% a.i.)</td>
</tr>
<tr>
<td>NC99</td>
<td>6-8 gal</td>
</tr>
<tr>
<td>Lime sulfur (LS)</td>
<td>6-10%</td>
</tr>
<tr>
<td>Crocker’s Fish Oil + LS</td>
<td>2% + 2-3%</td>
</tr>
<tr>
<td>Summer oil + LS</td>
<td>1-1.5% + 2-3%</td>
</tr>
<tr>
<td>Winter oil + LS</td>
<td>0.5-1% + 2-3%</td>
</tr>
<tr>
<td>Vegetable Oil Emulsion (VOE)</td>
<td>10-16 gal</td>
</tr>
</tbody>
</table>

+ postbloom thinning programs at discretion of individual growers
CHEMICAL THINNING GOALS

#1 Minimize production costs – indicated by fruit set/blossom cluster

#2 Optimize retention of high quality fruit (size, color, shape, finish, sugars, acids, etc.) – indicated by fruit size

#3 Promote consistent annual cropping by maintaining proper balance of vegetative and reproductive growth – indicated by return bloom
## WTFRC Apple Chemical Bloom Thinning

**Honeycrisp/M.9, 3rd leaf, Wiley City WA 2003**

<table>
<thead>
<tr>
<th></th>
<th>Fruitlets per 100 blossom clusters</th>
<th>% blossom clusters blanked</th>
<th>Harvest fruit diam (cm)</th>
<th>Relative box size</th>
<th>Soluble solids (% Brix)</th>
<th>% titratable acids</th>
<th>% fruit russeted</th>
<th>% return bloom 2004</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CFO + LS</strong></td>
<td>71 b</td>
<td>51 a</td>
<td>7.93 a</td>
<td>84</td>
<td>13.8 a</td>
<td>0.56 a</td>
<td>73(^1) ns</td>
<td>52 a</td>
</tr>
<tr>
<td><strong>LS</strong></td>
<td>74 b</td>
<td>53 a</td>
<td>7.77 b</td>
<td>88</td>
<td>13.6 a</td>
<td>0.54 a</td>
<td>60</td>
<td>40 a</td>
</tr>
<tr>
<td><strong>ATS</strong></td>
<td>100 a</td>
<td>42 b</td>
<td>7.71 bc</td>
<td>90</td>
<td>12.8 b</td>
<td>0.49 b</td>
<td>73(^2)</td>
<td>12 b</td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td>107 a</td>
<td>44 b</td>
<td>7.57 c</td>
<td>95</td>
<td>12.8 b</td>
<td>0.47 b</td>
<td>56</td>
<td>9 b</td>
</tr>
</tbody>
</table>

\(^1\) increased russet on fruit shoulders  
\(^2\) increased russet in stem bowls
Proven chemical bloom thinners of apple
Incidence of results significantly superior to untreated control
WTFRC apple chemical bloom thinning trials 1999-2009

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fruitlets / 100 blossom clusters</th>
<th>Harvested fruit diameter</th>
<th>Return bloom</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATS</td>
<td>15 / 57 (26%)</td>
<td>10 / 60 (17%)</td>
<td>4 / 51 (8%)</td>
</tr>
<tr>
<td>NC99</td>
<td>15 / 31 (48%)</td>
<td>7 / 33 (21%)</td>
<td>2 / 27 (7%)</td>
</tr>
<tr>
<td>Lime sulfur</td>
<td>25 / 54 (46%)</td>
<td>12 / 48 (25%)</td>
<td>9 / 47 (19%)</td>
</tr>
<tr>
<td>CFO + LS</td>
<td>59 / 103 (57%)</td>
<td>26 / 94 (28%)</td>
<td>21 / 91 (23%)</td>
</tr>
<tr>
<td>JMS + LS</td>
<td>14 / 24 (58%)</td>
<td>8 / 23 (35%)</td>
<td>4 / 22 (18%)</td>
</tr>
<tr>
<td>WES + LS</td>
<td>14 / 27 (52%)</td>
<td>4 / 26 (15%)</td>
<td>4 / 26 (15%)</td>
</tr>
<tr>
<td>VOE</td>
<td>13 / 29 (45%)</td>
<td>4 / 28 (14%)</td>
<td>2 / 30 (7%)</td>
</tr>
</tbody>
</table>

1 Data from 2009 trials not included
Postbloom thinning
WTFRC Internal Program
Apple postbloom thinning agents evaluated 1998-2007
(# of formulations tested in parentheses)

- NAA (2)
- Carbaryl (3)
- Accel
- RiteSize
- Amid Thin
- Ethrel
- MaxCel
- Exilis (4)

- RiteWay
- Genesis 6-BA
- Crocker’s Fish Oil
- Lime sulfur
- Citric acid
- Clove oil
- Potassium sulfate
- Matran
Crop load effects of postbloom thinners 2009
Gala/M.9 - Grandview, WA

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fruitlets/100 clusters</th>
<th>% Blanks</th>
<th>% Singles</th>
<th>Weight (g)</th>
<th>Box Size</th>
<th>% Russet</th>
</tr>
</thead>
<tbody>
<tr>
<td>BA + NAA</td>
<td>126 b</td>
<td>38 a</td>
<td>23 ns</td>
<td>202 ns</td>
<td>94</td>
<td>9 ns</td>
</tr>
<tr>
<td>Carbaryl + BA</td>
<td>104 c</td>
<td>45 a</td>
<td>23</td>
<td>199</td>
<td>96</td>
<td>14</td>
</tr>
<tr>
<td>Carbaryl + NAA</td>
<td>122 bc</td>
<td>39 a</td>
<td>21</td>
<td>204</td>
<td>93</td>
<td>4</td>
</tr>
<tr>
<td>Control</td>
<td>164 a</td>
<td>26 b</td>
<td>21</td>
<td>191</td>
<td>100</td>
<td>5</td>
</tr>
</tbody>
</table>
Proven chemical postbloom thinners of apple
Incidence of results significantly superior to untreated control
WTFRC apple chemical postbloom thinning trials 2002-2009

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fruitlets / 100 blossom clusters</th>
<th>Harvested fruit diameter</th>
<th>Return bloom¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>BA</td>
<td>2 / 18 (11%)</td>
<td>0 / 19 (0%)</td>
<td>0 / 18 (0%)</td>
</tr>
<tr>
<td>Carb + BA</td>
<td>28 / 75 (37%)</td>
<td>9 / 73 (12%)</td>
<td>8 / 71 (11%)</td>
</tr>
<tr>
<td>Carb + NAA</td>
<td>11 / 51 (22%)</td>
<td>7 / 51 (14%)</td>
<td>4 / 48 (8%)</td>
</tr>
<tr>
<td>BA + NAA</td>
<td>5 / 11 (45%)</td>
<td>2 / 11 (18%)</td>
<td>0 / 9 (0%)</td>
</tr>
<tr>
<td>Carb + NAA + Ethephon</td>
<td>0 / 5</td>
<td>0 / 5</td>
<td>2 / 5</td>
</tr>
<tr>
<td>Carb + NAA + BA</td>
<td>0 / 8</td>
<td>0 / 8</td>
<td>3 / 8</td>
</tr>
</tbody>
</table>

¹ Data from 2009 trials not included
PGRs to combat alternate bearing

NAA
Ethrel

ON

GA??

OFF
GA$_3$ effects on return bloom
Fuji/M.26 – Orondo, WA  WTFRC 2008

2009 floral density (flower clusters/cm$^2$ TCSA)

<table>
<thead>
<tr>
<th>ppm</th>
<th>0</th>
<th>100</th>
<th>300</th>
<th>500</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>a</td>
<td>c</td>
<td>bc</td>
<td>ab</td>
</tr>
</tbody>
</table>

ppm
Mechanized Thinning: The U.S. and N.Z. Experience

Craig Hornblow, AgFirst Consultants
Karen Lewis, WSU Extension
It looks very scary in operation
But Surprisingly effective
Darwin Trials in U.S.

Darwin 300
• Apples (WA and PA)
• Peaches / Nectarines (WA, CA, SC, PA)
• Apricots (WA)
• Cherries

Darwin 250
• Peaches (PA, SC, CA)
Key Findings – Darwin Apple

- Reduced green fruit thinning
- Anticipate increased fruit size
- No wood Damage
- No Secondary Drop (Gala/leaf damage/rain)
- Fireblight
Darwin - Cherries
Key Findings – Peaches/Nectarines

• Bloom stage: pink to petal fall
• Blossom removal: 20-55%
• Reduced labor costs: 25-65%
• Fruit size - increased in all but one trial
• Net economic impact - $462-$1490 and $230-$847 per acre for processing and fresh market peaches
Key Findings – Apricot
Key Findings – Apricot

'Goldbar' Apricot Final Fruit Size and Weight

- GFT: Size (in) = 2.06, WT (grams) = 8.85
- Danerin: Size (in) = 2.39, WT (grams) = 13.55
- HBT: Size (in) = 2.54, WT (grams) = 8.63

- Size (in) - Orange
- WT (grams) - Blue
Drum Shaker

Citrus ➔ Blackberry

PA Only
The Bonner (UniBonn)

- Prototype from Germany
- Mounts to front forks
- 3 fully adjustable arm
- Programmable RPM

‘Sweetheart’
‘Gala’
SCRI – Innovative technologies
THANKS!!

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www.treefruitresearch.com