Light interception into canopies

M. Elena Garcia and Linda Boccuzzo

Light Interception

- Orchard production is directly related to the amount of light intercepted by the orchard

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Light Interception

- Economic fruit yields and fruit quality are a function of:
  - Light distribution within the canopy
  - Efficiency of light use

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Light Interception

- Orchard production is maximized at 70% light interception

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Light Interception

- Light interception and distribution in an orchard is dependent on:
  - Orchard design
  - Tree training system
  - Pruning and training practices

Orchard Design

- Spacing
- Density
- Tree height: tractor alley
- Row orientation
  - North- South
- Canopy characteristics
Light Penetration

Light Penetration for Four Sides of a Mature Apple Canopy
(Spur Type 'Delicious'/MM.111)

Time

% of Full Sun

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Light Penetration

Light Penetration at 3 Heights of a Mature Apple Canopy (Spur Type 'Delicious'/MM.111)

Time

% of Full Sun

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Light Penetration

Light penetration into the canopy of a large tree

Effective light penetration into an unrestricted canopy is ~ 1 m

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Tree size

- As tree size decreases, the heavily shaded areas within the tree decreases

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Light Penetration

Tree shape
- Volume : surface area ratios

Effect of tree size on light exposure

16 ft 24.45% shade
12 ft 12% shade
8 ft 1.6% shade
Light

- Large vs. small trees
- Small McIntosh tree (10.5 ft branch spread) produced 80.6% more fruit on a per unit area basis than a large tree (29.0 ft branch spread) (Forshey and McKee, 1970)

Light Penetration

% of full radiation needed for various quality factors in apples

<table>
<thead>
<tr>
<th>Character</th>
<th>Satisfactory development</th>
<th>Unsatisfactory development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit size</td>
<td>&gt;50%</td>
<td>&lt;50%</td>
</tr>
<tr>
<td>Red color</td>
<td>&gt;70%</td>
<td>&lt;40%</td>
</tr>
<tr>
<td>Spur development</td>
<td>&gt;30%</td>
<td>&lt;25%</td>
</tr>
</tbody>
</table>

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Apple Tree Canopy Forms

Globular
- Typical of large open center trees
- Very unproductive
  - Interior shading
  - Productive area on top

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Apple Tree Canopy Forms

Conical
- Light efficient
- Open framework allows sunlight to penetrate the interior

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Apple Tree Canopy Forms

**Vertical tree wall**
- Branch spread is limited
- Adequate light penetration throughout the tree

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Apple Tree Canopy Forms

**Horizontal**
- Attempts to provide light exposure to the entire bearing surface

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Apple Tree Canopy Forms

“Y” or “V”

- Maximizes light exposure of the bearing surface

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Training Systems

Objective:

- To maximize light penetration and distribution

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Common orchard Training Systems

<table>
<thead>
<tr>
<th>Training system</th>
<th>General description</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Density</th>
<th>Rootstock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central leader</td>
<td>Free standing Most common Single, central trunk Pronounced cenic shape Separate and distinct tiers of scaffold branches</td>
<td>High yields at full canopy High fruit quality</td>
<td>Slow to come into production High labor costs due to use of ladders and the pruning of large branches</td>
<td>Low to moderate 250-400 trees/AC</td>
<td>MM 111 MM 106 M7 Mark</td>
</tr>
<tr>
<td>Slender spindle</td>
<td>Needs support Very successful in Euapa</td>
<td>Early cropping High tree density Minimal pruning Efficient use of labor</td>
<td>High initial cost Sunburn</td>
<td>High 800-1100</td>
<td>Dwarfing Rostockia M9 Mark</td>
</tr>
<tr>
<td>Vertical axis</td>
<td>Tall and narrow with a supported, dominant central leader</td>
<td>Early production Efficient use of labor</td>
<td>Tail trees require ladders Excessive growth of the central leader</td>
<td>500-700 trees/AC</td>
<td>M 9 EMLA 26 EMLA 7 EMLA 106</td>
</tr>
</tbody>
</table>

Light penetration into different canopies

- Four sites were selected
- HRC and 3 orchards
- Light measurements into the canopy were taken with a Light Quantum Sensor instrument.
In most instances, light readings were taken on one side of the canopy at:
- Outer (~ 2 ft)
- Middle (~ 4 ft)
- Interior (~ 6 ft)
Central leader tree before summer pruning

- Light Penetration into Central Leader (June 27, before summer pruning)
- HRC-McIntosh/M26
  - At 2 ft into canopy: 89%
  - At 4 ft into canopy: 48%
  - At 6 ft into canopy: 37%

Light penetration

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Pruned material

Central leader trained tree after summer pruning
Light penetration into canopy

- Light penetration into Central Leader (June 27, after summer pruning)
  - HRC-McIntosh/26
    - At 2 ft into canopy: 90%
    - At 4 ft into canopy: 72%
    - At 6 ft into canopy: 41%

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Slender spindle/
Vertical axis trained
tree before summer pruning

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Light penetration into canopy

- Light penetration into Slender Spindle/Vertical Axis (June 27, before summer pruning)
- HRC-NE-183/M26
  - At 2 ft into canopy: 98%
  - At 4 ft into canopy: 92%
  - At 6 ft into canopy: 73%
Light penetration into canopy

- Light penetration into Slender Spindle/Vertical Axis (June 27, before summer pruning)
- HRC-NE-183/M26
  - At 2 ft into canopy: 97%
  - At 4 ft into canopy: 98%
  - At 6 ft into canopy: 90%

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### Light penetration into canopy

#### Farm 1

<table>
<thead>
<tr>
<th>Canopy</th>
<th>Lower tier (% light)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 ft</td>
<td>99</td>
</tr>
<tr>
<td>4 ft</td>
<td>95</td>
</tr>
<tr>
<td>6 ft</td>
<td>60</td>
</tr>
</tbody>
</table>

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### Light penetration into canopy

#### Farm 1 (round canopy)

<table>
<thead>
<tr>
<th>Canopy</th>
<th>Lower tier (% light)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 ft</td>
<td>97</td>
</tr>
<tr>
<td>4 ft</td>
<td>45</td>
</tr>
<tr>
<td>6 ft</td>
<td>16</td>
</tr>
</tbody>
</table>

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Light penetration into canopy

- Farm 2 (standard size, pruned)

<table>
<thead>
<tr>
<th>Canopy (approx. depth)</th>
<th>Lower tier (% light)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 ft</td>
<td>98</td>
</tr>
<tr>
<td>4 ft</td>
<td>85</td>
</tr>
<tr>
<td>6 ft</td>
<td>70</td>
</tr>
<tr>
<td>8 ft</td>
<td>38</td>
</tr>
</tbody>
</table>

- Farm 2 (standard size, unpruned)

<table>
<thead>
<tr>
<th>Canopy</th>
<th>Lower tier (% light)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 ft</td>
<td>78</td>
</tr>
<tr>
<td>4 ft</td>
<td>20</td>
</tr>
<tr>
<td>6 ft</td>
<td>3</td>
</tr>
<tr>
<td>8 ft</td>
<td>5</td>
</tr>
</tbody>
</table>
Light penetration into canopy

- It was dark inside!

Farm 3 (support with 4 wires)

<table>
<thead>
<tr>
<th>Canopy (Avg 5 trees)</th>
<th>% light Avg (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 ft</td>
<td>92 (100 – 79)</td>
</tr>
<tr>
<td>4 ft</td>
<td>68 (100 – 42)</td>
</tr>
<tr>
<td>6 ft</td>
<td>56 (100 – 25)</td>
</tr>
</tbody>
</table>
Light penetration into canopy

- Farm 3 ‘V’ trellis

<table>
<thead>
<tr>
<th>Canopy</th>
<th>% light (not pruned)</th>
<th>% light (pruned)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 ft</td>
<td>80</td>
<td>89</td>
</tr>
<tr>
<td>4 ft</td>
<td>75</td>
<td>80</td>
</tr>
<tr>
<td>6 ft</td>
<td>50</td>
<td>69</td>
</tr>
</tbody>
</table>

Summary

- Canopies can be modified
  - pruning and tree training
  - rootstock and scion
  - spacing
If what you want is this…..

Summary

- Use techniques or practices that result in increased light distribution and interception
- This will result in improved fruit quality and yield
Thank You