• Ideally, we need 20-25 small branches on each axis.
• It is not recommended to top the tree axis on apple.
This system doubles the number of shoots and reduces their length to half compare to spindle planted at the same distance.
Fuji: Year 4 (Ravenna) - Data 2006 – Shoots number at various tree heights

Shoots number at various tree heights:

- **0-1.2 m**
  - Bi-axis: a
  - Spindle: b
  - P < 0.01

- **1.2-1.8 m**
  - Bi-axis: a
  - Spindle: b
  - P < 0.01

- **1.8-2.4 m**
  - Bi-axis: a
  - Spindle: b
  - P < 0.01

- **>2.4 m**
  - Bi-axis: a
  - P < 0.01

Bi-Axis: an Alternative to Slender Spindle for Apple Orchards

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Proc. IXth IS on Orchard Systems
Ed.: T.L. Robinson
Acta Hort. 903, ISHS 2011

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Fuji: Year 4 (Ravenna) - Data 2006 – 1-year shoot length at various tree heights

Bi-Axis: an Alternative to Slender Spindle for Apple Orchards

A. Dorigoni, P. Lezzè and N. Dallabetta
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Location: Marrara (Ferrara)
Graft combination: Toshiro/M9 T337
Training system: Bi-axes and Spindle
Year of planting: 2005
Planting distance and density:
Spindle 4.0 x 0.9 m (2,778 trees/ha)
Bi-axes 4.0 x 1.2 m (2,083 trees/ha)
TOSHIRO/M9 T337: Marrara (FERRARA) Year of planting 2005. Productive and vegetative traits (Years 2006-08). Comparison: Spindle vs Bi-axes

<table>
<thead>
<tr>
<th>Training system 2006</th>
<th>Planting density</th>
<th>Fruit number</th>
<th>Yield /tree (kg)</th>
<th>Fruit weight (g)</th>
<th>TSA (cm²)</th>
<th>Yield effic. (kg/cm²)</th>
<th>Calc. Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bi-axes</td>
<td>2083</td>
<td>61</td>
<td>15,67</td>
<td>258 a</td>
<td>7,9</td>
<td>1,99</td>
<td>32,6</td>
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<tr>
<td>Spindle</td>
<td>2778</td>
<td>61</td>
<td>14,6</td>
<td>241 b</td>
<td>7,3</td>
<td>2,01</td>
<td>40,6</td>
</tr>
<tr>
<td>Significatività</td>
<td>ns</td>
<td>ns</td>
<td>*</td>
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<td>ns</td>
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<table>
<thead>
<tr>
<th>Training system 2007</th>
<th>Planting density</th>
<th>Fruit number</th>
<th>Yield /tree (kg)</th>
<th>Fruit weight (g)</th>
<th>TSA (cm²)</th>
<th>Yield effic. (kg/cm²)</th>
<th>Calc. Yield (t/ha)</th>
</tr>
</thead>
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<tr>
<td>Bi-axes</td>
<td>2083</td>
<td>57,8</td>
<td>12,51</td>
<td>224</td>
<td>11,25</td>
<td>1,13</td>
<td>26,1</td>
</tr>
<tr>
<td>Spindle</td>
<td>2778</td>
<td>44,8</td>
<td>9,99</td>
<td>222</td>
<td>10,71</td>
<td>1,05</td>
<td>27,8</td>
</tr>
<tr>
<td>Significatività</td>
<td>ns</td>
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<td>ns</td>
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<table>
<thead>
<tr>
<th>Training system 2008</th>
<th>Planting density</th>
<th>Fruit number</th>
<th>Yield /tree (kg)</th>
<th>Fruit weight (g)</th>
<th>TSA (cm²)</th>
<th>Yield effic. (kg/cm²)</th>
<th>Calc. Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bi-axes</td>
<td>2083</td>
<td>111,9 a</td>
<td>25,7 a</td>
<td>230</td>
<td>12,46</td>
<td>2,11 a</td>
<td>53,5</td>
</tr>
<tr>
<td>Spindle</td>
<td>2778</td>
<td>88,7 b</td>
<td>20,3 b</td>
<td>229</td>
<td>11,79</td>
<td>1,74 b</td>
<td>56,5</td>
</tr>
<tr>
<td>Significatività</td>
<td>**</td>
<td>**</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>**</td>
<td>ns</td>
</tr>
</tbody>
</table>
Fuji (Ravenna):

different overcolor in the bottom part of the tree – Year 4
Materials and Methods

Location: Migliaro (Ferrara)

Graft combination: Rosy Glow/M9T337

Training system: Bi-axes and Spindle

Year of planting: 2006

Planting distance and density:
Spindle: 3.3 x 0.8 m (3,788 trees/ha)
   10.8’ x 2.6’ (1,534 trees/A)

Bi-axis: 3.3 x 0.8 m (3,788 trees/ha)
   10.8’ x 2.6’ (1,534 trees/A)
## Rosy Glow/M9 T337 – Medelana (FERRARARA) Planting year 2006. Productive and vegetative traits 2007

<table>
<thead>
<tr>
<th>Training system</th>
<th>Planting density (trees/ha)</th>
<th>Planting density (trees/A)</th>
<th>Fruit number</th>
<th>Yield kg/tree</th>
<th>Avr. fruit weight (g)</th>
<th>TCSA (cm²)</th>
<th>Yield effic. (kg/cm²)</th>
<th>Calc. Yield (t/ha)</th>
<th>Calc. Yield (tonne/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bi-axis</td>
<td>3,788</td>
<td>1,533</td>
<td>21.2</td>
<td>5.02</td>
<td>a</td>
<td>238</td>
<td>5.34</td>
<td>0.97</td>
<td>19.0</td>
</tr>
<tr>
<td>Spindle</td>
<td>3,788</td>
<td>1,533</td>
<td>23.2</td>
<td>5.18</td>
<td>b</td>
<td>226</td>
<td>4.27</td>
<td>1.24</td>
<td>19.6</td>
</tr>
<tr>
<td>Significance</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>ns</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bi-axes</th>
<th>Planting density (trees/A)</th>
<th>Fruit number</th>
<th>kg/tree</th>
<th>Avr. fruit weight (g)</th>
<th>TCSA (cm²)</th>
<th>Yield effic. (kg/cm²)</th>
<th>Calc. Yield (t/ha)</th>
<th>Calc. Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large branch</td>
<td>1,533</td>
<td>8.8</td>
<td>b</td>
<td>2.07</td>
<td>238</td>
<td>3.41</td>
<td>0.61</td>
<td>7.8</td>
</tr>
<tr>
<td>Small branch</td>
<td>1,533</td>
<td>12.4</td>
<td>a</td>
<td>2.95</td>
<td>239</td>
<td>2.25</td>
<td>1.37</td>
<td>11.2</td>
</tr>
<tr>
<td>Significance</td>
<td></td>
<td>*</td>
<td>*</td>
<td>ns</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Significance:**
- ns: not significant
- *: significant

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Cumulated yield and the average fruit weight in the canopy
MODI: Fruiting *habit* investigation

- Single picking time
- Three canopy levels: < 0.8m = low, 0.8-1.8m = medium, >1.8m = high
**Modi: Habitus investigation**

Results: comparison among training systems

Yield (kg) per training systems divided by bearing wood 2011

---

**Investigation of ‘Modi®’ Habitus in Relation to Training Systems**

S. Musacchi\(^1\,\,^2\), D. Bucci\(^1\), V. Ancarani\(^1\), F. Gagliardi\(^1\) and S. Serra\(^1\,\,^2\)

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Ed.: K. Theron

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Percentage of spurs per canopy level

Farm T

**bi-axis**
- High: 28.2%
- Middle: 45.3%
- Low: 26.5%

**spindle**
- High: 47.7%
- Middle: 42.1%
- Low: 10.3%
Quality Optimization

• Pruning physiology
• Cultivar habit
• Rootstocks
• Nursery products
• Main training systems
• HDP pruning technique
• Quality (Light, crop load, Harvest and Mechanization)
MUR FRUITIER PRUNING

Fruit wall?  Concept of pruning

12 leaves pruning
Summer 2-3 h/ha

Pommier, le Mur fruitier, 2002 A. Masseron

Winter manual pruning to integrate the mechanical
Fruit wall - Filling surface
13,000 to 17,000 m² of surface per ha (25 fruits/m²) 400,000 fruit /ha (161,900 fruits/acre)
Effect of mechanical pruning on flower bud formation
Quality Optimization

- Pruning physiology
- Cultivar habit
- Rootstocks
- Nursery products
- Main training systems
- HDP pruning technique
- Quality (Light, crop load, Harvest and Mechanization)
Monteith (1977) has demonstrated a fundamental relationship, a landmark in modern crop physiology, between crop dry matter production and seasonal accumulated light interception by the crop.
The total amount of light intercepted by an apple orchard system depends primarily on orchard design factors:

- Increasing tree density per acre
- High ratio of leaf area per tree to land area allocated per tree (LAI)
- Reducing distance between rows
- Increasing height of the tree
- Orienting rows north-south

These various factors have been well researched over the past 30 to 35 years (see reviews by Jackson, 1980; Lakso, 1994; Palmer, 1989; Wagenmakers, 1991).

Wunsche and Lakso, 2000
Summarized relationship between apple fruit yield and mid-season percent total orchard light interception from several reports in the literature.

- Below about **50% light interception yield** is linearly related to light interception.
- Such orchards frequently have open and well-exposed canopies.
- In contrast, **fruit yields vary considerably when light interception is over 50%**, indicating that factors other than total light interception may become limiting.
Light Interception

Training System, Rootstock, and Pruning Effect on LAI and Light Interception

- **Optimal Range** *(Robinson, 1978; Wunsch and Lakso, 2000)*
  - 65 – 75%

- **Poor Coloration and Quality** *(Jackson 1978)*
  - <50-55%

- **Inhibit Fruit Growth** *(Bepete and Lakso 1998)*
  - <50-55%

- **Reduced C-Export from Shoot to Fruit** *(Corelli-Grappadelli 1994)*
  - <35%

- **Ceased Growth, Fruit Abscise** *(Bepete and Lakso 1998)*
  - <20%
Why is so important light interception and distribution?

Because we can maximize yield and fruit quality

How we can maximize yield and fruit quality?

• Open, well-exposed canopies with high amounts of sunlight captured by spur leaves are needed early in the growing season since it appears that fruit yield depends primarily on early spur canopy light microclimate.

• Avoid canopy closure until at least 4 to 6 weeks after full bloom to prevent a shade-induced reduction of fruit growth.

• Continuous exposure to light to produce good spur complexes and to allow good exposure of spurs for flower bud development.

• Late summer pruning may help fruit color but will not reverse detrimental effects on fruit growth and internal fruit quality of excessively dense early-season canopies.

Wunsche and Lakso, 2000
Fig. 7. Canopy light distribution pattern at four times during the growing season for 11-year-old ‘Empire’/M.9 trees trained as slender spindles. Values are percent full sun as determined by fisheye photography, n = 3.
Poor Distribution of Light - Size + Color Implications

- WA38 in August of 2016
- Same tree, different light climates due to poor light distribution
  - Excessive light at the top
    - Sunburn
  - Minimal light at the bottom
    - Poor color and size
- Non-Uniform Fruit Quality
2D CANOPY
Photoselctive Nets
DRY matter and its application
DRY MATTER

Net total DM of an apple orchard is a function of:

- **light availability,**
  Incident solar radiation is independent of production system (dep. on climate).

- **light interception** (is the main factor limiting orchard productivity)
  PPF (photosynthetic photon flux) intercepted by an apple orchard depend on:
  - Orchard design
  - Leaf area index
  - Length of growing season

- **photosynthesis**
- **respiration** (Wünsche et al., 1996).
Fig. 3 - Con il procedere dell’età e della dimensione dell’albero la quantità di sostanza secca investita nel tronco e nelle radici va progressivamente diminuendo rispetto a quella utilizzata per la produzione. (Da CHALMERS e VAN DEN ENDE, 1975).
• Estimated dry matter production of 12.8-17.5 t/ha over the last 3 years.

• Higher productions were achieved by higher tree densities (higher LAI and light interception).

• % allocation of DM to leaves was constant over 5 yrs only a small decline from 1980 to 1984.

• Partitioning to leaf fraction slightly affected by crop load.

• Dry matter production was proportional to tree densities at the beginning.

• In the later years doubling the tree densities increased the yield by 23% and total dm of 28%.
Need of predictors of eating quality based on the physiological and metabolic knowledge.

DMC = dry matter concentration relates to maturity and consumer preference.

- DMC in kiwifruit is a predictor of ripe soluble solids content after storage.
- Fruit harvested at low DMC are less preferred than the high DMC ones by consumers.
- Consumer liking is not only associated to highest TSS (Harker et al., 2009).
- DM % had been developed as a fast and low technology alternative for assessing maturity in avocado.
- Consumer showed higher intent to buy and liking for highest DMC avocado fruit (Gamble et al., 2010).

The graph shows the distribution of DM % across different maturity stages: Immature, Early, Mid, and Late. The box plot indicates that DM % increases from Immature to Late maturity, with a peak around Mid maturity.
McGlone et al., 2003: In Royal Gala apples, DM correlates strongly with the total carbohydrate level in fruit. DM prediction to guess the post-storage SSC in these apples.
8 cultivars together

- **DMC in apple is not a maturity metric**, since during harvest, while maturity parameters such as background color, SPI, ethylene emission vary, DMC shows minor changes in this period of time.
- Firmness and TA are more dynamic during maturation and storage.
- **DMC needs to be used before or at harvest as predictor of the sensory potential of fruit after many months of storage.**
- DMC can be consider a complementary quality index (Palmer et al., 2010).

**Table 2.** DMC, TSS, fruit firmness and titratable acidity (malic acid equivalent g kg⁻¹) of ‘Royal Gala’ apple fruit after 10–12 weeks at 0.5°C and 1 day at 20°C. Means are based on six orchard blocks (two regions, three orchard blocks per region, 86–91 fruit per block), analysis of variance P-values (12 d.f.e.), and 5% least significant differences (LSD) are displayed.

<table>
<thead>
<tr>
<th>Dry matter category</th>
<th>DMC (g kg⁻¹)</th>
<th>Soluble solids (°Brix)</th>
<th>Firmness (kgf)</th>
<th>Titratable acidity (g kg⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>157</td>
<td>13.6</td>
<td>6.62</td>
<td>2.9</td>
</tr>
<tr>
<td>Moderate</td>
<td>143</td>
<td>12.7</td>
<td>6.21</td>
<td>2.6</td>
</tr>
<tr>
<td>Low</td>
<td>132</td>
<td>11.8</td>
<td>6.19</td>
<td>2.4</td>
</tr>
<tr>
<td>P-value</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>0.1133</td>
<td>0.02</td>
</tr>
<tr>
<td>5% LSD</td>
<td>4.5</td>
<td>0.40</td>
<td>0.45</td>
<td>0.30</td>
</tr>
</tbody>
</table>

**Figure 5.** Relationship between DMC and TSS after 12 weeks of cool storage of 22 individual fruit from eight apple cultivars sourced from Hawke’s Bay, New Zealand, 2006.
Crop Load Definition

Crop load, as a measure of orchard productivity, is defined as the amount (e.g., number or weight) of fruit produced per tree or branch unit.

Yield Efficiency

The term yield efficiency is often used when crop load is expressed as the fruit yield per whole-canopy leaf area, trunk cross-sectional area (TCA), canopy volume or tree light interception.

Wunsche and Ferguson, 2005
Crop load and Quality

• Crop load is a key cultural component of final fruit quality.
• Crop manipulation and effects of harvest time and fruit maturity are of particular importance to growers in enhancing the proportion of the crop achieving desired qualities.
# Factors Affected by Crop Load

## Tree and fruit response to crop load in apple

### 1. Vegetative response

As crop load increases, there is a decrease in:
- Leaf area, with heavier & thicker leaves
- Shoot growth, seen in shoot number and/or mean shoot length
- Trunk and root growth - although proportionally the least increment!
- Dry matter

### 2. Reproductive response

A heavy crop results in:
- Fewer flowers, and lower flower quality
- Reduced fruit set, growth rate, size/weight and dry matter
- Retarded maturity, seen in colour, SSC, TA and firmness
- Less storage disorders such as bitter pit, watercore, and internal breakdown

### 3. Physiological and biochemical responses

With higher crop loads, there is an increase in:
- Gas exchange - NCER, transpiration, dark respiration, $g_d, g_m$
- Chlorophyll fluorescence - $q_p, \Delta F/\Delta F_{m}'$, ETR
- Water consumption
- Mineral nutrient uptake

and a decrease in:
- Concentration and content of carbohydrates

## Physiological explanation

- Lesser amounts of assimilates / dry matter partitioned into vegetative sinks due to strong fruit sinks
- Hormonal (GA) regulation
- Carbohydrate supply limitation due to low leaf : fruit ratio
- High Ca:K conc. ratio
- No feedback regulation of photosynthesis due to low source - sink ration and carbohydrate accumulation
- Greater leaf photosynthetic efficiency
- Hormonal (ABA) regulation

---

Wunsche and Ferguson, 2005
Honeycrisp Crop load
HC crop load trial: yield 2014
(harvest August 28, 2014)

Crop Load Influences Fruit Quality, Nutritional Balance, and Return Bloom in ‘Honeycrisp’ Apple

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Rachel Leiss
Tree Fruit Research and Extension Center, Washington State University, Wenatchee, WA 98801; Department of Horticulture, Washington State University, Pullman, WA 99164; and Tree Fruit Research Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Wenatchee, WA 98801

Luca Giordani, Lee Kalesits, and Stefano Musacchi
Tree Fruit Research and Extension Center, Washington State University, Wenatchee, WA 98801; and Department of Horticulture, Washington State University, Pullman, WA 99164

Additional index words: apple, crop load, LAD, fruit quality parameters, fruit size, nutrition

Table 1. Effect of crop load on number of fruit/trunk cross-sectional area (TCSA), yield per tree, average fruit weight (g) and yield efficiency (kg/TCSA) for ‘Honeycrisp’ apple fruit grown in the northwest United States.

<table>
<thead>
<tr>
<th>Target no. of fruit per tree</th>
<th>No. of fruit per tree</th>
<th>No. of fruit/cm² TCSA</th>
<th>Yield/tree (kg)</th>
<th>Fruit wt (g)</th>
<th>Yield efficiency (kg/cm² TCSA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30–40</td>
<td>72–204</td>
<td>4.7 c</td>
<td>6.6 c</td>
<td>196.3 a</td>
<td>0.9 c</td>
</tr>
<tr>
<td>50–65</td>
<td>55.7 c</td>
<td>7.5 c</td>
<td>8.5 c</td>
<td>151.8 ab</td>
<td>1.1 c</td>
</tr>
<tr>
<td>75–85</td>
<td>83.7 b</td>
<td>11.3 b</td>
<td>12.0 b</td>
<td>143.7 b</td>
<td>1.6 b</td>
</tr>
<tr>
<td>90–100</td>
<td>95.0 b</td>
<td>12.5 b</td>
<td>14.0 b</td>
<td>147.7 ab</td>
<td>1.8 ab</td>
</tr>
<tr>
<td>125–135</td>
<td>130.0 a</td>
<td>16.0 a</td>
<td>17.0 a</td>
<td>130.8 b</td>
<td>2.1 a</td>
</tr>
</tbody>
</table>

Significance:

*** Significant with proc GLM in SAS, type III sums of squares. Means comparisons were established with post hoc Tukey test. Means in a column followed by the same letter are not statistically different at P < 0.05.

* Significant or not significant at P ≤ 0.05, 0.01, or 0.001, respectively.

CROP LOAD as fruit per tree range

<table>
<thead>
<tr>
<th>CROP LOAD as number of fruit/TCSA cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>30–40</td>
</tr>
<tr>
<td>4.7</td>
</tr>
<tr>
<td>50–65</td>
</tr>
<tr>
<td>7.5</td>
</tr>
<tr>
<td>75–85</td>
</tr>
<tr>
<td>11.3</td>
</tr>
<tr>
<td>90–100</td>
</tr>
<tr>
<td>12.5</td>
</tr>
<tr>
<td>125–135</td>
</tr>
<tr>
<td>16.0</td>
</tr>
</tbody>
</table>
Crop Load Influences Fruit Quality, Nutritional Balance, and Return Bloom in ‘Honeycrisp’ Apple

HC crop load trial: fruit quality at T0 (1 month after harvest)

Table 2. Effect of crop load on measures of fruit quality and maturity shortly after harvest (1 month of storage at 1 °C), and differences in measures of fruit quality and maturity according the $I_{AD}$ classification for ‘Honeycrisp’ apple fruit grown in the northwestern United States.

<table>
<thead>
<tr>
<th>Crop load (no. fruit/cm² TCSA)</th>
<th>$I_{AD}$ (T0)</th>
<th>Wt (g)</th>
<th>$I_{AD}$ (T0)</th>
<th>Red-blushed surface (overcolor) (%)</th>
<th>Overcolor (hue)</th>
<th>Overcolor (chroma)</th>
<th>Background (hue)</th>
<th>Background (chroma)</th>
<th>Starch (1–6)</th>
<th>IEC (µmol)</th>
<th>pH²</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.7</td>
<td>0.65 c</td>
<td>191.7 a</td>
<td>71 a</td>
<td>33.5 c</td>
<td>43.5 a</td>
<td>102.3 b</td>
<td>45.9 a</td>
<td>4.0 –</td>
<td>0.5 b</td>
<td>3.34 –</td>
<td></td>
</tr>
<tr>
<td>7.5</td>
<td>0.84 b</td>
<td>185.4 ab</td>
<td>66 a</td>
<td>39.8 c</td>
<td>38.6 b</td>
<td>101.5 b</td>
<td>42.1 b</td>
<td>4.2 –</td>
<td>1.1 a</td>
<td>3.32 –</td>
<td></td>
</tr>
<tr>
<td>11.3</td>
<td>0.85 b</td>
<td>175.6 bc</td>
<td>53 b</td>
<td>54.6 b</td>
<td>35.2 c</td>
<td>106.5 a</td>
<td>44.0 ab</td>
<td>4.6 –</td>
<td>0.2 b</td>
<td>3.34 –</td>
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<tr>
<td>12.5</td>
<td>0.96 ab</td>
<td>174.4 bc</td>
<td>54 b</td>
<td>55.9 b</td>
<td>35.0 c</td>
<td>107.8 a</td>
<td>44.7 a</td>
<td>4.6 –</td>
<td>0.2 b</td>
<td>3.32 –</td>
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<tr>
<td>16.0</td>
<td>1.10 a</td>
<td>168.5 c</td>
<td>40 c</td>
<td>66.1 a</td>
<td>33.7 c</td>
<td>109.1 a</td>
<td>45.4 a</td>
<td>4.2 –</td>
<td>0.0 b</td>
<td>3.35 –</td>
<td></td>
</tr>
</tbody>
</table>

Significance:<sup>a</sup>

<sup>a</sup>Significance of differences in measures of fruit quality and maturity according to the $I_{AD}$ classification for ‘Honeycrisp’ apple fruit grown in the northwestern United States.

Crop load

4.7 fruit/cm²

16.0 fruit/cm²

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Fruit distribution in $I_{AD}$ classes: comparison between different crop loads (at $T0=1$ month after harvest)
Higher the fruit Dry Matter (DM), greater the consumer acceptability. DM suggested as a fruit final quality predictor (Palmer et al., 2010).
## HC crop load trial: return bloom 2015

<table>
<thead>
<tr>
<th>Crop Load</th>
<th>TCSA (cm²)</th>
<th>num cluster/tree</th>
<th>blossom density (cluster/TCSAcm²)</th>
<th>heighth (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-40</td>
<td>8.09</td>
<td>309.7 a</td>
<td>38.14 a</td>
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<tr>
<td>50-65</td>
<td>6.87</td>
<td>109.7 b</td>
<td>15.68 b</td>
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<tr>
<td>75-85</td>
<td>7.83</td>
<td>37.3 b</td>
<td>4.81 b</td>
<td>297</td>
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<tr>
<td>90-105</td>
<td>8.05</td>
<td>53.0 b</td>
<td>6.79 b</td>
<td>301</td>
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<tr>
<td>125-135</td>
<td>7.47</td>
<td>28.7 b</td>
<td>4.28 b</td>
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</tbody>
</table>

significance: NS ** ** NS

HC crop load trial: return bloom 2015
Orchards mechanizations

Harvest
<table>
<thead>
<tr>
<th>kg</th>
<th>mm</th>
<th>mm</th>
<th>kg</th>
<th>mm</th>
<th>mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>2500 x 1160/1260</td>
<td>2500 x 1160/1260</td>
<td>300</td>
<td>900 / 1000</td>
<td>230 / 280</td>
</tr>
</tbody>
</table>

Source: http://www.nblosi.com/it/prodotti/bintreno.php
THANK YOU FOR YOUR ATTENTION !!!
Apple fruit quality: Overview on pre-harvest factors

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Light
Temperature
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Maturity indices
Phytochemicals
Quality standards

ABSTRACT

Apple is the fourth most important fruit produced and eaten around the world with a production of 84 million tonnes in 2014. The modern cultivated apple (Malus × domestica Borkh) is probably the result of interspecific hybridization and, at the moment, ten thousand or more apple cultivars are listed in the European Apple Inventory. The large number of cultivars reflects also a broad range of variability in the quality traits. “Fruit quality” is a dynamic concept changing on the basis of the consumer needs and perceptions that reflect sociocultural evolution. Almost all the characteristics determining apple quality can be measured or classified. Consumers assess apples by its appearance (colour, size, shape, absence of defects) and then by its eating quality, although the latter may determine the willingness to buy the product again. Furthermore, the high level of polyphenols confer apples relevant nutraceutical properties. Apple consumption has been deeply encouraged and a broad range of varieties are competing in the market, but the indisputable quality of a commodity is proved by the repeating purchase by consumers. In this review, the most common worldwide utilized external and internal quality parameters (i.e. firmness, starch, soluble solid content, titratable acidity) and conventional techniques as well as some new approaches to assess them are explored. New quality metrics recently developed, like IAD and dry matter, are discussed too. The current review discusses the impacts and potentials of both environmental conditions, and agronomic factors. Environmental and agronomic factors along all the growing season strongly affect the final apple quality including the nutraceutical aspects. Temperature and light contribute to several modifications of external and internal apple quality like red overcolor and dry matter accumulation, but also can trigger unwelcome disorders like sunburn. Orchard design, training system and pruning can dramatically impact the skin overcolor and the maturity of the fruit. Crop load and thinning can determine physiological adjustments that benefit the dry matter accumulation in the fruit. Irrigation and nutrition can modified the overcolor and the chemical composition of the flesh.
Thank you!

WSU TREE FRUIT ENDOWMENT