Comparaison des modes de conduite en fuseaux étroits (Tall Spindle) et en multiaxes (Multiple Leaders)

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STUDYING TREE ARCHITECTURE

Multi-leader FRUIT WALL  TRADITIONAL

1968-1990

• First major shift in apple growing from:
• 3D giants  to
spindle/M9
Harvest in a standard orchard in Trentino Alto Adige (Italy)

In the last 30 years, yields have grown steadily from 30 to about 70 tons/ha

Now the main goal is to increase economic and ecologic sustainability of the apple industry by:

1. Cutting down costs (input of chemicals and labour) while keeping these high yields
2. Moving towards more environmental benign techniques (less chemicals)

More yield with less input

Can this be achieved by just changing tree architecture?
TRADITIONAL TREE ARCHITECTURE
(from above)

FRUIT WALL TREE ARCHITECTURE
(from above)

No distinction between “IN” and “OUT”

LESS chemicals and MORE mechanical
Scheme of tree architecture

Standard canopy

Ideal Fruit wall

fruiting wood
(spurs, brindilla, etc.)

Second shift: the fruit walls (1990- ...)?

Need for

• great control of vigour and

• plasticity

BiBaum®/MLT is a strong tool to achieve vigour control

BiBaum® trees are extremely “plastic”
CENTRIFUGAL effect of long pruning
CENTRIFUGAL effect of long pruning (Chile)

In both training systems the **structural wood** is absent.

Photo Craig Hornblow – New Zealand
Appletree plasticity

Shape and size of propagated trees are both under major control of the environment (cultural techniques)

How can we build a short fruit wall and get rid of structural wood (secondary structure)?

There are several tools that can be used:

1) Increasing the number of leaders from 1 to 2 or more
2) Short pruning instead of long pruning (not alone!)
3) Replacing dormant pruning with “Lorette” and postharvest cuts
4) Make use of mechanical pruning to shape trees
5) Standard growth control (root pruning, PGRs, etc.)

1) Increasing the number of leaders (Bibaum® and multi-leader trees)
Multi-leader trees are receiving positive evaluation all over the World.

A superspindle near Kelowna (B.C.)
Left: spindle  Right: 2 leader
A 4 leader Pink Lady at 2.0 m between trees

Vigour of each leader according to the number of leaders per tree (model)

\[ y = 100x^{-1} \]  
\[ R^2 = 1 \]
Shoot number distribution at different tree heights (Gala - V. Adige, 2012)

Branch length distribution at different tree heights (Golden - V. Adige)
Increasing the n. of leaders is a powerful tool for building a fruit wall

1) By building more than 1 central leader as the only structural wood, vigour is diverted to form a more complex primary structure (more leaders = more dwarfing)

2) Bibaum and ML trees tend to form naturally a fruit wall, with little or no secondary structure, flat and with no gaps

Vigour-wise, increasing the n. of axes “looks like” shifting progressively to more dwarfing rootstocks

N. of leaders: additional variable for choosing the right system in new plantings (beside cv, rootstock and spacing)

Standard free-standing MM 106 at 4 m between rows
Golden / MM106 at the end of 6th leaf

- Spindle
- 2 leaders (Bibaum)

8 leader MM 106 at 3 m between rows
A 3 and 4 leader tree of Golden / MM106 at the end of 6th leaf

A 6 leader tree of Golden / MM106 at the end of 6th leaf
Fuji trained with Spindle / long pruning

Multi-leader fruit wall of Gala
TSA of each leader in spindle and multi-leader trees after 7 years
Fuji trained with 1-6 leaders

\[ y = 139.19e^{-0.3361x} \]

\[ R^2 = 0.9798 \]

TSA of trees trained with different number of leaders 7 years after planting

Golden Gala Fuji Pink Lady
Yield of a semi-pedestrian 8-leader Fuji orchard at 2.75 m between rows (52 kg from 238 apples in the 6° leaf)

Semi-pedestrian 8-leader Fuji orchard at 2.75 m between rows
Bibaum planting tend to form naturally a Fruiting wall

Yield of a spindle and of a 2 leader tree

<table>
<thead>
<tr>
<th>spindle</th>
<th>height</th>
<th>2 leader tree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2-3 m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-2 m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0-1 m</td>
<td></td>
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</tbody>
</table>
Yield of Fuji spindle trained and 2 leader trained

Fruit color distribution in 2 orchards trained spindle and Bibaum

<table>
<thead>
<tr>
<th></th>
<th>0-20%</th>
<th>20-50%</th>
<th>50-80%</th>
<th>80-100%</th>
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<tbody>
<tr>
<td>FERRARA Bibaum</td>
<td>3</td>
<td>33</td>
<td>58</td>
<td>6</td>
</tr>
<tr>
<td>FERRARA Spindle</td>
<td>10</td>
<td>49</td>
<td>38</td>
<td>2</td>
</tr>
<tr>
<td>LUGO Bibaum</td>
<td>5</td>
<td>27</td>
<td>56</td>
<td>13</td>
</tr>
<tr>
<td>LUGO Spindle</td>
<td>18</td>
<td>56</td>
<td>33</td>
<td>13</td>
</tr>
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</table>

Tall fruit wall of Golden Delicious (4 leaders)

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>n. trees/ha</td>
<td>1800</td>
<td></td>
<td></td>
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<tr>
<td>fruits/tree</td>
<td>246</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>kg/tree</td>
<td>64</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tons/ha</td>
<td>122</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fruit weight (g)</td>
<td>263</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
Tall fruit wall of Bibaum of Gala

<table>
<thead>
<tr>
<th>n. trees/ha</th>
<th>2600</th>
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</thead>
<tbody>
<tr>
<td>fruits/tree</td>
<td>196</td>
</tr>
<tr>
<td>kg/tree</td>
<td>39</td>
</tr>
<tr>
<td>tons/ha</td>
<td>103</td>
</tr>
<tr>
<td>fruit weight (g)</td>
<td>202</td>
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<tr>
<td>red overcolor %</td>
<td>95</td>
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Tall fruit wall of Pink Lady

<table>
<thead>
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<th>n. trees/ha</th>
<th>3070</th>
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<tbody>
<tr>
<td>fruits/tree</td>
<td>294</td>
</tr>
<tr>
<td>kg/tree</td>
<td>61</td>
</tr>
<tr>
<td>fruit weight (g)</td>
<td>211</td>
</tr>
<tr>
<td>red overcolor %</td>
<td>74</td>
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</table>
Yield of semi-pedestrian Gala planted in 2012
2 leaders at 2.5x1.2m - 4 leaders at 2.5x1.6m
(3333 trees/ha)  (2500 trees/ha)

Yield of semi-pedestrian Fuji planted in 2012
2 leaders at 2.5x1.2m - 4 leaders at 2.5x1.6m
(3333 trees/ha)  (2500 trees/ha)
4 leaders Fuji 2 years old - Spacing: 2.25 m (between rows) x 1.6 (btw. trees)

3 and 4 leader Golden / M9 at the end of 6th leaf
A 4 leader tree of Fuji at the end of 3rd leaf

A 6 leader tree of Fuji at the end of 3rd leaf
A 8 leader tree of Fuji at the end of 3rd leaf

A 6 leader tree of Fuji at the end of 7th leaf
A 8 leader tree of Fuji at the end of 7th leaf

A 8 leader tree of Red Del spur/MM106 at the end of 7th leaf
4 leader Pink Lady 5 leaf at 2m spacing between trees

2) Short pruning
CENTRIFUGAL effect of long pruning (Chile)

CENTRIFUGAL effect of long pruning (II leaf)

(flower buds at 50-110cm)
CENTRIPETAL effect of short summer pruning (I leaf, Fuji)

Flower buds a 15-40cm

40cm 30cm 20cm 10cm

June cut

Flower buds

1 year old Fuji pruned in June (V. Non, Italy 27/9/13)

3) Replacing winter pruning with “summer” pruning
"This year we have gathered four pears" or "I haven't a single pear this year."

But why this pitiful result? Because the majority of garden owners, if they have their trees pruned in winter by more or less competent professional gardeners, almost always omit to carry out summer pruning and the pinching back of shoots during the growing season. The result is great confusion among

Lorette pear trees (1919)  S. Maria pear reaction after June cut (2013)
“De-constructing” effect of early June pruning

Principle: divert sap towards fruits and buds at the expense of new unnecessary growth and direct light into the canopy

Pruning can be done by hand or by machine

“Lorette” as well as other forms of non-dormant pruning helps “de-structuring” canopies: getting rid of old structural wood and turning it back into bearing wood

Strong “reset effect” of Summer pruning on the scaffold of Empire
**MECHANICAL PRUNING** of 4 leader pedestrian orchard at 2.5 m between rows (May 22/2015)

At the end of Summer, 3-4 months after the “Lorette” pruning, the terminal stipulary eyes at the base of the leaf on 1-year old wood produce new spurs near the cut.
Fruits of Golden set in May 2010 on flowerbuds formed by “Lorette” pruning of 1/6/09

4 leaders Gala 3 years old - Spacing: 2.25 m between rows
2 and 4 leader semi-pedestrian Golden Delicious at 2.5 m between rows, 5° leaf

<table>
<thead>
<tr>
<th>Treatm.</th>
<th>tons/ha</th>
<th>kg/tree</th>
<th>fruit/tree</th>
<th>fruit weight (g)</th>
<th>fruit size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 leaders</td>
<td>99</td>
<td>30</td>
<td>118</td>
<td>251</td>
<td>87.6</td>
</tr>
<tr>
<td>4 leaders</td>
<td>91</td>
<td>36</td>
<td>142</td>
<td>256</td>
<td>88.2</td>
</tr>
</tbody>
</table>

Yield of semi-pedestrian Gala planted in 2012
2 leaders at 2.5x1.2m - 4 leaders at 2.5x1.6m
(3333 trees/ha)  (2500 trees/ha)

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 leaders</td>
<td>27</td>
<td>37</td>
<td>53</td>
<td>75</td>
</tr>
<tr>
<td>4 leaders</td>
<td>18</td>
<td>29</td>
<td>44</td>
<td>62</td>
</tr>
</tbody>
</table>
Multi-leader fruit wall of Gala

1.9m free passage

2.7m betw. rows
Ultra-narrow training:
From multi-leaders to Guyot
Potential for Bibaum trees

**Plasticity** def.: “the capability of being molded, …or assume a desired form”

Bibaum trees can be easily molded into different shapes

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**Guyot training: beyond the permanent multi-leader**

The geometry of trees is rotated of 90°

- **Secondary structure**: upright semi-permanent branches (*suckers/leaders*)
Guyot training: beyond the permanent multi-leader

The geometry of trees is rotated of $90^\circ$

Secondary structure: upright semi-permanent branches (suckers/leaders)

Primary structure:
1 or 2 semi-horizontal stems

2 year old double Guyot of Gala

April 2015
Planting at 2m between rows (2000 Bibaum® /ha)

April 2015:
Bending the main stems to the horizontal
**Bibaum plasticity:** double Guyot of Gala at 2 m between rows (August 2016, 2° leaf) with about 15 vertical limbs/tree

<table>
<thead>
<tr>
<th>n. trees/ha</th>
<th>2000</th>
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<tbody>
<tr>
<td>fruits/tree</td>
<td>50</td>
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<tr>
<td>kg/tree</td>
<td>12</td>
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<tr>
<td>tons/ha</td>
<td>24</td>
</tr>
<tr>
<td>fruit weight (g)</td>
<td>243</td>
</tr>
<tr>
<td>red overcolor %</td>
<td>96</td>
</tr>
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Same trees of Fuji. Weed control: only mechanical

<table>
<thead>
<tr>
<th>n. trees/ha</th>
<th>1792</th>
</tr>
</thead>
<tbody>
<tr>
<td>fruits/tree</td>
<td>33</td>
</tr>
<tr>
<td>kg/tree</td>
<td>11.2</td>
</tr>
<tr>
<td>tons/ha</td>
<td>19.5</td>
</tr>
<tr>
<td>fruit weight (g)</td>
<td>336</td>
</tr>
<tr>
<td>red overcolor %</td>
<td>79</td>
</tr>
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</table>
Short trees of double Guyot of Golden at 2.2 m between rows

Weed control: only mechanical

Machines can pass even with 2 meters between the rows
Precision horticulture: multi-leader trees are suitable to segmentation

5 fruits*5 wires*8 leaders* 1543 trees*0.19kg = 70 tons/ha

Before and after thinning to 8 fruits/ml
The equilifruit can be also used for assessing the right crop on ultra-narrow canopies.

There is a positive feed-back loop among the different tools to achieve growth control:

- Increasing n. of leaders (from 1 to n)
- Suitability to mechanical pruning
- Suitability to hand summer pruning
- Suitability to post-harvest pruning
A single Guyot of Fuji

A single Guyot tree of Gala at the end of 1st leaf
Double Guyot of Gala 2016 in the second leaf
Spacing: 2m (between rows) x 2.4 (between trees)

Pedestrian multi-leader Fuji orchard at 1 m from Davor Baum (3° leaf)
Double rows of double Guyot in the second leaf (2.3+1.3m btw. rows)

Conclusions

• After 50 years of single leader training (spindle, solaxe) preformed MLT is an option that can alter fruit tree architecture.

• MLT productivity and quality is as good or better than the best spindle trained orchards. Its management is much simpler for the grower and projected toward the future.

• Multi-leader though not suitable for every grower, can result in viticulture-like tree heights, spacing and machinery.

• New techniques are made possible by pedestrian fruit walls, including mechanization, microclimatic modification through anti-rain nets and multi-task microsprayers on the canopy.
Thanks to:

• Franco Micheli and Piero Malfatti, who run the 2 experimental farms (Maso Part in valle dell’Adige and Maso Maiano in valle di Non),
• the staff of the two “Masi”
• Daniel Bondesan and Claudio Rizzi for the efficacy study on tunnels and fixed spraying systems
• Luisa Mattedi for the pest control in the new orchard system
• The “meteo” staff for the microclimatic data
• Boscato Reti s.r.l. and Keep In Touch ‘system’ for the AltCarpò and the anti-rain nets
• Bertoni and Lochman for the tunnel sprayers
• Poppi and Netafim for the fixed spraying systems on the canopy
• FAMA for the window pruning machine
• Agri Com for the support in any mechanization
• Anselmi Brothers for the AltCarpò net movimentation
• Agricenter for the tools for alternative weed control
• Mingozzi for the support in the alternative weed control trough fire

Thank you for your attention!