Progress in Cherry Rootstock and Cultivar Research

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This research brought into rootstock breeding procedure the valuable and diverse plant material.

Number of accessions in trial:

- Prunus fruticosa ........................................ 63 genotypes
- Prunus mahaleb ........................................ 32 genotypes
- Prunus cerasus ........................................ 43 genotypes
- Prunus avium ........................................ 9 genotypes

Standard cherry rootstocks:

- Gisela 5, Gisela 6
- Colt
- PHL -A

Selection goal:
Precocious and dwarfing rootstock
Valuable asset of germplasm preservation work is network of collaborators.

The most valuable asset is inexhaustible sources of ideas.
On farm examples of rootstock/scion interactions

'Oblačinska' sour cherry/Lara

'Oblačinska' sour cherry/Summit
In situ and on farm accession mapping using GPS record keeping program
Genetic diversity

Natural populations – *P. mahaleb*, *P. avium*, *P. fruticosa*

‘Oblacinska’ sour cherry - Chance seedlings where genetic diversity is continuum of morphological characteristics as result of heterozygosity, self-compatibility and cross-pollination with related germplasm
Vegetative propagation of Prunus genotypes

- Micropropagation
- Softwood cuttings
- Hardwood cuttings

First research goal:
- Efficient introduction of genetic diversity to anatomical and field evaluation
Rooting of soft wood cuttings under fogging system works well with all species
MICROPROPAGATION
Faster way for introduction of clonal germplasm to the rootstock breeding programme

Bud sterilization with pealing outer scales
Micropropagation protocols are strongly influenced by species and genotype.

Application of double-phase medium on *P. cerasus* and ‘Gisela’6 have good results for shoot number and elongation of proliferated shoots.

- *P. fruticosa* genotype required higher IBA concentrations:
  - Selection SV1- 2 mg/l (88.8%)
  - Selection SV2- 2.5 mg/l (80%)

- *P. mahaleb* require reduction of IBA concentration:
  - Selection M 1 - 0.8 mg/l (90%)
Morphological characterisation

- **Plant and shoot:**
  - Plant vigour, plant habit, branching, one-year-old shoot coloration, one-year-old shoot thickness, one-year-old shoot length of internode, number of lenticels, size and position of vegetative bud in relation to shoot. (9)

- **Leaf:**
  - Leaf blade length, leaf blade width, length/width ratio, leaf blade shape, angle of apex, length of tip, shape of base, petiole length, presence of leaf nectaries, number of nectaries, position of nectaries, color and shape of nectaries. (13)

- **Fruit (in situ):**
  - Fruit petiole length, fruit weight, fruit stone weight, stone/fruit ratio, fruit color, fruit shape. (6)

*In situ material*

Plants grown first year in pots.
### Root system morphology.

<table>
<thead>
<tr>
<th></th>
<th>P. avium</th>
<th>P. mahaleb</th>
<th>Colt</th>
<th>Gisela 6</th>
<th>‘Oblačinska’ sour cherry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of fine roots</td>
<td>15,00</td>
<td>7,00</td>
<td>12,00</td>
<td>23,50</td>
<td>5,00</td>
</tr>
<tr>
<td>Total length of fine roots(cm)</td>
<td>186,51</td>
<td>128,49</td>
<td>189,77</td>
<td>210,30</td>
<td>117,83</td>
</tr>
<tr>
<td>Number of medium roots</td>
<td>8,67</td>
<td>5,00</td>
<td>6,33</td>
<td>5,38</td>
<td>4,67</td>
</tr>
<tr>
<td>Total length of medium roots(cm)</td>
<td>140,32</td>
<td>155,54</td>
<td>170,58</td>
<td>89,40</td>
<td>137,45</td>
</tr>
<tr>
<td>Number of coarse roots</td>
<td>5,67</td>
<td>5,67</td>
<td>5,67</td>
<td>3,37</td>
<td>3,67</td>
</tr>
<tr>
<td>Total length of coarse roots(cm)</td>
<td>111,67</td>
<td>147,69</td>
<td>181,96</td>
<td>90,70</td>
<td>129,88</td>
</tr>
<tr>
<td>Root system total length(cm)</td>
<td>438,50</td>
<td>431,72</td>
<td>542,31</td>
<td>390,40</td>
<td>385,16</td>
</tr>
<tr>
<td>Root stem diameter(cm)</td>
<td>2,65</td>
<td>3,45</td>
<td>3,37</td>
<td>2,41</td>
<td>2,37</td>
</tr>
</tbody>
</table>

- **P. avium**: Prunus avium
- **‘Oblačinska’ sour cherry/sweet cherry**: A sour cherry variety
- **P. mahaleb**: Prunus mahaleb
- **Colt**: A cherry variety
- **Gisela 6**: A cherry variety
Total and active root surface area

Active root surface area represents radial root system conductivity
Differences in the cortical thickness and presence of suberized exodermis

• Method of methylene blue absorption by root surface
Anatomical characterisation

**Radial cross sections:**
- Roots
- Rootstock stem
- Scion shoot

- Cross-section characteristics:
  - Cross-section area,
  - Cross-section diameter, periderm area, phloem area, secondary wood (wood) area, wood/phloem ratio.

- Secondary wood (xylem) characteristics:
  - Xylem area, ray area, vessel area, average vessel size, number of vessels, affiliation of vessels to different size classes (<700 μm², 700 - 2000 μm² and > 2000 μm², for roots, and < 300 μm², 300 - 700 μm² and > 700 μm² for stems).

Based on the anatomical measurements, theoretical axial hydraulic conductance ($k_h$) of root, rootstock stem and scion stem per visual field, as well as for total cross-section area, were calculated according to the expression given by Tyree and Ewers (1991), based on Hagen-Poiseuille’s law:

$$k_h = \frac{\pi \cdot \rho}{128 \cdot \eta} \sum_{i=1}^{n} d_i^4$$

where $d$ was the diameter of the vessels in meters, $\rho$ was the fluid density (assumed to be $10^3$ kg m⁻³ for water at 20°C) and $\eta$ was the viscosity (assumed to be 1.002 $10^{-9}$ MPa s for water at 20°C).
Characteristics of root radial cross sections

- *P. fruticosa* sel. SV 2
- *Gisela 5*
- ‘P. cerasus’OV16
- *P. fruticosa* sel. SV 5
- *P. mahaleb*
- ‘P. cerasus’OV18
- *P. fruticosa* sel. SV 4
- PHL-A
- ‘P. cerasus’OV33
The PCA scatter plot indicated six subgroups of genotypes.
Rootstock stem/scion shoot anatomical characteristics

Rootstock / scion pith overlapping, hydraulic conductivity

- Rootstock stem pith
- Rootstock stem inner wood ring
- Rootstock stem middle wood ring
- Rootstock stem outer wood ring
- Rootstock stem phloem
- Rootstock stem periderm
- Scion stem pith
- Scion stem inner wood ring
- Scion stem middle wood ring
- Scion stem outer wood ring
- Scion stem phloem
- Scion stem periderm
Simulation of functional plant constituents hydraulic conductivity

- **Functional root system hydraulic conductivity**
  \[ K_{h\ (Rc)} = (K_{h\ (R)} \times C_{wu}) \]
  Theoretical root system hydraulic conductivity corrected for the coefficient of active surface area

- **Functional rootstock stem hydraulic conductivity**
  \[ K_{h\ (RStf)} = K_{h\ (RSt)} - K_{h\ (RSt-ir)} \]
  Theoretical rootstock stem hydraulic conductivity reduced for the coefficient of inner ring hydraulic conductivity

- **Functional scion stem hydraulic conductivity**
  \[ K_{h\ (SSt)} \] (all three secondary wood rings)
  Theoretical scion stem hydraulic conductivity = Functional hydraulic conductivityIt is in agriment with estimated hereditary scion vigor
Functional hydraulic conductance of cherry tree constituents (10^{-5} Kg m/MPa s)

- **Prunus avium**
- **Prunus mahaleb**
- **Colt**
- **Prunus cerasus 'oblačinska'**
- **Prunus fruticosa SV2**
- **Gizela 5**
Plant vigor simulation model based on functional hydraulic conductance

- Prunus avium
- Prunus mahaleb
- Colt
- Prunus fruticosa SV2
- Prunus cerasus ‘oblačinska’
- Gisela 5
<table>
<thead>
<tr>
<th>THE STRUCTURAL PART OF THE CHERRY TREE</th>
<th>GENOTYPE</th>
<th>Source of genetic material</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROOTSTOCK</td>
<td>Gisela 5, Weiroot 158</td>
<td>Wertheim (1998); Gulen et al. (2004); Stefančič et al., (2005); Ljubojević et al., (2011)</td>
<td>►</td>
</tr>
<tr>
<td></td>
<td>Prunus avium, Prunus mahaleb, Colt</td>
<td>Webster (1996); Wertheim (1998); Bibalani (2011)</td>
<td>▼</td>
</tr>
<tr>
<td></td>
<td>Prunus Avium</td>
<td>Webster (1996); Wertheim (1998); Bibalani (2011)</td>
<td>▼</td>
</tr>
</tbody>
</table>

### PHENOTYPE

- The possibility of vegetative reproduction by softwood cuttings.
- The possibility of vegetative reproduction by semi-hardwood cuttings.
- Manual and mist system for rooting cuttings.
- Basal heating, peat/perlite as substrate.
- The possibility of vegetative reproduction by semi-hardwood cuttings.

### ENVIRONMENT

- Growing trees without support.
- Good anchorage.
- High frequency of strong winds.
- Good water supply.
- Good anchorage.
- Water supply (varied).
- Precipitation with values > 600 mm per year and > 400 mm during the growing season.
- Water supply (variable).
- Precipitation with values > 600 mm per year and > 400 mm during the growing season.
- Extremes in rootstock stem (trunk) secondary thickenings.
<table>
<thead>
<tr>
<th>THE STRUCTURAL PART OF THE CHERRY TREE</th>
<th>GENOTYPE</th>
<th>ENVIRONMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRAFT UNION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cambial activity of rootstock stem identical to sweet cherry scion stem</td>
<td>Selection <em>Prunus fruticosa</em> SV2</td>
<td>Absence of the graft union swelling</td>
</tr>
<tr>
<td>Xylem vessels whorls</td>
<td>Gisela 5</td>
<td>Slower water solution flow</td>
</tr>
<tr>
<td>Graft union phloem characteristics ²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scion xylem characteristics ²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 ± 20 vessels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>400 ± 25 µm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40000 ± 0.04 µm²/mm²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HP$_{vp}$ = 0.02 $\times$ 10¹³ MPa s⁻¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HP$_{g}$ ≤ 7 $\times$ 10¹² MPa s⁻¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scion phloem characteristics ²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>³ Rootstock selection on the first level, defined by the model of breeding process in low-vigourous cherry rootstocks selection.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>⁴ Rootstock selection on the second level, defined by the model of breeding process in low-vigourous cherry rootstocks selection.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>⁵ Rootstock selection on the third level, defined by the model of breeding process in low-vigourous cherry rootstocks selection.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>⁶ The theoretical hydraulic conductance of visual field (HP$<em>{vp}$), rootstock stem (HP$</em>{s}$), rootstock (Ro), graft union (Gu) and scion (Sc).</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Variety Summitt
- Phloem thickness: Ro/Gu/Sc. 0.5/1/0.5
- Greater number of smaller vessels in scion stems.
- Scion stem xylem hydraulic conductivity higher than root and rootstock stem hydraulic conductivity.
Specific rootstock / scion interactions

Sweet cherry Sylvia
Scion cultivar breeding
Hybridization
The concept of character

Choice of parents for crossing on the basis of the knowledge of cultivar vegetative characteristics and reproductive potential

**Selection goal**
- Breeding early maturing varieties

**Parentage**
- Đurđevka (01.06.)
- Rita (15.06.)
- Burlat (01.07.)
- Valerij Cskalov (01.07.)
- New Star (07.07.)
- Carmen (07.07.)
- Peter (10.07.)
<table>
<thead>
<tr>
<th>Variety</th>
<th>Dry matter (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Đurđevka</td>
<td>12.6</td>
</tr>
<tr>
<td>Rita</td>
<td>19.9 (6 mm)</td>
</tr>
<tr>
<td>Bigarreau Burlat</td>
<td>35.4</td>
</tr>
<tr>
<td>Valerij Cskalov</td>
<td>29.1</td>
</tr>
<tr>
<td>New Star</td>
<td>54.4</td>
</tr>
<tr>
<td>Carmen</td>
<td>51.6</td>
</tr>
<tr>
<td>Peter</td>
<td>49.3</td>
</tr>
</tbody>
</table>
Embryo culture using O.P. seeds from advanced selections of P. fruticosa

Selection goal
To broaden initial genetic variability and generate continuum in genetic diversity in anatomical and physiological characteristics important for vigour control

Vigor differences in cherry rootstocks between the most vigorous and dwarfing are not bigger than 40%.
Thank you for your attention