ROOT PRUNING EFFECT ON GROWTH AND YIELD OF SWEET CHERRY

Pal Monica Diana, Viorel Mitre
University of Agricultural Sciences and Veterinary Medicine, Faculty of Horticulture, 3-5 Manastur Street, Cluj-Napoca 400372, Romania; pal.monicadiana@gmail.com, mitreviorel@yahoo.com

Abstract. The influence of root pruning on growth and fruiting of five sweet cherry cultivars ‘Earlise’, ‘Bigarreau Burlat’, ‘Merchand’, ‘Kordia’, ‘Regina’), under the pedoclimatic conditions of Cluj-Napoca, Romania, in 2014-2015, was studied. The trees were grafted on Gisela 5 rootstock, trained as Zahn Spindel and the orchard had a density of 1666 trees/ha. Root were cut twice, at 50 cm distance from the trunk, in an angle of 45° and 30 cm depth, as followed: first time, to the autumn, in fall leaves time, on one side of the row and the second time, in spring, at blooming time, at the other side of the row. The treatments influenced the shoot growth, height of the trees, cumulative yield, trunk cross sectional area, the ratio of the yield to a trunk sectional area, with differences statistically assured. Root pruning reduced the average length of shoots. The longest shoots, in mean values, gave unpruned root variant (96.7 cm). Root pruning decrease the average length of annual growth (49.6 cm). The biggest average trunks cross sectional area with the unpruned root system were obtained (45.2 cm²). Also root pruning influenced the height of the trees. The best cumulative yield was obtained in variant of root pruning system (26.12 t/ha) followed by unpruned root system (20.0 t/ha). Finally root pruning increased productivity. The biggest value ‘Regina’ in root pruned variant has registered (0.17 kg/cm²). The lowest value of productivity index in unpruned system variant was obtained.

Keywords: root pruning, vegetative growth, fruiting, yield, trunk cross-sectional area

INTRODUCTION

Maintaining an optimal balance between growth and fruiting is an ongoing concern of research in fruit growing. Besides the classical methods of reducing the vigor (low vigor rootstocks and cultivars, compact types, pruning in green, balanced fertilization etc.) cutting root in order to reduce growth vigor and increase the number of fruit formation is increasingly more used. Performance of a culture system of fruit trees are largely related to creating an optimal balance between growths and fruiting. Luxuriant vegetative growth delay the shade crown for entry bearing trees and reduce yield and fruit quality (Mitre et al., 2012).

In high-density apple orchard, otherwise as in any fruit growing culture, the vegetative growth must temperate and turn them as bearing branches or as branches support. In addition, the vegetative growth must be balanced with flowering (Hugard, 1980; Sharma et al., 2009; Walker, 1980).

The maintenance of properly equilibrium between the vegetative and reproductive processes is a major challenge in tree fruit production (Sharma et al., 2009). There are many horticultural ways to maintain a permanent balance between growth and fruiting: rootstocks (who control directly vegetative growth), dormant pruning, summer pruning, root pruning, branches orientation, scoring, girdling and bark inversion, plant growth regulators, deficit irrigation, fertilization, but to date none have proven to be universally successful (Sharma et al., 2009). Rootstocks have provided apple growers with trees of reduced stature suited to a wide range of planting densities (Faust, 1989) but are
partially successful in controlling excess growth (Sharma et al., 2009). Limiting the uptake of water and nutrients can be achieved through manipulating root systems of fruit trees. Root pruning can decrease resource uptake or create a plant hormone imbalance which can adversely affect shoot growth.

Pruning of root systems has been successful in some fruits but less efficacious with others (Sharma et al., 2009). Pruning root of young and mature apple trees reduced shoot growth and thus controlled tree size (Ferree, 1989; Schupp and Ferree, 1988; Sharma et al., 2009). Root pruning reduced the number of apple tree root in the top 30 cm of soil (Ferree, 1994). In 15-years-old apple trees, this method of root pruning reduced trunk cross sectional area (TCSA) and shoot length without reducing fruit yield (Schupp and Ferree, 1988). A later study indicated that yield, as well as trunk cross sectional area (TCSA) of ‘Golden Delicious’ was reduced by root pruning that were grown on different rootstocks (Ferree and Knee, 1997; Sharma et al., 2009). The timing of root pruning is an important factor and root pruning in the dormant season or at full bloom was more effective in reducing shoot elongation than at June drop (Schupp and Ferree, 1987).

Root pruning is a mechanical mean of controlling tree size which could reduce growth, pruning time, preharvest drop etc. (Ferree and Rhodus, 1993). In the same note the present paper approaches the influence of root pruning in a high-density cherry orchard depending on the cultivar on growth and fruiting of the trees.

**MATERIALS AND METHODS**

The research has been carried out at a sweet cherry orchard, set up in spring of 2012 at Cluj-Napoca, in the centre of Transylvania, Romania. The planting system chosen for the experimental plot was 4 m between rows and 1.5 m between trees within row, resulting a high density orchard with 1666 trees/ha.

The experience was a bi factorial one: first experimental factor was the root pruning system of the trees having two graduations (unpruned root and pruned root) and the second one the cultivar with five graduations (‘Earlise’, ‘Bigarreau Burlat’, ‘Merchant’, ‘Kordia’ and ‘Regina’). In order to correspond to such a bi factorial model, there were formed 30 experimental plots comprising the 10 variants (2 x 5) in three replication. There were made observations on some growth parameters (length of shoots, trunk sectional area, height of trees) and fructification (cumulative yield for 2014-2015 period, productivity index).

For the experiment apple trees were grafted on Gisela 5 rootstock. The technology of culture was a specific one to the sweet cherry high density orchard. Root were cut mechanically twice, at 50 cm distance from the trunk, in an angle of 45° and 30 cm depth, as followed: first time, in the autumn fall leaves on one side of the row and the second time, in spring, before blooming time on the other side of the row.

The results obtained were processed with the variant analysis of the bi factorial model of the divided plots, using analysis of variance, respectively Duncan’s Test to determine the significant differences between groups.

**RESULTS AND DISCUSSIONS**

Data of the Table 1 show an important influence on average length of annual growth in the experimental field with differences statistically assured. The longest shoots,
in mean values, gave unpruned root variant (96.7 cm). Root pruning decrease strongly average length of annual shoots (49.6 cm).

The cultivars behaved differently regarding the average length of shoots having differences statistically assured between them. The highest value of shoots average in ‘Bigarreau Burlat’ was registered (85.8 cm), followed by ‘Earlise (73.8 cm), ‘Merchant’ (71.3 cm), ‘Regina’ (66.5 cm) and ‘Kordia’ (68.3 cm).

The shoots having optimal length, especially in the early stages of the trees, are an important indicator of growth and fruition potential of the future plantation but also achieve a balance between two processes; also annual branches placed in the right position helps form a strong framework of branches, allows air and light into the tree, induces flower and fruit bud formation, restricts tree size and maintains a balanced shape (Mitre et al., 2012).

Taking into account the combined action of two experimental factors, one can say that the longest shoots were obtained in combining ‘Bigarreau Burlat’ in unpruned root variant (111.3 cm) and the shortest shoots at ‘Regina’ in root pruned variant (42.7 cm). Ferree (1989), Schupp and Ferree (1988) also showed that pruning root of young and mature apple trees reduced shoot growth and thus controlled tree size. Root pruning reduced shoot growth and fruit load in Empire and McIntosh apple trees (Elfving et al., 1996).

Excessive vegetative growth reduces flowering and ultimately fruiting (Forshey and Elfving. 1989; Luckwill. 1970). A certain amount of growth is necessary to maintain vigor and healthy bearing canopy with an adequate leaf surface (Sharma et al., 2009).

The influence of root pruning and the cultivar on average length of shoots (cm) (Cluj-Napoca, Romania, 2014-2015)

<table>
<thead>
<tr>
<th>Cultivar/ root pruning system</th>
<th>Unpruned root</th>
<th>Root pruned</th>
<th>Mean cultivar</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Earlise’</td>
<td>95.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>52.3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>73.8&lt;sup&gt;B&lt;/sup&gt;</td>
</tr>
<tr>
<td>‘Bigarreau Burlat’</td>
<td>111.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>60.3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>85.8&lt;sup&gt;A&lt;/sup&gt;</td>
</tr>
<tr>
<td>‘Merchant’</td>
<td>95.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>47.3&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>71.3&lt;sup&gt;B&lt;/sup&gt;</td>
</tr>
<tr>
<td>‘Kordia’</td>
<td>91.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>45.3&lt;sup&gt;d&lt;/sup&gt;</td>
<td>68.3&lt;sup&gt;B&lt;/sup&gt;</td>
</tr>
<tr>
<td>‘Regina’</td>
<td>90.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>42.7&lt;sup&gt;d&lt;/sup&gt;</td>
<td>66.5&lt;sup&gt;BC&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mean treatment</td>
<td>96.7&lt;sup&gt;M&lt;/sup&gt;</td>
<td>49.6&lt;sup&gt;N&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>SD 5% cultivar</td>
<td>4.18</td>
<td>4.51</td>
<td></td>
</tr>
<tr>
<td>SD 5% treatment</td>
<td>2.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD 5% interaction</td>
<td>5.91</td>
<td>6.8</td>
<td></td>
</tr>
</tbody>
</table>

* Note: Different letters between cultivars denote significant differences

Besides length of shoots, another important element that defines the vigor of growth is the height of the trees. Looking at the data of the Table 2 one can observe that there are differences statistically assured between variants.

Regardless the treatment, the highest value of the height of the trees in ‘Merchant’ cultivar was registered. It has to be underlined that the others cultivars behaved similarly from the statistically point of view.

Regardless the cultivar, the biggest value of trees height in unpruned root variant was obtained (385.2 cm) and the lowest in root pruned one (350.5 cm). Regarding
The combined influence of the two experimental factors the tallest tree in ‘Bigarreau Burlat’ and unpruned root variant was registered (405 cm) and the smallest in ‘Merchant’ cultivar and pruned root system (342.7 cm).

Tab. 3 introduces data referring to the influence of the root pruning system of the sweet cherry trees and the cultivar on average trunk sectional area. There were no differences statistically assured between ‘Earlise’, ‘Merchant’, ‘Kordia’ and ‘Regina’.

Table 2

The influence of root pruning and the cultivar on height of the trees
(Cluj-Napoca, Romania, 2014-2015)

<table>
<thead>
<tr>
<th>Cultivar/ root pruning system</th>
<th>Unpruned root</th>
<th>Root pruned</th>
<th>Mean cultivar</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Earlise’</td>
<td>380.0</td>
<td>344.7</td>
<td>362.3</td>
</tr>
<tr>
<td>‘Bigarreau Burlat’</td>
<td>405.0</td>
<td>362.0</td>
<td>383.5</td>
</tr>
<tr>
<td>‘Merchant’</td>
<td>376.7</td>
<td>342.7</td>
<td>359.7</td>
</tr>
<tr>
<td>‘Kordia’</td>
<td>377.3</td>
<td>350.3</td>
<td>363.8</td>
</tr>
<tr>
<td>‘Regina’</td>
<td>387.0</td>
<td>352.7</td>
<td>369.8</td>
</tr>
<tr>
<td>Mean treatment</td>
<td>385.2</td>
<td>350.5</td>
<td></td>
</tr>
</tbody>
</table>

SD 5% cultivar 10.92 11.8
SD 5% treatment 6.91
SD 5% interaction 15.44 17.78

* Note: Different letters between cultivars denote significant differences

In the present experience, there are differences statistically assured regarding the trunk cross sectional area only between ‘Bigarreau Burlat’ which had the biggest value of this character (50.8 cm²) and the others cultivars. These differences could be explained only from genetically point of view.

Table 3

The influence of root pruning and the cultivar on average trunk sectional area (cm²)
(Cluj-Napoca, Romania, 2014–2015)

<table>
<thead>
<tr>
<th>Cultivar/ root pruning system</th>
<th>Unpruned root</th>
<th>Root pruned</th>
<th>Mean cultivar</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Earlise’</td>
<td>43.9</td>
<td>37.8bc</td>
<td>40.8</td>
</tr>
<tr>
<td>‘Bigarreau Burlat’</td>
<td>55.5</td>
<td>46.2b</td>
<td>50.8</td>
</tr>
<tr>
<td>‘Merchant’</td>
<td>39.9</td>
<td>34.2</td>
<td>37.1</td>
</tr>
<tr>
<td>‘Kordia’</td>
<td>43.8</td>
<td>39.5bc</td>
<td>41.6</td>
</tr>
<tr>
<td>‘Regina’</td>
<td>43.0b</td>
<td>36.3c</td>
<td>39.7</td>
</tr>
<tr>
<td>Mean treatment</td>
<td>45.2</td>
<td>38.8</td>
<td></td>
</tr>
</tbody>
</table>

SD 5% cultivar 4.78 5.17
SD 5% treatment 3.02
SD 5% interaction 6.76 7.78

* Note: Different letters between cultivars denote significant differences
Regardless the cultivar, the biggest average trunks cross sectional area with the unpruned root system were obtained (45.2 cm²). The smallest trunk cross sectional area with the root pruned system was registered (38.8 cm²).

Data inside the table shows the combined influence of two experimental factors. The biggest average trunk cross sectional area with ‘Bigarreau Burlat’ and unpruned root system was registered and the smallest one with ‘Merchant’ with root pruned system.

According to the results of Ferree and Knee. (1997); Sharma et al., (2009), Mitre et al., (2012), this experiment proved that root pruning has influenced the surface of the trunk cross sectional area.

Figure 1 introduces data referring to the influence of the root pruning and the cherry cultivar upon cumulative yield of 2014 and 2015 growing seasons.

Following the Fig.1, one can see that, the best cumulative yield was obtained in variant of root pruning system (26.12 t/ha) followed by unpruned root system (20 t/ha) with differences statistically assured between these two treatments.

Regardless the treatment only between ‘Regina’ and the others cultivars there are differences statistically assured. The best cumulative yield gave ‘Regina’ (10.5 t/ha) and the lowest ‘Earlise’ (7.73 t/ha).

Regarding the combined influence of two experimental factors, the best cumulative yield was obtained at ‘Regina’ (12.33 t/ha) followed by ‘Kordia’ (11.07 t/ha) in root pruned system.

Cumulative yield is by far the most important indicator that reflects the performance of orchards (Mitre et al., 2012). Contrary to the results from the literature (Ferree and Knee. 1997) root pruning increased yield per surface unit and obviously cumulative yield.
Data of the Table 4 shows that root pruning increases productivity index in the experiment with the five sweet cherry cultivars. Four of the cherry cultivars of this study behaved similarly without differences statistically (‘Earlise’, ‘Regina’, ‘Merchant’, ‘Kordia’). Bigarreau Burlat registered the lowest value of productivity index between the five cherry cultivars.

Table 4

The influence of root cutting and the cultivar on productivity
(Cluj-Napoca, Romania, 2014-2015)

<table>
<thead>
<tr>
<th>Cultivar/ root pruning system</th>
<th>Unpruned root</th>
<th>Root pruned</th>
<th>Mean cultivar</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Earlise’</td>
<td>0.16\textsuperscript{a}</td>
<td>0.12\textsuperscript{a}</td>
<td>0.14\textsuperscript{A}</td>
</tr>
<tr>
<td>‘Bigarreau Burlat’</td>
<td>0.07\textsuperscript{b}</td>
<td>0.10\textsuperscript{b}</td>
<td>0.09\textsuperscript{B}</td>
</tr>
<tr>
<td>‘Merchant’</td>
<td>0.10\textsuperscript{b}</td>
<td>0.15\textsuperscript{a}</td>
<td>0.12\textsuperscript{A}</td>
</tr>
<tr>
<td>‘Kordia’</td>
<td>0.09\textsuperscript{b}</td>
<td>0.15\textsuperscript{a}</td>
<td>0.12\textsuperscript{A}</td>
</tr>
<tr>
<td>‘Regina’</td>
<td>0.10\textsuperscript{b}</td>
<td>0.17\textsuperscript{a}</td>
<td>0.14\textsuperscript{A}</td>
</tr>
<tr>
<td>Mean treatment</td>
<td>0.10\textsuperscript{M}</td>
<td>0.14\textsuperscript{N}</td>
<td></td>
</tr>
</tbody>
</table>

DS 5% cultivar 0.05
DS 5% treatment 0.03
DS 5% interaction 0.06 0.07

* Note: Different letters between cultivars denote significant differences

Analyzing data in the last row of the table one can observe that the lowest values of productivity index in the unpruned system variant were obtained (0.1) and the biggest value in root pruned variant (0.14). This means that cutting root is a safe measure that can increase productivity index and root pruning is an important measure in creating the right balance between growth and fruiting in high density cherry orchards.

CONCLUSIONS

1. Managing growths of cherry trees at an optimal level and in the right position respectively setting them on fruiting as soon as possible are the main goals in training sweet cherry trees in high density orchards.
2. Root pruning reduced the vegetative growth, height of the trees, trunk cross sectional area of all sweet cherry studied cultivars.
3. In the root pruning variants the yield of the trees and the productivity index increased obviously as compared to the un-pruned root control.
4. Root pruning is an easy way to control the balance between growth and fruiting, especially in high density cherry orchards.

REFERENCES