Abstract

It is generally accepted that nitrogen fertilization must be ceased a month before the cherry fruit ripening because of the negative effects of nitrogen on the fruit quality. On the other hand, fertigation, an indispensable element of the intensive cherry production, requires frequent fertilizer applications and any breach of the regimes of nutrient supply may become limiting to both growth and yield of cherry trees. The objective of this study is to investigate the effect of fertigation on fruit quality under both continuous and interrupted fertilizer supply during the month prior to fruit harvesting. For this purpose an experiment was carried out with ‘Burlat’/Mazzard and ‘Lapins’/‘Gisela5’ combination (twelfth and thirteenth leaf) under the conditions of fertigation, respectively through microsprinkling and drip irrigation. Fertigation was ceased one month before fruit harvesting. Results were compared to ones from a drip-irrigated control where the fertigation (including nitrogen) was continuous. Fruit quality was estimated based on measurements of mass, height, width, thickness and firmness, as well as by analyzing fruit flesh content of N, P, K, Ca, Mg, Fe, sugars, acids, vitamin C, juice pH, and dry mass. Before the second experimental vegetation the trees of the ‘Lapins’/‘Gisela5’ combination were severely pruned in order to provide proper leaf-to-fruit balance. According to the obtained results, there were no significant differences between the variants, both with and without interruption of the nitrogen supply before fruit harvesting. Hence, fertigation, especially with nitrogen, may be applied continuously without negative effects on the cherry fruit quality.

Key words: Prunus avium, fertilization, nitrogen, timing of applications

INTRODUCTION

It is generally accepted that nitrogen fertilization must be ceased 3-4 weeks prior to sweet cherry (Prunus avium L.) harvesting, when fruit increases rapidly in size, because of nitrogen’s negative effects on the fruit quality (Bright and Marte, 2004; James, 2010). These effects can include delayed and uneven ripening, reduced shelf life, softer fruit and increased susceptibility to physiological disorders. On the other hand, when micro-irrigation is in use it is a common practice to introduce fertilizers into the tree zone with the irrigation water (fertigation). The fertilization dose is usually divided into parts and supplied according to the crop nutrient assimilation during the vegetation period (Haynes, 1985; Neilsen and Neilsen, 2008; Kafkafi and Tarchitzky, 2011). Fertigation is an indispensable element of intensive cherry production. It includes frequent fertilizer applications and since the active roots are confined to the volume of the wetted soil, any breach of the regimes of nutrient supply may become limiting to both growth and yield of cherry trees. This is especially true for the nitrogen because the restriction of its supply suppresses the protein synthesis (Kramer and Boyer, 1995). The objective of this study is to evaluate the effect of fertigation on fruit quality under both continuous and interrupted fertilizer supply in the course of the month prior to fruit harvesting.

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MATERIALS AND METHODS

The experiment was set up in two separated plots in a 1.2 ha sweet cherry orchard. In the first plot the cherry trees were 'Lapins' cultivar grafted on 'Gisela 5' rootstock and planted in the spring of 2001 at a 4 × 2 m distance. In the second plot the trees were 'Bigarreau Burlat' (Hâtif) cultivar grafted on 'Mazzard' (*Prunus avium* L.) rootstock and planted in the spring of 2002 at a 6 × 4 m distance. The soil was a sandy loam Luvisol. Three variants of fertilizer application were set in each of the experimental plots: V1 – fertigation by microsprinkling (interrupted); V2 – fertigation by drip irrigation (interrupted); and V3 – fertigation by drip irrigation (continuous). Each variant consisted of three cherry trees and each tree was used as a replication.

The microsprinkling system consisted of one irrigation lateral per row with microsprinklers located along the row at a 1.0 m distance with a discharge of 25 L h⁻¹ and an effective radius of 1.0 m. Thus, the irrigation water and the fertilizers dissolved in it were evenly spread over a 2.0 m wide row strip. The drip irrigation system had two parallel irrigation laterals per row located at 0.5 m on both sides of the trees with drippers located at 1.0 m along the laterals and with a discharge of 2.0 L h⁻¹. Drip irrigation was planned to wet a 2.0 m wide row strip as well. A proportional dosing pump (DOSATRON INTERNATIONAL, Bodeaux, France) was used for injecting the fertilizers into the irrigation system. The water and fertilizer application rates were equal in all treatments.

Experiments were carried out in 2013 and 2014. Fertilizer applications were based on leaf-analysis data and the fertilizers used were of the "Kristalon" (YARA) series. The annual fertilization rates were split into 14 parts/doses according to current understanding of cherry-tree nutrient requirements (Table 1). Additionally, 14 doses of ammonium nitrate were applied between the main doses at intervals of three to five days in order to maintain nitrate concentrations in the soil solution. The fertigation in V1 and V2 was ceased about a month prior to harvesting.

<table>
<thead>
<tr>
<th>Fertilizers</th>
<th>Annual rates (kg ha⁻¹)</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>Sept.</th>
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</thead>
<tbody>
<tr>
<td><em>N</em></td>
<td>160</td>
<td>27</td>
<td>30</td>
<td>17</td>
<td>11</td>
<td>9</td>
<td>6</td>
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<tr>
<td><em>P₂O₅</em></td>
<td>43</td>
<td>19</td>
<td>16</td>
<td>50</td>
<td>6</td>
<td>5</td>
<td>4</td>
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<tr>
<td><em>K₂O</em></td>
<td>62</td>
<td>31</td>
<td>27</td>
<td>15</td>
<td>11</td>
<td>9</td>
<td>7</td>
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<tr>
<td><em>Year 2013 - 14 doses of &quot;Kristalon&quot;(YARA) + 14 doses of ammonium nitrate</em></td>
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<td><em>N</em></td>
<td>158</td>
<td>13</td>
<td>20</td>
<td>28</td>
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<tr>
<td><em>P₂O₅</em></td>
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</table>

After harvesting the fruit quality was estimated for each fertigation variant and cultivar/rootstock combination. The average fruit mass was determined from samples consisting of 50 fruits. Samples of 30 fruits (Koumanov, 2011) were used for estimating the fruit height, width and thickness as well as the firmness of fruit flesh. The fruit flesh firmness was measured by a penetrometer with 6 mm tip diameter and estimated as an average from the readings taken in two perpendicular directions. The biochemical analysis of fruit flesh included the content of dry matter, *N*, *P*, *K*, *Ca*, *Mg*, *Fe*, sugars, acids, *vitamin C*, and the fruit juice reaction (pH). In order to obtain larger fruits in 2014 the Lapins/Gisela5 cherry trees were severely pruned in the 2013-2014 dormancy period. The significance of the differences between the means of the studied variants was verified using Student’s *t*-test. For easier perception, the results are presented graphically with the means and the standard deviations.
RESULTS AND DISCUSSION

The results for the yield are presented on Figure 1. The fruit-biometry data are illustrated on Figure 2 and Figure 3 for ‘Burlat’/Mazzard (BB/Mz) and ‘Lapins’/‘Gisela5’ (La/G5) combinations respectively. The results concerning fruit biochemistry are shown on Figures 4 and 5.

Figure 1. Yield and fruit mass of two sweet cherry cultivar/rootstock combinations ‘Burlat’/Mazzard (BB/Mz) and ‘Lapins’/‘Gisela 5’ (La/G5) under different fertigation regimes. MS – microsprinkling with ceased fertigation one month before harvesting, DI – drip irrigation with ceased fertigation one month before harvesting, DI + F – drip irrigation with continuous fertigation. Standard deviations are shown by bars.

Generally, the studied fertigation variants did not significantly differ in 2013 as far as both the yield per tree and the average fruit mass were concerned. There was no statistically proven difference between the cultivar/rootstock combinations either. Taking in account the much smaller size of the La/G5 trees, however, it became obvious that these trees were fruit-overloaded. The yield calculated per unit area ranged from 33750 kg ha$^{-1}$ to 38750 kg ha$^{-1}$ while the BB/Mz combination yielded from 11667 kg ha$^{-1}$ to 18750 kg ha$^{-1}$. With both cultivar/rootstock combinations the average fruit mass was about 6 g.

The severe pruning of La/G5 trees significantly lowered the crop load in 2014 to 7.1—11.3 kg per tree (8875—14125 kg ha$^{-1}$) while that of BB/Mz trees was 18.2—33.0 kg per tree (7583—13750 kg ha$^{-1}$). Also, the small trees showed advantage regarding the average fruit mass (9.5—10.0 g with La/G5 versus 8.5—8.8 g with BB/Mz) and, respectively, their average sizes were: 28 mm with La/G5 versus 27 mm with BB/Mz. The severe pruning of the La/G5 trees provided average shoot length of 43 cm. Apparently, this growth had improved the leaf/fruit ratio, thus contributing significantly to the increase in fruit size.
Figure 2. Fruit dimensions and fruit firmness of 'Burlat' sweet cherry cultivar on Mazzard rootstock under different fertigation regimes. MS: microsprinkling with ceased fertigation one month before harvesting, DI: drip irrigation with ceased fertigation one month before harvesting, DI+ F: drip irrigation with continuous fertigation. Standard deviations are shown by bars.
Figure 3. Fruit dimensions and fruit firmness of ‘Lapins’ sweet cherry cultivar on ‘Gisela 5’ rootstock under different fertigation regimes. MS: microsprinkling with ceased fertigation one month before harvesting, DI: drip irrigation with ceased fertigation one month before harvesting, DI+F: drip irrigation with continuous fertigation. Standard deviations are shown by bars.
Figure 4. Fruit biochemical and mineral composition in 2013 of two sweet cherry cultivar/rootstock combinations ‘Burlat’/Mazzard (BB/Maz) and ‘Lapins’/‘Gisela 5’ (La/G5) under different fertigation regimes. MS: microsprinkling with ceased fertigation one month before harvesting, DI: drip irrigation with ceased fertigation one month before harvesting, DI+F: drip irrigation with continuous fertigation. Standard deviations are shown by bars.
Figure 5. Fruit biochemical and mineral composition in 2014 of two sweet cherry cultivar/rootstock combinations ‘Burlat’/Mazzard (BB/Maz) and ‘Lapins’/‘Gisela 5’ (La/G5) under different fertigation regimes. MS: microsprinkling with ceased fertigation one month before harvesting, DI: drip irrigation with ceased fertigation one month before harvesting, DI+F: drip irrigation with continuous fertigation. Standard deviations are shown by bars.
In both 2013 and 2014 the studied fertigation variants did not significantly differ regarding fruit biometry and fruit biochemistry. There were no differences found between variants even after the fruit-size dramatic increase in the severely pruned La/G5 trees. Hence, nitrogen fertigation may be carried out without interruption during the month before harvesting. The value of frequent nitrogen applications by fertigation is demonstrated in Stoilov et al. (1999) and Neilsen et al. (1998, 1999). Moreover, frequently replenished supply of nitrogen is vital for the trees with a dwarfing, spatially confined root system because the vegetative growth depends on the nitrogen metabolism to synthesize proteins, and nitrate reductase, which catalyzes the process (Kramer and Boyer, 1995).

CONCLUSIONS

According to the results for yield and fruit quality, there were no significant differences between the variants with and without interruption of fertigation one month prior to harvesting. Hence, fertigation can be carried out without interruption, thus providing essential continuous supply of nutrients to the small trees inherent in the intensive cherry production.

Literature Cited


