The influence of early cropping on productivity and fruit quality of apple cv. ‘Golden Delicious Reinders’

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Abstract

Investigation of the influence of early cropping on productivity and fruit quality of apple cv. ‘Golden Delicious Reinders’/M9 (T337) was conducted in the second end third growing year of high density apple orchard. In the second growing year, after June fruit drop (when fruit diameter was 20-25 mm), fruit set was adjusted by hand in order to establish five levels of crop load: 10, 20, 30, 40 and 50 fruit tree⁻¹. The third growing year was considered as a “control year”. The obtain results was shown that a good balance between growth and cropping in second leaf is very important when feathered nursery trees have been used to establish a new apple orchard. Trees of ‘Golden Delicious Reinders’ can be loaded up to 40 fruit without a negative influence on fruit size, fruit quality and yielding in the following year. Higher crop load per tree may have a negative influence on mentioned parameters.

Key words: Fruit quality, crop load apple, early cropping, ‘Golden Delicious Reinders’

Introduction

Over the years, the length of time for full orchard productivity has become shorter and shorter (Treder et al., 2010). When feathered nursery trees have been used for establishment of apple orchard, tress in second leaf in more cases bloom abundantly and set too many fruits to optimize yield per tree, fruit size and return bloom. The mean weight of an apple, as well as its size, signifies a negative correlation with the number of apples in a tree (Palmer, 1992; Treder et al., 2010; Yuri et al., 2011). The competition among fruits reduces their size if there is excessive fruit set (Dennis, 2000; Dussi et al., 2006), but the apple growers are under increasing pressure to increase fruit size to satisfy consumer demands (Raines, 2000). Consequently, crop load regulation immediately after planting is important and its influence on growth and productivity during the years of apple orchard establishment (Link, 2000; Unuk et al., 2008). Therefore, it is particularly important to find out how many fruits per tree in young high-density planting apple orchard should be retained to obtain optimum fruit quality, vegetative growth and adequate yield.

This study was designed to examine five different crop load levels in the second leaf on apple cultivars ‘Golden Delicious Reinders’ on M.9 rootstock in high planting density orchard. The main objective of this study was to determine how the different crop load levels affect tree cropping and fruit quality with emphasis on fruit size. The results could be used to determine an optimum crop load for examined cultivar.

Material and methods

The study was carried out at commercial orchard established within “Delta Group” company located in Čelarevo (Serbia). The area has a temperate continental climate with an average annual rainfall of 615 mm. The orchard soil is calcareous chernozem. The orchard was established in 2008. The experiment was conducted during the period of 2009-2010, in the second end third growing year of apple cultivar ‘Golden
Delicious Reinders’ on M.9 rootstock (T337). Planting distance was 3.2 m between the rows and 0.8 m in the row (3906 trees/ha). High quality one-year-old nursery trees with 7 and more lateral branches were used for establishing orchard. Trees were trained as slender spindle.

In the second leaf, twenty trees which were uniform in the trunk cross sectional area (TCSA) and canopy volume were selected. The trees were assigned to five levels of fruit crop load, in a complete random design with four replications per treatment. In the second growing year, after June fruit drop (when fruit diameter was 20-25 mm), fruit set was adjusted by hand in order to establish five levels of crop load: 10, 20, 30, 40 and 50 fruit tree⁻¹. In the third growing year the trees of all treatments from previous year had been chemical thinned with AMID-THIN® W concentration was 80g/100 l of water, with 800 L solution per ha) and after that hand thinning was no performed. In the third growing year the influence of crop load from previous year on yield and fruit characteristics was studied. The third growing year was considered as a “control year”.

Fruits were harvested during September in both years. Fruit was graded for size into five groups for each replicate over two years. The yield of each group was measured. The fruit weight was calculated as ratio of total yield and number of fruit per tree.

Samples of 5 randomly selected fruit from each replicate were examined for various traits as follows: index of fruit shape, fruit firmness, soluble solids content and total acidity content. Fruit flesh firmness was measured with a penetrometer type a tip with a diameter of 11 mm. Juice obtained from the apples during the firmness measurements was collected and soluble solids concentration assessed with an Atago PR-1 digital refractometer. Total acidity was measured by neutralization to pH 7.0 with 0.1 N NaOH and expressed as percent of malic acid equivalent. The return bloom was estimated the following year by counting of generative bud number per tree.

A statistical analysis was performed using software Statistica 6.0 for Windows. Data were calculated by ANOVA. Mean separation was done by Tukey HSD test at 5% level of significance.

### Results and discussion

Tree crop load had directly influence on obtained fruit weight. Trees with 50 fruit showed statistically lower values of fruit weight in comparison to all other treatments with lower levels of crop loads (Table 1.).

The competition among fruits reduces their size if there is an excessive fruit set (Dussi et al., 2006; Stopar et al., 2002), but it is acceptable until to certain level. However, trees with 40 fruit had fruit weight similar to those obtained in other treatments, whereas the largest fruits were found on the trees with 20 fruit. Bussakorn et al.(2001) were shown that reducing crop load from the commercial level by one third improved fruit size under deficit irrigation, but not under commercial irrigation (Wünsche and Lakso (2000) were found that flower thinning of Braeburn trees at different severities resulted in 50% heavier fruit in the low-cropping trees compared to the high cropping trees.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Fruit weight (g)</th>
<th>Index of fruit shape</th>
<th>Firmness (kg cm⁻²)</th>
<th>Iodine starch index</th>
<th>Soluble solids (%)</th>
<th>Total acidity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 fruits per tree</td>
<td>218a</td>
<td>0,94</td>
<td>8,2a</td>
<td>3,0</td>
<td>15,5a</td>
<td>0,25a</td>
</tr>
<tr>
<td>20 fruits per tree</td>
<td>228a</td>
<td>0,91</td>
<td>7,8ab</td>
<td>2,7</td>
<td>14,6a</td>
<td>0,24ab</td>
</tr>
<tr>
<td>30 fruits per tree</td>
<td>219a</td>
<td>0,91</td>
<td>7,9ab</td>
<td>2,9</td>
<td>15,4ab</td>
<td>0,23ab</td>
</tr>
<tr>
<td>40 fruits per tree</td>
<td>216a</td>
<td>0,93</td>
<td>7,4b</td>
<td>2,8</td>
<td>14,7ab</td>
<td>0,23ab</td>
</tr>
<tr>
<td>50 fruits per tree</td>
<td>176b</td>
<td>0,92</td>
<td>7,7ab</td>
<td>2,5</td>
<td>14,2b</td>
<td>0,18b</td>
</tr>
<tr>
<td>F</td>
<td>*</td>
<td>ns</td>
<td>*</td>
<td>ns</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

*P < 0.05 according to Tukey’s test*

Index of fruit shape was not differed significantly under various crop loads, whereas fruit firmness was the highest on the trees with lowest crop load (treatment with 10 fruit per tree) and the lowest on the trees with 30 fruit per tree. The differences obtained were statistically significant. However, crop load did not express significantly influence on starch content in the fruit, but significant difference among the treatments was observed in soluble solids content and total acidity. It was found out the highest cropping trees produced the fruit with lowest content of soluble solids and total acids. As opposed to our results, Cmelik et al. (2006)
indicated that crop loads did not influence any of the fruit quality characteristics such as TA, SSC, FF and SPI.

Yield was highly affected by different levels of crop load. By increasing the crop load yield enhancement per tree was also detected, but it can only be noticed till the level of 40 fruit. The current study also confirms the statement that heavy cropping inhibits the young tree growth, especially if they bear fruit in the second growing year; after that the relationship between growth and crop load is weaker (Unuk et al., 2008). Further increasing the crop load until 50 fruit per tree did not influence yield enhancement, but also it was almost the same as those obtained on trees with 40 fruit. Fruit growth, as indicated by maximum diameter, was significantly and negatively related to crop load from about 60 days until fruit harvest when individual fruit mass increased by about 35% with each decrease in cropping density (Palmer et al., 1997).

Trees with fruit number of 40 and lower did not have fruit with smaller diameter of 70 mm (Fig. 1). In these treatments the fruits with diameters of 75-80 mm and 80-85 mm had a dominant share. The highest share of fruits with diameters of 70-75 mm and 75-80 mm was recorded on trees loaded with 50 fruit.

Figure 1. Effect of crop load in second leaf on fruit size distribution in second leaf (A) and third leaf (B). Size classes represent fruit diameters of: < 70, 70-75, 75-80, 80-85 and >85 mm.

A proper flower and fruitlet manipulation in the second growing year after planting is necessary to establish a continually increasing yield dynamics and good tree growth development for further seasons (Unuk et al., 2008). In the present study, the high crop load did not have a significantly influence on forming of fruiting buds. The highest number of fruiting buds was recorded on the trees loaded with 10 and 40 fruits. Conversely, Cmelik et al. (2006) were concluded that excessive crop load can reduce return bloom.

The effect of different crop load in 2nd leaf was investigated during the following year on the same trees. Regarding fruit quality parameters, significant difference among the treatments was only observed for fruit weight (Table 3).

Trees loaded with 30 fruit had the largest fruit size, whereas those with 20 fruit had the smallest one. This study also demonstrated that crop load, across a commercial range of fruit numbers per tree, and the time at which that crop load was set, had only minimal effect on apple fruit firmness at harvest, or on fruit softening patterns in storage. Contrary to many reports, apple fruit size had little influence on fruit firmness at harvest or on softening behavior in storage, when fruit were harvested at the same maturity (Saei et al., 2011).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>2009 Yt (kg tree⁻¹)</th>
<th>2009 Yt (t ha⁻¹)</th>
<th>2009 Generative bud (No tree⁻¹)</th>
<th>2009 Fruits (No tree⁻¹)</th>
<th>2010 Yt (kg tree⁻¹)</th>
<th>2010 Yield (t ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 fruits per tree</td>
<td>2.2d</td>
<td>8.6d</td>
<td>73.5</td>
<td>88.5a</td>
<td>17.1a</td>
<td>66.7</td>
</tr>
<tr>
<td>20 fruits per tree</td>
<td>4.7c</td>
<td>18.3c</td>
<td>70.8</td>
<td>86.5a</td>
<td>16.4a</td>
<td>64.0</td>
</tr>
<tr>
<td>30 fruits per tree</td>
<td>6.4b</td>
<td>25.0b</td>
<td>66.0</td>
<td>63.5ab</td>
<td>13.5ab</td>
<td>52.6</td>
</tr>
<tr>
<td>40 fruits per tree</td>
<td>8.7a</td>
<td>34.0a</td>
<td>73.3</td>
<td>84.8a</td>
<td>16.4a</td>
<td>64.0</td>
</tr>
<tr>
<td>50 fruits per tree</td>
<td>8.8a</td>
<td>34.3a</td>
<td>53.3</td>
<td>47.8b</td>
<td>9.5b</td>
<td>37.0</td>
</tr>
<tr>
<td>F</td>
<td>*</td>
<td>*</td>
<td>ns</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

P < 0.05 according to Tukey's test
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Table 3. The influence of crop load in the second leaf on fruit quality parameters in the third leaf

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Fruit weight (g)</th>
<th>Index of fruit shape</th>
<th>Firmness (kg cm⁻²)</th>
<th>Iodine starch index</th>
<th>Soluble solids (%)</th>
<th>Total acidity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 fruits per tree</td>
<td>195ab</td>
<td>0.87</td>
<td>8.1</td>
<td>4.5</td>
<td>12.4</td>
<td>0.26</td>
</tr>
<tr>
<td>20 fruits per tree</td>
<td>190b</td>
<td>0.91</td>
<td>8.3</td>
<td>4.6</td>
<td>11.8</td>
<td>0.31</td>
</tr>
<tr>
<td>30 fruits per tree</td>
<td>213a</td>
<td>0.91</td>
<td>7.8</td>
<td>4.6</td>
<td>13.1</td>
<td>0.25</td>
</tr>
<tr>
<td>40 fruits per tree</td>
<td>195ab</td>
<td>0.90</td>
<td>8.1</td>
<td>4.4</td>
<td>12.3</td>
<td>0.30</td>
</tr>
<tr>
<td>50 fruits per tree</td>
<td>198ab</td>
<td>0.90</td>
<td>7.6</td>
<td>4.4</td>
<td>12.2</td>
<td>0.32</td>
</tr>
</tbody>
</table>

P < 0.05 according to Tukey’s test

Trees with high crop load in previous year had the lowest yield and fruit number per tree. It was not found difference among the other treatments studied.

Only trees loaded with 30 fruits did not have the fruits smaller than 70 mm in diameter, but these trees had larger fruits than 85 mm in diameter. Trees loaded with 40 fruits in previous year showed similar yield and fruit quality as those with 10 or 20 fruit per tree.

Conclusion

Creating a good balance between growth and cropping is very important when feathered nursery trees have been used to establish a new high density apple orchard. Some fruit retention on young trees was better than maintaining low or non-bearing trees in the second growing year (Unuk et al., 2008).

Trees of ‘Golden Delicious Reinders’ can be loaded up to 40 fruit without a negative influence on fruit size, fruit quality and yielding in the following year. Higher crop load per tree may have a negative influence on mentioned parameters.

References


Acknowledgements

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