Influence of partial rootzone drying on vegetative and productive parameters of ‘Polka’ raspberries canes grown in pots

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Abstract
This field experiment was designed to assess the vegetative and productive response of ‘Polka’ raspberry canes grown in pots after application of partial rootzone drying (PRD). The experiment was conducted in Kosovo (Prishtina region) during 2015. Four levels of irrigation were studied: 100% control-one lateral, two laterals, side lateral, and without irrigation. Each treatment contained 5 plants. Using ANOVA irrigation had significant changes on fruit weight, total yield, number of leaves and fruits diameter-differences were at level P<0.05%, for leaf surface, leaf area, leaf area index (LAI) and shoot length-differences were P<0.01% while, changes were not significant for length of fruit. Two lateral treatment gave higher values of vegetative and productive parameters, followed by control, side lateral and lastly without irrigation. PRD in our experiment does not effect in yield raspberries.

Key words: Polka, pots, water stress, PRD

Introduction
Production of raspberry (Rubus idaeus L.) is considered of particular importance for the economy of Kosovo. Until now about 500 ha are planted with raspberry. Water shortages in the territory of Kosovo, especially during the growing season, necessitate intervention with supplemental irrigation, but the application of partial rootzone drying (PRD) can start from the beginning or middle of June due to the fact that Kosovo has sufficient rainfall during May.

Climatic conditions determine water needs. When calculating the amount of water needed for raspberries using drip irrigation, only the root zone area needs to be irrigated. Drip irrigation applies water to a part of the root zone and does not broadcast the water as an overhead or flood method does, so it allows more efficient application of water to the desired crop (Funt and Ross, 2013).

PRD is an innovative irrigation technique which is thought to reduce plants’ water consumption based on the induction of changes in the plants’ hormonal balance and chemical signalling of roots in the drying soil (Davies et al., 2000), namely is a variant of deficit irrigation (DI), a technique with plenty of advantages, ranging from water saving, reduction of costs, minimization of nutrient and pesticide leaching to ground water (Pulupol et al., 1996), reduction of excess vegetative growth (Marsal et al., 2002) and quality improvements. DI is a system for the management of soil water to impose periods of water deficit to the plant in such a way as to be economically advantageous. It involves the use of a smaller amount than the calculated need for water (Kullaj, 2007). There was some evidence that the PRD treatment even enhanced yield while it simultaneously reduced vegetative growth (Stoll et al., 2002; Dry et al., 1996, 2000; Spreer et al., 2006). In other words PRD is an irrigation technique that was recently developed in Australia for grapes (Vitis vinifera L.) (Dry et al., 1995; Dry and Loveys, 1998). With PRD, only one half of the rootzone is irrigated whereas the other half is not. The physiological basis for PRD is that roots in drying soil produce abscisic acid (ABA) which is translocated to the shoots, indicating a developing soil-water deficit (Dry et al., 1995), which improves water use efficiency without significant yield reduction (Stikic et al., 2003).
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Watering alternately only part of the root system, a partial drying of the rootzone can be achieved. Under drying soil conditions, roots are able to sense variations of soil water content and send chemical signals (plant hormones) to the leaves, which are instrumental in reducing the aperture of leaf stomata, thereby reducing transpirational water loss and growth. This strategy has particular significance in that it can improve water use efficiency without affecting fruit yield (Stoll et al., 2002).

Pot experiments with split-root plants and two years of field experiments with manipulation of soil water content have shown that PRD does not affect yield in raspberries, 'Glen Ample' and 'Glen Prosen'. In some cases PRD can reduce stomatal conductance, thus reducing water loss (Grant et al., 2004).

The objective of this study was to determine the impact of PRD in 'Polka' raspberries, canes grown in pots.

Material and methods

This field experiment was designed to assess the vegetative and productive response of 'Polka' raspberry plants in pots after the application of PRD. The experimental set up was a nested design, whereby the categories of nested factor within each level of the main factor are different, i.e. different plants of cv. Polka raspberry give rise to the leaf/fruit samples within each of the main irrigation treatment. At the beginning the canes were planted in plastic bag (2014) (volume 5 L). The bags contained a potting mixture consisting of sand and decomposed pine bark (1/3, v/v) together with limestone (2 g/L). The plants were allowed to grow for one season in a netting tunnel. After a cold treatment at winter (2 °C for 5 weeks) they were transferred into squared pots (volume 18 L) (Stoll et al., 2002). Four levels of irrigation were applied: 1. 100% of evapotranspiration (ET) as control, one lateral-normal irrigation; 2. two laterals; 3. side lateral and 4. without irrigation. Canes were planted in pots on April 2015. In normal irrigation (control) and side lateral each pot has one dripper while, in two laterals each pot had two dippers. Each treatment (each level of irrigation) has been in a row. For each treatment we used 5 plants. Drippers delivered 1.6 liters of water/h. Two irrigations were applied per day to maintain the soil water close to field capacity. The fourth treatment (dry) received 2 L of water to the entire root system every 6 days. To evaluate the effects of partial rootzone drying, we have compared both vegetative and productive parameters. Shoot length was measured (cm) on all plants on August 28th. Numbering of leaves for all plants was carried out on August 29th. Leaf surface (cm²) of 10 leaves per plants was conducted on August 29th. Leaf area and leaf area index (LAI) measurement (m²) was conducted on October 1st. All fruits in all plants were counted. Their size (diameter and length of fruits) was measured (mm) at the equator with a calliper (electronic digital calliper) using all fruits per plant, all the time during every harvest (first measurement on July 25th and last measurement on October 30th). Average fruit weight was measured (g) using an analytical balance for all fruits, each harvest. Yield (in g/plant) was calculated at all period of the harvest time measuring the total weight of all fruits per plant. Our state has a moderate continental climate with a coastal impact which penetrates through the valley of the Drini Bardhë moderating markedly continental climate elements. In Kosovo average temperature (1951-1980) is 10.3 °C, that of vegetation 16.5 °C. Regarding the annual rainfall is 744.8 mm, and during vegetation is 346.7 mm which shows the need to intervene with supplementary irrigation. Water shortages in the territory of Kosovo, especially during the growing period, need supplemental irrigation (Lepaja et al., 2014; 2015b). The amount of rainfall for Prishtina region for a 30–year period is 608 mm and 325.9 mm during the growing season.

Data from the measurements were analysed using ANOVA two–way with post hoc testing with StatPlus 2010 from AnalystSoft Inc. USA.

Results and discussion

The results showed that the effect of PRD on 'Polka' raspberry canes grown in pots was found significant changes in a series of vegetative and productive parameters, which confirms the results of other authors (Davies et al., 2000). At the end of the treatments period, all values of vegetative and productive parameters were higher in two laterals treatment.

At the first these results can be obtained primarily as a result of weather conditions: temperature and rainfall during the time the experiment, furthermore long-term effects of deficit irrigation, together with climatic conditions, crop techniques variations, type of soil, age of plants etc. must be considered, because the long-
term plant responses to regulated deficit irrigation (RDI) or partial rootzone drying (PRD) are more accurate than short-term responses (Lepaja et al., 2015a; Lepaja et al., 2015c; Fereres et al., 2003).

Using ANOVA we found that in vegetative parameters irrigation had significant changes on all parameters but, for leaf surface, leaf area, LAI and shoot length differences were at level P<0.01% and for number of leaves at level P<0.05%. In number of leaves, leaf surface, leaf area and LAI the differences between treatments were the same (Table 1.). Number of leaves and leaf surface had reflected in leaf area and LAI. In vegetative parameters two laterals treatments gave higher values followed by normal irrigation, side lateral and lastly without irrigation.

Table 1. Average data for vegetative parameters with differences between treatments

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Number of leaves</th>
<th>Leaf surface (cm²)</th>
<th>Leaf area (m²)</th>
<th>LAI (m²)</th>
<th>Shoot length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal irrigation</td>
<td>73.25</td>
<td>31.83a</td>
<td>0.23a</td>
<td>0.18a</td>
<td>74.50a</td>
</tr>
<tr>
<td>Two laterals</td>
<td>95.00a</td>
<td>39.13b</td>
<td>0.37b</td>
<td>0.29b</td>
<td>100.00b</td>
</tr>
<tr>
<td>Side lateral</td>
<td>83.25</td>
<td>29.80a</td>
<td>0.26a</td>
<td>0.20a</td>
<td>92.25b</td>
</tr>
<tr>
<td>Without irrigation</td>
<td>53.75b</td>
<td>24.03c</td>
<td>0.12c</td>
<td>0.09c</td>
<td>67.00a</td>
</tr>
<tr>
<td>LSD 0.05%</td>
<td>22.2785</td>
<td>2.2198</td>
<td>0.0756</td>
<td>0.0612</td>
<td>14.7084</td>
</tr>
<tr>
<td>LSD 0.01%</td>
<td>32.0094</td>
<td>3.1893</td>
<td>0.1087</td>
<td>0.0879</td>
<td>21.1328</td>
</tr>
</tbody>
</table>

These results for vegetative parameters are smaller than results of canes grown in open field. Based on ANOVA in productive parameters irrigation had significant changes on fruit weight, number of fruits, total yield and fruit diameter where differences were at level 0.05% (LSD testing) while, changes were not significant for length of fruit. Also in productive parameters two laterals treatments gave higher values followed by normal irrigation, side lateral and lastly without irrigation (Table 2.).

Concerning some parameters (fruit weight and total yield) researched by the authors (Stoll et al., 2002) our results are consistent with the authors concerned.

As shown in the Table 2, the number of fruits influences other fruiting parameters, especially in their average weight than in diameter and length of fruit and total yield. Differences in number of fruits were found only between two laterals with without irrigation. The two laterals treatment gave a higher total yield than normal irrigation and side lateral.
Conclusions
Based on our investigations on the partial rootzone drying under the agroecological conditions of Kosovo, (Pristina region) grown in pots in the first year, several conclusions can be drawn.

At the end of the treatment period (normal irrigation, two laterals, side laterals, without irrigation), of PRD application, we found changes in a series of vegetative and productive measurements. Grant et al., (2004) published that PRD in their experiment did not effect on yield of raspberries and that PRD also, had no advantage compared to DI in maintaining plant water status and berries yield (Liu et al., 2007).

Based on ANOVA irrigation had significant changes on fruit weight, total yield, number of leaves and fruit diameter-differences were at level 0.05%, leaf surface, leaf area, leaf area index (LAI) and shoot length-differences were at level 0.01% while, changes were not significant for length of fruit. Two lateral treatment gave higher values of these vegetative and productive parameters, followed by normal irrigation (control), side lateral and lastly without irrigation. In our weather condition two laterals treatment gave higher values of yield so, this study suggests using two laterals.

References


