Effect of early basal leaf removal on grape structure and quality of Prokupac (*Vitis vinifera* L.)

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Abstract

Defoliation is a measure directly regulating the ratio of the vine leaf surface, as the assimilator producer (source), and the grape bunches, as the consumers of such assimilators (sink). Depending on the phase in which the above measure is carried out, the influence on berry development and grape quality differs. The goal of the present paper is to examine influence of the assimilation surface decrease on the grape bunch and berry structure, and therefore on the grape quality, implementing the three-phase defoliation: flowering, berry set and veraison. Results of the two-year examination of cultivar Prokupac indicate that defoliation carried out during the flowering and 3-5 mm berry diameter most considerably influences decrease in the number of berries, decrease of the berry size, increase of the dry matter content in must, while increase in the content of total phenols and anthocyanins in berry skin has occurred only with the flowering phase defoliation.

Key words: defoliation, leaf area/crop weight, dry matter, total anthocyanins, total phenols.

Utjecaj rane defolijacije bazalnih listova na strukturu i kvalitetu grožđa sorte Prokupac (*Vitis vinifera* L.)

Sažetak

Defolijacija je mjera koja izravno regulira omjer površine listova vinove loze, kao izvora asimilativa (source) i groždova, kao potrošača (sink). Ovisno o fazi u kojoj se mjera provodi, utjecaj na razvoj bobica i kvalitetu grožđa se razlikuje. Cilj ovog rada je ispitati utjecaj smanjenja asimilacione površine provođenjem defolijacije u tri termina: cvatnja, oplodnja i šara, na strukturu grožđa, a time i na njegovu kvalitetu. Rezultati dvogodišnjih ispitivanja sorte Prokupac ukazuju na to da defolijacija provedena tijekom cvatnje i u fazi promjera bobica od 3-5 mm, najviše utječe na znatno smanjenje broja bobica, smanjenje veličine bobica, povećanje suhe tvari u moštu, dok je do porasta u sadržaju ukupnih fenola i antocijanina u koži bobica došlo samo u fazi cvatnje.

Ključne riječi: defolijacija, lisna površina / vegetativna masa, suha tvar, ukupni antocijani, ukupni fenoli

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Introduction

Partial removal of leaves from the shoots in the zone of bunches within flowering phenophase is the standard measure which should improve canopy microclimatic conditions; in fact, it should primarily improve bunch sensitivity which prompts accumulation of dry matter in must, anthocyanins and polyphenol compounds in berry skin (Kliewer 1970; Hunter et al.1991). In addition to that, better airing of bunches lowers the degree of damage caused by grey rot (Smart et al.1990; Gubler et al.1991). Defoliation carried out within this phase does not considerably influence the berry number and size within a bunch, nor the yield per vine.

Early defoliation, carried out within the intensive shoot growing phase, causes the total shoot photosynthesis level to decrease up to 70%, due to the removal of the photosynthetically active surface. The photosynthetic shock caused in such manner causes a halt in the sink organs development, which shows through the decreased number of berries within bunches, smaller berry size and change in the skin to pulp ratio (Poni et al.2005, 2006). Such grape structure changes are related to the increased accumulation of dry matter in must and phenol content in berry skin. The most prominent changes in the grape and berry structure occur when defoliation is carried out during the phase of intensive berry cell division after the end of flowering. Within that phase, the number of pericarp cells is determined and each halt in assimilator inflow results in a decreased cell number. Especially beneficial effects are achieved with the wine cultivars characterized by bigger bunches and berries, such as cultivar Prokupac. These cultivars, after defoliation, produce smaller and looser bunches, less yield and more beneficial berry skin to pulp ratio (Intrieri et al., 2008).

Material and methods

Cultivar Prokupac (Vitis vinifera L.) was examined in the production vineyard in village Rivica near Irig, Vojvodina, during 2008-2009. According to the location, the cultivar belongs to vineyards of Fruška Gora, characterized as a moderate continental climate.

The vineyard was established in 2003 with the planting space of 3 × 0.5 m. The short-cutting Lyra, composed of eight spurs, with one winter bud per spur, was established as the trellising system.

The experiment was set as a random block design with 20 vines per experiment treatment, each vine representing an observation unit. The vines were tagged and randomly assigned to the following treatments: (a) non-defoliated (control) labelled as K; (b) hand removal of the first six basal leaves at the phenological stage 65 (full flowering: 50% of flowerhods fallen according to BBCH scale, Lorenz et al.1994) labelled as I; (c) hand removal of the first six basal leaves at the phenological stage 73 (berries groat sized, ovary diameter varying from 2-5 mm according to BBCH scale, Lorenz et al.1994) labelled as II; (d) hand removal of the first six basal leaves at the stage 79 (majority of berries touching, according to BBCH scale, Lorenz et al.1994) labelled as III.

Berry size was monitored by measuring equatorial diameter of 30 randomly chosen berries per treatment, using an electronic caliper.

Cluster compactness was visually estimated using OIV (Organisation Internationale de la Vigne et du Vin) code 204 (OIV 1983), which ranks "berries in grouped formation with many visible pedicels" as 1 and "misshaped berries" as 9.

After the grape harvest, a representative sample of 3-5 kg of grape was taken from each experimental version and used for must and berry epidermis chemical analysis. Must quality was determined from representative samples during the grape harvest. Concentration of the total soluble solids (Brix) was determined by refractometer. Titratable acidity (TA) was measured by titration with 0.1 N NaOH to a pH 8.2 and point. Total anthocyanins and phenolics were determined by Vis-spectrophotometry.

Results and discussion

Decrease in the assimilation inflow during the first 3-4 weeks of berry development, caused by early defoliation, was influenced on the berry size in treatments I and II to decrease in comparison with the version III and the control, which all persisted until the moment of harvest. Irreversible decrease in the berry size was caused due to the decreased assimilator inflow during the cell division phase, taking place within the first phase of berry development only (Mullins et al.1992; Ollat and Gaudillere, 1998).
Defoliation carried out in flowering (stage 65) and fruit set (stage 73) phases caused statistically relevant differences in the number of berries due to the decrease in the degree of full blossomed berries (Table 1). This caused decrease in bunch compactness during the first two defoliation terms. The decreased assimilation surface during the flowering and fruit set phenophases resulted in a small number of set berries, as the consequence of the increased degree of flower abortions which has also been confirmed by other authors (Caspari and Lang 1996; Clingeleffer et al. 2001; Poni et al. 2005; Intrieri et al. 2008).

Since the yield per vine depends on the number of bunches, as well as on the berry number and size, yield fluctuations per experiment version might be expected. Therefore, within treatments I and II, when the berry number and weight decreased, the yield and average bunch weight (Table 1) were also decreased, which was in accordance with similar examinations of Poni et al. (2006).

Influence of the defoliation time on the change in the skin to pulp ratio, has not been recorded within the present experiment. The size of skin and seed tissue grows simultaneously and proportionally to the berry (Roby and Matthews 2004; Matthews 2007).

| Table 1. Average value of the yield's elements, grape and berry structure depending on the defoliation timing (2008-2009) |
|---|---|---|---|---|---|---|
| Yield (kg per vine) | Bunch weight (g) | Berry number per bunch | Berry weight (g) | Cluster compactness (OIV code 204) | Skin to pulp ratio |
| I | 0.97<sup>a</sup> | 142.0<sup>a</sup> | 65<sup>a</sup> | 2.33<sup>a</sup> | 3 | 0.046<sup>a</sup> |
| II | 1.79<sup>b</sup> | 303.0<sup>b</sup> | 102<sup>b</sup> | 2.59<sup>ab</sup> | 3-5 | 0.056<sup>a</sup> |
| III | 2.54<sup>c</sup> | 369.5<sup>bc</sup> | 146<sup>c</sup> | 2.63<sup>bc</sup> | 7 | 0.050<sup>a</sup> |
| k | 2.25<sup>c</sup> | 417.3<sup>c</sup> | 149<sup>c</sup> | 2.84<sup>c</sup> | 7 | 0.044<sup>a</sup> |
| LSD<sub>0.05</sub> | 0.43224 | 79.9711 | 19.2311 | 0.242041 | - | 0.0123611 |

The content of soluble solids was statistically considerably different between the treatments I and II and the treatment III and the control (Table 2). The highest total acid content was recorded within the control. Chemical analysis of skin indicated that the statistically considerably higher content of total anthocyanins was recorded in the treatment I only, and total phenols in treatment I and II (Table 2). Many investigations have confirmed that the light exposure of bunches positively influences increase in the content of dry matter, total anthocyanins and phenols, decrease in the total acids and pH and the malate content (Kliewer 1970; Smart et al. 1985; Morrison and Noble 1990; Dokoozlian and Kliewer 1996). Increase in the content of dry matter, the total anthocyanins and phenols in skin, due to early defoliation, may be a consequence of the sourcesink ratio disorder between the assimilation surface and bunches. Previous studies have shown that removal of a part of the leaves from shoots directs assimilator transportation to bunches (Koblet et al. 1993). According to the Poni et al. (2005), the early defoliation treatment influences development of more lateral shoots, which younger leaves have higher photosynthetic intensity during the ripening period. However, in our case it remains unclear why the anthocyanin content increased only within defoliation in the flowering phase, but not within the two other terms. The reason is not a very small berry within the I treatment, since its size has not influenced the more beneficial skin to pulp ratio (Table 1). The reason may be the fact that, within the treatments II and III, bunches get exposed to the temperatures higher than optimum for anthocyanin and phenols accumulation, causing berry overheating and its disintegration. Examinations of the Cabernet Sauvignon exposure to light, carried out by Bergqvist et al. (2001) indicate that influence of sunlight to the berry content depends on the berry temperature. At high temperatures, many metabolical processes cease or get less intensive (Jones, 1992). Temperature about 30°C is considered critical for grapevine (Coombe, 1987). Temperatures which exceed 30°C cause inhibition of anthocyanin accumulation in berries (Kliewer 1970; Mori et al., 2004).

| Table 2. Influence of defoliation time on the cultivar Prokupac must and epidermis chemical content in 2008-2009. |
|---|---|---|---|---|
| Soluble solids (Brix%) | Total acids (g l-1) | Total anthocyanins (mg g-1FW) | Total phenols (mg l-1 GAE) |
| I | 23.5<sup>a</sup> | 7.0<sup>a</sup> | 6.35<sup>a</sup> | 632.4<sup>a</sup> |
| II | 23.3<sup>a</sup> | 7.0<sup>a</sup> | 5.69<sup>b</sup> | 573.1<sup>b</sup> |
| III | 22.6<sup>b</sup> | 7.1<sup>a</sup> | 5.61<sup>b</sup> | 524.8<sup>b</sup> |
| K | 22.2<sup>b</sup> | 7.3<sup>b</sup> | 5.69<sup>b</sup> | 518.13<sup>c</sup> |
| LSD<sub>0.05</sub> | 0.612985 | 0.184976 | 0.65261 | 28.935 |
Conclusion

This examination has confirmed considerable defoliation influence on the bunch structure and chemical content. Defoliation carried out during the period of pericap cell division and growth causes irreversible decrease in the berry size in comparison with the later defoliation terms (flowering) and the control. Early defoliation has also influenced the lower degree of fruitset, resulting in looser grape bunches of less average weight. Therefore, the average yield within the early defoliation treatment has been lower. Early defoliation causes higher soluble solids content in must, higher content of the total phenols and anthocyanins in skin and lower content of the total acids.

Literature


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