Changes of stem water potential of grapevine cv. Frankovka (*Vitis vinifera* L.) in different crop load models

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**Abstract**

Water status of grapevine, observed as stem water potential (\(\Psi_{stem}\)) have been investigated in field conditions on plants that were in different yields treatments. Plant water status was examined through the measurement of stem water potential (\(\Psi_{stem}\)) at the interval of 7 – 10 days, from June to September. The research goal has been to monitor water status changes in the field conditions that might occur depending on the pruning strength. Numerous factors, from climatic to the various number of shoots and bunches, depending on the load variant, simultaneously influenced and possibly caused certain changes. Differences in yield were affected by leaving of 8 (v1), 16 (v2) and 24 (v3) winter buds per vine. Tree-year study showed that minimum values of stem water potential were recorded in the variant with 8 buds per vine, when the average yield was 2.03 kg per vine. The leaf area/crop weight was averagely 1.11 m²/kg in this variant. In case of the mentioned bud load, \(\Psi_{stem}\) values ranged to -0.93 Mpa (July 15, 2004) and -0.65 MPa (July 27, 2006). These values indicated on unfavorable water status in v1 than other two variants, in which the values are not decreased below -0.81 Mpa (22.7.2004) and -0.65MPa (27.7.2006). The average yield in these variants were v2=3.4 kg per vine and v3=4.8 kg during the examined period.

When statistically relevant differences were recorded among \(\Psi_{stem}\) values of v1 and the other two bud load variants, their values considerably approached critical values which indicating the commencement of stressful conditions due to water deficit.

**Key words:** \(\Psi_{stem}\) - stem water potential, bud load, yield, crop load.

**Introduction**

The overall exchange process, intake – transmission – consumption of water is the water regime of plants, which generally denotes the presence of water in all physiological processes. Modern studies of crop load in which special attention is paid to the achieved relationship between vegetative growth and yield are unimaginable without the tracking of changes of physiological processes in plants. Stem water potential is an important indicator of the plant’s condition, and it is closely connected to other processes such as growing, fertility, accumulation of important chemical substances in a berry etc. The plant water regime is also influenced by a great number of factors – from climatic (precipitations, solar radiation, wind), soil (water retention capacity of soil, inclination), biological properties of the grapevine rootstock and cultivar, to the number of agrotechnical measures (irrigation, soil maintenance, winter and green pruning, that is yield, amleness etc.). Therefore, the influence of particular factors on the plant water status within field conditions is very difficult to monitor, since the matter requires strict control of a large number of elements.

Leaf water potential measuring is in practice most frequently carried out in two manners, either by a psychrometer or by a Scholander Pressure Chamber, the so called nitrogen bomb. Chone et al., (2001) point out that the easiest and the quickest way to precisely measure water status of grapevine is through the implementation of a Scholander Pressure Chamber (Scholander et al., 1965), and there are three manners of
measurement: leaf water potential at pre dawn ($\Psi_{dawn}$), leaf water potential at noon ($\Psi_{leaf}$) and stem water potential ($\Psi_{stem}$).

The authors determined medium high correlation between water potential at dawn and transpiration flow ($r^2=0.65$). Leaf water potential during the day is indicator has not shown considerable differences between the experimental stem and the stem water potential. Stem water potential ($\Psi_{stem}$) indicates efficiency of water transmission from the soil to the atmosphere, and the authors have concluded that it is quite appropriate as an early indicator of grapevine water deficit. The correlation between this indicator and the transpiration flow is very high ($r^2=0.73$).

Data from literature indicate that results of many grapevine water status researches are contradictory, which speaks in favour of the fact that the present element control and monitoring are complex.

Naor et al., (1997) indicate that the most authors have been engaged in the investigation of the yield influenced water regime changes on the container-grown plants, while there are only few researches of vines in the field conditions. Experiment results concerning the container-grown grapevine indicate that the leaf water potential is higher with grape-bearing vines than with the plants with no yield, while data from the outdoor conditions vary. This author determined that leaf water potential is by 0.14MPa higher with the treatment of two bunches than one bunch per shoot with cultivar Souvignon, within field conditions. Downton et al., 1987, Jones (1992), Gal and Naor (1996) have also claimed that yield influences increase in the grapevine leaf water potential. As for the field experiments, certain data have indicated that various yield does not influence changes in plant water regime. In case of non-irrigated cultivar Tempranillo, within various yields fluctuating from 6 to 11t/ha, Rubio and Yuste (2005) have registered no statistically relevant differences in leaf water potential at dawn ($\Psi_{dawn}$) between the mentioned possibilities. Dufourcq et al., (2005) have similar conclusions about cultivars Duras, Malbec and Negret, since they have not noticed any relevant stem water status differences due to the yield load.

Smart and Coombe (1983), and Sivilotti et al., (2005) have reached a completely different conclusion that the leaf water potential decrease, i.e. that plant water deficit is caused by yield increase. According to the authors, a possible explanation might be that bunches utilize more water in case of water deficit, since the plant prefers the reproductive function to the vegetative one, which is shown through the decrease of the leaf water potential value.

The objective of this study was to determine a changes of grapevine water status through tracking stem water potential in the field condition as function of different yield.

**Materials and methods**

Investigations were conducted on cv. Frankovka (*Vitis vinifera* L.), planted in 1994 in an experimental vineyard at the Experimental Station “Radmilovac”, which belongs to the Faculty of Agriculture, University of Belgrade. The location falls within the Sumadija-Velika Morava wine region, which is characterized by Maritime Temperate or Cfb climate (Kottek et al. 2006). The vine spacing was $3 \times 1$ m, vines trained as a double Guyot, with 90 cm high trunks, pruned to a mix of canes and spurs. The vine row orientation was East-West. Yield was manipulated by winter pruning of vines to 8 (T$_1$), 16 (T$_2$) and 24 (T$_3$) nodes per vine, retained on both canes and spurs. The experiment was replicated in three blocks with all three treatments in each. Each treatment replicate consisted of 15 vines selected for their uniformity. Pruning treatments continued through three seasons and measurements were taken in each of the 2004, 2005 and 2006 cropping seasons. At commercial harvest all vine bunches were counted and weighed in order to determine bunch weight.

Plant water status was examined through the measurement of stem water potential ($\Psi_{stem}$) in a Scholander Chamber (Scholander et al. 1965). The measurements, which included six leaves per treatment, were carried out in the afternoon (11.00 a.m. – 1.00 p.m.), at the interval of 7 – 10 days, from June to September. Each leaf had been covered in PVC bag and alu-foil before it was taken off from the shoot (Chone et al. 2001). The Scholander Chamber model used in these examinations was PMS Instruments 3115 (USA).

All data were analysed using the analysis of variance (ANOVA). Treatment effects were compared using mean separation by LSD and polynomial contrasts. Regression analysis was conducted to determine the relationship between different factors and phenolic compounds. All analyses were performed using the Statgraphics Plus 5.1 (Statistical Graphics Corp. 2001.). All reported correlation coefficients were significant at the p=0.05 level.
Results and discussion

During June and July of 2004, water potential values decreased constantly with all three bud load variants, in order to reach their minimum on July 15 and 22 (Figure 1a). One may notice that from June 27 to the end of the monitoring period, the lowest values were measured with the minimum bud load treatment (v1), the minimum value of -0.93MPa recorded on July 15 or -0.91MPa recorded on July 22. As soon as from the third decade of July water potential values increased up to August 20, after which the value slightly decreased. The minimum value was once again measured with the first bud load variant (-0.74MPa) at the last measurement term which was on September 1. The stem water potential differences noticed between the terms of September 15, September 22 and September 1 were tested by the analysis of variance and proven as statistically relevant.

Data concerning the stem water potential during the year 2005 are presented in the Figure 1b. Within the seasonal dynamics, one might notice rising and falling tendencies with three minimum values. The minimum values of -0.42MPa (September 18), -0.35MPa (August 15) and -0.56MPa (August 7) were recorded in the minimum load variant. As soon as the beginning of water potential measurement of the relevant vegetation until August 28, no statistically relevant differences were determined, but from that date on, considerable differences concerning v1 variant occurred on August 28 and September 7.

In terms of seasonal dynamics of stem water potential, a tendency similar to the one from the two previous vegetation years continued in the year 2006 as well (Figure 1c). All bud load levels showed the decrease in water potential value, from the first half of June to July 21. The minimum values were measured with the minimum bud load variant and that -0.56MPa (July 13) and -0.69MPa (July 21). Differences that occurred in these terms were greatly different from those in variants v2 and v3. After the minimum value of stem water potential was measured on July 21, its value gradually increased until August 17, after which date the water potential of all three bud load variants started to decrease again, with the minimum values also recorded within v1 variant. Differences that occurred with the stem water potential of v1 variant during the three last measurement terms were greatly different. As for the experiment with cultivar Frankovka, the primary research goal has been to monitor water status changes in the field conditions that might occur depending on the pruning strength. In other words, numerous factors, from climatic to the various number of shoots and bunches, depending on the load variant, simultaneously influenced and possibly caused certain changes.

Figure 1 (a, b, c). Changes of stem water potential (Ψstem), depending of bud loads per vine during 2004. (a), 2005 (b) and 2006. (c). v1 – variant with 8 buds per vine; v2 - variant with 16 buds per vine; v3 - variant with 24 buds per vine.

Table 1. Influence of bud load per vine on average values of yield, Ravaz index (ratio between crop weight and shoot pruning weight) and ratio between leaf area and crop weight, v1 – variant with 8 buds per vine; v2 - variant with 16 buds per vine; v3 - variant with 24 buds per vine. (2004-2006).

<table>
<thead>
<tr>
<th></th>
<th>Yield (kg/vine)</th>
<th>Ravaz index (Yield/shoot pruning weight)</th>
<th>Leaf area/crop weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>v1</td>
<td>2,033</td>
<td>4,34</td>
<td>1,11</td>
</tr>
<tr>
<td>v2</td>
<td>3,440</td>
<td>3,96</td>
<td>1,48</td>
</tr>
<tr>
<td>v3</td>
<td>4,800</td>
<td>2,95</td>
<td>1,67</td>
</tr>
<tr>
<td>Lsd 0.05</td>
<td>1.01668</td>
<td>2.30134</td>
<td>0.330842</td>
</tr>
</tbody>
</table>
It is well known that increase of number of winter buds per vine leads to increase of shoots number and leaf area per vine. Also, with an increasing bud load comes to increasing of grapes number and yield. Presented results in Table 1. shows that increased number of buds did not accompanied by expected changes in value of Ravaz index and ratio between total leaf area and grape weight. There was a greater degree of increasing of the leaf area in relation to increase of the yield per vines. Similar results presented by Murisier and Ziegler (1992), who investigated the influence of bud load on the vegetative growth and yield of cv. Chasselas. They found that increasing of the bud load affect the non-linear increase of the yield.

The influence of a particular winter bud on the $\Psi_{stem}$ values became evident in 2004 and 2006, from the period of flowering phenophase to the full grape maturity, while in 2005 it happened after veraison. During tree-years period of investigation, the statistically considerably lower $\Psi_{stem}$ values were occured within pruning variant characterized by the least winter bud load, when the average yield was 2.03 kg per vine. The leaf area/crop weight was averagely 1.11 m²/kg in this variant. In case of the mentioned bud load, $\Psi_{stem}$ values ranged to -0.93 Mpa (July 15, 2004) and -0.65 MPa (July 27, 2006). These values indicated on unfavorable water status in v1 than other two variants, in which the values are not decreased below -0.81 Mpa (22.7.2004) and -0.65Mpa (27.7.2006). The average yield in these variants were v2=3,4kg per vine and v3=4,8kg during the examined period.

When statistically relevant differences were recorded among $\Psi_{stem}$ values of v1 and the other two bud load variants, their values considerably approached critical values which indicating the commencement of stressful conditions due to water deficit.

Similar result, that is improvement of the plant water status under the influence of a greater yield is recorded by Naor et al., (1997), who, examining influence of the treatment with one and two bunches per shoot in cultivar Souvignon, within field conditions. This author determined that leaf water potential is by 0.14MPa higher with the treatment of two bunches. The same has been confirmed by the cultivar Souvignon researches carried out by Gal and Naor (1996), who monitored the influence of two different crop loads, indicated by the number of shoots per vine (14 and 44) and yield (9 and 32t/ha), on stem water potential ($\Psi_{stem}$). The authors have determined that its values are higher in case there are more bunches per vine (-0,86MPa) than in case of a less load value (-1,06 MPa), while the number of shoots does not considerably influence the change in $\Psi_{stem}$ value.

In their researches, Downton et al., 1987 and Jones (1992) explain yield influence on the water status regulation. These authors have concluded that the greater yield influences increase in the grapevine leaf water potential, that is that bunches may have the function of reservoirs providing shoots with water during dry periods, while at the same time berries decrease by 1% a day due to the transfer of water to shoots. In other hand, less number of shoots per vine that are obtained by leaving a less winter bud, have influenced to the increase of solar radiation and temperature in vines zone during summer months, which resulted to the increase in the intensity of transpiration and the deterioration of water status.

**Conclusion**

In this investigation, stem water potential (Ψstem) as indicator of plant water status has shown quite appropriate as an early indicator of grapevine water deficit. During tree-year period, the statistically considerably lower Ψstem values were recorded within v1 variant characterized by the least winter bud load. Their values considerably approached critical values which indicating the commencement of stressful conditions due to water deficit.

**References**


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Acknowledgement
This paper was realized as a part of the project "Studying climate change and its influence on the environment: impacts, adaptation and mitigation" (43007) financed by the Ministry of Education and Science of the Republic of Serbia within the framework of integrated and interdisciplinary research.

sa2012_0801