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Full Length Research Paper

Photosynthetic activities on leaves and shoot of Sila cultivar before grape harvest

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Photosynthesis takes place in all green parts of the grapevine plant, but it is most intensive in the leaves of main shoots and laterals. Importance of various strata and categories of leaves is still not quite clear, even to experts. With this in mind, an investigation was undertaken of photosynthetic activity in leaves of main shoots and laterals of a newly developed Serbian grape variety Sila, which was grown under the ecological conditions of Fruška Gora Mountain. An LCpro+ instrument was used to measure the rates of photosynthesis and transpiration in the top leaf of the main shoot, and in the third leaf from the base of the lateral, that developed in the axilla of that leaf. Measurements were made just before grape harvest, on intact control vines and the vines from which shoots that emerged from secondary and tertiary latent buds were removed in the spring and, later on, grape bunches were removed from laterals. The leaves on the laterals had a higher rate of photosynthesis than the leaves on the top of the main shoots (7.9 and 6.9 µmol $CO_2 \times m^{-2} \times s^{-1}$, respectively). The leaves on the laterals also had a higher transpiration rate than the leaves on the top of the main shoots (2.5 and 2.4 mmol H_2O m^{-2} s^{-1}, respectively).

Key words: Grapevine, photosynthesis, lateral, main shoot.

INTRODUCTION

Although photosynthesis takes place in all green parts of the plant, leaves, as plant parts with largest surface, are main producers of carbohydrates. They are the most important source of organic matter in grape plants, too. Moreover, all parts of the grapevine with no photosynthetic activity receive the carbohydrates they need from leaves. These plant parts drain leaves of photosynthetic products (Chaumont et al., 1994). For grape growers, berries in the grape bunch are most important sinks of photosynthetic products, especially sugars. However, in the course of their development, the berries do not have a uniform demand for organic matter.

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Inflorescences and newly developed bunches are not important sinks, since they start an intensive sugar accumulation with the approach of the veraison stage (Edson et al., 1995; McArtney and Ferre, 1998). Sugar accumulation in grape juice is particularly intensive during the ripening stage, so that is the time when it is necessary to have a sufficiently large and active leaf area capable of meeting the requirements for organic matter (Kuljančić et al. 2009). During that period, the leaves in the middle and upper parts of the shoots and those on the laterals are most important (Edson et al., 1995; Kastori, 1998; Poni and Giachino, 2000; Vasconselos and Sastagnoli, 2001). These leaves are younger, and therefore photosynthetically more active, than the leaves in the middle and near the base of the shoots.

In addition to age, leaf productivity depends, among other factors, on shoot fertility and water status of tissues.

Kastori (1998) found that fertile shoots had higher photosynthetic activity in leaves than barren shoots. He explained it by a rapid transport of photosynthetic products through fertile shoots, from leaves to grape bunches. Soil water deficit reduces the rates of photosynthesis and transpiration in leaves (Al-Hazmi et al., 1997; Kastori, 1998; Flexas et al., 2005; Poni et al., 2009).

In general, after reaching one third of their full size, young leaves start producing excess photoassimilates, translocated afterwards to the other parts of the vine (Kastori, 1998). With further growth and development of leaves, their photosynthetic productivity increases and reaches its peak, which is maintained for some time. As the leaves age, their photosynthetic activity and their contribution to the production of organic matter decrease (Hirano et al., 1994).

An experiment of Edson et al. (1995a) showed that, just before harvest, photosynthetic activity was the highest in leaves that were last to reach full development, and that their activity was positively correlated with the total photosynthetic activity of the vine. Thus they concluded that the photosynthetic activity in a single leaf can be used as an indicator of impact of yield load on the photosynthetic activity of the entire vine.

When they have only two fully developed leaves, laterals produce excess photoassimilates that may be translocated to other parts of the vine (Vasconcelos and Sastagnoli, 2001).

Measurements of the leaves on laterals and main shoots, conducted by Hirano et al. (1994) at the time of grape ripening, indicated that the leaves on laterals had a higher rate of photosynthesis than the leaves on main shoots.

It seems necessary to point out the important role of leaves on the laterals in sugar accumulation in grape juice, because complete removal of laterals or their pruning to a small number of leaves is a frequent practice in vineyards in Serbia. It is exactly the objective of this research - to measure the photosynthetic activity of leaves on the laterals and main shoots in order to demonstrate that the laterals are not unnecessary but useful plant parts that help the vine, at the time of grape ripening, to accumulate sufficient amounts of organic matters in grape juice and vine.

MATERIALS AND METHODS

The experiment was conducted on 12-year-old (*Vitis vinifera* L.) cv Sila vines, which had been grafted on (*V. Berlandieri* x *V. Riparia*) Kober 5BB rootstock. Planting in pairs of grafts was applied. The spacing was 3.0 x 1.6 m. Vine training system was the single Guyot with arched canes. Canes and spurs were left with bud loads of 13 and 2 buds, respectively, so that the bud load per unit area was 6.25 buds. The vineyard was established in 1998 at the Experimental field of the Faculty of Agriculture, Novi Sad, located in Sremski Karlovci 45°12'00.31'' N and 19°55'59.05'' E.

Sila is a new domestic grape cultivar intended for production of white wine. Because of its late maturation and a relatively slow accumulation of sugars (Cindrić et al., 2000), this cultivar was selected for the study of the role of individual leaves in the production of sugars at the time of grape ripening. Two types of vine treatment were used for the measurements:

- In the variant "treatment", additional green pruning operations were applied: the shoots that emerged from secondary latent buds were removed (while the shoots were about 15 cm long), and inflorescences were removed from laterals.
- In the variants "control", the above green pruning operations were not performed.

Each variant was planted in three density replications, with 20 vines per replication. A difference between the means of the two experimental variants was assessed by the t-test.

The rates of photosynthesis and transpiration were measured with an LCpro+ portable photosynthesis system (ADC BioScientific Ltd.). Light conditions were adjusted, by means of a LCpro+ unit, at a photosynthetically active radiation level of 1000 mmol m^{-2} x s^{-1}. Ambient air was pumped into the leaf chamber at a constant rate of 100 mmol s^{-1}. Air humidity was maintained at 10. CO_2 temperature and concentration in the chamber depended on the ambient conditions.

Three vines were selected from each replication and a single shoot was randomly chosen from each of them. The shoots' top leaf (the first one below the place of topping) was used for measurement. Measurements were also done on the third leaf from the base of the lateral that emerged in the axilla of the top leaf. In the control variant, on the lateral, there was always a grape bunch on the opposite side of the measured leaf. The measurements were performed on 24 September, 2009.

RESULTS AND DISCUSSION

In the control variant, the rates of photosynthesis and transpiration were significantly higher in the leaves from laterals than in those from main shoots (Table 1).

In the treatment variant, there were no statistically significant differences in the rates of photosynthesis and transpiration between the leaves from laterals on those from main shoots. In both variants, the rate of photosynthesis was higher in the leaves from laterals than in the leaves from main shoots. This is in agreement with the findings reported by Hirano et al. (1994).

The significantly higher photosynthetic activity and the rate of transpiration of the leaves from main shoots in the treatment variant compared with the control variant was the consequence of better light interception resulting from deshooting.

The higher rate of photosynthesis in the leaves of laterals in the control variant compared with the treatment variant confirm the finding of Kastori (1998) that the leaves of fertile shoots had a higher photosynthetic activity than the leaves on unfertile shoots.

In order to compare the leaves from lateral with apical leaves of main shoots, the experimental variants were disregarded. The rate of photosynthesis was significantly higher in the leaves of laterals (Table 2). The result was in agreement with the reports of Edson et al. (1995a) and Hirano et al. (1994). The increased rate of transpiration in leaves with high rate of photosynthesis is consistent with

Table 1. Rates of photosynthesis and transpiration in individual leaves of the cultivar Sila, 2009.

Replication	Control				Treatment			
	Lateral		Main shoot		Lateral		Main Shoot	
	A	E	A	E	A	E	A	E
I	8.9	2.5	7.6	2.3	9.4	2.5	8.1	2.6
II	7.1	2.5	6.2	2.3	7.0	2.2	6.9	2.5
III	7.9	2.7	5.3	2.2	7.2	2.8	7.5	2.7
Average*	8.0 a	2.6a	6.4 b	2.3 b	7.9 a	2.5a	7.5 a	2.6 a

Legend: A – Rate of photosynthesis (μmol CO_2 ×m^{-2} × s^{-1}), E – Rate of transpiration (mmol H_2O m^{-2} s^{-1}), * Different letters stand for statistical difference at 0.05 significance level.

Table 2. Differences in the rates of photosynthesis and transpiration between laterals and main shoots regardless of experimental variant.

Variable	A (μmol CO_2 ×m^{-2} × s^{-1})	E (mmol H_2O m^{-2} s^{-1})
Lateral	7.9	2.5
Main shoot	6.9	2.4
Statistical significance of difference	**	ns

Legend: ** - Statistically significant difference at 0.01significance level, ns - No statistically significant difference, A – Rate of photosynthesis (μmol CO_2 ×m^{-2} × s^{-1}), E – Rate of transpiration (mmol H_2O m^{-2} s^{-1}).

the results of Chaumont et al. (1994). The rate of transpiration was higher in the leaves from laterals, but the differences were not statistically significant because grape bunches were removed of laterals in the treatment variant.

Conclusion

Immediately before grape harvest, the leaves from laterals had higher rates of photosynthesis and transpiration than the top leaves from main shoots, although the latter were believed to be most active part of the main shoot.

The leaves on the top part of the main shoots and on the laterals were most important sources of photosynthetic products at the time of grape ripening. Therefore, they should be maintained in suitable quantity and in good health condition.

Further research should confirm the viability of the above claims, and possibly provide explanation of the effect of the applied treatment on the quantity and quality of grape yield.

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