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Impact of yield standardization on leaf gas exchange of dessert grape cultivars

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Abstract

A study was carried out to determine the impact of yield standardization in the dessert grape cultivars Victoria, Palieri, Matilda and Bolgar on their leaf gas exchange parameters. Divergent impact of yield standardization on the leaf gas exchange parameters - transpiration and stomatal conductance was found. For these traits, there were no statistically proven differences between the different variants. There was specificity regarding the impact of the cultivars studied and yield standardization on leaf gas exchange parameters. The highest values of transpiration intensity were observed in Victoria, Palieri and Bolgar, of stomatal conductance - in Victoria and Bolgar. No comprehensive effect of standardization and cultivar on photosynthetic rate and A / g_s ratio was demonstrated.

Keywords: dessert grape cultivars, yield standardization, leaf gas exchange parameters, net photosynthetic rate, transpiration intensity, stomatal conductance

INTRODUCTION

In the viticultural literature, numerous scientific works focus on the physiological characteristics of grapevine leaves during the growing season, particularly following the application of green pruning, with the aim of optimizing the balance between grape quantity and quality. Most studies examine the levels and variation of these indicators in relation to shoot length, suckers, planting density, rootstocks, training systems, green pruning, girdling, application of growth regulators, and different winter eye loads at pruning (Stoev et al., 1966; Lazić et al., 1968; Stoev, 1983; Dorokhov et al., 1986; Todorov, 1978; Roychev & Vassilev, 2003; Roytchev et al., 2005). According to Stoev (1983), sugar accumulation in grapes depends not only on leaf function and photosynthetic activity, but also on processes that facilitate active synthesis, proper distribution of assimilates, and their movement into the grapes and other plant organs. The photosynthetic rate in grapevine leaves is closely related to leaf age (Milosavlievich & Radulov, 1967). The reduction of leaf mass in vines contributes to a decrease in sugar accumulation in grapes and in the fertility of winter buds (Todorov & Zankov, 1964). Varying the vine's load with shoots and bunches alters the intensity of physiological processes in the leaves and affects the overall productivity of the vine. The presence of bunches on the shoots accelerates leaf photosynthesis to some extent, as they require the organic substances produced. Overloading the vines leads to a reduction in photosynthetic activity and an increase in respiration and transpiration (Stoev, 1983).

Drought resistance in grapevine varieties is an important trait in crop selection and breeding, particularly in light of the increasingly widespread issue of water scarcity (Pagay et al., 2022). Research on plant adaptation to drought has attracted the attention of numerous authors (Sánchez-Ortiz et al., 2024; Ribalta-Pizarro et al., 2021; Soltekin & Altındişli, 2012).

The aim of this study was to determine the effect of yield standardization in dessert grapevine cultivars on leaf gas exchange parameters, which serve as indicators of the photosynthetic apparatus's tolerance to drought.

MATERIALS AND METHODS

The experimental work was conducted in a vineyard located in the land of Brestnik village, near Plovdiv. The study included the dessert grape cultivars Victoria, Palieri, Matilda, and Bolgar. The vines of all four cultivars were grafted onto the SO4 rootstock and trained using the Stem Two-Arm Guyot formation, with a planting distance of 3.00 × 1.20 m. At the time of pruning at maturity, an equal load was applied to all experimental vines, consisting of six trunks with two eyes each and two fruiting canes with twelve eyes each, totaling 36 winter eyes. At the beginning of the 'berry growth' phenophase (pea size), on an equal number of shoots developed from trunks and fruiting canes, four yield standardization variants were applied through cluster thinning: V1 – no cluster standardization; V2 – 15 bunches per vine (7 on shoots from trunks and 8 on shoots from fruiting canes); V3 – 20 bunches per vine (10 on shoots from trunks and 10 on shoots from fruiting canes); V4 – 25 bunches per vine (12 on shoots from trunks and 13 on shoots from fruiting canes). Each variant included 30 vines, arranged in three replicates of 10 vines.

Leaf gas exchange, including net photosynthetic rate (A), transpiration intensity (E), and stomatal conductance (gs), was measured over three consecutive years on leaves opposite bunches from the same shoots and vines, by cultivar and variant—before cluster thinning (V1) and ten days later (V2–V4)—using a portable photosynthetic system (LCA-4, ADC, England). Measurements were taken in early and mid-July, between 10:00 and 12:00 h, at air temperatures of approximately 30–35 °C and photosynthetic photon flux density (PPFD) of 1300–1800 μmol m^{-2} s^{-1}. For each variant, five to eight replicates were recorded for transpiration, stomatal conductance, and photosynthetic rate.

For each cultivar, a comparative evaluation was made on all studied traits by applying a one-factor analysis of variance and LSD-Test to prove statistically significant differences compared to the variant without cluster standardization. The comprehensive effects of cultivar and individual yield standardization variants on leaf gas exchange were determined using two-factor analysis of variance and Duncan's test to evaluate differences at 0.05 statistical significance. Statistical processing of the experimental data was performed using IBM SPSS Statistics 26 software (Field, 2000; Landau & Everitt, 2004; Sarwono, 2017; Kafle, 2019).

RESULTS AND DISCUSSION

The results of the analysis conducted on the effect of cluster standardization on transpiration, stomatal conductance, leaf photosynthesis, and the A/gs ratio showed no significant differences in these traits across the different vine cultivars and study variants (Table 1). Only the Matilda cultivar exhibited a response to yield standardization with 15 bunches (V2), showing the lowest leaf transpiration rate (2.61 mmol H_2O m^{-2} s^{-1}) compared to all other variants. No statistically significant effect of standardization on the A/gs ratio was observed in any of the cultivars studied. However, in Victoria and Matilda, the highest A/gs values were recorded in variant V2, while in Palieri and Bolgar, they occurred in variant V3. The maximum value was observed in Matilda under the second standardization variant (61.38).

The combined effect of cultivar and yield standardization variants on the studied traits is presented in Table 2. According to the experimental data, a statistically significant effect was confirmed for transpiration and stomatal conductance.

Table 1. Comparative evaluation of leaf gas exchange parameters of the studied grape cultivars by variants

Cultivar	Variant	Transpiration rate mmol H_2O m^{-2} s^{-1}	Stomatal conductance mol m^{-2} s^{-1}	Photosynthetic rate µmol CO_2 m^{-2} s^{-1}	A / g_s
Victoria	V_1	4.49	0.13	6.03	46.37
	V_2	4.22 n.s.	0.14 n.s.	7.03 n.s.	50.21 n.s.
	V_3	4.85 n.s.	0.17 n.s.	5.95 n.s.	35.00 n.s.
	V_4	4.44 n.s.	0.14 n.s.	6.41 n.s.	45.79 n.s.
	Average	4.50	0.14	6.35	45.36
	P-Value	0.516	0.488	0.702	0.644
Palieri	V_1	3.40	0.11	5.21	47.36
	V_2	4.77 n.s.	0.15 n.s.	6.82 n.s.	45.47 n.s.
	V_3	3.96 n.s.	0.11 n.s.	5.33 n.s.	48.45 n.s.
	V_4	4.18 n.s.	0.12 n.s.	4.80 n.s.	40.00 n.s.
	Средно	4.08	0.12	5.54	46.17
	P-Value	0.259	0.438	0.381	0.914
Matilda	V_1	3.46	0.11	5.75	52.27
	V_2	2.61*	0.08 n.s.	4.91 n.s.	61.38 n.s.
	V_3	3.36 n.s.	0.10 n.s.	4.88 n.s.	48.8 n.s.
	V_4	3.56 n.s.	0.11 n.s.	5.55 n.s.	50.45 n.s.
	Average	3.25	0.10	5.27	52.7
	P-Value	0.004	0.249	0.866	0.231
Bolgar	V_1	4.68	0.16	5.19	32.44
	V_2	4.14 n.s.	0.15 n.s.	6.71 n.s.	44.73 n.s.
	V_3	3.97 n.s.	0.14 n.s.	6.58 n.s.	47 n.s.
	V_4	4.55 n.s.	0.17 n.s.	6.53 n.s.	38.41 n.s.
	Average	4.33	0.16	6.25	39.06
	P-Value	0.216	0.467	0.642	0.141

Legend: * - level of statistical significance of differences 0.05; n.s.- no proven differences between variants with and without standardization

The highest, although statistically unproven, photosynthetic rates were measured in the Victoria cultivar for V2 (7.03 µmol CO_2 m^{-2} s^{-1}), Palieri for V2 (6.82 µmol CO_2 m^{-2} s^{-1}), and Bolgar for V2 (6.71 µmol CO_2 m^{-2} s^{-1}). The lowest rates were recorded in Palieri for V4 (4.80 µmol CO_2 m^{-2} s^{-1}), Matilda for V3 (4.88 µmol CO_2 m^{-2} s^{-1}), and Matilda for V2 (4.91 µmol CO_2 m^{-2} s^{-1}). Maximum leaf transpiration values were found in Victoria for V3 (4.85 mmol H_2O m^{-2} s^{-1}), followed by Palieri for V2 (4.77 mmol H_2O m^{-2} s^{-1}) and Bolgar for V1 (4.68 mmol H_2O m^{-2} s^{-1}). The minimum transpiration value was recorded in Matilda for V2 (2.61 mmol H_2O m^{-2} s^{-1}). Stomatal conductance was highest in Victoria for V3 and Bolgar for V4 (both 0.17 mol m^{-2} s^{-1}), and lowest in Matilda for V2 (0.08 mol m^{-2} s^{-1}). All A/gs ratio data showed no statistically proven differences by cultivar or variant.

Table 2. Effect of yield standardization and vine variety on leaf gas exchange parameters

Cultivar	Variant	Transpiration rate mmol H_2O m^{-2} s^{-1}	Stomatal conductance mol m^{-2} s^{-1}	Photosynthetic rate µmol CO_2 m^{-2} s^{-1}	A/g_s
Victoria	V_1	4.49^{ab}	0.13^{abcd}	6.03	50.92
	V_2	4.22^{abcd}	0.14^{abcd}	7.03	51.48
	V_3	4.85^{a}	0.17^{a}	5.95	36.88
	V_4	4.44^{abc}	0.14^{abcd}	6.41	49.04
Palieri	V_1	3.40^{de}	0.11^{cde}	5.21	54.40
	V_2	4.77^{a}	0.15^{abcd}	6.82	52.75
	V_3	3.96^{abcd}	0.11^{cde}	5.33	55.53
	V_4	4.18^{abcd}	0.12^{cde}	4.80	44.18
Matilda	V_1	3.46^{cde}	0.11^{cde}	5.75	54.51
	V_2	2.61^{e}	0.08^{e}	4.91	61.18
	V_3	3.36^{de}	0.1^{de}	4.88	47.73
	V_4	3.56^{de}	0.11^{cde}	5.55	49.20
Bolgar	V_1	4.68^{a}	0.16^{ab}	5.19	31.66
	V_2	4.14^{abcd}	0.15^{abcd}	6.71	44.21
	V_3	3.97^{abcd}	0.14^{abcd}	6.58	46.88
	V_4	4.55^{ab}	0.17^{a}	6.53	38.90
Average		4,04	0.13	5.85	48.09
St. Deviation		0,81	0.04	1.66	16.40
p-value		0,000	0.001	0.685	0.654

CONCLUSIONS

n the studied dessert grape cultivars—Victoria, Palieri, Matilda, and Bolgar—no statistically significant effect of yield standardization was observed on leaf gas exchange parameters, including transpiration, stomatal conductance, and the photosynthetic/stomatal conductance ratio. An exception was noted in variant 2 of the Matilda cultivar, although no statistically proven differences were found between the individual variants for the traits studied. There is cultivar-specific variation in the response of leaf functional activity traits to yield standardization. A statistically confirmed combined effect of cultivar and yield standardization on transpiration and stomatal conductance levels was established. The highest stomatal conductance values were recorded in Victoria and Bolgar, while the highest photosynthetic rates were observed in Victoria, Palieri, and Bolgar.

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