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ARTICLE

The effect of progressive drought on water relations and photosynthetic performance of two grapevine cultivars (*Vitis vinifera* L.)

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ABSTRACT Preliminary measurements were carried out in order to asses the effect of water deficit on photosynthesis and water relations of two grapevine cultivars (*Vitis vinifera* L. cv. Kékfrankos and *Vitis vinifera* L. cv. Portugieser grafted on 5BB rootstock) tolerance and sensitive to drought, respectively. Three treatments were applied on both cultivars such as 100%, 50% and 30% field capacity under glasshouse conditions. Pre-dawn water potential and gas-exchange parameters (assimilation rate, transpiration, stomatal conductance) were consistently lower in drought stressed plants indicating moderate water stress at 50% field capacity and severe water deficit at 30% field capacity. Midday water potential indicated "close to isohydric" characteristic of both cultivars. Moderate water deficit resulted in an increase in water-use efficiency (WUE). However, Kékfrankos had a significantly higher WUE than Portugieser.
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KEY WORDS

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Grapevine (*Vitis vinifera* L.) is a traditionally non-irrigated crop, however under arid and Mediterranean-type regions irrigation practices such as partial root-zone drying (PRD) (Dry et al. 2000) and regulated deficit irrigation (RDI; de Souza et al. 2005) have been introduced in order to improve/sustain yield and quality. Under cool climate conditions occurrence of soil water depletion is partly due to the increasing effect of climate change, (uneven and decreased precipitation accompanying with heat spells and high vapour pressure deficit) (Schultz 2000; Domokos 2003) low soil water holding capacity and steep slope exposure (van Leeuwen and Seguin 2006). Moderate water deficit has a beneficial effect on wine quality and composition, especially when grapevines are stressed during the ripening period. However, long term and severe water shortage may endanger economic yield and quality parameters of the wine. In addition, during drought periods the survival of individual plants in new plantations is also endangered without irrigation. Therefore, enhancement of water use efficiency (WUE) has become a main objective for many crops. In grapevine, moderate water stress has a positive impact on WUE (Cifre 2005), however there is evidence for variation in WUE among grapevine cultivars (Bota et al. 2001). Vineyards have high mesoclimatic variability as a result of different aspect, exposure and soil type. Under the same macroclimatic system very different water conditions can be found even within a small wine region and thus grapevines can be regularly exposed to water deficit year by year. Therefore the choice of appropriate cultivar for the given area ('terroir'- variety combination) is essential considering mesoclimatic-soil characteristics and the grapevine strategies against abiotic stresses.

The aim of our preliminary measurement was to compare two grapevine cultivars (*Vitis vinifera* L. Kékfrankos and *Vitis vinifera* L. Portugieser) under severe, moderate and non-stressed conditions to reveal possible differences in some ecophysiological responses of the varieties including WUE. Our results present some evidence for the importance of variety selection in terms of physiological background and may provide useful additional data for determining optimal 'terroir'-variety combinations.

Materials and Methods

Two grapevine cultivars *Vitis vinifera* L. Kékfrankos and *Vitis vinifera* L. Portugieser were submitted to regulated deficit irrigation under greenhouse conditions. Each grapevine were planted in 50L white container using perlite (20%), loamy soil (30%) and peat (50%) (v/v) mixture as a substrate. Three treatments were applied on varieties as 100% (non-stressed), 50% (moderately stressed) and 30% (severely stressed) field capacity. Physiological measurements were taken after 5-8 days when stressed plants reached the desired water deficit. Pre-dawn (Ψ_p) and midday water potentials (Ψ_m) were recorded with Scholander pressure-chamber (PMS, USA). Leaf gas-exchange was measured with an ADC-4 portable

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Table 1. Pre-dawn (Ψ_p), midday (Ψ_m) water potential, stomatal conductance (g_s), water use efficiency (WUE) of Kékfrankos (K100%, K50% and K30%) and Portugieser (P100%, P50% and P30%) grapevine (*Vitis vinifera* L.) cultivars grafted on 5BB rootstock under different water regimes (100%, 50% or 30% field capacity). Each data is the average of 3-5 records with standard deviation.

Treatments	Ψ_p (MPa)	Ψ_m (MPa)	g_s (mol m^{-2} s^{-1})	WUE (Pn/E)
K100%	-0.1 ± 0.01	-1.55 ± 0.06	0.17 ± 0.01	1.69 ± 0.2
K50%	-0.29 ± 0.01	-1.58 ± 0.1	0.09 ± 0.01	2.65 ± 0.3
K30%	-0.76 ± 0.2	-1.27 ± 0.5	0.02 ± 0.01	0.91 ± 0.7
P100%	-0.12 ± 0.02	-1.41±0.07	0.26 ± 0.04	1.68 ± 0.2
P50%	-0.26 ± 0.03	-1.62±0.07	0.12 ± 0.02	1.83 ± 0.2
P30%	-0.93 ± 0.1	-1.23±0.02	0.01 ± 0.02	0.98 ± 0.7

infrared gas analyser (ADC Bioscientific Ltd. UK.). Each measurement was taken on individual plants on leaves fully exposed to the sun at saturating light intensities.

Results and Discussion

A significant decrease was observed in pre-dawn water potential in grapevine plant under moderate and severe water deficit. Interestingly, midday water potential of severely stressed plants showed higher values in both cultivars. Non-stressed Portugieser plants exhibited a slightly higher Ψ_m than moderately stressed vines. In contrast, no differences were observed in Kékfrankos leaves Ψ_m between the treatments of 100% and 50% field capacity (Table 1). It suggests that these varieties have isohydric behaviour as it was reported by Schultz (2003) in the case of Grenache grapevine. However, Kékfrankos exhibited stronger isohydric behaviour than Portugieser.

Better water supply resulted in significantly higher stomatal conductance (g_s; Table 1), net-photosynthesis (Pn) and transpiration rate (E) (Düring 1987; de Souza 2005; data not shown). Under non-stressed and moderately stressed conditions Portugieser showed higher gs and E than Kékfrankos. However, CO_2 fixation was higher only in non-stressed Portugieser plants and no differences were found between the assimilation rates of the cultivars under moderate stress. Our results are matching with other findings (Cifre 2005) as moderate water deficit lead to an increase of water use efficiency in grapevine leaves. In addition, at this level of water stress Kékfrankos cultivar showed a higher WUE than Portugieser (Table 1). The higher WUE is partly due to the stronger stomatal regulation of Kékfrankos, however examination of metabolic processes are required to reveal the detailed physiological background of water restriction mechanisms.

In conclusion, our preliminary results presented scientific evidence for differences in water-use efficiency between grapevine cultivars. Grapevine plantation is an expensive and long time investment, therefore the choice of the appropriate cultivar is essential. The increasing frequency of heat spells and dry periods in cool climate wine regions may endanger economic yield and quality. The most endangered vineyards are on hill steep slopes and with soils with low water-holding capacity. Thus, physiological characterisation of the cultivars may provide useful additional data for the choice of the optimal terroir - variety combination.

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