Proceedings of the 8th Hungarian Congress on Plant Physiology and the 6th Hungarian Conference on Photosynthesis, 2005

Volume 49(1-2):211-213, 2005
Acta Biologica Szegediensis
http://www.sci.u-szeged.hu/ABS

Water relations and photosynthetic responses of Kékfrankos grapevine (*Vitis vinifera* L.) in two terroirs with different ecological conditions

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ABSTRACT Behaviour of Kékfrankos (*Vitis vinifera* L.) grapevine in two terroirs (Eger-Nagyeged–hill and Eger-Kőlyuktető) were examined during the growing season 2003. There was a close relationship between physiological responses, yield, fruit quality and terroir environmental conditions. Lower water supply in Eger-Nagyeged-hill was detected during the season due to its sloping exposure and soil characteristics. Pressure-volume curves (PV-curves) indicated that there was no osmotic adjustment in the leaves of this variety. Higher osmotic concentration was measured in the leaves of the unstressed terroirs presumably due to higher photosynthetic activity. Differences in soil water content of the 2 terroirs resulted in altered cell wall elasticity of the Kékfrankos variety. Photosynthetic production per unit leaf area and total canopy surface was also affected by available soil water content being lower in Eger-Nagyeged-hill. Physiological distinction of the vines in the 2 terroirs resulted in altered yield and wine quality. Lower yield in Eger-Nagyeged-hill is partly connected to decreased photosynthetic production of the canopy. Improved wine quality of Eger-Nagyeged-hill is due to moderate water stress having positive effect at the end of the growing season and other microclimatic factors, *i.e.* elevated soil temperature and better sun exposure of leaves and clusters.
Acta Biol Szeged 49(1-2):211-213 (2005)

KEY WORDS

grapevine
terroir
drought
water relations
photosynthesis

Terroir experiments in viticultural research have come to the front recently. The special characteristics of wines due to the complex effects of a given terroir arise as the result of several physiological processes. Physiological responses of the grapevine on drought are only one, though an important aspect of terroir experiments. The responses of grapevine photosynthesis and water relations to water stress include many physiological processes as parts of stress tolerance or avoidance strategies that vary with genotype (Schultz 1996). Several defence mechanisms can maintain water status in plants. The earliest response to mild drought to restrict transpiration is stomatal closure (Lawlor 1995). Stomatal movements are influenced by lots of factors such as soil water deficit, air humidity, embolisms in the xylem etc. (Sperry 1986; Jones 1997). As a result of more severe water stress down-regulation of photosynthetic electron transport is also detected (Medrano et al. 2002). On cell level there are two strategies for sustaining turgor. The first one is lowering osmotic potential through increasing osmotically active solutes in the cytoplasm and the second one is cell wall regulation which cost less energy than osmoregulation (Peltier and Marigo 1999).

The aim of the present work is to demonstrate the effect of two different terroirs on Kékfrankos physiology, yield and wine quality.

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Materials and Methods

Description of the terroirs

Eger-Nagyeged hill: Its gravel rich brown soil was formed on marine limestone. The layer rich in humus is shallow, 60-80 cm. Clay content is between 21-24 percentages. Mud fraction is dominant and its rate is 40-55%. Water holding capacity is under the average and pH is neutral.

Characteristics of the plantation: exposure North-South, training system umbrella, vine spacing 3x1 m, pruning level 24 buds/vine, rootstock B.xR.T.5C.

Eger-Kőlyuktető: Brown soil with lessivage with a gentle slope formed on rhyolite tuff. The clay content is between 39-42 percentages, increasing towards deeper layers. The water holding capacity of the soil is good. pH is slightly acid, mostly in the upper parts. The rate of sand fraction is between 23-38 percentages, decreasing towards deeper layers. Characteristics of the plantation: exposure North-South, training system umbrella, vine spacing 3x1,2 m, pruning level 22 buds/vine, rootstock B.xR.T.5C.

Soil water content was measured with penetrometer four times during the growing season. Plant water status was monitored with a Scholander-pressure chamber (Scholander 1965). Midday vessel (xylem) water potential (Ψ) was measured between 1:00-3:00 pm four times on each occasion.

Pressure - volume curves (PV-curves) were taken according to Scholander (1965). PV-curves show the relationships

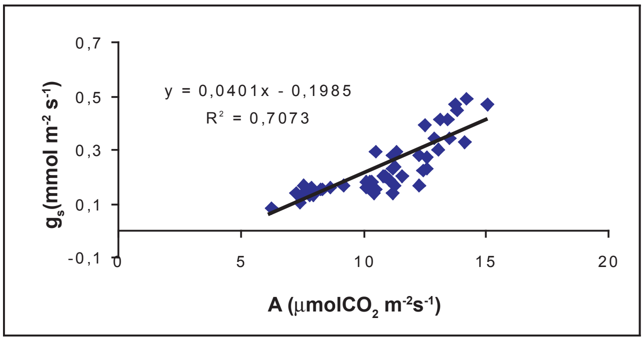

Figure 1. Correlation between stomatal conductance and assimilation rate in the drought stressed terroir (Eger-Nagyeged-hill).

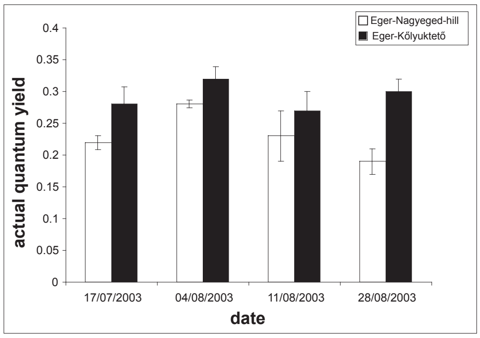

Figure 2. Changes in actual quantum yield in Eger-Nagyeged-hill and Eger-Kőlyuktető.

between water saturation deficit (WSD) and Ψ (1/Ψ *vs.* WSD). Apoplastic water fraction and osmotic potential at full turgor (π_{100}) were determined from linear regression fitted on the PV data as the complement to the x-intercept (apoplastic volume fraction) and the reciprocal value of the y-intercept (π_{100}). Bulk modulus of elasticity (ε) was calculated according to Wilson et al. (1979); $\varepsilon = (\pi_{100} \text{ x } WSD_{TLP})/(1\text{-}WSD_{TLP})$.

Leaf gas exchange rates were measured with an ADC-4 portable infrared gas analyser (ADC Bioscientific Ltd. UK.) 5-10 times per treatment. Actual quantum yield was detected with a PAM-2000 fluorimeter. Measurements were taken on leaves fully exposed to sun at saturating light intensities.

Results and Discussion

Penetrometer measurements showed large differences with a significantly higher soil water content in Eger-Kőlyuktető. Midday xylem water potential (Ψ) values of Eger-Nagyeged–hill were more negative almost in every case. Limited photosynthetic activity was observed in Eger–Nagyeged–hill compared to Eger-Kőlyktető which is due to stomatal coductivity and decreased yield of actual elctrontransport (Figs. 1, 2). Although there were obvious differences in physiological responses between the terroirs, values of midday water potential and stomatal conductance at the drought stressed growing site did not show the stress level that was expected. The following conclusions can be drawn from these facts: i. Midday water potential is not suitable to determine the stress level of the Kékfrankos variety. Our pilot pre-dawn measurements (not shown) reflected the water deficit more effectively in agreement with the results of other authors (Medrano et al. 2002). ii. Kékfrankos variety may maintain its water potential (Ψ) on a "more positive" level than other cultivars as part of stress avoidance strategy.

Lack of correlation between osmotic potential and turgor loss point, values of bulk modulus of elasticity (ε) proved that cell wall regulation played a central role in delaying turgor loss (Table 1). Higher ε values of the leaves from Nagyeged-hill showed rigid cell walls which reduced the effectiveness of turgor adjustment. Rigid cell walls which caused turgor loss at lower water saturation deficit resulted in reduced vegetative growth in Eger-Nagyeged-hill. Although there were significant differences in osmotic potential of leaves at full turgor and turgor loss ($\pi_{100,}$ π_0) between the terroirs, more negative osmotic potential was not due to a higher stress level. On the contrary, better environmental conditions in Eger-Kőlyuktető caused higher photosynthetic activity, which probably resulted in a higher osmotic concentration.

Lower yield in Eger-Nagyeged-hill (not shown) is partly connected to decreased photosynthetic production of the canopy. Improved wine quality of Eger-Nagyeged-hill (not shown) is due to moderate water stress having positive effect at the end of the growing season and other microclimatic factors, *i.e.* elevated soil temperature and better sun exposure of leaves and clusters.

Table 1. Results of pressure-volume curves from the two terroirs.

	Eger-Kőlyuktető					Eger-Nagyeged-hill				
Date	*TLP(%of WSD)*	π_{100} *(-Mpa)*	π_0 *(-Mpa)*	*ε (Mpa)*	*A (%)*	*TLP(%of WSD)*	π_{100} *(-Mpa)*	π_0 *(-Mpa)*	*ε (Mpa)*	*A (%)*
07/08	14,9±0,65	1,40±0,29	1,94±0,11	8,97±0,50	25,33±9,29	11,35±1,06	1,20±0,20	1,55±0,20	9,44±0,67	52,50±9,19
07/16	16,76±2,05	1,73±0,02	2,14±0,21	8,70±1,19	23,16±15,88	11,10±0,10	1,31±0,64	1,58±0,28	10,50±0,42	48,33±3,21
07/28	14,76±0,80	1,35±0,08	1,91±0,19	7,84±0,54	48,00±7,55	13,00±0,00	0,95±0,00	1,56±0,00	9,05±0,00	44,00±0,00
08/11	15,30±0,30	1,68±0,07	2,06±0,33	9,51±2,29	24,50±12,02	9,50±0,80	1,18±0,18	1,31±0,16	11,47±2,50	44,66±6,42
09/24	21,63±2,10	1,32±0,24	1,63±0,14	4,83±0,96	10,83±5,83	13,70±1,69	1,15±0,20	1,27±0,18	7,27±0,25	14,00±5,65

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