

## Research Note

## Modelling photosynthetic-light response on Syrah leaves with different exposure

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**Key words:** light saturation and compensation index, photosynthesis.

**Abbreviations:**  $\alpha$ : Photochemical efficiency [ $\mu\text{mol}(\text{CO}_2) \mu\text{mol}(\text{photon})^{-1}$ ];  $\theta$ : Light-curve convexity, dimensionless;  $I_s$ : Light saturation index [ $\mu\text{mol}(\text{photon}) \text{m}^{-2} \text{s}^{-1}$ ];  $I_c$ : Light compensation index [ $\mu\text{mol}(\text{photon}) \text{m}^{-2} \text{s}^{-1}$ ];  $\text{Pn}_{\text{sat}}$ : Net saturated photosynthetic rate [ $\mu\text{mol}(\text{CO}_2) \text{m}^{-2} \text{s}^{-1}$ ]; PPFD: Photosynthetic photon flux density [ $\mu\text{mol}(\text{photon}) \text{m}^{-2} \text{s}^{-1}$ ];  $R_d$ : Dark respiration [ $\mu\text{mol}(\text{CO}_2) \text{m}^{-2} \text{s}^{-1}$ ].

**Introduction:** Radiation intercepted by leaves varies significantly within a grapevine canopy affecting leaf photosynthesis. Light intensity and quality received during growth affects the biochemical composition of the photosynthetic machinery (CARTECHINI and PALLIOTTI 1995), the light saturation and compensation indexes, and the saturated photosynthetic rate (GARCIA DE CORTÁZAR *et al.* 2005). Spatial and temporal radiation variability within the canopy is difficult to characterize due to the number of measurements required with the methods commonly used. Simulation models have become the main research tool to overcome this problem, to scale up from single leaf functioning to whole canopy performance (SCHULTZ 2003), and to study the influence of different cultural practices on leaf and canopy physiology. It is therefore important to understand the response to different light intensities of different type of leaves (ZUFFEREY *et al.* 2000). The objective of this work was to analyse the photosynthetic response of leaves with different location within the canopy to different light intensities.

**Materials and Methods:** The experiment was conducted during the 2006/07 season in an own rooted 'Chenin blanc' vineyard planted in 1981 and re-grafted in 2001 with 'Syrah' in Mendoza (33° 00'S, 68° 51'W). The vineyard was planted at 2.5 m between rows and 1.25 m between plants in NS oriented rows. Vines were conducted in a divided canopy trellis system and pruned to 4 fruiting canes and 4 spurs with 22–28 buds per vine.

Photosynthetic-light response curves were performed at bloom, veraison and harvest on 5 interior leaves of the canopy (IL) and 5 sun-exposed leaves (SL) that had been initially selected at bloom. Leaves located between the fifth

and the eight nodes were randomly chosen for measurements. The IL received  $\leq 300 \mu\text{mol m}^{-2} \text{s}^{-1}$  of PPFD while SL received  $\geq 1500 \mu\text{mol m}^{-2} \text{s}^{-1}$ . Curves were performed between 09:00 and 12:00 h (solar time) by exposing leaves to decreasing levels of PPFD for 2–3 min at each level before measurements were taken. Leaf temperature was between 27 and 30 °C and  $\text{CO}_2$  concentration was set at  $370 \mu\text{mol mol}^{-1}$ .

A non-rectangular hyperbola (MARSHALL and BISCOE 1980) was used to model the leaf photosynthetic-light response. This model has four variables ( $\text{Pn}_{\text{sat}}$ ,  $\alpha$ ,  $\theta$  and  $R_d$ ) which provide a large degree of flexibility in relation to the shape of the curve (ZUFFEREY *et al.* 2000). According to these authors, curves fit better with  $\theta$  values between 0.7 and 1. The photochemical efficiency was calculated as the slope of the lineal portion of the response curve when  $\text{PPFD} \leq 100 \mu\text{mol m}^{-2} \text{s}^{-1}$  (PASIAN and LIETH 1989). Light saturation ( $I_s$ ) and compensation indexes ( $I_c$ ) were calculated following PASIAN and LIETH (1989). Curve fitting was performed with Table & Curve 2D v.2.03 software (Jandel Scientific, San Rafael, USA). Data analysis was carried out through confidence interval calculation for a  $p \leq 0.05$ .

Photosynthetic measurements were performed with a portable open circuit infrared gas analyser (CIRAS-2, PP Systems, Hertfordshire, U.K.), with an automatic leaf-chamber with 2.5 cm<sup>2</sup> measurement area (PLC6 (U) CRS121, PP Systems, Hertfordshire, U.K.) and a led unit (PLC6 (U) Broad CRS131, PP Systems, Hertfordshire, U.K.). Leaf temperature was measured with a built-in infrared sensor.

**Results:** For all type of leaves, net photosynthesis increased with PPFD until light saturation ( $I_s$ ) (Figure). The SL showed higher  $\text{Pn}$ ,  $I_s$ , and  $\text{Pn}_{\text{sat}}$  values than IL. At bloom,  $I_s$  was  $884 \mu\text{mol m}^{-2} \text{s}^{-1}$  for SL and  $397 \mu\text{mol m}^{-2} \text{s}^{-1}$  for IL (Figure, Table). The  $I_s$  remained relatively constant along the season on IL, while on SL it decreased to  $617 \mu\text{mol m}^{-2} \text{s}^{-1}$  at veraison and increased to 806 at harvest. Nevertheless, SL showed higher  $I_s$  values than IL. On IL, the light compensation index decreased about 40 % from bloom to harvest (Table 1). The SL showed a higher  $I_c$  than IL. However,  $I_c$  values were relatively low reaching about  $5 \mu\text{mol m}^{-2} \text{s}^{-1}$ . The  $\text{Pn}_{\text{sat}}$  decreased along the season for all types of leaves. The SL had higher  $\text{Pn}_{\text{sat}}$  than IL all along the season. Photochemical efficiency ( $\alpha$ ) was higher for IL than SL, except at veraison when SL showed higher values. Calculated values of  $\alpha$  were around  $0.042 \mu\text{mol CO}_2 \mu\text{mol photon}^{-1}$  until veraison, and thereafter they decreased to about 0.020 at harvest.

**Discussion:** Photosynthetic-light response curves were similar to those observed on previous research conducted on grapevines (CARTECHINI and PALLIOTTI 1995, SCHULTZ 2003, GARCIA DE CORTÁZAR *et al.* 2005). Values of  $I_s$  may change with cultivar (ZUFFEREY *et al.* 2000), leaf type, age, and leaf temperature (ZUFFEREY and MURISIER 2000). According to these authors, healthy adult leaves can reach  $I_s$  values of  $1500 \mu\text{mol m}^{-2} \text{s}^{-1}$  with temperatures between 30 and 35 °C. In our conditions, leaf temperature during photosynthetic-light responses curves were between

Table

Light saturation index ( $I_s$ , [ $\mu\text{mol (photon) m}^{-2} \text{s}^{-1}$ ]), light compensation index ( $I_c$ , [ $\mu\text{mol (photon) m}^{-2} \text{s}^{-1}$ ]), net saturated photosynthetic rate ( $Pn_{\text{sat}}$ , [ $\mu\text{mol (CO}_2\text{) m}^{-2} \text{s}^{-1}$ ]), photochemical efficiency ( $\alpha$ , [ $\mu\text{mol (CO}_2\text{) } \mu\text{mol photon}^{-1}$ ]) on sun-exposed leaves (SL) and interior leaves of the canopy (IL) in 'Syrah' at bloom, veraison and harvest (stages 23, 35 and 38). Average of 5 values  $\pm$  confidence interval at  $p \leq 0.05$ . Mendoza 2006/07

	Sun-exposed leaves (SL) (PPFD $\geq 1500 \mu\text{mol m}^{-2} \text{s}^{-1}$ )				Interior leaves (IL) (PPFD $\leq 300 \mu\text{mol m}^{-2} \text{s}^{-1}$ )			
	$I_s$	$I_c$	$Pn_{\text{sat}}$	$\alpha$	$I_s$	$I_c$	$Pn_{\text{sat}}$	$\alpha$
Bloom	884 $\pm$ 81	5.60 $\pm$ 0.5	16.2 $\pm$ 0.7	0.037 $\pm$ 0.0022	397 $\pm$ 47	5.80 $\pm$ 0.7	7.86 $\pm$ 0.4	0.042 $\pm$ 0.0018
Veraison	617 $\pm$ 49	4.46 $\pm$ 0.3	13.3 $\pm$ 0.7	0.045 $\pm$ 0.0027	530 $\pm$ 158	4.45 $\pm$ 1.3	9.70 $\pm$ 0.8	0.042 $\pm$ 0.0086
Harvest	806 $\pm$ 88	5.50 $\pm$ 0.9	7.6 $\pm$ 0.9	0.016 $\pm$ 0.0054	416 $\pm$ 7	2.83 $\pm$ 0.0	5.70 $\pm$ 0.3	0.029 $\pm$ 0.0024

25 and 30 °C and  $I_s$  values were close to 900  $\mu\text{mol m}^{-2} \text{s}^{-1}$  at bloom on fully expanded sun-exposed leaves. The  $I_c$  values obtained in the present study were lower than those determined for similar leaves for 'Riesling' and 'Chasselas' (ZUFFEREY *et al.* 2000).

Photochemical efficiency ( $\alpha$ ) was also similar to those previously reported in grapevines (CARTECHINI and PALLIOTTI 1995). The dependence of  $\alpha$  on radiation is still under debate. Several authors have found higher values on shaded leaves than on sun-exposed leaves (CARTECHINI and PALLIOTTI 1995, SCHULTZ 2003) coincident with the data presented here where shade leaves showed higher  $\alpha$ , except at veraison when shaded leaves showed lower values than sun-exposed leaves.

Information provided here may be useful for modelers to scale up from single leaf measurements to the whole canopy level. The use of simulation models to predict responses to biotic and abiotic factors have increased in recent years because they allow reproducing the effects of possible environmental scenarios before performing field experiments. They also permit to analyze big volumes of information and to integrate the physiological interactions whether at leaf or canopy scale.

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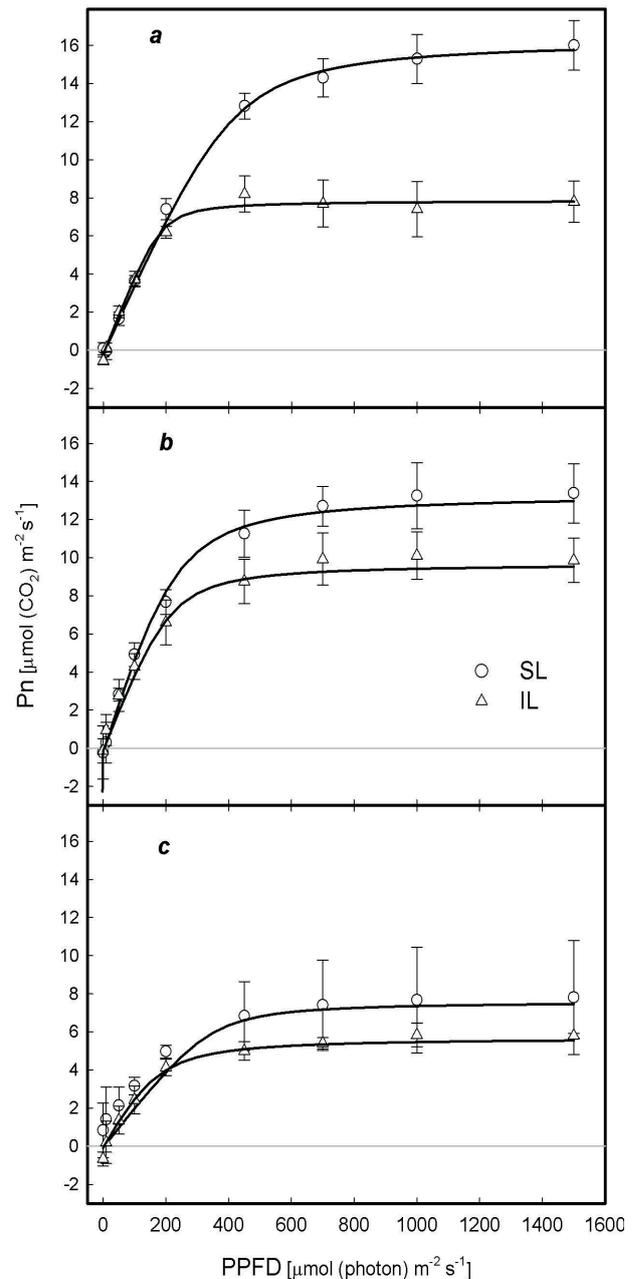


Figure: Photosynthetic-light response curves at bloom (a), veraison (b), and harvest (c) in sun-exposed leaves (SL) ( $\geq 1500 \mu\text{mol m}^{-2} \text{s}^{-1}$  of PPFD) and interior leaves (IL) ( $< 300 \mu\text{mol m}^{-2} \text{s}^{-1}$  of PPFD), in 'Syrah'. Each point is the average of 5 measurements  $\pm$  confidence interval at  $p \leq 0.05$ . Mendoza, 2006/07.