PHOTOSYNTHETICALLY ACTIVE RADIATION LEVELS IN A SYRAH VINEYARD IN A BRAZILIAN TROPICAL SEMIARID AREA: PRELIMINARY RESULTS

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Summary

This work aimed to determine the photosynthetically active radiation (PAR) incidence at the berry level at east (E) and west (W) direction in a Syrah vineyard growing in a tropical semiarid area of Brazil. During the first semester of 2010 microclimate measurements were performed in a Syrah vineyard in order to quantify incident PAR on the wall of grapevine rows with north-south orientation in two treatments of leaf removal and shoot trimming: T1 – control (according to farm management) and T2 – no leaf removal and shoot trimming at 35 days after pruning - DAP (berries lead-shot size stage). The T1 treatment was characterized by leaf removal in two different occasions (35 DAP - berries lead-shot size stage and 45 DAP – berries pea-sized stage) and by shoot trimming occurred at 53 DAP (beginning of berry touch stage). The results showed that the ratio between the photosynthetically active radiation and the solar global radiation incident at the top of Syrah vineyard was around 40%. The clusters located on the grape walls facing east are more exposed to the photosynthetically active solar radiation than that ones on grape walls facing west. The practice of leaf removal and shoot trimming lead different values of photosynthetically active solar radiation at the berry.

INTRODUCTION

The Brazilian tropical semiarid is starting to produce young wines, mainly from Syrah and Cabernet Sauvignon grapevines, being considered as a new wine making region and one of the most important in tropical zones. The climate is unique and classified as semi arid, where the total annual precipitation is 540 mm, the pan evaporation is about 2700 mm and the air temperature is 26.5 °C (Moura *et al.*, 2009). The climate conditions associated to irrigation management allow the vines to produce grapes throughout the whole year.

The information about the vineyard microclimate, especially light interception in the fruit zone, is very important to determine the grape berry composition (Bergqvist *et al.*, 2001; Haselgrove *et al.*, 2000); it affects the rippening rates – sugar and acid content (Mullins *et al.*, 1992); grapevine leaf polyphenolic content and disease interaction (Di Stefano *et al.*, 2007; Dalla Marta *et al.*, 2008). Grifoni *et al.* (2008) studied the incident PAR radiation on the wall of grapevine rows and confirmed that PAR was much influenced by row orientation. On the other hand, Tarara *et al.* (2005) observed that row orientations resulted in similar differences between both sides of the canopy in total irradiance at the fruiting zone, but the timing of peak intensity on the side receiving higher irradiance differed by row orientation.

The photosynthetically active radiation (PAR, 400 – 700 nm) levels are very important to determine the production of some quality compounds and grapevine yield. According to Griffoni *et al.* (2008) the highest portion of vines received higher levels of daily PAR radiation. Despite its importance there is a lack of study about PAR levels in grapevine in Brazil, mainly in Northeast region. Then, this work aimed to determine the photosynthetically active radiation (PAR) incidence at the berry level at east (E) and west (W) direction in a Syrah vineyard growing in a tropical semiarid area of Brazil.

MATERIAL AND METHODS

During the first semester of 2010 microclimate measurements were performed in a Syrah vineyard in order to quantify incident PAR on the wall of grapevine rows with north-south orientation.

Site description: This study was carried out in an irrigated Syrah vineyard located at Casa Nova, Bahia, Brazil (Lat.: 09° 16' S Long.: 40° 52' W). Grapevine cultivar Syrah, grafted to IAC766 rootstock, were arranged in north-south oriented rows spaced 3.0 m apart, with a distance of 1.0 m between vines; the canopy is between 0.6 and 1.8 m of height from the ground, the training system is vertical shoot positioning.

The pruning occurred on March 08 and the harvest on July 19. Crop management for weed and disease control was done based on that recommended for the region.

The studied treatments consisted in the practice of leaf removal and shoot trimming: T1 – control (according to farm management) and T2 – no leaf removal and shoot trimming at 35 days after pruning - DAP (berries lead-shot size stage). The T1 treatment was characterized by leaf removal in two different occasions (35 DAP – berries lead-shot size stage and 45 DAP – berries pea-sized stage) and by shoot trimming occurred at 53 DAP (beginning of berry touch). All the basal leaves above the last bunch from east side were eliminated.

Experimental design and microclimate conditions: Vineyard microclimate measurements were taken positioning sensors between the rows. The PAR measurements were performed on a vertical plane parallel to the grapevine row (looking to the opposite row) at the cluster level (85 cm above the ground) on both sides (east - E and west - W). The global solar radiation (Rg) was measured above the vines (3.0 m). In addition, the cluster temperature (Tc) was measured with copper-constantan thermocouple, also, on both sides of the vines. The measurements were automatically taken each 10 seconds and recorded by each 15 minutes, during 122 days (from 12 days after pruning until the harvest day), characterized by cloudy and clear sky conditions.

The PAR-to-Sr ratio (PAR/Sr) was quantified at two timescales – 15 minute and daily. The incidence of PAR above vines was related to PAR measurements on the east and west 'walls' of grapevine for each treatment.

PAR was expressed in μmole of photons (μmole $s^{-1}m^{-2}$). These units may be converted to W m^{-2} dividing by 4.6. to be compared to Sr. The daily sum of Sr and PAR are presented in MJ m^{-2} day^{-1}. The Tc unit is degree Celsius (°C).

RESULTS AND DISCUSSION

Daily-accumulated solar radiation (Sr) and photosynthetically active radiation (PAR): The global solar radiation (Sr) measured above vineyard slightly decreased from values around 20 MJ m^{-2} day^{-1} after pruning (March) to 13 MJ m^{-2} day^{-1} at harvest (July) as a consequence of the Earth movement through the grapevine growing cycle studied (Figure 1).

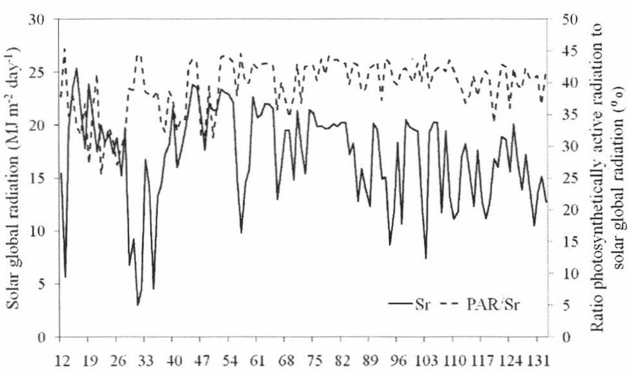

Figure 1. Daily solar global radiation (Sr, MJ m^{-2} day^{-1}) and the ratio between the photosynthetically active radiation (PAR/Sr, %) at the surface in a Syrah vineyard located in Casa Nova, BA, Brazil.

The behavior of the ratio between the photosynthetically active radiation and the solar global radiation (PAR/Sr) incident at the top of Syrah vineyard is presented in Figure 1. Note that this ratio was around 40%, except for cloudy days, when its value was reduced to 33%, mainly at the begin of productive cycle. Cloudy days are frequent during the rainy season between January to April in the surround area of this vineyard site, and occurs during the productive cycle of vines pruned on the first semester in tropical Brazilian semi arid areas.

Photosynthetically active radiation (PAR) from the sun provides the energy that supports photosynthesis and primary production by green plants and several effects on grapevine (*Vitis vinifera*), mainly because of its relation to light quality, particularly to ultraviolet radiation (UV) that stimulates the production of some important compounds directly implied in determining yield characteristics (Grifoni *et al.*, 2008). The practice of leaf removal and shoot trimming, and the timing of this management practice can modify the PAR levels at the cluster, consequently grapes microclimate changes are observed.

Daily-accumulated values of PAR on grape walls faced to east (E) and west (W) in treatments T1 and T2 at the cluster heigth are presented in Figure 2. The treatment 2 (T2) is characterized to be less destructive than treatment 1 (T1), once T2 consisted in no leaf removal and shoot trimming at 35 days after pruning. On the other hand, T1 treatment was characterized by leaf removal in two times (35 DAP and 45 DAP) and by shoot trimming occurred at 53 DAP.

According to Figure 2, it can be observed closure and high values of PAR at the cluster level at the initial growth stage. The average of the accumulated PAR on the grapes walls faced to east was 3.27 MJ m^{-2} day^{-1} and 3.02 MJ m^{-2} day^{-1} on treatments 1 (T1) and 2 (T2), respectively, while on the walls faced to west these values were 2.54 MJ m^{-2} day^{-1} for both treatments (Table 1).

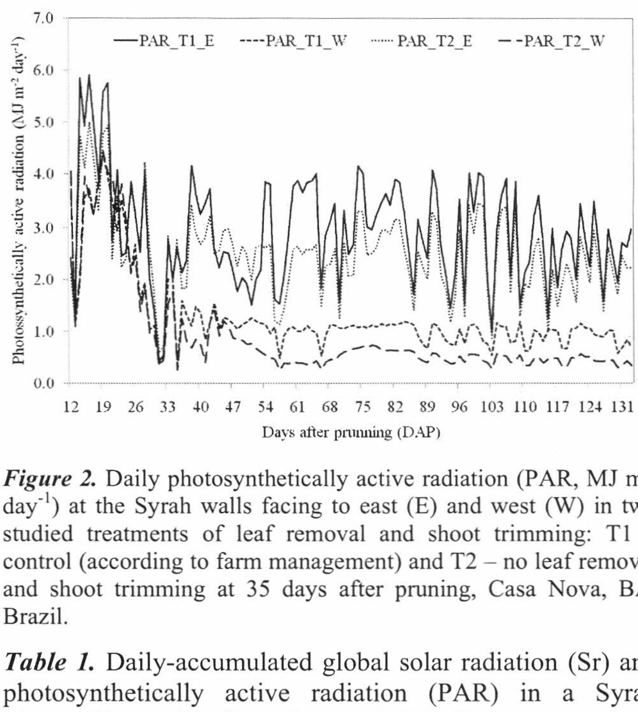

Figure 2. Daily photosynthetically active radiation (PAR, MJ m^{-2} day^{-1}) at the Syrah walls facing to east (E) and west (W) in two studied treatments of leaf removal and shoot trimming: T1 – control (according to farm management) and T2 – no leaf removal and shoot trimming at 35 days after pruning, Casa Nova, BA, Brazil.

Table 1. Daily-accumulated global solar radiation (Sr) and photosynthetically active radiation (PAR) in a Syrah vineyard located in Casa Nova, BA, Brazil.

Radiation* (MJ m^{-2} day^{-1})	Phenological Time (productive cycle) < 35DAP	35-45DAP	45-53DAP	Average
Sr	16.29	16.40	21.93	17.04
PAR_t	5.52	5.95	8.49	6.67
PAR_T1_E	3.27	3.02	2.07	2.91
PAR_T1_W	2.54	1.18	1.18	1.30
PAR_T2_E	3.02	2.65	2.58	2.50
PAR_T2_W	2.54	0.85	0.85	0.93

* Sr = solar radiation, PAR_t = photosynthetically active radiation at the top of vineyard, PAR_T1_E = photosynthetically active radiation at the east side in Treatment 1, PAR_T1_W = photosynthetically active radiation at the west side in Treatment 1, PAR_T2_E = photosynthetically active radiation at the east side in Treatment 2, PAR_T2_W = photosynthetically active radiation at the west side in Treatment 2.

These elevated values verified at the initial growth stage are mainly due to the lower quantity of leaves and shoots after pruning. The similarity of values is because of the treatment's implementation occurred after the berries lead-shot size stage (35DAP). So, before this time, the small differences between treatments are induced by plants vigour and architecture resulted from previous management practices. Other observation is that the accumulated values for west are minor that the ones verified for east face of the vineyard (Table 1).

The average PAR east side values verified for 35-45 DAP period were 3.02 MJ m $^{-2}$ day^{-1} and 2.65 MJ m $^{-2}$ day^{-1} respectively for T1 and T2 treatments, while to the west side they were 1.18 MJ m $^{-2}$ day^{-1} and 0.85 MJ m $^{-2}$ day^{-1}, respectively (Table 1). For this period, the T1 was growing after leaf removal on east side, so the PAR east side value was higher than for T2 (no leaf removal, shoot trimming).

The period from 45 to 53 days after pruning (DAP) was marked by vines of the T1 treatment growing after another leaf removal on east side occurred at 45 DAP. Then, its PAR value was 2.07 MJ m $^{-2}$ day^{-1} contrasting to 2.58 MJ m $^{-2}$ day^{-1} verified in east side of T2 treatment. The phenological phase is characterized by berries quickly moving from pea-sized stage to the beginning of berry touch, when water and light are very important to the increase of berry size. Lastly, the PAR levels at cluster height during the veraison, when the berries are soften and change color (begin to ripen), and after, during maturation, are very important to determine the grape berry composition. So, after 53 DAP, the PAR east side levels were 2.89 MJ m $^{-2}$ day^{-1} and 2.32 MJ m $^{-2}$ day^{-1} on T1 and T2 treatments, respectively, while for the west side these values were 0.97 MJ m $^{-2}$ day^{-1} and 0.49 MJ m $^{-2}$ day^{-1}.

Daily average cluster (Tc) temperature: The daily average of cluster temperature (Tc, °C) is presented in Figure 3. It can be observed that temperature was higher on clusters located in east side for both treatments, and the treatment T1 presented cluster warmer than treatment T2. And, same behavior was observed in the clusters located on west side of the vineyard.

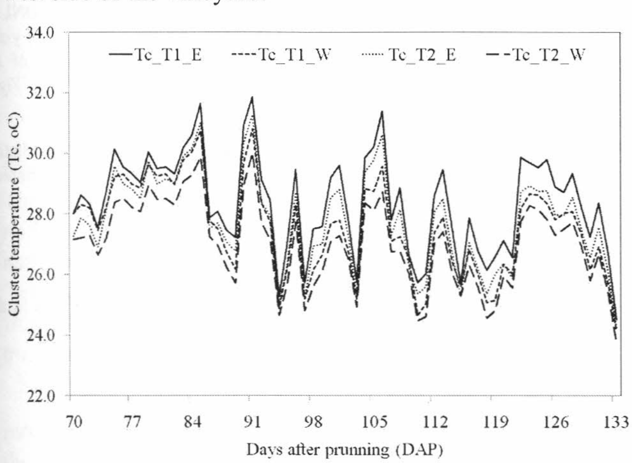

Figure 3. Daily average temperature at the Syrah clusters located in East (E) and West (W) side of the vines walls in two studied treatments of leaf removal and shoot trimming (T1 and T2), Casa Nova, BA, Brazil.

The average was calculated for 70-133 DAP period, and it was observed that the clusters in east side of treatment T1 presented 28.38 °C, that means 0.60 °C warmer than treatment T2; while for the clusters in west side the difference between treatments T1 and T2 was almost the same (0.55 °C), but this side presents clusters cooler (T1 = 27.53 °C and T2 = 26.98 °C). For the same vines, the cluster temperature was 0.85 °C and 0.80 °C warmer in east side for treatments T1 and T2, respectively.

15-minute timescale of photosynthetically active radiation (PAR) and cluster temperature (Tc): The diurnal cycle of the incoming solar radiation (Sr) and photosynthetically active radiation (PAR) incident at the top of the vineyard and on the vines walls facing to east and west are presented on Figure 4 for a sample day in the initial growth stage (a, 24th March, 2010 – 16 days after pruning) and for a day in the ripening stage (b, 22nd June, 2010 – 106 days after pruning). It was hard to find full clearly day, mainly at the begin of growth stage. Besides Figure 4a represents a cloudy day, it is possible to verify low values of PAR at noon, however it can be observed peaks of PAR at east side at 9h15 AM Local Time for treatment T1 (294.13 W m^{-2}) and T2 (251.52 W m^{-2}), and at west side at 16h00 PM Local Time with values of 268.91 W m^{-2} (T1) and 180.00 W m^{-2} (T2).

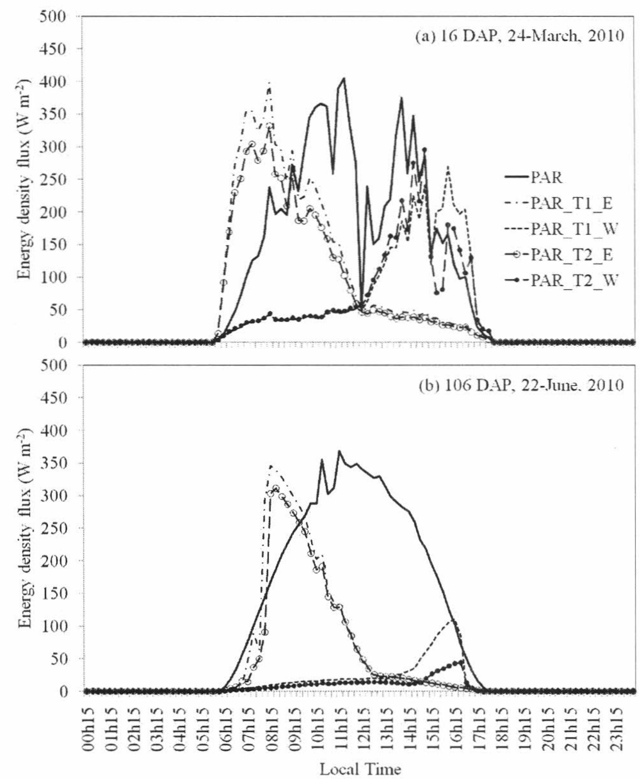

Figure 4. Diurnal incoming photosynthetically active radiation (PAR, W m^{-2}) at the Syrah vineyard and at the Syrah walls facing to east (E) and west (W) in two studied treatments of leaf removal and shoot trimming (T1 – control, according to farm management, and T2 – no leaf removal and shoot trimming at 35 days after pruning), Casa Nova, BA, Brazil: (a) initial growth stage, and (b) ripening stage.

It is expected that a North-South row orientation, with east and west-side fruits, provides a balanced insolation profile for the grapes (Weiss *et al.*, 2003). At the beginning of the studied productive cycle, the vines presented this balance between morning and afternoon time, but in practical aspects, the vines management may contribute to change the insolation at berries levels, and consequently the skin berry temperature with obvious consequences for grape and wine quality.

In Figure 4b, after treatments applications, the peak values for east side were 346.09 W m^{-2} in treatment T1 and 303.04 W m^{-2} in treatment T2 at 08h15 (local time), while in the afternoon, the peaks occurred at 16h15 (local time) for the west side and they were 110.48 W m^{-2} in treatment T1 and 42.41 W m^{-2} in treatment T2.

The leaf removal was made only at east side in treatment T1, then the light at cluster level may be different according to its exposure, consequently the berry temperature changes. For this study, the diurnal cluster temperature is presented only for June 22nd, 2010, because of at the beginning there were not clusters for measurements. According to Figure 5, the air temperature changed from a minimal value of 17.3 °C to a maximum of 32.1°C (average 25.4 °C). The maximum cluster temperature were 38.5 °C, 36.8 °C, 38.7 °C and 34.2 °C, respectively for T1 east, T1 west, T2 east and T2 west, while the minimal values were 17 °C for both sides of T1, and 16.8 °C and 17.0 °C for east and west side of T2.

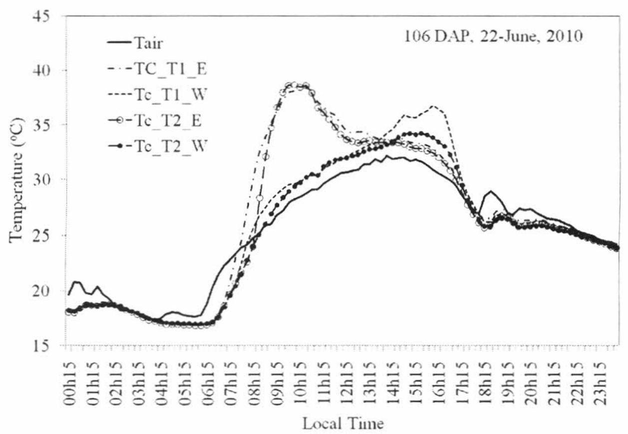

Figure 5. Diurnal air (Tair) and clusters (Tc) temperature in East (E) and West (W) side of the vines walls measured in a Syrah vineyard located in Casa Nova, BA, Brazil, under two treatments of leaf removal and shoot trimming (T1 and T2).

According to Tardaguila *et al.* (2008) the timing of leaf removal had a marked effect on berry maturity, wine composition and sensory properties of Grenache wines made from grapes grown under dry-farmed conditions. The effects induced by defoliation were likely more related to the local cluster microclimate rather than to the general balance of the vine. These authors inform that late leaf removal was much less effective than early leaf removal in modifying final wine composition and quality, and the wine from the early defoliation treatment was rated the most preferred as of global value, by the panelists.

The clusters located on the grape walls facing east were more exposed to the photosynthetically active solar radiation than that ones on grape walls facing west in a Semiarid Brazilian vineyard pruned on the first semester. The practice of leaf removal and shoot trimming lead to different values of photosynthetically active solar radiation and cluster temperature. The leaves left on west site can prevent sunburn and others heat damages on the berries.

The effects of light on vines, clusters and wines is a complex subject, mainly in a new winemaking region, like Brazilian semiarid areas, and this work has produced information that will be used to find the best interaction among cluster microclimate and plant growth, berries harvest quality, and wine compounds.

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