(DOI): 10.5935/PAeT.V7.N1.03
This article is presented in English with abstracts in Spanish and Portuguese
Brazilian Journal of Applied Technology for Agricultural Science, Guarapuava-PR, v.7, n.1, p.29-37, 2014

Cientific Paper

Defoliation levels on gas exchange and composition of grape clusters cv. Italia

Essione Ribeiro Souza[1]
Valtemir Gonçalves Ribeiro[2]
Bárbara França Dantas[3]
José Moacir Pinheiro Lima Filho[4]
Elizabeth Orika Ono [5]

Abstract

The objective of this study was to evaluate the influence of defoliation on gas exchange of vine leaves at different phenological stages, and also in the development of clusters and berries of cv. Italia in the Valley of Submédio San Francisco. It was performed four levels of defoliation (5, 10, 15 and 20 leaves kept in production branch) and nine repetitions. The assessments of gas exchange (CO_2 assimilation rate (A, µmol CO_2 m^{-2} s^{-1}), transpiration rate (E, mmol water steam m^{-2} s^{-1}), stomatal conductance (gs, mol m^{-2} s^{-1}), water use efficiency (USA µmolCO_2; mmol H_2O)$^{-1}$, carboxylation activity of the ribulose enzyme 1,5-diphosphate carboxylase (Rubisco) and leaf temperature were determined in four phenological phases (60, 72, 84 and 106 days after pruning). It was also evaluated: yield per plant (kg $plant^{-1}$), diameter (mm), length (mm) and volume (mL) average of berries; soluble solids content (°Brix) and titratable acidity. Results revealed no significant differences between the levels of defoliation in the traits studied during the development stages of the berries, indicating that removal of leaves did not affect the gas exchange process of the leaves opposed to the cluster.

Keywords: *Vitis vinifera* L.; assimilation rate; berry growth.

Efeito da desfolha sobre as trocas gasosas e a composição dos cachos da cultivar Itália

Resumo

O objetivo do trabalho foi avaliar a influência da desfolha nas trocas gasosas de folhas de videira em diferentes fases fenológicas e, também, no desenvolvimento dos cachos e bagas da cv. Itália no Vale do Submédio São Francisco. Foram realizados quatro níveis de desfolha (5, 10, 15 e 20 folhas mantidas no ramo de produção) e nove repetições. As avaliações de trocas gasosas, taxa de assimilação de CO_2 (A, µmol CO_2 m^{-2} s^{-1}), taxa de transpiração (E, mmol vapor d'água m^{-2} s^{-1}), condutância estomática (gs, mol m^{-2} s^{-1}), eficiência do uso da água (EUA, µmolCO_2 (mmol H_2O)$^{-1}$), atividade de carboxilação da enzima ribulose 1, 5- difosfato carboxilase (Rubisco) e temperatura da folha, foram determinadas em 4 fases fenológicas (60, 72, 84 e 106 dias após a poda). Também foram avaliados: produção por planta (kg $planta^{-1}$), diâmetro (mm), comprimento (mm) e volume (mL) médio de bagas; teor de sólidos solúveis (ºBrix) e acidez titulável. Os resultados obtidos não revelaram diferenças significativas entre os tratamentos de níveis de desfolha, em relação às características estudadas, durante as fases de desenvolvimento das bagas, indicando que a remoção das folhas não afetou os processos de trocas gasosas das folhas opostas ao cacho.

Palavras-chave: *Vitis vinifera* L.; taxa de assimilação; crescimento baga.

Efecto de la defoliación en el intercambio de gases y composición de los racimos de la vid Italia

Resumen

El objetivo de este estudio fue evaluar el efecto de la defoliación sobre el intercambio gaseoso de las hojas de vid en las diferentes etapas fenológicas y también en el desarrollo de racimos y bayas del cv. Italia, en el valle del Submédio

Received at: 12/08/2013 Accepted for publication at: 26/02/2014

1 Doctorate student with CAPES scholarship, UNESP – Universidade do Estadual Paulista. Belém street, n° 11, Dom Tomaz Neighborhood, Juazeiro, BA/Brazil, Phone: (74) 3611-9077. CEP 48.907-214, essione.r@hotmail.com. Author for correspondence.
2 UNEB – Universidade Estadual da Bahia (DTCS/UNEB), Juazeiro, BA, Brazil.
3 Researcher of the Embrapa Semiarido, Petrolina, PE, Brazil.
4 Researcher.
5 Institute of Biosciences (IBB), UNESP - Universidade Estadual Paulista, Campus of Botucatu, Botanic Department, Botucatu, SP; E-mail: mingo@ibb.unesp.br; eoono@ibb.unesp.br

San Francisco (Brasil). Cuatro niveles de defoliación (5, 10, 15 y 20 hojas de guardado en el talo de producción) y nueve repeticiones. Las evaluaciones del intercambio de gases, tasa de asimilación de CO_2 (A, $m^{-2} s^{-1}$ micromol CO2), la tasa de transpiración (E, mmol vapor de agua $m^{-2} s^{-1}$), conductancia estomática (gs mol $m^{-2} s^{-1}$), la eficiencia del uso del agua (EE. UU., µmol CO_2 (mmol $H_2O)^{-1}$), actividad de carboxilación de la enzima ribulosa 1,5-difosfato carboxilasa (Rubisco) y temperatura de la hoja, fueran determinados en cuatro fases fenológicas (60, 72, 84 y 106 días después de la poda) también se evaluaron: rendimiento (kg $planta^{-1}$), el diámetro (mm), longitud (mm) y el volumen promedio (mL) de bayas, contenido de sólidos solubles (° Brix) y La acidez titulable. Los resultados obtenidos no revelaron diferencias significativas entre los niveles de los tratamientos de defoliación en las características estudiadas durante las etapas de desarrollo de las bayas, lo que indica que la eliminación de las hojas no afectó el proceso de intercambio de gases de hojas opuestas al rácimo.

Palabras clave: *Vitis vinifera* L.; tasa de asimilación; crecimiento del fruto.

Introduction

The viticulture of the Valley of Submédio San Francisco is based, mainly, in managements introduced by farmers, including some managements originated from the IAC. However, the existing climatic conditions in the Submédio San Francisco, especially the temperature and radiation, imply in very large changes in the reaction of plants when cultivated in this region (MOURA et al., 2009; TEIXEIRA, 2009; KELLER, 2010). Therefore, in order to obtain a better production in the Submédio São Francisco it is necessary to adjust the management techniques.

Among the several practices used in the culture management, there is the defoliation, which consists in removing the vine leaves, mainly that closest to the clusters and the oldest, in order to not compromise the nutrients supply (MANDELLI and MIELE, 2003). According to VIEIRA et al. (2010) the new leaves behave as drains, intermediate and mature leaves, provide assimilates for the drains of the basal and apical region of the plant.

The defoliation allows to alter the air temperature, solar radiation incidence and aeration in the clusters region; improve the coloration and maturation of berries; reduce the incidence of diseases in the clusters and maximize the grape quality, yet for this, it must be performed during the fruit fixation and with care, because when inadequate, it can compromise the photosynthetic activity of the plant (MANDELLI and MIELE, 2003).

Leaves are responsible by the performance of photosynthesis, transpiration and respiration. The photosynthesis and respiration depends of a constant flow of CO_2 and O_2 in the cells. In the photosynthesis, this flow depends of the stomatal opening, which controls most part of the gas flow and concentration of CO_2 and O_2 in the intercellular spaces (MESSINGER et al., 2006). The photosynthesis is directly proportional to the luminosity and the stomatal opening diminishes, as the luminosity rate decreases (LARCHER, 2006).

The aim of this study was to assess the influence of defoliation on the gas exchange of vine leaves in different phenological stages, and also in the development of clusters and berries of the cv. Italia in the Valley of Submédio São Francisco.

Material and Methods

The experiment was conducted in a commercial vineyard, which had 17 years, in the irrigated perimeter Senador Nilo Coelho, in Petrolina – PE, with plants of the cultivar Italia, planted in a spacing of 3.0 x 3.0 and budded on the IAC-572 ('Jales') rootstock, conducted in a system of the type trellis and irrigated by microsprinklers.

The experimental design used was in randomized blockS 4 X 9 (4 levels of defoliation in the branches of production and nine repetitions).

The plants were submitted to different defoliation intensities: 5, 10, 15 and 20 leaves per branch of production. The defoliation was made manually, when the fixation of clusters took place and the berries had 6 to 8 mm, thus establishing the following treatments: T1 – plants kept with 5 leaves; T2 – plants with 10 leaves; T3 – plants with 15 leaves and T4 – plants with 20 leaves in the branch of production, and in the different stages of berries growth was performed the assessments of gas exchange, 60 days after the pruning – DAP (berries growth); 72 DAP (berries growth); 84 DAP (berry softening); 106 DAP (maturation).

The evaluations of gas exchange performed were: assimilation rate of CO_2 (A, µmol CO_2 $m^{-2} s^{-1}$), transpiration rate (E, mmol water steam $m^{-2} s^{-1}$) and stomatal conductance (g_s, mol $m^{-2} s^{-1}$). These variables were calculated by the program of data analysis of the equipment used to measure photosynthesis, which uses the general equation of gas exchange of VON CAEMMERER and FARQUHAR (1981). The water use efficiency (USA, µmol CO_2 (mmol $H_2O)^{-1}$) was determined through the relation between assimilation of CO_2 and transpiration rate (A/E), described by BERRY and DOWNTON (1982). From the measured data above, it was calculated the activity of the ribulose enzyme 1, 5-diphosphate carboxylase (Rubisco) through the relation of assimilation rate of CO_2 and internal concentration of CO_2 in the leaf (A/Ci).

In order to homogenize the repetitions, the flow density of photons photosynthetically active (DFFFA) used was 1500 µmol m^{-2} s^{-1}. The concentration of CO_2, reference used during the assessments was present in the environment, 380 µmol mol^{-1} of air. The used measures were taken during the period of 9:00 to 11:00 a.m. in sunny days in totally expanded leaves, opposed to the cluster, without signs of senescence and healthy.

115 days after the production pruning was performed the harvest, all clusters were weighed to obtain the total production per plant (PTP), whereas for the biometric and chemical analysis were collected 2 clusters with similar lengths and representatives of the useful part of the plot, per treatments and repetition, from which were taken all berries, next collecting a random sample of 100 berries, to determine the diameter and length of the berry (with caliper in millimeters) and average volume of berries (measured in a test tube, through the division of dislocated water volume after the introduction of 100 berries (dislocated volume/100), in milliliters), soluble solids (SS) (°Brix) and titratable acidity (tartaric acid g. / 100 g of pulp). To determine the soluble solids (SS), it was used a manual refractometer, and the titratable acidity (AT) was determined according to the methodology described by CARVALHO et al. (1990).

The results obtained were submitted to variance analysis (F test) and the averages compared through the Tukey test at 5% of probability.

Results and Discussion

It is well known that photosynthetic rates vary depending on the environmental conditions, thus, as is observed in Figure 1 the climatic data in the months of December of 2009 and January of 2010 presented, respectively, average monthly temperature of 27.4° C and 27.1° C, average monthly minimum temperature of 23° C and 22° C, average maximum monthly temperature of 33.7° C and 33.8° C and relative humidity of 60% and 61%, respectively.

According to LIMA FILHO et al. (2009), the temperature range considered optimal for vine leaves express its maximum photosynthetic capacity is between 25° C and 30° C, range of temperature found during this study, in this range the enzymes involved in the photosynthetic process are capable of expressing its maximum activity. Thus, the temperature conditions observed in the local where

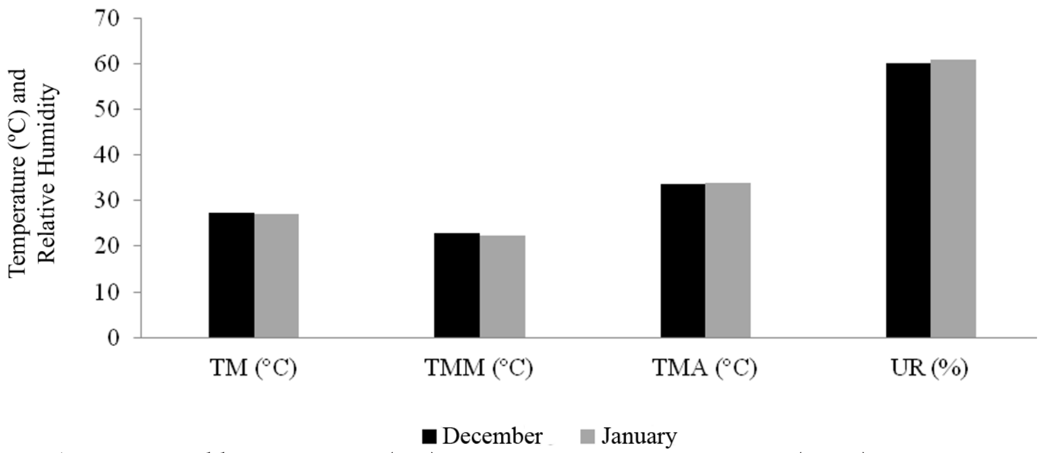

Figure 1. Average monthly temperature (TM), minimum average temperature (TMM), maximum average temperature (TMM) and monthly relative humidity (UR) of the environment during the assessments of gas exchange in the vine cv. Italia in different stages of berries growth submitted to different defoliation intensity. Petrolina-PE.

this study was performed can be considered optimal for the maximum photosynthetic capacity, despite of the leaves temperature keep on the range between 32º C and 38º C (Figure 2F).

Thus, the temperature conditions observed in the local where this study was performed can be considered optimal for the maximum photosynthetic capacity, despite of the leaves temperature being on the rage of 32º C to 38º C (Figure 2F).

The photosynthesis is the primary source of carbohydrates for all growth processes (MAGALHÃES FILHO, 2009). It is observed that (Figure 2A) the highest assimilation rate of CO_2, was observed in the treatment with 5 leaves at 60 days after the pruning (DAP), growth stage of berries, being superior to 10, 15 and 20 leaves on the branches of production. This can be justified by the foliar area reduction, which allowed greater radiation intensity on the leaves. Consequently, increased the efficiency of carboxylation (Figure 2D) and the water use efficiency (Figure 2E). However, this higher rate of liquid assimilation of CO_2 did not result in a wider stomatal opening (Figure 2B).

At 72 DAP, the treatment with 10 leaves presented higher assimilation rate of CO_2, being superior to 49.67%; 21.81% and 24.42% for 5, 15 and 20 leaves, respectively. At 84 DAP the treatments with 10 and 15 leaves on the branch presented similar assimilation rates of CO_2, being superior to the other treatments. Although, at 106 DAP all treatments presented similar results.

It was also observed that the treatment with 10 leaves in different phenological stage presented gradual increase, reducing only at 106 DAP and a lesser oscillation on the data, indicating that this amount of leaves is ideal for distribution of photoassimilates in the plant.

It was observed at 60 DAP that the treatment with 10 leaves presented higher stomatal conductance (Figure 2B), which led to an increment of the transpiration rate (Figure 2C) and in the rate of liquid assimilation of CO_2 (Figure 2A). Consequently, the carboxylation efficiency (Figure 2D) and water use efficiency (Figure 2E) decreased.

Now, at 72 DAP there was similar behavior among treatments, except for the one of 5 leaves, which presented lesser conductance, and consequently lesser assimilation rate (Figure 2A), transpiration (Figure 2C) and carboxylation efficiency (Figure 2D). According to CHAVES and OLIVEIRA (2004), the photosynthetic rate is compromised, mainly, by the reduction of the stomatal conductance. On the other hand, at 84 DAP, all treatments presented similar results. At 106 DAP the best results were observed in the plants with 5 and 10 leaves.

The physiological mechanism that the vascular land plants have for control of transpiration is the reduction of stomatal conductance (MESSINGER et al., 2006), important physiological process of the plant, which limits the water loss and reduces the gas exchange.

Figure 2C shows that the smaller transpiration rate was observed at 72 DAP for the different treatments (5, 10, 15 and 20 leaves), coinciding with the lowest value of stomatal conductance (*gs*). As stated by PAIVA et al. (2005), the increase of resistance to gas diffusion and the reduction in the assimilation rate of CO_2 determine a lesser loss of water through transpiration, besides of being able to influence the photosynthesis.

Now the higher transpiration was observed in the treatment with 10 leaves at 60 and 84 DAP, and in the treatments of 15 and 20 leaves at 84 and 106 DAP. This higher transpiration, although promoting great water loss by plants, becomes beneficial, once this factor is directly linked to the photosynthetic rate by diffusion of CO_2 at the leaf mesophyll and the high activity of the ribulose enzyme 1.5 - diphosphate carboxylase (Rubisco), where can take place higher absorption of CO_2. For VIEIRA et al. (2010), the foliar area is associated to the energetic balance of the own leaf, being that this balance depends of solar radiation interception by the leaves.

The transpiration of most vegetal species, including the vine, is determined by the climatic demand related to solar radiation, physiological mechanisms related with stomatal responses and environmental factors, index of foliar area and availability of water in the soil (TAIZ and ZEIGER, 2009).

Therefore, the different levels of defoliation of this study could influence in the characteristics of gas exchange of the vine, once that the defoliation reduces the foliar area and, consequently, reduces the photosynthetic surface, the absorption of luminous energy and loss of water through transpiration. However, on the assessed characteristics, such as photosynthetic rate, stomatal conductance and transpiration, this negative effect was not observed on the vine cv. Italia. Because the production per plant was 18.61; 14.08; 15.03; 18.47 for the 5, 10, 15 and 20 leaves, respectively (Table 1), not being verified statistical difference between treatments.

Analyzing the carboxylation efficiency (Figure 2D), it is observed that at 60 DAP the plants with 5 leaves on the branch presented greater efficiency, being superior 13.85%; 18.21% and 12.52% to the treatments with 10, 15 and 20 leaves, respectively. This is a result of smaller foliar area, there was need of greater activity in the carboxylation efficiency, as well as higher rate of liquid assimilation of CO_2 (Figure 2A) necessary for the directing of photoassimilates for maintenance of clusters and maturation of berries. Being that the mass and shape of the fruit depends of the availability of photoassimilates produced by the source organs (DUARTE and PEIL, 2010; FAGAN ET al., 2006).

On the other hand, at 72 and 84 DAP, the highest activity was observed in the treatment with 10 leaves, and at 106 DAP they presented similar behavior. For being a limiting aspect for the photosynthesis, the activity of the Rubisco can influence in the photosynthetic rate. This result suggests that the efficiency of the Rubisco enzyme can be considered as one of the factors associated to the productive capacity of the Italia cultivar.

The plants with 5 leaves on the branch presented greater water use efficiency (Figure 2E) at 60 DAP. While that at 72 and 106 DAP the best results were achieved in the plants with 10 leaves, leading to a greater carboxylation efficiency (Figure 2D) and to a lesser transpiration rate (Figure 2C). At 84 DAP the plants with 15 leaves presented greater efficiency and the ones with 20 leaves a smaller efficiency.

Despite of presenting low efficiency in water use, the plants with 20 leaves presented in this same stage (84 DAP), expressive values of assimilation rate of CO_2 (Figure 2A), stomatal conductance (Figure 2B) transpiration rate (Figure 2C), carboxylation efficiency (Figure 2D) and higher leaf temperature (Figure 2F), indicating that the larger foliar area reduced the water use efficiency (Figure 2E).

Through Figure 2F it can be observed that there was variation in the temperature inside and among the treatments in the different phenological stages. In which the plants with 5 leaves presented temperature oscillating between 32 and 35º C, being the lowest temperature observed at 106 DAP in the maturation stage, which was also seen in the treatments with 10 and 20 leaves.

The treatment with 15 leaves presented smaller oscillation in temperature, if within the range of 35 to 37º C. These temperature data did not influence the assimilation rate, stomatal conductance, transpiration, carboxylation efficiency and water use efficiency.

The different defoliation levels did not influence the response of the variables production per plant, diameter, length, volume, soluble solids and titratable acidity in vine berries of the cv. Italia (Table 1), agreeing with the results obtained by SOUZA, et al., (2012), who worked with defoliation intensities for quality of the 'Superior Seedless' vine clusters, they observed that the amount of leaves kept on the branches did not influence in these variables.

FELIPPETO (2008), studying the natural defoliation of the cv. Cabernet Sauvignon in the conditions of Bento Gonçalves-RS noted that the high defoliation had influence on the phenology (maturation delay) and on the production potential (11% n° of clusters per plant) in relation to the control and to the intermediate defoliation (25% and 50%), there was a moderate control of growth (-9,9% branches, -11,6% foliar area) followed by an increment in the number of berries per cluster (+23%), with lesser weight and individual diameter, favoring the relation peel/pulp (+5,8%), which is beneficial for oenological purposes.

ANZANELLO et al. (2011) observed that the treatments of defoliation performed up to the height of the clusters in the vine cultivars did not influence in the production per plant, cluster mass, AT, SS and pH of the wort, and that the localized removal of leaves up to the clusters height, during the beginning of the berries maturing, do not alter the quantitative and qualitative variables of the fruits. Moreover, they verified that for the 'Niagara Branca' and 'Concord' cultivars the defoliation performed above the clusters causes a maturation delay of the grapes and negatively affects the physical-chemical characteristics of fruits.

CHAVARRIA et al. (2010) studying the Moscato Giallo grape in protected cultivation, observed decrease in the rate of sugars increment during the maturation, result attributed to the lesser incidence of radiation at the clusters level, because the cover restricted up to 56% of this radiation.

RADÜNZ et al. (2013) observed that the realization of drought pruning exerts influence over the albedo of the Bordô vine and the highest values are observed when the pruning occurs during the normal season and without defoliation.

According to MAIN and MORRIS, 2004; PONI et al., 2005; BAVARESCO et al., 2008, the season

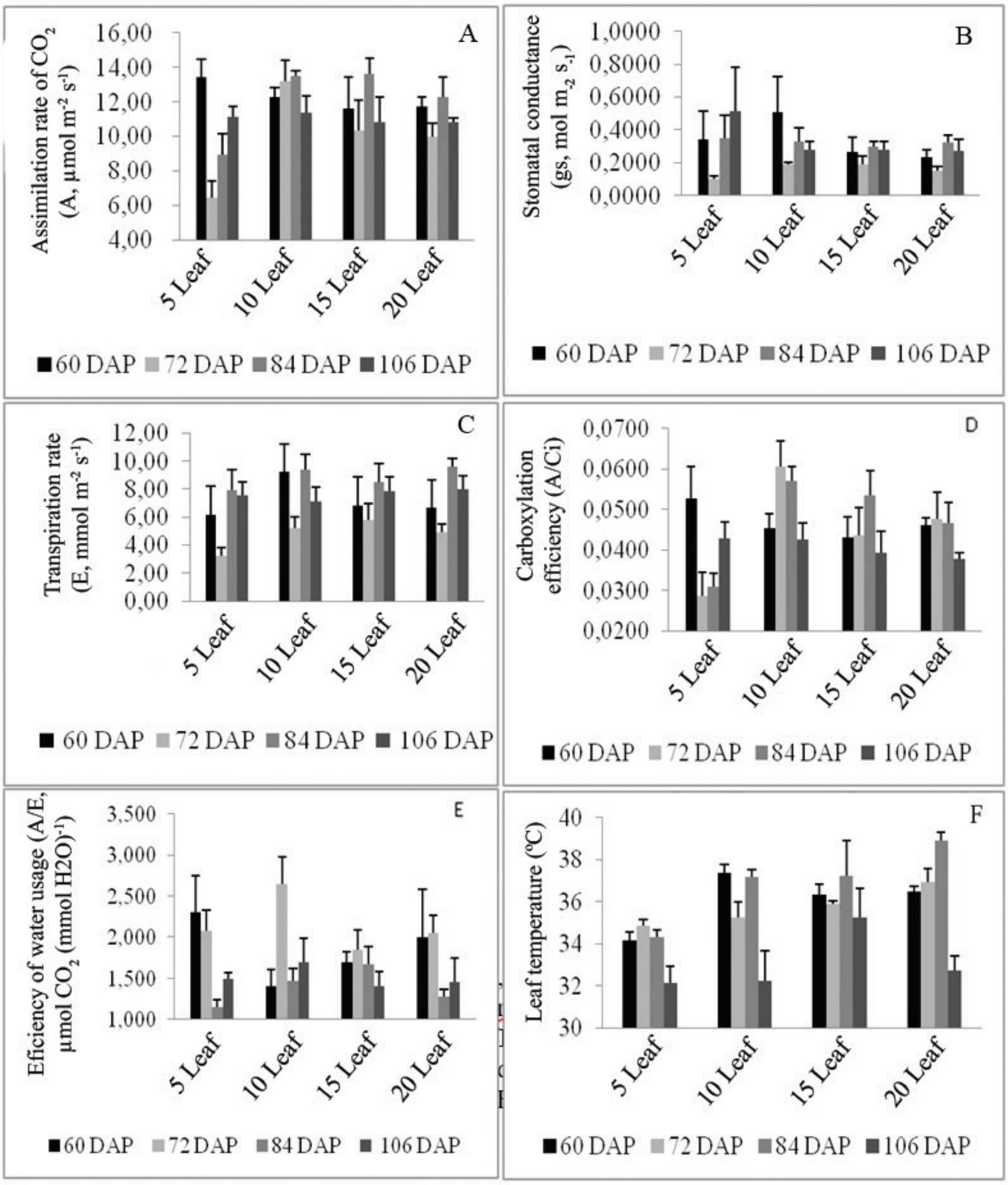

Figure 2. (A) Assimilation rate of CO_2 (A, µmol m^{-2} s^{-1}), (B) stomatal conductance (gs, mol m^{-2} s^{-1}), (C) transpiration rate (E, mmol m^{-2} s^{-1}), (D) Carboxylation efficiency (A/Ci), (E) efficiency of water usage (A/E, µmolCO_2 (mmol H_2O)$^{-1}$) and (F) leaf temperature (ºC) in vine leaves cv. Italia in different growth stages of berries submitted to different defoliation intensity. Petrolina-PE

and intensity of performance of the pruning of vine can present distinct results in the physical-chemical characteristics of fruits.

Manipulating the relation source/ drain can affect the photosynthesis rate of the vine, being that the removal of clusters can cause reduction of the photosynthetic activity, while the partial removal of leaves may cause its increment (KLIEWER, 1990). Such fact did not occur during this study, indicating that it may have occurred translocation of photoassimilates for the berries development, which is characterized for being strong metabolic drain of the vine. As stated by SANTOS (2006) the relations of proportionality that exist in the vine plant, such

Table 1. Total mass of the bunch (PTP, kg plant-1), average diameter of the berry (DB, mm), average length of the berry (CB, mm), berry volume (mL), soluble solids (ºBrix) and titratable acidity (g of tartaric acid /100g of pulp) of vine cv. Italia kept with 5, 10, 15 and 20 leaves per branch of production. Petrolina (PE).

Treatments	PTP (kg)	DB (mm)	CB (mm)	VB (mL)	SS (°Brix)	AT
5 Leaves	18.61	21.43	23.96	6.10	13.85	1.89
10 Leaves	14.08	21.49	23.83	6.23	13.48	1.82
15 Leaves	15.03	21.54	23.94	6.09	13.73	2.01
20 Leaves	18.47	21.70	23.81	6.27	13.72	1.99
F Test	2.36 ns	0.20 ns	0.09 ns	0.14 ns	1.01 ns	1.73 ns
CV (%)	27.52	3.43	2.98	11.73	3.33	10.51

ns= non significant (p>= 0.05)

as: aerial part x root and vegetative growth (leaves and branches) x production (clusters) are relations coordinated by the proportion between source and drain that exists among the different tissues of a plant.

SCARPARE FILHO et al. (2010) observed lesser yield of the cv. Niagara Rosada, in kg plant^{-1}, as function of the foliar area reduction caused by the incidence of fungal diseases, presenting diseased plants, resulting in only 55% of the yield obtained with the treatment without defoliation and with phytosanitary control.

It is observed that the acidity content was high in all treatments, this can be justified by the anticipation of harvest, for 115 days, being that the cycle of this cultivar for the Brazilian semiarid condition is of 120 days. FELIPPETO (2008) found after performing defoliation intensities of 0, 25, 50 and 75% in the cv. Cabernet Sauvignon, lesser acidity with the treatments of 50 and 75% of defoliation.

Conclusions

The removal of leaves in the cv. Italia vine did not alter the assimilation rate of CO_2, the stomatal conductance and the transpiration, being that it may be a recommended technique for the vine management in the irrigated areas of the semiarid of the Valley São Francisco.

The quantity of leaves kept on the branch of production of the cv. Italia did not interfere in the clusters composition.

References

ANZANELLO, R.; SOUZA, P. V. D.; COELHO, P. F. Desfolha em videiras americanas e viníferas na fase de pré-maturação dos frutos. **Ciência Rural**, v.41, n.07, p.1132-1135, 2011.

BERRY, J. A.; DOWNTON, W. J. S. Environmental regulation of photosynthesis. In: GOVINDJEE, D., (Ed.). **Photosynthesis: development, carbon metabolism, and plant productivity.** New York: Academic Press, 1982. v. 2, p. 263-343. (Cell Biology: A Series of Monographs). Available in:: <http://www.amazon.com/s/ref=ntt_athr_dp_sr_1/17890563970735510?_encoding=UTF8&field-author=Govindjee&search-alias=books&sort=relevancerank>. Access 13 Jun. 2013.

BAVARESCO, L. ET al. Effect of leaf removal on grape yield, berry composition, and stilbene concentration. **American Journal of Enology and Viticulture**, v. 59, n. 03, 0.292-298, 2008. Available in: (http: //www.ajevonline.org/cgi/reprint/59/3/292>. Access in: 22 April. 2014.

CARVALHO, C.R.L.; MANTOVANI, D.M.B.; CARVALHO, P.R.N.; MORAES, R.M. de. **Análises químicas de alimentos.** Campinas: Instituto de Tecnologia de Alimentos, 1990. 121p. (Manual Técnico).

CHAVES, M.M., OLIVEIRA, M.M. Mechanisms underlying plant resilience to water deficits: prospects for water-saving agriculture. J**ournal of experimentalBotany**, v. 55, n. 407, p. 2365-2384, 2004.

CHAVARRIA, G.; SANTOS, H.P.; ZANUS, M.C.; MARODIN, G.A.B.; CHALAÇA, M.Z.; ZORZAN, C. Maturação de uvas Moscato Giallo sob cultivo protegido. **Revista Brasileira de Fruticultura**, v.32, n.01, p.151-160, 2010.

DUARTE, T. S.; PEIL, R. M. N. Relações fonte: dreno e crescimento vegetativo do meloeiro. **Horticultura Brasileira**, v. 28, n. 03, p. 271-276, 2010.

FAGAN, E. B. et al. Expansão de frutos de meloeiro hidropónico em dois intervalos de irrigações. **Revista Brasileira de Agrociência**, v. 12, n. 03, p. 287-293, 2006.

FELIPPETO, L. **Influência da desfolha natural sobre o comportamento vegetativo e qualidade de produção da safra seguinte da uva Cabernet Sauvignon.** 2008. 55f. Monografia (Curso Superior de Tecnologia em Viticultura e Enologia) - Centro Federal de Educação tecnológica de Bento Gonçalves.

KELLER, M, Managing grapevines to optimize fruit development in a challenging environment: A climate change primer for viticulturists. **Australian Journal of Grape and Wine Research**, v.16, p. 56-69, 2010.

KLIEWER, W.M. **Fisiologia da videira: como produz açúcar uma videira.** Trad. POMMER, C.V. e PASSOS, I.R.S. Campinas: Instituto Agronômico de Campinas, 1990. 20p. (Documentos IAC, 20).

LARCHER, W. **Ecofisiologia Vegetal.** São Carlos: RIMA, 2006. 531p.

LIMA FILHO, J. M. P.;DANTAS, B. F.;ASSIS, J. S. de;SOUZA, C. R. de;ALBUQUERQUE, T. C. S. de.Aspectos fisiológicos.In: SOARES, J. M.; LEAO, P. C. de S. (Ed). **A vitivinicultura no Semiárido brasileiro.** Brasília, DF: Embrapa Informação Tecnológica; Petrolina: Embrapa Semi-Árido, 2009. cap. 3, p. 73-108.

MAGALHÃES FILHO, J. R. **Photosynthetic responses to changes in root temperature of sweet orange 'Valência' plants grafted on Rangpur lime.** 2009. 50f. Dissertação (Mestrado em Tecnologia da Produção Agrícola) – Pós-graduação – Instituto Agronômico de Campinas. IAC – Campinas.

MAIN, G.L.; MORRIS, J.R. Leaf-removal effects on Cynthiana yield, juice composition, and wine composition. **AmericanJournal of Enology and Viticulture**, v.55, n.2, p.147-152, 2004. Available in: <http://www.ajevonline.org/cgi/reprint/55/2/147>. Access in: 22 April 2014.

MANDELLI, F.; MIELE, A. Embrapa Uva e Vinho: **Uvas Viníferas para Processamento em Regiões de Clima Temperado. Sistema de Produção**, 4 ISSN 1678-8761 Versão Eletrônica Jul./2003. Available in: <sistemasdeproducao.cnptia.embrapa.br>. Access in 12 April 2013.

MESSINGER, S. M. et al. Evidence for involvement of photosynthetic processes in the stomatal response to CO2. **Plant Physiologic**, v. 140, p. 771-778. <http://dx.doi.org/10.1104/pp.105.073676>

MOURA, M.F.; TECCHIO, M.A.; TERRA, M.M. ; CIA, P. ; HERNANDES, J.L.; BENATO, E.A.; SIGRIST, M.M.J.; PIRES, E.J.P.; BETTIOL NETO, J.E. Influência do ácido naftalenoacético e do cloreto de cálcio na redução da degrana em uva Niagara Rosada cultivada em Jales. In: XIX Congresso Brasileiro de Fruticultura, 2006, Cabo Frio-RJ. Frutas do Brasil: Saúde para o mundo. Palestras e resumos. **Anais.** Viçosa-MG: JARD Editora, 2006, v. 1, p. 284.

PAIVA, A. S.; FERNANDES, E. J.; RODRIGUES, T. J. D.; JOSÉ E. P.; TURCO, J. E. P. Condutância estomática em folhas de feijoeiro submetido a diferentes regimes de irrigação. **Engenharia na Agricultura. Jaboticabal**, v.25, n.1, p.161-169. <http://dx.doi.org/10.1590/S010069162005000100018>

PONI, S. et al. Effects of early removal on cluster morphology, shoot efficiency and grape quality in two Vitis viniferacultivars. **Acta Horticulturae**, n.689, p.217-226, 2005. <https://fbcdn-sphotos-a-a.akamaihd.net/hphotos-ak-frc3/t1.0-9/s526x395/10303457_10152150777797989_6664189938370011788_n.jpg>:<http://www.actahort.org/members/showpdf?session=20373>. Accessin: 22 Abr. 2014.

RADÜNZ, A. L.; SCHÖFFEL, E. R.; HALLAL, M. O. C.; BRIXNER, G. F. Efeito da época de poda e da desfolha na interceptação de radiação solar na videira Bordô. **Bragantia**, Campinas,v.72, n.4, p.403-407, 2013.

SANTOS, H. P. **Aspectos ecofisiológicos na condução da videira e sua influência na produtividade do vinhedo e na qualidade dos vinhos**. Bento Gonçalves: Embrapa, 2006. 9 p. (Comunicado Técnico, 71).

SCARPARE FILHO, J. A.; MORAES, A. L. de.; RODRIGUES, A.; SCARPARE, F. V. Rendimento de uva 'Niagara Rosada' submetida à redução de área foliar. **Revista Brasileira de Fruticultura**, Jaboticabal - SP, v. 32, n. 3, p. 778-785. <http://dx.doi.org/10.1590/S0100-29452010005000105>.

SOUZA, E. R.; RIBEIRO, V. G.; PIONÓRIO, J.A de. A.Intensidades de desfolha para qualidade de cachos da videira 'Superior Seedless' no Submédio São Francisco. **Revista Brasileira de Tecnologia Aplicada nas Ciências Agrárias**, Guarapuava-PR, v.5, n.1, p.87-98, 2012.

TAIZ, L.; ZEIGER, E. **Fisiologia vegetal**. Trad. de E, R. Santarém. Porto Alegre: Artmed, 2009. 819 p.

TEIXEIRA, A, H, DE C, **Water productivity assessments from field to large scale: a case study in the Brazilian semi-arid region**, Saarbrücken, Germany: LAP Lambert Academic Publishing, 2009, 226p.

VON CAEMMERER, S.; FARQUHAR, G. D. Some relationships between the biochemistry of photosynthesis and the gas exchange of leaves. **Planta**, Berlin, v. 153, n. 4, p. 376-387, 1981. Available in: <http://link.springer.com/article/10.1007%2FBF00384257#page-2>. Access 22 April. 2013.

VIEIRA, E.L.; SOUZA, G.S.de.; SANTOS, A.R.dos.; SILVA, J.dos.S. **Manual de Fisiologia Vegetal**. São Luiz: EDUFMA, 2010. 230p.