Ciência Rural
ISSN: 0103-8478
cienciarural@mail.ufsm.br
Universidade Federal de Santa Maria
Brasil

Corrêa da Silva de Deus, Bruna; Mazzei Moura de Assis Figueiredo, Fábio Afonso; Venturotti Braun de Almeida, Luciana; Massi Ferraz, Tiago; Oliveira Martins, Amanda; Pereira Rodrigues, Weverton; Hespanhol Viana, Leandro; dos Santos Esteves, Barbara; Campostrini, Eliemar

Photosynthetic capacity of 'Niagara Rosada' grapes grown under transparent plastic covering

Ciência Rural, vol. 46, núm. 6, junio, 2016, pp. 950-956
Universidade Federal de Santa Maria
Santa Maria, Brasil

Ciência Rural, Santa Maria, v.46, n.6, p.950-956, jun, 2016 http://dx.doi.org/10.1590/0103-8478cr20150400
ISSN 1678-4596
CROP PRODUCTION

Photosynthetic capacity of 'Niagara Rosada' grapes grown under transparent plastic covering

Capacidade fotossintética da videira 'Niagara Rosada' cultivada sob cobertura plástica transparente

Bruna Corrêa da Silva de Deus[I] Fábio Afonso Mazzei Moura de Assis Figueiredo[II] Luciana Venturotti Braun de Almeida[I] Tiago Massi Ferraz[II] Amanda Oliveira Martins[I] Weverton Pereira Rodrigues[I] Leandro Hespanhol Viana[I] Barbara dos Santos Esteves[I] Eliemar Campostrini[I*]

ABSTRACT

New techniques in tropical regions such as use of transparent plastic covering (TPC), have been employed in grapes to avoid the wetting leaves and fruits, which can reduce the occurrence of fungal diseases, reduce the use of sprays, and reduce damage caused by hail and high winds. TPC may significantly affect the photosynthetic rates of grapevines cultivated in tropical regions, and thus have strong effects on plant productivity and improve fruit quality. However, in the North of Rio de Janeiro region there are lacks of studies related to TPC effects on photosynthetic capacity. The objective of this study was to evaluate the photosynthetic capacity in 'Niagara Rosada' vines grown under TPC and without transparent plastic covering (WTPC). The experiment was conducted between April and June 2013, on Tabuinha farm, located in the 3rd district of São Fidélis, Rio de Janeiro State, Brazil. A completely randomized block design was used with two treatments (TPC and WTPC) and twelve replications. Evaluations consisted of climatological variables, gas exchange and maximum quantum efficiency of open photosystem II centers-quantum yield (F_v/F_m) It was possible to observe that under TPC maximum temperature increase of 2.3°C, relative humidity reduced 1.5%, vapor pressure deficit increase 0.4kPa, and light intensity reduced 47.7%. These changes did not cause photochemical damage to the leaves. The TPC promoted higher net photosynthetic rate at 800h, which was associated with higher stomatal conductance. Thus, the TPC used in the northern region of Rio de Janeiro State did not impair the photosynthetic capacity of 'Niagara Rosada' vines.

Key words: *photosynthesis, chlorophyll fluorescence, **Vitisla brusca**, covered system.*

RESUMO

A cobertura plástica tem sido utilizada com a finalidade de evitar os efeitos negativos do molhamento foliar sobre a incidência de doenças em videiras 'Niagara Rosada', reduzir a aplicação de defensivos agrícolas e, dessa maneira, melhorar a qualidade dos frutos. Contudo, na região Norte Fluminense, não se tem estudos relacionados aos efeitos do uso da cobertura plástica na assimilação fotossintética do carbono e na eficiência fotoquímica associada ao fotossistema II (PSII) dessa espécie. O objetivo deste experimento foi avaliar a capacidade fotossintética em videiras 'Niagara Rosada' cultivadas sob cobertura plástica e sem cobertura plástica no Norte Fluminense. O experimento foi realizado entre abril e junho de 2013, no sítio Tabuinha, localizado no 3º distrito do município de São Fidélis, RJ. O delineamento experimental utilizado foi inteiramente casualizado com 2 tratamentos, com cobertura plástica e sem cobertura plástica, e 12 repetições. As avaliações foram relacionadas às variáveis climáticas, às trocas gasosas e ao rendimento quântico máximo do fotossistema II. Nesta pesquisa, sob a cobertura plástica, foi possível observar a elevação no valor da temperatura máxima do ar em 2,3ºC, redução na umidade relativa em 1,5%, incremento no déficit de pressão de vapor do ar_{max} em 0,4kPa, e redução na intensidade luminosa em 47,7%. Essas alterações não causaram comprometimento na eficiência fotoquímica das folhas. O sistema com cobertura plástica promoveu maior taxa fotossintética líquida (A) pela manhã (8h), e este aumento em A foi associado à maior condutância estomática nesse horário. Neste trabalho, a cobertura plástica utilizada não causou comprometimentos na capacidade fotossintética da videira 'Niagara Rosada'.

Palavras-chave: *fotossíntese, fluorescência da clorofila, **Vitislabrusca**, sistema coberto.*

INTRODUCTION

Brazil is currently in 12th position on the list of grape producing countries (FAOSTAT, 2014).

[I]Centro de Ciências e Tecnologias Agropecuárias, Universidade Estadual do Norte Fluminense Darcy Ribeiro (UENF), Av. Alberto Lamego, 2000, 28013-602, Campos dos Goytacazes, RJ, Brasil. E-mail: campostenator@gmail.com. *Corresponding author.
[II]Departamento de Química e Biologia, Universidade Estadual do Maranhão (UEMA), Imperatriz, MA, Brasil.

Received 03.17.15 Approved 11.03.15 Returned by the author 02.06.16
CR-2015-0400.R3

In recent years the Brazilian consumption of *in natura* grapes has grown and because of this an increase in the cultivated area and a greater use of technology in grape cultivation has been observed leding to significant increases in yield (IBGE, 2011). One of the techniques employed in vine cultivation is transparent plastic covering (TPC) over the plants, using wooden structures with a special transparent plastic covering. TPC can minimizes the damaging effects of temperature, wind and rain on the leaves and fruit (CHAVARRIA et al., 2010). These damaging effects in general are caused by hail and strong winds, or by the occurrence of diseases due to leaf wetting (CHAVARRIA et al., 2007).

TPC can be used both on grapes destined for wine production (SILVA et al., 2008) and on grapes destined for *in natura* consumption, known as table grapes (LULU et al., 2005). Effects of using TPC on yield and vine fruit quality have been studied in some regions such as Minas Gerais, where the effects were assessed on cycle length and changes in development on shaded vines (FERREIRA et al., 2004), and in Rio Grande do Sul state, where COMIRAN et al. (2012) assessed the development and production on organics vines grown under TPC.

The north and northeast of the state of Rio de Janeiro is a region that is becoming important in table grapes cultivation, where favorable environmental conditions can be found for the cultivation of this species, such as abundant water, suitable air temperatures and solar radiation considered as optimal levels. Increase in the planted area and consequently in yield have allowed fruit of the species to be supplied to grocery stores in the region. However, there are few studies on this region concerning the effect of plastic cover on the photosynthetic capacity. Among the cultivars, 'Niagara Rosada', derived from a natural somatic mutation of the cultivar 'Niagara Branca' (POMMER et al., 1997) has been outstanding to date, with high economic interest because it is a specie for *in natura* consumption as a table grape.

The objective of the present research was to assess the responses in the photosynthesis capacity of the vine 'Niagara Rosada' to the use of TPC in the Northern region of Rio de Janeiro state. For this, the present study assessed the effects of this technique on the carbon photosynthetic assimilation and the maximum quantum efficiency of open photosystem II centers-quantum yield of the vines cultivated in this region.

MATERIALS AND METHODS

The experiment was conducted from April to June 2013, in vines of the 'Niagara Rosada' cultivar, on Tabuinha farm in the 3rd district of the municipality of São Fidélis, in the northern region of Rio de Janeiro state, Brazil, at 21°30'58"S and 41°42'49,6"W. According to Köppen, the climate in this region is wet tropical, with a rainy summer and a dry winter.

The experiment was carried out using the cropping systems with transparent plastic covering (TPC) and without transparent plastic covering (WTPC). Vineyard cover consisted of a low density (LDPE), 160µm thick polyethylene film, with an arched roof and open sides. Distance between the TPC and the canopy was about 50cm. The WTPC area was covered with an anti-bird screen that allowed passage of 90% of the photosynthetically active radiation (PAR).

In TPC and WTPC, the plants were conducted in a tutored system with 2.7m between row spacing and 2.0m between plant spacing. The cuttings were planted on 10th January 2010. The rootstock used was IAC 766. The cultivation treatments were those established by the farmer for commercial cultivation. Pruning was carried out on 07/03/2013. In the two systems studied, the irrigation sheets were determined from the reference evapotranspiration (ETo) and the crop evapotranspiration (ETc=ETo x kc) and soil was kept close to the field capacity. All the assessments in both TPC and WTPC began 42 days after pruning (DAP). In the TPC and WTPC systems, the micrometeorological measures were obtained from a mini Watch Dog climatological station (Spectrum Technologies, Illinois, USA) equipped with automatic sensors for collecting temperature PAR and relative humidity (RH) data.

Calculation of vapor pressure deficit (VPD_{air}) was based on the temperature and relative humidity during the measurement period (JONES, 1992):

$$VPD_{air}=0.61137*\exp((17.502*T°)/(240.97+T°))*(1-(UR\%/100)).$$

At 42, 56, 68, 90 and 105 DAP, the gas exchange assessments, net photosynthetic rate (*A*), stomatal conductance (*gs*) and transpiration (*E*) were carried out on one expanded leaf per plant and opposite the fruit cluster. The measurements were taken by an infrared gas analyser (IRGA), model LI-6400 (LI-COR, Lincoln, NE, USA) between 800h and 1200h every 14 days.

Instant light response curves of fluorescence were measured on the same attached leaf used for the gas exchange measurements, using a fluorimeter model Pocket PEA (England) with mini-cuvettes provided by Hansatech Company every 14 days. Chlorophyll fluorescence emission was measured at 400 (predawn) and 1200h (midday) in all treatments. Leaf tissue was dark adapted for 30 minutes so that all the reaction centers were in the open state (Q_a oxidized) (BOLHÀR-NORDENKAMPF et al., 1989). Initial fluorescence (F_0), maximum fluorescence (F_m) and variable fluorescence (F_v) were measured. F_v/F_m (maximum quantum efficiency of open photosystem II centers-quantum yield) (BÒLHAR-NORDENKAMPF et al., 1989) was calculated from the values of F_v and F_m. A completely randomized block design was used with two treatments and twelve replications. The means were compared by the Tukey test at 5% probability.

RESULTS AND DISCUSSION

The microclimate under TPC presented air temperature similar to the WTPC (TPC=22.6°C and WTPC=22.0°C) (Figures 1A and B). However, higher

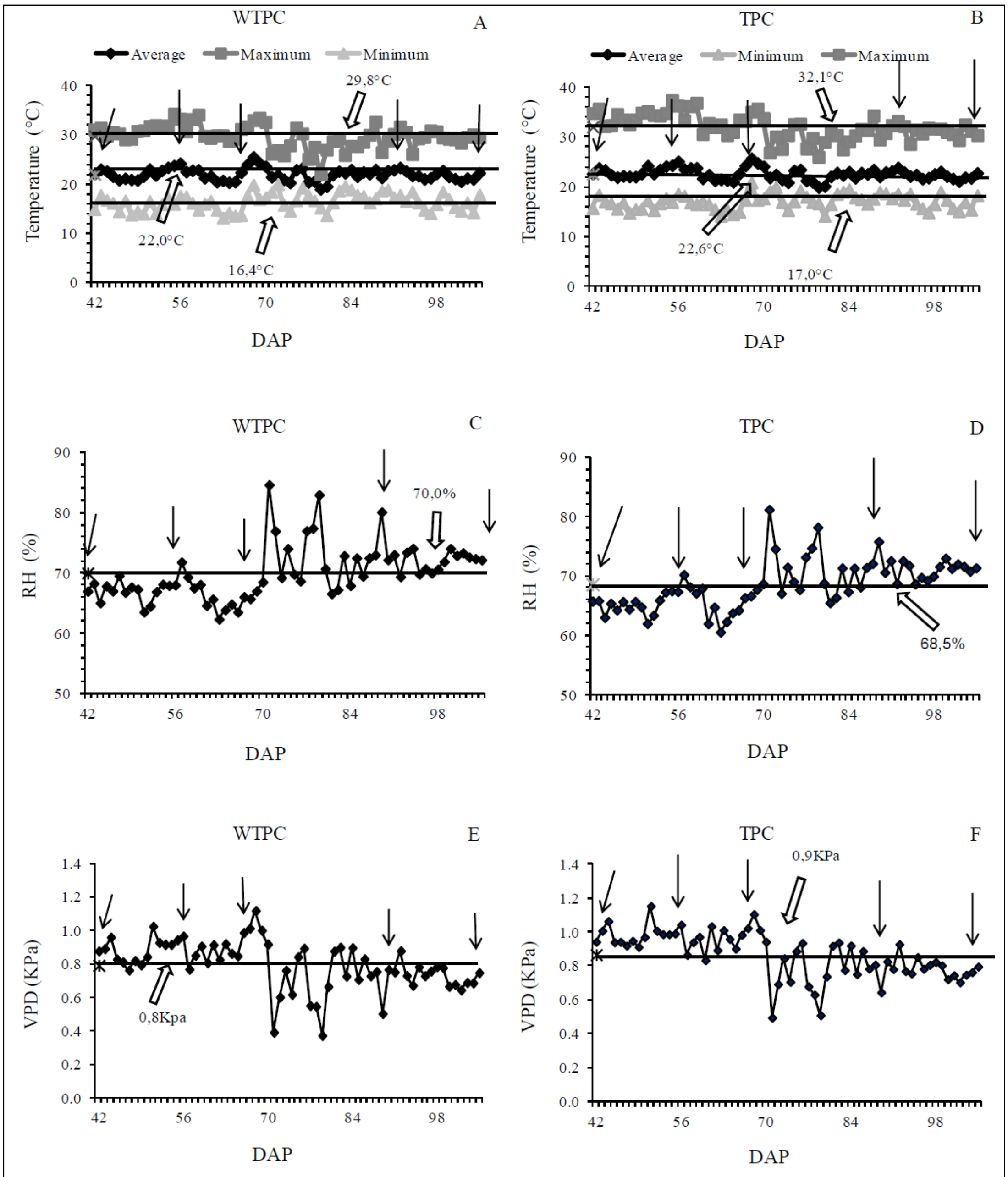

Figure 1 - Air temperature (°C) (A e B), relative humidity (%) (C e D) and vapour pressure deficit (kPa) (E e F) during the experimental period in the WTPC and TPC cultivation systems. Black arrows indicate the assessment days and the wide arrows and the horizontal lines indicate the mean of the data shown throughout the experimental period (April to June, 2013, São Fidélis, RJ, Brazil).

maximum temperature values were observed in the TPC treatment (32.1°C) compared to the maximum temperatures of the WTPC treatment (29.8°C). An increase of 2.3°C in the TPC system was observed. CARDOSO et al. (2008) showed that the maximum temperature reached under TPC was 3.4°C. However, the type of construction of the plastic cover can affect the air temperature. In the present research, the highest air temperature values reported under the TPC may have been associated to the proximity of the sensor to the cover. According to BURIOL et al. (1997), TPC reduces air movement close to the surface, and contributed to the higher maximum temperature values in the TPC system. According to CARDOSO et al. (2008), the TPC reduces wind speed by up to 90% close to the plant canopy and this is an important factor because wind accounts for mechanical damage to the plants and stomata closure (PEDRO JÚNIOR et al., 1998). Reduced leaf wetting was also observed which decreased disease incidence (CHAVARRIA et al., 2010).

The RH presented similar values in both the cultivation systems (Figures 1C and D). The WTPC system presented 70% average RH while the TPC treatment presented 68.5% average RH. The VPD_{air} observed was on average 0.8kPa in the WTPC system and 0.9kPa in the TPC treatment (Figures 1E and F). Relationship between the VPD_{air} and plant growth is associated to stomata closure, since high values of this variable decrease *gs* (EL-SHARKAWY et al., 1985; REIS & CAMPOSTRINI, 2008). This occurs because the water loss from the leaves is controlled by the leaf-air vapor pressure gradient and depends above all on the $VPD_{ar.}$ However, the RH assessed by the VPD in the range of 1.0 to 0.2kPa (55 to 90% RH at 20°C) has reduced effect on the physiological and growth processes in vegetable species (GRANGE & HAND, 1987). In the present research, in both the systems assessed, the mean general $VPDV_{air}$ values were below 1kPa.

The PAR obtained in the experimental period shows that the TPC provides maximum light interception of 47.7% (Figures 2A and B). This reduction is important because on days with high light intensity the plastic cover may prevent excess

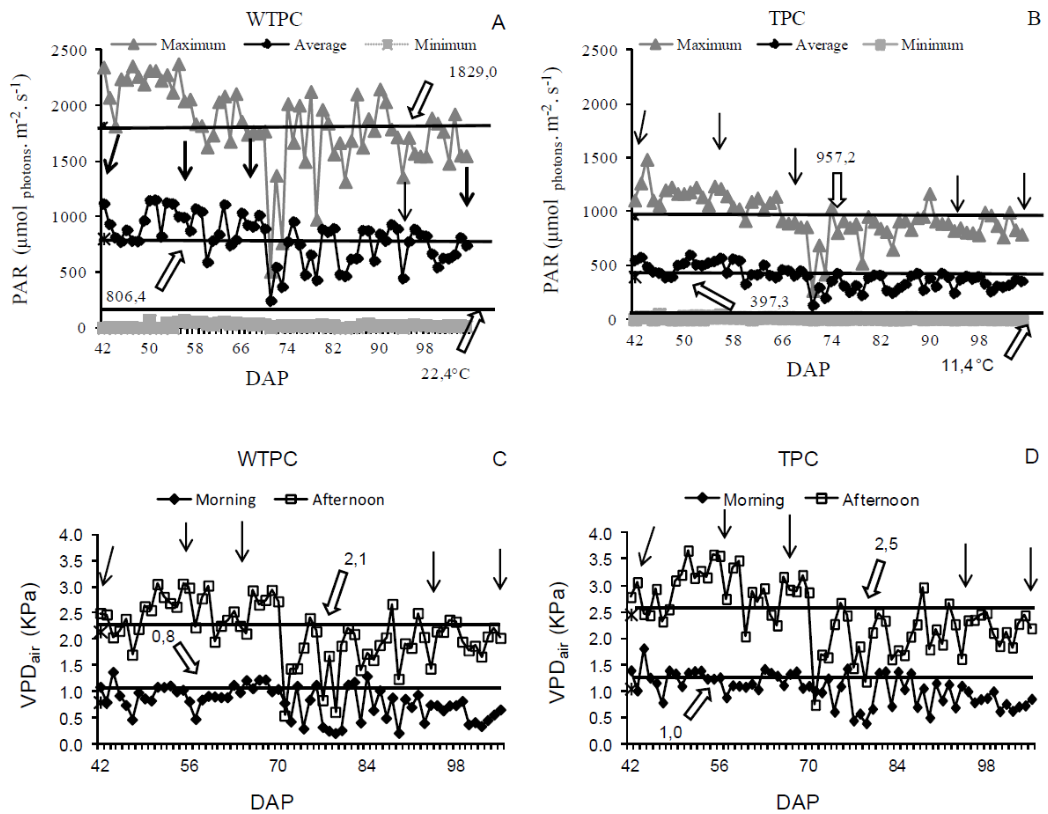

Figure 2 - Photosynthetic active radiation (PAR)(μmol m^{-2} s^{-1}) during the experimental system in the WTPC (A) and TPC (B) cultivation systems and vapour pressure deficit (VPD_{air}) (kPa) WTPC (C) e TPC(D) obtained at the time of assessments in the experimental period. Black arrows indicate the assessment days and the wide arrows and the horizontal lines indicate the mean of the data are shown throughout the experimental period (April to June 2013, São Fidélis, RJ, Brazil).

luminous energy on the leaf that causes photo oxidative damage, increase in temperature and leaf respiration (MULLINS, 1992).

The *A* values at 800h were greatest in the TPC system and were observed at 42; 56 and 105 DAP (Figures 3A and B). However, at 12 noon, no difference was observed between the cultivation systems. This result was similar to that reported by MOTA et al. (2009), who assessed between 900h and 1100h vines cultivated under a system protected with

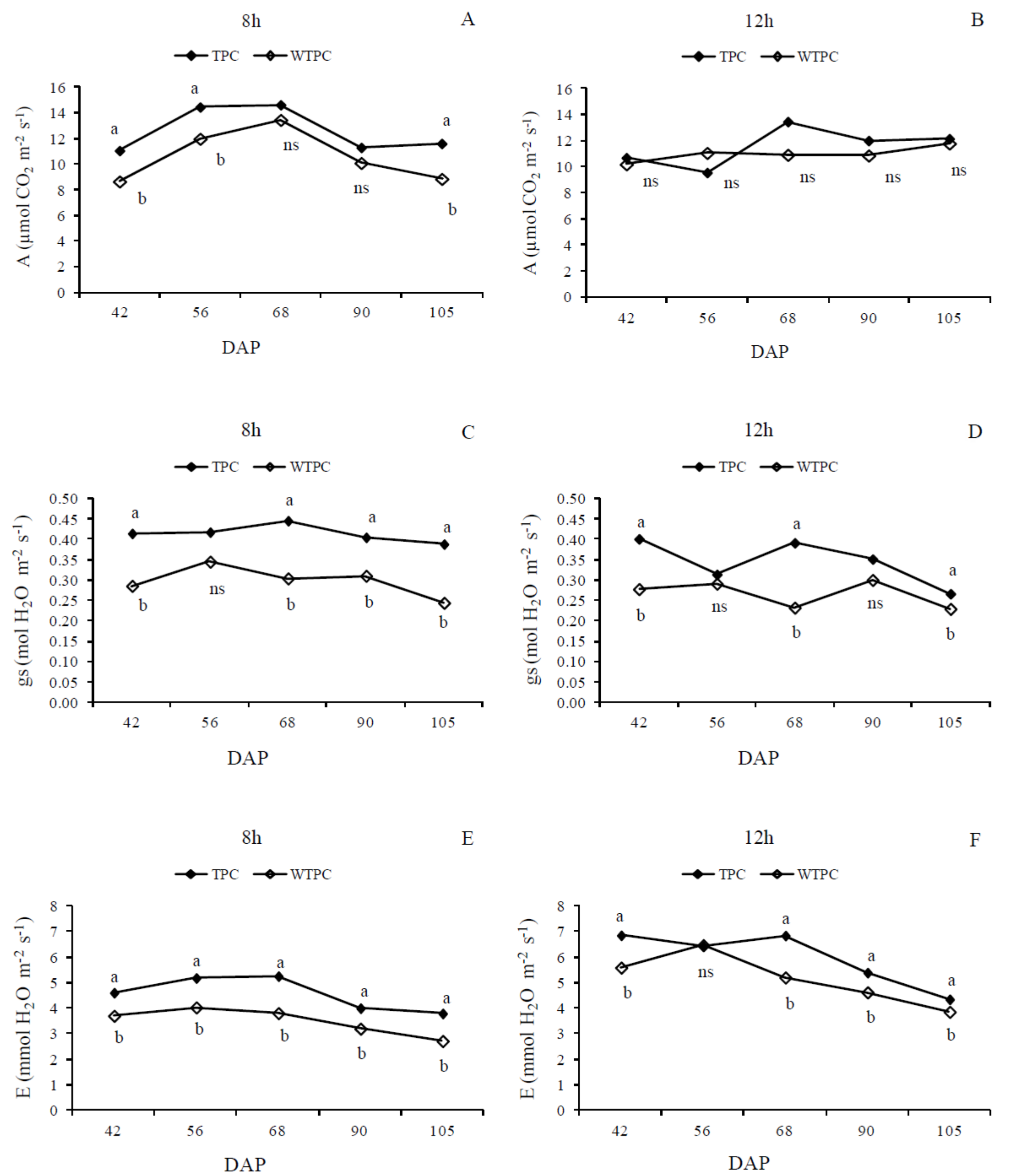

Figure 3 - Net photosynthesis rate (A), stomatal conductance (g_s) and transpiration obtained at 800h(A) and 1200h(B) in `Niagra Rosada´grapes cultivated under TPC and WTPC during 105 DAP. Each treatment corresponds to an average of 12 replications. Means followed by the same letter do not differ statistically by the Tukey test at 5% probability.

150µm thick translucent woven polypropylene plastic canvas and grapes cultivated WTPC and the authors observed that *A* was different between the cultivation systems.

The difference in the *A* values between the two systems found at 800h was associated to the higher *gs* value in the plants cultivated in the TPC system compared to the plants in the WTPC system (Figures 3C and D). Nevertheless, at 1200h, both the treatments showed reduction in *gs*, and under TPC treatment *A* value was lower than in the WTPC system. Even so it was observed that the TPC treatment showed higher *gs* values compared to the WTPC treatment. A similar result was reported by MOTA et al. (2007) in grapess cultivated under TPC.

The higher sensitivity of the stomatal conductance in the TPC system at 1200h was associated to the greater maximum VPD_{air} under this condition (2.5kPa) compared to the same time in the WTPC system (2.1kPa) (Figures 2C and D). However, since the maximum quantum efficiency of open photosystem II centers-quantum yield function was not damaged at this time (Figures 4A and B), possible biochemical damages associated to the Calvin/Benson cycle may justify the absence of response of *A* in the plants in the TPC system, even though they presented a greater *gs*value than the plants in the WTPC treatment. This information showed that the gain in carbon photosynthetic assimilation in `Niagra Rosada´ plants cultivated in the TPC system, compared to WTPC system, occurred only in the morning. In the afternoon, with the air heating, the VPD_{air}rises cause greater stomata closure in plants in the system. However, a nonstomatal effect associated to the biochemical reactions may also be associated.

The TPC system presented higher *E* values under the WTPC system both at 800h and 1200h (Figures 3E and F). These higher *E* values in the TPC system were associated to the greater *gs* in the leaves of the plants in the system (Figures 3C and D).

The F_v/F_m was not different between the treatments at 400h (Figures 4A and B). However, at 1200h the grapes cultivated under TPC showed greater values (0.80) compared with the WTPC vines (0.78). Nevertheless, both at 400h and 1200h, treatments showed F_v/F_m values between 0.75 and 0.85, indicating that there was no damage to the maximum quantum efficiency of open photosystem II centers of plants. According to BOLHÀR-NORDENKAMPF & ÖQUIST (1993), under optimal environmental conditions, the F_v/F_m is between 0.75 and 0.85. Values below 0.85 indicate the occurrence of photoinhibition, due to reduced PSII activity resulting from high radiation (BERTAMINI & NEDUNCHEZHIAN, 2004).

CONCLUSION

Under transparent plastic covering (TPC) the maximum air temperature showed highest values. The RH and VPD_{air} showed similar average values in the TPC and WTPC systems. The light interception caused by the TPC was 47.7% and there was no damage to the photosynthetic capacity in the `Niagra Rosada´ grapes cultivated in the North of Rio de Janeiro State in the period studied.

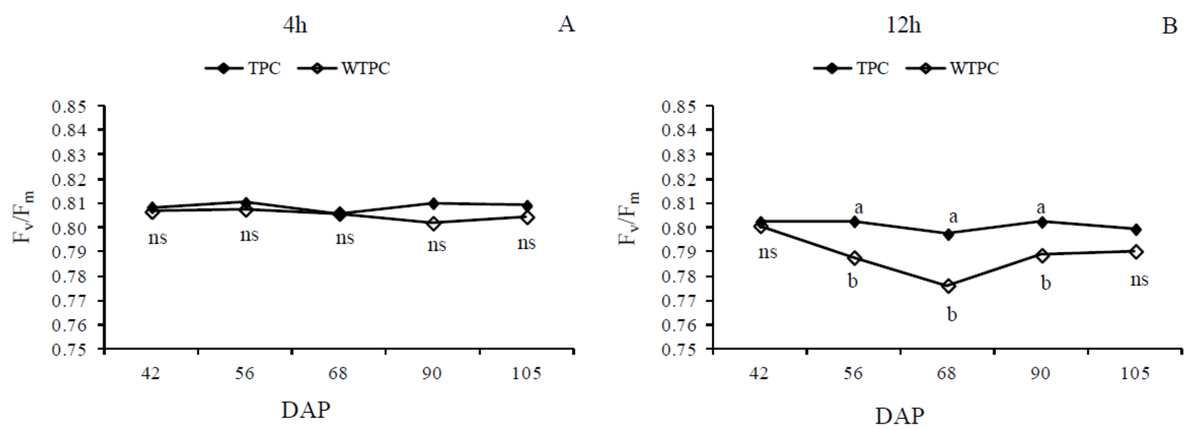

Figure 4 - F_v/F_m obtained at 400h (predown)(A) and1200h(B) in 'Niagara Rosada' cultivated under TPC and WTPC during 105 DAP. Each treatment corresponds to an average of 12 replications. Means followed by the same letter do not differ statistically by the Tukey test at 5% probability.

ACKNOWLEDGEMENTS

The authors are grateful to Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for grant scholarship during this study.

REFERENCES

BERTAMINI, M.; NEDUNCHEZHIAN, N. Photoinhibition and recovery of photosystem 2 in grapevine (***Vitisvinifera*** L.) leaves grown under field conditions. **Photosynthetica**, v.41, p.611-617, 2004. Available from: <http://link.springer.com/article/10.1023%2FB%3APHOT.0000027528.30472.b0#page-1>. Accessed: Mar. 12, 2015. doi: 10.1023/B:PHOT.0000027528.30472.b0.

BOLHÀR-NORDENKAMPF, H.R.; ÖQUIST, G.O. Chlorophyll fluorescence as a tool in photosynthesis research. In: HALL, D.O. et al. Photosynthesis and production in a changing environment. **A field and laboratory manual**. London: Chapman & Hall, p.193-206, 1993.

BOLHÀR-NORDENKAMPF, H.R. et al. Chlorophyll fluorescence as a probe of the photosynthetic competence of leaves in the field: a review of current instrumentation. **Functional Ecology**, v.3, p.497-514, 1989. Available from: <http://www.jstor.org/stable/2389624?seq=1#page_scan_tab_contents>. Accessed: Jan. 06, 2016. doi: 10.2307/2389624.

BURIOL, G.A. et al. Effect of ventilation of polyethylene low tunnels on microenvironment and lettuce growth. **Revista Brasileira de Agrometeorologia**, v.5, p.17-24, 1997. Available from: <http://www.sbagro.org.br/revistas/volumes_completos_do_1%C2%BA_ao_7%C2%BA_volume.pdf>. Accessed: Mar. 16, 2015.

CARDOSO, L.S. et al. Micrometeorological alterations in vineyards by using plastic covering. **Pesquisa Agropecuária Brasileira**, v.43, p.441-447, 2008. Available from: <http://www.scielo.br/pdf/pab/v43n4/a01v43n4.pdf>. Accessed: Mar. 12, 2015. doi: 10.1590/S0100-204X2008000400001.

CHAVARRIA, G. et al. Grapevine maturation of moscato giallo under plastic cover. **Revista Brasileira de Fruticultura**, v.32, p.151-160, 2010. Available from: <http://www.scielo.br/pdf/rbf/v32n1/aop01410.pdf>. Accessed: Mar. 12, 2015. doi: 10.1590/S0100-29452010005000014.

CHAVARRIA, G. et al. Incidence of diseases and needs of control in overhead covered grapes. **Revista Brasileira de fruticultura**, v.29, p.477-482, 2007. Available from: <http://www.scielo.br/pdf/rbf/v29n3/a14v29n3.pdf>. Accessed: May 25, 2015. doi: 10.1590/S0100-29452007000300014.

COMIRAN, F. et al. Microclimate and production of 'Niagara rosada' grapevines in organic cultivation under plastic covering. **Revista Brasileira de Fruticultura**, v. 34, n. 1, p. 152-159, 2012. Available from: <http://www.scielo.br/pdf/rbf/v34n1/v34n1a21.pdf>. Accessed: Jan. 09, 2016. doi: 10.1590/S0100-29452012000100021.

EL-SHARKAWY, M.A. et al. Stomatal response to air humidity and its relation to stomataldensityin a wide range of warm climate species. **Photosynthesis Research**, v.7, p.137-149, 1985. Available from: <http://link.springer.com/article/10.1007%2FBF00037004#page-1>. Accessed: Mar. 12, 2015. doi: 10.1007/BF00037004.

FAOSTAT (2014**). FAO data for agriculture**: statistics database. Online. Available from: <http://faostat.fao.org/site/339/default.aspx>. Accessed: Mar. 12, 2015.

FERREIRA E.A. et al. Harvest anticipation for 'Niagara Rosada' grapes in southern Minas Gerais, Brazil. **Ciência e Agrotecnologia**, v. 28, n. 6, p. 1221-1227, 2004. Available from: <http://www.scielo.br/pdf/cagro/v28n6/a01v28n6.pdf>. Accessed: Jan. 09, 2016. doi: 10.1590/S1413-70542004000600001.

GRANGE, R.I.; HAND, D.W. A review of the effects of atmospheric humidity on the growth of horticultural crops. **Journal of Horticutural Scinces**, v.62, p.125-134, 1987. Accessed: Jan. 07, 2016. doi: 10.1080/14620316.1987.11515760.

(IBGE) **Instituto Brasileiro de Geografia e Estatística**. Online. Available from: <http://www.sidra.ibge.gov.br/bda/agric/default.asp?t=5&z=t&o=11&u1=1&u2=1&u3=1&u4=1&u5=1&u6=1>. Accessed: Mar. 16, 2015.

LULU, J. et al. Effect of microclimate in the quality of 'romana' (a 1105) table grape cultivated under plastic cover. **Revista Brasileira de Fruticultura**, v.27, p.422-425, 2005. Available from: <http://www.scielo.br/pdf/rbf/v27n3/27788.pdf>. Accessed: Mar. 12, 2015. doi: 10.1590/S0100-29452005000300020.

MOTA, C.S. et al. Water supply, solar radiation and photosynthesis in 'cabernet sauvignon' grapevines under plastic covering. **Revista Brasileira de Fruticultura**, v.31, p.432-439, 2009. Available from: <http://www.scielo.br/pdf/rbf/v31n2/v31n2a17.pdf>. Accessed: Mar. 12, 2015. doi: 10.1590/S0100-29452009000200017.

MULLINS, M.G et al. **Biology of horticultural crops**: biology of the grapevine. Cambridge: Cambridge University, 1992. 239p.

PEDRO JÚNIOR, M.J. et al. Efeito do uso de quebra-ventos na produtividade da videira 'Niagara Rosada'. **Revista Brasileira de Agrometeorologia**, v.6, n.1, p.75-79, 1998. Available from: <http://www.sbagro.org.br/revistas/volumes_completos_do_1%C2%BA_ao_7%C2%BA_volume.pdf>. Accessed: Jan. 07, 2016.

POMMER, C.V. et al. **Variedades de videira para o estado de São Paulo**. Campinas: Instituto Agonômico de Campinas, 1997. 59p. (Boletim Técnico, 166).

REIS, F.O.; CAMPOSTRINI, E. Leaf gas exchange and potential photochemical efficiency of field-grown papaya plants. **Bragantia**, v.67, p.815-822, 2008. Available from: <http://www.scielo.br/pdf/brag/v67n4/02.pdf>. Accessed: Mar. 12, 2015. doi: 10.1590/S0006-87052008000400002.

SILVA, M.A. et al. Agronomic performance of sugarcane families in response to water stress. **Bragantia**, v.67, p.656-661, 2008. Available from: <http://www.scielo.br/pdf/brag/v67n3/a14v67n3.pdf>. Accessed: Mar. 12, 2015. doi: 10.1590/S0006-87052008000300014.