Scientia Agraria Paranaensis

Scientia Agraria Paranaensis – Sci. Agrar. Parana.
ISSN: 1983-1471 – Online
DOI: https://doi.org/10.18188/sap.v20i3.27267

LEAF ANATOMY OF CULTIVATED VINE PLANTS IN CULTIVATION ENVIRONMENTS AND ALTITUDE REGIONS

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SAP 27267 Received: 27/04/2021 Accepted: 19/06/2021
Sci. Agrar. Parana., Marechal Cândido Rondon, v. 20, n. 3, jul./sep., p. 301-305, 2021

ABSTRACT - Plants can develop anatomical variations depending on the cultivation environment, and such characteristics can influence their physiology and significantly alter their capacity. The aim of the study was to evaluate the anatomical characteristics of the leaves of 'Niágara Rosada' grape varieties grown in different growing environments and different regions in the 2019/20 production cycle. An experiment was carried out in three cultivation conditions (full sun, under canvas and under plastic) in the region of Lages-SC. Another test was conducted in orchards with crops under full sun, in the regions of Lages-SC and Caçador-SC, altitudes of 1100 and 900 m, respectively. The variables analyzed were: stomatal density and stoma size, plant production and average cluster mass and chlorophyll index. In the first experiment, higher stomatal density was observed in plants grown in full sun compared to plants under canvas and greater stomatal area in plants grown under plastic in relation to the other conditions. The chlorophyll index was higher in plants grown under canvas, with no differences for plants grown under plastic. Plants grown under plastic showed higher production and average mass of clusters compared to plants grown under canvas and full sun. The stomatal density of vines produced in Caçador is higher than vines produced in Lages. The cultivation of vines under plastic cover is very advantageous in several aspects, such as: increased production and also protects against natural events, such as hail.
Keywords: *Vitis labrusca* L., stomata, protected cultivation.

ANATOMIA FOLIAR DE PLANTAS DE VIDEIRA CULTIVADAS EM AMBIENTES DE CULTIVO E REGIÕES DE ALTITUDE

RESUMO - As plantas podem desenvolver variações anatômicas conforme o ambiente de cultivo, sendo que, tais características podem influenciar a fisiologia e alterar significativamente sua capacidade. O objetivo do estudo foi avaliar as características anatômicas das folhas de videiras da cultivar Niágara Rosada em diferentes ambientes de cultivo e diferentes regiões no ciclo produtivo 2019/20. Um ensaio foi conduzido em três condições de cultivo (pleno sol, sob tela e sob plástico) na região de Lages-SC. Outro ensaio foi conduzido em pomares com cultivos à pleno sol, nas regiões de Lages-SC e Caçador-SC, altitudes de 1100 e 900 m, respectivamente. As variáveis analisadas foram: densidade estomática e dimensão de estômatos, produção das plantas e massa média dos cachos e índice de clorofila. No primeiro experimento, foi observada maior densidade estomática nas plantas cultivadas a pleno sol em comparação as plantas sob tela e maior área estomática em plantas cultivadas sob plástico em relação às demais condições. O índice de clorofila foi superior em plantas cultivadas sob tela, sem diferenças para plantas cultivadas sob plástico. Plantas cultivadas sob plástico apresentaram maior produção e massa média dos cachos em relação às plantas cultivadas sob tela e pleno sol. A densidade estomática de videiras produzidas em Caçador é maior do que videiras produzidas em Lages. O cultivo de videiras sob cobertura plástica se mostra muito vantajoso em vários aspectos, como: aumento produtivo e proteção contra eventos naturais, como granizo.
Palavras-chave: *Vitis labrusca* L., estômatos, cultivo protegido.

INTRODUCTION

The grape is one of the most cultivated fruits in the world with approximately 79 million tons. in 2018 (FAOSTAT, 2020). In Brazil, there is a predominance of the cultivation of grapes of the *Vitis vinifera* species for the production of fine wines and of the *Vitis labrusca* species, characterized by American and hybrid grapes used in the preparation of both table wines and juices and for consumption in natura. Between the two species, 1.59 million tons were produced. in 2018, with a decrease compared to 2017 (FAOSTAT, 2020). The plantations are located both in regions with the greatest winter cold (South) and in tropical regions, such as the São Francisco River Valley, but with a large variation in altitude between these locations. And it is noticed, a different behavior between the same cultivars, when planted in different regions, mainly in the phenological issue and visual aspect of the fruits.

The elevation of altitude implies: decrease in air temperature, increase in solar radiation, increase in leaf temperature, increase in O_2 and CO_2 diffusion coefficients,

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increase in water vapor pressure, increase in wind speed, increase in precipitation and decrease in air humidity and in partial pressures of O_2 and CO_2 (TRANQUILLINI, 1964). Due to variations in these environmental factors, the morphological and physiological characteristics of plants can usually present changes such as changes in leaf area and contents, in gas exchange, among others (KÖRNER, 2007; THOMAS, 2011).

Control of stomatal movement consists of 'short-term' changes, stomatal opening and/or closing in response to the availability of water, light, temperature, wind speed, and carbon dioxide, as well as 'long-term' changes, as changes in stomatal density, which defines the limits for maximum stomatal conductance in response to atmospheric CO_2 concentration and other environmental factors (DAVIES et al., 2000; CASSON et al., 2009).

Some hypotheses have been proposed to explain the relationship between stomatal characteristics of plants of the same species, but cultivated at different altitudes. The hypothesis of reduced CO_2 availability suggests that photosynthesis may be limited at high altitudes by declining CO_2 partial pressure, and that plants may increase their stomatal density or stomatal conductance to increase carbon gain (PATO; RAMON, 2012).

The productivity and quality of the grapes produced, as well as other temperate fruits such as apples, depend on several factors, which involve the rate of floral differentiation, flowering and fertilization, fruit set, cell division rate and fruit growth, which will be directly dependent on the photosynthetic or CO_2 fixation rate and the partition of photoassimilates with the other growing organs, such as shoots, which are strong drains (WÜNSCHE; LAKSO, 2000). In this sense, the objective of the study was to evaluate the anatomical characteristics of the leaves of vines of the ‘Niagara Rosada’ variety cultivated in different environments and growing regions.

MATERIAL AND METHODS

The study was carried out in the region of Lages - SC (under geographic coordinates: south latitude of 27º 49' and 50º 20' of west longitude), located at approximately 1100 m altitude, this region has annual maximum and minimum temperatures of 21, 7 and 11.5ºC, respectively, classified as hot and temperate climate (*Cfb*), according to Köppen, with average annual rainfall of 1441 mm. Samples were also collected in the region of Caçador - SC (under geographic coordinates: latitude south of 26° 46' 33" and longitude of 51° 0' 56” west), with an altitude of approximately 900 m, classified as hot and temperate climate (Cfb), according to Köppen, with an average annual temperature of 16.3ºC and an average annual rainfall of 1707 mm. The variety of ‘Niagara rosada’ (*Vitis labrusca*) was used, in the 2019/2020 production cycle, in different cultivation environments and comparative evaluations were also carried out between the different cultivation places of the plants grown without cover in full sun.

The study was carried out in a completely randomized design, with 3 treatments and 10 replications, with treatments in three growing environments: net cover, plastic cover and open environment (full sun). The vine orchards were provided by producers from Caçador and Lages to carry out the study. From the beginning of the experiment until the end, the orchards were conducted in accordance with the management practices recommended for grape growing.

The variables analyzed were: stomatal density and size of stomata in different environments and growing regions; production, average mass of clusters and estimated productivity in different cultivation environments. To determine the stomata density, two fully expanded leaves per plant were used. From each of them, a slide was made with samples of the abaxial surface (bottom of the leaf), using the technique of printing the epidermis with universal instant adhesive (Superbonder®), described by Segatto et al. (2004) for the potato crop, and effectively for use on apple tree leaves (GABARDO et al., 2018).

The records were performed on sunny days (between 10:00h and 10:30h), and all the leaves sampled were exposed to sunlight and inserted in the middle third of the plant. With the aid of an optical microscope, the slides were focused at 40x magnification and the images were captured with the aid of the computer program Toup View®. Stomata density (stomata mm^2) and mean stomata area (μm^{-2}) were calculated by counting the number of stomata of known area per image. For recording in photographs, 40x magnification was used. Evaluations of chlorophyll indices were also carried out, with the aid of a portable chlorophyll meter, Minolta, model SPAD-502.

Statistical analysis of data was performed using analysis of variance (ANOVA). The variables whose results reveal significance ($p<0.05$) had the averages compared by Tukey's test, at 5% error probability. Statistical analyzes were performed using the Sisvar program, version 5.3 (FERREIRA, 2010).

RESULTS AND DISCUSSION

It was verified that the covering in the plants affects the anatomical characteristics of the leaves, being able to reflect in the photosynthetic capacity, productivity and in the characteristics of the fruits produced. The stomatal density in plants grown in unprotected environments (full sun) was higher than that observed in plants grown under screen, 4.97 and 4.14 stomata.mm^{-2}, respectively (Table 1). In plants grown under plastic cover, the stomatal density was 4.69 stomata.mm^{-2}, not differing from the other treatments, however, the stomatal area was higher than the other treatments (6108.4 μm^2), 23.35% higher than cultivation under screen (4951.99 μm^2) and 17.88% higher than that observed in plants grown in full sun.

The crops under screen cover and plastic cover showed an accumulation of total chlorophyll in the leaves of 44 and 42.5 respectively, with no significant differences between them, whereas the plants grown in full sun had a lower index, only with 39.4 (Table 2). Solar radiation acts on photoenergy processes (photosynthesis) and on photostimulus processes (movement and formation processes). The radiation absorbed by the culture interferes in the vegetative cycle of the vine and in the period of fruit development. A higher intensity of incident solar radiation promotes higher levels of sugars in the fruits. It is the main source of energy for the evapotranspiration process. The radiation potential that falls on the vineyard is determined by the location and time of year.

Table 1 - Density and stomatal area in leaves of vines grown in cultivation environments.

Cultivation environments	Stomatal density (stomata mm^{-2})	Stomatal area (μm^2)
Plastic cover	4.69 ab*	6108.40 a
Net cover	4.14 b	4951.99 b
Full sun	4.97 a	5181.87 b
Averages	4.58	5375.54
CV(%)	16.40	14.90

*Means followed by the same letter in the column do not differ by Tukey's test, at 5% error probability.

Table 2 - Chlorophyll contents, production and estimated productivity of vine plants in growing environments.

Cultivation environments	Chlorophyll Contents	Production		Average clusters mass (g)	Yield (ton ha^{-1})
		Clusters $plant^{-1}$	Kg $plant^{-1}$		
Plastic cover	44.0 a*	16.4 b	1.7 c	107.4 c	2.2 c
Net cover	39.4 b	19.8 b	3.1 b	153.7 b	4.1 b
Full sun	42.5 ab	30.8 a	8.2 a	270.8 a	10.6 a
Averages	42.0	22.3	4.3	177.3	5.6
CV(%)	6.74	22.36	24.42	22.05	24.04

*Means followed by the same letter in the column do not differ by Tukey's test, at 5% error probability.

The total production differed in the different cultivation environments, and in cultivation environments under plastic cover there was a higher production rate, greater mass and number of clusters per plant. The environment under plastic also stood out with the highest average mass of clusters, thus totaling a productivity of 10.6 ton ha^{-1}. In full sun, the yield was 4.1 ton ha^{-1}, higher than the yield of 2.2 ton ha^{-1}, in the cultivation under screen, however, yields were lower in relation to the one under plastic cover.

Lulu et al. (2005) concluded, in an experiment carried out with 'Romana' table grapes grown under plastic cover, that this type of cover promotes a considerable reduction in the appearance of phytosanitary diseases compared to 'Romana' vines grown without cover. Such occurrence is directly linked to the increase in productivity, as the authors also verified a significant difference in the mass of the clusters, which was greater in the treatments carried out with plastic cover, being directly linked to the fact of the reduction in the rots of the crops with cover, because, berries that have rots become lighter due to the wilting that the disease causes. Another factor observed in the study was the effectiveness of plastic covering against natural damage, such as hailstorms or heavy rains for a long period of time and winds, being effective even against insects and birds.

However, growing vines under plastic cover requires a lot of caution, because, due to the lack of rain and the decrease in ultraviolet radiation, the residual time of the fungicides becomes longer. This becomes worrying both for grapes grown for consumption in natura and for those used in the manufacture of wines, as it alters the performance of yeasts at the time of fermentation. But, in general, the use of plastics for covering vines is very efficient because it ends up reducing fungal diseases and thus reducing the use of fungicides (CHAVARRIA; SANTOS, 2009).

Comparing the vine crops in the regions of Caçador and Lages, both cultivated in full sun, without any type of cover, it was verified that the stomatal density of the leaves of vines in the region of Caçador was higher than that of Lages, with 8.55 and 4.97 mm^{-2} stomata, respectively (Table 3). In the stomatal area (μm^2) there were no significant differences between regions.

TABELA 3 - Densidade e área estomática em folhas de plantas de videira conduzidas nos ambientes de cultivo.

Cultivation environments	Stomatal density (stomata mm^{-2})	Stomatal area (μm^2)
Lages-SC	4.97 b*	5181.87 ^{ns}
Caçador-SC	8.55 a	5222.01
Averages	6.76	5201.94
CV(%)	25.20	14.70

*Means followed by the same letter in the column do not differ by Tukey's test, at 5% error probability. *ns = not significant (P>0,05).

CONCLUSIONS

The cultivation of vines under plastic cover is very advantageous in several aspects, such as: increasing stomatal area, increasing stomatal density, greater number and mass of clusters per plant, greater productivity and also protecting against natural events, such as hail, being economically viable for regions with high rainfall and disease incidence at the end of the production cycle.

The region of Caçador has a great productive potential for grapes, with a greater number of stomata present in the leaves of the vines in relation to the leaves of vines grown in Lages.

ACKNOWLEDGMENTS

To the research support fund (FAP), from the University of Alto Vale do Rio do Peixe (UNIARP), for the support received during the execution of this experiment.

REFERENCES

AHMED, F.F.; SHAABAN, M.M.; ABD EL-AAL, A.M.K. Protecting Crimson Seedless grapevines growing in hot climates from sunburn. **Research Journal of Agriculture and Biological Sciences**, v.7, n.1, p.135-141, 2011.

AMARANTE, C.V.T.; ARGENTA, L.C.; BASSO, C.; SUZUKI, A. Composição mineral de maçãs ‘Gala’ e ‘Fuji’, produzidas no Sul do Brasil. **Pesquisa Agropecuária Brasileira**, v.47, n.4, p.550-560, 2012.

ARGENTA, L.C.; VIEIRA, M.J.; SOUZA, F.; PEREIRA, W.S.P.; EDAGI, F.K. Diagnóstico da qualidade de maçãs no mercado varejista brasileiro. **Revista Brasileira de Fruticultura**, v.37, n.1, p.48-63, 2015.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. **Regulamento técnico de identidade e qualidade da maçã.** Brasília, 2006. 9p. (Instrução Normativa, 5).

CHAVARRIA, G.; SANTOS, H.P. Manejo de videiras sob cultivo protegido. **Ciência Rural**, v.39, n.6, p.1917-1924, 2009.

FAOSTAT. FOOD AND AGRICULTURE ORGANIZATION AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS STATICAL DATABASES. Disponível em: <http://www.fao.org/faostat/en/#data/QC>. Acesso em: 1 abr. 2021.

FELICETTI, D.A.; SCHRADER, L.E. Changes in pigment concentrations associated with sunburn browning of five apple cultivars. II. Phenolics. **Plant Science**, v.176, n.1, p.84-89, 2009.

FENILI, C.L.; PETRI, J.L.; STEFFENS, C.A.; MARTIN, M.S.; AMARANTE, C.V.T.; HEIZEN, A.S. Alternativas para incrementar a coloração vermelha da epiderme em maçãs ‘Daiane’ e ‘Venice’. **Revista Brasileira de Fruticultura**, v.41, n.2, e128, 2019.

FERREIRA, D.F. Sisvar: a computer statistical analysis system. **Ciência e Agrotecnologia**, v.35, n.6, p.1039-1042, 2011.

GABARDO, G.C; SILVA, C.D.S, FENILI, C.L.; MARTIN, M.S.; COSER, W.; BLATTMANN, E. Densidade estomática de plantas de macieira cultivadas em regiões com diferentes altitudes. **Revista da 15a Jornada de Pós graduação e Pesquisa. Congrega Urcamp**, v.15, n.15, 2018.

IUCHI, V.L. **Botânica e fisiologia.** In: EMPRESA DE PESQUISA AGROPECUÁRIA E EXTENSÃO RURAL DE SANTA CATARINA - EPAGRI. A cultura da macieira. Florianópolis: Epagri, 2006. Ed.1, p.59-104.

IWANAMI, H. Breeding for fruit quality in apple. **Breeding for fruit quality**, p.173-200, Ed.1, 2011.

LAL, N.; SAHU, N. Management strategies of sun burn in fruit crops - a review. **International Journal of Current Microbiology and Applied Sciences**, v.6, n.6, p.1126-1138, 2017.

LI, F.; MIN, D.; SONG, B.; SHAO, S.; ZHANG, X. Ethylene effects on apple fruit cuticular wax composition and content during cold storage. **Postharvest Biology and Technology**, v.134, n.8, p.98-105, 2017.

LULU, J.; CASTRO, J.V.; PEDRO JUNIOR, M.J. Efeito do microclima na qualidade da uva de mesa ‘Romana’ (A 1105) cultivada sob cobertura plástica. **Revista Brasileira de Fruticultura**, v.27, n.3, p.422-425, 2005.

MELGAREJO, P.; MARTINEZ, J.J.; HERNANDEZ, F.; MARTINEZ-FONT, R.; BARROWS, P.; EREZ, A. Kaolin treatment to reduce pomegranate sunburn. **Scientia Horticulture**, v.100, n.3, p.349-353, 2004.

PETRI, J.L.; LEITE, G.B.; COUTO, M.; FRANCESCATTO, P. Avanços na cultura da macieira no Brasil. **Revista Brasileira de Fruticultura**, v.33, n.especial, p.48-56, 2011.

SANHUEZA, R.M.V., PROTAS, J.F.S., FREIRE, J.M. **Manejo da macieira no sistema de produção integrada de frutas.** Empresa Brasileira de Pesquisa Agropecuária-EMBRAPA. Bento Gonçalves: Embrapa Uva e Vinho, Ed.1, p.164. 2006.

SALVI, L.; CATALDO, E.; SECCO, S.; MATTII, G. Use of natural biostimulants to improve the quality of grapevine production: first results. **Acta Horticulturae**, v.45, n.1148, p.77-84, 2016.

SCHUHKNECHT, H.; DAMEROW, L.; KUNZ, A.; BLANKE, M. Einfluss von biostimulanzien und lichtreflexionsfolie auf die fruchtqualität und farbentwicklung bei apfel. **Erwerbs-Obstbau**, v.60, n.2, p.89-103, 2018.

SEZERINO, A.A. **Sistema de produção para a cultura da macieira em Santa Catarina.** EMPRESA DE PESQUISA AGROPECUÁRIA E EXTENSÃO RURAL DE SANTA CATARINA - EPAGRI. Florianópolis: Epagri, 2018, Ed.1, 136p.

SIERRAS, N.; BOTTA, A.; STAASING, L.; MARTINEZ, M.J.; BRU, R. Understanding the effect of amino acids based biostimulant by an enantiomeric analysis of their active principles and a proteomic profiling approach. **Acta Horticulturae**, n. 1148, v.11, p.93-100, 2016.

VALDEBENITO-SANHUEZA, R.M.; CANTILLANO, R.F.F.; BARTNICKI, V.A.; SPOLTI, P. Protetor solar diminui a incidência das podridões ‘olho-de-boi’ e ‘branca’ em maçãs ‘Fuji Standard’ e ‘Pink Lady’. **Revista Brasileira de Fruticultura**, v.38, n.1, p.92-98, 2016.

SCHVEITZER, B.; SUZUKI, A. **Métodos de análises químicas de polpa fresca de maçã.** EMPRESA DE PESQUISA AGROPECUÁRIA E EXTENSÃO RURAL DE SANTA CATARINA - EPAGRI. Florianópolis (Epagri - Documentos 241). 2013. 23p.

SEGATTO, F.B.; BISOGNIN, D.A.; BENEDETTI, M.; COSTA, L.C.; RAMPELOTTO, M.V.; NICOLOSO, F.T. Técnica para o estudo da anatomia da epiderme foliar de batata. **Ciência Rural**, v.34, n.5, p.1597-1601, 2004.