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Training systems and rootstocks on yield and agronomic performance of 'Syrah' grapevine in the Brazilian semiarid

Sistemas de condução e porta-enxertos na produtividade e desempenho agronômico de videiras 'Syrah' no semiárido brasileiro

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ABSTRACT

The Vale do São Francisco stands out among the main Brazilian wine regions, and 'Syrah' is a grape cultivar very important to produce red wines. The objective of this study was to evaluate the influence of training systems and rootstocks on the yield and other agronomic variables of 'Syrah' grapevines during eight consecutive harvests in the tropical semiarid environment in the Vale do São Francisco. An experiment was carried out in Petrolina, state of Pernambuco, with 'Syrah' trained to lyre and espalier systems and grafted on IAC 572, IAC 766, IAC 313, SO4, 1103 Paulsen and Harmony rootstocks. A randomized block design with four replicates and split plots was used. There was a significant interaction between the training system and rootstock for yield, number of clusters and foliar mass. The lyre system increased yield, cluster number and Ravaz index, favoring the development of more balanced grapevines. The IAC 572 rootstock promoted greater vigor by reducing yield, cluster number, bud fertility and Ravaz index. The other rootstocks were similar to each other in most variables. Net photosynthesis, stomatal conductance and instantaneous efficiency of water use were not influenced by the training system and the rootstock. The results obtained evidenced the influence of the training system associated to the rootstock on agronomic variable and yield of 'Syrah', recommending lyre training and grafting on 1103 Paulsen or IAC 313 in the semi-arid tropical conditions of the Vale do São Francisco.

Index Terms: Winegrape; tropical viticulture; *Vitis vinifera*.

RESUMO

O Vale do São Francisco destaca-se entre as principais regiões vitivinícolas brasileiras, sendo o cultivar 'Syrah' muito importante na elaboração de vinhos tintos. O objetivo deste trabalho foi avaliar a influência do sistema de condução e porta-enxerto sobre o rendimento e outras variáveis agronômicas do cultivar 'Syrah' durante oito safras consecutivas em ambiente tropical semi árido no Vale do São Francisco. Um experimento foi realizado em Petrolina, PE, avaliando-se videiras 'Syrah', conduzidas nos sistemas de lira e espaldeira e enxertadas sobre os porta-enxertos IAC 572, IAC 766, IAC 313, SO4, 1103 Paulsen e Harmony. Utilizou-se delineamento experimental em blocos ao acaso com quatro repetições e parcelas subdivididas. Observou-se interação significativa entre sistema de condução e porta-enxerto para produção, número de cachos e massa foliar. O sistema de condução em lira aumentou a produção, número de cachos e índice de Ravaz, favorecendo o desenvolvimento de videiras mais equilibradas. O porta enxerto IAC 572 promoveu maior vigor reduzindo significativamente a produção, número de cachos, fertilidade de gemas e índice de Ravaz. Os demais porta enxertos foram similares entre si na maioria das variáveis. Fotossíntese líquida, condutância estomática e eficiência instantânea do uso da água não foram influenciadas pelo sistema de condução e porta enxerto. Os resultados obtidos evidenciam a influência do sistema de condução associado ao porta-enxerto sobre variáveis agronômicas da videira 'Syrah', recomendando-se o seu cultivo em lira enxertada sobre 1103 Paulsen ou IAC 313 nas condições tropicais semiáridas do Vale do São Francisco.

Termos para indexação: Uva de vinho; viticultura tropical; *Vitis vinifera*.

INTRODUCTION

Tropical winegrowing in Brazil is concentrated in the Vale do São Francisco between 9º and 10º South latitude, where the tropical semiarid climate combined with the availability of water for irrigation favors the development of viticulture with unique characteristics, compared to other wine regions in the world. In tropical conditions the duration of a vine's phenological cycle (budburst to full maturation) is reduced 30 to 50 days compared to that in temperate climate and the grapes harvested can have high soluble solids content throughout the year (Leão; Silva, 2014). In addition, up to two harvests can be carried out at any time of the year, which is the main competitive advantage of tropical viticulture.

The production of *Vitis vinifera* wines is distributed in an area of ≈ 400 ha of vineyards, whose grapes are processed in four wineries, obtaining about four million liters of red, white and sparkling wines per year. They are characterized as young wines, known as ‘wines of the sun’, presenting typical aromas and flavors, and to a lesser rate, wines aged in barrels, that spend a few years in oak barrels, which promotes a greater complexity of aromas and structure of the wines. In the Vale do São Francisco, ‘Syrah’ corresponds to approximately 65% of the red wines, and it is still used in the elaboration of sparkling wines (Camargo et al., 2011). The ‘Syrah’ wines made in this region are characterized by the high content of tannins, structure, acidity and high alcohol potential.

The grapevine has a climbing habit and therefore requires a structure to support the vegetative canopy, called the training system. What distinguishes the existing training systems are the forms of division and orientation of the canopy, being able to be classified in three main types: a) espalier: the shoots of the vines grow vertically; b) pergola: the shoots of the vines develop in the horizontal direction and c) lyre or Y-trellis: the shoots grow on a 45° angle to the cane or cordon. Each of these systems is related to the exposure of the leaf area and the clusters to the direct incidence of solar radiation, modifying the microclimate inside the vineyard.

The training system shall meet the following objectives: (a) allow adequate distribution of arms and shoots of the grapevine in order to maximize the interception of light; b) facilitate the mechanization of vineyard operations and the efficiency of phytosanitary control; c) avoid competition of leaves by light; d) allow the renewal of the vegetative canopy by pruning and maintenance of vine shape and architecture and productivity over time (Reynolds; Vanden Heuvel, 2009).

The espalier is one of the most important training systems adopted in most of the viticulture countries of the world, especially for the production of wine grapes. It is characterized by the vertical position of the vegetative canopy, spur pruning and cordon training. The lyre system was developed by the INRA (Bordeaux Research Center, France) and is characterized by a canopy divided into two vegetation planes slightly inclined outwards, which promotes a high exposed leaf surface (ELS), increasing the interception of solar energy and photosynthetic activity and consequently producing fruits of better quality.

The training system changes the microclimate, canopy architecture, vine spacing, shading, and canopy leaf area (Rodrigues et al., 2016). These changes significantly affect the efficiency of the grapevine as to the interception of the radiation that will be used in photosynthetic processes (Norberto et al., 2009). The vegetative canopy division that occurs in lyre, GDC and Scott Henry-type training systems favors the reduction of shading with positive effects on the increase of fruiting, yield and improvement in the composition of the grapes (Reynolds; Vanden Heuvel, 2009).

In the same way as the training system, the rootstock also has effects on water relations, gas exchange, phenology, vigor, yield and quality of grapes and wines (Dias et al., 2012; Souza et al., 2015; Miele; Rizzon, 2016; Loureiro et al., 2016). Its use should be recommended for adaptation to abiotic stresses such as salinity, dryness, acidic, alkaline, low fertility and shallow soils, as well as biotic stresses such as pests and diseases.

In the Vale do São Francisco, evaluation of rootstocks was carried out mainly in ‘Thompson Seedless’, ‘Sugraone’ and ‘Crimson Seedless’ table grapes (Leão et al., 2011; Leão; Borges, 2011), and in commercial areas IAC 572, IAC 313, IAC 766, SO4, 1103 Paulsen and Harmony have been used. In Jundiaí, São Paulo state, IAC 572 and IAC 571-6 rootstocks showed higher production for Syrah (Orlando et al., 2008). However, in the state of Minas Gerais, 1103 Paulsen favored a better balance between vigor and yield, also resulting in better Syrah grape quality (Dias et al., 2012).

Despite the importance of the training system and the rootstock, as well as of a possible interaction between them, there is no information available in the literature for ‘Syrah’ grapevine in semiarid tropical conditions. The present research has the objective to study the influence of the training system associated to rootstocks on the yield and agronomic performance of the ‘Syrah’ grapevine during eight consecutive harvests in a semiarid tropical environment in the Vale do São Francisco, in northeast Brazil.

MATERIAL AND METHODS

Experimental area and plant material

The experiment was carried out in the experimental field of Bebedouro, belonging to Embrapa Semiarido, municipality of Petrolina, State of Pernambuco (9° 08’03” S, 40° 18’28” W and 370 m of altitude), during the period of 2013 to 2017, with three harvests in the first growing season of the year and five harvests in the second half of each year, for a total of eight production cycles. According to the climatic classification of Koppen-Geiger, the climate is semi-arid tropical, BSwh type, dry and warm (Reddy; Amorim Neto, 1983), with an annual average temperature around 26 ºC and annual rainfall of ≈ 500 mm, concentrated between the months of January and April. The maximum, mean, and minimum temperatures, radiation and precipitation, monthly averages for the experimental period are in Figure 1.

The experimental area presents soil classified as Plistilic abrupt Eutrophic Red Argisol with moderate A, medium texture and flat relief (Cunha et al., 2008).

'Syrah' was grafted onto rootstocks IAC 313 (Golia X *Vitis cinerea*), IAC 572 (*Vitis caribaea* X 101-14 Mgt), IAC 766 (Ripária do Traviú X *Vitis caribaea)*, 1103 Paulsen (*Vitis berlandieri* X *Vitis rupestris*), SO4 (*Vitis berlandieri* X *Vitis riparia)* and Harmony ((Solonis X Courdec 1613) X Dog Ridge) and grown on lyre and espalier systems. The IAC group are Brazilian rootstocks developed by grape breeding program of Instituto Agronômico de Campinas, São Paulo. The experimental design was a randomized block in split plots, the plot being represented by two training systems and the subplots composed of six rootstocks. Each subplot was represented by 10 vines.

In both training systems, three wires were used, the first one at a 0.90m height where the cordons were tied and the other wires spaced ≈ 0.5 m apart. The lyre presented an opening of 30° between the two planes of the vegetative canopy.

The grapevines were planted at a 3.0 x 1.0 m spacing on the espalier and 4.2 x 1.0 m in the lyre and drip irrigated, using two drippers per vine spaced at 0.50 m, with medium flow of 2.10 $L.h^{-1}$. The irrigation had daily frequency, and the amount of water applied was determined based on crop evapotranspiration ($ETc = ET_0 \times Kc$). The nutrients were supplied by means of fertigation according to the needs indicated by the soil analysis (Silva et al., 2010). Two pruning were performed per year in a spur-pruned cordon, with an average of 17 nodes per vine on the espalier and 32 nodes per vine in the lyre. In addition to pruning, the cultural treatments included weekly sprays for phytosanitary control, mechanical cultivation and herbicide application for weed control, and management of the canopy by removing unnecessary shoots and hedging of the shoots.

Agronomic evaluation

The following agronomic variables related to the production and vigor components of the grapevines were evaluated in three vines per plot: a) Fresh mass of the shoots and leaves: determined after pruning by weighing the vegetal material on a digital electronic scale (Ramuza DCR-15), in kilograms (kg); b) Ravaz index: determined by the ratio between mass of clusters harvested and mass of cane prunings expressed in kg of grapes kg^{-1} of cane prunings (Cus, 2004); c) yield per vine: evaluated at harvest by weighing all clusters harvested on each vine, by digital scale, in kilograms (kg); d) yield per hectare: estimated by multiplying yield per vine by the density of vines per hectare, expressed in tons per hectare ($t\ ha^{-1}$); e) number of clusters: obtained by counting all clusters; f)

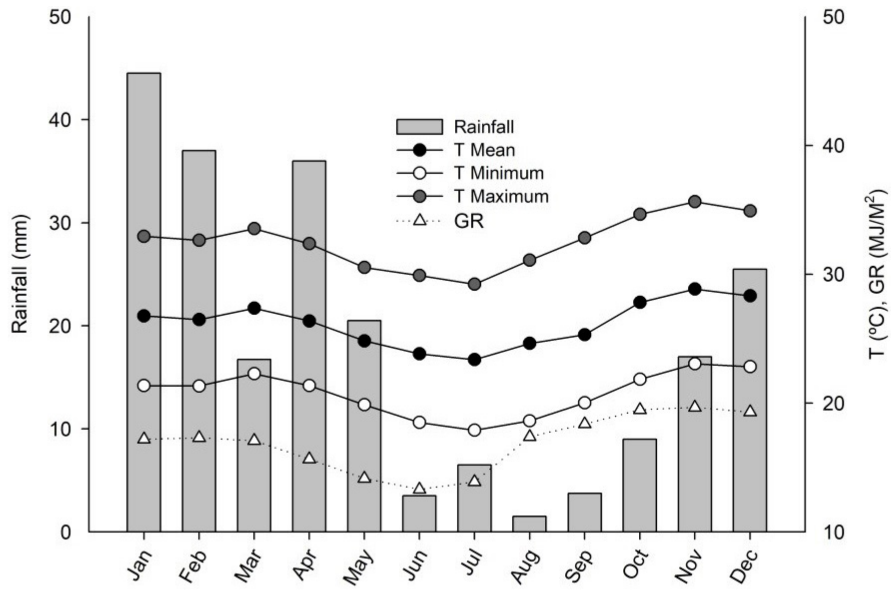

Figure 1: Monthly averages of rainfall (mm); mean, minimum and maximum air temperature (°C); and global radiation (MJ/m2) during the period of 2013 to 2017 in the experimental station of Bebedouro, Petrolina, Pernambuco, Brazil.

mass of the cluster: determined by dividing the total mass of clusters by the cluster number per vine, expressed in grams (g); f) sprouting: determined in the phenological stage of sprouting by counting all buds and shoots, and calculated by the equation: (number of shoots/number of buds) X 100, expressed as a percentage (%) and; g) Fertility Index of Buds: obtained by count of shoots and clusters, and calculated by the equation (cluster number/ number of shoots) and expressed as cluster $shoot^{-1}$.

Gas exchange

Gas exchange evaluations were carried out on two consecutive days in both 1st and 2nd stages of fruit growth, at 55 and 90 days after pruning, respectively, in the years of 2015 and 2017. Between 0800 and 1200h the following variables were estimated: net photosynthesis (A), stomatal conductance (g_s), transpiration rate (E), the ratio of internal concentration and environment CO_2 (C_i/C_a) and the instantaneous water use efficiency (A/E) using the portable infrared gas analyzer (LI-6400 model, LI-COR, NE), and the evaluations performed on healthy, adult and external leaves of upper shoots of vines in an open system, under saturating photon flux density of 1100 $\mu mol\ m^{-2}\ s^{-1}$ ambient CO_2 concentration (Chaves et al., 2016). Data are presented as the mean of the two evaluation days, with their respective standard error.

Statistical analysis

The results were submitted to the normality test of the Shapiro-Wilks variance. The variables that met the normality assumption were submitted to analysis of variance (F Test, $p \leq 0.05$) and Tukey mean comparison test ($p \leq 0.05$), being considered as sources of variation the main plot and the rootstocks as subplots. The variables cluster number per vine and percentage budburst did not show normal distribution and were transformed into log (x). The gas exchange data were presented with the average and its respective standard error.

RESULTS AND DISCUSSION

Yield per vine and cluster number were influenced by the interaction between training system and the rootstock in the first growing season of the year (Table 1), while in the second harvest, this interaction occurred for cluster number and leaf mass (Table 2). In the first growing season of the year, the lyre favored a greater yield in the grapevines grafted on Harmony, IAC 313 and 1103 Paulsen, but in the other rootstock there were no differences between the training systems (Table 1).

Lyre-trained vines showed higher yields in the average of the harvests of the second growing season of the year (Table 3), as a consequence of the higher cluster number, which is in agreement with several studies on other cultivars in split canopy systems (Reynolds; Vanden Heuvel, 2009). Favero et al. (2010) also found higher yields on ‘Syrah’ grapevines conducted with split canopy of GDC type compared to espalier, with similar results in ‘Cabernet Sauvignon’ (Pedro Júnior et al., 2016) and ‘Riesling’ (Reynolds et al., 2004). The higher yield of *V. vinifera* in divided canopy training systems such as lyre and GDC can be attributed to a greater exposed leaf surface for the light interception, as well as the higher number of buds per unit length of cordon (Reynolds; Vanden Heuvel, 2009).

Table 1: Mean values and coefficients of variation for production (kg/vine), and number of clusters per vine in ‘Syrah’ grapevines on the lyre and espalier systems on six rootstocks; means of four harvests in the first growing season of the year, Petrolina, PE, Brazil, 2012 to 2017.

Rootstocks	Yield (kg $vine^{-1}$)		Number of clusters[2]	
	Espalier	Lyre	Espalier	Lyre
Harmony	3.0abB	4.2aA	22abB	32aA
IAC 313	3.4aB	4.4aA	24aB	37aA
IAC 572	2.5bA	2.3bA	18bB	24bA
IAC 766	2.6abA	4.9aA	19abB	39aA
1103 Paulsen	3.4abB	5.1aA	24aB	38aA
SO4	3.3abA	4.4aA	23aB	33aA
Mean	3.0B	4.3A	22B	34A
CV (%)	13.69	16.39	3.28	2.83

[1]Means followed by the same small letter in the column and capital letter in the line do not differ by Tukey test ($p < 0.05$); ns: not significant; [2]Data did not show normal distribution and were transformed into root (x) +1.

Table 2: Mean values and coefficients of variation for number of clusters per vine and leaf mass (g/vine) in 'Syrah' grapevine son the lyre and espalier systems on six rootstocks; means of five harvests in the second growing season of the year, Petrolina, PE, Brazil, 2012 to 2017.

Rootstocks	Number of clusters[2]		Mass of leaves ($kg.vine^{-1}$)	
	Espalier	Lyre	Espalier	Lyre
Harmony	15bB	21cdA	0.546cA	0.502dA
IAC 313	17aB	28abA	0.744aA	0.730abA
IAC 572	12cB	17dA	0.726abA	0.811aA
IAC 766	14 bcB	25abcA	0.760aA	0.644bcB
1103 Paulsen	17aB	30aA	0.634bcA	0.581cdA
SO4	17aB	24bcA	0.612cA	0.608bcdA
Mean	15B	24A	0.670A	0.646A
CV (%)	2.46	4.59	6.46	9.03

[1]Means followed by the same small letter in the column and capital letter in the line do not differ by Tukey test (p <0.05); ns: not significant; 2Data did not show normal distribution and were transformed into root (x) +1.

Table 3: Mean values and coefficients of variation for production and vigor components in 'Syrah' grapevine strained to lyre and espalier systems on six rootstocks, Petrolina, PE, Brazil, 2012 to 2017.

Training Systems	Yield ($kg.vine^{-1}$)	Number of clusters[2]	Cluster mass (g)	Mass of cane prunings ($kg.vine^{-1}$)	Mass of leaves ($kg.vine^{-1}$)	Fertility index ($clusters.shoot^{-1}$)	Ravaz Index
Average harvest of the 1st growing season of the year							
Espalier	3.0b	22b	143.8^{ns}	0.58^{ns}	0.93b	0.81^{ns}	5.8b
Lyre	4.2a	34a	130.3	0.63	1.26a	0.69	8.0a
Mean	3.6	28	137.1	0.60	1.09	0.75	6.9
CV(%)	15.75	3.04	12.98	17.63	15.0	16.50	21.9
Harmony	3.6a	27a	137.6^{ns}	0.72ab	0.88c	0.73ab	9.4a
IAC 313	3.9a	31a	137.6	0.72ab	1.27a	0.80a	6.1bc
IAC 572	2.5b	22b	128.9	0.74a	1.26a	0.57b	4.0c
IAC 766	3.8a	29a	137.7	0.63abc	1.13ab	0.75ab	6.3b
1103 Paulsen	4.3a	31a	142.4	0.55cd	0.90bc	0.88a	8.0ab
SO4	3.8a	28a	138.4	0.57bc	1.12abc	0.77a	7.7ab
Average harvest of the 2nd growing season of the year							
Espalier	2.5b	15b	163.9a	0.55b	0.67^{ns}	0.77a	4.4b
Lyre	3.2a	24a	139.0b	0.62a	0.65	0.61b	5.2a
Mean	2.9	20	151.5	0.59	0.66	0.69	4.8
CV(%)	10.65	9.95	8.16	14.32	7.8	11.59	6.4
Harmony	2.3b	18c	134.2b	0.36d	0.52c	0.67ab	5.6a
IAC 313	3.5a	22ab	163.9a	0.63bc	0.74a	0.77a	5.3ab
IAC 572	2.0b	15d	137.6b	0.78a	0.77a	0.57b	2.3c
IAC 766	3.1a	19c	165.2a	0.65b	0.70a	0.67ab	4.2b
1103 Paulsen	3.4a	24a	150.8ab	0.52c	0.61b	0.77a	6.2a
SO4	3.0a	20bc	157.2a	0.57bc	0.61b	0.69b	5.1ab

[1]Means followed by the same letter in the column do not differ by Tukey test (p <0.05); ns: not significant; [2]Data did not show normal distribution and were transformed into root (x) +1.

The cluster number per vine was higher in the lyre-trained vines in all rootstocks and in the two production periods evaluated in this study (Tables 1 and 2), consistent with other authors in different cultivars of *V. vinifera* (Pedro Junior et al., 2016; Favero et al., 2010), as a consequence of the higher bud load maintained after pruning in grapevines with split canopy. The IAC 572 rootstock reduced the yield and cluster number independent of the training system used, but no differences were observed in the first harvest of the year (Table 1).

In the second growing season of the year, yield was lower on IAC 572 and Harmony, while the cluster number on grapevines grafted on 1103 Paulsen was higher than the other rootstocks except IAC 313 (Table 3).

These results disagree with Orlando et al. (2008) which achieved higher yields on 'Syrah' grapevines grafted on IAC 572. Dias et al. (2012) mentioned that there were no effects of the SO4, 110 Richter and 1103 Paulsen rootstocks on the yield of 'Syrah' in the South of Minas Gerais, but in another study in this same region, the IAC 766 rootstock increased yield and cluster number in 'Syrah' compared to other rootstocks including 1103 Paulsen and SO4 (Dias et al., 2017). The different results obtained with the same cultivar demonstrate that the responses to the rootstocks depend on the interaction of several factors such as the edaphoclimatic conditions of the producing region, vineyard management, and vine age, among others.

In the first harvest of the year, the estimated average yields were similar in both training systems, reaching 10 $t.ha^{-1}$, while in the second harvest; there was a reduction in yield whose estimated averages reached 7.9 $tons.ha^{-1}$ in the lyre and 8.6 $tons.ha^{-1}$ in the espalier system. The differences between yield per vine, whose values were higher in the lyre, and the estimated yield per hectare, can be justified by the lower density of vines in the lyre system. Considering the same density of 3333 vines per hectare in the lyre and espalier, the estimated yield in the lyre would be 14.2 $tons.ha^{-1}$ for the first growing season of the year and 10.8 $tons.ha^{-1}$ in the second half, representing increases of 29 and 22%, respectively, compared to the espalier.

The cluster mass reached higher values in the espalier training system and in the rootstocks IAC 766, IAC 313, SO4 and 1103 Paulsen (Table 3). The bud fertility index was lower in grapevines grafted on IAC 572 in the first and second growing season of the year, as a consequence of the greater vigor and shading of the grapevines in this rootstock. The fertility of grapevine buds is reduced by shading and overlapping layers of leaves that prevent the exposure of the buds to solar radiation. According to Reynolds and Vanden Heuvel (2009), split canopy systems reduce shading which favors the increase of buds' fertility, which was not observed in this study.

Vines grown in lyre increased the mass of the shoots, which can be explained by the higher number of shoots observed in the split canopy (Favero et al., 2010; Reynolds and Vanden Heuvel, 2009). Responses were observed of the rootstock to the leaves and mass of cane prunings, with higher values in the rootstock of the IAC group, however IAC 572 was the most vigorous rootstock, whose cane pruning mass differed from 1103 Paulsen and SO4 in the first growing season of the year, and all the other rootstocks in the second one (Table 3). Greater leaf mass was observed in the IAC 572 and IAC 313 rootstocks than in Harmony and 1103 Paulsen, however, in the second harvest of the year, there was a significant interaction between the training systems and the rootstocks, but there was still a tendency of greater leaf mass on IAC 313 and 572 in both training systems (Table 2).

The higher vegetative vigor observed in grafted grapevines on IAC 572 can be explained by the greater root development of this rootstock (Bassoi et al., 2007), since the development of the aerial part of the grapevine is intrinsically associated with its root development (Smart et al., 2006). The highest number of canes on IAC 766 rootstocks were observed in the Syrah (Dias et al., 2012) and Cabernet Sauvignon cultivars (Souza et al., 2015) and also in IAC 572 in 'Niagara Rosada' (Mota et al., 2010). The 1103 Paulsen rootstock stood out in terms of lower vine vigor, consistent with Dias et al. (2012), who also found lower cane pruning mass of 'Syrah' on this rootstock. In general, low or moderate vigor rootstocks promote the production of better quality wines, as a consequence of the greater luminosity in the region of the clusters and the better balance between vegetative and reproductive growth.

The relationship between the reproductive and vegetative growth of the grapevine determines the grapevine balance, and can be expressed by the Ravaz index, which is the relation between yield per vine and weight of cane prunings, whose values suggested by Bravdo et al. (1985) for *Vitis vinifera* should be between 10 and 12, while Smart and Robinson (1991) recommend values between 5 and 10. The vineyard management should aim at the development of balanced grapevines, ensuring stable yields over consecutive crops and without compromising the quality of the grapes.

The lyre training system favored the development of grapevine with higher Ravaz index in the first and second growing seasons of the year, as a consequence of the higher production of grapes in this training system. Rootstocks with moderate vigor such as Harmony, 1103 Paulsen and SO4 resulted in more balanced grapevines with values ranging from 7.7 to 9.4 in the first harvest of the year and 5.1 to 6.2 in the harvest of the second. These values evidenced the development of balanced grapevine and were higher than those observed in ‘Cabernet Sauvignon’ on 1103 Paulsen in Santa Catarina state, in southern Brazil (Brighenti et al., 2012).

The values of net photosynthesis, stomatal conductance and instantaneous water use efficiency in 2015 and 2017 (Figures 2 and 3) did not differ between the training systems and rootstocks, indicating that the vines did not obtain positive benefit with the adoption of a specific training system or rootstock.

Only transpiration values (Figures 2C and 3C) tended to be higher in vines grown on espalier, which may be due to the greater exposure of their leaves to the incidence of solar radiation, air temperature and the effect of air currents that provide greater need of vines transpiration in order to avoid heating in the physiological systems of the vines (Chaves et al., 2008). Noberto et al. (2009) obtained similar responses in ‘Folha de Figo’ and ‘Niagara Rosada’ grapevine cultivated in lyre and espalier in Caldas, Minas Gerais state, in which there was no interference of the training system in the components of the gas exchange. In another study, Sanchez-Rodriguez et al. (2016), evaluating gas exchange in ‘Niagara Rosada’ on lyre and Y-trellis, did not find a positive effect when comparing the training systems. Based on the information described so far, the adoption of different grapevine training systems did not provide significant gains in gas exchange.

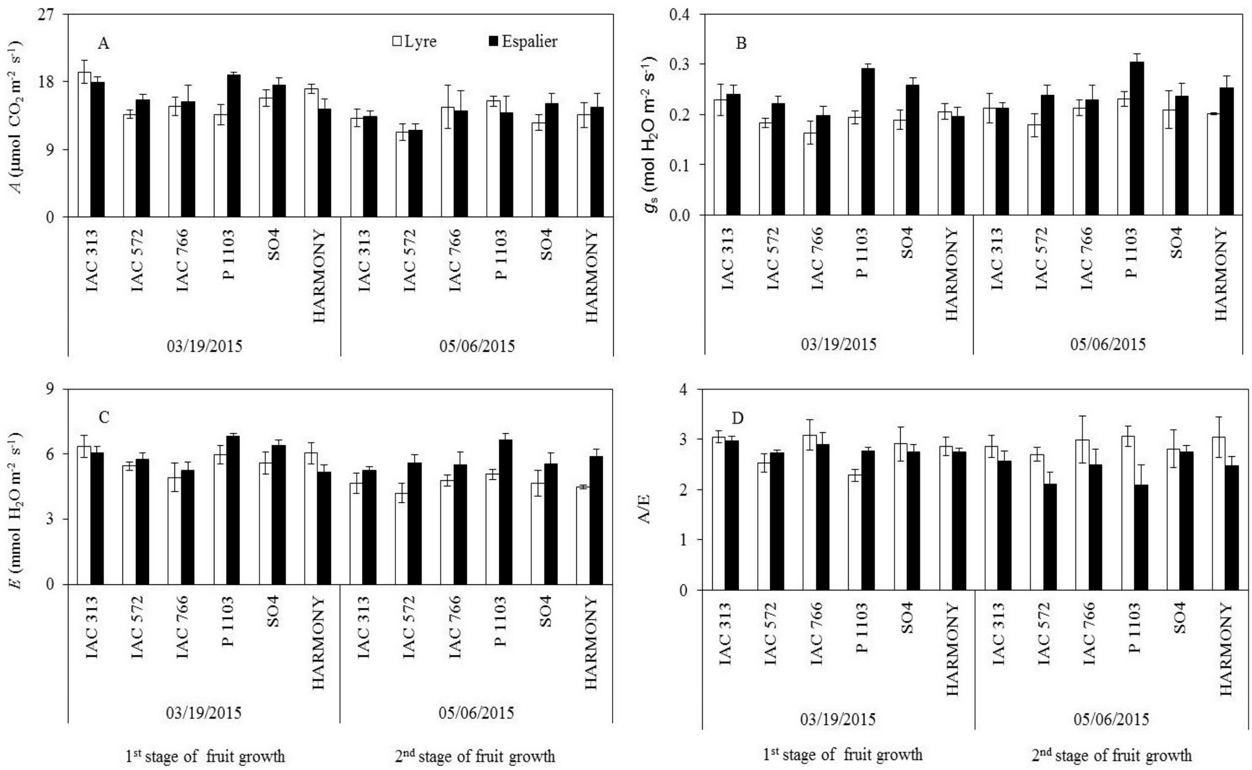

Figure 2: Values of net photosynthesis (*A*) [*A*], stomatal conductance (g_s) [B], transpiration (*E*) [C] and instantaneous water use efficiency (*A/E*) [D], observed in ‘Syrah’ grapevines, grafted on six rootstocks and cultivated in lyre (empty columns) and espalier (full columns), in the 1st and 2nd stages of fruit growth in the 2015 cycle, Petrolina, Pernambuco, Brazil. Each column represents an average of four vines and the bars indicate an error standard of the average.

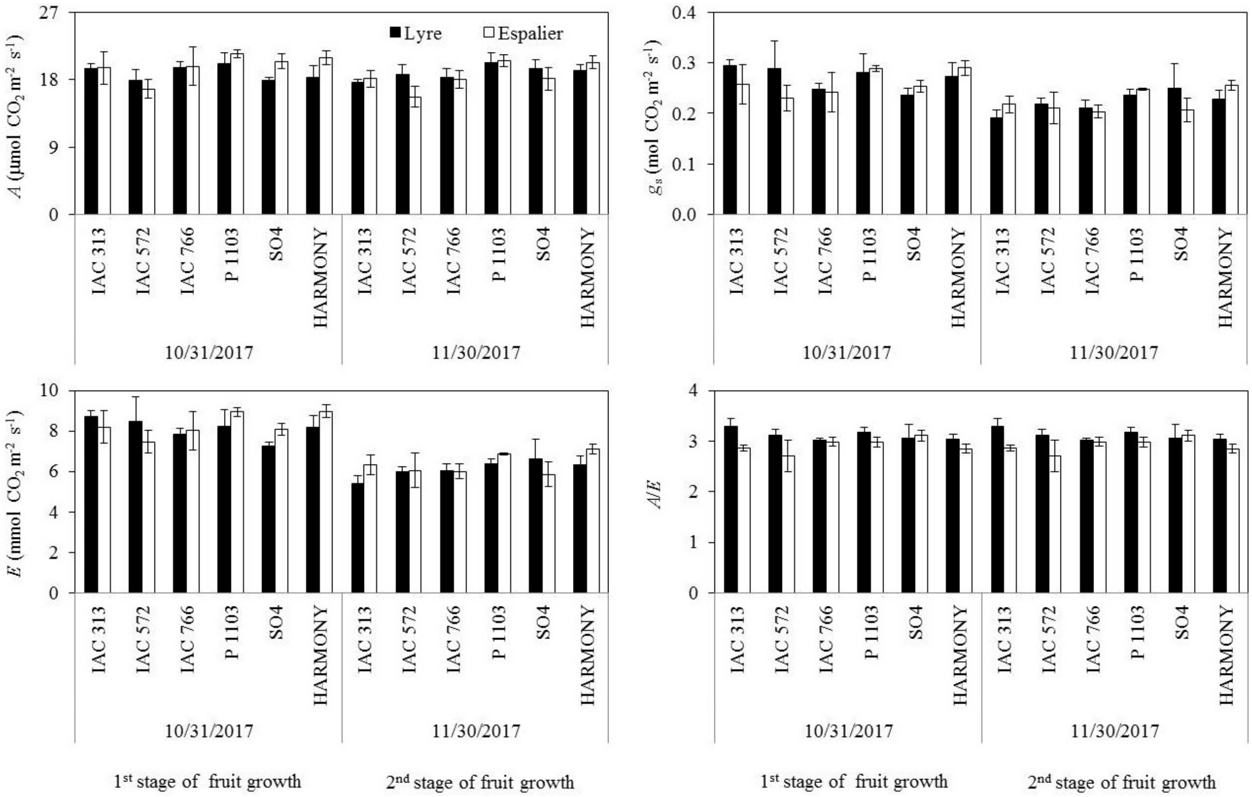

Figure 3: Values of net photosynthesis (*A*) [A], stomatal conductance (g_s) [B], transpiration (*E*) [C] and instantaneous water use efficiency (*A/E*) [D] observed in 'Syrah' grapevines, grafted on six rootstocks and cultivated in lyre (empty columns) and espalier (full columns), in the 1st and 2nd stages of fruit growth in the 2017 cycle, Petrolina, Pernambuco, Brazil. Each column represents an average of four vines and the bars indicate error standard of the average.

CONCLUSIONS

The training system associated with rootstock have influence on the yield and agronomic performance of 'Syrah' grapevines, but few responses are observed in the physiological variables. 'Syrah' should be grown on the lyre system using either 1103 Paulsen or IAC 313 rootstocks in order to optimize yield and vine balance in semi-arid tropical conditions such as those of the Vale do São Francisco, in northeast Brazil. However, a recomendation of training system and rootstock should also consider results of the physical-chemical and sensory characteristics of Syrah wines in the vale do São Francisco.

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