Ecophysiology and yield performance of grape *Cabernet sauvignon* cultivated under different exposures

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ABSTRACT. Grapes are widely grown in various regions of the world; in Brazil, viticulture is considered to be an important form of agriculture. There are two distinct market branches: wine and other distilled alcoholic products and natural juice, plus the domestic consumption. The production of wine, grape-juice and by-products from the wine industry occurs in twelve Brazilian regions, with a larger concentration in the states of Rio Grande do Sul and São Paulo. Grape-crop management depends upon such agro-meteorological variables as temperature, solar radiation, atmospheric humidity and water availability, since these can greatly influence both crop yield and quality. For regions where most of the rain coincides with the development and maturation of the fruit, the search for alternative management is justified, the aim being to mitigate that impact over the quality of the fruit, particularly with respect to wine production. An experiment with grape-wine was carried out in Jundiaí (SP), at *Centro de Fruticultura do Instituto Agronômico* (Fruit-growing Center of the Farming Institute), IAC (23º06' S; 46º55' W, 715m). The search was focused on the microclimate modification in the environment of cultivated grapes, from its conduction in a partially modified crop-cultivation environment, as well as to evaluate the impact of this practice on the growth and development of the crop. A comparison was made by observing the growth of the same culture in a natural environment. The results showed that the use of a plastic cover to cultivate grapes created a micro-environment that was characterized by a decrease in the levels of solar radiation, an increase of the maximum temperatures and the persistence of higher saturation deficit levels.

Key words: *Cabernet sauvignon*, microclimate.

RESUMO. Parâmetros ecofisiológicos e produtividade da videira *Cabernet sauvignon* conduzida sob diferentes ambientes. O cultivo da videira é amplamente difundido nas diversas regiões do mundo, sendo uma cultura de importância agrícola no Brasil. Há dois mercados distintos, o de vinho e outros destilados alcoólicos e o da fruta de mesa e suco natural. A produção de vinhos, suco de uva e derivados do vinho ocorrem em doze regiões brasileiras, com maior concentração nos estados do Rio Grande do Sul e São Paulo. As práticas de cultivo da videira estão condicionadas a variáveis agrometeorológicos, particularmente, pela temperatura, radiação solar, umidade atmosférica e disponibilidade hídrica no solo, que influenciam na produtividade e qualidade da produção. Para regiões onde a maior incidência pluvial coincide com o desenvolvimento e maturação dos frutos, se justifica a busca de alternativas de cultivo para atenuar esse impacto sobre a qualidade da produção, principalmente de uvas viníferas. Um experimento com a cultivar *Cabernet Sauvignon* foi conduzido em Jundiaí (SP), no Centro de Fruticultura do Instituto Agronômico, IAC (23º06' S, 46º55' W, 715m). Objetivou-se estudar as alterações microclimáticas ocorridas no ambiente de cultivo de videira-vinífera advindas da sua condução em ambiente parcialmente modificado, bem como avaliar o impacto desta prática sobre parâmetros do crescimento e desenvolvimento da cultura, comparando-se com observações feitas no cultivo em ambiente de céu aberto. Os resultados mostraram que o uso de túnel de polietileno no cultivo da videira causou, no micro-ambiente estabelecido, a diminuição do nível de radiação solar, aumento das temperaturas máximas e persistência de maiores níveis de déficit de saturação.

Palavras-chave: Cabernet-sauvignon, cultivo protegido, microclima

Introduction

Grapes are widely cultivated in Brazil. They are grouped into more than 90 species, amongst which are those from America (*Vitis labrusca L.*) and from Europe (*Vitis vinifera L.*), whose economic yield value is recognized.

The production of wine, grape-juice and by-products of grapes occurs in twelve regions of the country, with most of it being concentrated in the states of Rio Grande do Sul and São Paulo (Embrapa Uva e Vinho, 2003).

Among the varieties used for wine production is the *Cabernet Sauvignon*, whose origin is in the Médoc region of Bordeaux, in France.

For those regions of Brazil where most of the vineyard production is of the table-grape type, the surplus of rain, during the fruit development and maturation period, sometimes does not allow sufficient fruit-sugar accumulation to produce qualities wine. The best quality wines are those made from grapes with high levels of sugar concentration and low levels of acidity (Bevilaquia, 1995).

The water availability theme has been considered a controversial issue in traditional viticulture, because one of its major effects on grapevines has increased plant growth. The use of assimilates for leaf growth restricts the fruit set and development, whereas excessive leaf area can lead to excessive water loss, fungal diseases and shading of the fruit, causing reduction in both fruit and wine quality (Sousa e Martins, 2002). Therefore variation in grape quality is largely dependent upon irrigation dosage and scheduling, environmental conditions and cultivar (Medrano *et al.*, 2003). Moreover, the combined incidence of micro-meteorological variables, such as temperature and solar radiation, can create fluctuating conditions of vapor pressure deficit, which can, in turn, influence water-use efficiency, leaf-gas exchange, and therefore grape yield and quality.

The use of cultivation under a plastic greenhouse has been shown to be promising for many species, improving the final quality of products (Sousa, 2001). Cultivation based upon partial modification of the environment, however, can influence the relationship between plant and the near atmosphere, due to the alteration in the micro-meteorological regime of variables such as average maximum and minimum temperatures, and solar radiation, which can impact on the growth and development processes and the final yield (Buriol, 1993; Farias, 1993).

For plastic greenhouses, one of the most changed variables is the incidence of solar radiation. Plastic used in greenhouses is permeable for short-wave and long-wave radiation, whose values lie between 80 and 90%, varying with the thickness of the plastic, its chemical composition, age and dust-level presence. The most common phenomenon expected for the plastic greenhouse environment is the retention of energy, which is retained inside by the plastic covering.

The cultivation of grapevines under plastic cover is not well documented, and could be an alternative management strategy, envisaging quality yield for wine production. This is particularly important for the State of São Paulo, where the incidence of rain is concentrated during the period of fruit set, development and maturation.

This experiment is therefore aimed at studying the impact on the growth, development and yield of the Cabernet Sauvignon grapevine when cultivated under plastic greenhouse conditions, compared to its cultivation in the natural environment, searching for basic support for grapevine management.

Material e methods

Time and place

The experiment was carried out in the vineyard of Centro APTA Frutas- Instituto Agronômico (IAC), located at Jundiaí (SP), (23º06’ S; 46º55’ W, 715m).

A two-year old Cabernet Sauvignon grapevine was used in the trial. The vines were trained on a vertical trellis, and spaced at 1m in the row and 2 m between rows. The rows were orientated in an east-westerly direction. The vines were grafted on the following rootstocks: IAC 766 - Campinas, IAC 572 - Jales, and Ripária do Traviú.

Water for the vines inside the plastic greenhouse was delivered by a micro-trickle system. The depth of water delivered was in accordance with the vine’s water requirements for the climatic region, following “class A Pan” averaged evaporation. The pruning of the vineyard was last done on the 26th of August, 2002.

Crop management for weed and disease control was done based on that recommended for the region.

Growing conditions

Two parallel systems of cultivation were conducted in the vineyard: a vineyard of about 400m^2 in area was cultivated in natural conditions (ANC), while another of approximately the same area was installed under plastic cover. This environment was a polyethylene tunnel in shape(APGH) (Figure 1)

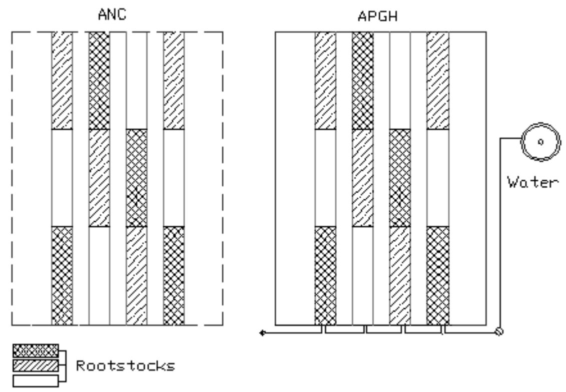

Figure 1. Diagram showing the general layout of the experiment for the Cabernet Sauvignon, cultivated in three different rootstocks, set in a) natural conditions (ANC) and b) under plastic cover (APGH), in Jundiaí, State of São Paulo, Brazil.

For the construction of the plastic greenhouse, a low-density polyethylene, 150 µm thick and designed to block ultraviolet light, was used.

The covering of a tunnel shape, was installed in the growing season of 2001/2002. The plastic covering was set out with a 3m "right-column" and a central vertical free space of 4m. The ends and sides of the tunnel were kept permanently open. The total area of the plastic greenhouse was 350m^2, and its orientation arranged on an east-westerly axis.

Statistical layout

The experiment was set in a randomized block design. Treatments were consisted of a *Cabernet Sauvignon* grapevine, grafted in three different rootstocks: IAC 572 *Jales*, IAC 766 *Campinas*, and *Ripária do Traviú*. For each cultivation environment (APGH and ANC), three different treatments (rootstocks), with four replications, were used. The experimental plots were formed by six vine plants, and the two plants in the center of the row were considered as effective for analysis.

Micro-meteorological and soil-water data

Hourly and daily data of the dry and wet air temperatures, sun radiation and rain in both sets of growing conditions for the vine (ANC, APGH) were gathered during the growing season of 2002/2003. For this purpose, psychrometries (HPMP35AC, Vaisala) and a Piranometer (LI200SZ, Licor Inc.) were installed on the top of the culture. A pluviometer (TB3, Hydrological Service, Ltd) was used in the experiment. Data were scanned every 10 seconds and averaged and stored every 30 minutes in a CR10 data-logger (Campbell Scientific, Logan).

Characterization of the daily variation of micro-meteorological parameters in both cultivation sets (ANC and APGH) was done based upon the analysis of average and extreme data using the Variance analysis for paired data (Sokal and Rohlf, 1969). The F-test was used to verify the statistical difference in the data.

Analysis of variance was also used to test results from yield-related parameters in both sets in the experiment.

A collection of soil-water dynamics during the growing season was read by two sets of TDR (time-domain reflectometry) installed at 25cm intervals in both cultivation sets.

LAI analysis

Leaf samples (about 100) of varying size and age were sampled in both sets of vine cultivation for LAI analysis. A methodology described in Pedro-Jr *et al.* (1986) was used to determine LAI in the experiment, in a non-invasive way. This was achieved by contouring the leaf over paper, thus performing planimetry to measure LAI. For each leaf the average leaf width was simultaneously determined. This was done taking into account that the vine leaf can be regarded as an approximate circle. Therefore, the estimate of LAI can be done by the following equation:

$$LAI = C.\pi.\left(\frac{W}{2}\right)^2 \quad (1)$$

where W is the leaf width (cm), and C the calibration factor.

Later on in the experiment, the measurement of leaf width was performed during the growing season for four branches in each treatment replication. By using the equation (1) above, previously established for the vine, the LAI was determined. Analysis of the variance was performed in order to study LAI differences among treatments and cultivation sets.

Yield and fruit-sugar concentration (ºBrix)

Yield (g/plant) and Sugar concentration (ºBrix) were determined in both cultivation sets by the end of the 2002/2003 growing season. The ºBrix was taken by a pocket refractometer (Atago model). For the determination of ºBrix, three berries were taken from the upper, middle and lower part of each vine bunch. Determination of the yield and ºBrix was done for each treatment, replication and cultivation set. Comparison of data was done by variance analysis (ANOVA).

Results and discussion

Figure 2 shows the evolution of the soil-water content in both sets of vine cultivation (ANC, APGH), along the rain curve for the vine in field conditions. Soil-water in the ANC have higher values than the APGH from November to the beginning of

December, due to the surplus of water, which can be seen by the incidence of rain and by analysis of the soil-water balance for the time (Figure 3a).

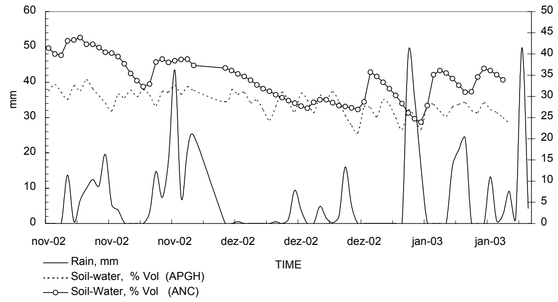

Figure 2. Time step of rain and soil-water in the two sets of vine cultivation, ANC and APGH, over the time of the experiment.

During the month of December, the soil-water inside the APGH is closer to that in the ANC, though slightly higher for a few days. In fact, the rainfall decreased in December, and the soil-water balance shows a persistence of low stress during most of the month; also in December the water-holding capacity values were persistently low during the whole month, as shown in Figure 3b.

In general, during the time of the experiment, the ANC cultivation set shows an average soil-water line of between 25 and 30% (Figure 2), thus not having faced any significant water-stress environment for most of the time. The depletion of water reached its highest value in December, with values of about 60% of water-holding capacity (Figure 3b).

The curves for global solar radiation in both sets of vine cultivation are shown in Figure 4. The average values for the ANC set were 20.6 MJ $m^2 day^{-1}$, while those for the APGH set were 17.6 MJ $m^{-2} day^{-1}$. It was observed that the values for sun radiation remained lower for the APGH during the whole experiment time. These results are in accordance with Camacho *et al.* (1995) and Folegatti *et al.* (1997), who found similar contrasts elsewhere.

The incidence of sun radiation inside the greenhouse is in fact attenuated by the polyethylene and by the dust settling onto it, thus influencing the radiation balance. This fact, along with the sun angle and atmospheric path, are the main causes of the fluctuation of sun radiation inside the plastic greenhouse.

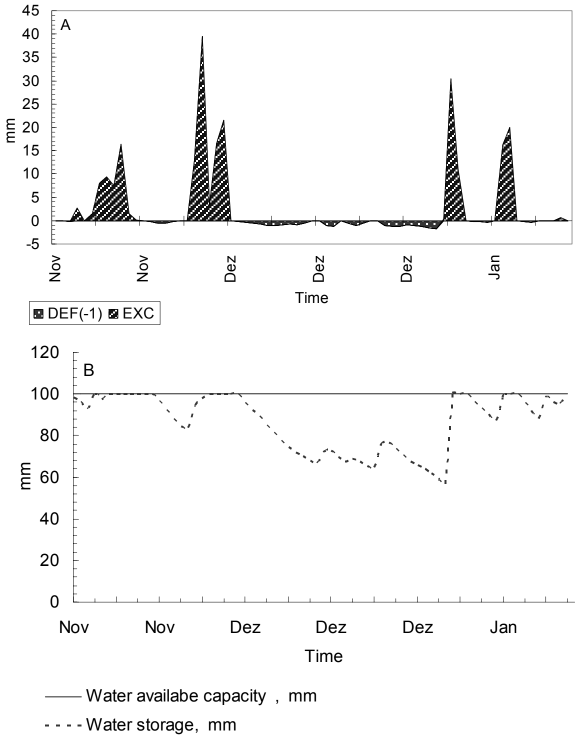

Figure 3. (A) Soil-water Balance (Thornthwaite, 1955) and (B) Soil water-holding capacity evolution for the area of vineyard cultivated in natural conditions (ANC), throughout the time of the experiment.

Figure 5 shows that during the grapes' growing cycle, the peak of sun radiation for both sets of cultivation matches the greatest differences in the curves.

For the part of day where clear sky is present, the direct radiation is for the most part in the incident spectrum, and so in the ANC environment the total radiation tends to be higher.

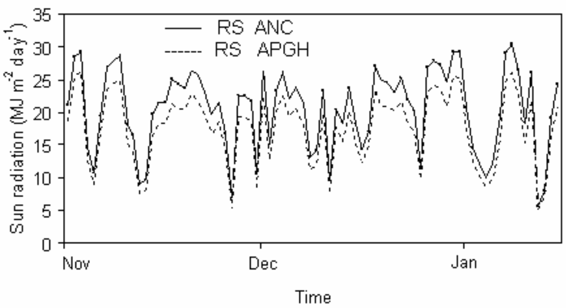

Figure 4. Daily steps of solar radiation (SR) during the experiment time for the two cultivation sets (ANC, APGH), for the *Cabernet Sauvignon* grapevine.

For the days, or hours of the day with a scatter sky, diffuse radiation rises in the global radiation spectrum. Diffuse radiation is not dependent upon direction and the plastic greenhouse contributes to the scattering of radiation. Therefore, at the start of the morning and at the end of the afternoon the rising diffuse radiation also raises the total radiation inside the greenhouse, thus closing the curves of incidence (Figure 4).

The issue discussed here has deep implications in the energy balance of the interior of greenhouses, which can influence plant growth and development. Moreover, diffuse radiation has better penetration in the canopy of plants. Therefore, inside the plastic greenhouse, the radiation-use efficiency is sometimes higher than outside, as demonstrated by Radin (2002). This can clearly be seen in Figures 6a and 6b for separated days. For a clear sky (Figure 6a), direct radiation is the greater part of the global spectrum, and the curves peak has a more pronounced difference. However, for a scatter sky (Figure 5b), the radiation curves tend to be closer, due to the rising of diffuse radiation inside the greenhouse.

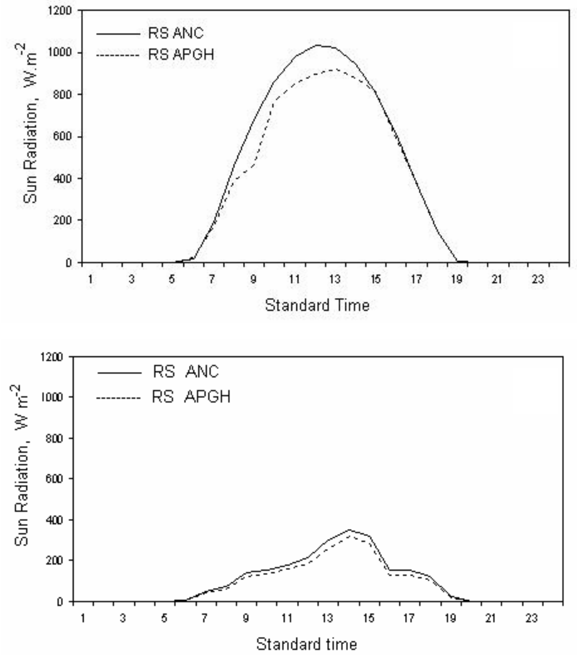

Figura 5. (A) Hourly steps of sun radiation (SR) for a clear sky (Nov 3rd, 2002) and (B) scatter sky (Jan 13th, 2003), in a vineyard of Cabernet Sauvignon, conducted in ANC and APGH.

Figure 6 shows the daily steps of sun radiation transmitted to the inside of the plastic cover. On average, 85.5% of the incoming radiation outside was transmitted through the polyethylene during the growing season analyzed. Different results were obtained by different authors and sites. Galvani (2001), in his work with cucumber under plastic cover, shows an average transmission of 70,8% for the winter and 75,0% for the summer. In their work with lettuce cultivated in a plastic greenhouse, Galvani *et al*. (1998) observed a transmissibility of 78.3% and 73.6% for the greenhouse orientated east-west and north-south, respectively.

In fact, the transmissibility of global sun radiation to the inside of the plastic greenhouse, in the context of this work, is dependent upon the hourly sun angle and degree of solar declination. Therefore, the latitude of observation is also an important factor to be considered in this case. Furthermore, the atmospheric path and its chemical composition will also influence the transmissibility of global sun radiation inside the plastic cover.

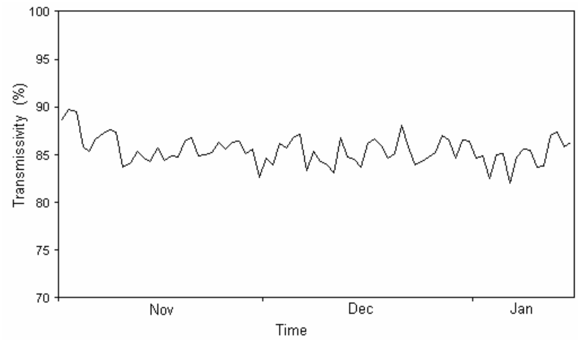

Figure 6. Transmissibility of global sun radiation (SR) in a vineyard cultivated under a plastic greenhouse in the 2001/2002 climatic growing season.

The values for maximum air temperature (Figure 7) in the APGH were higher than those for the ANC. On average, the difference was 4.4ºC. The average maximum air temperature was 32.6ºC for the inside and 31.4ºC for the outside. The effect of plastic cover on the maximum temperatures was also observed by researchers elsewhere (Martins *et al.*, 1981; Scatolini, 1996). In fact, the incidence of minor global sun radiation is compensated by the retention of more long-wave radiation, and also there is the effect of the plastic cover on the movement of the air mass, which inside the plastic greenhouse is disconnected from the main drag force that renews the air mass in the outside.

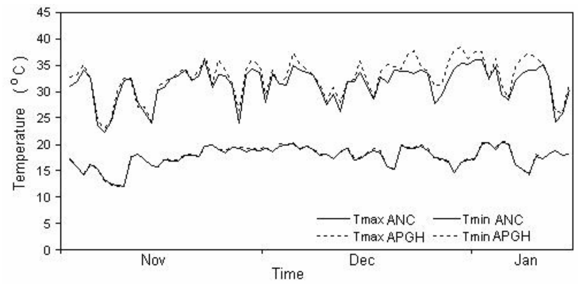

Figure 7. Maximum (Tmax) and minimum air temperatures (Tmin) in a vineyard cultivated in natural conditions (ANC) and under a plastic greenhouse (APGH).

The minimum air temperature observed in the APGH was always higher than that on the outside (ANC). The maximum differences peaked at 0.6ºC. Farias *et al.* (1993) and Camacho *et al.* (1995) also found such behavior for minimum air temperature in a similar comparison. In those studies, the minimum air temperature was always higher than outside, and the difference between cultivation sets ranged from 0ºC to 4.6ºC. Probably the range for the minimum air temperature was lager in those cases due to the also larger fluctuation in the local environment temperature.

As a result of the behavior of the maximum and minimum air temperature observed for the plastic greenhouse environment, the thermal amplitude was higher in this cultivation set, in comparison to the outside. This amplitude averaged out at 13.8ºC for APGH and 14.0ºC for ANC. Values peaked to 23.1ºC in the APGH and 20.1ºC for the ANC.

The joint effect of daily profile of maximum and minimum air temperature in both cultivation sets imposed higher values of vapor pressure deficit (VPD) for the plastic greenhouse environment (Figure 8). Apparently a higher level of VPD for the APGH would suggest a persistence of a higher level of transpiration during the experiment. This could have led to a decrease in water-use efficiency in this environment, which could ultimately influence the balance between grape yield and quality. However, to be precise in this issue, the water transport in the soil-atmosphere continuum must be monitored in both cultivation sets. In fact, transpiration, in this case, can be the combined result from elements of atmospheric demand for both cultivation sets. Therefore, the same level of VPD may possibly occur both inside and outside the plastic greenhouse. However, the air-energy level can be different for both environments. The control of transpiration by stomata or by the leaf boundary layer can also vary among environments for the same level of VPD.

Table 1 illustrates the compilation of resulted comparison for micro-meteorological variables performed by paired-data analysis. In general, modifications implied by the use of plastic greenhouses show that the plastic covering did not contribute much to environment stability. There was an incidence of extremes for some variables such as temperature, and also the persistence of higher "sink" for the water vapor, although the incidence of some variables such as rain and wind stress was attenuated.

Regarding the minimum air temperature, although the average differences amongst cultivation sets are as low as 0.1ºC, it was significant for the F-test.

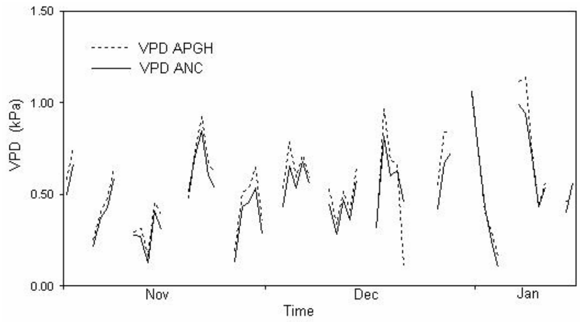

Figure 8. Vapor pressure deficit in a Cabernet Sauvignon vineyard cultivated outside (ANC) and inside a plastic greenhouse (APGH).

Table 1. Micro-meteorological variables gathered in the ANC and APGH.

Variable	Mean difference among treatments	SL	Results
		F	
Tmax (ºC)	1.3	**	APGH > ANC
Tmin (ºC)	0.1	**	APGH > ANC
Thermal amplitude (ºC)	1.1	**	APGH > ANC
RH_max. (%)	0.1	ns	ANC > APGH
RH min. (%)	2.4	**	ANC > APGH
VPD (kPa)	0.4	**	APGH > ANC
Sun Radiation ($MJ.m^{-2}.day^{-1}$)	3.0	**	ANC > APGH

SL = Significance level for the ANOVA for paired-data analysis. * $P < 0.05$; ** $P<0.01$. n.s. denotes non-significance.

The average values for LAI gathered in the APGH set are displayed in Table 2. The F-test performed on it shows no influence of rootstock on the final LAI measured at the harvest. Even for the ANC set, the results of the F-test have a similar conclusion, since the averaged values show no statistical difference (Table 2). However, in both *Cabernet Sauvignon* cultivation sets, the rootstock IAC 766 provided a trend for higher LAI. This is in accordance with results from Pauletto *et al*. (2001), who found similar results when testing IAC 766.

The statistical combined-analysis (Banzato e Kronka, 1989) for LAI in both cultivation sets shows differences among environments for the final LAI (Table 3). In fact, plants, whose growth and development was conducted in an environment of shortening of sun radiation, are different in some aspects from those with growth in an environment with more available radiant energy, considering the same species. In general, they are characterized by thinner leaves, bigger chloroplasts and lowered light saturation point (Jones, 1992). Therefore, while the "sun leaves" tend to be thicker, the "shade leaves" tend to be thinner, probably, compensating the low levels of sun radiation by raising the LAI values.

Table 2. Averaged LAI values (m^2/plant) for *Cabernet Sauvignon*, in the set APGH and ANC, for different rootstock and results form f-test.

Rootstocks	APGH	ANC
IAC 572	2.54	2.03
IAC 766	2.97	2.28
Traviú	2.34	1.84
F (treatment)	1.88 ns	1.67 ns

Table 3. Results of F-test for the statistical combined-analysis (APGH and ANC) for final LAI.

CV	GL	SQ	QM	F
Test blocks	7			
Treatment (T)	2	1.173	0.587	3.49 ns
Locations (Environments, A)	1	1.921	1.921	11.43 **
Interaction (A x T)	2	0.041	0.021	0.12 ns
Average Residue	12	2.016	0.168	
Total	24			

ns >denotes non-significance. ** P < 0.01.

The final yield for the 2001/2002 growing season was evaluated and results are in Table 4 and 5. For the APGH the yield averaged 1200, 1400 and 606 g/plant for IAC 766, IAC 572 and Ripária do Traviú, respectively. For the ANC those values were 1118, 1507 and 638 g/plant, for the same rootstocks. According to the results from analysis of variance (Table 4) the rootstocks differed in the sets of cultivation and IAC 766 and IAC 572 had the best performance. The rootstock *Ripária do Traviú*, supposed to be the most used rootstock in the climatic region under analysis, was clearly the one with the worst yield performance in both cultivation sets.

The statistical combined-analysis for final yield achieved in the different rootstocks and cultivation sets (Table 5) showed that, although the treatments (rootstocks) differed amongst each others, they were not influenced by the cultivation environment, since the F-test for the relationship between treatment and environment was not statistically significant.

Table 4. Averaged Final yield (g/plant) for *Cabernet Sauvignon* cultivated outside and inside plastic greenhouse on different rootstocks. Summary of variance analysis is shown.

Rootstocks	APGH	ANC
IAC572	1200[a]	1188[a]
IAC766	1400[a]	1507[a]
Traviú	606 b	638 b
F (treatment)	6.13*	8.28*

F: F-test; *: Significant, P<0.05; Coincident letters denotes non-significant difference by the Duncan test, P<0.05.

Results from the sugar-concentration test (ºBrix) in the APGH and ANC sets are presented in Table 6. In spite of the performance of rootstock IAC 766 which exceeded the others under test, the F-test showed no statistical difference between treatments in relation to the soluble solids, in both sets of cultivation. Therefore, rootstocks had no influence on sugar concentration level (ºBrix), when considering separated environment of cultivation.

Table 5. Summary of statistical combined-analysis for yield values through rootstocks and cultivation sets.

CV	GL	SQ	QM	F
Test blocks	7			
Treatment (T)	2	2894114.58	1447057.30	12.72 *
Locations (Environments, A)	1	10416.67	10416.67	0.09 ns
Interaction (A x T)	2	14427.08	7213.54	0.06 ns
Average residue	12	1364791.66	113732.64	
Total	24			

F: test F; NS denotes non-significance; *: Significant. P<0.05

The statistical combined-analysis for sugar concentration (ºBrix) through the sets of cultivation (Table 7) suggested that the treatments (rootstocks) differed. Furthermore, the environment influenced the behavior of the rootstocks in relation to the soluble solids, since the F-test was shown to be significant for the interaction between environment and treatments.

Table 6. Average sugar concentration (ºBrix) for vineyard cultivated outside and inside a plastic greenhouse. Summary of ANOVA is shown.

Rootstock	APGH	ANC
IAC572	13,73	15,05
IAC766	14,73	15,35
Ripária do Traviú	13,93	13,65
F (treatment)	2,02 ns	4,56 ns

F: F-test; NS denotes non-significance.

Table 7. Summary statistical combined-analysis for values of sugar concentration in APGH and ANC.

CV	GL	SQ	QM	F
Test blocks	7			
Treatment (T)	2	6,25	3,13	29,53 *
Locations (Environments, A)	1	1,87	1,87	17,64 *
Interaction (A x T)	2	2,58	1,29	12,17 *
Average residue	12	1,27	0,11	
Total	24	23,97		

F: F-test; *Significant, P < 0.05.

Table 6 indicates that there was not a clear trend for the fruit-sugar concentration to be higher inside the plastic greenhouse. Interactions between the microclimatic regime and physiological process of fruit soluble solids accumulation do not favored such a result.

In fact, variation in grape quality is largely dependent on water availability and environmental conditions. These factors play an important role in the regulation of the fragile balance between grape yield and quality. Figure 3 shows that, except a short period in December, the soil water outside the shelter had higher values during the growing season, with water surplus most of the time. This can be seen in Figure 3 for the ANC environment. Although the incidence of rain was avoided inside the plastic greenhouse, the controlled delivery of water for the grapes did not favor greater Brix values. Probably a precise timing and water-deficit amount should be considered, inside the plastic greenhouse, as a way of finding a balance between water deficit, energy balance and grape quality.

Concluding

The environmental conditions for grapes cultivated inside a plastic greenhouse were characterized by minor sun radiation, rising of the maximum air temperature and maintenance of higher levels of vapor-pressure deficit, during the growing season.

Modification in the environment of grape growth and development influenced the storage of soluble solids. However, the interaction between the micro-meteorological regime and grape growth did not clearly favor higher levels of sugar concentration (ºBrix).

The rootstock *Ripária do Traviú* showed the worst performance in both sets of vineyard cultivation. The IAC 766, on the other hand, showed the best performance for both cultivation exposures.

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