Effect of partial net shading on the temperature and radiation in the grapevine canopy, consequences on the grape quality of cv. Gros Manseng in PDO Pacherenc-du-vic-Bilh

Thierry Dufourcq[1,2], Alicia Thomas[2], Frédéric Lopez[2], Daniel Vergnes[3] and Carole Feilhes[1]

[1] IFV Sud-ouest V'Innopole, Lisle/Tarn, France
[2] IFV Sud-ouest, Château de Mons, Caussens, France
[3] Chambre d'Agriculture des Pyrénées Atlantiques, Pau, France

***Corresponding author:** thierry.dufourcq@vignevin.com

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Abstract

As elsewhere, southwestern France vineyards face more recurrent summer heat waves these last years. Among the possibilities of adaptation to this climate changing parameter, the use of net shading is a technique that allows for limiting canopy exposure to radiations. In this trial, we tested net shading installed on one face of the canopy, on a north-south row-oriented plot of cv. Gros Manseng trained on VSP system in the PDO Pacherenc-du-Vic-Bilh. The purpose was to characterize the effects on the ambient canopy temperatures and radiations during the season and to observe the consequences on the composition of grapes and wines. Two sorts of net were used with two levels of obstruction (50% and 75%) of the photosynthesis active radiation (PAR). They have been installed on the west side of the canopy and compared to a netless control. Temperature and PAR sensors registered hourly data during the season. On specific summer day (hot and sunny) manual measurements took also place on bunches (temperature) and in different spots of the canopy (PAR). The results showed that, on clear days, the radiation is lowered by the shade nets respecting the supplier criteria. The effects on the ambient canopy temperature were inconstant on this plot when we observed the data from the global period of shading between fruit set and harvest. However, during hot days (Tmax>25°C), the temperature in the canopy was reduced during afternoon and the temperature of the bunch surface was reduced as well comparing to the control. A decrease of the maturity parameters of the berries, sugar and acidity, was observed. The delayed maturity of the grapes also modified consequently the aromatic profile of the wine.

Introduction

The Gros Manseng variety is native from the Pyrenean and Gascony vineyards. Its geographical and historical origin is located near the Bay of Biscay. This place would have been one of the European refuges of Vitis *vinifera* during the ice ages (Bordenave, Lacombe et al. 2007) . In this respect, this grape variety contributes to the originality of the white wines from the southwestern France vineyards.
In 2021, 3900 ha of Gros Manseng were cultivated in France for wine production, in Geographical Indication (PGI) Côtes de Gascogne (70%) and Designation of Origin (PDO) Jurançon, Tursan, Irouléguy and Pacherenc-du-vic-bilh (30%)
The oenological potential of this grape variety is original, it can accumulate sugars during ripening while maintaining a high level of acidity. Gros Manseng wines have a very diversified aromatic potential. Grape varietal thiols are found in large quantities (Tominaga 2000, Dagan 2006), as well as terpenes and norisoprenoids (Dagan, 2006). The presence of dimethyl sulfide precursors in the grapes has also been highlighted, which gives the wine the potential to express truffle notes during its aging (Dagan, 2006).
Climate change is likely to impact significantly both the organoleptic characteristics of wines, in particular by reducing the level of acidity in grapes and wine (Pons, Allamy et al. 2017). In southwest of France, we observe an increase of the annual mean temperature of 0.3°C per decade since the 1960s. The Huglin index (Tonietto and Carbonneau 2004) went from a class "temperate warm" to "warm" these last years with already some maximum close to the class "very warm" (Dufourcq and Katgerman 2020). The number of days where the

maximum temperature raises above 35°C is an indicator of extreme event with negative effect on grapevine functioning (Ollat, Zito et al. 2021). It occurs generally around 3 days per year locally but recently reaches up to 10 days in 2019, 11 days in 2020 (25 days in 2003).
Numerous studies seeked to analyze protective techniques against heat waves for fruit production in different countries (Cartechini and Palliotti 1995, Gindaba and Wand 2005, Caravia, Collins et al. 2016, Martinez, Chen et al. 2020). Shading the canopy with a net is a technique that allows to limit its exposure to radiations and protect bunches from sunburn. Our field trial seeks to characterize the protective effect on grapevine with the use of net shading in our local climatic conditions. The purpose of the study was to characterize the consequences of the use of partial net shading on the composition of grapes and wines attributes.

Materials and methods

The experimental plot was located in the PDO vineyard Pacherenc-du-vic-bilh, (43°575893N, -0°110432E) on cv. Gros Manseng trained in vertical shoot positioned system, with 2.50m x 1m spacing vines and on a north-south oriented rows (azimuth 154°).
The nets are black in color and made of high-density polyethylene. They have been installed on one row for each treatment over a length of 80 m. They have been placed on the western side of the canopy under the more stressful conditions during high temperature. According to the azimuth of the row and at this latitude, the sun is active on the western face from 11h UTC until sundown around 19h UTC in summer.
Two sorts of net were used with two levels of protection, 50% and 75% according to the supplier, and compared to a netless control. The protective period occurred from fruit set until harvest during 76 days in 2020 and 95 days in 2021. 3 blocks were selected on each treatment to insure statistical analysis.
For the 3 treatments, control (TEM), net with 50% protection (NR50), net with 75% protection (NR75), 3 temperature sensors, warito-logger® of WaranetSolutions placed in normalized weather shelter, Davis Instruments, were installed at 1.10m above the ground in the canopy close to the bunch zone. They recorded 1 measure per hour during the period of study. Photosynthetically Active Radiation (PAR) meter, Apogee Instrument PQ100, were placed on the west side (behind the net if present) and above the canopy (for the 100% PAR). An Infrared thermometer Fluke was used to record on specific days the bunch surface temperatures. A manual PAR sensor, Apogee Instrument MQ200, was used to evaluate the real percentage of protection of the net.
Five consecutive vines close to the sensors were harvested in 3 replicates at the same date for each treatment. Berry and wine analysis were run at IFV Sud-ouest laboratory following standard methods. Aroma compounds in wine were analyzed at Nyseos, Montpellier (France) after micro-vinifications (3L) in triplicate. Statistical analysis were made with XLSTAT of Addinsoft software for ANOVA treatments and Newman Keuls test for group sampling.

Results and discussion

The climatic conditions were very different in the two study vintages. 2020 was a very hot (11 days above 35°C) and dry year during the summer period with moderate water stress for the vine. The rains were spread mainly over winter and spring. The mean of the isotopic discrimination of ^{12}C and ^{13}C ($\delta^{13}C$) on the must at harvest was around -26.9 with no differences between the treatments. 2021 presented temperatures that follow the average of the last 15 years (3 days with maximum temperature above 35°C) but with significantly higher precipitations. These rains occurred during the spring, beginning of summer and especially in September.
The continuous PAR data recorder indicated a strong decrease in radiation on the protected west side as shown for example in figure 1, comparing the data collected from control and the NR75 net on 5 consecutive days in 2021.
Manual PAR measurements in 2021 respectively on 20th july and 20th august in the afternoon, when the sun is active on the west side of the canopy, showed significance differences (p value < 0.0001) between the 3 treatments: respectively, the control received 72% and 95% of the PAR, the NR50 net received 28% and 47%, the NR75 net received 17% and 25%. These results confirmed the protection efficiency announced by the supplier
The effects on the ambient canopy temperature were inconstant on this plot when we observed the data from the global period of shading between fruit set and harvest. The nets attenuated the temperature by up to 0.6°C on average which was weak.

The mitigation of temperature in the canopy appeared to increase when the maximum temperature was increasing (figure 2.1). We were even able to observe that the temperature within the vegetation was higher on the treatment with net than on the control when the maximum temperature of the day was below 25°C (cool summer day). The mitigation took effect when the Tmax of the day was in between 25°C and 30°C and was at is maximum when temperature exceeded 35°C. These observations are of the same order regardless of the year, 2020 or 2021. Cumulative degree hours above 35°C between fruit set and harvest (Winter, Lowe et al. 2007) showed a decrease of 27% for the NR50 net in 2020 compared to the 1706°C.h of the control.
Also, the bunch surface temperature located on the west side decreased of 4°C behind the net when measured in the afternoon of a clear day with mean ambient temperature around 27°C (figure 2.2).
No effect was recorded on yield components for the 2 years of study. No damage of berry sunburn or shriveling was observed on the plot.
The grape quality was impacted especially in year 2021 (table 1). Less sugar, more acidity, more nitrogen and less tanins for the grape under the nets which refers to a lower maturity for the same harvest date compared to the control.
Aroma compounds in wine were not improved nor altered in 2020 although the number of days above 35°C was high for the local climate. We maybe should consider that, in these conditions, a protection on one side is not enough to completely modify the quality of the vine production. However, in 2021, with standard conditions in temperature and rainy periods we observe a change of the aromatic composition of the wines produced under nets: varietal thiols, β-damascenone significantly decreased while fermentative compounds increased. Respectively, these compounds are sensitive to temperature (Wu, Drappier et al. 2019), radiations (Gambetta, Romat et al. 2021) and must nitrogen content (Robinson, Boss et al. 2014). We should analyze this change in aromatic composition of wines produced with grapes under net as a consequence of a delay in ripening compared to the control wine.

Conclusion

The use of shading nets is a promising technique for adapting viticulture to climate change. The nets attenuated the radiation. The effects on temperature were more contrasted. Warming effects in the vegetation are observed in days with a low maximum temperature but the attenuation effect was more marked when the temperature exceeded 35°C, which is expected more and more frequently in the coming years.
Positioning on one side, the net did not completely change the functioning of the plant or the production. In a hot year, under our conditions, the effects were weak on the quality of the grapes and the aromatic potential of the wine was not modified. In a year with less radiation, the maturity was delayed and consequently the aromatic profile of the wine modified.

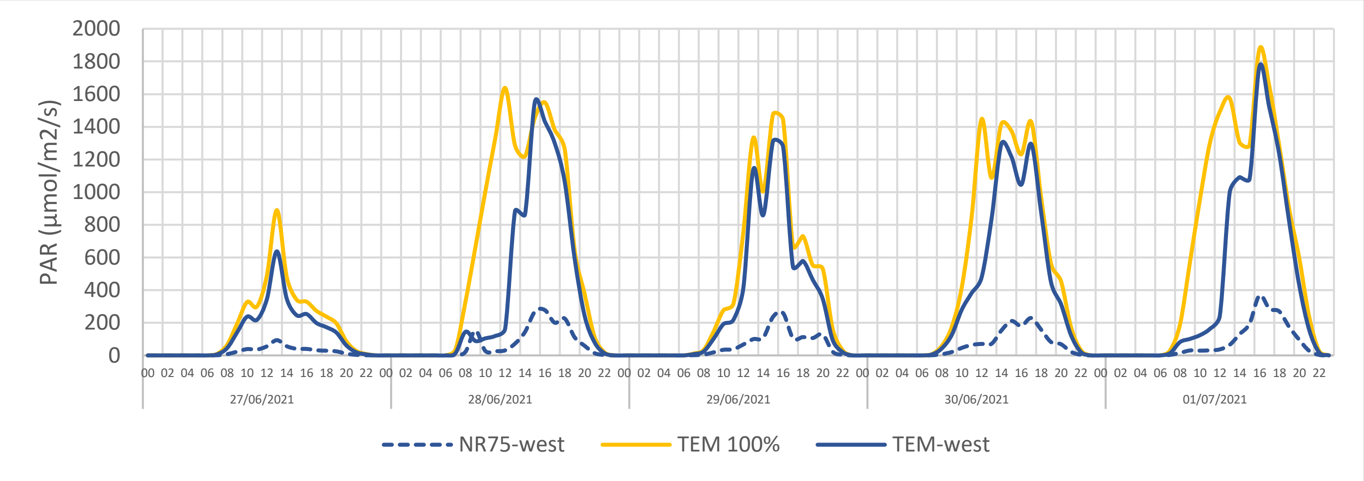

Figure 1. PAR data recorded on the NR75 net west side (NR75-west), the control west side (TEM-west) and above the control canopy (TEM100%) on 5 consecutive days in 2021.

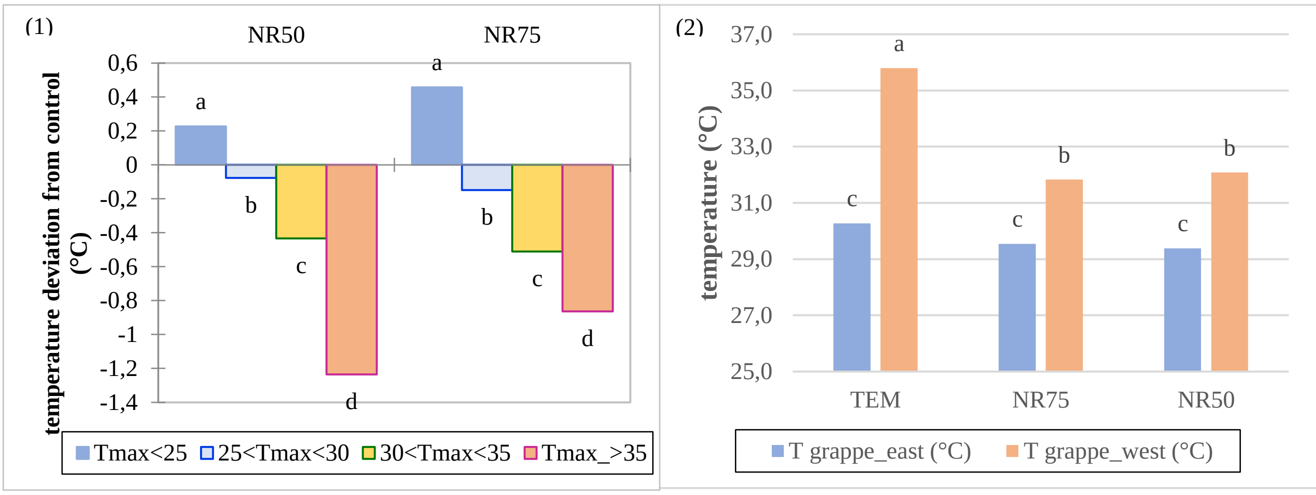

Figure 2. Temperature deviation from the control in canopy for 50% or 75% net protection in relation with different class of maximum temperature of the day (1) ; Afternoon measurement of the bunch surface temperature, bunch located on the east side (non-exposed) of the row or west side (exposed) (2).

Table 1. yield component, grape composition and wine aroma composition of the net shading (NR50, NR75) and control (TEM) treatments during year 2020 and 2021 ; cv. Gros Manseng.

Year	2020			2021		
Treatment	**NR50**	**NR75**	**TEM**	**NR50**	**NR75**	**TEM**
Yield component						
yield (kg/vines)	2,6	2,1	2,4	3,7	3,7	4,5
Number of bunches per vine	19,2	16,8	18,5	22,9	23,3	24,4
Bunch weight (kg)	0,135	0,129	0,127	0,163	0,158	0,185
Grape composition						
Berry weight (g)	1.11	1.09	1.13	1.12	1.08	1.13
Potential alcohol [% Vol]	15.2^{b}	15.1^{b}	**15.5^{a}**	13.6^{b}	13.2^{c}	**14.2^{a}**
Total acidity [g/l H_2SO_4]	4.6	5.2	4.5	7.7^{a}	7.6^{a}	**6.8^{b}**
pH	3.3	3.28	3.36	3.11^{b}	3.09^{b}	3.14^{a}
Tartaric acid [g/l]	4.1	4.3	3.9	6.1^{a}	6.0^{a}	**5.8^{b}**
Malic acid [g/l]	2.7	3	2.4	4.6^{a}	4.5^{a}	**3.8^{b}**
Yeast Assim. Nitrogen [mg/l]	162	179	160	181^{a}	173^{b}	**153^{c}**
TPI (DO280)	11.9	12.3	12	6.9	6.8	6.9
Phenol acids [mg/l]	*nd*	*nd*	*nd*	63	61	60
Tanins [mg/l]	*nd*	*nd*	*nd*	249^{b}	248^{b}	**256^{a}**
Wine aroma composition						
Thiols (nmol/) (x2)	0,7	0,4	0,9	4.0^{ab}	3.4^{b}	**4.5^{a}**
Esters/acetates (µmol/l) (x6)	32,8	32,5	31,6	**34.9**	**34.7**	30.5
βdamacenone (nmol/l)	40,3	41,5	42,7	27.0^{c}	30.7^{b}	**35.3^{a}**
terpenols (nmol/l) (x4)	42,7	43,3	42,2	45.8	44.5	45.8
P-DMS (µmol/l)	2,1	2,7	2,4	2.4	2.5	2.4

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References

Bordenave, L., Lacombe, T., Laucou, V., & Boursiquot, J. M. (2007). Etude historique, génétique et ampélographique des cépages Pyrénéo Atlantiques. *Bulletin de l'OIV: Revue Internationale de Viticulture, Oenologie, Economie, Droit Viti-Vinicole, 80*(920), 553-586.

Caravia, L., Collins, C., Petrie, P. R., & Tyerman, S. (2016). Application of shade treatments during Shiraz berry ripening to reduce the impact of high temperature. *Australian Journal of Grape and Wine Research, 22*(3), 422-437. https://doi.org/10.1111/ajgw.12248

Cartechini, A., & Palliotti, A. (1995). Effect of Shading on Vine Morphology and Productivity and Leaf Gas Exchange Characteristics in Grapevines in the Field. *American Journal of Enology and Viticulture, 46*(2), 227-234.

Dufourcq, T., & Katgerman, P. (2020). *Quelles réelles évolutions du climat depuis 20 ans sur nos vignobles ?* Paper presented at the 5e Assises des vins du Sud-ouest, Toulouse.

Gambetta, J. M., Romat, V., Schmidtke, L. M., & Holzapfel, B. P. (2021). Secondary metabolites coordinately protect grapes from excessive light and sunburn damage during development. *Biomolecules, 12*(1), 42. https://doi.org/10.3390/biom12010042

Gindaba, J., & Wand, S. J. (2005). Comparative effects of evaporative cooling, kaolin particle film, and shade net on sunburn and fruit quality in apples. *HortScience, 40*(3), 592-596. https://doi.org/10.21273/HORTSCI.40.3.592

Martinez, J., Chen, C. C. L., Brillante, L., & Kurtural, S. K. (2020). Mitigating Heat Wave and Exposure Damage to 'Cabernet Sauvignon'Wine Grape with Partial Shading under Two Irrigation Amounts. *Frontiers in Plant Science, 11*, 1760. https://doi.org/10.3389/fpls.2020.579192

Ollat, N., Zito, S., Richard, Y., Aigrain, P., Brugière, F., Duchêne, E., . . . Bois, B. (2021). La diversité des vignobles français face au changement climatique : simulations climatiques et prospective participative. *Climatologie, 18*, 3. https://doi.org/10.1051/climat/202118003

Pons, A., Allamy, L., Schüttler, A., Rauhut, D., Thibon, C., & Darriet, P. (2017). What is the expected impact of climate change on wine aroma compounds and their precursors in grape? *OENO One, 51*(2), 141-146. https://doi.org/10.20870/oeno-one.2017.51.2.1868

Robinson, A. L., Boss, P. K., Solomon, P. S., Trengove, R. D., Heymann, H., & Ebeler, S. E. (2014). Origins of grape and wine aroma. Part 1. Chemical components and viticultural impacts. *American Journal of Enology and Viticulture, 65*(1), 1-24. https://doi.org/10.5344/ajev.2013.12070

Tonietto, J., & Carbonneau, A. (2004). A multicriteria climatic classification system for grape-growing regions worldwide. *Agricultural and forest meteorology, 124*(1-2), 81-97. https://doi.org/10.1016/j.agrformet.2003.06.001

Winter, E., Lowe, S., & Bulleid, N. (2007). Bunchzone Temperature Monitoring throughout Ripening and Grape and Wine Quality of Shiraz in North-East Victoria, Australia. *KTBL SCHRIFT, 456*, 149-158. https://doi.org/10.20870/oeno-one.2017.51.2.1647

Wu, J., Drappier, J., Hilbert, G., Guillaumie, S., Dai, Z., Geny, L., . . . Pieri, P. (2019). The effects of a moderate grape temperature increase on berry secondary metabolites. *OENO One, 53*(2). https://doi.org/10.20870/oeno-one.2019.53.2.2434