

## RESEARCH NOTE

# Effect of Shading on the Performance of *Vitis vinifera* L. cv. Cabernet Sauvignon

E. Archer<sup>1</sup> and H.C. Strauss<sup>2</sup>

1) Department of Viticulture, University of Stellenbosch, 7600 Stellenbosch, Republic of South Africa.

2) Viticultural and Oenological Research Institute (VORI), Private Bag X5026, 7600 Stellenbosch, Republic of South Africa.

Date submitted: August 1989

Date accepted: October 1989

Keywords: Sunlight energy, radiant energy, canopy density, grape composition, grapevine, shading.

**The effect of shading on the performance of Cabernet Sauvignon was studied. Significant different levels of canopy density were created using the growth of neighbouring vines, thus ensuring no artificial change in natural light composition. Light penetration in these canopies differed significantly between treatments. Berry mass, bunch mass and yield as well as skin colour were decreased with increasing levels of shading, while pH, K-concentration and TTA were increased. Tartaric acid decreased while malic acid increased with an increase in shading. Wine quality was negatively affected.**

The effect of canopy microclimate on the quantitative and qualitative performance of grapevines has been the subject of various studies (Shaulis, Amberg & Crowe, 1966; Shaulis & May, 1971; Smart, 1973, 1974, 1985, 1987a, 1987b, 1987c; Carbonneau, Casteran & Le Clair, 1978; Kliewer, 1982; Smart, Shaulis & Lemon, 1982; Smart *et al.*, 1985a & Smart, Dry & Loffler, 1987; Kliewer *et al.*, 1988; Smart & Smith, 1988). Mainly because of the work done by Smart, the advantages of low canopy density for higher quantity and quality grapes are presently better understood. Smart, Smith & Winchester (1988) recently showed that not only light quantity but also light quality plays an important role in grape composition.

Canopy microclimate depends on the number and spatial distribution of the leaves. Although trellising systems affect canopy microclimate (Carbonneau *et al.*, 1978; Carbonneau & Huglin, 1982; Carbonneau, 1987), canopy management practices such as defoliation (Peterson & Smart, 1975; Williams, Biscay & Smith, 1987; Bledsoe, Kliewer & Marois, 1988; Hunter & Visser, 1988b & 1988c), shoot positioning (Reynolds, Pool & Mattick, 1986; Smart, 1988), desuckering (Archer & Beukes, 1983) and topping (El-Zeftawi & Weste, 1970; Koblet, 1977) exert a great effect on the arrangement of leaves within the canopy. In most of the above-mentioned reports, high canopy density and thus shade are mentioned as producing negative characteristics. This study used the borrowed foliage technique, suggested to the authors by R. Smart as a means of quantifying the effects of natural shading on winegrapes in South Africa (see Smart, 1987a).

### MATERIALS AND METHODS

**Vineyard:** - A 10-year-old *Vitis vinifera* L. cv. Cabernet Sauvignon vineyard in the Stellenbosch district, grafted onto 99 Richter (*Vitis Berlandieri* var. Las Sorres x *Vitis rupestris* var. du Lot) and cordon trained onto a vertical trellising system (cordon height: 700 mm; foliage height: 1 800 mm) was used. Thirty representative vines were selected of which ten were used for each of three treatments, namely control, single and double shading. Individual vines served as replicates. The plant spacing in this vineyard was 2,7 m x 1,4 m. Vegetative growth in the vineyard could be described as

vigorous and the vines produced approximately 18 shoots/m cordon.

For the single shading treatment one long cane from each adjacent vine was used and positioned directly beneath each cordon arm of the treatment vine, thus creating two "extra" long canes per vine. The double shading treatment on the remaining ten vines was created by using a total of four long canes (two from each adjacent vine) per treatment vine. These "extra" canes were treated with cyanamide ensuring maximum budding percentage and the flower clusters were removed before full bloom. All the treatment and control vines were spur pruned to 20 buds per vine and normal desuckering and shoot positioning were carried out.

**Measurements:** - Measurements were taken during the 1987/88 growth season. Radiant energy received at cluster level on a typical cloudless summer day was measured between 12:00 and 14:00 during ripening using a LI-COR 191 SB Line Quantum Sensor placed within the canopy in line with the cordon. Five measurements per vine were recorded. Canopy density during the same period was measured using the point quadrat method (Smart, 1988). Thirty probes per vine were made horizontally through the canopy at cluster level. Ten bunches per vine were randomly sampled at full ripeness for bunch mass recordings. All the berries from these bunches were used for a random selection of 100 berries per vine to record berry mass.

Skin colour densities were measured using the method described by Hunter & De la Harpe (1987). Must analyses were done using standard procedures employed by the Department of Oenology, University of Stellenbosch.

**Winemaking:** - Wine was made in triplicate from all three treatments by standard VORI procedures and an experienced panel of at least five members was used to rank the wines in order of preference, based on overall quality. This was done for two consecutive years.

### RESULTS AND DISCUSSION

**Radiant energy:** - The radiant energy, expressed as photosynthetic photon fluence rate (PPFR), received at cluster level, is given in Table 1. Although the PPFR values obtained

Acknowledgements: Mr J.J. van Rensburg, Nederburg Wines, for providing the vineyard and his assistance in applying pruning treatments.

for control vines were higher than the critical light compensation point ( $\approx 30 \mu\text{E m}^{-2}\text{s}^{-1}$ ) they were considerably lower than values measured in New Zealand by Smart (1988). This can probably be ascribed to differences in vegetative growth occurring between warm and cool climate regions. It is clear that the shading treatments significantly impaired radiant energy reception at cluster level. Single shading already induced similar PPFR values of between 20 and  $35 \mu\text{E m}^{-2}\text{s}^{-1}$  which were frequently measured by the senior author in commercial South African vineyards. These low values of the treatment vines were clearly reflected by very early yellowing of interior basal leaves just before pea size stage was reached. This induced senescence is known to have a detrimental effect on the total photosynthetic efficiency of the canopy of vines (Hunter & Visser, 1988a & 1988c).

TABLE 1

Effect of shading on the photosynthetic photon fluence rate received at midday in the canopy during ripening of Cabernet Sauvignon, Stellenbosch

Treatment	Radiant energy ( $\mu\text{E M}^{-2}\text{s}^{-1}$ )
Control	40,7
Single shading	24,7
Double shading	3,6
D-value ( $p \leq 0,05$ )	15,8

**Canopy density:** - Both shading treatments resulted in a significant increase in canopy density (Table 2). Although the values obtained were higher than reported in other studies (Smart, 1988). measurements by the senior author in several commercial South African vineyards produced values of between seven and eight. This indicated that too high canopy densities is a common problem in local vineyards.

TABLE 2

Effect of shading on canopy density during ripening of Cabernet Sauvignon measured by the point quadrat method, Stellenbosch

Treatment	Canopy density (number of contacts)
Control	3,36
Single shading	7,20
Double shading	9,58
D-value ( $p \leq 0,05$ )	1,54

**Yield:** - Shading resulted in a significant decrease in berry mass, bunch mass and yield per vine (Table 3). The decrease in berry mass and bunch mass resulted in a direct decrease in yield per vine with obvious economic implications. The morphology of the bunches was visually adversely affected (Fig. 1). Unfavourable microclimatic conditions in the canopy during full bloom and subsequent fruit set probably caused this morphological degeneration. No signs of rot were de-

tected. Clearly, the endeavour to achieve optimal canopy density will result in a better economic performance for the wine producer.

TABLE 3

Effect of shading on berry mass, bunch mass and yield per vine of Cabernet Sauvignon, Stellenbosch.

Treatment	Berry mass (g)	Bunch mass (g)	Yield per vine (kg)
Control	1,09	125,4	4,62
Single shading	0,81	104,7	3,47
Double shading	0,63	77,2	2,44
D-value ( $p \leq 0,05$ )	0,19	20,65	0,094



FIGURE 1

Effect of shading on the morphology of Cabernet Sauvignon bunches, Stellenbosch 1988.

Left: Double shading  
Middle: Single shading  
Right: Control

**Grape and must composition:** - Shading significantly reduced the skin colour of Cabernet Sauvignon (Table 4). Skin colour of the control grapes was twice that of the double shading treatment grapes. This finding is supported by the well-known fact that the formation of anthocyanins is promoted by light and that it is mainly light in the shorter wavebands which was most effective (Bidwell, 1974).

Sugar concentration decreased while pH and K-concentration increased with an increase in shading (Table 5). Smart (1987a) and Smart *et al.* (1988) found that these increases might be ascribed to the inhibition of phytochrome driven enzyme reactions. The increase in the total titratable acid (TTA) was mainly the result of an increase in malic acid. This is in accordance with the results of Morrison (1988). Tartaric

acid, however, decreased with an increase in the level of shading. All the above unfavourable aspects, as well as colour loss which was enhanced by shading in the canopy, were clearly reflected in a decrease in wine quality (see order of preference in Table 5).

TABLE 4

Effect of shading on the skin colour density of Cabernet Sauvignon, Stellenbosch.

Treatment	Skin colour density (520 nm)
Control	0,595
Single shading	0,348
Double shading	0,253
D-value ( $p \leq 0,05$ )	0,094

TABLE 5

Effect of shading on the must composition and wine quality of Cabernet Sauvignon, Stellenbosch.

Treatment	Sugar concentration (°B)	pH	K-concentration (mg/l)	TTA (g/l)	Tartaric acid (g/l)	Malic acid (g/l)	Wine quality ranking*
Control	23,6	3,30	1215	6,53	4,53	3,74	1
Single shading	21,9	3,41	1520	7,21	4,26	4,32	2
Double shading	20,4	3,86	1704	7,97	4,10	4,57	3

\*Mean ranking for two consecutive years

### LITERATURE CITED

- ARCHER, E. & BEUKES, A.J., 1983. Suier van wyndruiwe. *Die Wynboer* 624, 79-81.
- BIDWELL, R.G.S., 1974. Plant Physiology. Macmillan Publishing Co., New York.
- BLEDSE, A.M., KLIEWER, W.M. & MAROIS, J.J., 1988. Effects of timing and severity of leaf removal on yield and fruit composition of Sauvignon blanc grapevines. *Am. J. Enol. Vitic.* 39, 49-54.
- CARBONNEAU, A., 1987. Stress modérés sur feuillage induits par le système de conduite et régulation photosynthétique de la vigne. In: (eds.) J. Bouard, & R. Pouget. Physiologie de la vigne. Proc. 3rd symp. Int. sur la Physiologie de la Vigne, 24-27 June 1986, Bordeaux, France 378-385.
- CARBONNEAU, A., CASTERAN, P. & LE CLAIR, P., 1978. Essai de détermination, en biologie de la plante entière, de relations essentielles entre le bioclimat naturel, la physiologie de la vigne et la composition du raisin. *Ann. Amélior. Plantes* 28, 195-221.
- CARBONNEAU, A. & HUGLIN, P., 1982. Adaptation of training systems to French regions. Proc. Symp. Grape and Wine Cent. June 1980. A.D. Webb (Ed.) Univ. of Calif., Davis, 367-385.
- EL-ZEFTAWI, B.M. & WESTE, H.L., 1970. Effect of topping, pinching, cincturing and PCPA on the yield of Zante currant (*Vitis vinifera* var.). *Vitis* 9, 184-188.
- HUNTER, J.J. & DE LA HARPE, A.C., 1987. The effect of rootstock cultivar and bud load on the colour of *Vitis vinifera* L. cv. Muscat noir (Red Muscadell) grapes. *S. Afr. J. Enol. Vitic.* 8, 1-5.
- HUNTER, J.J. & VISSER, J.H., 1988a. Distribution of <sup>14</sup>C-photosynthetate in the shoot of *Vitis vinifera* L. cv. Cabernet Sauvignon I. The effect of leaf position and developmental stage of the vine. *S. Afr. J. Enol. Vitic.* 9 (1), 3-9.
- HUNTER, J.J. & VISSER, J.H., 1988b. Distribution of <sup>14</sup>C-photosynthetate in the shoot of *Vitis vinifera* L. cv. Cabernet Sauvignon II. The effect of partial defoliation. *S. Afr. J. Enol. Vitic.* 9 (1), 10-15.
- HUNTER, J.J. & VISSER, J.H., 1988c. The effect of partial defoliation, leaf position and developmental stage of the vine on the photosynthetic activity of *Vitis vinifera* L. cv. Cabernet Sauvignon. *S. Afr. J. Enol. Vitic.* 9 (2), 9-15.
- KLIEWER, W.M., 1982. Vineyard canopy management - A review. In: (ed) A.D. Webb. Proc. Grape and Wine Cent. Symp., 18-21 June 1980, Univ. Calif. Davis. 342-351.
- KLIEWER, W.M., MAROIS, J.J., BLEDSE, A.M., BENZ, M.J. & SILVESTRONI, O., 1988. Relative effectiveness of leaf removal, shoot positioning and trellising for improving winegrape composition. In: (eds) R. Smart, R. Thornton, S. Rodriguez & J. Young. Proc. 2nd Int. Symp. Cool Climate Vitic. and Oenol., 11-15 January 1988, Auckland, New Zealand, 123-126.
- KOBLET, W., 1977. Translocation of photosynthetate in grapevines. In: Proc. Int. Symp. on the Quality of the Vintage, 14-21 Feb., Cape Town, Republic of South Africa. 45-51.
- MORRISON, J.C., 1988. The effects of shading on the composition of Cabernet Sauvignon grape berries. In: (eds) R. Smart, R. Thornton, S. Rodriguez & J. Young. Proc. 2nd Int. Symp. Cool Climate Vitic. and Oenol., 11-15 January 1988, Auckland, New Zealand. 144-146.
- PETERSON, J.R., & SMART, R.E., 1975. Foliage removal effects on Shiraz grapevines. *Am. J. Enol. Vitic.* 26, 119-124.
- REYNOLDS, A.G., POOL, R.M. & MATTICK, L.R., 1986. Effect of shoot density and crop control on growth, yield, fruit composition, and wine quality of Seyval blanc grapes. *J. Amer. Soc. Hort. Sci.* 111, 55-63.
- SHAULIS, N., AMBERG, H. & CROWE, D., 1966. Response of Concord grapes to light exposure and Geneva Double Curtain training. *Proc. Amer. Soc. Hort. Sci.* 89, 268-280.
- SHAULIS, N. & MAY, P., 1971. Response of Sultana vines to training on a divided canopy and to shoot crowding. *Am. J. Enol. Vitic.* 22, 215-222.
- SMART, R.E., 1973. Sunlight interception by vineyards. *Am. J. Enol. Vitic.* 24, 141-147.
- SMART, R.E., 1974. Photosynthesis by grapevine canopies. *J. appl. Ecol.* 11, 997-1006.
- SMART, R.E., 1985. Principles of grapevine canopy microclimate manipulation with implications for yield and quality. A review. *Am. J. Enol. Vitic.* 36, 230-239.
- SMART, R.E., 1987a. Influence of light on composition and quality of grapes. *Acta Horticulturariae* 206, 37-47.