Effect of Seasonal Canopy Management on the Performance of Chenin blanc/99 Richter Grapevines

C.G. Volschenk and J.J. Hunter

ARC Infruitec-Nietvoorbij, Private Bag X5026, 7599 Stellenbosch, South Africa

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The effect of seasonal canopy management on the performance of a Chenin blanc/99Richter vineyard with excessive vegetative growth and trained onto a Lengthened Perold trellising system, was studied. No canopy management (shoots growing in all directions) resulted in over-exposure of the bunch zone directly above the cordon, whereas sunlight reflection from the soil was drastically reduced. In contrast, canopy management led to a much more balanced penetration of sunlight into the bunch zone – here, shoot positioning played a big role. Air flow through the canopy was highest when partial defoliation, in combination with suckering and shoot positioning, was applied; these practices had the highest impact on canopy microclimate and appearance. Canopy management reduced the incidence and severity of *Botrytis*/sour rot – shoot positioning in particular seemed critical. Highest yields were obtained by applying shoot positioning and defoliation or topping. Although suckering was labour intensive and reduced yields, it resulted in significant labour savings for critical time-dependent actions such as pruning and harvesting. Total grape quality and wine typical flavour were improved by seasonal canopy management.

Excessive vegetative growth of vineyards commonly occurs and can in many cases be ascribed to injudicious fertilisation and irrigation. Improved soil management, the use of plant material free from harmful viruses, unsuited rootstock-scion combinations, and rootstocks that are resistant to unfavourable soil conditions also contribute to excessive growth. In South Africa favourable climatic conditions stimulate vegetative growth.

Confinement of excessive growth to a restricted canopy space (as determined by the trellis and vine spacing) causes an unfavourable canopy microclimate leading to a decrease in photosynthetic activity of leaves (Hunter & Visser, 1988a, 1988b, 1988c; Smart, 1985, 1988) and a reduction in yield (Smart *et al.*, 1982) as well as grape and wine quality (Smart, 1985; Smart *et al.*, 1990). Under such conditions various seasonal canopy management practices (e.g. suckering of infertile and sub-standard shoots carrying clusters, shoot positioning, partial defoliation, tipping and topping) are normally applied in order to create a suitable canopy microclimate to improve grape quality (Kliewer *et al.*, 1988; Koblet, 1988; Hunter *et al.*, 1995; Hunter, 1999, 2000). In addition, *Botrytis cinerea* Pers. infection is a serious disease on grapes and is associated with dense canopies or compact clusters (Savage & Sall, 1983). Under field conditions, evaporative potential is used to simplify the complexity of the interactions among temperature, relative humidity and wind speed on the development of *Botrytis* (Thomas *et al.*, 1988). Improved canopy microclimate, as created by partial defoliation, increased air flow through the canopy interior and decreased relative humidity (English *et al.* 1989; Hunter & Visser, 1990), reducing the incidence and severity of *Botrytis* bunch rot (Stapleton & Grant, 1992). Gubler *et al.* (1987) reported that the chemical control of *Botrytis* during severe periods of bunch infection did not provide adequate protection but, in combination with leaf removal, the effectiveness increased to such an extent that fungicide applications could be reduced.

The aim of this study was to use seasonal canopy management practices and combinations thereof to improve canopy microclimate, reduce the incidence of *Botrytis*/sour rot, and increase grape and wine quality. In addition, it was determined whether the labour input for these practices could be justified.

MATERIALS AND METHODS

Vineyard

A 12-year-old *Vitis vinifera* L. cv. Chenin blanc (clone 3/1061) vineyard grafted onto 99 Richter (clone 1/1/13) at the Robertson experimental farm was used. Vines were planted in a North-East to South-West direction, spaced 3.0 m x 1.2 m and trained to a vertical five-strand Lengthened Perold trellising system (Zeeman, 1981). Vines were pruned to nine two-bud spurs. Standard pest and disease control measures were applied, while irrigation was scheduled according to tensiometer readings. Standard cover crop management was also applied.

Treatments

The following six canopy management practices and combinations thereof were applied: shoot positioning; suckering & shoot positioning; shoot positioning & defoliation; shoot positioning & topping; suckering, shoot positioning & defoliation; and suckering, shoot positioning, defoliation & topping. Suckering was done at 30 cm shoot length and all infertile shoots as well as shoots not located on spurs were removed. Shoots were positioned (by hand) vertically above the spurs on a regular basis during the season and topped 30 cm above the top wire. Leaf removal (approximately one third) was done twice: a) at berry set in the zone opposite and below the bunches, and b) at pea size in the zone up to half of the canopy. The seventh treatment consisted of a control with no canopy management.

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Measurements

Photosynthetic active radiation of full sunlight and that received by the bunch zone was measured in the morning (from 10:00) and in the afternoon (from 14:00) using a Li-Cor Line Quantum sensor (LI-191SA). Measurements were done above and below the cordon as well as on the North-West and South-East sides of the bunch zone. Air flow and air temperature were measured using a Kane-May 4003 thermo-anemometer, whereas humidity was measured using a Kane-May 8000 humidity meter. These measurements were taken on sunny, cloudless days in the centre of the canopy just above the bunch zone. Evaporation potential was measured by placing a petri dish filled with water in the canopy just above the bunch zone. Water loss was measured after 24 h. Canopies were evaluated according to canopy gaps, number of leaf layers and bunch exposure. The percentage of bunches infected with *Botrytis* and/or sour rot (incidence), as well as the percentage of each bunch that was infected (severity), were also determined by visual inspection. Yields were determined at ripeness. A representative sample was taken and the must composition (soluble solids, titratable acidity and pH) determined according to standard methods. Free-amino-nitrogen (FAN) of the sample was determined according to an Auto Analyzer method using ammonium sulphate as reference (Anonymous, 1974). Grapes from replicates 1 and 2 and from 3, 4 and 5 were combined and wines made according to standard Nietvoorbij procedures. The labour requirement for the execution of different canopy management practices as well as pruning and harvesting was recorded in terms of man hours.

Statistics

The seven treatments were replicated five times in a randomised block design. Analysis of variance was performed on all data from the 95/96, 96/97 and 97/98 seasons. Wine quality was only determined during the 96/97 and 97/98 seasons. The least significant difference at a 5% level was used to compare treatment means.

RESULTS AND DISCUSSION

No canopy management resulted in a relatively high level of light penetration into the bunch zone, which occurred mainly from directly above the cordon (Table 1). This can be ascribed to shoots growing in all directions and hanging on the outer side of the trellising system wires. The centre of the canopy and some of the bunches were therefore overly exposed, whereas a high percentage of the leaves and bunches were shaded. A much more balanced interception of sunlight from the different sides occurred for the vines on which canopy management was applied, which will eventually lead to a more uniform ripening of all bunches. Shoot positioning had a major effect on the balance of sunlight penetration into the bunch zone. The highest air flow through the canopy occurred for the suckering-shoot positioning-defoliation treatment with or without topping, which confirms the results found by English *et al.* (1989) and Hunter & Visser (1990) (Table 2). In comparison to the control vines that had canopies with high light levels penetrating from directly above the cordon, the canopy management treatments surprisingly showed similar relative humidity and evaporation levels in spite of their slightly lower canopy temperatures. The microclimate results are complemented by the canopy appearance resulting from the different treatments (Table 3). The three to four leaf layers and bunch exposure of between 20% and 30% of treatments which included suckering, shoot positioning and defoliation, with or without topping, are considered optimum for obtaining high quality grapes (Smart, 1985; Hunter, 1999).

All canopy management practices and combinations thereof significantly decreased the incidence and severity of *Botrytis*/sour rot (Table 4). This will undoubtedly result in huge savings in terms of fungicides and contribute to obtaining higher-quality grapes. Shoot positioning contributed the most to *Botrytis*/sour rot control. Apparently, the best incidence control was obtained by the two treatments that included topping, whereas the best severity control was found for treatments that included topping and defoliation.

In spite of the positive effect of defoliation and topping (cf. also Koblet, 1984; Kliewer & Bledsoe, 1987; Hunter, 1999; Hunter, 2000; Hunter & Le Roux, 2000), all the treatments that included suckering showed a decrease in yield, caused by the removal of fertile but sub-standard shoots. In practice this can be avoided by judiciously suckering only infertile shoots that would contribute to canopy shade and can not be used for renewal purposes. However, as these fruit-bearing, sub-standard shoots normally cause shade in the canopy interior and "parasitise" on the rest of the vine (import assimilates) in order to ripen their grapes (Koblet, 1984), keeping them will eventually result in the quality

TABLE 1

Percentage distribution of sunlight interception by the bunch zone.

Canopy management practices	Morning				Afternoon				
	Position of measurement with reference to cordon				Position of measurement with reference to cordon				
	Above	North-West	South-East	Total (% of ambient)	Above	North-West	South-East	Below	Total (% of (ambient)
Control	62.3	15.0	22.8	9.6	58.9	27.5	7.8	5.7	22.7
Shoot positioning	37.3	18.2	44.6	5.6	51.8	22.7	9.3	16.2	13.0
Suckering & shoot positioning	41.6	15.3	43.1	6.4	48.2	26.4	9.3	16.2	15.8
Suckering, shoot positioning, defoliation & topping	46.6	14.4	39.1	10.8	46.5	22.8	11.3	19.4	17.6

of the whole batch of grapes being negatively affected. Highest yields were obtained by applying shoot positioning and defoliation or topping. The higher soluble solid accumulation of control vines could be the result of some bunches being highly exposed to direct sunlight over the midday period (Table 1), resulting in a high concentration of sugar. The control treatment displayed the lowest free-amino-nitrogen concentration in the must (Table 4).

The sensorial evaluation of the wines showed a slightly reduced tree fruit aroma (apricot, peach, apple) and increased tropical fruit aroma (pineapple, banana, guava) when canopy management was applied (Table 5). Canopy management therefore changed the flavour profile, enhancing the typical flavour of the cultivar. In the

TABLE 2

Canopy management effect on canopy microclimate and evaporation at ripeness.

Canopy management practices	Air flow (m/s)	Relative humidity (%)	Temperature (°C)	Evaporation (mL water/24h)
Control	0.29ab	32.1b	27.11a	13.1a
Shoot positioning	0.23c	32.7ab	27.05ab	14.3a
Suckering & shoot positioning	0.25bc	32.7ab	27.01ab	13.1a
Shoot positioning & defoliation	0.30ab	32.8a	26.82ab	13.3a
Shoot positioning & topping	0.30ab	32.7ab	26.76b	12.6a
Suckering, shoot positioning & defoliation	0.33a	32.4ab	26.83ab	14.0a
Suckering, shoot positioning, defoliation & topping	0.33a	32.2ab	27.05ab	12.8a

Values designated by the same letter do not differ significantly ($p \leq 0.05$).

TABLE 3

Canopy management effect on canopy appearance at ripeness.

Canopy management practices	Canopy gaps (%)	Number of leaf layers	Bunch exposure (%)
Control	*40	3	10
Shoot positioning	10	5	10
Suckering & shoot positioning	10	5	10
Shoot positioning & defoliation	15	4	20
Shoot positioning & topping	15	4	10
Suckering, shoot positioning & defoliation	20	3	30
Suckering, shoot positioning, defoliation & topping	25	3	30

*Shoots hung open.

TABLE 4

Canopy management effect on *Botrytis*/sour rot infection, yield and must composition at ripeness.

Canopy management practices	Botrytis/sour rot infection (%)		Yield (t/ha)	Soluble solids (°B)	Titratable acidity (g/L)	pH	FAN (mg/L)
	Incidence	Severity					
Control	60.5a	19.17a	26.2ab	19.72a	7.51bc	3.17ab	926d
Shoot positioning	32.2b	7.88b	26.6ab	18.58d	7.91ab	3.16abc	1154ab
Suckering & shoot positioning	30.3b	8.52b	23.4c	19.17bc	8.19a	3.19a	1202a
Shoot positioning & defoliation	34.2b	7.23b	27.9a	18.68cd	7.71bc	3.16abc	1048bcd
Shoot positioning & topping	25.4b	4.71b	27.1a	18.41d	7.87ab	3.15bc	1084abc
Suckering, shoot positioning & defoliation	31.0b	4.87b	23.3c	19.57ab	7.45bc	3.17abc	1024cd
Suckering, shoot positioning, defoliation & topping	25.6b	4.70b	24.5bc	19.17bc	7.93ab	3.14c	1002cd

Values designated by the same letter do not differ significantly ($p \leq 0.05$).

case of control vines, the high incidence and severity of *Botrytis*/sour rot probably played a role in the flavour of the wine.

Canopy management required higher labour input (Table 6). It seemed that suckering was the most labour-intensive practice. However, although yield was decreased by 13% as a result of suckering, labour input for pruning, compared to those treatments that were not suckered, decreased by more than 33%, whereas the labour input for harvesting these treatments decreased by more than 32% (cf. also Hunter & Le Roux, 2000). Labour input for shoot positioning and defoliation was also reduced as a result of suckering. Given the fact that actions such as harvesting and pruning are normally executed within limited time periods, the saving on labour in this regard as a result of suckering is an important consideration in the calculation of net income.

TABLE 5

Canopy management effect on wine quality (% acceptability and perceptibility).

Canopy management practices	Tree fruit	Tropical fruit
Control (none)	17.8a	29.9b
Shoot positioning	10.6ab	36.3ab
Suckering & shoot positioning	12.4ab	31.5ab
Shoot positioning & defoliation	16.6a	35.6ab
Shoot positioning & topping	12.6ab	40.1ab
Suckering, shoot positioning & Defoliation	14.4ab	32.3ab
Suckering, shoot positioning, defoliation & topping	9.2b	40.8a

Values designated by the same letter do not differ significantly (p≤0.05).

TABLE 6

Labour input for pruning, canopy management and harvesting (man hours per hectare).

Canopy management practices	Pruning	Suckering	Shoot positioning	Defoliation	Topping	Harvesting	Total
Control (none)	93.7a	*13.5b	0.0	0.0	0.0	133.7a	240.6d
Shoot positioning	84.8b	*16.4b	81.3b	0.0	0.0	132.9a	315.4c
Suckering & shoot positioning	65.6c	86.0a	71.9c	0.0	0.0	92.5b	316.0c
Shoot positioning & defoliation	94.6a	*15.7b	90.1a	61.9a	0.0	131.1a	377.8a
Shoot positioning & topping	84.0b	*16.1b	81.7b	0.0	24.1b	124.8a	330.7bc
Suckering, shoot positioning & defoliation	58.9cd	89.8a	61.4d	42.0b	0.0	85.4b	337.5b
Suckering, shoot positioning, defoliation & topping	54.8d	87.4a	76.7bc	41.3b	29.3a	87.7b	377.2a

Values designated by the same letter do not differ significantly (p≤0.05).
*Shoots were removed on trunks only.

CONCLUSIONS

Seasonal canopy management resulted in a more balanced exposure of the bunch zone to sunlight, which would favour uniform ripening of the berries. In contrast, no canopy management excessively exposed the bunch zone from the top, whereas sunlight reflection from the soil was reduced to a very low level. Partial defoliation, in combination with suckering and shoot positioning, had the highest impact on canopy microclimate. Canopy management, and shoot positioning in particular, seemed imperative for the control of *Botrytis*/sour rot, which will undoubtedly reduce fungicide costs and contribute to grape quality. Highest yields were induced by the application of shoot positioning and defoliation or topping. Although suckering was the most labour-intensive practice and reduced yields, it resulted in significant labour savings on critical actions such as pruning and harvesting and will contribute to the suitability of grapes for higher-quality wine. By applying seasonal canopy management, canopies favourable to the improvement of grape quality were created, whereas more typical cultivar wine flavour was induced. It is evident that judicious selection and application of seasonal canopy management practices can contribute greatly to environment-friendly production of higher-quality grapes and wine.

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