The Effect of Partial Defoliation on Growth Characteristics of *Vitis vinifera* L. cv. Cabernet Sauvignon I. Vegetative Growth

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The effect of partial defoliation of the whole canopy on vegetative growth of *Vitis vinifera* L. cv. Cabernet Sauvignon was investigated. Vegetative growth of vines followed the well-known pattern for 0%, 33% and 66% defoliation, i.e. an increase until véraison followed by a decline. Partial defoliation conducted from different developmental stages had no significant effect on leaf area and main shoot length at subsequent developmental stages. The earlier defoliation was applied, the more lateral shoot length and the number of lateral shoots increased, resulting in higher total shoot lengths but no significant differences in cane mass. Partial defoliation from véraison had no effect on lateral growth. Canopy density and relative humidity decreased, while sunlight penetration and windspeed increased in the canopy with partial defoliation. The improved canopy light environment facilitates improved photosynthetic efficiency of leaves as well as development and composition of grapes.

The vegetative growth of vines in South Africa tends to be excessive owing to generally improved viticultural practices such as soil management, fertilization, vineyard establishment, vine training, cultivation, and the use of high-quality propagation material. Moreover, the favourable climate in South Africa is also a contributing factor. Under conditions of excessive growth, shoot growth becomes a strong sink for products of photosynthesis, with other parts receiving little or no nutrients for growth and development (Hunter & Visser, 1988a, 1988b). Increases in shoot growth and leaf area, as well as the appearance of too many lateral shoots, water shoots and the outburst of basal buds may also create conditions of density and shading in the canopy interior. Bad pruning practices, such as the allocation of too many bearers on a restricted cordon length, resulting in too closely spaced bearers, also favour a dense canopy. This unfavourable condition is found to a certain extent in all trellising systems. Foliage management, therefore, becomes a major priority for the viticulturist in order to improve light conditions for photosynthesis of especially interior-canopy leaves, as well as for budding, bud fertility, fruit development and pest and disease control.

Extensive research has been done on the effect of defoliation on various parts of grapevines. Since the methods, levels and time of defoliation differed greatly, divergent results were obtained. Buttrose (1966) found that trunks of grapevines were least affected by defoliation, followed by shoots, berries and roots, while Kliewer & Fuller (1973) reported the opposite. Some investigators found reduced yields with partial defoliation (Coombe, 1959; May, Shaulis & Antcliff, 1969; Kliewer & Antcliff, 1970; Sidahmed & Kliewer, 1980), while others failed to demonstrate any differences (Peterson & Smart, 1975; Bledsoe, Kliewer & Marois, 1988; Koblet, 1988).

In general, 10-12 cm^2 leaf area is required to ripen one gram of fruit adequately in terms of soluble solid accumulation (Kliewer & Antcliff, 1970; Kliewer & Ough, 1970; Kliewer & Weaver, 1971). It is well-known that the photosynthetic efficiency of leaves increases when leaf area is reduced relative to the different sinks in the grapevine (Buttrose, 1966; May *et al.*, 1969; Kliewer & Antcliff, 1970; Kriedemann, 1977; Hofäcker, 1978; Johnson, Weaver & Paige, 1982; Hunter & Visser, 1988b, 1988c). Since the distribution of photosynthetic products is regulated by the so-called source: sink relationship (Johnson *et al.*, 1982), a decrease in the leaf area would cause a change in the availability of photosynthetates for the different sinks. Total dry matter production is, however, a function of how effectively a vine can utilize the soil and aerial environment. Therefore, the size of a grapevine canopy does not necessarily determine the magnitude and quality of a harvest.

Although leaf removal, together with foliage management practices such as suckering, shoot positioning, tipping and topping, is an existing practice, great uncertainty exists on how, when, where, and how many leaves must be removed. The effect of leaf removal on different vegetative parameters is also uncertain. Consequently, this investigation was carried out to determine the effect of different levels of defoliation, implemented continuously from different developmental stages of the vine, on the vegetative growth of *Vitis vinifera* L. cv. Cabernet Sauvignon. The effect on reproduc-

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tive growth is discussed in an accompanying paper (Hunter & Visser, 1990).

MATERIALS AND METHODS

Experimental vineyard: An eight-year-old *Vitis vinifera* L. cv. Cabernet Sauvignon vineyard (clone 4/R46) (*CS 46), grafted onto rootstock 99 Richter (clone 1/30/1) (*RY 30), situated at the Nietvoorbij experimental farm in the Western Cape was used. More detail was given by Hunter & Visser (1988a).

Experimental design: The experiment was laid out as a completely randomized design. Three defoliation levels were applied to the whole canopy, i.e. 0% (control), 33% and 66%. The control consisted of four treatments, whereas the 33% and 66% defoliation levels consisted of 10 treatments each (Fig. 1). The defoliation treatments were implemented as follows: Four from approximately one month after bud break, three from berry set, two from pea size and one from véraison. Data were collected at different developmental stages as shown in Fig. 1. Nine replications, comprising one-vine plots were used for each of the 24 treatments.

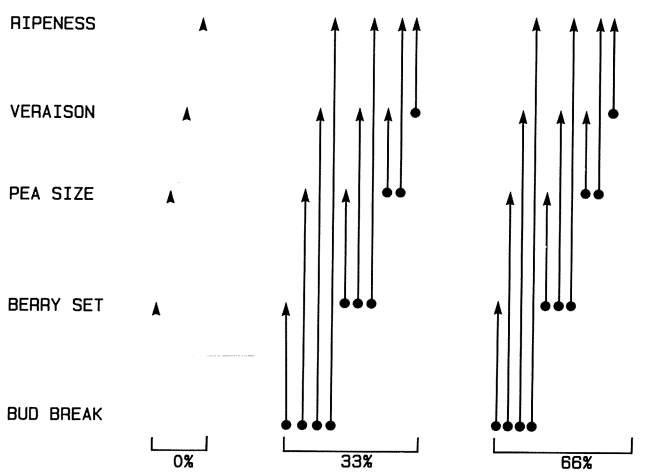

FIGURE 1
A schematic representation of different stages of defoliation and sampling.

Defoliation treatments: The defoliation treatments consisted of removing the first leaf out of every three (33%) or the first two leaves out of every three (66%), starting at the basal end of the shoot. All shoots, including lateral shoots, were treated likewise. Defoliation percentages were maintained until each sampling stage, i.e. leaves emerging after the initial defoliations were removed as described above at approximately monthly intervals.

Measurements: Leaf area (cm^2), main shoot length (cm), lateral shoot length (cm), the number of laterals, total shoot length (cm), cane mass (g), canopy density, relative humidity (%), windspeed (cm/s) and temperature (°C) were measured. Leaf area was determined with a LICOR LI 3000 portable area meter. Canopy density was determined by means of an apparatus consisting of an adjustable frame and a thin steel rod [based on the point-quadrat method described by Smart (1982)]. The rod was pushed horizontally through the canopy at five fixed distances just above the bunch zone over the whole cordon. Canopy density was expressed as the number of leaves contacted. The percentage relative humidity in the canopy was measured with a Kane-May 8000 humidity meter, and the windspeed and temperature were determined with a Kane-May 4003 thermo-anemometer just above the bunch zone.

Statistical analysis: Depending on the parameter, a one-way analysis of variance or two-way analysis of variance (standard VORI statistical software packages) was performed on the raw data. Statistical analyses for the determination of significant differences between treatment means were carried out using a Scott-Knott analysis. The experiment was conducted over three growth seasons. Since no interactions between growth seasons were found, the data represent the overall means.

RESULTS AND DISCUSSION

Effect of defoliation: The effect of the 33% and 66% defoliation levels at berry set, pea size and véraison is depicted in Table 1. The criterion for the determination of the percentage of remaining leaf area was total leaf number. It is evident that for both treatments the percentage of remaining leaf area per shoot (determined according to leaf area removed at the time of defoliation) was more than the theoretically expected value at each developmental stage. This is in agreement with the findings of Kliewer & Ough (1970) and Kliewer & Fuller (1973) with the cultivar Sultanina. At the higher defoliation level the percentage of remaining leaf area increased compared to the expected remaining leaf area. This tendency can be attributed to the fact that the method of treatment was dependent on the removal of specific leaves instead of leaf area.

TABLE 1
The effect of time and severity of defoliation on the remaining leaf area per shoot at different developmental stages.

Developmental stage	Defoliation (%)	Remaining leaf area (% of control)
Berry set	33	67,99 ± 2,81
	66	39,78 ± 2,65
Pea size	33	66,51 ± 1,12
	66	43,27 ± 5,82
Véraison	33	66,98 ± 4,08
	66	43,54 ± 10,81

A comparison between the average remaining leaf area per shoot calculated on the basis of leaves removed, and that

* *South African Vine Improvement Board clone number.*

calculated on the basis of leaves retained on the vine, is shown in Table 2. Differences between the leaf area calculated on the basis of leaves removed from vines and that calculated on the basis of leaves retained was approximately 4% for the 33% defoliation and 5% for the 66% defoliation treatment. These differences could have resulted from increases in the leaf areas of the remaining leaves following partial defoliation. Except for apical leaves, this was evident for the 66% defoliation treatment, albeit not significantly (Fig. 2). Leaf growth responses after defoliation was also found for lucerne (Hodgkinson, 1974). A possible increase in lateral shoot growth and/or number of laterals with partial defoliation could, however, also have contributed to increased remaining leaf areas. Nevertheless, the two methods for determining remaining leaf areas seem comparable. It can, therefore, readily be assumed that the method used in partially defoliating the vines yielded reliable results during the entire growth season.

TABLE 2
A comparison between the average remaining leaf area per shoot, calculated on the basis of leaves removed (A) and on the basis of leaves retained (B) on the vine.

Defoliation (%)	*Average remaining leaf area	
	A	**B
0	100,00	100,00
33	67,16	71,09
66	42,20	46,84

* As a percentage of controls.
* The average of leaf area measured at each developmental stage during the growth season.

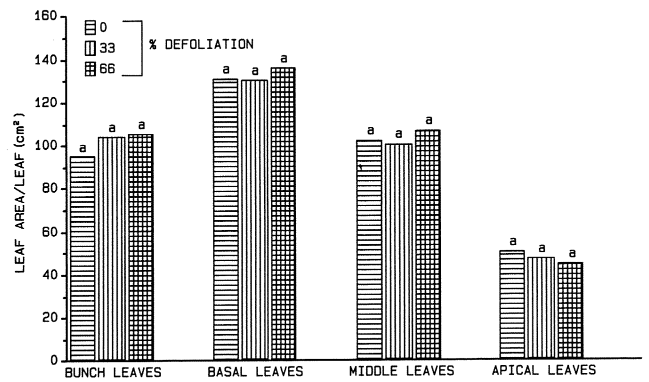

FIGURE 2
The effect of defoliation on areas of leaves in different positions on the shoot. Bars designated by the same letter do not differ significantly (p ≤ 0,05) for each leaf position.

Leaf area: As expected, the 33% and 66% defoliation levels significantly reduced the leaf area per shoot over the growth season (Table 3). Partial defoliation improved the canopy light environment, as is evident from the shade patterns (Fig. 3) and densities of the canopies (Table 4). The 33% defoliation level resulted in a more favourable situation, namely an even distribution of small sunflecks in the canopy, implying that sufficient sunlight penetrated the canopy for maximum light absorption by leaves. Contrastingly, the 66% defoliation was too severe and could result in a loss of potentially utilizable light energy. The leaf layer numbers of the 33% as well as the 66% defoliation treatments, however, approximated the optimum of three, as suggested by Smart (1985). Partial defoliation from different developmental stages during the growth season had no significant effect on leaf areas at subsequent developmental stages for each treatment.

TABLE 3
The effect of defoliation from different developmental stages of the vine on the total leaf area (cm^2) per shoot.

Developmental stage defoliation commenced	Developmental stage measured	Defoliation (%)		
		0	33	66
Bud break	Berry set	2961[b]	2641[b]	1773[c]
	Pea size	4010[a]	3224[b]	1982[c]
	Véraison	4294[a]	3166[b]	2159[c]
	Ripeness	4277[a]	2987[b]	1932[c]
Berry set	Pea size	4010[a]	2967[b]	1933[c]
	Véraison	4294[a]	3362[b]	2258[c]
	Ripeness	4277[a]	2954[b]	1950[c]
Pea size	Véraison	4294[a]	3029[b]	1767[c]
	Ripeness	4277[a]	2767[b]	2033[c]
Véraison	Ripeness	4277[a]	2931[b]	1780[c]
Cv (%)		18,15		

Values designated by the same letter do not differ significantly (p ≤ 0,05).
Data represent the means over three growth seasons.

TABLE 4
The effect of defoliation on canopy density over the growth season, expressed as the number of contacts with leaves (number of leaf layers).

Defoliation (%)	Number of leaf layers
0	5,29[a]
33	3,71[b]
66	2,98[c]
Cv (%)	22,02

Values designated by the same letter do not significantly (p ≤ 0,05).

In general, apparent increases in leaf area from bud break until véraison occurred, followed by a decline (Table 3). A similar growth pattern was found for the cultivar Cape Riesling (De la Harpe & Visser, 1985). The ostensible decrease in leaf area at ripeness may have resulted from leaf senescence. Partial defoliation also significantly reduced the water content of interiorly situated leaves (Table 5). Owing to the

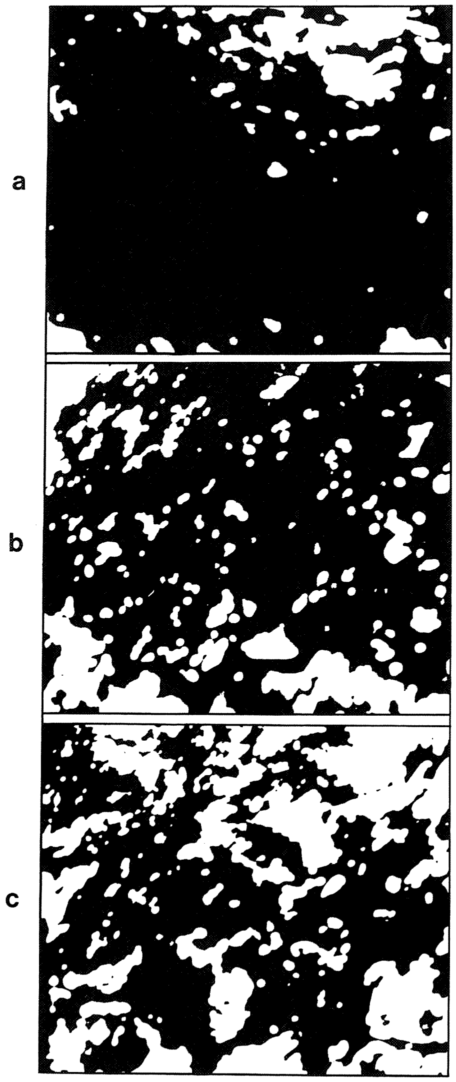

FIGURE 3
The shade patterns of canopies of vines defoliated (a) 0%, (b) 33% and (c) 66%.

gradual decline in water content as the season progressed (Table 5), the elasticity of petioles probably decreased and, therefore, the vulnerability of leaves to normal abscission and removal by wind increased. The decrease at ripeness seemed to be more pronounced for the leaves of partially defoliated vines, probably as a result of less dense canopies. Therefore, the leaves were probably more affected by unfavourable climatic conditions. Chlorosis of interior-canopy leaves generally occurred in control vines (data not shown). Although the specific fresh mass per leaf area tended to increase for the severe defoliation level (Fig. 4), the results confirmed those of Kliewer & Fuller (1973), who found no increases in leaf dry masses for 25%, 50% and 75% defoliated Sultanina vines compared to non-defoliated vines.

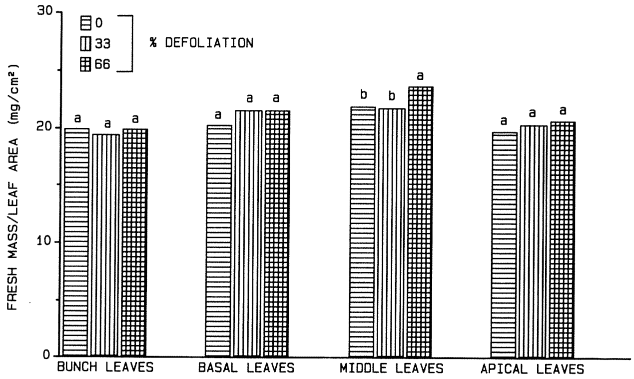

FIGURE 4
The effect of defoliation on specific fresh mass per leaf area of leaves in different positions on the shoot. Bars designated by the same letter do not differ significantly ($p \leq 0,05$) for each leaf position.

Main shoot length: Though not significant, the mean main shoot length decreased as a result of defoliation (Table 6). This apparent decrease may facilitate the diversion of photosynthetates to other parts of the vine. In contrast to the elongated internodes of interiorly-situated parts of the shoots of control vines, the shoots of partially defoliated vines had shorter internodes, occurring from the basis of the shoot (data not shown). This was also found by Kliewer & Fuller (1973)

TABLE 5
The effect of defoliation and the developmental stage of the vine on the water content (%) of leaves in different positions on the shoot.

DEVELOP-MENTAL STAGE	BUNCH LEAVES				BASAL LEAVES				MIDDLE LEAVES				APICAL LEAVES			
	*0	*33	*66	Mean	0	33	66	Mean	0	33	66	Mean	0	33	66	Mean
Berry set	72,06	72,21	71,40	71,89^{a}	73,29	73,10	73,02	73,14^{a}	73,61	73,53	73,77	73,64^{a}	74,81	74,46	75,12	74,79^{a}
Pea size	68,33	67,16	67,78	67,76^{b}	70,23	70,18	70,80	70,40^{b}	70,32	70.70	71,27	70,76^{b}	71,89	72,58	73,30	72,59^{b}
Véraison	66,77	64,13	60,52	63,80^{c}	64,96	65,19	63,38	64,51^{c}	65,35	65,00	64,74	65,03^{c}	65,04	65,95	66,52	65,83^{c}
Ripeness	64,64	61,64	60,62	62,30^{d}	63,06	60,62	59,57	61,09^{d}	61,48	60,82	60,70	61,00^{d}	61,52	60,52	63,28	61,77^{d}
Mean	67,95^{A}	66,29^{B}	65,08^{C}		67,89^{A}	67,27^{B}	66,69^{C}		67,69^{A}	67,51^{A}	67,62^{A}		68,31^{B}	68,38^{B}	69,55^{A}	
Cv (%)	1,05				0,79				0,94				1,02			

* Percentage defoliation.
Values designated by the same letter do not differ significantly ($p \leq 0,05$) for each plant part.

TABLE 6
The effect of defoliation from different developmental stages of the vine on the mean main shoot length (cm).

Developmental stage defoliation commenced	Developmental stage measured	Defoliation (%)		
		0	33	66
Bud break	Berry set	116[b]	112[b]	109[b]
	Pea size	130[a]	132[a]	123[b]
	Véraison	145[a]	133[a]	138[a]
	Ripeness	143[a]	142[a]	137[a]
Berry set	Pea size	130[a]	119[b]	137[a]
	Véraison	145[a]	140[a]	141[a]
	Ripeness	143[a]	140[a]	144[a]
Pea size	Véraison	145[a]	138[a]	130[a]
	Ripeness	143[a]	143[a]	141[a]
Véraison	Ripeness	143[a]	144[a]	145[a]
Cv (%)		9,57		

Values designated by the same letter do not differ significantly ($p \leq 0,05$).
Data represent the means over three growth seasons.

and Fournioux & Bessis (1984). The improved light conditions found in canopies of partially defoliated vines (Hunter & Visser, 1988c), may have played a role in the shortening of internodes (Leopold & Kriedemann, 1975). According to Salisbury & Ross (1978) a major function of phytochrome (P) is to detect mutual shading and to modify growth accordingly. A higher ratio of P_{fr}:P_r in the interior of control vine canopies may have been responsible for longer internodes (Morgan, Stanley & Warrington, 1985). This aspect needs to be investigated further. Although the growth of vines used in this study was not excessively vigorous, the apparent reduction in main shoot length with partial defoliation suggests that vigorous growth may be inhibited by leaf removal practices. Partial defoliation from different developmental stages had no significant effect on the main shoot length at subsequent developmental stages.

In general, the main shoot length increased until véraison and virtually ceased thereafter. This was also found by Zelleke & Kliewer (1979) and De la Harpe & Visser (1985) for the cultivars Cabernet Sauvignon and Cape Riesling, respectively.

Lateral shoot growth: Generally, lateral shoot length as well as the number of lateral shoots increased significantly when partial defoliation was implemented from bud break, berry set and pea size stages (Tables 7 & 8). Similar results were found for Perlette and Sultanina vines (Marangoni, Ryugo & Olmo, 1980). According to the latter investigators the uniformity of the carbohydrate content in the rest of the shoots and the reasonably good growth occurring during the next season suggested that the vine benefitted from the production of new leaves during midseason. In general, the earlier defoliation was implemented, the more the total lateral

TABLE 7
The effect of defoliation from different developmental stages of the vine on the total lateral shoot length (cm) per shoot.

Developmental stage defoliation commenced	Developmental stage measured	Defoliation (%)		
		0	33	66
Bud break	Berry set	63[d]	79[c]	91[b]
	Pea size	71[c]	118[a]	115[a]
	Véraison	57[d]	95[b]	105[a]
	Ripeness	60[d]	82[c]	92[b]
Berry set	Pea size	71[c]	86[b]	100[b]
	Véraison	57[d]	80[c]	92[b]
	Ripeness	60[d]	88[b]	73[c]
Pea size	Véraison	57[d]	90[b]	72[c]
	Ripeness	60[d]	58[d]	82[c]
Véraison	Ripeness	60[d]	58[d]	63[d]
Cv (%)		24,82		

Values designated by the same letter do not differ significantly ($p \leq 0,05$).
Data represent the means over three growth seasons.

TABLE 8
The effect of defoliation from different developmental stages of the vine on the number of lateral shoots per vine.

Developmental stage defoliation commenced	Developmental stage measured	Defoliation (%)		
		0	33	66
Bud break	Berry set	102[b]	143[a]	150[a]
	Pea size	97[c]	139[a]	134[a]
	Véraison	58[d]	85[c]	119[b]
	Ripeness	52[d]	59[d]	93[c]
Berry set	Pea size	97[c]	110[b]	111[b]
	Véraison	58[d]	84[c]	92[c]
	Ripeness	52[d]	64[d]	70[d]
Pea size	Véraison	58[d]	84[c]	85[c]
	Ripeness	52[d]	72[d]	74[d]
Véraison	Ripeness	52[d]	58[d]	57[d]
Cv (%)		21,82		

Values designated by the same letter do not differ significantly ($p \leq 0{,}05$).
Data represent the means over three growth seasons.

shoot length per shoot as well as the number of laterals per vine was increased (Tables 7 & 8). The latter results were also found by Kliewer & Fuller (1973). However, no compensatory growth at subsequent developmental stages occurred for each defoliation treatment. The stimulation in lateral growth is possibly associated with a substance, produced by the leaves during early developmental stages, which inhibited lateral bud growth (Kliewer & Fuller, 1973). The removal of leaves reduces the concentration of this substance. According to Leopold & Kriedemann (1975) the regulation of auxin formation may be involved in compensatory growth.

Apart from mobilising vine reserves (Koblet & Perret, 1982), increased lateral growth, and especially the number of lateral shoots, as well as the accompanied use of photosynthetates probably inhibited the distribution of compounds contributing to the development and quality of grapes. According to Koblet (1984), the shoot tip alone used the photosynthetates of one to six mature leaves. Since maximum lateral shoot length was reached relatively early during the season (pea size stage), however, the competitive effects could have been neutralised by the availability of recently matured, active leaves with high photosynthetic activities from véraison to harvest. According to Johnson & Lakso (1985) newly formed leaves continued to increase in size after shoot growth had stopped. Lateral shoots carried 25% to 50% of the total leaf area on the vine (Schneider, 1985). The potential to export photosynthetates was attained when 30% to 50% of the final size of the leaves was reached (Hale & Weaver, 1962; Koblet, 1977; Yang & Hori, 1980). Young leaves produced more organic acids and mature leaves more sugar (Kriedemann, 1977). Provided that the microclimate is optimal, the presence of young leaves on lateral shoots and the apical parts of carrier shoots during the period véraison to ripeness would, therefore, be important to ensure a balanced organic acid : sugar ratio in the fruit, especially in regions where a lack of acid in the grapes is experienced. The leaves of lateral shoots without grapes exported their carbohydrates to bunches of main shoots (Koblet, 1969; Koblet & Perret, 1971). The practice of removing lateral shoots to improve canopy microclimate should, therefore, be done with great caution. According to Koblet (1987) the growth of lateral shoots and the subsequent higher proportion of young leaves increased fruit quality.

Partial defoliation from véraison had no effect on lateral growth, probably because the vegetative growth of the vine had already virtually ceased. This is in agreement with the results found for Sultanina vines (Kliewer & Fuller, 1973). The inhibition or abscence of lateral shoots may not only save food reserves, but would also benefit pest and disease control, canopy microclimate and the photosynthetic activity of all leaves on the vine.

Total shoot length: As for leaf area (Table 3) and main shoot length (Table 6), the mean total shoot length followed the general pattern, i.e. a rapid increase until véraison, followed by a decline (Table 9). This tendency remained the same for all defoliation treatments. In general, partial defoliation significantly increased the total shoot length per bud. This increase may be ascribed to the increase in lateral growth (Tables 7 & 8). Although partial defoliation from earlier stages resulted in an increase in lateral shoot growth with concomitant increases in the leaf area and total shoot length, the method by which partial defoliation was applied in this study was still effective in improving light intensity especially at interior-canopy leaf positions as well as the photosynthetic activity of all leaves on the shoot (Hunter & Visser, 1988c). The distribution of photosynthetates was not affected (Hunter & Visser, 1988b).

Furthermore, it is evident from Table 10 that partial defoliation significantly increased windspeed but decreased the relative humidity in the canopy, whereas the canopy temperature was similar to that of control vines. Along with the less dense canopies of partially defoliated vines (Fig. 3, Table 4), the results imply that the incidence of diseases would be reduced and the chemical control of diseases by

TABLE 9
The effect of defoliation from different developmental stages of the vine on the mean total shoot length (main and lateral shoots) (cm).

Development stage defoliation commenced	**Developmental stage measured**	**Defoliation (%)**		
		0	**33**	**66**
Bud break	Berry set	178[b]	191[b]	201[b]
	Pea size	201[b]	250[a]	238[a]
	Véraison	203[b]	228[a]	243[a]
	Ripeness	202[b]	219[a]	229[a]
Berry set	Pea size	201[b]	205[b]	237[a]
	Véraison	203[b]	221[a]	233[a]
	Ripeness	202[b]	212[b]	217[a]
Pea size	Véraison	203[b]	226[a]	203[b]
	Ripeness	202[b]	202[b]	223[a]
Véraison	Ripeness	202[b]	203[b]	209[b]
Cv (%)		11,02		

Values designated by the same letter do not differ significantly ($p \leq 0,05$).
Data represent the means over three growth seasons.

spraying would benefit from the change in canopy microclimate as created by partial defoliation, as reported by Boniface & Dumartin (1977), Koblet (1987) and English *et al.* (1989).

TABLE 10
The effect of defoliation on windspeed, relative humidity and temperature in the grapevine canopy over the growth season.

Defoliation (%)	**Windspeed (cm/s)**	**Relative humidity (%)**	**Temperature (°C)**
0	12,78[c]	34,81[a]	29,59[a]
33	20,28[b]	33,69[b]	29,46[a]
66	27,78[a]	33,11[b]	29,57[a]
Cv (%)	27,67	5,51	4,55

Values designated by the same letter do not differ significantly ($p \leq 0,05$) for each parameter.

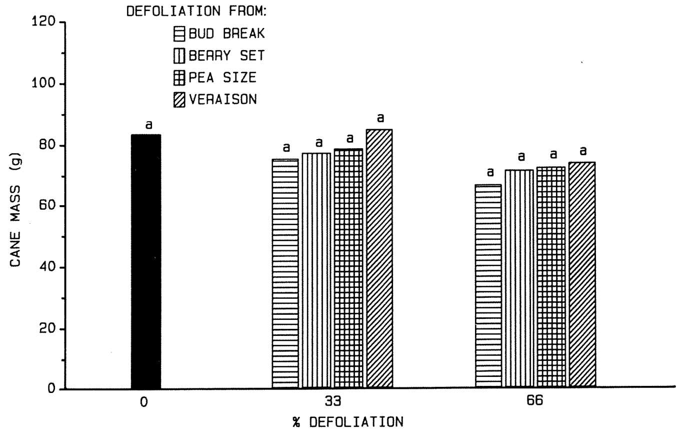

FIGURE 5
The effect of defoliation, implemented from different developmental stages of the vine, on cane mass at ripeness. Bars designated by the same letter do not differ significantly ($p \leq 0,05$).

Cane mass: The earlier and more severely partial defoliation was applied, the more cane mass was reduced, albeit not significantly (Fig. 5). Except for the 33% defoliation, carried out from pea size and véraison, cane mass per vine apparently also declined with defoliation. The apparent decrease in cane mass with long-term and severe defoliation could be due to a deprivation of vine reserves, differences in budding percentage as well as thinner shoots. According to Kliewer & Fuller (1973), cane mass does not seem to be a good indicator of reduced vine capacity as a result of defoliation, especially when applied at véraison or later.

CONCLUSIONS

Regardless of the degree of defoliation, the vegetative growth of vines generally increased until véraison, followed by a decline. In spite of the severe defoliation, the normal sigmoidal growth pattern of vines was not affected. This is important for the general well-being and longevity of vines and may have resulted mainly from the fact that leaves were removed evenly and not, as in some other studies by block-stripping or selectively.

Partial defoliation significantly reduced leaf area, but only slightly reduced main shoot length. The latter effect may have been more pronounced if the vines had grown more vigorously. Partial defoliation, however, especially from early in the growth season, significantly increased the lateral shoot length, the number of laterals and, therefore, the total shoot length. In spite of this, light microclimatic conditions in canopies of especially 33% defoliated vines were still more favourable compared to non-defoliated vines. Grape composition would benefit from the appearance of young and recently matured leaves in the canopy. The removal of lateral shoots at any stage should, therefore, be carried out with great care. Although cane mass was slightly smaller the earlier defoliation was applied, these reductions were not significant. Cane mass is, therefore, not a good indicator of changed vine capacity as a result of partial defoliation.

Owing to the problem of excessive growth in South African vineyards, grapevine canopies can be dense or become very dense when the overall canopy structure is reduced by, for example, severe topping early in the growth season or is expanded by applying more bearers and/or extending the cordon vertically and/or horizontally. Grapevine canopy management practices should, therefore, be aimed at creating a canopy consisting of well-positioned leaves, favouring the maximum interception of sunlight as well as maximum photosynthetic activity, without reducing the quantity and quality of the grapes. Although the vines used in this study were not excessively vigorous, the results indicated that partial defoliation would facilitate the formation of the required canopy. Recommendations in this regard can, however, be made only after studying the effect of partial defoliation on reproductive growth. That effect is discussed in a following paper.

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