The Effect of Irrigation System and Crop Load on the Vigour of Barlinka Table Grapes on a Sandy Soil, Hex River Valley *

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The effect of drip and micro-sprinkler irrigation, as well as crop load, on the vigour of Barlinka table grapes was studied in a field trial in the Hex River Valley over a 12-year period. Regulating soil water by means of tensiometers alone proved to be ineffective in the case of drippers, causing reduced vigour compared to micro-sprinklers. This could be rectified by using a fixed 2-day schedule and evaporation data. Increased bunch numbers per vine were found to have a pronounced and consistently depressive effect on shoot mass. It was proposed that an approach be followed of deciding on an acceptable vigour and then allocating bunches accordingly, using a formula developed from data obtained in this experiment. Significant seasonal variation in vigour caused by crop load and indications of similar effects due to calculated water deficits, were obtained. Combining these two factors in a regression model, shoot mass data were recalculated, revealing no consistent effect of irrigation systems on shoot growth. Mean seasonal water requirements were found to be 569 mm for micro-sprinklers and 411 mm for drippers. The more than 25% saving with drippers was mainly due to a reduced wetted soil volume.

Barlinka, a late-maturing, black grape variety, brought to South Africa in 1910 (Perold, 1926), is still an important cultivar in the South Africa range of table grapes. According to Unifruco statistics for the 1994 season, Barlinka comprised about 19% of the national export crop of 18,75 million 5 kg cartons and 34% of the Hex River Valley export of 9,53 million cartons. Barlinka is mainly grown in the Hex River Valley (92% of the national Barlinka export), where table grape production is virtually a monoculture. This region has a total mean annual rainfall of 284 mm, of which only 84 mm occurs in summer, giving it a "very arid" aridity index of 640 mm, i.e. the difference between 0,4 standard USA class A pan evaporation and seasonal rainfall (Smart & Dry, 1980). The sandy soils (less than 5% silt and clay) and boulderbeds, which are common in the Hex River Valley, together with the aridity, make irrigation of table grapes essential. However, because of relatively low spring temperatures, the Hex River Valley falls into Region III according to the Winkler *et al.* (1974) classification. Consequently it is a late region, with the late-ripening Barlinka maturing towards the end of March to early April, thus putting it in the high demand/low supply marketing period of the Northern Hemisphere. Additionally, during the maturation period there is a 16,1°C mean night/day temperature difference, compared to 13,7°C in the coastal Paarl region, enhancing the colouration of Barlinka, a variety known for its tendency towards inferior colouring (Saayman, 1988). Consequently more than 90% of all Barlinka vineyards in the RSA are situated in the Hex River Valley, making it unique in this respect.

Estimated water requirements of wine grapes in South Africa were proposed by Saayman & Van Zyl (1975). Van Zyl & Weber (1977) subsequently found that on high potential soils of the coastal region, judiciously applied supplementary irrigation of about 170 mm increased the growth and yield of Chenin blanc without loss of wine quality. Optimum response was obtained with an irrigation of about 90 mm at véraison.

Lysimeter studies showed that the table grape cultivar Waltham Cross (Regina, Dattier de Beyrouth), grown in sandy soil (98% sand), was very sensitive to variations in soil matrix potential and that this should not be allowed to drop below -10 kPa (Van Rooyen, Weber & Levin, 1980a). Contrary to popular belief, it was found that a wet soil water regime (85% available soil water) during the budbreak to veraison (vegetative) phase, caused negative effects and that a wet regime during the ripening phase was not detrimental to grape quality. As a compromise between negative (berry cracking, reduced sugar/acid ratio) and positive (increased growth and yield) effects of a wet regime during the vegetative phase, a mean minimum soil moisture regime of 70% available soil water (-15 kPa) was proposed for this period. For the ripening phase an 85% soil water regime (-5 kPa) was proposed. Evaluating the data of Van Rooyen *et al.* (1980a), Terblanche (1981) agreed with a regime of 70% plant-available water during the vegetative phase but recommended a soil water regime of 50% plant available water during the maturation phase. He also proposed maximum soil matrix potentials of respectively -15 kPa and -20 kPa on light-textured soil for these two growth phases. Corresponding values for medium-textured soils were -20 kPa and -30 kPa and for heavy-textured soils -30 kPa and -40 kPa.

Van Rooyen, Weber & Levin (1980b) concluded that the vine is not a drought-resistant plant as generally accepted but that it merely has a low water consumption and extensive root system. The mean consumptive water use over three seasons of lysimeter-grown Waltham Cross in the coastal region was 226 mm and crop factors varied from 0,1 to 0,7 over the season for a relatively wet

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soil water regime. Van Zyl & Van Huyssteen (1980a) studied irrigated Chenin blanc in the Robertson area and also came to the conclusion that vines use water more sparingly than most other crops. They found a steady decrease in crop factors from 0,48 three days after a mid-season irrigation, to as low as 0,1 after 45 days. Because of shading, large, slanting trellis-trained vines created a cooler microclimate and as a result did not necessarily use more water than smaller bush wines (Van Zyl & Van Huyssteen, 1980b).

For Colombar wine grapes in the Robertson area, Van Zyl (1984) concluded that irrigation can be a powerful tool to control unwanted growth and to improve quality, provided that the rooting volume is limited, as in the case of drip irrigation. Shoot growth should be suppressed during the period budbreak to flowering, whereas the vine should be well watered during flowering and Phase I of berry growth (cell division and rapid enlargement). The growth of berries during Phase II (slower cell enlargement, pip development) was found not to be very sensitive to water stress, therefore shoot growth can again be curbed at this stage by reduced irrigation. During Phase III (maturation), limited irrigation was found to increase sugar concentration and to lower acidity, without decreasing yield. High crop loads increased water consumption and water stress started at -64 kPa soil matrix potential (42% of plant available water), corresponding to a pre-dawn leaf water potential of -315 kPa (Van Zyl, 1987).

Crop factors for vines in South Africa were regularly updated (Van Rooyen, 1980; Terblanche, 1981; Van Zyl, 1981; Van Zyl & Fourie, 1988; Myburgh, 1992). During the early eighties, for a growing season from October to April, crop factors of 0,3 for the months October, March and April and 0,4 for the remaining months were considered to be appropriate for Barlinka in the Hex River Valley (J.L. van Zyl, 1982 - personal communication). Using these values, a consumptive use of 634 mm was calculated, which was considerably lower than the more than 1000 mm considered necessary by most producers. The crop factors later proposed by Van Zyl & Fourie (1988) for Barlinka in the Hex River Valley were more luxurious and implied a consumptive water use of 880 mm, which was 200% higher than that of supplementary irrigated wine grapes in the coastal (Stellenbosch) region. During the early part of the season, these crop factors for Barlinka are very similar to those proposed for intensively irrigated, high-yielding wine grapes in the interior regions, but are about 30% higher towards the end of the season (Van Zyl & Fourie, 1988).

Traditionally, under-vine sprinklers were used in the Hex River Valley, but during the late sixties Israeli-developed trickle or drip irrigation became popular, rapidly replacing the under-vine sprinklers. Problems with the water distribution ability of some soils and a general lack of managerial skills soon led to some disillusionment with drip irrigation and to the introduction of locally developed micro-sprinkler systems towards the end of the sixties. This system is very similar to the layout of drip irrigation, but requires a less elaborate filtering system and instead of drippers, small, inert, plastic sprinklers are screwed into the plastic laterals. At that time the merits or demerits of these two micro-irrigation systems were highly controversial, as they still are today.

In an effort to resolve this controversy, the effects of drip and micro-sprinkler irrigation were studied in a fertilisation trial with Barlinka on a sandy soil in the Hex River Valley. This paper reports in the experience gained with the two systems, the actual water applied, as well as the effect of crop load on the vigour of Barlinka.

MATERIALS AND METHODS

This investigation was done in a Barlinka (clone 47) table grape vineyard, grafted on Ramsey, on the experimental farm of the Nietvoorbij Institute at De Doorns in the Hex River Valley. The soil was classified as Fernwood 1110 (Soil Classification working Group, 1991), i.e. a pale, sandy topsoil, underlain by a leached,

TABLE 1

Mean physical properties of the Fernwood* soil used for an irrigation/fertilisation experiment with Barlinka/Ramsey; Nietvoorbij Experimental Farm, De Doorns, Hex River Valley.

Depth (mm)	Sand (%)			Silt (%)	Clay (%)	Bulk density (kg m⁻³)	Water retention (Vol. %)				
	Coarse 2,0-0,5	Medium 0,5-0,25	Fine 0,25-0,05				-5	-10	-100	-200	-1 500
		(mm Ø)							(kPa)		
0-300	18,9	52,5	23,9	2,5	2,2	1 410	6,5	4,6	2,5	2,2	1,6
300-600	20,2	52,3	22,9	2,3	2,3	1 438	5,6	4,4	2,6	2,3	1,7

* Soil Classification Working Group, (1991).

white, sandy, eluvial horizon without lamellae. The physical characteristics of the soil are summarised in Table 1.

Before planting the soil was delve ploughed to a depth of about 900 mm. After this operation, black plastic sheets (50 micron) were suspended vertically in trenches to a depth of 1 m from steel wires, which were strung on the soil surface midway between the future vine rows, in such a way that the rows of all future plots were isolated from one another between rows. This eliminated the need for buffer rows, a considerable saving in surface area.

Because of a shortage of plant material, only three replicates were planted during the winter of 1978, whilst the fourth was planted during 1979, all receiving 45 kg N ha^{-1} during their first seasons and all bunches being removed. Vines were planted at a spacing of 3 x 1,5 m, developed to six, short permanent arms on a 2,4 m slanting trellis and renewal pruned to one 6-8 bud bearer on each arm. Each autumn a cereal cover crop was sowed between rows, killed with a glyphosate herbicide and flattened before budbreak.

The experimental design consisted of ten randomised factorial treatments, arranged in four blocks, with two further treatments incorporated on a split plot basis (72 treatment combinations). Irrigation system treatments were separated between rows by the vertical plastic sheets and in rows by two border vines plus a 1,5m border path. There were five data vines per plot and treatments were as follows:

1. Drip and micro-sprinkler irrigation.

2. Three levels of nitrogen (N) fertilisation, applied through the irrigation systems, at 35, 70 and 105 kg N ha^{-1}. As from 1985/86 these levels were increased to 60, 120 and 180 kg N ha^{-1}.

3. Two seasonal patterns of N application, *viz*. 67% of total seasonal N applied fortnightly in even increments over the period budbreak till veraison and the balance in the same way over a period of four weeks after harvest. The other pattern was 50% of total seasonal N during the budbreak to veraison preharvest period and 50% during the four weeks after harvest.

4. Three crop loads: 15, 22 and 29 bunches per vine.

5. On a split plot basis: A 'stock' P + K fertilisation during soil preparation to increase the phosphourus (P) and potassium (K) concentrations of the soil to a level of 50 mg kg^{-1} and 100 mg kg^{-1} respectively, against a control of no P + K stock fertilisation.

Crop load was gradually increased from the second season, starting at 4, 6 and 9 bunches per vine and increasing it to 6, 8 and 10 bunches per vine during

1981/82, to 8, 11, 14 bunches per vine during 1982/83, 11, 16 and 22 bunches per vine during 1983/84 and finally to the design number of 15, 22 and 29 bunches per vine in 1984/95.

Drip-irrigated plots received water through 2 L ha^{-1} emitters, placed at 0,5 m intervals on the 3 m spaced laterals. Until the end of the 1981/82 season, water was applied in such a way that tensiometer readings stayed below 15-20 kPa. From the 1982/83 season onward, estimated evapo-transpiration (ET) water losses were replaced every second day, using American class A-pan evaporation and rainfall (which was measured daily on the farm), crop factors as shown in Table 2 and a water application efficiency of 95%. The calculated ET was further empirically reduced by 25% to compensate for the fact that the drippers did not wet the entire soil volume. Crop factors for Barlinka as proposed by Van Zyl & Fourie (1988) were used from the 1990/91 season.

Micro-sprinklers (32 L h^{-1}) were placed at 1,5 m intervals on the 3 m spaced laterals. Water application was initially also scheduled to keep tensiometer readings below 15-20 kPa. As from 1982/83, ET water losses were replaced twice weekly, using the crop factors as for drip irrigation. For the micro-sprinklers a water application efficiency of 85% was used and a complete wetting of the rooting volume was assumed.

Soil water fluctuations were monitored by two randomly placed sets of mercury manometer tensiometers for each irrigation system. Each set consisted of two tensiometers placed on the vine row, 0,5 m from a vine and 125 mm from an emitter, at depths of 300 mm and 600 mm respectively. Tensiometer readings were recorded daily. During 1982 impeller type water meters were installed for each irrigation system, allowing the amounts of water applied during each irrigation to be measured directly.

TABLE 2

Crop factors used for Barlinka/Ramsey irrigation/fertilisation trial, Nietvoorbij Experimental Farm, De Doorns, Hex River Valley.

| Month | Crop factor | |
	1982-1990*	1990-1992**
May-Aug. (dormancy)	0,20	0,20
September (budburst)	0,20	0,20
October	0,30	0,30
November (flowering)	0,40	0,36
December	0,40	0,46
January (véraison)	0,40	0,49
February	0,40	0,60
March (harvest)	0,30	0,60
April (postharvest)	0,30	0,39

* Adapted from factors proposed by Van Zyl (1981) for intensively cropped wine grape vineyards.

** Van Zyl & Fourie (1988).

The mass of winter prunings was used as indication of vigour, and yield was measured at harvest. Because of an increasing incidence of a phenomenon called "Red Leaf", which has a very negative effect on the growth and grape quality of Barlinka (Saayman & Lambrechts, 1993), only data from vines without a history of Red Leaf were eventually used. As from 1990/91 the experiment was drastically reduced by selecting only one vine without a history of Red Leaf per plot and eliminating the 50%-50% seasonal N application pattern and 15 and 29 bunches per vine crop load treatments. Were applicable, data were statically analysed using Genstat and Statgraphics software.

RESULTS AND DISCUSSION

The effect of irrigation systems on vine vigour is shown in Fig. 1. It is evident that the approach of maintaining a soil matrix potential above -15 kPa to -20 kPa by using only tensiometers (until the end of the 1982 season) inhibited the vigour of drip-irrigated vines significantly compared to micro-sprinkler irrigated vines. Tensiometer readings during the 1979/80 season, which can be regarded as representative for this period, showed that for extended periods, lower soil matrix potentials developed under drippers than under micro-sprinklers (Fig. 2a, 2b). With drippers, matrix potentials lower than

-30 kPa often occurred in the subsoil during the early season, in spite of a total of 25 applications, compared to the 18 irrigations with micro-sprinklers. It appeared that the long (for this sandy soil) and irregular intervals between irrigations (3-6 days during peak ET periods) often resulted in the development of too low soil matrix potential peaks, especially in the case of drip-irrigated vines. This may have caused inadequate horizontal wetting and excessive deep percolation losses because of the large amonts of water that had to be applied in order to lower tensiometer readings to about 10 kPa. By changing to a fixed, two-day irrigation frequency, replacing calculated ET losses over the previous two days during each irrigation, the vigour of drip-irrigated vines could be brought to the level of micro-sprinkler-irrigated vines within two seasons (1983-1984; Fig. 1).

Table 3 shows the quantities of water actually applied (since 1982/83 when direct measurements commenced) as well as relevant climatic parameters (ET calculated from American class A-pan data and the crop factors presented in Table 2) and the deviations of actually applied water from those estimated to be needed by the vines. From this it would appear as if the vines were over-irrigated up till about 1985 and subjected to various degrees of water deficits in subsequent seasons, drip-irrigated vines generally being less deprived.
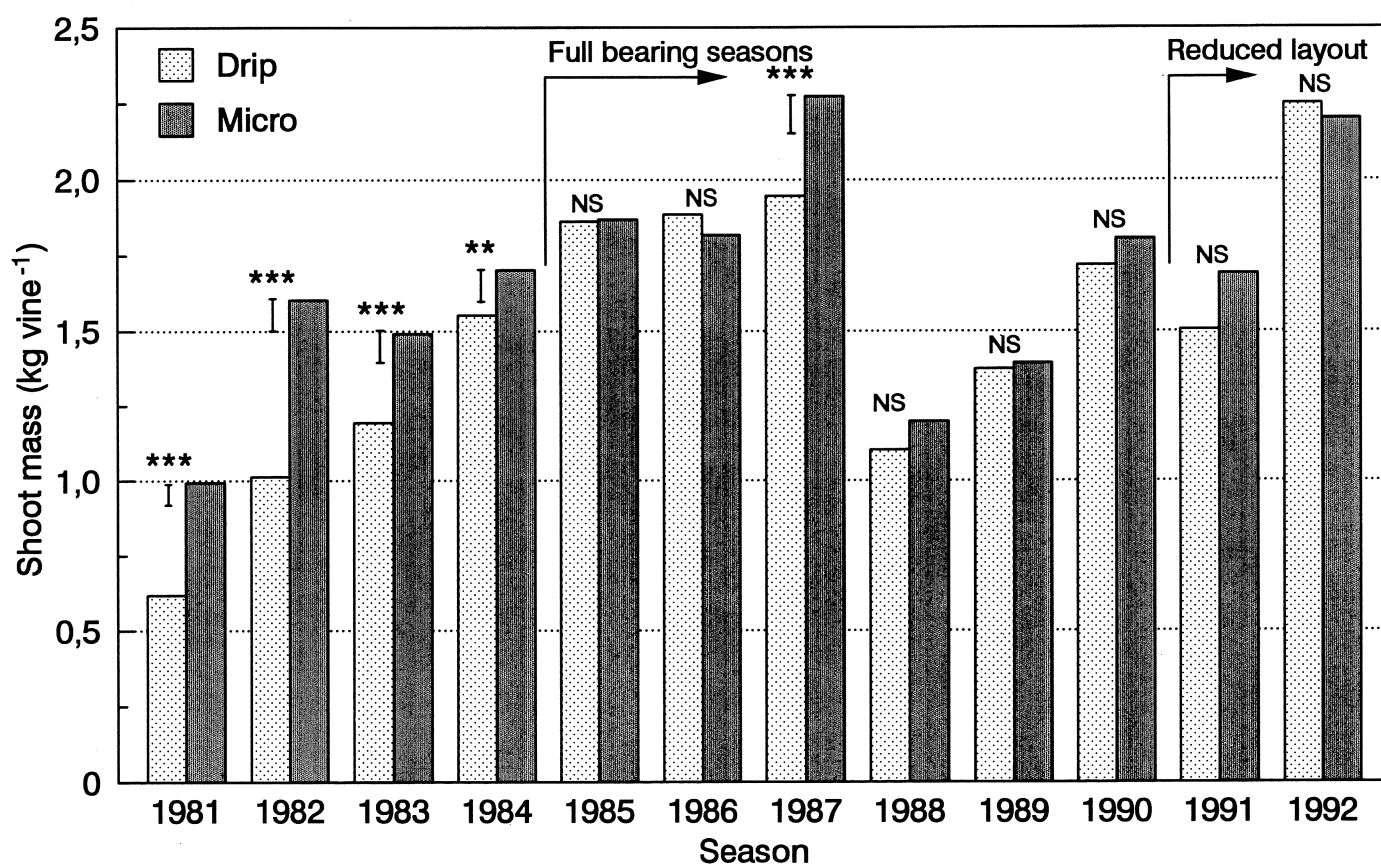

FIGURE 1

The effect of drip and micro-sprinkler irrigation systems on the vigour of Barlinka/Ramsey on sandy soil; *Nietvoortbij* Experimental Farm, De Doorns, Hex River Valley.
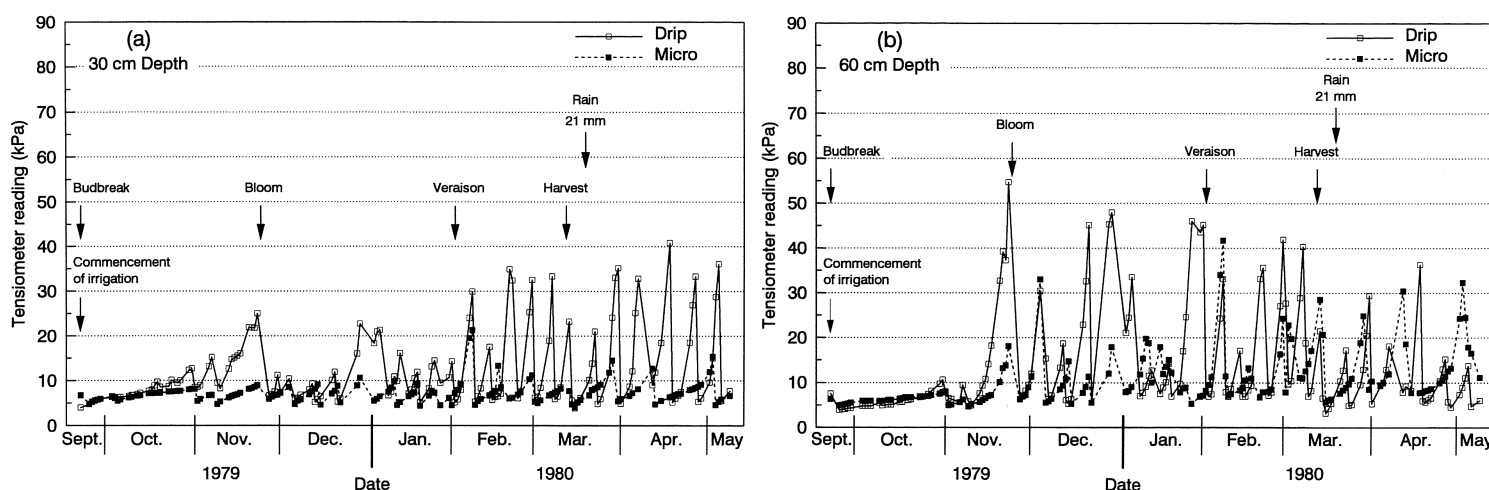NS: non-significant; ** p≤ 0,01; *** p≤ 0,0001).

FIGURE 2

Soil matrix potentials in drip and micro-sprinkler irrigated plots during 1979/80 at (a) 30 cm and (b) 60 cm depths: Barlinka/Ramsey irrigation/fertilisation experiment, *Nietvoorbij* Experimental farm, De Doorns, Hex River Valley.

Fig. 3 shows tensiometer readings that were registered during the 1983/84 season, when both drip- and micro-irrigated vines received close to the estimated quantity of water needed (Table 3). Irrigation commenced towards the end of October 1983 when tensiometer readings reached 11-17 kPa. From that time, in the case of drippers subsoil matrix potentials attained values lower than -20 kPa in the topsoil around veraison (Fig. 3a). The matrix potential of the soil irrigated by micro-sprinklers generally remained in the region of -10 kPa at both depths up till harvest (Fig. 3a, 3b).

Tensiometer readings during the low-vigour 1987/88 season revealed a short period of possibly grown-inhibitory water stress in the subsoil of drip-irrigated plots during December (Fig. 4b). A water deficit of 52 mm was calculated for dippers during this season (Table 3). In the case of micro-sprinklers, for which a water deficit of 117 mm was calculated (Table 3), low, fluctuating matrix potentials in the topsoil wete often recorded from bloom to veraison (Fig. 4a) and throughout the season in the subsoil (Fig. 4b).

TABLE 3

Water appled in a Barlinka/Ramsey irrigation/fertilisation trial, relevant climatic elements and deviations from calculated water application needs*; Nietvoorbij Experimental Farm, De Doorns, Hex River Valley.

Season	Water applied		Rain (mm)	Estimated ET (mm)	ET-0,75×Rain (mm)	Excess/Deficit **	
	Drip (mm)	Micro (mm)				Drip (mm)	Micro (mm)
1982/83	468	726	176	569	437	117	180
1983/84	426	612	81	565	504	27	16
1984/85	447	469	168	528	402	123	-3
1985/86	298	415	105	483	404	-20	-51
1986/87	347	579	36	532	505	-49	-13
1987/88	423	574	66	654	605	-52	-117
1988/89	426	548	63	654	605	-49	-139
1989/90	432	660	51	657	619	-54	-58
1990/91	406	541	58	625	582	-51	-122
1991/92	441	563	83	642	580	-16	-101
Mean	411	569	89	591	524	-1	-41

* Measured or calculated from beginning of October to end March.

** Assuming 95% and 85% application effifiency for Drip and Micro-sprinkler irrigation respectively and subtracting 25% of estimated ET for a smaller wetted soil volume in the case of Drip.

Although tensiometer readings during the 1983/84 and 1987/88 seasons seem to conform to calculated water deficits, neither parameters appear to adequately explain the seasonal differences in vigour encountered, as well as differences in vigour apparently caused by the irrigation system (Fig 1). Apart from the possibility that tensiometer monitor sites were inadequate and/or that crop factors were inaccurate, resulting in debatable water deficit calculations, other factors, apart from water stress, were obviously also involved in the observed variation in vigour.

Fig. 5 shows, apart from an obvious seasonal effect, the well documented but in this case almost spectacularly consistent negative effect of crop load per vine on shoot growth during the full bearing period. Regression analyses revealed a distinct high-vigour group of seasons as well as a low-vigour group, both showing a highly significant depressive effect of crop load per vine and per season on vigour (Fig. 6). Although crop load was regulated and a mean of 22 bunches per vine allotted since 1984/85, the desired goal was not always obtained for all seasons. In accordance with reduced shoot growth, the 1987/88 season had a high mean crop load. However, this was not the case for the almost equally low-vigour 1988/89 season when crop load was below average (Table 4), thus also not satisfactorily explaining all seasonal variation in vigour. From Fig. 6 it is also evident that the rates of vigour reduction were very similar for high- and low-vigour seasons, implying that this was relatively independent from other factors that also suppressed shoot growth.
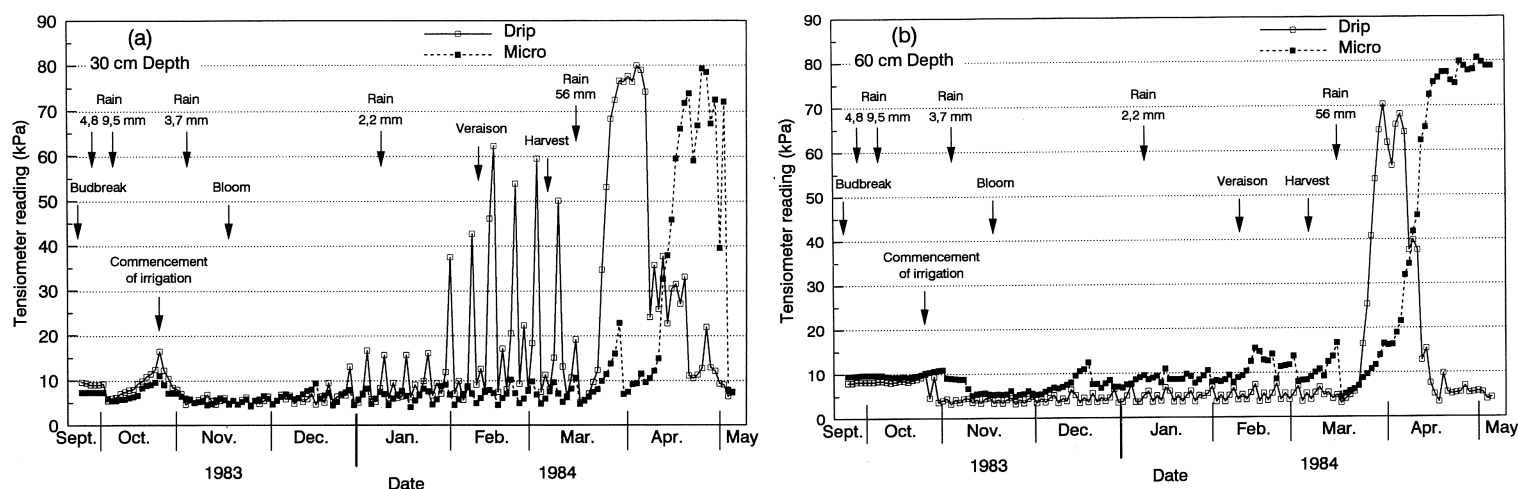

FIGURE 3

Soil matrix potentials in drip and micro-sprinkler irrigated plots during 1983/84 at (a) 30cm and (b) 60cm depths: Barlinka/Ramsey irrigation/fertilisation experiment, *Nietvoorbij* Experimental Farm, De Doorns, Hex River Valley.
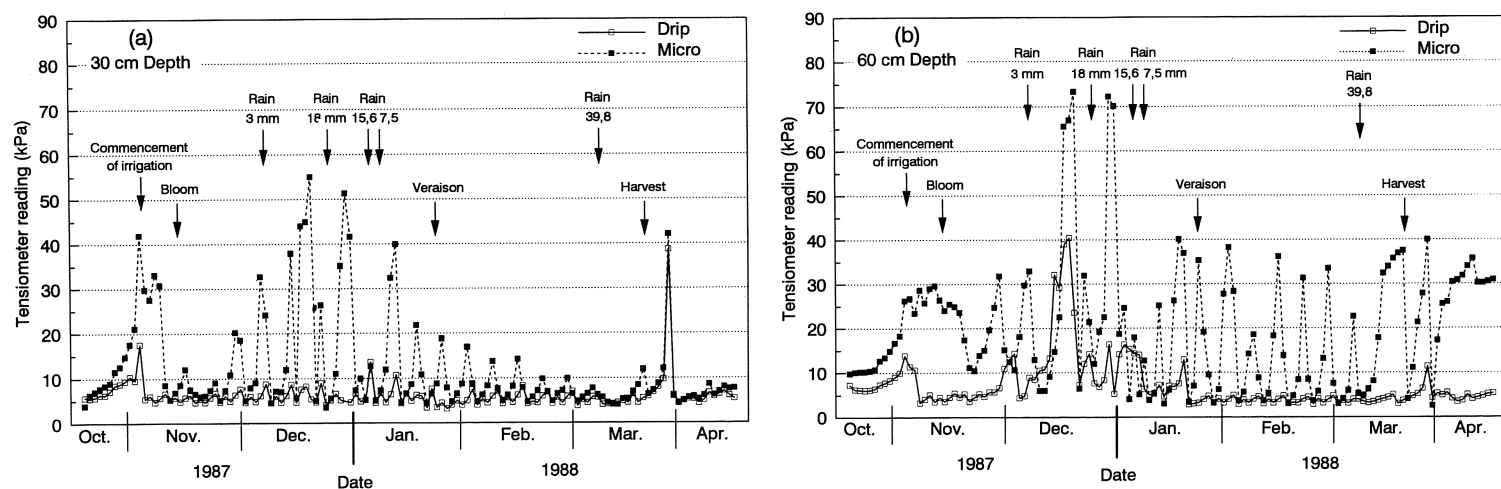

FIGURE 4

Soil matrix potentials in drip and micro-sprinkler irrigated plots during 1987/88 at (a) 30cm and (b) 60cm depths: Barlinka/Ramsey irrigation/fertilisation experiment, *Nietvoorbij* Experimental Farm, De Doorns, Hex River Valley.

Van der Merwe, Geldenhuys & Botes (1991) proposed 6.5 bunches per m² trellis area for Barlinka. Trellis area per vine in this trial was 3,6 m², dictating 23 bunches or a 15,2 kg crop load per vine according to this guideline (assuming a mean bunch mass of 650 g). The general recommendations of Uys (1991) for moderate vigour were 4,0-6,5 bunches (i.e. 2,6-4,2 kg) per m² trellis area or respectively a 12:1 to 10:1 bunch number: shoot mass ratio for a vigour of 0,50 and 0,55 shoots per m² trellis area. For this trial the mean shoot mass per vine was 1,822 kg, i.e. 0,506 kg m⁻² trellis area. Using the 0,50 kg shoots per m² norm of Uys, the mean optimum crop load for this vineyard can be calculated as 18 bunches or 11,7 kg crop load per vine.

The data presented in Fig. 6 suggest that an acceptable vigour should first be decided on, from which the crop load can then be calculated using the formula:

$$\text{Number of bunches} = \frac{(2,8 - \text{desired shoot mass in kg vine}^{-1})}{0,068 \times \text{bunch mass in kg}}$$

A regression model was subsequently developed ($R^2 = 0,30$; $n = 16$) in which the highly significant effect of crop load (Fig. 6) and indications of negative effects of calculated water deficits (shoot mass = 1,94 - 0,003 x water deficit; $R^2 = 0,17$, n = 16) were combined, resulting in:

Shoot mass = 3,669 - 0,138 (Crop mass) - 0,0017 (Water deficit)

Using this model, shoot mass data were "purified" and the effects of irrigation system recalculated for the period that the vines had a full crop load (1984/85 to 1991/92). This resulted in a much reduced seasonal variation over this period and only for the 1988/89 season in a significantly better performance of micro-sprinklers (Fig. 7).

Over the last ten-year period of the trial, the mean gross quantity of water applied was 411 mm for drippers and 569 mm for micro-sprinklers. About 28% less water was
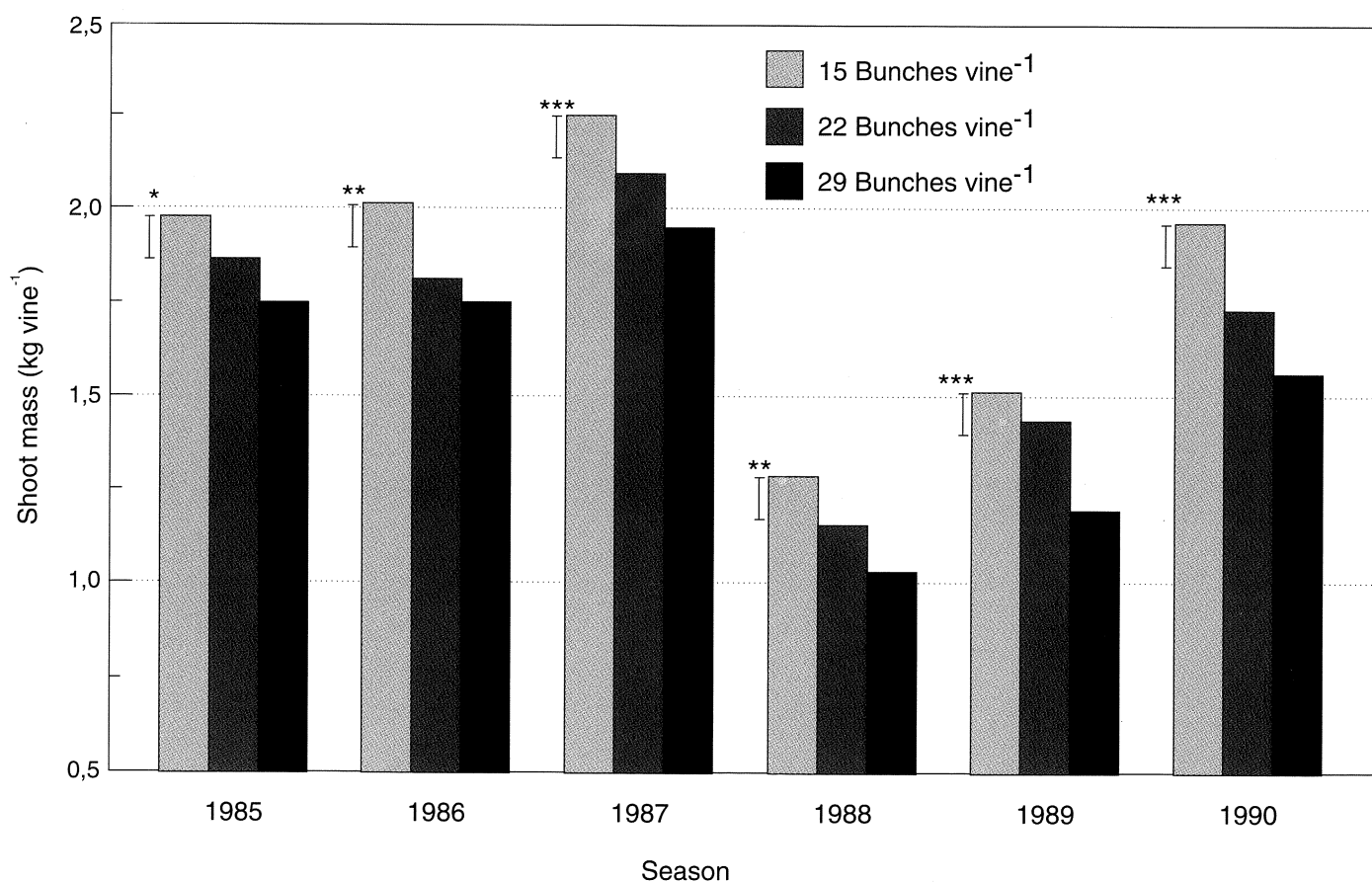

FIGURE 5

Effect of season and crop load on the vigour of Barlinka/Ramsey on sandy soil; Nietvoorbij Experimental Farm, De Doorns, Hex River Valley (NS: non-significant; * p≤ 0,05;** p≤ 0,01; *** p≤ 0,0001).

TABLE 4

Mean number of bunches allocated per vine: Barlinka/Ramsey irrigation/fertilization trail; *Nietvoorbij* Experimental Farm, De Doorns, Hex River Valley.

Season	Mean bunch number	
1984/85	22,23	bc
1985/86	22,90	cd
1986/87	22,13	bc
1987/88	23,97	d
1988/89	21,73	bc
1989/90	21,49	b
1990/91	24,05	d
1991/92	17,41	a
Mean	21,99	

soil volume but presumably also because of a smaller surface and application evaporation loss component, compared to that of micro-sprinklers.

Progressive drying of the subsoil during high summer (Jan-Feb.), as registered by the tensiometers, was often experienced in the case of micro-sprinklers (data not shown) and water application sometimes had to be increased by 25% for short periods. It was assumed that these temporary increased water needs were the result of a too optimistic water application efficiency factor that was used for micro-sprinklers, resulting in a gradually increasing water deficit in the subsoil, especially during high summer when evaporation can be expected to play a more prominent role in decreasing irrigation efficiency.
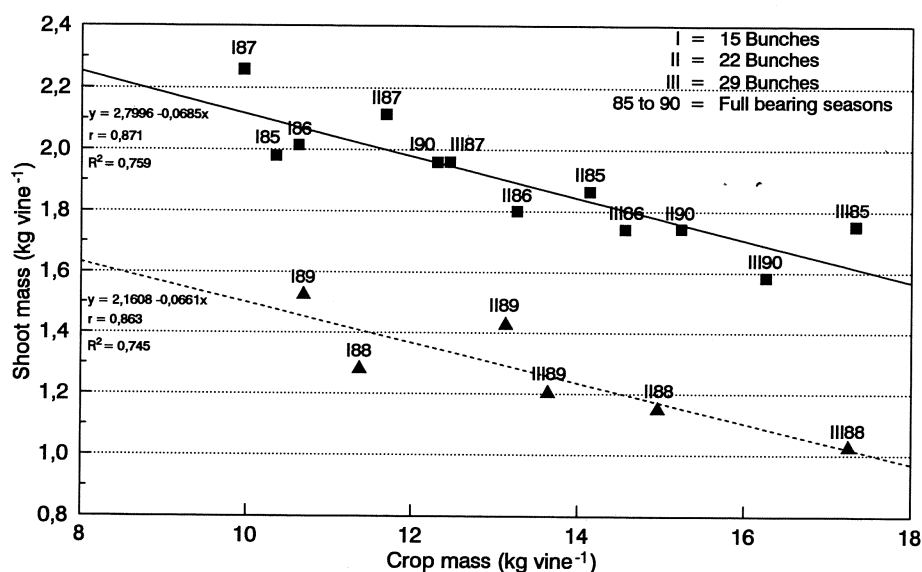

FIGURE 6

Relationships between crop load and shoot mass of Barlinka/Ramsey on sandy soil; *Nietvoorbij* Experimental Farm, De Doorns, Hex River Valley.
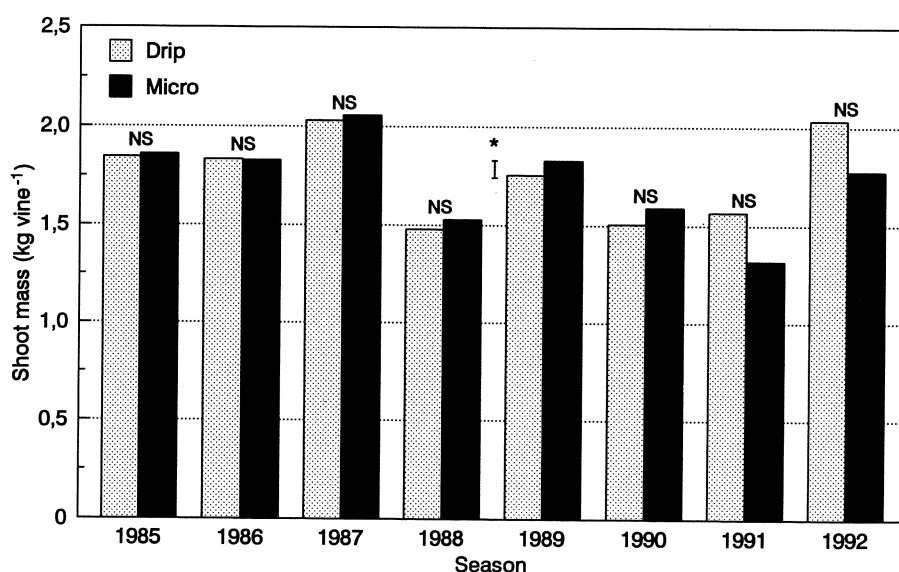

FIGURE 7

Effect of drip and micro-sprinkler irrigation systems on the shoot mass of Barlinka/Ramsey, adjusted for crop load and estimated water deficit, on sandy soil; *Nietvoorbij* Experimental Farm, De Doorns, Hex River Valley.

CONCLUSIONS

Based on the strong and consistent depressive effect of crop load on shoot growth of Barlinka, it is proposed that bunch allocation should not simply be made on the basis of shoot mass per vine or per m², as is the general practice for table grapes. In order to maintain a specific vigour, the relationship established in this trial implies that in the case of strong vigour, fever bunches should be allocated than for low vigour. A logical approach would therefore be to decide on a vigour that is acceptable for a given situation and then to calculate the number of bunches that will be in balance with that chosen vigour, using: number of bunches vine^{-1} = (2,8 - desired shoot mass in kg vine^{-1} / (0,068 x bunch mass in kg).

The dominant effect of crop load on the shoot mass of Barlinka, together with indications of water deficits that caused considerable variation over seasons, could largely be rectified by adjusting shoot mass with a crop load + calculated water deficit regression model, revealing no consistent effect of irrigation system on vigour during the full bearing period of the trial. It would seem that there is little to choose between the two systems in terms of efficiency on this medium-sand soil and associate climate, provided they are correctly managed. Although not measured in terms of actual consumption by vines, it appears that a saving of more than 25% water is possible using drip irrigation. Inevitably the smaller wetted soil volume allows less tolerance in terms of duration between irrigations, as was demonstrated during the first two years of the trial when drip irrigation was not effectively timed by means of tensiometers. Especially on sandy soil drip irrigation will require a higher level of managerial skills and control measures than a full surface wetting system.

Although the adequacy of water applied could only be judged by means of tensiometers and shoot growth, the contention is that the respective mean gross quantitites of about 569 mm and 411 mm of water actually applied with micro-sprinklers and drippers, can serve as useful guides in irrigation planning in the Hex River Valley. According to tensiometer readings, it was seldom necessary to commence with irrigation before November, a practice not followed by most producers, who tend to start irrigating too early. This probably partly explains their claims of water needs of about 1000 mm or more per season.

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