Effect of Soil Depth on Growth and Water Consumption of Young *Vitis vinifera* L. cv. Pinot noir

P.A. Myburgh[1], J.L. Van Zyl[2] and W.J Conradie[1]

1) Nietvoorbij Institute for Viticulture and Oenology, Agricultural Research Council, Private Bag X5026, 7599 Stellenbosch, South Africa

2) Institute for Tropical and Subtropical Crops, Agricultural Research Council, Private Bag X11208, 1200 Nelspruit, South Africa

Submitted for publication: October 1996
Accepted for publication: December 1996
Key words: Evapotranspiration, soil depth, water consumption, young grapevines

There is uncertainty about the optimum soil preparation depth for vineyards and to what extent irrigation can compensate for insufficient soil depth. Pinot noir was planted under non-irrigated conditions to soil preparation depths of 200 mm, 400 mm, 600 mm, 800 mm, 1 000 mm and 1 200 mm. Field lysimeters of 400 mm, 800 mm and 1 200 mm depths were constructed to study the effect of irrigation and to facilitate accurate measurement of water consumption. Vegetative growth and physiological activities responded positively to increasing soil depth under dryland conditions as well as under irrigation. Irrigation improved vegetative growth compared to non-irrigated treatments of corresponding depths. Under dryland conditions optimum vegetative growth and physiological response were achieved during the third year with 800 mm and 1 000 mm soil depths. Loosening the soil to 1 200 mm induced excessive growth on a lengthened Perold trellising system. Irrigation stimulated vigour and consequently sufficient vegetative growth was achieved at the end of the second season for 800 mm and 1 200 mm deep soil. This situation was only attained at the end of the third season for 400 mm deep irrigated soil. At this stage irrigation stimulated excessive vigour for 800 mm and 1 200 mm deep soils. Water consumption of irrigated vines increased during the first three years after planting. During the third year, water consumption of the 800 mm irrigated treatment was comparable to the 500 mm generally regarded as the norm for full-bearing vines in the coastal region of the Western Cape. Increased vegetative growth induced by increased soil depth reflected clearly in evapotranspiration. Three-year-old vines, which grew too vigorously on 1 200 mm deep soil, consumed 614 mm of water. On the other hand, where 400 mm soil depth limited growth, water consumption amounted to only 387 mm. During the first and second seasons irrigation should be reduced to 44,6% and 65,5% respectively of the irrigation generally required by bearing grapevines.

Bearing grapevines in the coastal region of the Western Cape require approximately 500 mm of water from September to April (Van Zyl & Van Huyssteen, 1984). Of this, an average of about 300 mm is contributed by rainfall, whereas the remainder must be supplied either by irrigation or water stored in the root zone. In many vineyards of the Western Cape root development is limited by unfavourable soil physical conditions (Saayman & Van Huyssteen, 1980; Saayman, 1982). Under dryland conditions the available soil water is generally depleted by January (Van Zyl & Weber, 1981). Deep soil preparation can, in some cases, increase the soil water storage capacity. If this water is released to the grapevine throughout the season, expensive irrigation systems could be eliminated. Consequently, soil preparation depths of at least 800 mm to 1 000 mm are recommended. Soil preparation to these depths, however, contributes considerably to the high costs of establishing grapevines. Furthermore, soil preparation to excessive depths can cause luxurious growth conditions, resulting in a decrease in grapevine fertility and unfavourable grape composition. Instead of deep soil preparation aimed solely at increasing the water supply to grapevines, irrigation might compensate for insufficient soil depth. An alternative, therefore, would be shallower soil preparation in combination with irrigation. However, there is as yet no cer tainty regarding the actual soil volume required by grapevines, and to what extent irrigation can compensate for a limited soil volume.

Soil depth and water requirements cited above were primarily derived from studies on full-bearing, mature grapevines. Young grapevines are generally boosted with water and nutrients, especially nitrogen, to produce maximum vegetative growth. The motivation for these actions is increased profitability, obtained by bringing vines into full production one year earlier. Since knowledge of the actual water requirements of young grapevines is limited, this often leads to over-irrigation and injudicious N applications. According to Williams (1993) seasonal water consumption of Thompson Seedless grapevines in California increased during the first four years after planting, to reach a maximum in the fifth year. This indicates that irrigation requirements should be adapted for young vines. The number of years for which such adaptations are necessary will, however, depend on the rate at which grapevines are developed. Furthermore, water requirements to sustain specific growth vigour levels, as controlled by edaphic factors, should also be considered.

The objective of this study was to determine the effect of soil depth on growth and water requirements of young grapevines from planting up to the full-bearing stage in a range of dryland as well as irrigated soil volumes established in the field.

MATERIALS AND METHODS

Experimental layout: The research was conducted on the Nietvoorbij Experimental Station near Stellenbosch. The field trail was situated on a 15° south-facing slope at an altitude of 120 m. The soil which formed *in situ* from weathered granite, was of the Glenrosa form (Soil Classification Work Group, 1991) common to vineyard soils in the coastal region of the Western Cape.

Acknowledgements: The assistance of the Soil Science Staff of Nietvoorbij is gratefully acknowledged.

TABLE 1

Treatments applied to determine the effect of soil depth and irrigation on growth and water consumption of young Pinot noir grapevines near Stellenbosch.

Treatment number	Water supply	Soil depth (mm)
T1 (control)	Dryland	200 (ploughed)
T2	Dryland	400 (ridged)
T3	Dryland	400
T4	Dryland	600
T5	Dryland	800
T6	Dryland	1000
T7	Dryland	1200
T8	Irrigated	400
T9	Irrigated	800
T10	Irrigated	1200

A range of dryland soil volumes was created during 1984 by digging trenches to depths of 400 mm, 600 mm, 800 mm, 1 000 mm and 1 200 mm by means of an excavator. Trenches were 2,7 m wide and 22,5 m long and separated by 300 mm of undisturbed soil. The 60,8 m^2 plots ran downhill to facilitate drainage of free soil water. While the trenches were open, plots were sealed off at the sides with 0,5 mm plastic sheets to prevent lateral root penetration and water movement between plots. The bottom of each trench was compacted mechanically to restrict root penetration to the subsoil. During excavation, the top layers (0 - 600 mm) and subsoil (below 600 mm) were kept separate and the necessary quantities of calcitic lime and superphosphate were applied to increase the pH (KCl) to 6,0 and the P content to 25 $mg.kg^{-1}$ (Conradie, Van Zyl & Myburgh , 1996). The excavated soil was subsequently carefully filled back in the original sequence. A control treatment, only ploughed to a depth of 200 mm and with no prior soil preparation, as well as a treatment consisting of soil ridged by hand to a height of 400 mm, was also included. The ridged treatment received no additional loosening. The crests of ridges had a 1,5 m wide flat shape. Both the control and ridged treatment were ameliorated to the above-mentioned levels.

For three irrigated treatments, trenches were excavated to depths of 400 mm, 800 mm and 1 200 mm, with the same length and width as described above. These trenches, however, were adapted to create field lysimeters of which the construction details and functioning are described by Conradie *et al.* (1996). The 10 different treatments described above were replicated five times in a randomised block design (Table 1).

Soil physical analysis: Soil bulk density and particle size distribution were determined prior to soil preparation. Plant available water (PAW) and bulk density were determined one year after soil preparation on undisturbed soil cores sampled at 300 mm depth increments. PAW was determined between -10 kPa and -1 500 kPa using the ceramic pressure plate technique. Standard Nietvoorbij procedures were used to quantify soil physical parameters. Prior to budbreak during 1988, soil strength was measured to 800 mm depths by means of an automatic recording penetrometer (Van Huyssteen, 1983) on the three irrigated treatments. Ten penetrations were done on each plot.

TABLE 2
Bulk density in the natural state and after soil preparation* as well as particle size distribution of a granitic Glenrosa soil near Stellenbosch.

Depth (mm)	Bulk density (kg m^{-3})		Clay (< 0,002 mm) (%)	Silt (0,002 - 0,05 mm) (%)	Fine sand (0,05 - 0,1 mm) (%)	Medium sand (0,1 - 0,5 mm) (%)	Coarse sand (0,5 - 2,0 mm) (%)	Gravel (>2,0 mm) (%)
	Natural State	After soil preparation						
0 - 300	1 541	1 550	25,1	25,7	14,7	8,4	27,6	47,1
300 - 600	1 743	1 555	25,2	26,9	14,9	7,9	25,3	27,3
600 - 900	1 764	1 575	25,6	24,4	14,1	6,9	31,5	24,0
900 - 1200	1 764	**	30,5	24,2	14,9	6,8	24,8	16,8

* Particle size analysis was done on soil fraction <2mm after gravel had been removed by sieving.

** Not sampled to avoid possible damage to plastic linings of lysimeters.

Experimental vineyard: After soil preparation the soil was allowed to stabilise for one year. Subsequently, the experimental plots were planted during late October 1985 to Pinot noir/99 Richter at a spacing of 1,5 m in the vine row. The rows, which consisted of 13 test vines and a buffer vine at the end of each plot, were 3,0 m apart. Except for one row alongside each of the outermost test rows, no other buffer rows were used. No soil tillage or vehicle traffic was allowed in the experimental vineyard following soil preparation. During March (post-harvest) of every year, the soil was completely covered with 7 t ha^{-1} wheat straw. The few weeds that emerged were controlled chemically.

Grapevines of all treatments were watered by hand once a month during the first season. However, the delay in planting resulted in poor growth. Furthermore, numerous grapevines were damaged by small antelope. Consequently all treatments were virtually replanted during September 1986; therefore 1986/87 was regarded as the first growing season. Grapevines were trained onto a lengthened Perold trellising system (Zeeman, 1981) and irrigation of treatments T8, T9 & T10, applied by means of 360° micro sprinklers, started at the beginning of December. Based on the soil water content, as measured using the neutron scattering technique, 17 mm irrigation was initially applied per week. Irrigation quantities were gradually increased to a maximum of 20 mm per week during January and February. After this, applications decreased to a minimum of 13 mm per week during April. Since the vines were not equally trained up to this stage, shoot masses were not measured.

During the second season (1987/88) the cordon arms were, where possible, developed to the capacity of the trellising system. Yield was negligible and not measured. Pruning mass, leaf water potential (pressure chamber technique of Scholander *et al.* (1965), photosynthetic activity and transpiration rate (by means of a portable ADC-photosynthesis meter) were determined. Plant physiological measurements were made during February. Unbagged, fully mature sunlit leaves on the upper third of shoots were used. Measurements were made on one leaf per experimental plot between 12:00 and 14:00. In total 439 mm irrigation was applied over a period of 21 weeks (11 November until 30 March) on the lysimeter plots (T8, T9 & T10). Initially 10 mm was applied weekly, but this quanitiy was gradually increased to a maximum of 30 mm per week in February and March. These quantities sufficed to replenish the soil water content to field capacity and to deliver at least 1 - 2 mm drainage water per irrigation (Conradie *et al.*, 1996). In the third year after planting (1988/89) yield was limited to approximately 12 bunches per vine on all treatments. Grapevine growth was studied on all treatments using the same parameters and methods as in the previous season. Irrigation was differentiated and amounted to 293 mm, 366 mm and 390 mm for the 400 mm, 800 mm and 1 200 mm deep treatments, respectively. Grapes were harvested during the last week of January.

Evapotranspiration: Changes in soil water content of the three irrigated treatments were measured weekly on all plots by means of a neutron probe at 300 mm depth intervals in three access tubes per plot. Actual irrigation quantities were measured by means of a water meter on each plot. All leachates were collected in storage tanks and outflow volumes recorded by means of water meters. Climatic data were obtained from a weather station situated approximately 1 km from the experimental vineyard. Evapotranspiration was calculated on a weekly basis using the universal water balance equation: $ET = P + I + \blacktriangle S - D - R$, where ET = evapotranspiration, P = precipitation, I = irrigation, $\blacktriangle S$ = change in soil water content between weekly measurements, D = drainage and R = run-off. All these parameters were converted to millimeters. Assuming that rain intercepted by canopies made no contribution to the soil water balance, only eighty percent of precipitation was considered effective. Due to the straw mulch, virtually no run-off occcurred and consequently this parameter was ignored. Crop coefficients were calculated as the ratio of ET to a reference evaporation. The latter was measured using a standard unscreened American Class-A evaporation pan. Evapotranspiration and crop coefficients were determined during the 1986/87, 1987/88 and 1988/89 seasons.

RESULTS AND DISCUSSION

Soil physical conditions: The Glenrosa soil on which the field trial was conducted had a sandy clay loam texture with a high gravel fraction and high bulk density in its natural state (Table 2). Once the soil had been loosened and ameliorated, it had a favourable average bulk density of 1 550 kg m^{-3} (Van Huyssteen, 1988). Penetrometer studies confirmed that soil preparation effectively loosened the soil at all depths (Fig. 1). Soil strength values never exceeded 2 000 k Pa, which is critical for grapevine root development (Van Huyssteen, 1983). Provisional observations in the second year after planting showed that the young grapevines were already exploiting the full soil depths at all treatments. Although the subsoil in its natural state was too dense for root penetration, it was exploited by grapevine roots once it had been loosened. The total plant available soil water (PAW) contents of the irrigated 400 mm, 800 mm and 1 200 mm depth treatments were 17,6 mm, 35,7 mm and 54,2 mm respectively. These relatively low values were due to the high gravel content and probably high macro porosity of the loosened soil.

Meteorological conditions: Average daily American Class-A pan evaporation and monthly rainfall during the growing season (September until April) for the duration of this study are presented in Table 3. The similarity of this data to the twenty-two-year average values for Nietvoorbij proved that adverse meteorological conditions, which could seriously affect growth and water consumption, were not encountered. In general, conditions at the experimental site were similar to norms for climatic region III (Saayman, 1981).

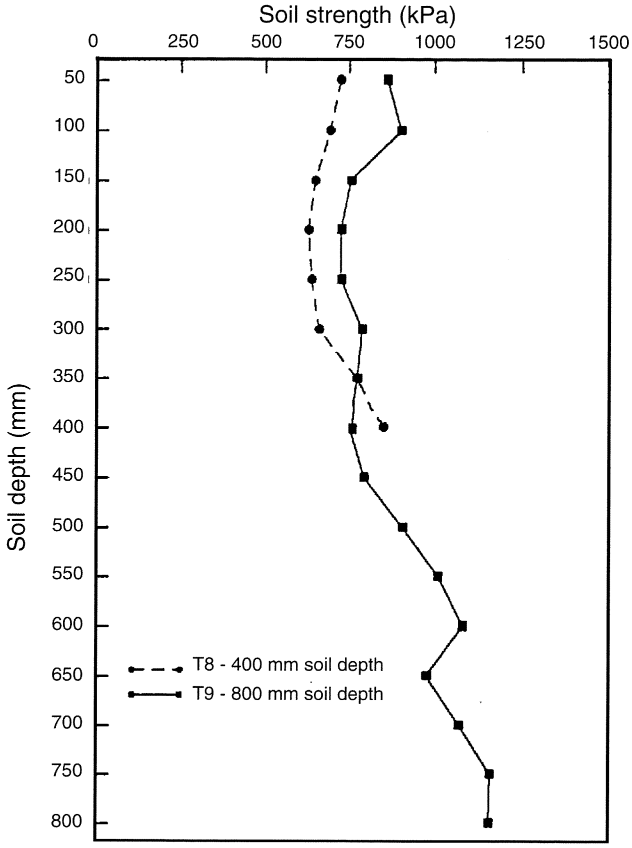

FIGURE 1
Soil strength of a granitic Glenrosa soil near Stellenbosch, as measured using an automatic recording penetrometer, four years after soil preparation.

Grapevine response under dryland conditions: During the 1987/88 season (second leaf) pruning masses of dryland treatments showed that neither ridging nor loosening the soil to 600 mm or less had any significant advantage over the control (Table 4). However, when soil preparation depth had reached 800 mm (T5) pruning mass was significantly higher compared to that of the control. Increasing soil depth to 1 000 mm yielded a pruning mass significantly higher than that of all treatment plots loosened to 600 mm and less, including ridging. By far the highest pruning mass was obtained from the 1 200 mm soil depth treatment (T7). According to Smart *et a*l. (1990) pruning mass ranging between 0,3 kg and 0,6 kg per meter cordon length would be acceptable for optimum production. The pruning mass of only T7 was within these limits. These criteria, however will vary according to variety. This suggested that under the given conditions, 1 200 mm soil induced sufficient vegetative growth to bring non-irrigated vines into production one year earlier. Photosynthetic and transpiration rates tended to increase with increasing soil depth (Table 5). At harvesting, leaf water potential (LWP), a fundamental measure of plant water status, tended to increase with increasing soil depth. Although LWP values of all treatments were relatively low, this does not disprove that significantly higher values could have existed during earlier stages of the growing season, contributing to the vigorous growth observed on the 1 200 mm depth treatments. During 1987/88 the highest water stress occurred on ridged plots, thereby confirming earlier findings (Myburgh & Moolman, 1991) regarding the sensitivity of non-irrigated grapevines on ridges to drought.

During the third season (1988/89) vegetative growth of the dryland treatments was less responsive to soil depth (Table 4). Compared to the control, pruning mass increased significantly only where the soil was loosened to 1 000 mm and deeper. Shoot growth of the control and ridged treatments (T1 & T2) were, however, still insufficient for an ideal canopy. In contrast, growth on the 1 200 mm deep treatment (T7) exceeded the capacity of the trellising system. Increasing soil depth only tended to favour plant physiological response (Table 5). Allowing only 12 bunches per vine on all dryland treatments prevented any manifestation of increasing yield with increasing depth (Table 4).

Grapevine response under irrigation: During the first year (1986/87) evapotranspiration of the irrigated treatments (T8 - T10) increased as shoot length and leaf area increased to reach a maximum during February (Table 6). The relatively low values during January were caused by the removal of excessive shoots in the training process of the vines. Compared to the 400 mm treatment, increasing soil depth to 800 mm and 1 200 mm increased total evapotranspiration (ET) by 24% and 43%, respectively. This sug-

TABLE 3

Average daily American Class-A pan evaporation and monthly rainfall measured during the growing season at Nietvoorbij from 1986 until 1989 as well as the long-term (22-year) average values for the same location.

Month	A pan evaporation (mm d^{-1})		Rainfall (mm per month)	
	1986 - 1989	Long-term average	1986 - 1989	Long-term average
September	3,7	4,5	71,7	56,7
October	5,9	6,9	34,6	44,2
November	7,6	8,2	15,8	23,9
December	8,6	8,9	30,0	24,6
January	7,7	8,8	15,8	21,4
February	7,7	7,8	12,1	20,7
March	5,7	5,7	55,7	37,1
April	3,4	3,5	63,7	72,5

TABLE 4

Effect of soil depth and irrigation on average pruning mass of Pinot noir/99 R during the second and third seasons growing on a Glenrosa soil near Stellenbosch.

Treatment* number			Yield (kg vine $^{-1}$)
	Second leaf (1987/88)	Third leaf (1988/89)	Third leaf (1988/89)
T1	0,09 f**	0,26 d	1,53 d
T2	0,11 f	0,26 d	1,59 d
T3	0,11 f	0,37 cd	2,32 bcd
T4	0,14 ef	0,44 bcd	1,97 cd
T5	0,21 de	0,48 bcd	1,81 d
T6	0,23 d	0,56 bc	2,66 abc
T7	0,40 b	0,85a	2,25 cd
T8	0,29 cd	0,49 bc	3,11 ab
T9	0,35 bc	0,61 b	3,12 ab
T10	0,56 a	0,94 a	3,31 a

* Refer to Table 1 for description of treatments.

** Values followed by the same letters do not differ significantly.

TABLE 5

Plant physiological response of Pinot noir/99 R to soil depth and irrigation as measured at harvest in the second and third leaf on a Glenrosa soil near Stellenbosch.

Treatment* Number	Photosynthetic rate (µmole m^{-2} s^{-1})		Transpiration rate (mmole m^{-2} s^{-1})		Leaf water potential (kPa)	
	1987/88	1988/89	1987/88	1988/89	1987/88	1988/89
T1	1,68 f**	2,38 cd	2,53 e	3,49 de	-1400 cde	-1560 b
T2	3,33 ef	0,89 d	2,67 e	2,46 e	-1500 e	-1480 b
T3	1,93 f	3,49 bcd	2,75 e	4,07 cde	-1450 ed	-1530 b
T4	3,93 def	3,46 bcd	3,45 de	3,62 cde	-1370 cde	-1400 ab
T5	6,14 de	6,26 abc	4,93 bcd	5,02 abcd	-1340 cd	-1390 ab
T6	5,20 de	5,83 abc	4,40 cde	4,98 abcd	-1300 bc	-1450 ab
T7	7,24 abc	6,60 abc	5,53 abcd	5,49 abcd	-1340 cd	-1404 ab
T8	6,77 bcd	7,76 ab	6,36 abc	6,08 abc	-1280 bc	-1260 a
T9	10,12 a	8,81 a	7,17 a	6,41 ab	-1160 ab	-1270 a
T10	9,07 ab	9,97 a	6,78 ab	7,21 a	-1090 a	-1260 a

* Refer to Table 1 for description of treatments.

** Values followed by the same letters do not differ significantly.

gested that, although the young vines of all treatments were manipulated to some extent, increasing soil depth still increased growth and water consumption. Similar effects were reported for peach trees growing in isolated soil volumes ranging from 0,025 m^3 to 1,0 m^3 (Boland *et al.*, 1994).

During the second season (1987/88) ET increased from September to reach maximum values during February and March. Continued shoot growth during late summer is typical of irrigated, non-bearing, young vines under favourable climatic conditions. Irrigation increased pruning mass to such an extent that the canopies of the 800 mm and 1 200 mm deep treatments were within the limits for an ideal canopy (Table 4). This suggested that 800 mm soil depth in combination with irrigation induced sufficient vigour to bring vines into production a year earlier in comparison to their shallower dryland counterparts. However, nutrient uptake indicated that a full crop load might not be sustainable with 800 mm soil depth and under the conditions of this trial (Conradie *et al.*, 1996). The effect of soil depth on growth again reflected clearly in ET, and compared to the 400 mm treatment, the 800 mm and 1 200 mm treatments used 25% and 52% more water, respectively. The lack of differences in transpiration rates between treatments (Table 5) suggested that the increased ET was primarily the result of increased vegetative growth (Tables 4 & 5). The comparable photosynthetic rates of the 800 mm and 1 200 mm irrigated treatments (T9 & T10) did not correspond to the difference in pruning mass and ET. However, measurement of LWP on vines on the 400 mm soil depth revealed significantly higher water stress compared to vines on the 1 200 mm depth plots (Table 5). These results were reflected by the respective pruning masses. Differences in PAW between irrigations could also have contributed to lower water consumption with decreasing soil depth. During January weekly evapotranspiration depleted PAW to 44,6%, 67,0% and 78,3% for the 400 mm, 800 mm and 1 200 mm soil depth treatments respectively. Leaf water potential corresponded to these soil water depletion levels. Transpiration and photosynthetic rate, however, were not affected by depletion of soil water.

During the third season (1988/89) increased shoot mass (Table 4) caused the total ET of the 400 mm, 800 mm and 1 200 mm treatments to be higher, compared to that of the second season (Table 6). Allowing the vines, however, to bear their first crop could also have contributed to these increases. Total ET of the 800 mm deep treatment (521,7 mm) was comparable to the 500 mm reported by Van Zyl & van Huyssteen (1984) for full-bearing vines. In the case of the 1 200 mm treatment, the relatively high ET of 614 mm indicated that growth conditions were more luxurious than normally encountered in vineyards of the Western

TABLE 6
Effect of soil depth on average monthly evapotranspiration for irrigated Pinot noir/99 R on a Glenrosa soil near Stellenbosch.

Month	Monthly evapotranspiration (mm)								
	First leaf (1986/87)			Second leaf (1987/88)			Third leaf (1988/89)		
	T8 (400 mm)	T9 (800 mm)	T10 (1200 mm)	T8 (400 mm)	T9 (800 mm)	T10 (1200 mm)	T8 (400 mm)	T9 (800 mm)	T10 (1200 mm)
September	-	-	-	4,5	11,6	19,1	29,9	33,7	44,2
October	22,3	23,6	25,6	18,8	28,5	37,2	42,0	48,5	56,2
November	19,6	25,8	30,8	32,7	40,6	57,5	38,8	47,7	64,7
December	40,5	46,0	55,3	36,1	45,6	52,4	81,1	102,8	110,7
January	32,4	42,4	46,5	43,2	52,1	58,4	80,7	122,0	150,6
February	45,3	52,4	56,7	61,8	96,1	116,9	81,7	116,2	133,8
March	23,6	37,0	47,7	71,4	67,7	78,2	62,8	84,5	98,4
April	17,6	28,7	36,4	50,0	48,0	48,0	-	-	-
Total*	183,7	227,2	262,6	264,0	330,6	400,6	387,1	521,7	614,4

* Only from October until March to allow comparison between years.

TABLE 7

Seasonal water consumption of young, developing Pinot noir grapevines in relation to the water consumption of bearing three year old grapevines on a Glenrosa soil near Stellenbosch.

Treatment number	Soil depth (mm)	Fraction of third leaf water consumption (%)	
		First leaf	Second leaf
T8	400	47,5	68,2
T9	800	43,6	63,2
T10	1 200	42,7	65,2
Mean		44,6	65,6

Cape. Similar to the previous season, the positive effect of soil depth on shoot mass was reflected in the seasonal ET of the three irrigated treatments (Table 6). The lack of differences in photosynthetic rate, transpiration rate and LWP between soil depth treatments (Table 5) again confirmed that increased ET resulted from increased vegetative growth induced by soil depth. At harvest weekly evapotranspiration depleted PAW to 0%, 23% and 37% for T8, T9 and T10, respectively. These differences in depletion levels, however, did not reflect in the plant physiological responses of the various treatments. Although the depletion levels were lower than during 1987/88, plant physiological response at harvest was comparable (Table 5). This suggested that plant physiological parameters might only be impaired if low levels of soil water are maintained for longer periods under adverse climatic conditions.

Seasonal water consumption of one-year-old grapevines, irrespective of soil depth, was considerably lower compared to that of three-year-old vines (Table 7). Despite the increase in vegetative growth during the second year, total ET of all treatments was still lower in comparison to three-year-old vines.

CONCLUSIONS

Increases in pruning mass, caused by increased soil depth, were to be expected under dryland conditions, since soil depth directly affects the quantity of nutrients and stored soil water. A soil preparation depth of 800 mm and deeper is more favourable to vigour under dryland conditions than preparation to shallower depths. Furthermore, under irrigation the positive effect of increased soil depth on pruning mass indicated that factors other than water alone determined aerial growth. Size of the root system and the balance between subterranean and above-ground growth were most probably involved. Nitrogen and other nutrients were estimated to be adequate for all treatments (Conradie *et al.*, 1996) and could not account for pruning mass differences.

Comparison of the irrigated and dryland treatments revealed higher pruning masses and less water stress for the irrigated treatments. With the exception of the 1 200 mm dryland soil depth, irrigation also favoured photosynthetic and transpiration rates. Similar to its dryland counterpart, the irrigated 1 200 mm deep treatment showed excessive growth for the trellising system. This may result in problems with canopy management, unfavourable microclimate in the canopy and eventually, in poor wine quality. In general, results of the photosynthesis and transpiration measurements supported the pruning mass data, i.e. they tended to increase with soil depth. Considering all indicators of grapevine growth and physiological activity up to the fourth year, optimum shoot growth was obtained on the 600 mm to 1 000mm deep dryland treatments as well as on the 400 mm and 800 mm irrigated treatments. From this it is clear that irrigation could, within limits, compensate for a lack of soil depth. These results were obtained for young grapevines. Research must continue to determine whether higher grapeloads will affect these tendencies.

Compared to previous experiments that were carried out on mature, full-bearing vines, water use of young grapevines was low after planting, but continuously increased up to the bearing stage. During the first and second seasons irrigation should be reduced to 44,6% and 65,5% of the irrigation generally required by bearing grapevines, respectively. Applying irrigation norms of mature vines to young, non-bearing vines will evidently result in over-irrigation. Increased vegetative growth induced by increased soil depth was also clearly reflected in the evapotranspiration. Irrigation norms should be adjusted to suit the evapotranspiration of specific soil-canopy combinations. Establishing these irrigation norms for full-bearing grapevines is part of an ongoing study.

The method used to create field lysimeters required high inputs with regard to labour and organisational skills, but was relatively inexpensive. Furthermore, the simplicity and relatively low cost allowed the use of large plots with enough test vines to meet statistical requirements regarding replication and randomisation. These lysimeters made it possible to quantitatively measure the various components contributing to the water balance of grapevines.

LITERATURE CITED

BOLAND, A.M., MITCHELL, P.D., GOODWIN, I & JERIE, P.H., 1994. The effect of soil volume on young peach tree growth and water use. *J. Amer. Soc. Hort. Sci.* **119**, 1157 - 1162.

CONRADIE, W.J., VAN ZYL, J.L. & MYBURGH, P.A., 1996. Effect of soil preparation depth on nutrient leaching and nutrient uptake by young *Vitis vinifera* L. cv. Pinot noir. *S. Afr. J. Enol. Vitic.* **17**, 43 - 52.

MYBURGH, P.A. & MOOLMAN, J.H., 1991. The effect or ridging on the soil water status of a waterlogged vineyard soil. *S. Afr. J. Plant. Soil.*. **8**, 184 - 188.

SAAYMAN, D., 1981. Klimaat, grond en wingerdbougebiede. In : BURGER, J. & DEIST, J. (eds.) Wingerdbou in Suid-Afrika. Nietvoorbij, Stellenbosch, South Africa pp 48 - 66.

SAAYMAN, D., 1982. Soil preparation studies: II. The effect of depth and method of soil preparation and of organic material on the performance of *Vitis vinifera* (var. Colombar) on Clovelly/Hutton soil. *S. Afr. J. Enol. Vitic.* **3**, 61 - 74.

SAAYMAN, D. & VAN HUYSSTEEN, L., 1980. Soil preparation studies: I. The effect of depth and method of soil preparation and of organic material on the performance of *Vitis vinifera* (var. Chenin blanc) on Hutton/Sterkspruit soil. *S. Afr. J. Enol. Vitic.* **1**, 107 - 121.

SCHOLANDER, P.F., HAMMEL, H.T., BRADSTREET, E.D. & HEMMINGSEN, E.A., 1965. Sap pressure in vascular plants. *Science* **148**, 339- 346.

SMART, R.E., DICK, J.K., GRAVETT, I.M. & FISCHER, B.M., 1990. Canopy management to improve grape yield and wine quality - principles and practices. *S. Afr. J. Enol. Vitic.* **11**, 3 -17.

SOIL CLASSIFICATION WORK GROUP, 1991. Soil classification - A taxonomic system for South Africa. Memoirs on natural agricultural resources of South Africa No. 15, Department of Agricultural Development, Pretoria, South Africa. 262 pp.

VAN HUYSSTEEN, L., 1983. Interpretation and use of penetrometer data to describe soil compaction in vineyards. *S. Afr. J. Enol. Vitic.* **4**, 59 - 65.

VAN HUYSSTEEN, L., 1988. Soil preparation and grapevine root distribution - A qualitative and quantitative assessment. In: VAN ZYL, J.L. (ed.). The grapevine root and its environment. Technical communication No. 215. Dept. Agric. & Water Supply, Pretoria, South Africa pp. 1 - 15.

VAN ZYL, J.L. & VAN HUYSSTEEN, L., 1984. Soil water management for optimum grape yield and quality under conditions of limited or no irrigation. Proc. of the fifth Australian Wine Industry Technical Conference 29 Nov. - 1 Dec. 1983, Perth, Western Australia pp. 25 - 66.

VAN ZYL, J.L., & WEBER, H.W., 1981. The effect of various supplementary irrigation treatments on plant and soil moisture relationships in a vineyard. *S. Afr. J. Enol. Vitic.* **2,** *83 - 99.*

WILLIAMS, L.E., 1993. Effects of irrigation and mineral nutrition on grape quality. Paper presented at VINANDINO '93 14 - 15 Nov. 1993, Mendoza, Argentina.

ZEEMAN, A.S., 1981. Oplei. In: BURGER, J. & DEIST, J. (eds.). Wingerdbou in Suid-Afrika. Nietvoorbij, Stellenbosch, South Africa. pp. 185 - 201.