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The Effect of Selected Minimum and Conventional Tillage Practices in Vineyard Cultivation on Vine Performance*

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A long-term vineyard cultivation experiment, comprising six tillage treatments which represent a "conventional" cultivation group as well as a group of "minimum" tillage practices, was started in 1968 at Nietvoorbij Experimental Farm of the OVRI, Stellenbosch. The first group included (i) the "shallow trench furrow", (ii) the "deep trench furrow", and (iii) the locally customary "clean cultivation" systems, and the second group comprised (i) a straw mulch cover on the soil surface, (ii) chemical weed elimination by herbicides, and (iii) a permanent "sward" of indigenous weeds.

Distinct differences in vine performance between treatments were found. The general appearance, nutritional status and some important growth parameters of vines, as well as yield and quality of grapes, musts and wines from the straw mulch and herbicide treated (minimum) plots were markedly superior to the same properties of vines, grapes and wines from the conventionally tilled plots and the sward treatment, the latter due to competition of weeds for water and nutrients.

However, a tentative economical analysis showed that the deep furrow trenching gave a sufficiently high yield to merit further consideration, although it could not reach the economical performance of the herbicide treatment.

The favourable alteration in a vineyard of physical and moisture conserving soil properties under dryland conditions, as induced by three "minimum" tillage methods in comparison with a "conventional" tillage practice has already been reported (Van Huyssteen & Weber, 1980a, 1980b). However, the real criterion of success or failure of a soil cultivation measure is not the change accomplished in the soil *per se* but the response of the crop.

Steinberg (1973) used shoot mass as an indicator of growth vigour for vines, and obtained a 94,4% higher shoot yield by means of a straw mulch in comparison with clean cultivation, a result apparently due to differences in soil moisture availability. According to Kasimatis (1967), and Van der Westhuizen (1974), a drastic decrease of the shoot growth rate, and an accompanying shortening of the internodia, occur when the soil moisture content approaches the permanent wilting point. In addition to shoot growth, Tarlapan (1965) used bunch mass and yield. These three parameters were higher on plots where herbicide applications replaced or supplemented soil cultivation, than on plots having received four cultivations.

Grbic & Zorsic (1963), and also Nedeltchev (1965), compared yield and berry quality of vines from differently cultivated soils. They found that when using herbidices, summer cultivation of the vineyards can be reduced to an absolute minimum or even completely omitted, with no adverse effects on yield and quality. Quidet, Trespeuch & Vial (1967) could also not find any differences in yield between mechanically clean cultivated and herbicide treated vineyards on different soil types in France.

These examples indicate that mechanically clean cultivation may be redundant. A long-term research project for studying the effects of different cultivation methods on a vineyard under dryland conditions was, therefore, initiated.

MATERIALS AND METHODS

Experimental site, design and treatments: The effect of six cultivation treatments on soil physical parameters and the response of wine grapes was studied in an experiment, discussed in detail by Van Huyssteen & Weber (1980a). The treatments were:

B_1 Shallow trench furrow
B_2 Deep trench furrow
B_3 Straw mulch
B_4 Chemical weed control
B_5 Clean cultivation
B_6 Permanent sward

Details of treatments B_3 to B_6 were given by Van Huyssteen & Weber (1980a), and treatments B_1 and B_2 were as follows:

B_1: A shallow trench furrow 150–200 mm deep was ploughed every year in alternate inter-row spaces. Prunings were put into these furrows, and ploughed under. In the other inter-row spaces a cover crop was grown, as described in the paper mentioned above. Weeds on the strips underneath the vines were hoed by hand. Growth of weeds in the inter-rows was controlled by disc-harrow as often as necessary during the growing season of the vines.

B_2: Similar to B_1, except that the furrow was 250–300 mm deep.

The latter two treatments, together with the clean cultivation treatment (B_5) using the disc-harrow, represented the "conventional" group of cultivation practices. The so-called "minimum" tillage methods comprised the previously described straw mulch cover on the soil surface (B_3), chemical weed control by herbicides (B_4), and a permanent sward of indigenous weeds and grasses cut frequently with a rotary bush-cutter (B_6).

Vine performance measurements: Six years after planting the vineyard, root counts were made simultaneously with pedological profile studies in pits dug 0,4 m from the stem of a datum vine. The thickness, as well as the position, of each root in the profile wall nearest to the vine, were plotted on graph paper. For shoot growth measurements two bearer shoots of comparable vigour on each of ten data vines were chosen randomly on every plot of the first replication. The lengths of the twenty shoots were measured at weekly intervals throughout the growing season. The mass of shoot prunings obtained from each plot was measured in winter for five consecutive years (1973–1978). During three seasons (1974/75 to 1976/77), two leaves situated between the third and fifth internodia of the data shoots were picked in mid-January, washed, and dried as described by Beyers (1962), and their macro and micro element concentrations were determined by means of standard automated analysis procedures, as employed by the OVRI. Grapes from all treatments were picked on the same day. Until 1975, grapes were harvested and weighed at a soluble solids content of 20°B but afterwards at a soluble solids/acid ratio of 2,5–3,0, which is regarded a better indication of optimum ripeness (Du Plessis, 1977). Total soluble solids (TSS) in °B, total titratable acidity (TTA) of the must in g $\times$ ℓ^{-1}, and pH of the must, were determined according to standard OVRI procedures.

Grapes from all replications of each of the B_1, B_3 and B_6 treatments were pooled per treatment to make experimental wines, which were subsequently judged by a panel of experienced wine-tasters according to standard OVRI procedures, as described by Tromp & Conradie (1979).

Eventually, an attempt at evaluating the different treatments economically was made, using cost and benefit data obtained from the Department of Agricultural Economics of the University of Stellenbosch.

The results of all determinations were subjected to analyses of variance and averages compared according to the Neumann-Keuls method (Snedecor & Cochran, 1969).

RESULTS AND DISCUSSION

Responses of root growth to treatments: The density of root distribution under the different treatments is depicted in Fig. 1(a–d). Table 1 presents the results of actual counts for the different root size classes. From these figures and the table, large differences between the treatments are evident. It appears that roots of all sizes were abundant under the herbicide (B_4) treatment, and frequent under the straw mulch cover (B_3), but comparatively rare under the clean cultivation (B_5) and sward (B_6) treatments. In all profiles, single fine roots were only occasionally found deeper than 750 mm, this being apparently due to the extremely high bulk density of the 700–900 mm layer. On the clean cultivation (B_5) plots no roots were found at depths shallower than 200 mm, which is the general tillage depth. This observation also applies to the permanent sward (B_6) treatment. On the other hand, the upper 200 mm soil layer is well rooted under the straw mulch cover (B_3), but comparatively densely rooted under the herbicide (B_4) treatment.

Elimination of weeds with herbicides (B_4), therefore, not only induced the highest root density in general but also the occurrence of the greatest number of medium sized (5–1 mm) and very fine (< 0,5 mm) roots, especially in the upper 200 mm soil layer, where very fine and fine (1–0,5 mm) roots were predominant. In contrast the presence of weeds on the B_6 plots provided sufficient competition to suppress root growth of the vines almost completely in the top 200 mm soil layer. Consequently, the total number of vine roots was reduced to 50%, and the number of medium and very fine roots to only about 33% of those found under the herbicide (B_4) treatment.

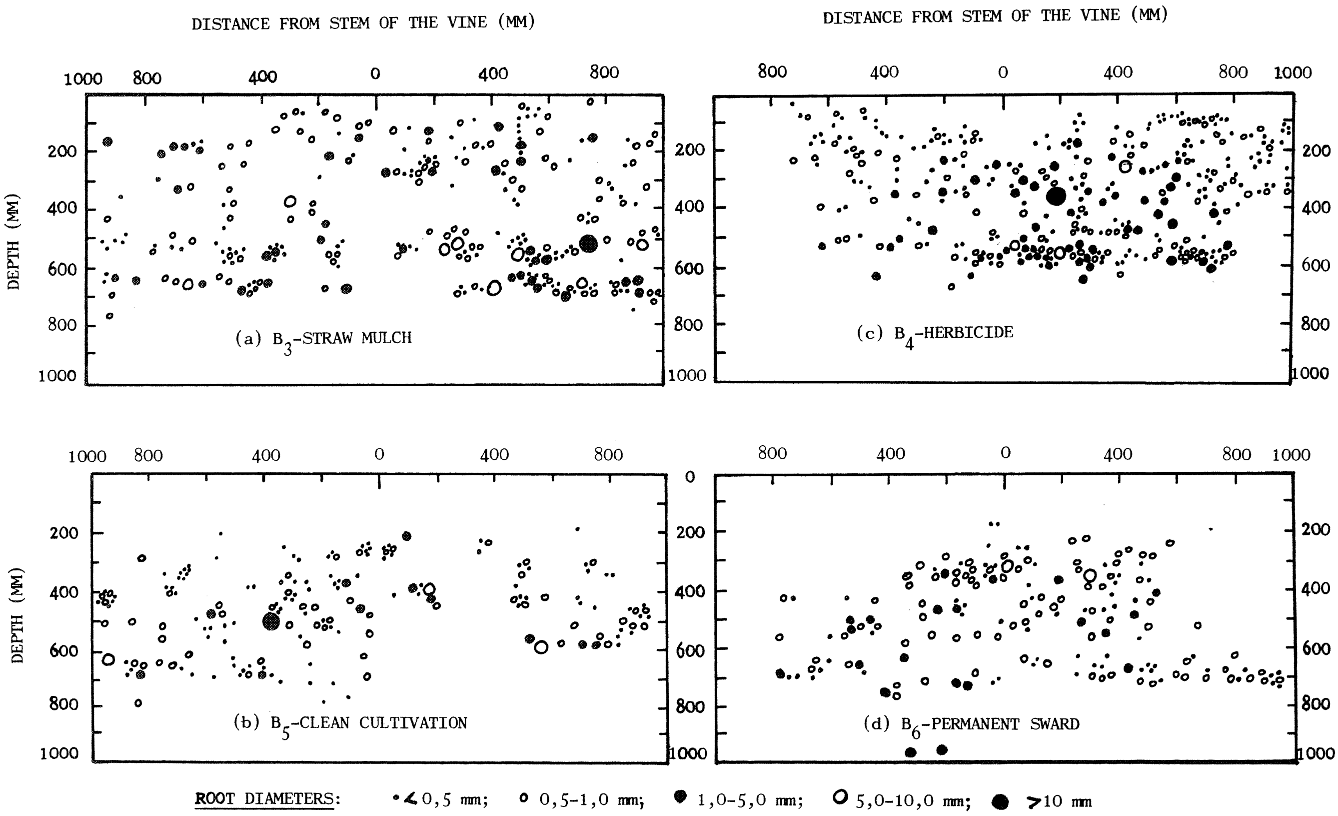

FIG. 1.
Root distribution of vines under four different cultivation treatments.

TABLE 1
Number of roots of all size classes under different cultivation treatments (treatments arranged according to abundancy)

Treatment	Root size classes (Diameters in mm) Very Coarse >10	Coarse 10–5	Medium 5–1	Fine 1–0,5	Very Fine <0,5	Total number of roots	Differences in root numbers between treatments	Relative abundancy of roots
Herbicide (B_4)	1	3	58	93	174	329		100,0
Straw mulch (B_3)	1	8	39	103	105	256	73	77,8
Clean cultiv. (B_5)	1	3	11	58	101	174	82	52,9
Perm. sward (B_6)	0	2	21	82	59	164	10	49,8

The root growth response to the clean cultivation treatment (B_5) is also notable. Fig. 1c and Table 1 indicate that the repeated tillage down to 200 mm depth prevented roots from penetrating that layer, so that the vines could not make use of the soil moisture and nutrient supplies retained in this part of the solum. The 200–300 mm depth zone was also more or less inaccessible to roots, because of its extremely high density (Van Huyssteen & Weber, 1980a), so that only the lower zone of the profile between 300 and 700 mm depth was available to supply water and nutrients to the vines. The dense traffic and tillage pan (Van Huyssteen & Weber, 1980a) would have impeded gas exchange, so that growing conditions for roots would have been poor. From Fig. 1(c & d) and Table 1 it is evident that the root distribution was similar under the B_5 and B_6 treatments but that there were differences between the numbers of roots in different classes.

Responses of shoot growth to treatments: In Fig. 2 curves of shoot growth rates during the 1976/77 growing season are shown. Throughout this season, treatments B_3 and B_6 differed distinctly from the other four treatments, which gave a group of curves running very close to each other until about véraison (1976.12.08).

Calculations for shoot growth rate, in mm/day, during three consecutive physiological growth phases of vines are presented in Table 2. The shoots of the straw mulch (B_3) treatment maintained the fastest growth rate during all growth phases. After flowering, the growth rate of shoots from the herbicide (B_4) treatment was close to that of the B_3 treatment. Clean cultivation (B_5) and sward (B_6) induced the slowest growth rate throughout the season.

Shoot growth rate was found by Kasimatis (1967), and Van der Westhuizen (1974), to be an indicator of moisture supply to vines, and this was confirmed by this study. The

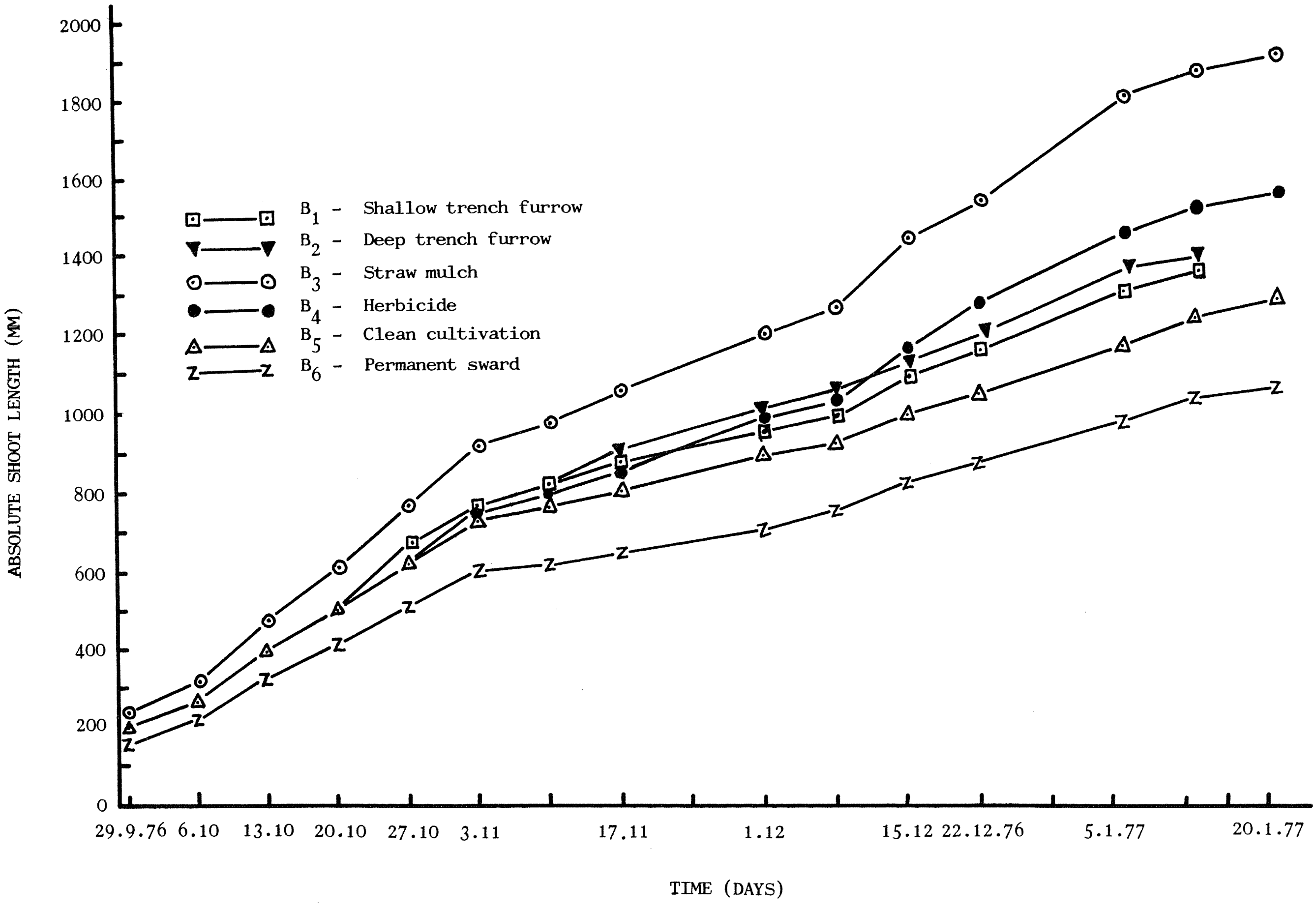

FIG. 2.
Shoot growth rates of vines on differently treated plots during the 1976/77 season.

TABLE 2

Mean rate of shoot growth in mm/day for three different growth stages of Chenin blanc vines under different soil cultivation practices and dryland conditions

Physiological phase at date	Budburst to Flowering (29.9.76) (3.11.76)	Flowering to Véraison (3.11.76) (8.12.76)	Véraison to Harvest (8.12.76) (24.2.77)
Treatment	mm/day	mm/day	mm/day
Shallow trench furrow (B_1)	14,4	6,8	10,5
Deep trench furrow (B_2)	15,6	6,7	10,0
Straw mulch cover (B_3)	18,2	10,1	16,9
Herbicide (B_4)	14,8	8,2	14,5
Clean cultivation (B_5)	14,5	5,6	9,2
Permanent sward (B_6)	12,5	4,4	8,1

TABLE 3

Pruning masses (t. ha^{-1}) for seven growing seasons as obtained from differently treated plots

Season	Pruning mass (t. ha^{-1}) from treatments						D-value
	B_1	B_2	B_3	B_4	B_5	B_6	P = 0,05
1971/72	0,333	0,343	0,460	0,288	0,301	0,070	0,203
1972/73	0,567	0,651	1,152	0,553	0,490	0,171	0,335
1973/74	0,651	0,803	1,08	0,903	0,683	0,159	0,464
1974/75	1,16	1,43	1,11	1,22	1,14	0,312	0,510
1975/76	1,37	1,63	2,64	1,75	1,65	0,420	0,73
1976/77	2,11	2,42	3,70	3,10	2,49	0,640	1,32
1977/78	1,71	1,96	2,78	2,44	1,96	1,08	1,26
Treatment mean values	1,120	1,310	1,840	1,460	1,240	0,400	0,454

superior moisture conserving capabilities of the two minimum tillage practices, B_3 and B_4, were already reported by Van Huyssteen & Weber (1980b). The slow shoot growth rates after flowering in the B_5 and B_6 treatments, and even in the B_1 and B_2 treatments, are in accordance with the low soil moisture content in the soil, as was shown by Van Huyssteen & Weber (1980b). This observation is also in accordance with the conclusion of Vaadia & Kasimatis (1961), viz. that increasing soil moisture stress causes a corresponding decrease in rate of shoot growth, and vice versa.

Pruning mass data are shown in Table 3. Vines on the straw mulch (B_3) treated plots had a significantly higher mean pruning mass than those on all other treatment plots. This also applies to the individual 1972/73 and 1975/76 seasons. The mean growth vigour of the vines under the B_1, B_2 and B_5 (i.e. the "conventional" tillage-group) treatments was very similar. In all seasons, the sward (B_6) treatment produced significantly lower pruning masses than all other treatments. These results, as was to be expected, tally with the shoot growth rate curves in Fig. 2.

The effect of treatments on the chemical composition of leaves: Although for three consecutive seasons (1974/75 to 1976/77) the straw mulch treatment induced a 16,0%, 22,3% and 6,7% higher nitrogen content in leaves compared to the sward treatment, these differences were not statistically significant ($P \leq 0,05$), nor were those for any of the other nine elements analysed (Van Huyssteen, 1977). Analytical results are, therefore, not presented. However, the reduction in the uptake of nitrogen and phosphorous, as well as several other elements, in consequence of moisture deficits leading to lower concentrations in leaves, has been well documented by Begg & Turner (1976).

Responses of grape yield to treatments: The yields of seven seasons (1971/72–1977/78), expressed in t/ha, are presented in Table 4. The overall higher yields of 1978 are due to more bearers having been left during pruning in 1977. The figures show that the straw mulch (B_3) treatment had a significantly better response than B_1, B_5 and B_6 in the 1971/72, 1972/73, 1973/74 and 1976/77 seasons. B_3 was only significantly ($P \leq 0,05$) better than B_4 in the 1971/72 and 1972/73 seasons, and than B_2 in the 1972/73 and 1976/77 seasons. In the 1974/75 season the straw mulch (B_3) treatment had an unexpected low yield, due to the effect of volunteer wild oats *(Avena fatua)* present in the straw during spring 1974. The B_3 treatment regained and kept its leading position during the following years when herbicides were applied to control the wild oats. The low yield during the 1972/73 season on the herbicide (B_4) plots was due to the delayed application of herbicides late in spring, which caused scorching of the buds and subsequent new growth.

Permanent sward (B_6) consistently caused significantly lower yields than all other treatments. The detrimental role of weeds under dryland conditions becomes clear when comparing the yield of this (B_6) treatment with those of the weed control by chemical (B_4) and mechanical (B_5) means: the permanent presence of weeds on the B_6 plots depressed vine yield by 68,2%, compared to B_4, and 64,6% compared to B_5. The additional effect of a prolonged soil moisture conservation by means of a straw mulch (B_3), is demonstrated by the 296,4% and 26,1% higher yield obtained with this treatment, as compared to the sward (B_6) and chemical weed control (B_4) treatments, respectively.

The 1976/77 growing season was marked by the exceptionally cool and wet summer months November and December (Van Huyssteen & Weber, 1980b), i.e. during the important flowering and green-berry stages. This unfavourable weather condition at this growth stage of the vines, is generally assumed to be the cause of yield depressions, as were actually found on the shallow (B_1) and deep (B_2) trench furrow, as well as clean cultivation

TABLE 4
Grape yields of different cultivation treatments for seven growing seasons

Season	Grape yields (t. ha^{-1} @ 20°B) of different treatments						D-value (P = 0,05)
	B_1	B_2	B_3	B_4	B_5	B_6	
1971/72	4,32	4,89	7,64	4,35	4,11	1,60	3,24
1972/73	4,83	5,07	8,07	3,73	4,74	1,23	2,32
1973/74	5,86	7,40	9,93	7,87	6,00	1,81	2,87
1974/75	7,50	9,18	9,53	9,81	7,72	1,47	3,49
1975/76	8,58	10,75	12,29	10,84	10,29	3,39	5,45
1976/77	7,85	9,19	13,63	10,94	9,38	3,40	4,20
1977/78	16,71	20,28	25,13	20,84	19,28	8,85	12,05
Total	55,65	66,76	86,22	68,38	61,52	21,75	25,79
Mean	7,95	9,54	12,32	9,77	8,79	3,11	3,68

(B_5) treatment plots, viz. decreases of 8,5%, 14,4% and 8,8% respectively, as compared to the yields from the same plots in the preceding (1975/76) season. This explanation appears to be the more valid because in that season depressed grape yields were observed throughout the entire Western Cape. But then the yields of all treatments should have been depressed alike. Yet a yield increase of 10,9% from the straw mulch (B_3) treatment, in the same season, was obtained, whilst the yield from the herbicide (B_4) and permanent sward (B_6) plots remained virtually constant in comparison with those of the previous season. This observation indicates that the way the soil was treated must have had a decisive influence on the later growth of vines, irrespective of the abovementioned depressive effect of a bad-weather period at so early and sensitive a stage. As reported by Van Huyssteen & Weber (1980b), it appears that the straw mulch (B_3) and, to a lesser extent, also the herbicide (B_4) treatments were capable of conserving the summer rain more efficiently and for a longer period than the conventional tillage treatments, and that the sward (B_6) treatment had, at least, the highest infiltration rate. It must have been the benefit of this additional amount of available water in the straw mulch, herbicide and the otherwise very dry sward plots, therefore, that helped the vines to overcome the after-effects of a detrimental factor, as, e.g., a cool-wet period during an important physiological growth phase, and to respond with better yields than under conventional tillage practices.

Taking the yield of the clean cultivation (B_5) treatment as control (Table 4), it appears that in all except the first two seasons, the shallow trench furrow (B_1) treatment yielded lower than the control, although not statistically significant. This indicates that this treatment has no additional benefits over and above clean cultivation except to get rid of prunings. However, the deep trench furrow (B_2) treatment fared a bit better than B_1, and gave yields that compare well with those of the control. This result points to some beneficial effect of the B_2 treatment on soil physical conditions, and is probably due to the combined effect of the deeper loosening of the soil and the counteracting of subsoil compaction.

Treatment effects on quality factors in musts: Results presented so far indicate that the straw mulch (B_3) treatment induced the most favourable, and the sward (B_6) the most unfavourable plant responses. Regarding the must quality factors, Table 5 shows that B_3 produced the lowest, and B_6 the highest mean and seasonal total soluble solids (TSS) contents in the grapes at the date of harvest. Up to the 1974/75 season there were no statistically significant differences between treatments. The sward (B_6) treatment produced a significantly higher TSS content than the straw mulch (B_3) treatment in the 1975/76, 1976/77 and 1977/78 seasons, as well as over the total of six seasons. Although the straw mulch cover (B_3) and herbicide application (B_4) induced higher total titratable acid contents in the musts than the other treatments, these differences were not significant. The grapes from the B_1, B_2, B_3, B_4 and B_5 treatments would have reached the same TSS contents if they were picked later, but then they would not have been harvested at optimum maturity with regard to the sugar/acid ratio, as specified by Du Plessis (1977).

TABLE 5
Total soluble solids (°B) of six harvesting seasons

At the end of growing season	T S S (°B) as affected by cultivation treatments						D-value P = 0,05
	B_1	B_2	B_3	B_4	B_5	B_6	
1972/73	23,07	25,27	23,20	24,90	25,50	25,10	NS
1973/74	25,40	24,03	22,43	23,80	24,57	26,07	NS
1974/75	21,73	21,60	21,46	22,20	22,43	23,36	NS
1975/76	21,93	22,76	21,70	23,13	22,96	24,23	1,56
1976/77	21,37	21,27	19,67	21,50	21,40	22,63	2,54
1977/78	21,13	20,33	18,46	20,63	20,20	20,26	1,67
Treatment mean	22,44	22,54	21,15	22,69	22,84	23,61	2,28

The effect of treatments on wine quality: The sensory evaluation results of experimental wines made from grapes harvested on treatment plots B_1 (shallow trench furrow), B_3 (straw mulch) and B_6 (sward) are presented in Table 6. During the wine-making seasons of 1975 and 1976, "quality wines" were obtained from grapes of the B_1 and B_3 plots but B_6 wines were unacceptable and inferior because of incomplete fermentation.

TABLE 6
Sensory evaluation of experimental wines made of grapes from different cultivation treatments under dryland conditions

Treatment	Harvest year (season)	Wine Score (%)	D-value P = 0,05
B1	1974	50,3	
B3	(1973/74)	44,6	7,0%
B6		Stuck fermentation	
B1	1975	68,2	
B3	(1974/75)	69,2	5,3%
B6		Stuck fermentation	
B1	1976	64,85	
B3	(1975/76)	67,65	6,3%
B6		Stuck fermentation	

Quality categories for experimental wines (OVRI)

Distilling wine	<40%
Table wine	40–54%
Quality wine	55–85%
Superior wine	>85%

Stuck fermentation was first observed in the 1974 harvest year (1973/74 season) in musts from the sward (B_6) treatment plots. At first, the N-content of the leaves was thought to be a sensitive indicator of the N-content of the vines. Although the results were not statistically significant, the leaves of vines on the B_6 treatment plots contained 13,8%, 18,2% and 6,3% less nitrogen than other leaves from the B_3 plots for the 1973/74, 1974/75 and 1975/76 growing seasons. However, after the 1975/76 season the musts were also analysed for total nitrogen content, and it was found that the nitrogen status in the vines was indicated more sensitively in the must than in the leaves. Results of total nitrogen concentration determinations on musts during three seasons are given in Table 7, which also shows, in accordance with the leaf analyses of the previous years, that musts of the B_6 treatment contained the lowest nitrogen. Agenbach (1977) found that the addition of inorganic nitrogen to the stuck-prone musts of the B_6 treatment ensured proper fermentation. The same author reported that to ensure sufficient yeast growth for complete fermentation a must of 20 to 23 °B at 25 °C, the minimum assimilable nitrogen requirement was approximately 130 mg/ℓ juice. The low N-content in the B_6 grape musts, therefore, explains the fermentation problems encountered with these musts. The better nitrogen nutrition in 1977 and 1978 may be ascribed to the "wet" 1976/77 growing season which, amongst others, could have given rise to a more thorough mineralization of organic matter in the soil, leading to smaller differences between B_3 and B_6, as is shown by the nitrogen concentrations of the musts in Table 7.

The relatively low nitrogen contents of both leaves and musts of the permanent sward (B_6) treatment were apparently caused by the weeds which competed with the vines for nutrients and water. In addition, it should be pointed out that all plots received the same amount of fertilizer calculated for a production level of 10 t/ha. Therefore B_6, having produced only 3,4 t/ha, was grossly over-fertilized in comparison with the straw mulch (B_3) and herbicide (B_4) treatments, and should therefore have had a higher N concentration.

These results clearly suggest that the reduced growth observed as a result of moderate water deficits may arise from a disturbance in mineral nutrition, as well as the direct effects of water deficits. Nutrient levels in the field are usually highest in the top soil layer, but this is the first part of the solum to dry out in a drying cycle. Although the plants may have roots penetrating the deeper and moister part of the solum, the inaccessibility of nutrients in the dry surface soil layer may limit growth, and yield more than the soil moisture deficit *per se*. This was well illustrated in a study reported by Garwood & Williams (1967).

Partial cost/benefit assessment of the treatments: In Table 8 a partial economical comparison of the net results of the different treatments was attempted. The clean cultivation (B_6) treatment acted as control against which the various costs and yields could be measured in terms of monetary values prevailing during winter, 1977.

According to these results, the viticulturally most favourable treatment, viz. straw mulch (B_3), appears not to be economically feasible due to the high straw prices in all seasons (R2 900/ha as total for seven seasons), which could not be compensated for by the high yields obtained. If it were possible to reduce the costs of straw by, for instance, growing crops in the vineyard which can produce the material needed for a mulch cover, this treatment would be economically feasible. Nearly equally economically unfavourable was the shallow trench furrow (B_1) cultivation with a calculated loss of R417/ha compared to the control. It would, therefore, seem that no merits are to be found in this tillage practice. The deep trench-furrow (B_2) cultivation resulted in a gain of R503/ha, whereas the application of herbicides (B_4) rendered the highest profit, viz. R653/ha over the whole observation period. This favourable balance proves that chemical weed elimination was not only viticulturally but also economically much

TABLE 7.
Total nitrogen in the must* for three seasons

Treatment	1975/76	1976/77	1977/78
Sward (B_6)	163 mg/ℓ juice	350 mg/ℓ juice	353 mg/ℓ juice
Clean Cultivation (B_5)	—	—	421 mg/ℓ juice
Herbicides (B_4)	—	—	369 mg/ℓ juice
Straw Mulch (B_3)	473 mg/ℓ juice	620 mg/ℓ juice	529 mg/ℓ juice
Deep Furrow Trench (B_2)	—	—	429 mg/ℓ juice
Shallow Furrow Trench (B_1)	—	—	410 mg/ℓ juice

*The musts from the three replications were pooled before analysis.

TABLE 8.
A partial cost/benefit assessment of the different cultivation treatments versus clean cultivation as a control treatment

Treatments	Total grape yield over six[a] seasons (t/ha)	Increase or decrease vs. control (t/ha)	Increased or decreased income vs. control (R/ha)[b]	Total assessed costs over seven[a] seasons (R/ha)[c]	Increased or decreased costs versus control (R/ha)	Net gain or loss vs. control over seven[a] seasons (R/ha)
B_5 (Control)	42,23	–	–	R 172,73	–	–
B_1	38,96	– 3,27	–R 408,75	R 181,26	–R 8,53	–R 417,28
B_2	46,48	+ 4,25	+R 531,25	R 200,64	–R 27,91	+R 503,34
B_3	61,08	+18,85	+R2 356,25	R3 072,65	–R2 899,92	–R 543,67
B_4	49,05	+ 6,82	+R 852,50	R 371,99	–R 199,26	+R 653,24
B_6	12,91	–29,32	–R3 665,00	R 269,32	–R 96,59	–R3 761,59

[a] There were seven seasons of cultivation (the first for soil preparation) and six harvests.
[b] Calculation based on a minimum price of R125/t for good Chenin blanc grapes.
[c] The prices of June, 1977, were used for this calculation.

more successful than mechanical weed control (B_2 & B_5). The permanent sward (B_6) treatment was the most unfavourable of all treatments, viticulturally and economically. It showed a comparatively huge net loss of R3 762/ha, which was mainly due to the very low yields obtained.

CONCLUSION

Results showed irrefutably that a vineyard under dryland conditions must be free of weed competition during the growing season of the vines. These weeds must be eliminated as competitors before budburst. Practices in which weeds and/or cover crops are only controlled, but not killed, will result in a serious decrease in vegetative growth and yield.

It may, however, also be concluded that under the conditions of this experiment, the technically highly favoured straw mulch treatment is, for reasons of economy, much less feasible than chemical weed elimination. The application of herbicides is not only more practical but rendered also, on a monetary basis, the highest net gain of all treatments, which makes this no-tillage practice very attractive in both respects, technically and economically. On the other hand, the surprising economical results from the conventional tillage practices B_2 (deep furrow trenching) and, though only very moderately, also clean cultivation (B_5), prove that not all mechanical cultivation methods should be rejected, because some may still be technically efficient as well as economical if the use of implements could be reduced to a practical minimum, and provided weed control is adequate.

REFERENCES

AGENBACH, W. A., 1977. A study of must nitrogen content in relation to stuck fermentations, yeast production and fermentation activity. *Proc. S. Afr. Soc. Enol. Vitic.* pp. 67–88.

BEGG, J. E. & TURNER, N. C., 1976. Crop water deficits. *Adv. Agron.* 28, 161–219.

BEYERS, E., 1962. Diagnostic leaf analysis for deciduous fruit. *S.A. J. Agric. Sci. 5,* 315–329.

DU PLESSIS, C. S., 1977. Grape components in relation to white wine quality. Pp. 117–128. International Symposium on The Quality of the Vintage. Cape Town, South Africa. 14–21 February, 1977.

GARWOOD, E. A. & WILLIAMS, T. E., 1967. Growth, water use and nutrient uptake from the subsoil by grass swards. *J. Agric. Sci.* 69, 125–130.

GRBIC, V., & ZORSIC, M., 1962. One surface cultivation in the summer with the use of herbicides in grapevine growing. (Russian.) Sov. Poljopriv., 1962, No. 12, pp. 911–919, bibl. 9, illus. (Abstr.: *Hort. Abstr.* 34, 2453, 1963.)

KASIMATIS, A. N., 1967. Grapes. *In*: Irrigation of agricultural lands. (Edts. R. M. Hagan, H. R. Haise & T. W. Edminster.) Agron. Series II, pp. 719–739. Am. Soc. Agron. Madison, Wisconsin.

NEDELTCHEV, N., 1965. Non-cultivation in vineyards. Progr. agric. vitic., 1965, 164; 121–130, bibl. 5, illus. (Abstr.: *Hort. Abstr.* 36, 534, 1965).

QUIDET, P., TRESPEUCH, J. & VIAL, J., 1967. Weed control in vineyards and orchards. (French). C.R. 4e Conf. Com. franc. mauv. Herbes (COLUMA), 1967, 643–650. (Abstr.: *Hort. Abstr.* 39, 225, 1968).

SNEDECOR, G. W. & COCHRAN, W. G., 1969. Statistical methods. The Iowa State University Press. Ames, Iowa, USA.

STEINBERG, B., 1973. Der Einfluss der Bodenbearbeitung auf die Wurzelentwicklung der Reben. *Mitt. Rebe u. Wein* 22 (5), 303–312.

TARLAPAN, M. I., 1965. Herbicides and the problem of summer cultivation. Vinodeliei Vinogradarstvo, 1965, 25 (3), 26–31 (Abstr.: *Hort. Abstr.* 35 (4), 7410, 1965).

TROMP, A. & CONRADIE, W. J., 1979. An effective scoring system for sensory evaluation of experimental wines. *Am. J. Enol. Vitic.* 30 (4), 278–283.

VAADIA, Y. & KASIMATIS, A. N., 1961. Vineyard irrigation trials. *Am. J. Enol. Vitic.* 12, 88–98.

VAN DER WESTHUIZEN, J. H., 1974. Water management and irrigation requirement of wine grapes: Criterion for the determination of the irrigation requirement of wine grapes. Final Report, Dept. Agr. Tech. Serv. (OVRI), Project (S)WI 47/2, Stellenbosch.

VAN HUYSSTEEN, L., 1977. 'n Vergelykende ondersoek na die effektiwiteit van verskillende konvensionele en minimum grondbewerkingspraktyke in die wingerdbou ten opsigte van grondvogbewaring en ander fisiese eienskappe. M.Sc.-tesis, Univ. Stellenbosch.

VAN HUYSSTEEN, L. & WEBER, H. W., 1980a. The effect of conventional and minimum tillage practices on some soil properties in a dryland vineyard. *S. Afr. J. Enol. Vitic.* 1 (1), 35–45.

VAN HUYSSTEEN, L. & WEBER, H. W., 1980b. Soil moisture conservation in dryland viticulture as affected by conventional and different minimum tillage practices. *S. Afr. J. Enol. Vitic.* 1(2), 67–75.