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

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The effect of depth and method of soil preparation and of organic material on the performance of a Chenin blanc/101–14 Mgt. vineyard, grown on a Hutton/Sterkspruit soil, was studied in the Robertson irrigation area. The apparent lack of response to depth of soil preparation was traced to soil variation and to the inability of the deep delving implement to work down to the desired depth. A general tendency, directly relating shoot growth and yield to soil depth, could be demonstrated. It appears that the high cost of soil preparation is justified, and that the delve plough was more efficient than a ripper. No technical benefit was obtained from the application of either straw or compost during soil preparation.

It is recognised that good physical condition of the soil favours better air-water relationships (Neal, 1953; Baver, 1959; Schulte-Karring, 1963; Wind & Plattje, 1964), better growth of plants and functioning of the roots (Russel, 1958; Adams, *et al.*, 1960), and that organic material creates and stabilises a favourable soil structure (Neal, 1953; Kuipers, 1960; Boekel, 1963). However, very little is known concerning the qualitative effect of soil preparation and organic material on physical conditions of the soil and vine performance. In California, soil conditions generally seem to be favourable and in some cases only deep ripping is done (Winkler, *et al.*, 1974). In Europe excessive moisture seems to be the main problem, and soil preparation is, therefore, mainly aimed at alleviating this problem. Wourtsakis (1971) reviewed the history of soil preparation, and Beckel (1963) and Schönhals (1969) stressed the necessity of characterising the soil in terms of structure, compaction, depth, parent material and rooting depth in order to decide on the proper technique and depth of preparation. The chemical properties of a soil indicate the need for and/or type of ameliorants which should be added (Schmid & Weigelt, 1967). Although the importance of a proper mixing of ameliorants with the soil is recognised, it is difficult to attain when large quantities are involved (Rojahn, 1973). Not all soils benefit from deep preparation, and the natural horizon sequence should sometimes be kept intact, as in the case of duplex soils (Szekrenyi, 1969). The soil type should also dictate the type of implement to be used (Rojahn, 1973).

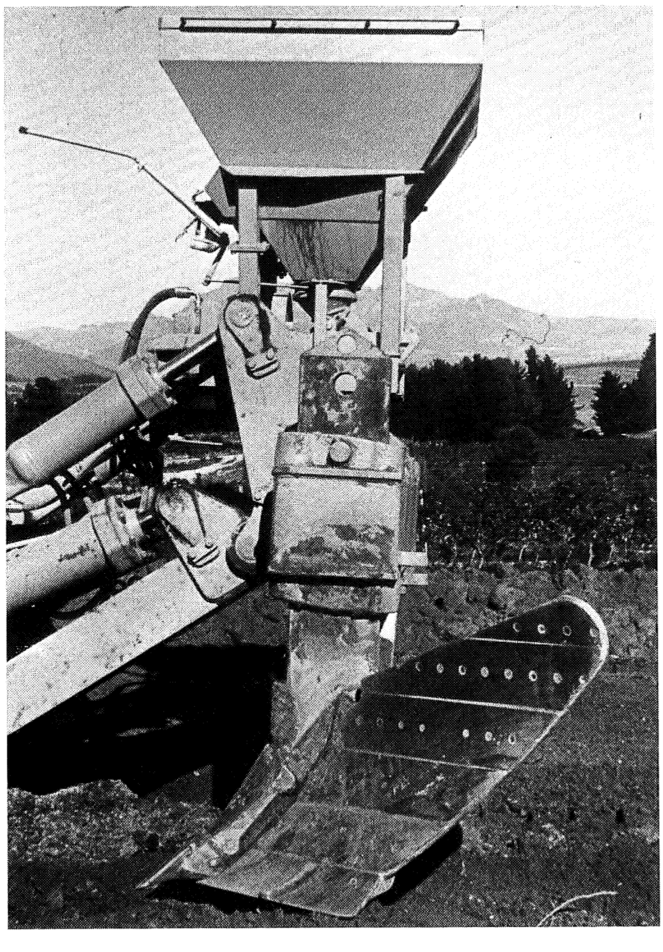
The general beneficial effect of the application of organic material on soil structure and plant growth is widely recognised (Russel, 1958; Schulte-Karring, 1970; Kannenberg, 1976), but in practice little is known about its effect on vine performance. According to Kononova (1961), organic material should be placed deep in warm climatic regions in order to prevent rapid decomposition, whereas deep placement in the usually wet, calcareous soils of Europe may lead to enhanced iron chlorosis (Scholl, 1979). Other researchers believe that the favourable physical conditions created by means of deep ploughing, should be maintained by means of lime applications, the deep placement of NPK that stimulates root growth and microorganism activity, as well as by means of a rational cultivation programme (Schmid, 1967; Schulte-Karring, 1970; Rojahn, 1973).

Little information is available with regard to the deep preparation of vineyard soils under mediterranean climatic conditions. In the wine producing areas of the Western Cape, the replanting of vineyards is almost invariably preceded by laborious and costly soil preparation processes. In the Coastal area, the apparent need for this is related in most cases to the general inferior physical properties of the soils, such as compactness and massiveness, strongly developed blocky or prismatic structure, as well as duplex characteristics. Deep soil preparation has, therefore, become traditional and usually involves powerful crawler tractors (224 kW) and huge deep penetrating implements (Plate 1). Currently, contracting firms charge ca. R80/h for soil preparation work, fuel excluded. This amounts to an investment of R600 to R900 per hectare, depending on the severity of soil compaction or the presence of hardpans or rock in the subsoil.

Although it is generally recognised and accepted in South Africa that soil preparation is necessary in order to obtain optimum vine performance, no practical norms exist for deciding which type of implement is to be used under specific conditions, or which type of soil should receive attention. A surface area of ca. 5 000 ha is presently being replanted to vines each year, involving approximately R3,75 million for soil preparation. If, furthermore, it is taken into account that a vineyard has a life expectancy of 25 to 30 years during which very little can be done to improve unfavourable or deteriorating subsoil conditions, it is obvious that the general lack of concrete information concerning soil preparation is very serious.

MATERIAL AND METHODS

Locality and soil: The experimental vineyard was planted during July 1967 at the OVRI experimental farm at Robertson, which is situated in the Breede River valley irrigation area. The soil concerned is reddish brown, of medium to heavy texture, contains lime in varying quantities and has a slope of 1–2%. The general association of these soils in nature, is schematically shown in Fig. 1. They occur widely on old, alluvial terraces and were considered to be representative for the area (Saayman,



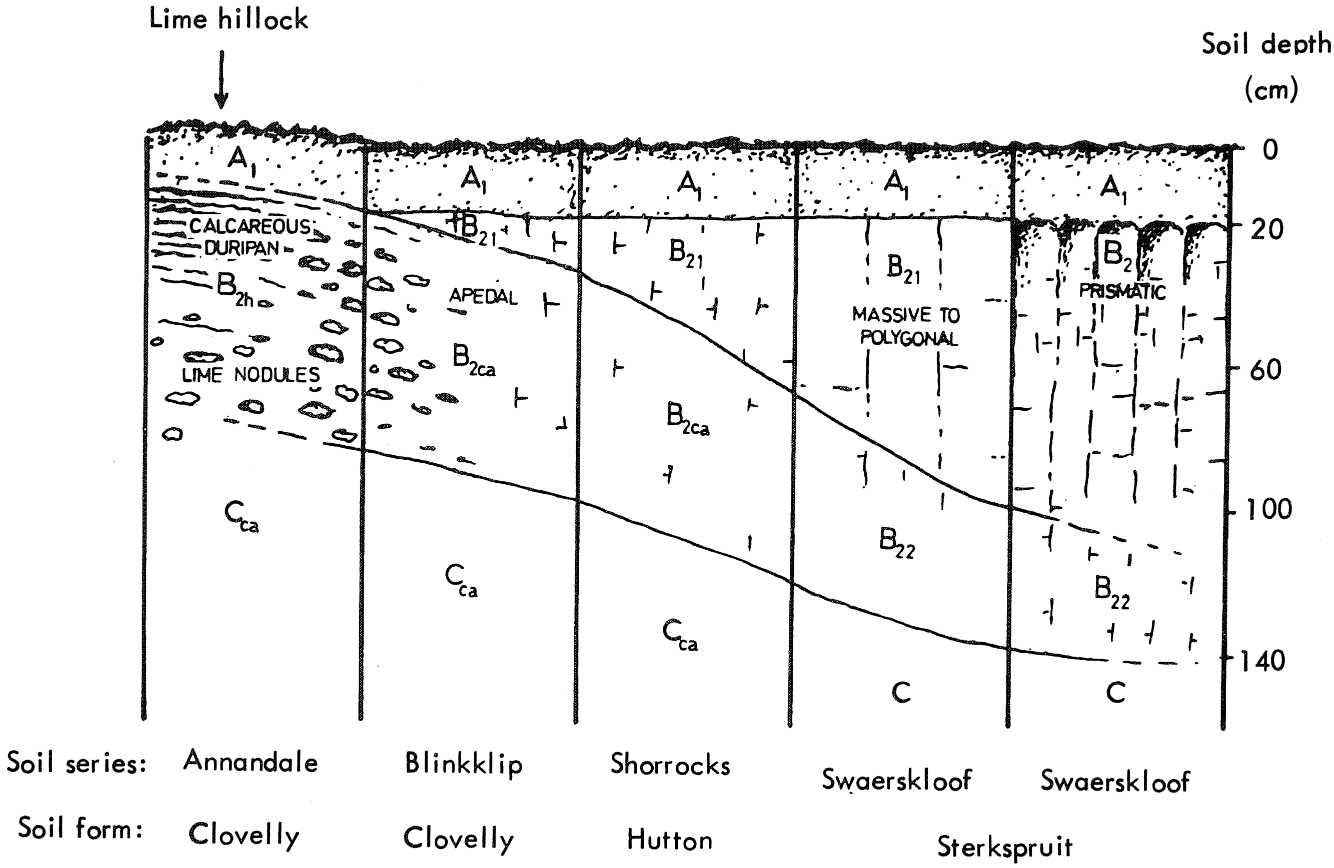


FIG. 1
Sequence of soil associations commonly occurring on higher terraces along the Breede River.

1973). According to the heat summation technique (Winkler *et al.*, 1974), the Robertson area falls in Region IV, with a heat summation of 2 170 degree-days. The region receives about 260 mm of rain annually, of which 40% occurs during the growing season, which means that 300–350 mm irrigation is required to ensure optimum production (Van Zyl & Van Huyssteen, 1980).

Experimental design: Chenin blanc vines, grafted on 101–14 Mgt., spaced 3 × 1,5 m, were used as test plants. For practical reasons the trial was divided into two experiments, viz.:

Experiment I: A randomised block design was used consisting of 4 blocks, each block split into two ploughing depth treatments (75 cm and 120 cm), and each split plot containing six organic material (OM) subtreatments. The latter were:

- I(a): No organic material
- I(b): 1 170 Bales of straw/ha (ca. 19 t straw/ha)
- I(c): 1 759 Bales of straw/ha (ca. 28 t straw/ha)
- I(d): 54 m³ Municipal compost/ha (ca. 19 t compost/ha)
- I(e): 80 m³ Municipal compost/ha (ca. 28 t compost/ha)
- I(f): 1 170 Bales of straw + 54 m³ municipal compost/ha.

Sub-treatment plot size was 279 m², each containing 21 experimental vines flanked by two border rows of vines on either side.

Experiment II: A randomized block design was used, consisting of 4 blocks, each comprising five ploughing depth/organic material (OM) combination treatments, viz:

- IIA: Shallow delve plough (22–30 cm) + no organic material
- IIB: Subsoiler (100 cm) + no organic material
- IIC: Deep delve plough (120 cm) + no organic material
- IID: Deep delve plough (120 cm) + 1 750 bales of straw/ha
- IIE: Deep delve plough (120 cm) + 80 m³ municipal compost/ha.

Plot size was 743 m², each containing 46 experimental vines flanked by two border rows of vines on all sides.

Soil preparation and cultural practices: For the delve plough treatments a drawbar type, single share plough and a 175 kW crawler tractor was used. The same tractor coupled to a drawbar type, single tine subsoiler (ripper) was used to apply the ripper treatments. Organic material was applied manually against the slanted wall of the delve furrow after each pass of the tractor. Superphosphate was applied simultaneously at a rate of 2 t/ha as a blanket treatment.

The vines were trained on a factory trellising system (Le Roux, 1968; Uys, 1976) with four permanent cordons (H-development) and, depending on vigour, pruned to approximately 20 two-bud spurs (bearers) per vine (ca. 42 000 buds/ha). The vineyard was clean cultivated until 1974, but since then chemical weed control was applied to the strip underneath the vines and the cover crop (barley), and natural grasses in the middle of the rows were controlled by a bush-cutter. Until the end of the 1973/74 season the vineyard was irrigated by means of under-vine sprinklers according to evaporative demand estimated from Class A-pan data. Subsequently, irrigation was reduced by up to 30% in order to subject the vines to moisture stress.

Measurements: Vine vigour and production were measured annually by determining shoot and crop mass. Total soluble solids (TSS) and total titratable acidity (TTA) were determined in musts using standard OVRI methods. Trunk circumferences were measured on all vines in Exp. II during 1978.

Gravimetric soil moisture measurements were made on each plot during the first two seasons after planting, and soil density measurements were made with a neutron/gamma moisture/density depth probe twelve years after planting in Exp. II in the middle of the interspace between vine rows. At the same time, penetrometer readings were taken in both Exp. I and II, using a continuous recording constant speed double cone penetrometer (Carter, 1967).

Root studies were conducted during 1979 by digging out 37,5 × 50 cm soil segments of 20 cm thickness on a grid pattern in an area of 3 × 1,5 m and to a depth of 120 cm around representative vines on treatments A, B and C of Exp. II. The soil sections thus obtained were subsequently crumbled and passed through a 6,5 mm sieve to collect the roots. The roots were separated into three classes, viz.: 2,0 mm, 2,0–7,0 mm and > 7,0 mm thickness. The roots, trunk and canes were dried, their mass determined and analysed for N, P, K, Ca, Mg and Na, using standard OVRI methods. The root distribution was plotted three-dimensionally on a mass/soil segment basis using a computerised plotter. In addition, profile pits were dug diagonally across vine rows in each of three replicates of treatments IIA, IIB, IIC and IIE. The roots thus exposed were painted white, plotted on graph paper and counted, again using the three thickness classes described previously. The soil was mapped, and representative samples were analysed chemically and mechanically according to standard OVRI methods.

RESULTS AND DISCUSSION

Shoot growth and Yield: Detailed data on the vigour and production of the vines over a period of 10 years are presented in Tables 1 and 2. The effect of organic material as well as the effect of different depths and methods of soil preparation on yield and shoot growth are shown in Fig. 2 (treatment I(f) being omitted for ease of interpretation) and Fig. 3, respectively.

No statistically significant differences associated with straw or compost in either Exp. I (Fig. 2a) or Exp. II (Fig. 2b) were found. It is clear, therefore, that OM in quantities as used in these experiments, had no beneficial effect on vine performance. This result may be due firstly to the fact that the mixing of 40 tons of compost (80 m^3) or 28 tons of straw (1 750 bales) per hectare to a depth of 120 cm, would imply an initial increase in OM content of the soil from the original ca. 1% to a maximum of only 1,12% (i.e. a 12% increase). This is low when compared to an increase of from 1% to 2,25% (over a depth of 30 cm) by the addition of 100 tons/ha OM as commonly used in nurseries. Chaler (1978) estimated that 22,5 t dry OM would be needed in order to raise the OM content of the soil from 1% to the desired 1,5% in the top 30 cm layer. This is not economically and practically feasible under Mediterranean conditions.

Secondly, the lack of vine response to the OM treatments in this experiment may be due to the slanted "sandwich" effect usually obtained with the deep placement of OM during the delve operation, resulting in thin isolated bands of OM in the soil solum as illustrated in (Fig. 4). Rojahn (1973) experienced a similar problem.

According to Fig. 3a, vine performance was not improved by delve ploughing the soil deeper than 75 cm. This was unexpected because the soil concerned is generally characterised by a hardened calcareous subsoil layer (duripan) or a very compact or structured subsoil (Fig. 1)

TABLE 1

Effect of organic material (OM) amendments and soil preparation depths and methods on the cumulative mass (tons/ha) of shoots of Chenin blanc/101–14 Mgt. in the Robertson area

Treatment	Season									
	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77	1977/78
75 cm delving depth	1,5	3,8	7,0	12,7	17,1	21,8	25,4	28,3	31,6	34,1
120 cm delving depth	1,4	4,0	7,2	12,7	17,7	22,8	26,2	29,2	32,2	34,6
Significance/(D-value)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Ia–no OM	1,3	3,9	7,0	12,6	17,2	21,8	25,1	28,1	31,2	33,7
Ib–1 170 bales/ha	1,7	4,3	7,6	13,3	18,4	23,8	27,7	30,9	34,3	36,9
Ic–1 750 bales/ha	1,4	3,7	6,8	12,3	16,9	21,8	25,2	28,1	31,1	33,5
Id–54 m^3 compost	1,2	3,5	6,5	11,7	16,2	20,9	24,4	27,4	30,5	32,9
Ie–80 m^3 compost	1,5	4,1	7,6	13,3	17,9	22,7	26,3	29,2	32,3	34,8
If–1 170 bales + 54 m^3 compost	1,5	4,0	7,3	13,1	17,8	22,7	26,1	29,0	32,0	34,3
Significance/(D-value)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
IIA–shallow ploughed	1,4	3,7	6,5	11,7	15,7	19,5	23,2	26,5	29,7	32,4
IIB–ripped	1,8	5,0	8,7	15,2	20,1	25,1	29,5	33,5	37,7	41,4
IIC–deep delved + no OM	2,6	5,8	9,7	16,3	20,7	25,4	29,4	33,5	37,4	40,3
IID–deep delved + 1 750 bales	2,3	5,5	9,7	16,3	21,1	25,7	29,9	33,8	37,6	41,4
IIE–deep delved + 80 m^3 compost	2,1	4,9	7,8	13,3	17,5	21,6	25,4	28,7	32,0	35,0
Significance/(D-value)	*(1,0)	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = Not significant; * = Significant ($P \leq 0,05$)

TABLE 2

Effect of organic material (OM) amendments and soil preparation depths and methods on the cumulative mass (tons/ha) of grapes of Chenin blanc/101–14 Mgt. in the Robertson area

Treatment	Season								
	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77	1977/78
75 cm delving depth	8,3	35,2	61,8	93,5	123,0	155,2	180,2	194,9	219,1
120 cm delving depth	7,5	33,9	61,2	94,4	123,1	153,5	176,6	192,1	214,9
Significance/(D-value)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Ia–no OM	8,4	33,7	60,3	91,7	118,7	148,4	170,6	184,9	207,9
Ib–1 170 bales/ha	7,5	33,8	60,2	92,5	121,8	156,0	192,9	197,3	222,0
Ic–1 750 bales/ha	8,0	33,7	61,2	93,5	122,9	153,2	176,4	191,1	213,9
Id–54 m³ compost/ha	6,4	30,8	55,8	87,9	117,7	148,5	171,3	187,3	211,0
Ie–80 m³ compost/ha	8,4	38,3	65,6	98,6	128,9	160,2	185,1	201,1	224,7
If–1 170 bales + 54 m³ compost/ha	8,7	36,8	65,6	99,6	128,3	160,3	184,5	199,6	222,6
Significance/(D-value)	NS	NS	NS	NS	NS	NS	NS	NS	NS
IIA–shallow ploughed	8,5	30,8	51,1	81,2	109,7	138,5	167,3	181,4	208,0
IIB–ripped	11,2	39,3	63,9	94,7	120,6	149,9	179,3	192,0	217,7
IIC–deep delved + no OM	10,6	45,9	75,4	111,6	138,0	169,4	199,3	212,2	238,1
IID–deep delved + 1 750 bales	11,8	40,0	70,3	106,3	138,2	172,0	203,7	220,9	247,5
IIE–deep delved + 80 m³ compost	11,9	40,5	68,4	99,2	127,7	156,3	184,7	199,1	223,9
Significance/(D-value)	NS	*(14,04)	**(17,3)	*(24,0)	*(23,7)[A]	*(27,9)	*(36,4)	*(38,0)	(40,6)

NS = Not significant; * = Significant (P ⩽ 0,05); ** = Highly significant (P ⩽ 0,01)

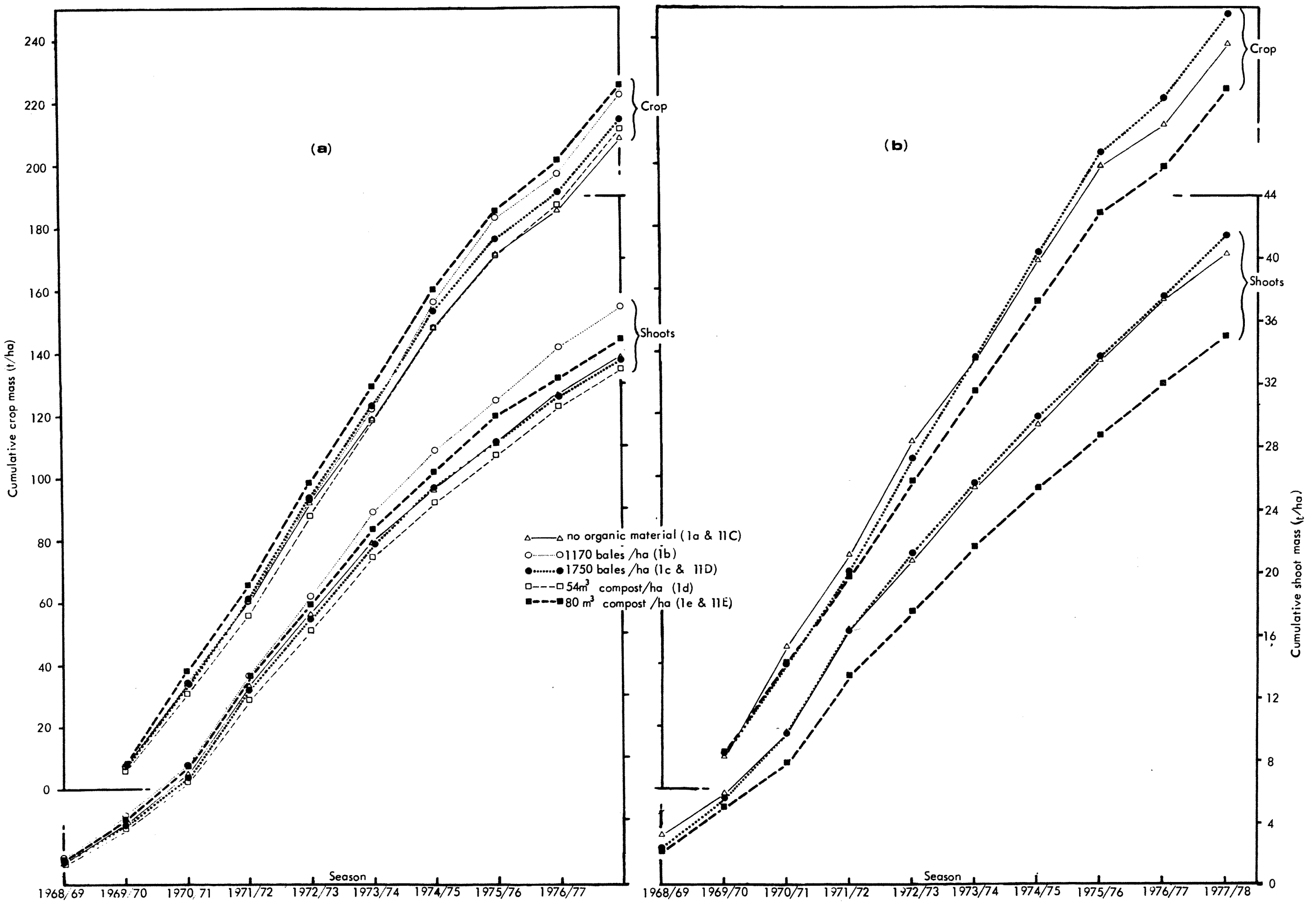


FIG. 2

The effect of organic material on the yield and shoot mass of Chenin blanc/ 101–14 Mgt., Robertson: (a) Experiment I; (b) Experiment II.

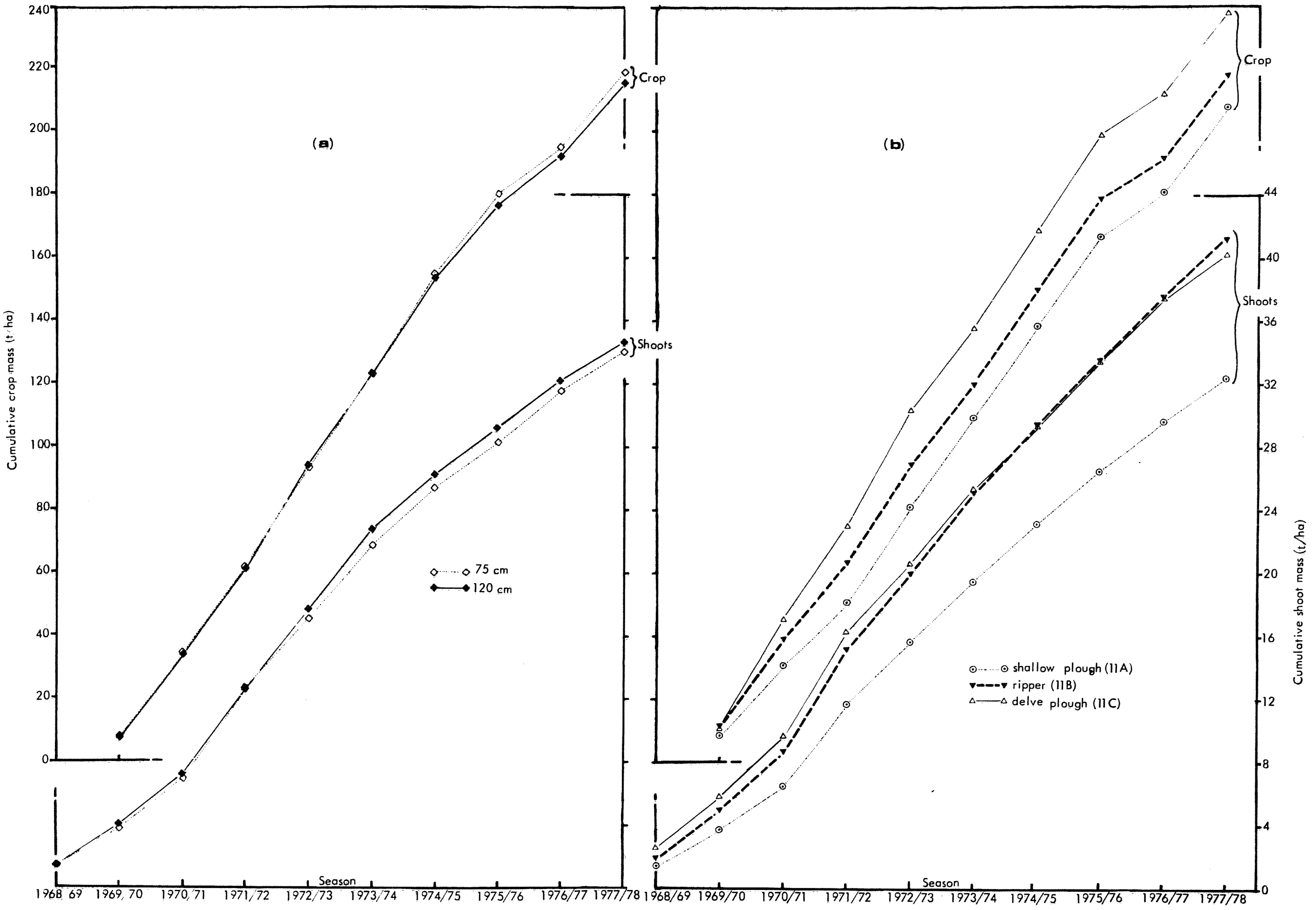


FIG. 3

Effect of (a) depth and (b) method of soil preparation on the yield and shoot mass of Chenin blanc/ 101–14 Mgt., Robertson.

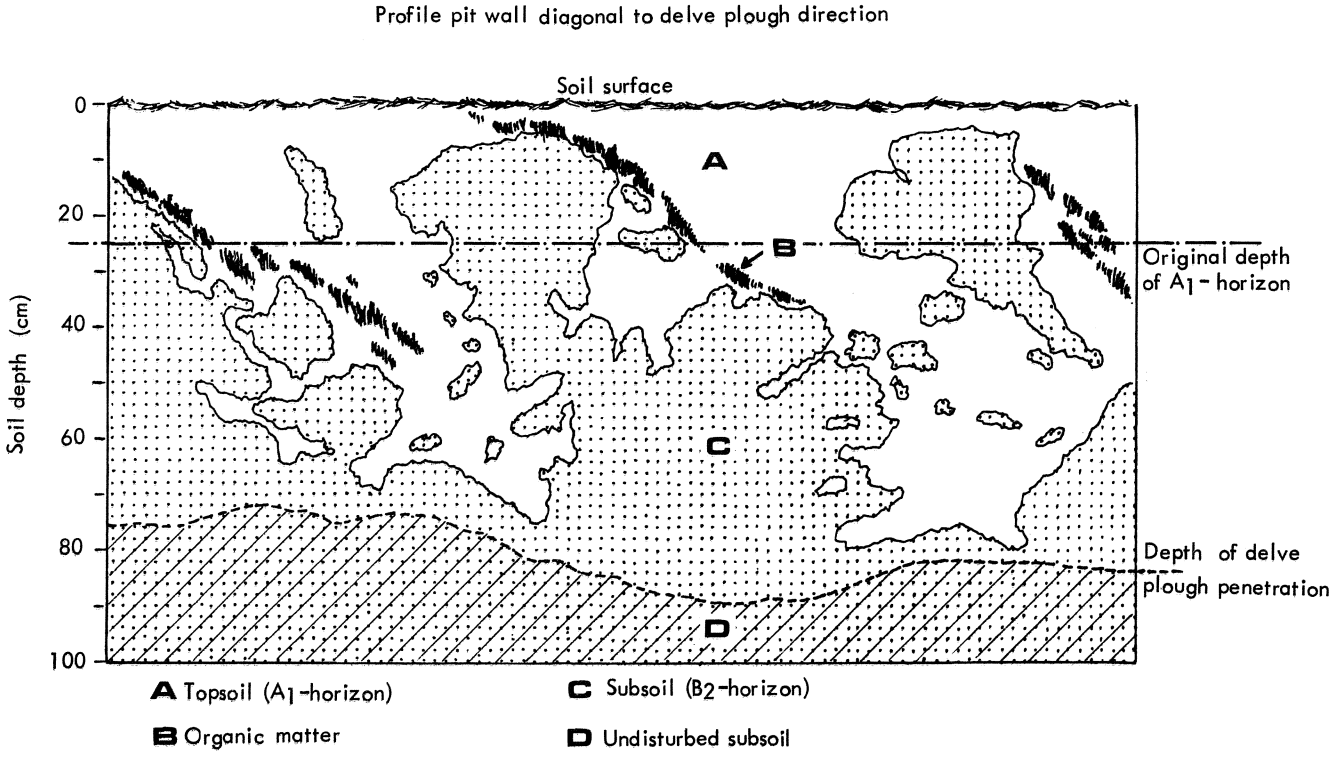


FIG. 4

General distribution pattern of topsoil, subsoil and organic material after delve ploughing.

which, judging from previous profile pit inspections, clearly impedes root growth. The lack of response to the deeper delved treatments could only be ascribed, therefore, either to an ability of the vine to thrive equally well in 75 cm deep as in 120 cm deep soil, or to a natural soil variation which made the experimental design ineffective. Shallow ploughing caused a measureable although not statistically significant decrease in shoot growth when compared to ripping or delve ploughing (Fig. 3b, Table 1). With delve preparation significantly higher yields were obtained than with shallow ploughing from the 1970/71 season until the 1974/75 season (Fig. 3b, Table 2).

The reason for this unexpected more significant effect of method of soil preparation on yield than on shoot growth, is difficult to explain but is tentatively ascribed to a higher coefficient of variation for shoot growth (24%) compared to that of yield (13,3%). Another complicating factor may have been the practice of topping the shoots to ensure proper aeration once they grew beyond the top wire of the slanted trellis roof, thereby possibly equalising differences that may have occurred.

It appears that soil preparation to a depth of 120 cm did have a considerable advantage over shallow ploughing (22–30 cm), resulting in a gain of ca. 30 tons of grapes per ha over a period of nine years. At the current official natural wine price of R171/ton of grapes and assuming that the cost of deep preparation is R700/ha, a yield increase of 5,0 tons/ha would be sufficient to cover preparation costs. Cumulative increases in yields of this magnitude were already obtained during the second year of production, i.e. three years after planting (Table 2). Yields of vines on the ripper plots were intermediate between those of delve and shallow ploughed plots, and indicate a tendency for the ripper to be inferior to delve ploughing in this type of soil.

Trunk circumference: The measurements made to determine the effect of treatments of Exp. II on trunk circumference, revealed a mean trunk circumference of 14,6 cm for vines on shallow ploughed soil, 15,3 cm for those on ripped soil and 15,8 cm for vines on delved soil. However, these differences were not statistically significant, and again there was no measureable effect of OM additions, the mean trunk circumference being 15,7 cm and 15,1 cm respectively for straw and compost.

Must composition: The total titratable acidity (TTA) and total soluble solids (TSS) of musts, are presented in Fig. 5 (data for 1976/77 for Exp. I not available). It appeared that the addition of either straw or compost during soil preparation had no consistent or significant effect on TTA or TSS (Fig. 5a & 5b). In view of the negative results already reported concerning the effect of OM on shoot growth or yield, this is not unexpected. Only during the 1974/75 season did the deeper ploughing induce a significantly higher TSS content of the must, a tendency which seemed to continue towards the end of the trial. There was evidence too of higher TTA content of musts from deep ploughed plots during the period before 1974/75 (Fig. 5c).

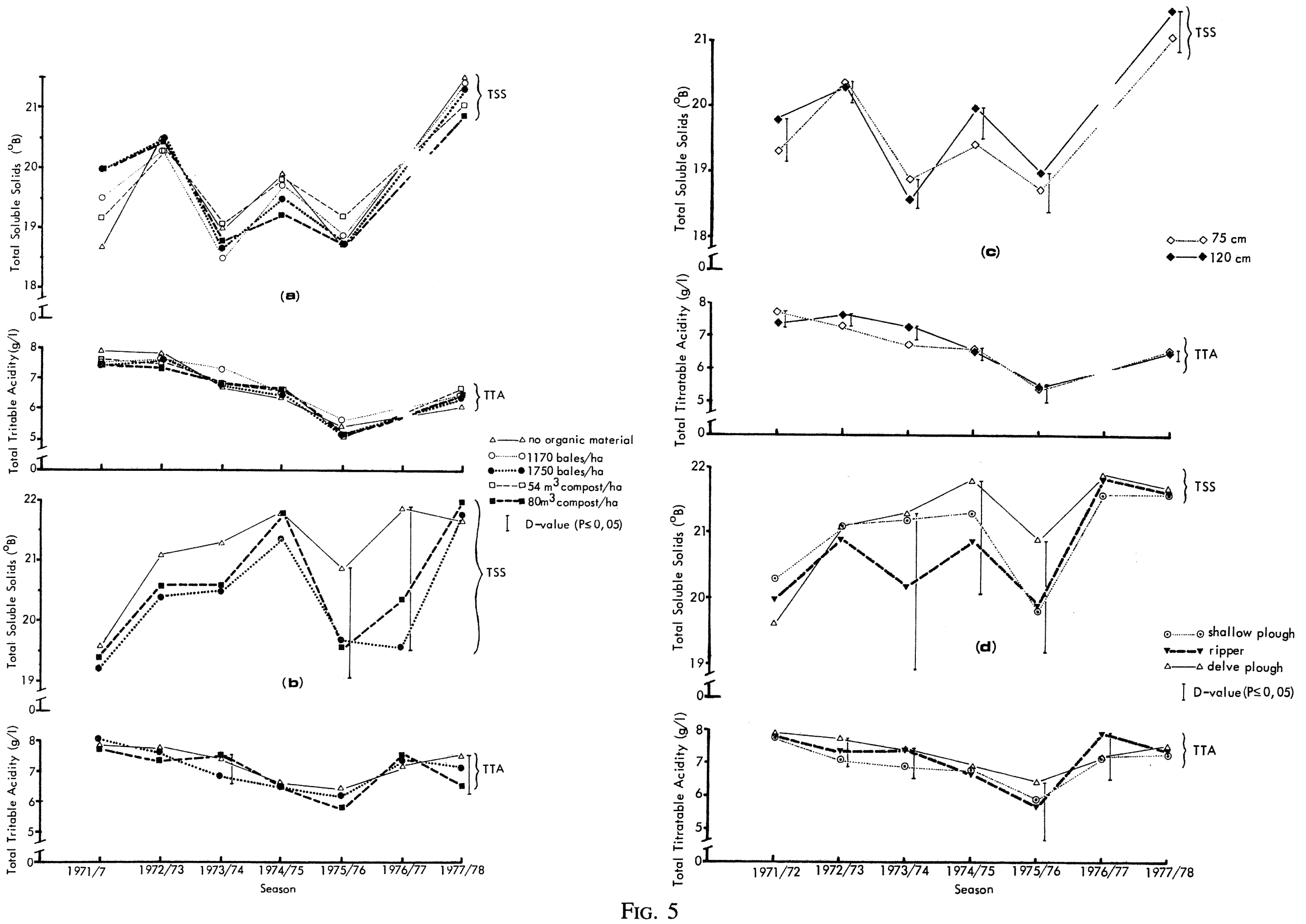


FIG. 5

Effect of organic material ((a) Experiment I, (b) Experiment II)), depth (c) and method (d) of soil preparation on the Total Soluble Solids (TSS) and Total Titratable Acids (TTA) in the must of Chenin blanc.

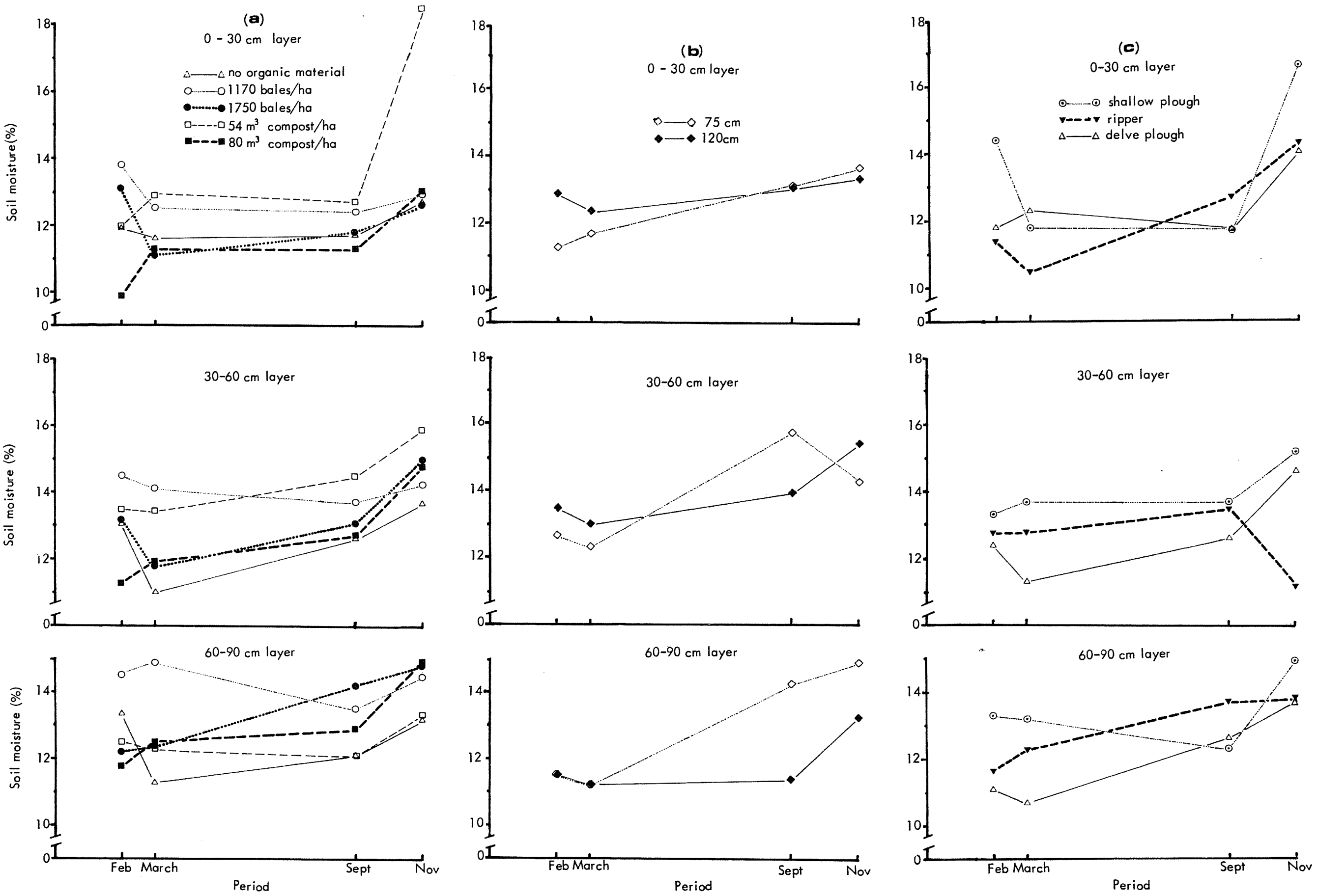


FIG. 6

Changes in soil moisture at different depths as affected by (a) organic material additions, (b) depth and (c) method of soil preparation, Robertson.

Soil moisture: The results of the gravimetric soil moisture measurements made after planting, are shown in Fig. 6. With regard to the effect of OM additions on soil moisture content (Fig. 6a) there seems to be no logical explanation for the differences found. These differences must be ascribed, therefore, to soil variation or to the questionable reproducibility of gravimetric soil moisture measurements. The same conclusions have to be arrived at as far as the effect of depth (Fig. 6b) or method (Fig. 6c) of soil preparation are concerned.

Root studies: The results of the root studies effected by digging out selected individual vines on shallow ploughed, ripped and delve ploughed plots in Exp. II, are presented in Table 3. These data indicate that root mass did not reflect the expected effect of method of preparation. The two and three dimensional distribution of total root mass as shown in Fig. 7 also shows a general deviation from that which would have been expected. The roots of the vine on ripped soil were more concentrated immediately below the vine compared to vines on shallow or delve ploughed plots. This was probably due to a ripped zone incidentally being directly underneath the vine. However, it could be calculated that respectively 80,1% and 82,5% of the total root mass was present in the 0–60 cm soil layer in the case of shallow ploughed and ripped soil, whereas the corresponding soil layer of the delved soil contained only 64,8% of total root mass. This points to a more uniform root distribution with depth in the latter case. It is evident that data from individual vines have limited value, especially in view of the unacceptable amount of labour that would be involved should a larger number of vines per treatment be studied by this method.

The results of the root studies conducted in profile pit walls placed diagonally to the vine row, are shown in Fig. 8, representing the mean of 3 replicates. Roots in the shallow ploughed soil were less than in the ripped or delve

TABLE 3

Dry mass of components of 10 year old Chenin blanc/101–14 Mgt. vines grown on differently prepared Hutton/Sterkspruit soil, Robertson

Treatment	Roots (g/vine)				Aerial Parts (g/vine)			Aerial/ Roots
	Fine	Medium	Thick	Total	Trunk + Cordons	Shoots	Total	
Shallow ploughed	1 448	1 285	1 587	4 320	2 885	1 080	3 965	0,92
Ripped	1 217	1 668	1 691	4 576	4 500	1 900	6 400	1,40
Delve ploughed	1 271	1 433	1 315	4 019	3 450	1 480	4 930	1,23
Mean	1 312	1 462	1 531	4 305	3 612	1 487	5 099	1,18

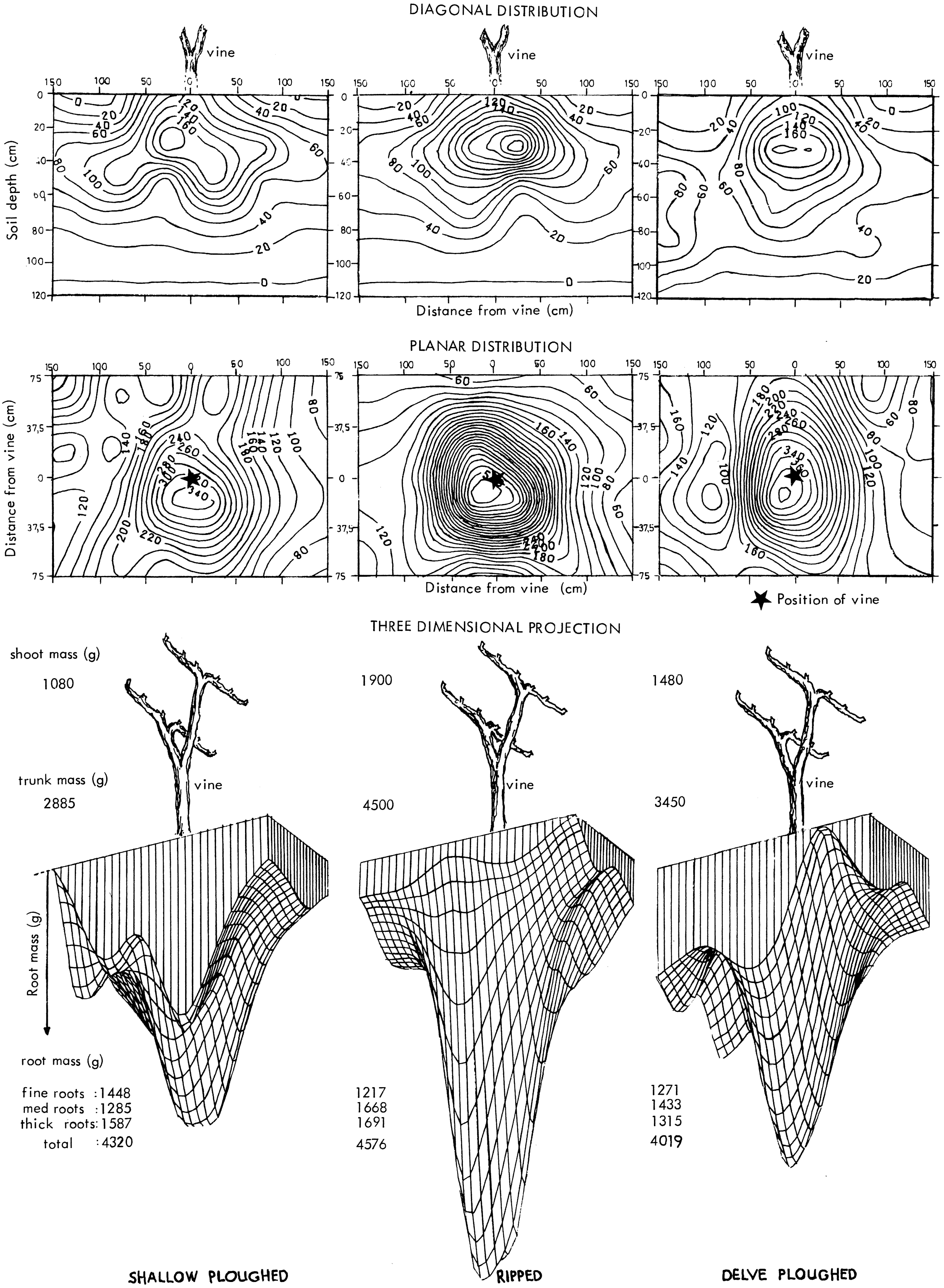


FIG. 7

Diagonal (a), planar (b) and three dimensional projections of root mass distribution in differently prepared soils, Robertson.

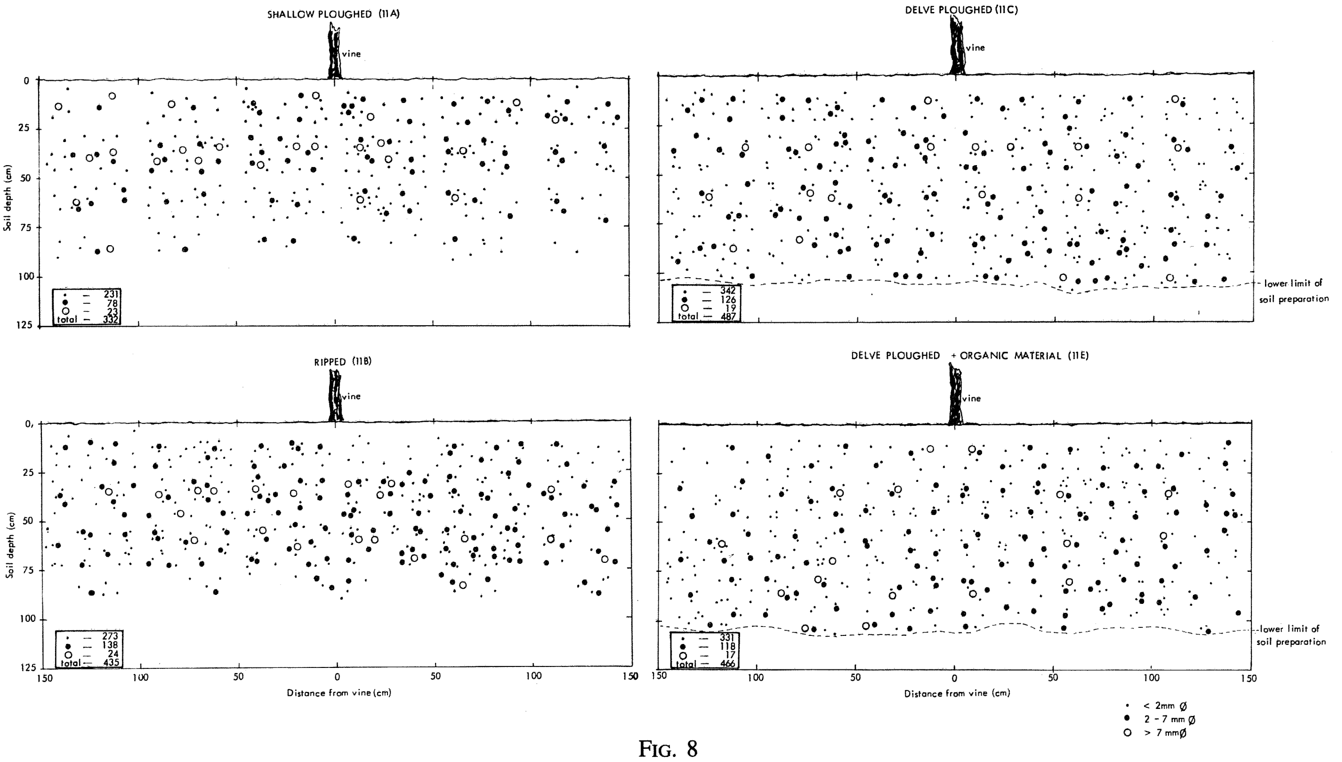


FIG. 8

Amount and distribution of roots in profile pit wall as affected by different methods of preparation of a Hutton/Sterkspruit soil, Robertson.

ploughed soil, and tended to be more concentrated in the upper layers of the soil (60–75 cm deep), with only occasional roots in the 75–90 cm zone. In the case of the ripped and delve ploughed soil, the roots were clearly mainly distributed in the loosened zones, and were abruptly restricted by the lower, still undisturbed duripan. The general rooting depth of the ripped plots was between 75 cm and 90 cm, whereas that of the delve ploughed soil was in the vicinity of 100 cm. More fine roots were present in the delve ploughed soil than in the ripped, and especially in the shallow ploughed soil. The addition of OM (80 m^3 compost/ha) had no visible effect on root distribution.

Again it is clear that no pronounced differences existed between shallow ploughed, ripped and delve ploughed plots as far as rooting depth was concerned, thus partly explaining the general lack of significant differences in vine performance. Apparently the soil was of such a nature that a general rooting depth of approximately 60 cm could easily be achieved by the vines, even in shallow ploughed (22–30 cm) soil. At deeper levels, the mechanical resistance of the shallow ploughed soil became prohibitive to root growth. In the case of the ripper and delve plough treatments, the soil was not loosened to a depth of more than 100 cm, and sometimes even lesser depths were attained despite deeper settings of the plough. Therefore, because of the general characteristics and variability of the soil, as well as the occasional deep penetration of roots in the case of shallow ploughed soil, and the inefficiency of the deep preparation processes, especially on very compact zones (Sterkspruit soil), the vines on the shallow ploughed soil had virtually the same moisture reserves as those on the deeper ploughed soil.

Nutrition and Soil Properties: Because of the inherent fertility of the soil, the slight restriction of the zone of maximum root concentration in the case of the shallow ploughed plots (Fig. 8), apparently did not affect nutrition. According to Table 4, the upper layers of the soils in the trial were satisfactorily to well supplied with P and very well supplied with K.

Inspection of the profile pits where the three vines were uprooted, revealed that the ripped plot vine had grown on a Hutton (Shorrocks series) soil, whereas the vines from the shallow ploughed and delved plots had grown on Sterkspruit (Swaerskloof series) soil, and that the shallow ploughed plot vine had derived additional benefit from an unusually deep surface soil layer. There was therefore no obvious relationship between the chemical properties of the soil (Table 4) and the mineral content of the vines (Table 5). However, the pronounced effect of these soil types on vine performance has already been demonstrated (Saayman, 1973). The differences in mineral content of the vines studied must, therefore, be ascribed mainly to differences in the physical properties of the soil (Table 4) which dominate growth and nutrition.

Soil density and depth: The complications experienced with soil variation as well as preliminary results which indicated that the efficiency of differential soil preparation is questionable, necessitated further investigations. In this respect the results of soil density measurements made with a neutron/gamma probe on treatments A, B and C of Exp. II, are shown in Fig. 9. At the 30–60 cm level, ripping and delve ploughing caused a significant reduction in soil compaction. In absolute terms these differences were not very large (max. 160 kg/m^3) but in the high soil density

TABLE 4
Chemical and mechanical properties of Hutton and Sterkspruit soils, Robertson

Soil	Horizon	Depth (cm)	pH (KCl)	R (ohms)	P* (ppm)	K* (ppm)	Total exchangeable cations (me%)				CEC (me%)	Mechanical composition (%)				
							Ca	Mg	K	Na		Coarse sand	Medium sand	Fine sand	Silt	Clay
Hutton	A	0–30	7,18	859	122	202	8,35	2,03	0,65	0,33	4,43	5,0	13,0	67,1	4,8	9,4
	B_{21}	30–78	7,52	764	45	171	26,80**	8,41	0,61	0,34	6,48	2,3	8,8	62,8	12,0	11,9***
	B_{22}–C	78–120	7,57	612	13	116	31,10**	8,30	0,59	0,51	9,87	15,3	17,5	58,8	7,0	1,7***
Sterkspruit	A	0–35	6,58	1 048	62	196	3,80	1,81	0,56	0,19	4,25	2,3	7,4	72,0	5,5	10,6
	B_2	35–110	6,35	558	2	125	7,65	4,13	0,58	0,43	9,16	2,5	6,9	46,9	10,0	31,3

*Bray No. 2 extraction
**Free lime present
***Low clay values probably due to lime, silica and Fe sementation (duripan)

TABLE 5

Mineral content of dormant Chenin blanc/104–14 Mgt. vines as affected by method of soil preparation

Plant organ	Mode	N A[+]	N B	N C	P A	P B	P C	K A	K B	K C	Na A	Na B	Na C	Ca A	Ca B	Ca C	Mg A	Mg B	Mg C
Shoots	%	0,76	0,68	0,68	0,100	0,110	0,097	0,48	0,50	0,47	0,024	0,025	0,020	0,39	0,46	0,44	0,15	0,18	0,20
	g/vine	8,21	12,92	10,06	1,09	2,09	1,44	5,18	9,50	6,96	0,26	0,48	0,30	4,21	8,74	6,51	1,62	3,42	2,96
Trunk & Cordons	%	0,38	0,36	0,32	0,065	0,062	0,052	0,43	0,47	0,31	0,037	0,018	0,028	0,65	0,65	0,61	0,13	0,12	0,14
	g/vine	10,96	16,20	11,04	1,88	2,79	1,79	12,41	21,15	10,70	1,06	0,81	0,97	18,75	29,25	21,04	3,75	5,40	5,17
Fine Roots	%	1,09	1,17	1,14	0,21	0,22	0,12	0,44	0,52	0,45	0,20	0,18	0,20	1,42	1,84	1,32	0,23	0,32	0,25
	g/vine	15,78	14,24	14,50	3,04	2,68	1,53	6,37	6,33	5,72	2,90	2,19	2,54	20,56	22,39	16,78	3,33	3,89	3,18
Medium Roots	%	1,29	1,22	1,19	0,20	0,25	0,14	0,31	0,38	0,32	0,10	0,11	0,10	1,15	1,37	1,03	0,16	0,20	0,28
	g/vine	16,58	20,35	17,05	2,57	4,17	2,01	3,98	6,34	4,59	1,29	1,83	1,43	14,78	22,85	14,76	2,06	3,34	2,58
Coarse Roots	%	1,14	1,02	0,90	0,24	0,28	0,16	0,29	0,38	0,29	0,05	0,04	0,06	0,98	1,03	0,78	0,14	0,14	0,14
	g/vine	18,09	17,25	11,83	3,81	4,73	2,10	4,60	6,43	3,81	0,79	0,68	0,79	15,55	17,42	10,26	2,22	2,37	1,84
Mean Total	%	0,84	0,74	0,72	0,15	0,15	0,10	0,39	0,45	0,36	0,08	0,05	0,07	0,18	0,92	0,15	0,03	0,03	0,03
	g/vine	69,62	80,96	64,48	12,35	16,45	8,85	32,54	49,75	31,78	6,30	5,95	6,00	73,85	100,65	69,35	12,98	18,42	15,73
D-value (P ≤ 0,05) Mean	%	NS			0,052*			0,058*			NS			0,21*			NS		
Total	g/vines	NS			5,25			NS			NS			21,25**			4,10*		

[+]A = Shallow ploughed; B = Ripped; D = Delve ploughed
*Significant (P ≤ 0,05); **Highly significant (P ≤ 0,01); NS = Not significant

range of these soils, this may have had a positive effect on root growth. Unfortunately, the density measurements could not be done deep enough to give a clear picture for layers deeper than 75 cm.

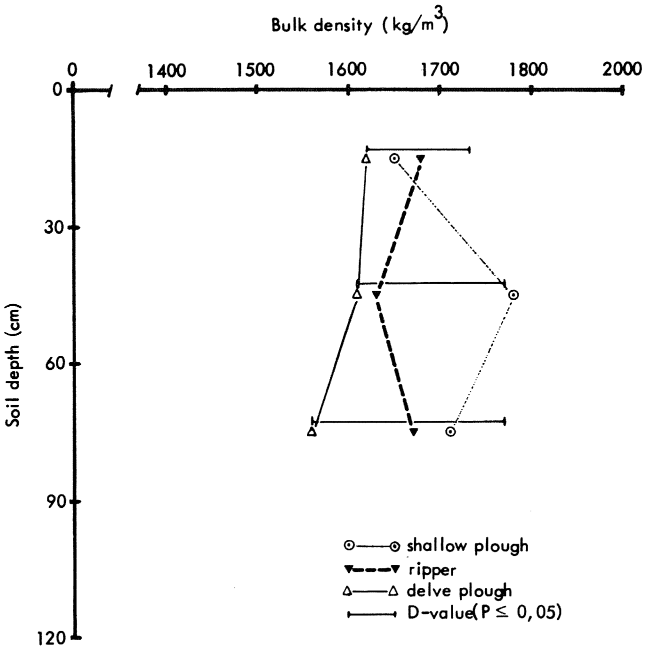


FIG. 9
Soil density of a Hutton/Sterkspruit soil as affected by different methods of soil preparation.

The results obtained in Exp. I with the continuous recording penetrometer, are shown in Table 6. The depth at which the penetrometer reading passed 70 kPa $\times$ 10^2 was taken as the lower limit of loosened soil, although the resistance value which would inhibit root growth is probably much lower. These results clearly show that there were no significant differences between the two depths of delve ploughing as far as the actual depth of loosened soil was concerned. Judging by the usual calcareous hardpan properties of the subsoil and profile inspections, it is also unlikely that the soil had returned to its original state after preparation. Therefore, it must be assumed that the delve plough was unable to penetrate properly when a ploughing depth of 120 cm was desired. This adequately explains the lack of differences noted between the performance of vines on 75 cm and 120 cm deep prepared plots (Fig. 3a).

Similar penetrometer measurements were subsequently carried out on Exp. II, the results of which are shown in Fig. 10. It is again clear that the desired depth of soil loosening was not obtained with either the ripper or the delve plough and between the latter two treatments there was only a mean difference in depth of soil preparation of ca. 10 cm. Between the delve and shallow plough treatments the difference in depth of soil preparation shows a positive relationship with the tendencies noted in vine performance as shown in Fig. 3b.

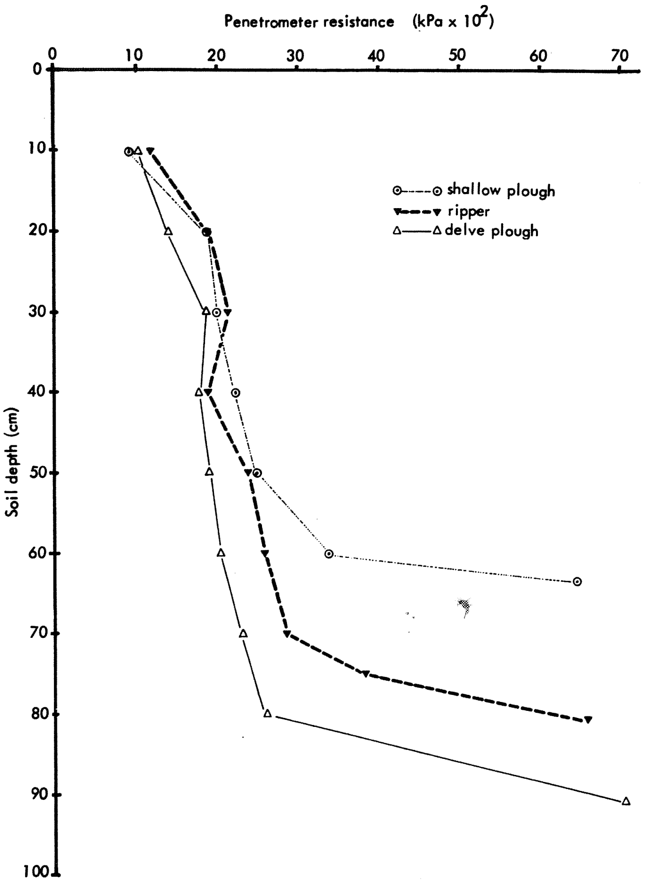


FIG. 10
Effect of method of soil preparation on the mechanical resistance of a Hutton/Sterkspruit soil to a continuous reading penetrometer.

In a subsequent study aimed at evaluating the effect of soil depth on vine performance, linear regressions of soil depth on yield, as well as on shoot growth, were made on data from both Exp. I and II. The results as shown in Fig. 11 give a clear indication that effective soil depth, as determined by means of a penetrometer, was directly related to vine performance.

TABLE 6
Mean depth* of a Hutton/Sterkspruit soil, Robertson, as affected by depth of delve ploughing

Treatment	Depth at which penetrometer reading exceeded 70 kPa $\times$ 10^2 (cm)					
	Repetition					
	I	II	III	IV	Mean	LSD
75 cm Ploughing depth	75,8	78,6	73,9	80,9	76,9	NS
120 cm Ploughing depth	84,9	68,8	77,7	89,0	81,5	

*Each value is mean of 9 determinations per plot

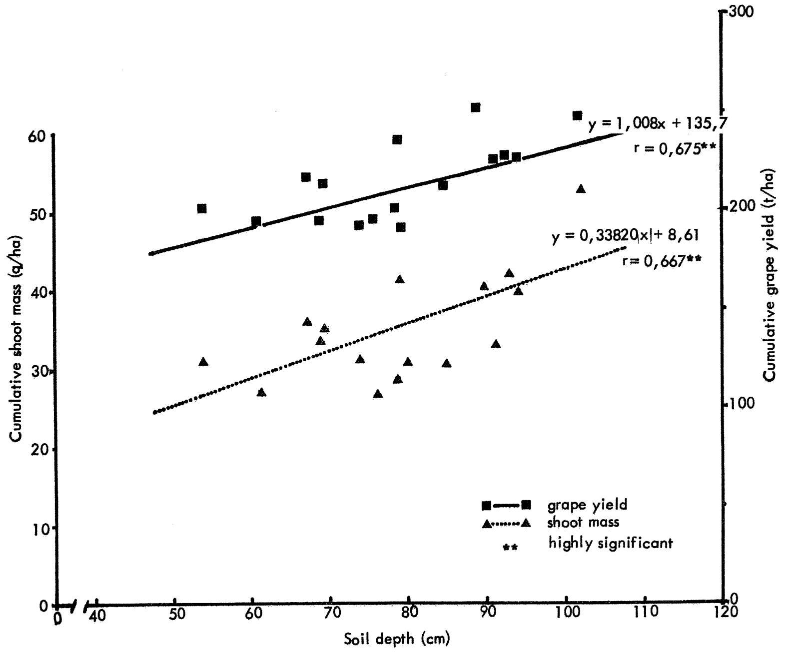


FIG. 11
Relationship between soil depth and vine performance: Hutton/Sterkspruit, Robertson.

CONCLUSIONS

One of the outstanding characteristics of this investigation was the general lack of significant response of vines to OM addition, depth of delving and method of soil preparation treatments. However, this could be traced to soil variation and the disappointingly small differences in the actual depth of soil preparation eventually achieved. Once this was verified and taken into consideration, the main effects of the treatments could be explained.

The addition of straw or compost during the soil preparation process, a costly operation, clearly did not improve vine performance. This popular practice should, therefore, be discouraged, at least on these Hutton/Sterkspruit types of soil which commonly occur in the Breede River Valley. It also appears that soil depth does have an effect on vine performance. Unfortunately, the range of soil depths that could be evaluated eventually, was limited. No clear indication was found as to the minimum depth of soil preparation. However, judging from the results obtained in Exp. II, it appears that a soil depth of less than 60 cm definitely tends to have a negative effect on vine performance. It can be recommended, therefore, that under conditions similar to those of this experiment, soil preparation should attain a depth of at least 70–80 cm. It would also appear that the cost involved could be recovered within three years after planting, and that the delve plough is technically and economically more efficient than the ripper. Owing to the shatter characteristics of such soils, the latter implement seems to be quite effective in calcareous hardpan soils (Hutton). Its performance in the massive or strongly structured subsoil of the closely associated Sterkspruit soils is less convincing. This implement can be recommended for shallow soils on shale, partly weathered bedrock or extremely hard duripans, whereas the Sterkspruit type of soils call for a more thorough breaking and mixing, such as can be achieved with a delve plough.

As regards soil density measurements, the neutron/gamma probe yielded good results. However, the continuous recording penetrometer proved to be an invaluable tool in pinpointing restricting layers and in giving a clear qualitative as well as a quantitative measure of subsoil conditions. Although a reading of 70 kPa $\times$ 10^2 was used for identifying the lower limit of loosened soil, the resistance value which would inhibit root growth is probably much lower. Further research into this aspect is clearly indicated in order to refine techniques and to establish practical norms for determining the necessity as well as the efficiency of soil preparation.

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