The Effect of Cover Crop Management on Soil Conditions and Weed Control in a Colombar Vineyard in Oudtshoorn[1]

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Wimmera and vetch were used as vineyard cover crops in the hot and dry Klein Karoo region. The effect of different masses of dry cover crop residues used as mulches, as well as that of a growing crop, on soil moisture conservation was compared with the effect of a "bare soil" treatment.

Data obtained confirmed the common notion that in vineyards under dry-warm conditions any growing plants other than vines removed water from the soil which should have been available to the vines. Accumulative water consumption over the whole season on the mulched plots was 50 mm less than the total of 530 mm on plots with a growing cover crop. The mulch played an important role in moisture conservation, especially in the early and critical growth phase of the vines. The higher moisture content on the mulched plots was determined not only in the top layers, but also down to a depth of 120 cm.

Under these climatic conditions a crop factor of 0,50 for vineyards with growing cover crops is suggested. The implications of growing a cover crop in dry areas for organic matter production, weed control and moisture conservation are discussed.

It was concluded that biological weed control by means of mulches, produced by growing cover crops in the vineyard, can replace pre-emergence herbicides.

Increasing concern about the compaction of South African vineyard soils as well as economical considerations brought about a change towards production methods requiring less soil tillage and maintaining plant residues on the soil surface. The use of herbicides, instead of mechanical cultivation, has permitted the use of no-till practices in vineyards. Soils under minimum tillage systems are generally wetter, cooler and have more favourable physical conditions (Van Huyssteen & Weber, 1980a & b).

In spite of the world-wide concern that repeated use of soil residual herbicides could affect the vines and soil micro-organisms adversely, the judicial use of herbicides has generally not resulted in any disadvantage to the biological activity of the soil or vine performance (Clay & Davison, 1976; Van Huyssteen & Weber, 1980 a & c; Schruft, 1982). There are still many cases for which residual herbicides such as simazine, cannot be recommended, viz. high pH soils, light textured soils and in young vineyards. Furthermore, in a review of herbicide usage in vineyards throughout the world, Daris (1982) concluded that chemical control is increasing, but that biological control of weeds would be desirable.

Trials have shown that the cultivation of vineyards with grass cover (temporary or permanent) is a very effective method of soil structure maintenance (Meyer & Cuinier, 1977; Van Huyssteen & Weber, 1980a; Saayman & Van Huyssteen, 1983). In regions with high rainfall and in sloping vineyards, permanent grass cover can be maintained. However, in regions with insufficient rainfall and on poor soils only a temporary cover crop can be recommended (Meyer & Cuinier, 1977) in order to minimize the possibility of competition. Steinberg (1981) found that a permanent cover crop proved harmful with annual precipitations below 400 mm. He also considered organic mulches superior to growing cover crops on steep slopes.

As reviewed by Jacks, Brind & Smith (1955), mulches are useful in moisture conservation and a light mulch (2t acre^{-1}) is almost as effective as a thick one (16t acre^{-1}). However, according to Gardner (1959) attempts to limit evaporation by a surface mulch may have little long term benefit. Cahoon, Stolzy & Morton (1961) stated that the moisture conservation effect of mulching materials, or any other treatment, were limited only to the 0-15 cm soil layer and that rewetting of non-mulched plots was deeper than under mulched plots. Contrary to this Walter (1974) found measurable increases in soil moisture with application of different mulches, but concluded that it was uneconomical. Van Huyssteen and Weber (1980b) found that on drylands water was conserved not only under a real mulch, but also under a weedfree, dried soil surface acting as a mulch. Stevenson (1975) found that clean cultivated plots contained on average 11 per cent more moisture before the next irrigation than plots under cover crop plants.

Very little is reported on mulches formed from cover crops grown in the vineyard and their effects on soil moisture conservation and biological weed control. Furthermore, results obtained under cool European conditions are not necessarily applicable to the hot and dry climatic conditions in South Africa.

The primary purpose of this investigation was to appraise the soil moisture conservation potential of different management techniques of cover crops and their ability to control weeds during the growing season of a vineyard under irrigation.

MATERIALS AND METHODS

Different methods of plant residue management were investigated in an existing cultivation-irrigation experiment on an experimental farm near Oudtshoorn in the Klein

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Karoo. The vineyard used for this investigation had been under minimum cultivation for the past six years; one half with Wimmera ryegrass *(Lolium multiflorum)*, and the other half with vetch *(Vicia sativa)* as cover crops. The cover crops were sown in March, sprayed with herbicide in August before bud burst of the vineyard, and left as a mulch during the growing season.

Four treatments for both ryegrass and vetch as cover crops were included.

T 1 — Bare soil surface, non-cultivated. The above-ground plant material was cut and removed from the plots to give an undisturbed bare soil surface.

T 2 — Growing cover crop. The cover crop was left to complete its growth cycle and to ripen naturally.

T 3 — Single layer of residue. Cover crops on these plots were sprayed with herbicide (glyphosate) before bud burst and left as a mulch on the soil surface.

T 4 — Double layer of residue. Cover crops on these plots were also sprayed with glyphosate, but the plant material removed from the T 1 plots was added to these plots to form a mulch of approximately double the thickness of that of the T 3 plots.

Treatments were replicated six times in a randomized block design for each of the cover crops, and measurements made during the 1981/82 season. Plot sizes were 3 m x 3 m, with at least 3 m buffer distances between adjacent plots. All these plots were fitted in between the vine rows, which were 3 m apart.

The soil was a 150 cm deep alluvium, classified as an Oakleaf-Vaalrivier series according to the South African soil classification system described by Mac Vicar *et al.* (1977), with a fine sandy loam texture throughout the profile. The organic carbon content was 0,96%, the pH (1 M KCl) 7,1 and the soil was well supplied with P and K. Representative soil samples were analysed chemically and mechanically according to standard V O R I methods. Gravimetric soil moisture samples were taken at weekly intervals on all treatments, from 8/9/81 to 10/2/82 for the following depths: 0-15, 15-30, 30-60, 60-90 and 90-120 cm. This sampling was done on three replicate plots, but immediately before and three days (field capacity assumed) after irrigations five replicates were sampled. Infiltration rate was measured by means of both the dam and double ring infiltrometer method immediately before irrigation on 12/11/81 and again on 12/2/82. Soil temperatures were measured at the 5,0, 22,5 and 45,0 cm depths on all four treatments of one replication of the ryegrass block. At the end of the experiment penetrometer readings were also taken to determine soil strength.

The vineyard was flood-irrigated when an estimated 50% of the total available moisture of the soil was depleted, as determined from Class A-pan evaporation data using provisional crop factors for vineyards in this area (Van Zyl, 1981).

The mass of above-ground dry plant matter was determined on the T 1 plots at commencement of the experiment, but on the T 2, T 3 and T 4 treatment plots not until the end of October. Postponement of mass determination for the latter three treatments was necessary since cover crops on the T 2 plots were allowed to complete their growth cycles and the herbicide had to be allowed sufficient time to have its effect on the T 3 and T 4 plots. At the termination of the experiment the dry residue mass was again determined. Samples of the two cover crops were analysed chemically.

The number of genera and dry mass of weeds were determined on all plots in January, before termination of the experiment.

RESULTS AND DISCUSSION

Penetrometer measurements, chemical soil analyses, organic carbon determinations and aggregate stability showed no differences between any of the treatments. This should be ascribed to the fact that this soil had been under minimum cultivation for the past six years and that a stable condition had already been reached.

Mulch characteristics: Due to natural variation in denseness and height of the cover crops a range of mulch masses was obtained — for the ryegrass ranging from 3,3t ha^{-1} on some of the T 3 plots to 14,1t ha^{-1} on the best of the T 4 plots, and the vetch between 2,7 and 8,4t ha^{-1}, respectively. The dry matter production of the cover crops is given in Table 1.

TABLE 1

Dry matter production of two cover crops measured on different dates — Oudtshoorn

Cover crop	Dry material production (t ha^{-1})		Significance
	26/8/81	11/11/81	
Wimmera	5,18	10,08	**
Vetch	8,47	9,50	N.S.
Significance	*	N.S.	

*, ** Statistical significant differences at 5% (*) and 1% (**) levels.

N.S. Not significant.

The Wimmera almost doubled its dry matter production, viz. by 94,5% when allowed to ripen, compared to its mass at the end of August. During the same period, the vetch showed an increase of only 12,5% in dry matter production. However, vetch produced significantly more (63,5%) dry matter than Wimmera in the pre-bud burst period (due to a shorter natural growth cycle), although the final plant material production was almost identical.

The mulches differed in their rate of decomposition (Table 2). There was a definite tendency for the thicker

TABLE 2

Decomposition of Wimmera and vetch residues over a three months periods — Oudtshoorn

Treatment	Residue dry mass (t ha^{-1}) at:		% Decomposition
	11/11/81	10/2/82	
Wimmera: T3	5,17	4,14	19,82
T4	8,43	6,36	24,53
Vetch: T3	3,10	2,44	21,31
T4	6,86	4,12	39,96

T3 — Single layer of residue

T4 — Double layer of residue

mulches to show more rapid decay than for the thinner mulches. Apparently, this is due to the fact that the thicker mulches stayed wet for longer periods, especially the plant material in direct contact with the soil. From the figures in Table 2, supported by visual observations, it was clear that the decay was more rapid for vetch than for Wimmera, especially in the case of T 4. This can be explained by the fact that vetch not only lost its leaves earlier, but that it is more susceptible to microbiological breakdown due to its narrower C/N-ratio than Wimmera (Alexander, 1961).

Typical of leguminous plants, the vetch had double the amount of N and Ca available for recycling as plant food (Table 3). With an average dry matter production, e.g. 6,0t ha^{-1}, 123 and 352 kg N ha^{-1} could become available from the above-ground residues of Wimmera and vetch, respectively. The significance of this lies in the fact that a grass cover crop withdraws all this N from the soil, and may, through competition, cause a deficiency in the vines (Van Huyssteen & Weber, 1980c; Saayman & Van Huyssteen, 1983), while part of the N in legumes (60 - 80 kg N ha^{-1} according to Götz 1979), and as much as 120 to 150 kg N ha^{-1} for certain medics (Clarke, 1980), is produced by N-fixing bacteria.

TABLE 3

Chemical analysis of Wimmera and vetch residues — Oudtshoorn

Cover crop	% of Element					
	N	P	K	Na	Ca	Mg
Wimmera	2,05	0,057	1,55	0,33	0,38	0,17
Vetch	5,86	0,070	1,75	0,33	0,70	0,21

Weeds: The T 2, T 3 and T 4 treatments of Wimmera, as well as the T 2 of vetch, resulted in relatively weed-free plots until termination of the experiment (Table 4). On the T 2 plots of both cover crops the growing plants suppressed germination of summer weeds and after these cover crops died they formed very effective mulches for biological weed control. A double layer of residue (T 4) was needed in the case of vetch to keep the number of weeds down, whereas for Wimmera a mulch of 5,2t ha^{-1}(T 3) was as effective as one of 8,4t ha^{-1} (T 4). A vetch mulch of 3,1t ha^{-1} was clearly ineffective for controlling weeds. In the case of Wimmera only the bare soil (T 1) had significantly more weeds than the other treatments. All the vetch treatments differed significantly in this respect, and the Wimmera plots yielded significantly smaller numbers of weeds than the vetch for all treatments. Weed growth on the T 1 plots was vigorous, the main genera were: *Amaranthus, Chenopodium, Bromus, Portulaca, Euphorbia, Polygonum* and *Emex*. No statistical differences between treatments could be shown when the dry masses of weeds were compared.

The relationship between dry mass residue and weed growth is illustrated in Figure 1. There was a general tendency for weed numbers to decrease rapidly with increasing dry mass residue. Although a critical dry mass could not be established in this study, it seemed as if a mulch of 5t ha^{-1} for Wimmera and 8t ha^{-1} for vetch could be sufficient for biological weed control. The higher number of weeds on the vetch plots should be ascribed to the higher N content on these plots due to N-fixation.

TABLE 4

The effect of different residue management techniques on weed growth — Oudtshoorn

Cover crop	Treatment	Weeds	
		Number m^{-2}+	Dry mass ($g\ m^{-2}$)
Wimmera	T1	$43,9^{a}$	17,03
	T2	$5,2^{b}$	3,37
	T3	$10,7^{b}$	8,85
	T4	$9,6^{b}$	12,41
	$\overline{X}$	17,4	10,42
Significance		*	N.S.
Vetch	T1	$183,2^{c}$	55,66
	T2	$11,4^{b}$	11,25
	T3	$63,4^{d}$	26,02
	T4	$24,8^{e}$	25,45
	$\overline{X}$	70,7	29,60
Significance		*	N.S.
Wimmera versus vetch (all treatments)		**	*

\+ Figures followed by the same letter do not differ significantly
*, ** Statistical significant differences at 5% (*) and 1% (**) levels
N.S. Not significant
T1 — Bare soil
T2 — Growing cover crop
T3 — Single layer mulch
T4 — Double layer mulch

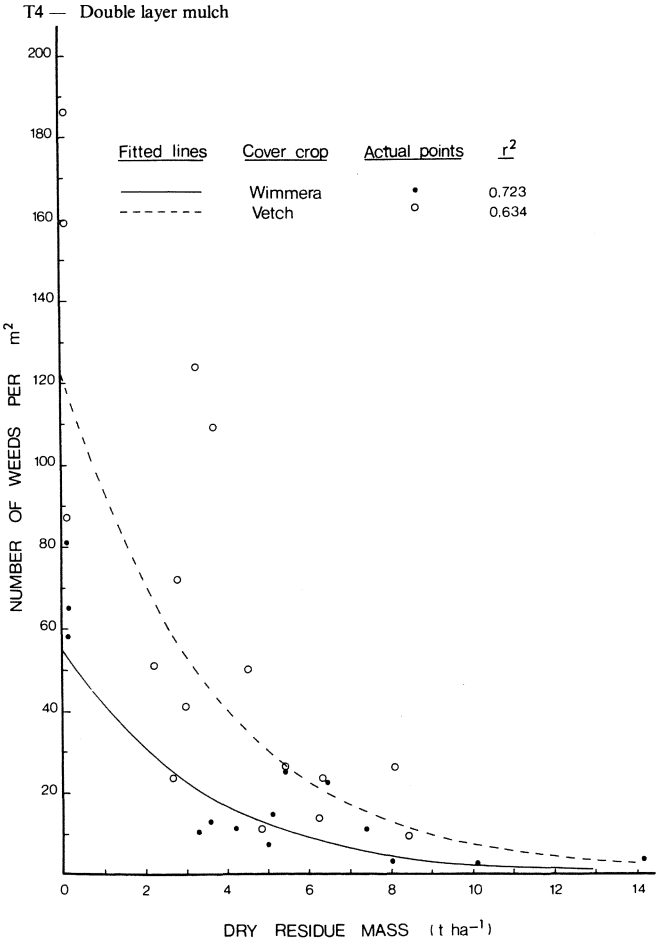


FIGURE 1
Relationship between dry plant residue mass and weed numbers (Residue mass was determined when germination of weeds started).

Soil moisture: Soil moisture depletion among the treatments differed greatly (Fig. 2; Table 5) from the start of the experiment — which is also the start of the growing season for vines — until the first irrigation at flowering. According to Van Zyl & Weber (1981) vines are very sensitive to soil moisture stress during this critical growth phase. Compared to the other treatments, the actively growing crops on T 2 depleted soil moisture at a very fast rate. However, after the cover crops on the T 2 plots had completed their growth cycle they acted as very effective mulches, especially in the case of Wimmera (Fig. 2(a)). When compared to bare soil (T 1) the mulches (T 3 & T 4) saved water before flowering (November) of the vines.

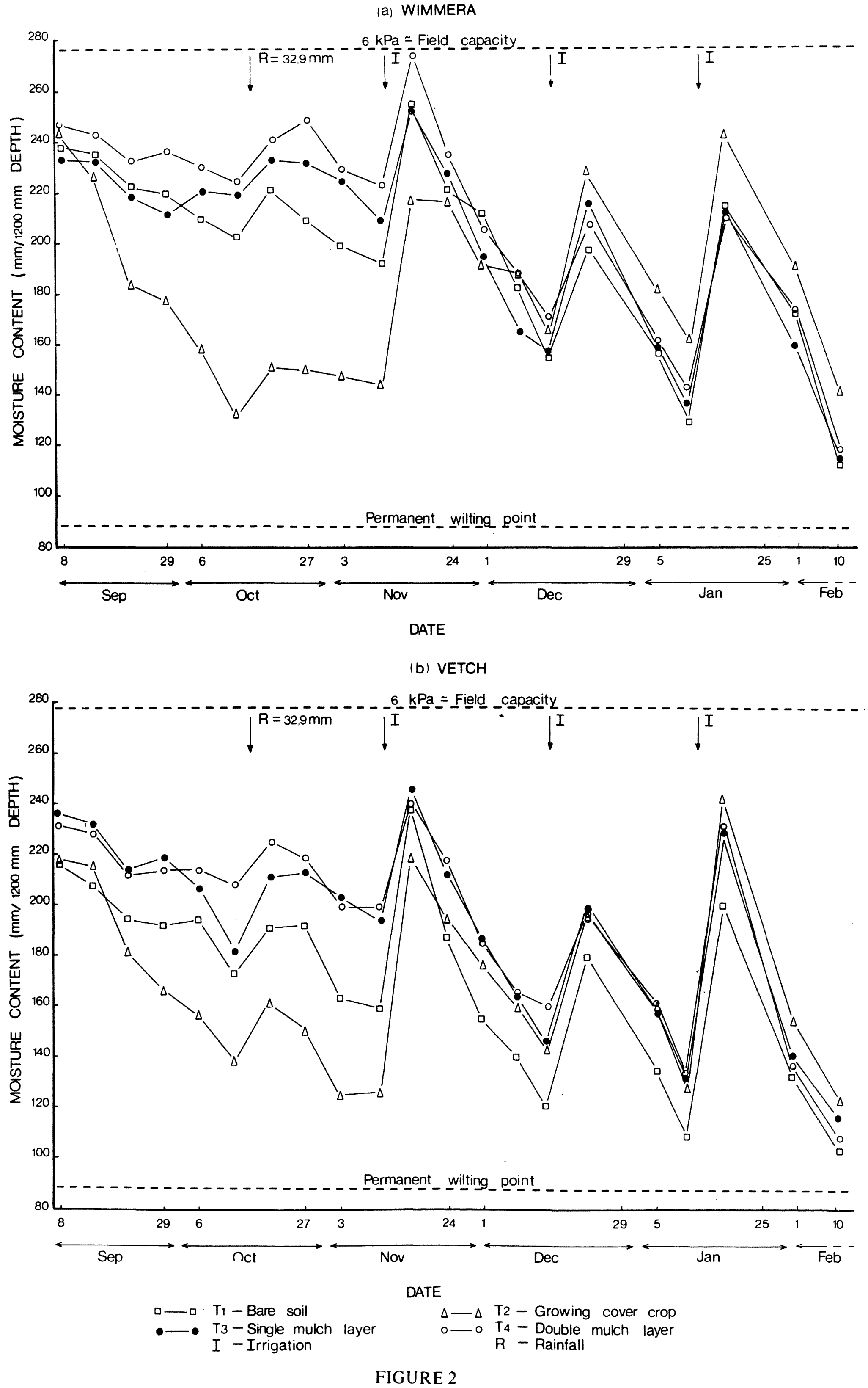


FIGURE 2

Soil moisture depletion and fluctuations under different cover crop management treatments.

TABLE 5

Treatments arranged in decreasing order according to soil moisture content as affected by various management techniques of Wimmera and vetch cover crops — Oudtshoorn

Classification of treatments in decreasing order at different dates[i])				
22/9/81	13/10/81	27/10/81	11/11/81	1/2/82
Treatment[ii])	Treatment	Treatment	Treatment	Treatment
4 a	4 ab	4 abc	4 abc	2 a
8 ab	3 ab	3 abcd	3 abcd	4 ab
1 ab	8 ab	8 abcd	7 abcde	1 ab
7 ab	1 abc	7 abcd	1 abcde	3 ab
3 ab	7 abc	1 abcde	8 abcde	6 ab
5 ab	5 abc	5 bcdef	5 bcdef	8 ab
6 ab	6 bc	6 cdef	2 cdef	7 ab
2 b	2 bc	2 def	6 def	5 b
CV = 10,1%	CV = 13,7%	CV = 9,7%	CV = 12,0%	CV = 13,5%

CV — Coefficient of variation

i) Not all dates with significant differences are shown, viz. 29/9/81, 20/10/81 and 3/11/81

ii) Treatment numbers:

	Wimmera	Vetch
Bare soil (T1)	1	5
Growing cover crop (T2)	2	6
Single mulch layer (T3)	3	7
Double mulch layer (T4)	4	8

ab...... Treatments followed by the same letter or combination of letters do not differ significantly at the 5% level.

From the middle of November (after the first irrigation) moisture extraction was very similar in all treatments except on T 1 (bare surface), which showed a lower moisture content until the end of the season, especially for vetch (Fig. 2 (b)). This is most probably due to weed growth which became noticeable from November onwards. These patterns of soil moisture depletion were determined at all depths of the soil profile, even in the deepest layers (Fig. 3).

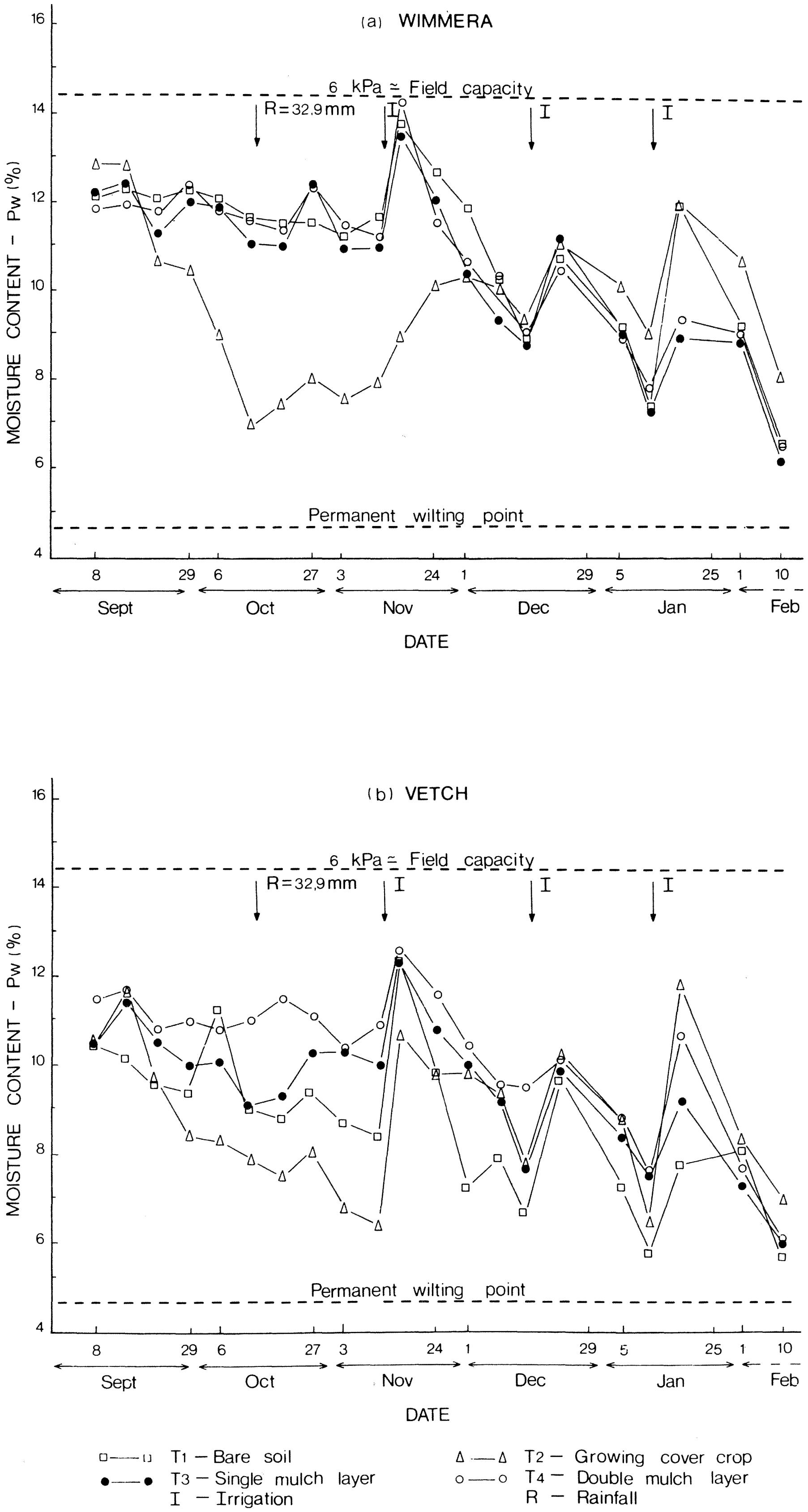


FIGURE 3
Soil moisture depletion from the 60 - 90 cm depth as affected by various plant residue management techniques.

Comparing the effectiveness of Wimmera and vetch as regards water conservation, it was evident that Wimmera was on the whole a better mulch (Fig. 4; Table 5). At comparable dry material productions (T 3 of Wimmera and T 4 of vetch) the Wimmera mulch maintained a significantly higher moisture content than the vetch mulch. Increasing dry residue mass did not have a significant effect on water conservation for both cover crops.

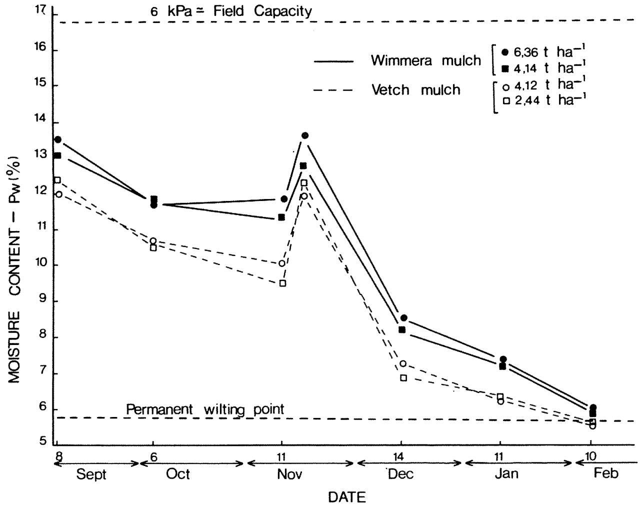


FIGURE 4
Mean gravimetric soil moisture content (%) measured in the 0 - 120 cm soil profile under different dry residue masses of wimmera and vetch. (Each point represent the mean of five replicates).

Treatment means of moisture content at different depths as affected by the soil surface condition (residue management) are illustrated in Fig. 5 (For ease of interpretation only the T 1 and T 4 treatments are shown). The best water conservation was obtained in the 0-15 cm depth layer, with Wimmera slightly better than vetch. The lower moisture content on the bare vetch plots was evident at all depths throughout the whole season — at first owing to high evaporation losses, and from November onwards due to moisture extraction by weeds (Table 4). A relatively weedfree, undisturbed bare soil surface can act as a mulch in itself once it has dried (Van Huyssteen & Weber, 1980b), and this could be the reason why the Wimmera T 1 plots ended up having moisture contents that compared favourably with a Wimmera mulch in soil layers below 30 cm depth. The beneficial effects of the mulches were also evident in the deeper layers, they became, however negligible at 90 - 120 cm depth. Apart from the top 0 - 15 cm layer, where evaporation would have contributed significantly to water loss, differences between treatments may be equated with inequalities in withdrawal of water by vine roots.

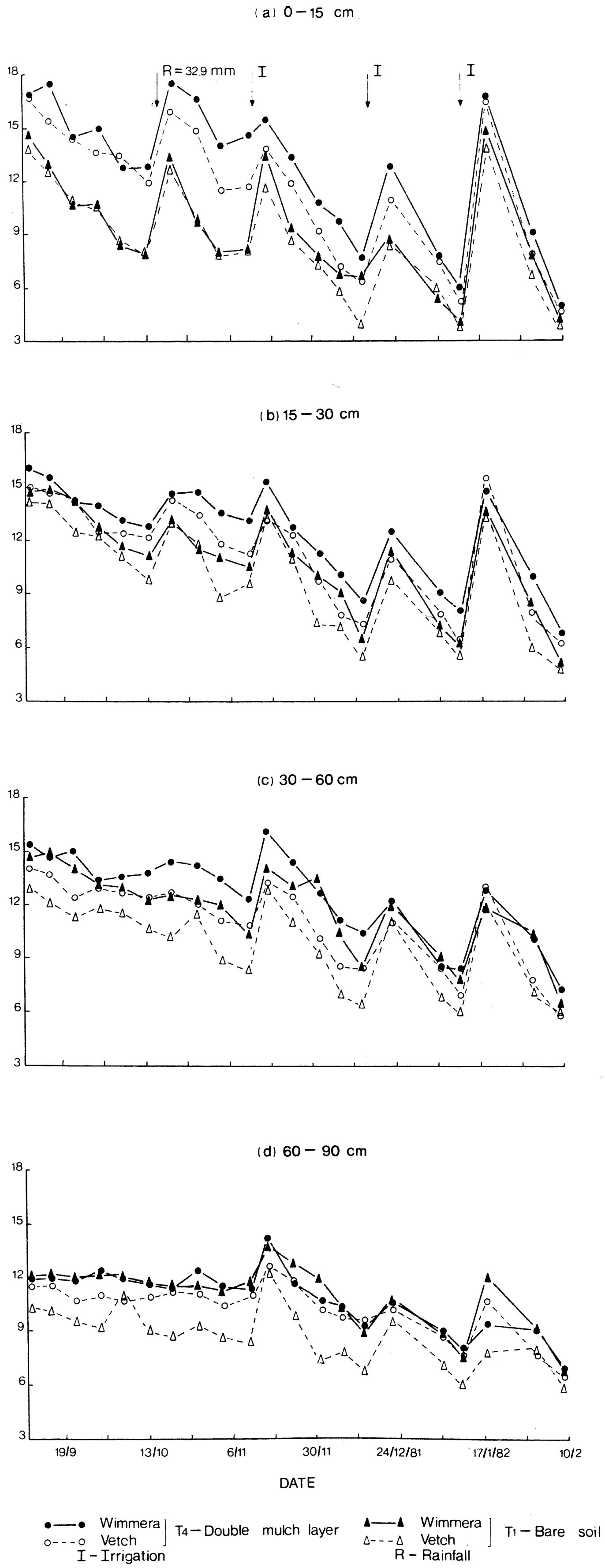


FIGURE 5
Gravimetric soil moisture content at different depths under various cover crop management treatments.

Soils of the T 2 treatments were not fully replenished to field capacity after irrigation due to excessive dryness (Fig. 2 & 6). Soil moisture replenishment by both rainfall and irrigation was affected by the soil moisture regime (dryness) before water applications, as well as by the soil surface condition. Undoubtedly water infiltration rate also played a role in this respect. The excellent water replenishment initially found on T 1 plots, from which cover crops were just removed, compared to T 2 confirmed this (Fig. 6). Later in the season the surface of the T 1 plots were puddled while that of the T 2 plots were still protected by a layer of plant residues. Supporting evidence was provided by infiltration measurements (data not shown) which yielded mean infiltration rates of 48,0 and 66,3 mm h^{-1} for the T 1 and T 2 plots, respectively, at the end of the season.

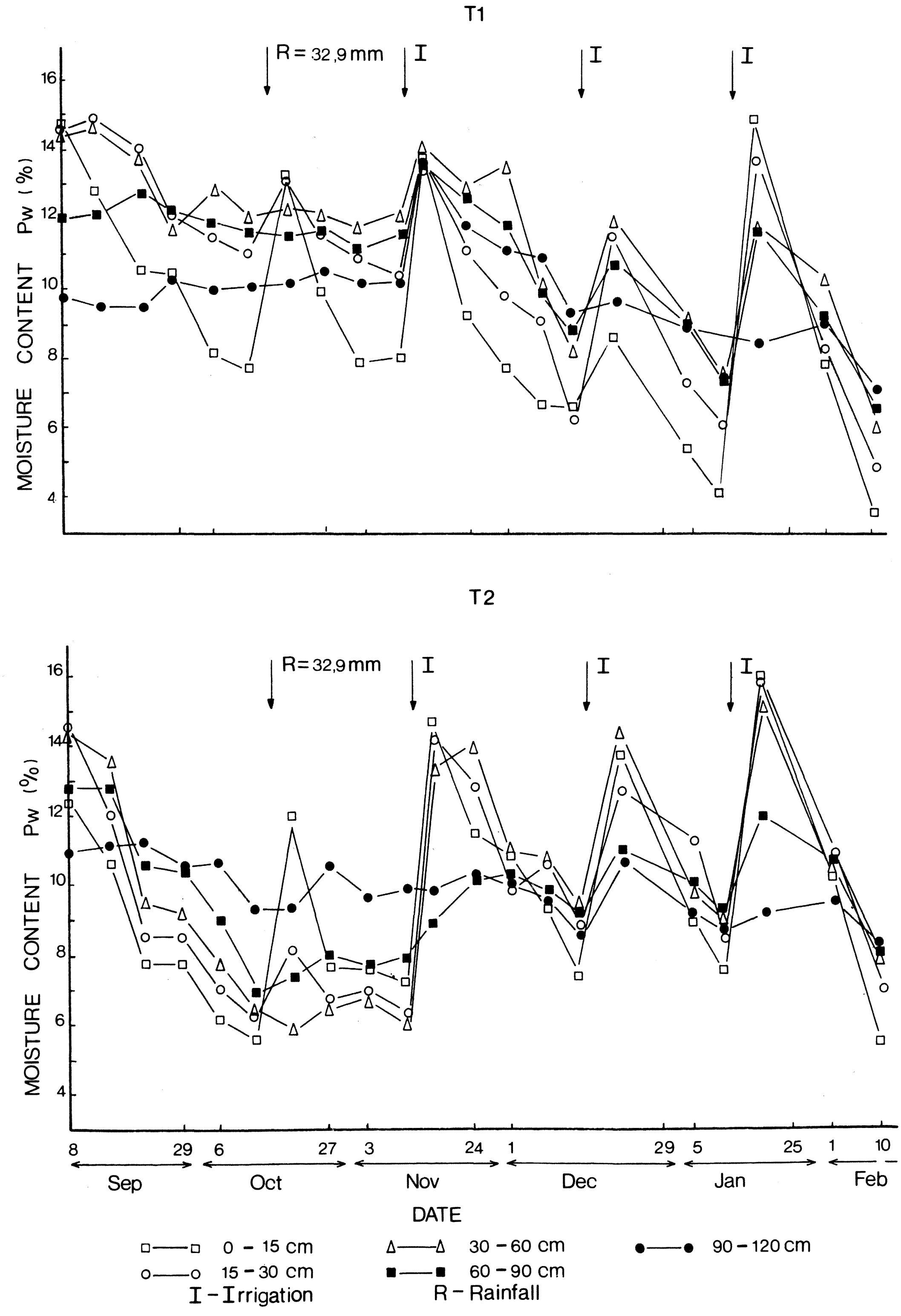


FIGURE 6
Soil moisture depletion in the different layers of the bare (T_1) and the growing Wimmera plots (T_2).

Consumptive water use figures for each interval between irrigations, and for the entire growth period from September 8 to February 10, are summarized in Table 6. It can be concluded that for the five months period the vines consumed *c.* 481 mm of soil moisture under an effective mulch (T 4 of both Wimmera and vetch, and T 3 of Wimmera). Whenever there were growing plants other than vines in the vineyard, even be it for part of the growth period only, the soil moisture consumption increased to *c.* 531 mm. This observation was applicable to the T 2 treatments of both cover crops at commencement of the experiment as well as for weeds during the second half of the growing season on the T 1 and T 3 vetch plots.

Although differences in total water consumption among treatments appear relatively small, the high water consumption of an actively growing cover crop was demonstrated by the fact that at least 75 mm more water was consumed during the 36 days from September 8 to October 13 on the T 2 Wimmera plots than on the other treatments.

Because on October 12 the soil of the T 2 plots approached wilting point (soil moisture stress of 1500 kPa) the water consumption dropped drastically to only 34,82 mm for the next period (13/10/81 — 11/11/81).

During the period September 8 to November 11, the two growing cover crops consumed almost the same quantity of water, viz. on an average 61,4 mm more water than the three treatments with the effective mulches (T 4 of Wimmera and vetch, and T 3 of Wimmera). Evapotranspiration losses from both the bare soil (T 1 treatments) and the T 3 treatment of vetch, the latter with its ineffective, thin mulch, were on an average 21,6% higher than those from the plots with effective mulches.

From November 11 onwards interpretation of the consumptive water use figures became increasingly difficult. This was probably due to the fact that plant roots withdraw water at a faster rate from wet soils than from dry soils — a fact which could have an equalizing effect amongst treatments (Hamblin, Tennant & Cochrane, 1982).

TABLE 6

Comparison of accumulative soil moisture consumption between irrigations and over the whole season under different mulch treatments — Oudtshoorn

Treatment	Accumulative soil moisture consumption (mm) for different periods						
	8/9 - 13/10	13/10 - 11/11	8/9 - 11/11	11/11 - 14/12	14/12 - 11/1	11/1 - 10/2	8/9 - 10/2
Wimmera							
T1	44,84	55,59	100,43	133,83	105,22	151,47	490,94
T2	119,48	34,82	154,30	114,89	107,14	153,84	530,17
T3	35,17	55,71	90,88	119,24	127,47	149,65	487,24
T4	42,96	46,40	89,36	142,77	106,87	139,67	478,66
Vetch							
T1	54,10	59,06	113,16	164,99	109,70	154,63	542,48
T2	88,25	58,68	146,93	99,71	103,53	185,23	535,40
T3	66,90	44,86	111,76	133,25	102,81	179,95	527,77
T4	32,36	54,96	87,32	99,16	101,18	190,00	477,66

Irrigation dates : 7/8/81, 12/11/81, 15/12/81, 12/1/82, 12/2/82

Rainfall dates : 14 - 17/10/81 (32,9 mm), 21 & 22/10/81 (6,4 mm), 7 & 8/11/81 (6,3 mm), 4/12/81 (1,8 mm), 14/12/81 (6,1 mm), 23 & 24/12/81 (2,9 mm)

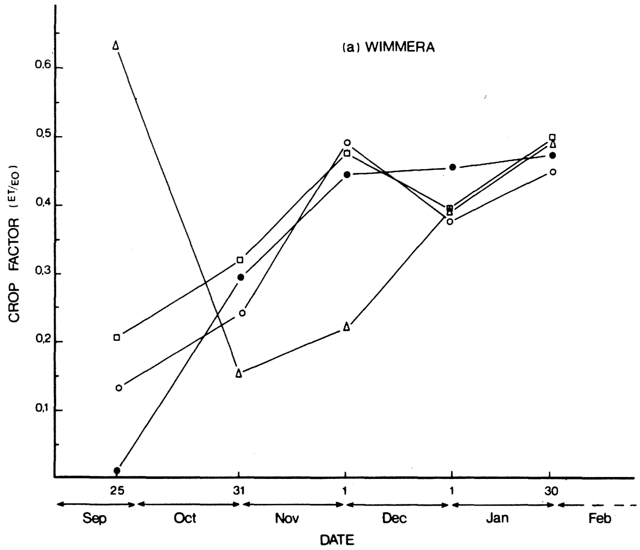
Crop factors (Fig. 7) for the different treatments were calculated using the following formula:

Crop factor = $^{ET}/_{Eo}$

where, Et = $(Sm_1 - Sm_2) + R$
Sm_1 = Soil moisture content (mm) at date 1
Sm_2 = Soil moisture content (mm) at date 2
R = Rainfall (mm)
Eo = Class A pan evaporation (mm)

Vines together with a growing cover crop yielded a crop factor of 0,50 ($^{Et}/_{Eo} = {}^{150,62}/_{302,3}$) during September and October (8/9/81 —11/11/81) compared to 0,30 ($^{Et}/_{Eo} = {}^{89,2}/_{302,3}$) for the effective mulches. The crop factors followed the general accepted pattern, viz. an increase as the season progressed (Fig. 7). However, crop factors for January suggested higher values than the presently recommended ones (Van Zyl, 1981).

Soil temperature: The highest soil temperatures (data not shown) were registered on the T 1 plots where maxima of 27,5°C were often measured even at a depth of 22,5 cm compared to 22,0°C on the T 4, T 3 and T 2 plots. The T 2 treatment had the lowest soil temperature throughout the season, with T 3 and T 4 intermediate, but the soil under the double layer was cooler than that under the thinner mulch (Fig. 8). The implication of this result is not clear because of incomplete basic information of soil temperature effects on root growth and metabolic functions. However, in a summary of temperature effects Willis and Amemiya (1973) indentified the following root functions as being generally greatly dependant on soil temperature: (i) nutrient uptake; (ii) water absorption; (iii) metabolite production; and (iv) carbohydrate storage. Large variations in soil temperature, as in the case of unmulched plots, can affect the functioning of plant roots, especially the absorption of nutrients and water, and also the biochemical processes (Varadan & Rao, 1983). The sudden changes in soil temperatures often measured on the bare plots are more deleterious to plants than slow changes (Daubenmire, 1974).



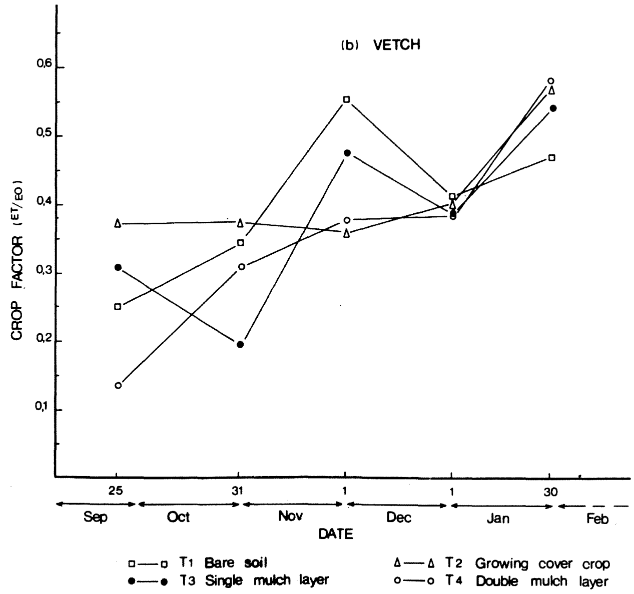


FIGURE 7
Variation in crop factor values for the different treatments under (a) Wimmera, and (b) vetch.

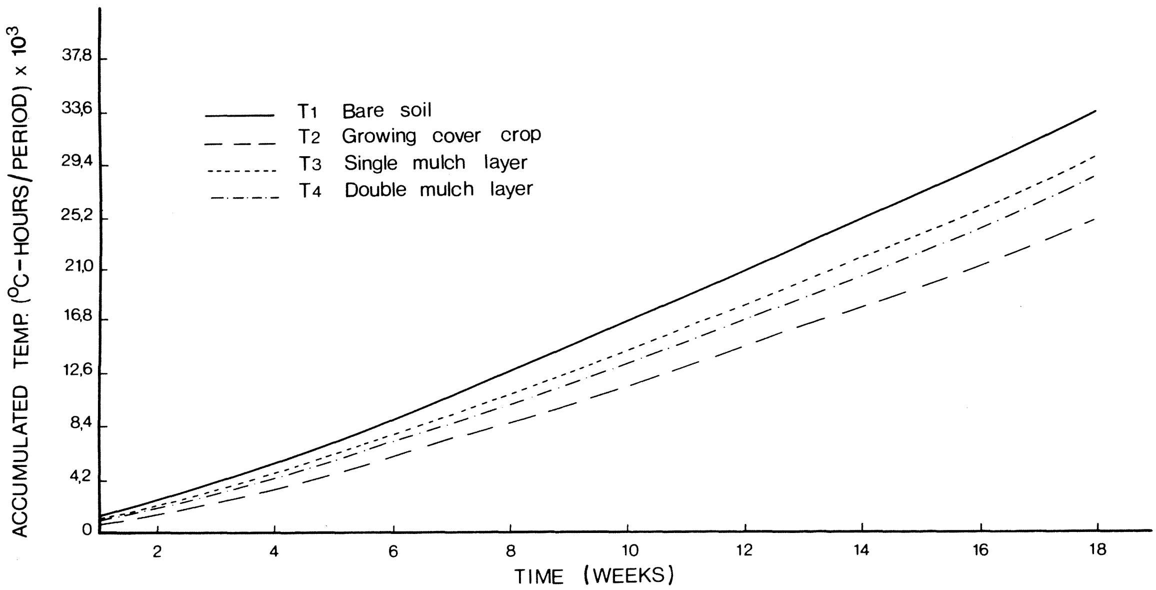


FIGURE 8
Daily soil heat sums (accumulated °C-hours day^{-1}) over 10° C at 45,0 cm depth under different cover crop (Wimmera) management techniques.

CONCLUSIONS

Weed growth which has been shown to be harmful can be controlled effectively by a mulch of plant residues from cover crops grown in the vineyard. Mulches can thus be applied to replace pre-emergence herbicides. A mulch with an initial mass of about 3,0t ha^{-1} could not control weeds sufficiently, but masses of 5,0 (Wimmera) and 8,0 (vetch) t ha^{-1} were adequate to control weeds. This quantity of dry plant matter can easily be produced in the vineyard.

In this study a mulched vineyard soil conserved water in comparison with a bare soil due to limited evaporation losses, with Wimmera being more effective than vetch in this respect. Water extraction by weeds on the bare soil also contributed to water loss. Cover crops allowed to complete their growth cycle after bud burst of the vineyard, wasted so much water — 75 mm in 36 days — that this practice cannot be recommended in a dry area with an uncertain water supply. The results showed that manipulations of the soil surface not only affect moisture conservation in the surface soil layers (0 - 15 and 15 - 30 cm) but, for that very reason, in the subsoil as well.

Differences noted in the consumptive water use have significance for management of cover crops in vineyards, because these figures supplied useful information on the quantities of water involved under different mangement techniques. Although these differences were not very large at the end of the season the unfavourable effects of the growing cover crops and weeds could be disastrous during the early critical growth periods of the vines. It should further be kept in mind that all plots received blanket irrigations. Should it have been possible to irrigate the plots separately the mulched plots would certainly have allowed longer irrigation cycles, while irrigations should have been more frequent on the unmulched plots. It may thus be concluded that mulched soils would need less frequent irrigations, which will result in even higher water savings than those reported in this study.

A slow infiltration rate, which is a problem with flood irrigation, improved when a plant residue covered the soil. Cooler soil temperatures during summer were found to be a further beneficial effect of plant residue on the soil surface.

In the fertilization programme of a vineyard provision must be made for the fact that N is fixed by legumes, but withdrawn by grasses. However, this N in the residues can be released slowly through mineralization for uptake by the vine roots. It may take two to four years before the N-cycle has reached equilibrium on a soil which has been switched from clean cultivation to minimum cultivation. Therefore additional N must be applied during this transition period, especially if grass cover crops are used. The quantities of N concerned, need to be investigated further, but according to results of this experiment, the following adjustment to the fertilization programme seem to be quite safe; subtract 100 kg N ha^{-1} when vetch is used as a cover crop and apply 50 kg N ha^{-1} additionally when Wimmera is being sown.

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