Improving grapevine production efficiency by modified root environment

FINAL REPORT to

GRAPE AND WINE RESEARCH & DEVELOPMENT CORPORATION

Project Number: **DAN 2V**

Principal Investigator: **Dr R A Spurway**

Research Organisation: **NSW Agriculture & Fisheries**

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FINAL PROJECT REPORT

Improving Grapevine Production Efficiency by Modified Root Environment

Authorised Body:	GRAPE & WINE RESEARCH COUNCIL
Project Number:	DAN 2V
Field of Research:	Cultural practices Field Code: 4
Research Organisation:	NSW Agriculture & Fisheries
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Location of Research:	Griffith Horticultural Research & Advisory Station and commercial vineyards in the Murrumbidgee Irrigation Area (MIA).
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Aims: 1. To investigate soil factors limiting grapevine root growth;
2. To evaluate techniques of modifying the root environment to improve vineyard productivity and irrigation efficiency.

Industry Significance:

Nature of problem: Past research suggested that in the MIA, root growth in grapevines was relatively poor due to unsatisfactory soil physical conditions. This may be an important limiting factor to vine productivity and could account for. the lack of response of vines in the MIA to improved irrigation and fertiliser management.

Potential benefits to industry: The potential impact of such problems on productivity was indicated by data from a commercial *Trebbiano* vineyard. Vine growth was apparently uniform, with an average yield of 20.4 t/ha, but the yields of individual rows were shown to vary from 8.3 to 29 t/ha. If the maximum yield had been attained throughout the vineyard, the grower's returns would have increased by $1350/ha, possibly with no additional costs beyond those of harvesting. Assuming a similar situation throughout the area, these data indicated that the MIA grape industries could be losing as much as $6 million/year through problems in the root environment.

Summary of Experiments:

Studies were conducted under the project towards the stated objectives as follows:
1. An investigation of the effects of topsoil depth and irrigation method on seasonal growth of grapevine roots.
2. Investigations of the effects of anaerobic soil conditions on vine growth.
3. Preliminary assessment of:
    1. soil inversion and mixing;
    2. gypsum slotting;
    3. mulching, cover crop and sod treatments

    for their effects on irrigation characteristics of a problem soil.
4. A survey of currently used management approaches in MIA vineyards and growers' reasons for their various choices.
5. Development of management systems for growing vines on problem soils.

INTRODUCTION

Root growth and water penetration problems: Past experiments had indicated that grapevines have very sparse root systems and do not respond to irrigation management in the MIA. Root length density was very low compared with other crops (Atkinson, 1980) and could be the reason for the irrigation response. The grapevine root length density in the MIA was similar to that for clay soils in Sunraysia (Nagarajah, 1987). His investigations in the Sunraysia showed that root density was lowest in sandy soils, where maximum values were 0.02 to 0.04 cm cm', in contrast to clay soils, where maximum root densities were 0.07 to 0.17 cm cm'. In light soils the roots were evenly distributed to 2.2 m, but in clay soils the rooting depth was restricted to 60 to 80 cm. Under the conditions at Griffith Horticultural Research & Advisory Station the roots are not restricted to the surface layers of soil, but are evenly distributed to a depth of 1.6 m. The soil bulk density at this depth is 1.8 g cm-J, which exceeds the threshold of 1.5 g cm-1 above which grapevine roots do not grow (Penkov, 1965). Roots at this depth were found in preferential pathways such as old root channels, soil fracture lines and voids. The roots did not extract the same quantities of water from the deep soil layers as from the surface layers (B.M. Freeman, unpublished data), hence the root system at depth may be ineffectual. However the roots measured in the Griffith experiments were sampled before new seasonal root growth occurred: subsequently, new root growth may have occurred in the more favourable soil layers and that new growth could have accounted for most of the water uptake and hence the soil moisture extraction pattern. Thus seasonal root growth needed to be specified to adequately describe water uptake.

Investigations in commercial vineyards had shown that major water infiltration problems occurred and that these problems were most serious in areas with shallow topsoils (B.M. Freeman, unpublished data). Associated with the infiltration problem were extended periods when the surface soil was saturated with water due to restricted infiltration. The topsoil could be saturated with water for several days, but this situation and effects of the resulting anaerobic soil conditions on grapevines had not been studies previously. Hence studies of the impact of shallow topsoils on root growth and responses of vines to anaerobic conditions forms part of this project.

Methods of overcoming root growth and soil problems: Various treatments may improve soil conditions to optimise root growth and improve infiltration and drainage of irrigation water. Potential management approaches include various sod or cover crop regimes, such as those discussed by Fourie and van Huysteen (1987), Lombard et al. (1988) and McCarthy (1988), in place of traditional management centred on frequent cultivation. Minimisation of cultivation and addition of organic matter improve soil characteristics important to water absorption (Tisdall et al., 1978) and root growth from cover crops or sod species together with earthworm channels should also enhance water infiltration and vine root growth in the absence of cultivation (Moore et al., 1989). The presence of a mulch or sod on the surface reduces crust formation due to raindrop impact (Lal, 1978) and slows and spreads flood irrigation water. An inactive mulch can reduce evaporative losses, and by keeping the soil surface moist reduce slaking (Collis-George and Lal, 1971), while the presence of an active sod may be disadvantageous because of competition with the vines for water and nutrients (Freeman and McLachlan, 1988).

Gypsum amendment may also be desirable in sodic soils with significant clay content (Loveday, 1975). Gypsum application together with ripping is a practice already familiar to most growers, but two techniques with additional potential benefits required evaluation: the modern technique of gypsum "slotting" (Jayawardane et al., 1987) and the use of mould boarding to mix surface soil with gypsum-rich subsoil. Both techniques break through compacted layers and at the same time provide calcium at the depth where it is required. An alternative approach to breaking through a shallow topsoil is to gather the topsoil into a vine bank. Adem and Tisdall (1988) developed a system for peaches using a mulched bank and micro jet irrigation. An un-replicated trial of a vine bank with furrow irrigation had been established in existing vines at Griffith Horticultural Research & Advisory Station in 1986/87.

Experiments to evaluate the performance of the above strategies in problem vineyard soils were conducted under this project.

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DETAILED RESEARCH REPORT

1. Effects of topsoil depth and irrigation method on root growth of grapevines:

Aims*:* To determine the effects of topsoil depth and irrigation method on root growth of grapevines and relate the water extraction to root length density patterns.

Method: An existing irrigation trial, which was about to be terminated was available on Griffith Horticultural Research & Advisory Station for 15 years the vines had been either trickle or furrow irrigated, or not irrigated at all. The soil type was Banna Sand, but included areas with a shallow (35 cm) and a deep (80 cm) surface horizon of sandy loam, overlying dense clay subsoil. Soil type could not be randomised, but each plot had 12 *Shiraz* vines, which were used as replicates. Cores were obtained using a 25 mm sampling tube at distances of 0.2, 1.0 and 1.7 m from the vine and perpendicular to the vine row, at 8 depths in equal increments to 1.6 m. Grapevine roots were washed from the soil cores and the length of live roots measured using a leaf area meter technique. Soil water extraction patterns were monitored using a neutron moisture probe.

Results*:* Some of the results are summarised in Table 1. Bulk density of the surface horizon was 1.48-1.54 g cm'", while that of the B horizon was 1.75-1.80 g cm-'. Root growth was related more to irrigation than soil depth, since irrigation increased the total root growth compared with no irrigation. No irrigation did not increase the depth of the vine root system, but concentrated roots between 60-80 cm. Frequent irrigation with trickle concentrated the roots near the surface and near the vine, compared with furow irrigation, which concentrated roots in the top and bottom soil layers. Root length density down the soil profile did not clearly relate to the depth of the A horizon, but in the dense subsoil roots were clumped together and concentrated in soil fractures or old root cavities, limiting their effectiveness in extracting water from the sub soil. The soil water extraction pattern reflected this, as water extraction pattern correlated with soil profile rather than the root length distribution.

Table 1: Some results from studies of influences of topsoil depth and irrigation method on root growth, soil moisture extraction and yield of grapevines.

Irrigation Method	Surface soil depth (cm)	Root length density (cm cm-J)	Yield (kg/vine)
Trickle	80	0.22	22.2
Trickle	35	0.18	15.6
Nil	80	0.05	12.7
Nil	35	0.03	4.3

Yields were reduced with the 35 cm topsoil compared with the 80 cm topsoil for all irrigation treatments, with a greater effect where there was no irrigation. Thus soil surface depth is important even with frequent irrigation, but is more critical without irrigation. Depth of surface soil did not significantly influence quality.

Conclusions: The depth of surface soil clearly is an important factor to the ability of vine roots to explore the soil for water and nutrients and does therefore have an impact on yield. Deep ripping has only a temporary effect on hardpans impeding root growth, but techniques such as gypsum slotting, while costly, could potentially offer longer-term improvements. Another practical means of deepening shallow surface soils is to gather the soil into a bank along the vine row. Early results of a small trial on the Research Station with such a technique were very promising in yield and also suggested increased phosphorus availability with a vine bank.

2. Effects of anaerobic soil conditions on vine growth.

Aim: To determine the effects on vine growth in various grape varieties of anaerobic soil conditions produced by water logging.

(a) Initial experiments:

In a pilot trial, one-year-old vines of *Cabernet sauvignon, Chardonnay* and *Semillon* planted in 10 L pots were subjected to waterlogging by immersing them in 20 L buckets filled with water. Photosynthetic rate, leaf water potential, canopy temperature and sap nitrate were measured. After 14 days of waterlogging, 80% of the *Chardonnay* and *Semillon* vines had died. *Cabernet sauvignon* survived the treatment, suggesting it was less susceptible to waterlogging than the other varieties, but photosynthesis did not recover to normal levels after the pots were allowed to drain.

In a second experiment, mature vines of eight varieties were transplanted into 200 L drums with the intention of studying the effects of waterlogging for 2, 4 or 6 days. However problems arose due to compaction and poor internal drainage of the field soil used and this approach was abandoned.

(b) Final experiment:

Method: One year old vines of *Cabernet sauvignon* and *Semillon* plants on their own roots, and *Semillon* on *Ramsey* rootstock were grown in sand in 20 L pails equipped with a hose at the single drainage outlet. The hose could be hooked to the top of the pail and provided full control of the duration of waterlogging. Prior to imposition of the four waterlogging treatments, each plant was trimmed back to the second node and the pruning weight recorded. Five replicates were used, with a single plant per pail.

Within continual 14-day cycles from December to May, 20L pails containing sand were waterlogged for 0, 2, 4 or 8 days and allowed to drain freely for the remainder of each cycle. Free draining plants were watered once to twice daily and water losses in waterlogged pots from evapotranspiration were replaced at the same interval. While free to drain, plants were supplied with a hydroponic solution every two days. Vines were kept to a single stem trained vertically. Measurements were made throughout the treatment period of stem extension and leaf growth, at least fortnightly

and for several cycles, at intervals of two days. At the conclusion of the season, vines were trimmed back to the second node and the pruning weights recorded. Vitipodal lengths were also determined. Vines were removed from their pails, the roots thoroughly washed and the dry weight of roots recorded.

Results: Some results based on means for data at the end of the trial are shown in Table 2. Several individual values were omitted in determining the means, where damage had occurred to a stem during the season, and these analyses should be regarded as preliminary as they are untransformed and have not been adjusted for plant size prior to imposition, of the waterlogging treatments. Nonetheless some clearly significant effects emerged:

[i] Variety effects. For total shoot extension and final pruning weight, means for *Cabernet* were significantly higher than *Semillon* and *Semillon* on *Ramsey,* which did not differ significantly. The number of nodes, and hence of leaf blades, did not differ significantly between varieties. Root growth did not differ significantly between *Cabernet* and *Semillon,* but was much lower in the *Ramsey* rootstock.

[ii] Waterlogging treatment effects. Waterlogging treatments had highly significant effects on all four varieties. For top growth measurements, means for the 0, 2 and 4 day treatments did not differ significantly" but all differed from the 8 day treatment. However for root growth, each treatment differed significantly from each of the others (all available data were included in these means). Refinements to statistical analyses will hopefully amplify these comparisons.

[iii] Interaction effects. Interaction effects were only significant with root growth data, where the interaction apparently arose in the lack of difference between the 0 and 2 days waterlogging treatments in *Semillon* on *Ramsey.* Again, refinements to statistical analyses will hopefully amplify these comparisons.

Table 2: Results of an experiment comparing the effects of different durations of waterlogging (0, 2, 4 and 8 days in every 14 day cycle) on the growth of *Cabernet sauvignon* and *Semillon* plants on their own roots, and *Semillon* on *Ramsey* rootstock.

Variety	Number of days water -logged	Total shoot extension (cm)	Final pruning weight (g)	Number of nodes	Root weight (g)
Cabernet sauvignon	0	304	121	57.6	302
	2	259	98	52.9	206
	4	252	100	51.7	144
	8	211	77	44.6	84
	Mean	**256**	**99**	**51.7**	**184**
Semillon	0	215	90	48.4	273
	2	218	91	50.8	221
	4	195	69	52.7	124
	8	120	28	42.6	48
	Mean	**187**	**70**	**48.6**	**166**
Semillon on *Ramsey*	0	184	75	48.7	131
	2	210	100	57.4	134
	4	184	71	51.8	75
	8	112	29	40.4	35
	Mean	**172**	**69**	**49.6**	**94**
Mean	0	**234**	**95.0**	**51.6**	**235**
	2	**229**	**96.6**	**53.7**	**187**
	4	**210**	**79.8**	**52.1**	**114**
	8	**148**	**44.6**	**42.5**	**56**
lsd (p=0.05) between:					
Variety means:		23.5	14.4	4.7	18.0
Waterlogging means:		27.1	16.6	5.4	20.8
Interaction means:		46.9	28.8	9.4	35.9
Significance of F test for:					
Variety effects:		**	**	ns	**
Waterlogging treatment:		**	**	**	**
Interaction:		ns	ns	ns	**

Discussion: These preliminary results indicate that even a short period of waterlogging is detrimental to vine root growth, though effects may not be evident in shoot growth. Further work is necessary to learn more of waterlogging effects on vine growth and to relate the results to a field situation where the entire rooting depth may not be waterlogged.

Greater vine vigour from *Cabernet* than *Semillon* was expected from their normal performance in the field. In this case vigour was expressed as longer internodes and larger leaf blades, but not in the number of leaves. *Ramsey* did not encourage greater top growth in the *Semillon,* but the shoot: root ratio with the rootstock was much higher than with either *Cabernet* or *Semillon* on their own roots. The lack of greater top growth and relatively poor root growth with the "invigorating" rootstock is an interesting outcome. Possible reasons we had considered for the lack of an effect of rootstock on top growth before measuring root growth were that the rootstock was of no benefit in a situation where water and nutrients were freely available (as was clearly the case in the controls), or that the rootstock had become pot bound. Since root growth was so much poorer with the *Ramsey* it is clear that it was not root bound, and since top growth of the *Semillon* was unaffected, it seems unlikely that the pot situation was particularly unfavourable for growth of *Ramsey.* We are keen to undertake further investigations of these questions.

Comparisons of average growth rates in each cycle for stem extension and leaf expansion will be able to make full use of the data and will reveal any differences over the season. The closer measurements within certain cycles will enable any association of growth with the actual period of waterlogging to be determined. These statistical analyses are currently underway. Once all results have been analysed, it is anticipated that they will be published immediately. Further work is anticipated to follow up some of the interesting findings of the experiment.

3. Preliminary assessments of various treatments for their effects on irrigation characteristics of a problem soil:

(a) Soil inversion and mixing:

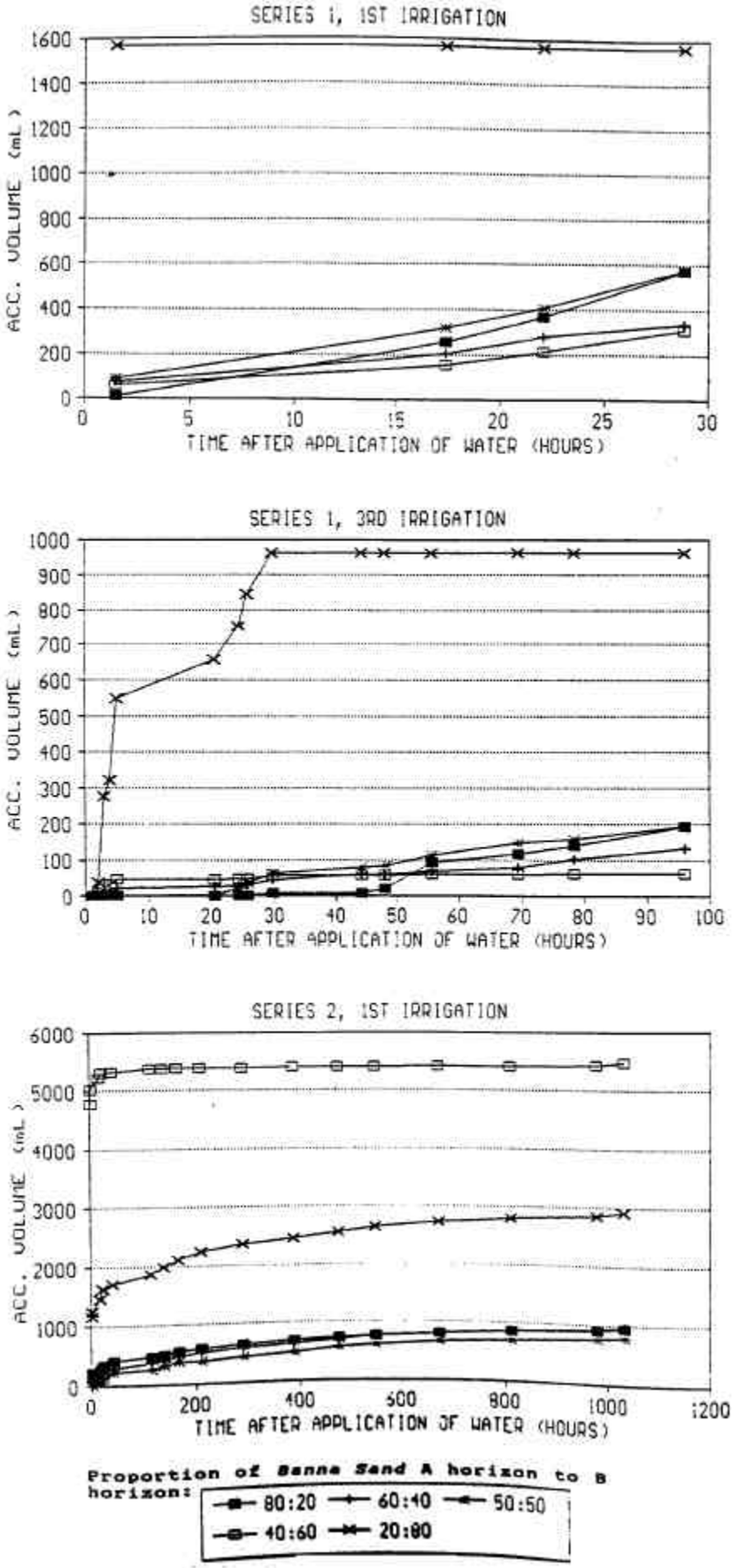
Aims: To determine whether mixing of surface soil with deeper layers, as would be done in practice by deep mouldboard ploughing, improved water movement through the soil and to determine the most desirable depth of mixing.

Method: In two unreplicated experiments, different proportions (20:80, 40:60, 60:40 and 80:20) of soil from the A and B horizons of Banna Sand were mixed and placed in 20 L pots with controlled drainage outlets. Infiltration of water was monitored by recording the volume of drainage water at intervals after applying a known quantity of water to the surface (2 to 5 L). This was repeated for several occasions without disturbing the soil, once surface ponding had disappeared in all treatments. The soil was then replaced with freshly mixed soil and a similar procedure followed using 6 L of water, for a single cycle only and with plastic covering to prevent losses by evaporation from the soil surface.

Results: Results for the first and third watering in the first series and the one watering in the second are shown in Figure 1. These results are indications only, as there is no replication, the volume available for drainage varied between treatments because of differences in soil water holding capacity associated with texture of the two horizons, and the extent of drying and cracking differed between waterings and between treatments. Results were as follows:

[i] Series 1. On the first watering of the first series, drainage from the pot with 20% A: 80% B-horizon was much more rapid than the other treatments, which drained very slowly and differed relatively little. Similar differences occurred for most of the succeeding waterings, but the total volume and rate of drainage was generally slower than in the first watering: .For some treatments on some occasions no drainage occurred over several days following watering. On occasion 5 all treatments drained particularly poorly, with a long delay before drainage water appeared. The

Figure 1: Some results from the soil inversion and. mixing trial, showing cumulative drainage from pots



second watering also behaved differently, with the 50:50 mix performing better than the other treatments.

[ii] Series 2. The best treatment for this evaluation was a 40% A horizon: 60% B-horizon mix, followed by the 20:80 mix. The other treatments did not appear to differ from each other.

Conclusions: The results suggest that for Banna Sand, soil inversion would have to be quite deep (>1 m) and would be very costly. The high levels of sodium and magnesium in the B-horizon are also of concern; hence imposition of such a treatment was considered impracticable and unwise, in this situation.

(b) Gypsum slotting:

Aim: To compare the effects of "gypsum slotting", "slotting" without gypsum, broadcast gypsum and an untreated control on soil moisture regime and grapevine growth and yield under furrow irrigation.

Method: An exploratory trial had been initiated prior to commencement of this project. Four replicates of the following treatments were applied to single panel plots in an existing area of *Doradillo* grapes on the Research Station:

1. Control;
2. Gypsum slotting (15 t gypsum/ha applied 20-60 cm deep in two slots 20 cm wide and 1 m deep, 1 m on either side of the vinerow;
3. Slotting as above, without gypsum;
4. Gypsum broadcast (15 t/ha spread on the surface and disced in).

Data recorded include bunch number and weight, cane number and weight at pruning and soil moisture (by neutron probe, with a single access tube per plot 50 cm from the vine row).

Results and Discussion: Although this site was chosen as a likely site for water penetration and root growth problems because of poor vine growth and yield, none of the treatments have had a significant effect on either the

plant measurements or the soil moisture regime. The plant data were highly variable, but those for soil moisture were reasonably consistent. The depth of sandy topsoil in the particular block used presumably accounts for the absence of response to either calcium amendment or slotting.

Conclusions: Such treatments warrant further evaluation, but should be tested in areas where there is known to be water penetration problems in the A or B horizon, associated with a high exchangeable sodium content or low calcium/magnesium ratio, and together with a significant clay content within rooting depth.

(c) Evaluation of mulch, cover crop and sod treatments:

Aim: To evaluate the effects of cover crop, sod or added mulch treatments on water infiltration and usage in the vineyard.

Methods: Two exploratory trials were conducted on the Research Station in existing vines. In the first, two replicates of three treatments were evaluated -a cultivated control, mown oats with added straw and oats suppressed by glyphosate herbicide. Oats were sown in mid 1987 and mown for frost control in spring. The mowing or herbicide treatments were then imposed. Extra straw (0.5 bales/vine, or 18.5 t/ha) was added to the mown oats because the slasher did not distribute the mulch evenly. Growth in the summer was controlled by further mowing or herbicide application, as appropriate. In 1988/89 the same treatments were imposed upon the regenerated oats and natural weed growth, without added mulch. In both years soil moisture was monitored by neutron probe.

In the second experiment, two unrep1icated treatments were implemented in 1987/88 -chemical weed control, using glyphosate without cultivation and a mulch of 1 bale rice straw/ vine.(37 t/ha), again without cultivation. Additional straw was added at one quarter that rate in 1988/89. Soil moisture was monitored at several points using the neutron probe.

Results and discussion: Results for the first trial in the first year are shown in Figure 2. In 1987/88, total water depletion in the herbicide-

Figure 2: Soil water content during the 1987/88 season in the first mulch experiment, comparing a mown oats cover crop/sod, herbicide-suppressed oats and cultivated soil. Arrows indicate rainfall events. Data extend from 27/10/87 to 12/2/88.

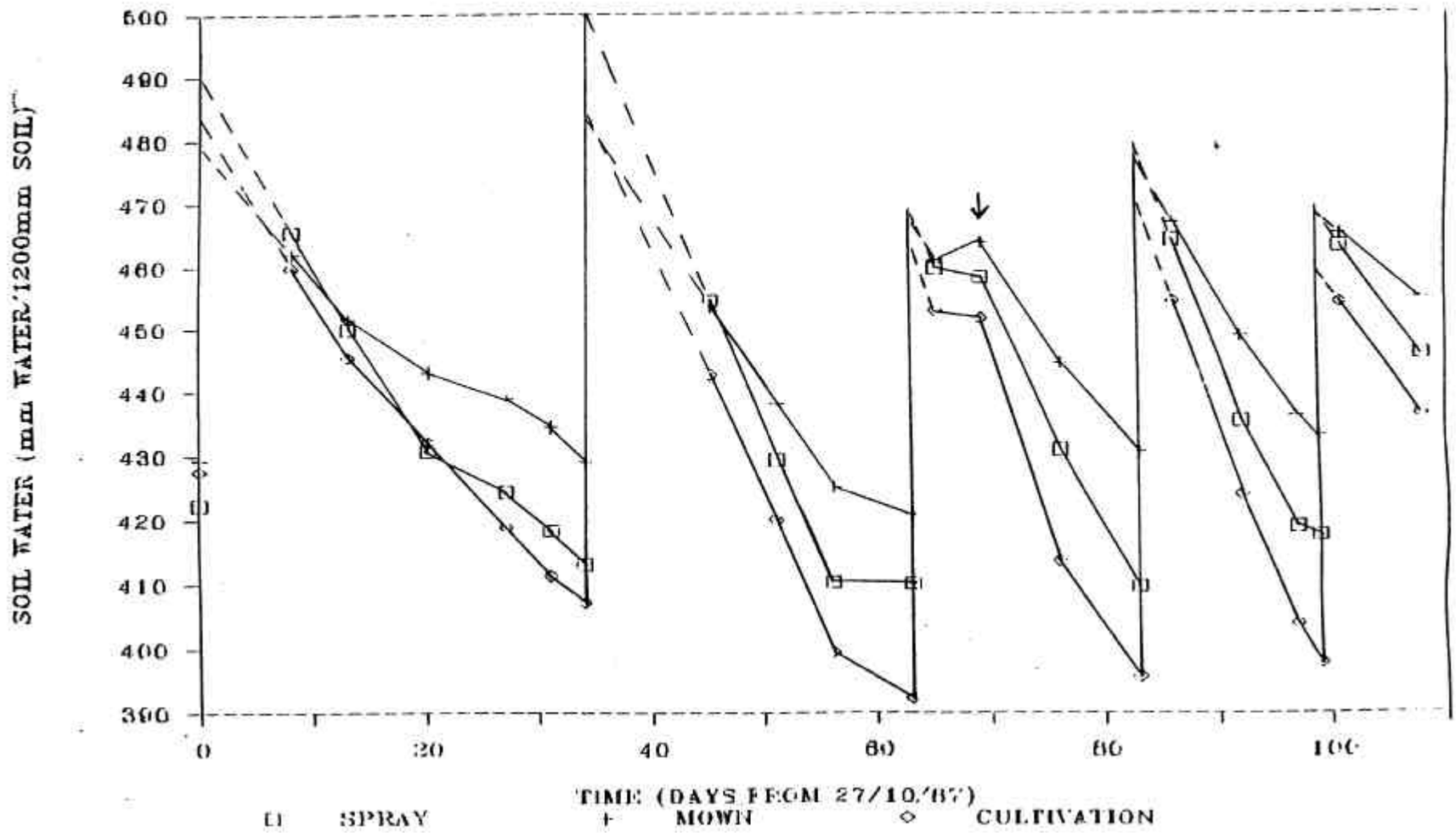
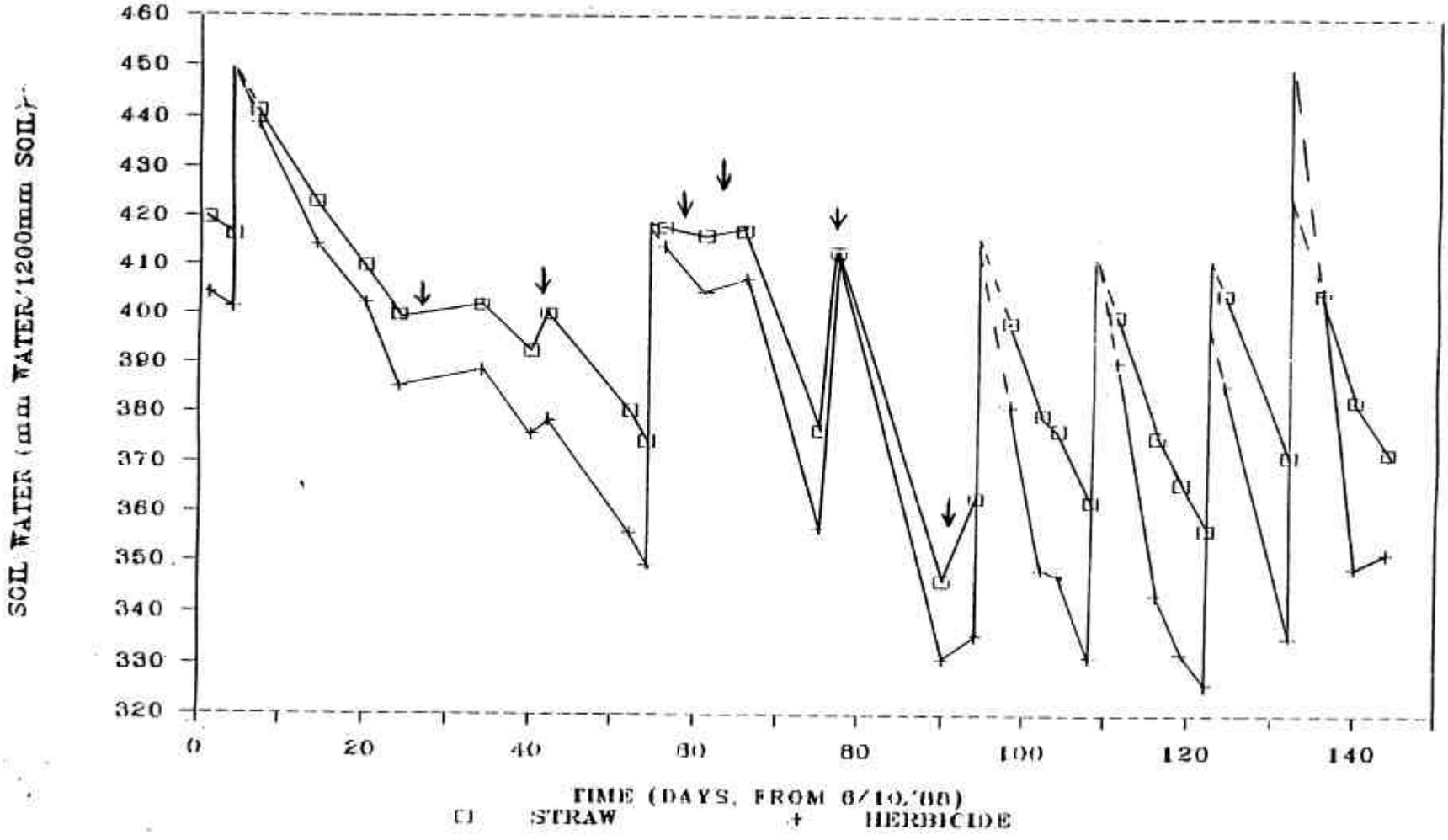


Figure 3: Soil water content during the 1988/89 season in the second mulch experiment, comparing a heavy rice straw mulch to bare, herbicide-treated soil. Arrows indicate rainfall events. Data extend from 7/10/88 to 3/3/89.

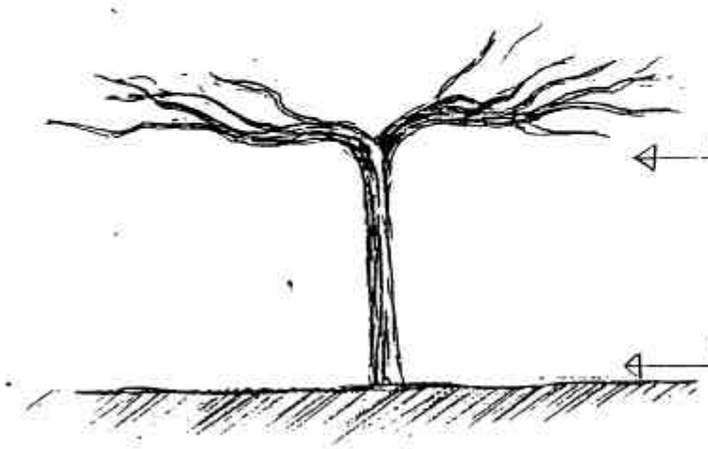


suppressed oats and cultivated treatments was 44% and 51%, respectively, greater than the mown oats/added straw treatment. A similar trend was seen in 1988/89, although the oats did not regenerate well and there was a higher proportion of weed growth. Water usage from the limited growth in the mown oats was apparently too little to significantly affect overall water usage and the greater volume of dry matter present in that treatment presumably accounted for its beneficial effects.

In the second trial, in both 1987/88 and 1988/89, the heavy rice straw mulch maintained higher soil water reserves than the herbicide treatment. The 1988/89 results are displayed in Figure 3. Compared with the seasonal soil water depletion in the mulch treatment, that in the chemical weed control treatment was 35% greater in 1987/88 and 63% greater in 1988/89.
The straw was successful in conserving water and encouraged root growth at the surface. In the first year the straw treatment caused visible symptoms of nitrogen deficiency and there was a rapid response when nitrogen fertiliser was applied. Straw suppressed weed growth and reduced the number of herbicide sprays from 3 to 1 per year. The straw remained more or less in situ and did not float downstream. The volume of mulch declined by the end of the 1988/89 season and the mulch had largely disappeared by the end of 1989/90. Subjectively, to maintain it at a volume similar to that present initially, half the original rate should have been added each year.

Conclusions: Cover crop, sod and mulch treatments offered advantages over cultivated soil or soil kept bare by herbicide, but with some problems in nutrition management under a heavy added mulch. Further research is necessary to select the best treatments and, very importantly, how to manage them to minimise competition for water and nutrients, while maintaining maximum benefits. The use of sod culture or mulches also has implications for frost risk. Measurements in both the above trials showed lower surface temperatures above a sod or mulch than on firm, bare soil (Figure 4). Whether or not the difference is evident at bud level will depend on the height of the buds above the surface as well as environmental conditions. Hence trellis design, choice of cover crop, sod or mulch species and management in frost danger periods are all-important.

Figure 4: Temperature measurements on the ground surface and at canopy height in the second mulch experiment, taken by a handheld radiometer.



		13/9/88 5.40pm,13oC	14/9/88 6am,3oC Light Frost
BUD TEMPERATURE:	STRAW MULCH	12.2oC	0.0oC
	CHEMICAL CONTROL (almost bare ground)	13.4oC	0.1oC
GROUND TEMPERATURE:	STRAW MULCH	8.5oC	-0.3oC
	CHEMICAL CONTROL	10.9oC	2.6oC

4. A survey of currently used management approaches in MIA vineyards and growers' reasons for their various choices.

During February-April 1989 we conducted a survey of about 40 of the 500-winegrape growers in the MIA, focussing on their soil and irrigation management. Growers were selected with the help of local District Horticulturists to cover the full spectrum of management approaches in use.

Soil and weed management: Practices in the under vine area ranged from cultivation only to herbicides only, as well as combinations of both measures. Reasons for the choice of method included saving costs, avoiding mechanical or chemical injury, and inadequate control with chemicals of problem weeds. During winter, most growers accepted or encouraged some growth in the inter-row area, either natural or planted. Growers differed in the measures they took to minimise frost risk. Practices in the inter- row area during the growing season included frequent cultivation (the traditional method); residual herbicide use (tried and abandoned by many because of cost, resistant weeds, and sealing of the soil in the absence of cultivation or weed growth); and permanent sods, maintained by mowing and or post emergent herbicides to suppress growth (favoured because of low cost and labour requirements, better watering, improved soil structure and less radiation reflection). Various combinations of these measures were used, e.g. to reduce water consumption and competition from a sod during summer. Some growers also preferred a clean inter-row area because of appearance, to avoid water back up on very low slopes and so they could readily see where irrigation water had reached.

Irrigation methods: Almost all MIA growers used some form of flood or furrow irrigation in the inter-row area, because of the topography and the ready supply of water without need to pump. Systems used for flood or furrow irrigation included flooding the entire inter-row area, two broad furrows, or two to four narrow furrows. Reasons for the choice of method included slope (including side slope), length of run, soil type, and whether or not a mulch crop or sod culture was used. Some growers varied between methods over the season or life of the crop, e.g. to minimise water application to young plants or early in spring, or to allow earlier field access. One grower interviewed had overhead sprays because of undulating

topography, and two were using under vine micro jets or micro Sprinklers, one with very satisfying results. Interest had been slow to build in such systems because of the ease and cheapness of flood and furrow methods and because of various perceived problems with them.

Conclusions: This study gave us an insight into current thinking by local growers in regard to soil and irrigation management which will continue to be useful in both trial planning and extension. It was concerning to see the lack of care taken with flow rates and flow duration by Some growers in irrigating their crops: many growers appeared unwilling to spend time and effort on irrigating and were little concerned with irrigation water and drainage costs. These sentiments are likely to change rapidly with recent increases in water charges and make growers very receptive to recommendations for improving their management.

5. Development of management systems for growing vines on problem soils.

Aim: To examine in detail the effects of a range of soil and irrigation management regimes on:

- soil structure;
- irrigation performance;
- vine and root growth and yield;
- temperatures in the vineyard during frost periods.

Method: A major trial with four replicates of six treatments was planted in 1988/89 and trellising completed in 1989/90. Four row plots were used to ensure thorough buffering and enable reliable determinations of vine root growth and yield as well as irrigation performance and changes in soil characteristics. The variety used was *Semillon* on *Ramsey.*

Treatments were decided after consideration of current district practices, the literature and the preliminary trials discussed above. The treatments, all of which have been initiated, are:

1. Standard inter row surface irrigation with frequent cultivation + gypsum applied pre-planting.
2. Standard inter row surface irrigation with frequent cultivation without gypsum applied pre-planting.
3. Under vine surface irrigation with frequent cultivation (+ gypsum).
4.Under vine surface irrigation with a heavy straw mulch (+ gypsum).
5. Under vine surface irrigation with a permanent sod (+ gypsum).
6. Microjet irrigated/mulched vinebank system (+ gypsum).

In addition to the above treatments, two plots at one end of the experimental area were treated with gypsum slotting, as a secondary comparison.

A thorough soil survey was conducted prior to planting, revealing a shallow hardpan and some problems below the surface due to sodicity. For these reasons, the area was deep ripped prior to planting and gypsum included as a treatment.

Two methods of flood irrigation were incorporated in the design, the traditional inter row flood/furrow method and application of the water directly under the vines, because the latter method had performed well on the Research Station in an area planted by Turkington. Both trickle and micro jet irrigation are likely to become important in the future in the MIA, but for the present the trial will concentrate on flood irrigation management. Micro jet irrigation is, however, incorporated in the mulched vine bank treatment.

Results and discussion: The trial is now well established and should continue for several years, so that changes in soil characteristics over time can be monitored and impacts on vine growth studied. New soil measurements have been taken to determine how vineyard establishment and treatments have altered soil conditions. Initial yield and quality data have been obtained but are of questionable value because of the youth of the vines: they indicate lower 'Brix' for the sod treatment than the other treatments, while treatments did not differ significantly for other quality varieties or yield.

Current status: A current Grape and Wine Research Council project (DAN7) is continuing funding of the trial.

IMPLICATIONS AND RECOMMENDATIONS

1. Topsoil depth is an important factor to the ability of the vine roots to obtain water, even under a trickle irrigation regime. At the same time, the water logging experiments indicated that periods of water logging during active growth are harmful, hence temporary ponding after irrigation may be detrimental to vine growth in a field situation. Therefore measures need to be considered for overcoming or avoiding constraints on root growth and water movement due to hardpans or a shallow A horizon. Experiments under way in the current project (DAN7 -*Soil and irrigation management strategies to improve and sustain vineyard productivity)* address that goal in a number of ways. These experiments include the use of sod culture or mulches to improve and maintain soil structure; application of gypsum together with techniques such as "slotting" and "agroploughing" to break through hardpans and overcome sodicity; and accumulation of available topsoil into a vine bank to maximise the volume available for effective root exploration. The vine bank system (similar to the Tatura system) is a drastic solution, but could be generally useful where shallow depth of good topsoil is a problem -e.g. to overcome acidic soils. We plan to follow the impact of those treatments on soil structure, irrigation water entry and drainage and on vine root growth.

2. Our survey of growers highlighted the need to improve irrigation management under furrow or flood irrigation, especially with large price increases for water. The current project addresses that goal. Irrigation management may also need to be changed along with changes in soil management. A further step will be to evaluate trickle and micro jet systems, which have yet to displace flood and furrow irrigation in MIA vineyards.

3. The results of the water logging experiments raise some concerns regarding the use of *Ramsey* rootstock in areas susceptible to temporary flooding. Some vines on *Ramsey* in commercial areas died following recent wet winters (Creecy, pers. comm. 1990). Effects of water logging on vines both in winter and during the growing season and differences between varieties warrant further evaluation.

PUBLICATIONS ARISING FROM PROJECT

Extension articles:

Sinclair P. and McLachlan G. (1989). Soil & irrigation management in MIA vineyards. *Australian Grapegrower and Winemaker* No. 304: 7-11.

McLachlan G.,. Sinclair P. and Freeman B. (1989). Soil moisture conservation using mulches. *Australian Grapegrower and Winemaker* No. ill: 42-44.

Sinclair P., McLachlan G., and Creecy H. (1990). Soil management in vineyards. *Agnote* Reg 5/90/3.

Creecy, H. and Sinclair, P. (1990). Weed control practices in the MIA. *Australian Grapegrower and Winemaker* No 319: 31-32.

Industry seminars:

P.J.Sinclair (1990). Soil management in MIA vineyards. *Autumn Viticulture Seminar 1990* pp 19-23. Hunter Valley Vineyard Association, Pokolbin, 16/5/90.

Conference and Symposia Proceedings:

Freeman B.M. & McLachlan G. (1988). Water use with a permanent sod in an irrigated vineyard. *Vineyard soil and sod culture management* pp 13- 26. (ASVO Seminar 24/6/88, Mildura).

Freeman, B.M. (1989). Effect of soil profile and management on grapevine development and grape quality. *Proceedings of the Seventh Australian Wine Industry Technical Conference* pp 26-28. Adelaide, 13-16/8/89.

Sinclair P. and McLachlan G. (1989). Soil and irrigation management in MIA vineyards. *Proceedings of the Seventh Australian Wine Industry Technical Conference* (Poster Paper) p 245. Adelaide, 13-16/8/89.

McLachlan G., Sinclair P., and Freeman, B. (1989). Soil moisture in mulched vineyards. *Proceedings of the Seventh Australian Wine Industry Technical Conference* (Poster Paper) p 232. Adelaide, 1.3- 16/8/89.