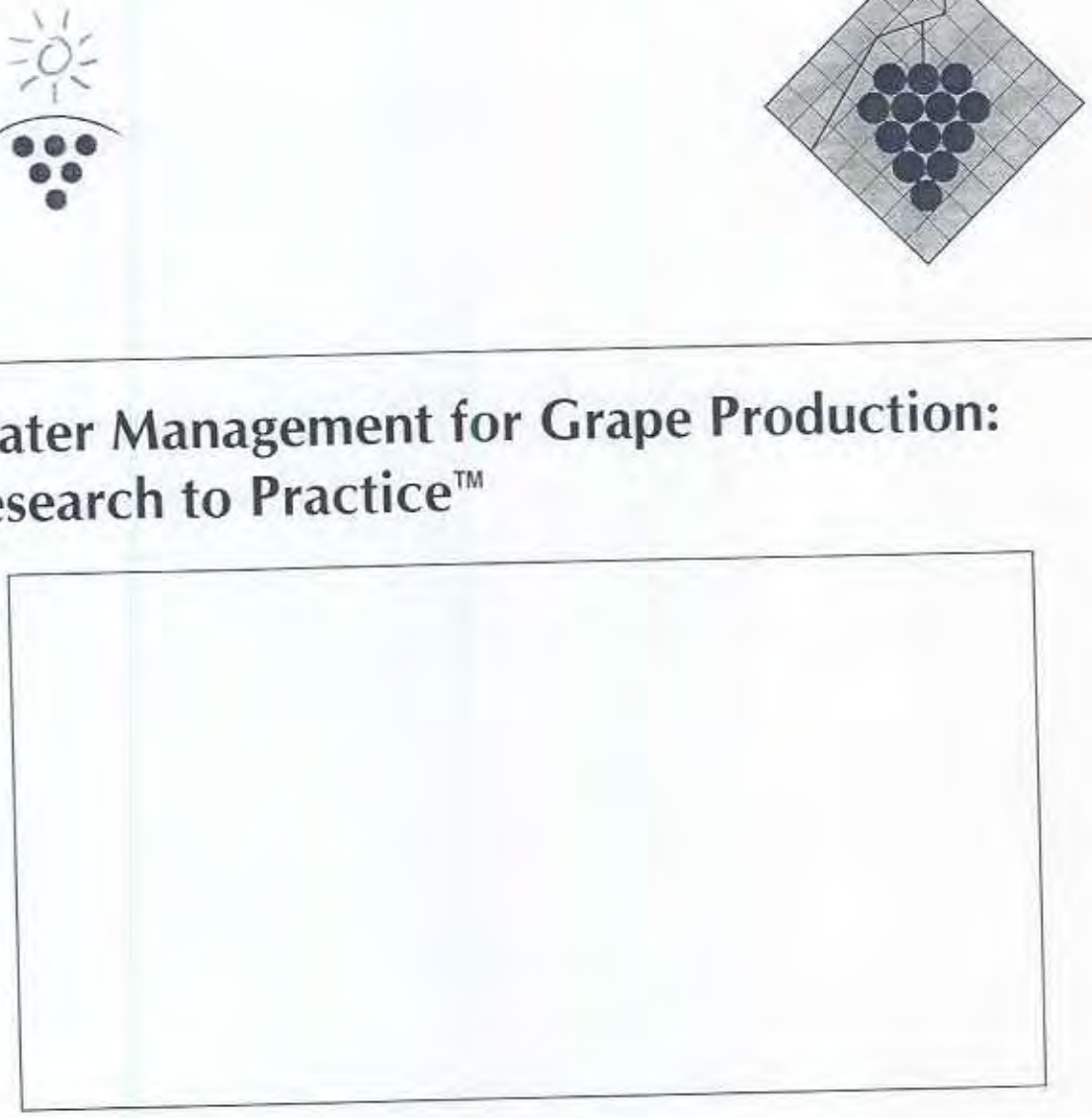
Water Management for Grape Production: Research to Practice™



FINAL REPORT to GRAPE AND WINE RESEARCH & DEVELOPMENT

Project Number: **CRV 97/1**

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Research Organisation: **CRC for Viticulture**

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Executive summary

The Water Management for Grape Production: Research to Practice™ training workshop was based on the format of the successful IPM Viticulture: Research to Practice™ workshop. These are three day workshops, two days initially early in the season, then a third follow up day after harvest. Research to Practice™ workshops are developed using adult learning principles and groups dynamics. They aim to create an environment where participants actively participate in the learning process. Information is delivered in a credible and practical manner and participants are encouraged to take on a new or changed practice at the end of the workshop. This is done in the form of a promise written at the end of the workshop, implemented over the current season then reported on at the follow up third day.

A total of 38 workshops were delivered in 21 regions of Australia to 763 participants. There were 42 presenters involved in the development and delivery of the workshop from a number of different agencies and companies Australia wide.

The workshop format and content was continually developed during the project. Feedback from the participants and presenters contributed to the development of the workshop. The aim of the changes were to make the content more relevant to growers and provide information in a format that was easy to understand, while still providing enough information to make growers confident enough to implement changes.

Overall the response to the workshop was extremely positive. Participants were generally very happy with the content and format of the workshop. The most significant impact the workshop had was to indicate the importance of soil moisture monitoring as part of a management strategy. This was reinforced by the extremely high number of participants who indicated installing equipment or increasing the frequency of monitoring as their promise. Nearly 4 times as many participants promised this than the next popular promise of trying Regulated Deficit Irrigation. Feedback at the third day indicated that participants observed savings in water use as a result of monitoring soil moisture. Many felt their irrigation management improved with subsequent improvements in berry quality and/ or vine health also observed.

Another activity that rated highly was the field session activity and the importance of knowing the vine root depth. Many participants at the third day indicated they had investigated these issues and the follow up phone survey conducted in 2001 indicated the session had a lasting impact on participants.

Follow up evaluation of a proportion of participants in a phone survey indicated that many continued to make changes in management after attending the workshop. Many also indicated that the workshop was part of a process of gathering information about various aspects they wanted to change, but generally not the only source. Many also indicated that often the workshop gave them the confidence they needed to implement a change they had been thinking about. Other comments indicated the value of integrating soil and irrigation management in one workshop. Surprise was often expressed after the workshop at the amount of soil information include but the value of it was quickly appreciated.

Overall the objectives of the project were achieved and in some cases exceeded. The continued support of the industry to the Research to Practice™ program indicates how highly valued it is. Planned improvements and continued development will ensure the Water Management for Grape Production: Research to Practice™ workshop continues to meet the needs of industry, ensuring best practice soil and irrigation management is maintained in the Viticulture industry.

Water Management for Grape Production: *Research to Practice*

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Introduction

Background to Project

Significant investment in research within the field of soil and water management had resulted in a number of novel management approaches available for implementation. Advances in the areas of irrigation management (RDI and PRD), salinity management, optimising soil resources and modelling vine physiology all had the potential to significantly improve the performance of soil and water management and end product quality. There was a requirement for these technologies to be delivered to industry in a useable form, resulting in practitioners confident enough to change practices by adopting the best available methods of production and management, having been through a positive learning process.

The aim with the 2 day training course was to standardise the content and principles being demonstrated and provide direct access to researchers from around Australia. Issues specific to various regions would be accommodated through a flexible system of delivery. A follow-up session after harvest provided participants with the opportunity to re-enforce the practices and principles discussed on the first two days. The third day also provided valuable feedback to the course designers and speakers.

The Research to Practice™ (Viticulture) concept has been developed specifically to facilitate the incorporation of research outcomes into practical and economically feasible strategies and practices for vineyard management and grape production in each viticultural region of Australia. The concept was developed at the Institute of Horticultural Development (IHD), Knoxfield (Agriculture Victoria) with the support of a team of research staff from a number of participating agencies of the Cooperative Research Centre for Viticulture.

The training program was modelled on the successful program IPM Viticulture: Research to Practice™. This training program is a 2 day structured interactive workshop with groups of 25 in each region. The IPM workshop focussed on current knowledge and then challenged each participant to commit to adopting a new technique based on greater confidence in scouting and monitoring and the strategic approach, as opposed to the traditional calendar approach to pest and disease management. During the development of the IPM workshop (CRV 94/4) considerable time was spent on embedding adult learning principles into the workshop structure. Considerable thought was given to the best format for adult learning and also the form in which information was delivered. The response from this program provided the industry and researchers with sufficient confidence in the model to adapt it to training for soil and water management. Several of the principles used in the IPM project were directly applicable to the Water Management for Grape Production: Research to Practice™ training workshop.

The principles of Research to Practice™ are detailed in the manual Demonstrating Best Practice in Vocational Education and Training, developed by the Departments of Natural Resources and Environment, and Education. This manual is part of the final report for the IPM Viticulture: Research to Practice™ project and can be accessed at the Grape and Wine Research and Development Corporation. These concepts were further refined during the development of the water workshop. Increased focus on the group sessions during the workshop provided the project with the opportunity to implement problem-solving sessions. These provided participants with the opportunity to focus closely on problems and issues they would find in their own vineyards and possible management scenarios they could implement after the workshop.

Objectives

The objectives of the project are as follows.

1. To provide Australian wine grape growers with a training framework to enable greater uptake of best practice in soil and water management for the production of wine grapes to specification.

2. To establish an avenue for improved and broader access to the outcomes of viticultural soil and water R&D in a consolidated, practical training format with a network of quality, commercially supported trainers.

3. To integrate the management of the soil resource with irrigation practices.

4. To enhance the management capacity and confidence of wine grape growers in initiating improved soil and water management practices.

5. To improve water use efficiency, product specification and enterprise performance through the adoption of 'best practice' soil and water management.

The Workshop

The workshop program

Research to Practice™ is a three-day workshop designed to promote the uptake of new soil and irrigation management strategies. The concept was developed by the Cooperative Research Centre for Viticulture with the education team at the Institute for Horticultural Development, Knoxfield, Agriculture Victoria. The three-day workshop is broken into two days initially then a third (follow-up) day after harvest. Central to the success of the workshop is the commitment of each participant to a promise (or learning contract) at the end of the first two days. This encourages growers to implement something new they gained from the workshop, with the opportunity to discuss the results and any problems at the follow-up day. An important part of the workshop process is ensuring that participants are comfortable during the learning process. Where venues are uncomfortable due to climate (both hot and cold), or there are distracting noises around the venue, participants understandably find it difficult to concentrate. To address this problem the Research to Practice™ team has endeavoured to be more specific about the venue requirements when discussing the hosting of a workshop with groups.

The workshops were delivered across all viticultural regions of Australia, with grape grower organisations, wine companies and others taking the responsibility for hosting the workshops. This involved coordinating the participants, booking the venue, catering and liaising with the workshop facilitator. The workshop facilitator was responsible for organising presenters, workshop equipment, travel and accommodation, plus other details as they emerged. The project coordinator developed the presentations in consultation with speakers, discussed the presentations with speakers highlighting possible questions and issues and kept the manual up to date. In this program the workshop facilitator and project coordinator were generally the same person, making the delivery of the workshops easier, but the load on one person quite heavy. While providing a large number of benefits to the program, this structure also has the major flaw of relying heavily on one person. If

problems arose with the availability of the project coordinator/ facilitator there were subsequent problems with program delivery. This issue was partially dealt with by increasing the number of facilitators familiar with the workshop. As part of the on-going development of the project, further efforts will be made to train more facilitators. Accessing facilitators from non-traditional areas (ie outside the viticulture industry) will also be investigated. Options include registered training providers and TAFE's.

The workshop structure

The workshop structure is based on the IPM Viticulture: Research to Practice™ workshops. When developing the workshop, adult group learning dynamics were considered. Foremost was the fact that most participants are generally very active people during the working day. The program for the workshop needed to take into account their not being used to sitting for two days and to provide timely breaks and adequate activities for them to interact with others in the group. The program for the workshops (figure 1) was also developed starting with the information needed to manage soil and irrigation in vineyards. This dictated starting with the basics, grapevine growth, soil requirements and soil and water quality, then moving into the sessions on specific management issues.

Figure 1: The program for the first two days of the Water workshop

Day 1

8.15	Registration
8.30	Introduction
9.00	The grapevine
9.30	Soil requirements to grow grapes
10.30	Break
10.45	Soil and water toxics
11.30	**Product targets (Group session)**
12.30	Lunch
1.30	Soil preparation for new vineyards
2.15	Managing soils in established vineyards
3.00	Afternoon tea
3.15	Soil pit demonstration including use of pH and EC meters, soil survey
5.00	Drinks.

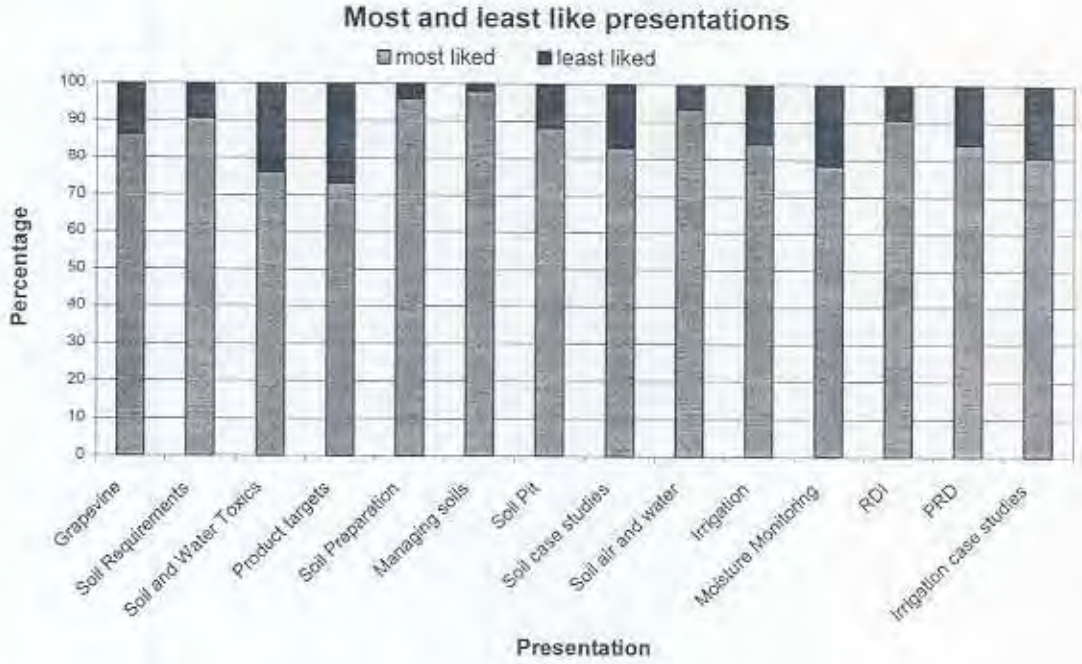
Day 2

8.30	**Case study on soils (Group session)**
10.00	Soil, air and water
10.30	Break
10.45	Irrigation
12.15	Soil moisture monitoring equipment
1.00	Lunch
1.30	Irrigation to meet product specification
2.00	Partial root zone drying
2.30	Break
2.45	**Case studies on irrigation (group session)**
3.30	Finish up with action plan
4.00	Finish

The first two days

The first two days of the workshop are highly structured and very busy. Participants are required to concentrate for extended periods of time and it is obvious by the end of the two days that they are tired and have had enough. Participants evaluate the structured content of the workshop and their comments and criticisms used to further develop the presentations. Overall, the feedback about the presentations is extremely positive (figure 2), with all the presentations liked by over 70% of participants. It is quite common for workshop participants to indicate that they liked all of the presentations delivered.

Figure 2: Responses from evaluation sheets regarding the presentations



It is important to note that the two highest rating presentations are the soils topics covered in the first afternoon (soil preparation and managing soil structure). Many participants underestimate the importance of soil management with respect to irrigation and find these two sessions the most useful. This re-enforces the decision to integrate soil and water management in this workshop and not deal with them as separate topics.

Workshop development

The Research to Practice™ process is very dynamic and workshop programs change rapidly as feedback and participant's needs are analysed. Presentations change from one workshop to the next not only to take into account regional variations, but also in response to evaluation by the participants and speakers. The program for the Water Management workshop has evolved through a number of forms, table 1 below shows both the original program and the current program. This provides some indication of the changes that have occurred over the three years.

The major changes to the program occurred after the pilot series of workshops. Cosmetic changes to the grapevine presentation were made as a result of increasing the number of people who presented this section. It was originally designed and presented in conjunction with Mike McCarthy, however newer speakers required more prompts and speakers notes. The *What is Soil?* and *Water Quality* presentation development is discussed in greater detail in the next section as an example of the processes that occurred during workshop development. The two sessions in the afternoon on soil were re-packaged so that the information was presented from a vineyard management perspective. As part of the development process questions such as "what do participants want to know", "what parts of the information we have are most relevant to them" and "what is the take home message" were used as guides to aid development. Further changes to these two sessions are planned.

Table 1 Changes to the workshop program during the 3 years of the project

Changes to workshop program	
Original Program	**Current Program**
Day 1	
Registration Introduction Grapevine Growth What is Soil?	Registration Introduction The Grapevine Soil requirements to grow grapes
10.30 Break	
Water Quality What are my current grape specifications	Soil and water toxics Product targets
12.30 Lunch	
Use of pH and EC meters Soil limitations to grape production Managing soil structure	Soil preparation for new vineyards Managing soils in established vineyards
3.00 Afternoon tea	
Soil pit demonstration of soil survey techniques	
Drinks	
Day 2	
How do I manage my (different soil issues) Irrigation systems	Case study on soils Soil, Air and Water Irrigation part 1
10.30 Break	
Soil/water/vine relationships Irrigation scheduling	Irrigation part 2 Soil moisture monitoring equipment
1.00 Lunch	
Irrigation to meet product specification	Irrigation to meet product specification Partial rootzone drying
2.30 Break	
What are my current practices (irrigation issues) Finish up with action plan	Case studies on irrigation Finish up with action plan
Finish	

The field session became one outside activity, instead of two (table 1, original program). This was mainly so that time commitments could be adhered to and feedback from participants indicated that it was difficult to link this activity to soil management issues.

Including it in the field session at the end of the day provided a context for determining soil pH and salinity. The group sessions are discussed in detail further on in the report.

Day 2 has been significantly revised during the project. It was a challenge to incorporate the irrigation information into the workshop. One of the main problems with irrigation was what level of detail about basic irrigation should be included. There are a substantial number of workshop programs around which deal with the basics of irrigation. We did not want to duplicate these, but were also aware that participants of this workshop may not have attended an irrigation workshop before. We needed to find a balance between providing enough information so that the rest of the irrigation management sections were meaningful, but not replicating what other training programs do. The irrigation presentation has been through a series of evolutions, resulting in a presentation which covers the basics, gives participants some tools they can use when irrigation scheduling and leads them into the more technical irrigation management strategies of the afternoon. There has been some feedback about the order of presentations on this day. Many participants are very interested in the irrigation to meet product specification and Partial Root Zone Drying sessions, however by the end of the second day when they are presented are feeling very drained. This causes them to not be able to give it the attention they feel it deserves. This issue will be discussed with various members of the delivery team with a view to re-arranging the day so that the irrigation management strategies are covered earlier in the day.

An example of presentation changes

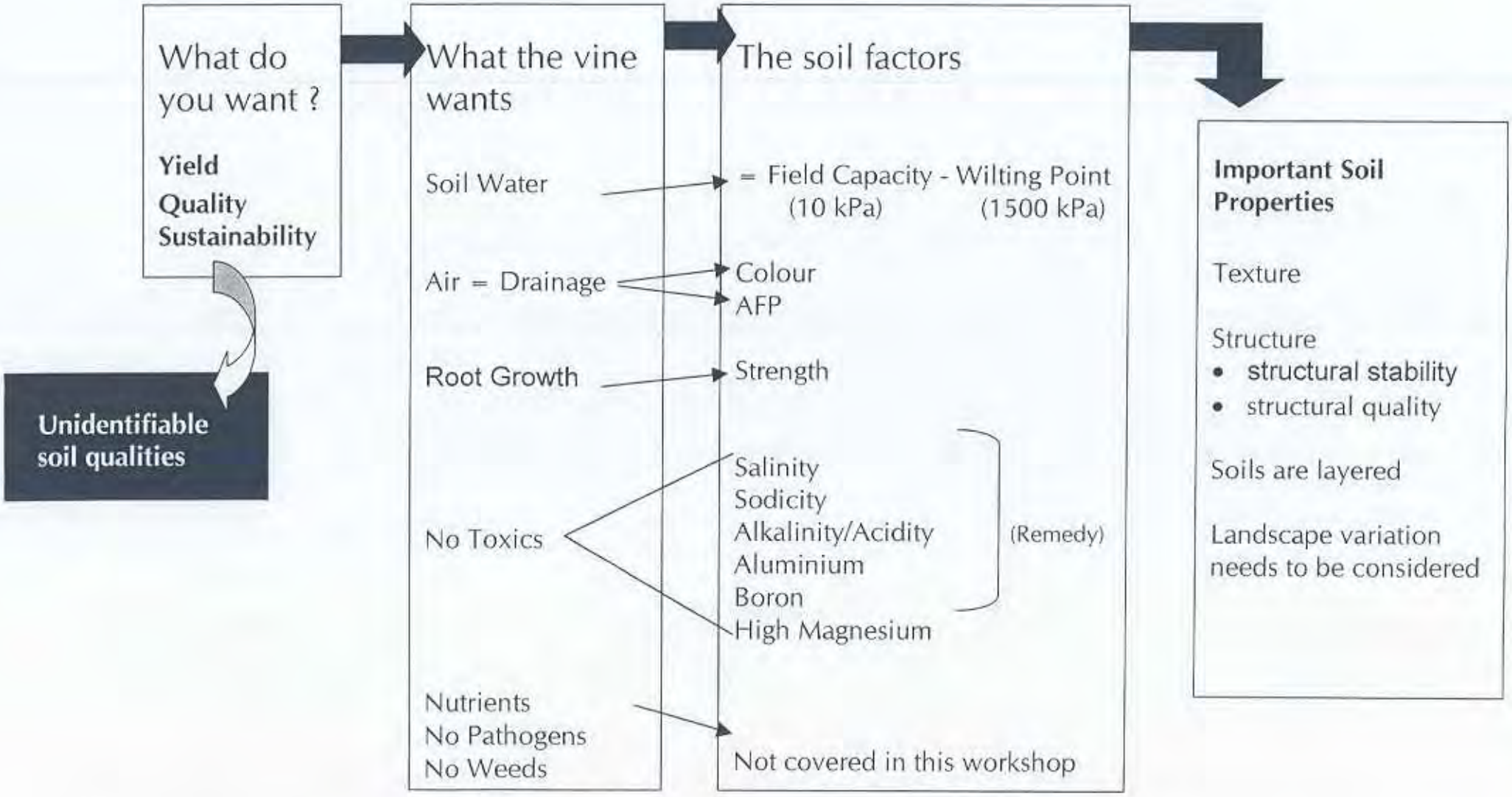
One very good example of how presentations and information delivery changed as a result of feedback is the Soil requirements to grow grape presentation. This presentation started as What is Soil ?, and was a very dry session on the basics of soil physics and chemistry. The structure of the session was as follows:

- Soil composition
- Soil depth
- Texture
- Colour
- Structure - Structure quality – RAW, PAW, Air-filled porosity, compaction
  - Structure stability
- pH
- Salinity
- Sodicity
- Carbonates

However as a result of feedback from participants and speakers, the session was approached in terms of "what is it that growers really want to know about soil?" The answer to that question became the new title of this session, *Soil requirements to grow grapes*. The session became more interactive, with presenters asking a series of questions of the participants and the answers moved the presentation along. The slides were re-developed so that each one built on the next and participants could see how each piece of information related to the whole (Appendix 1). The speaker's notes (figure 3) show the thought process behind the redevelopment and provided the basis for building the new presentation. All the soil chemistry information was removed due to significant duplication of concepts in this presentation and the water quality section. The soil chemistry information was combined with the water quality presentation and re-named Soil and water toxics. The concepts that apply to both areas were discussed, and then the specific benchmarks for soil and water were presented. These two sessions now work very well together.

Figure 3 Presenters notes for "Soil requirements for vine growth"

The boxes with borders are the questions asked by the presenter, participant's answers make the presentation occur.



The group sessions

There are three group sessions during the workshop, which provide opportunity for participants to look at issues in more detail than is possible during the presentations. The group sessions occur before lunch (Product targets, 11.30 am) on the first day, first thing in the morning (Soil case studies, 8.30 am) and just before the promise session (Irrigation case studies, 2.45 pm) on the second day (figure 1, highlighted sessions). The group sessions involve breaking the participants into 4 groups of 4-6 depending on the total number of participants. The value of the group sessions is in the opportunity it provides for the participants to get to know each other in smaller groups and find out their interests and ideas. The larger group during the workshop can be intimidating to some participants and they will not ask questions. However during the group sessions they can target people of interest and interact without the pressure of the whole group watching.

The group sessions changed as the workshop progressed to more accurately reflect the needs of growers. Originally the group sessions were very similar to those used by the IPM workshop. They focussed each small group on one issue and asked the following questions:

- what are you currently doing?
- what would you like to change?
- what do you need to make that change?

The feedback about the group sessions was overwhelmingly positive with 88% of participants finding them useful, only 1% did not find them useful at all. Comments about the group sessions indicated that the interaction and opportunity to meet people was most beneficial. Many people found the problem solving sessions (case studies) really helpful, giving them ideas they could try in their own situations. Where there were negative responses to the group sessions the comments indicated that mainly the problems were with personalities within the group. Participants disliked overbearing members of the small groups as they limited interaction between the group. One person disagreed with the concept of a group session completely and thought the time would have been better spent with the presenters talking. While this comment is valid, the significant positive response to the group sessions indicates that overall participants gain many benefits from contributing to these sessions.

Case studies

Two of the sessions were developed as opportunities to run through some case studies of real life situations the participants might have to deal with: one session on soils and one on irrigation. For the soil case studies, each small group was given a soil profile and description and asked how they would manage that soil in an established and in a new vineyard (example in appendix 2). There were a total of 18 case studies developed for this session (table 2), during the first full year of workshop delivery, only case studies 1 – 5 were available and of them 1, 2, 4 and 5 were the most commonly used. Case study 3 (calcareous clay) was relevant mainly to the Riverland/ Sunraysia districts. For the second full season of workshop delivery (1999) further case studies were developed during the year and used as required. However, case studies 1, 2 and 5 then became the most commonly used as they represent the most common vineyard soil problems in Australia.

Table 2: Soil case studies developed for the second group session

Case study number	Soil type / problem
1	Brown duplex, strongly bleached A2
2	Yellow duplex, compact
3	Calcareous clay
4	Terra Negra, shallow soil
5	Red brown earth, hard set and compact
6	Not used
7	Yellow duplex, highly degraded
8	Black cracking clay, shallow
9	Yellow duplex, bleached A2
10	Saline sand
11	Red brown earth, compact
12	Terra Brun, saline
13	Brown earth, saline
14	Red brown earth
15	Brown sand, compact
16	Brown duplex, compact
17	Yellow duplex, bleached A2
18	Saline yellow sand

Feedback from the evaluation sheets indicated that 83% of respondents liked the soil case study session and many commented on the usefulness of the case studies. The comments/feedback that each group was given by the expert in attendance was also highly regarded. The irrigation case studies are 4 scenario's and problems which participants were asked to comment on and talk about their management of these situations. This session helped tie the two days together and focussed participants on some of the management options they may have to consider with their future irrigation management.

Product targets

The first group session of the workshop proved to be more difficult to develop. The focus of this session was on how to achieve grape quality specifications using soil and irrigation management. The solution was to concentrate on the end product of the vineyard – the wine. This session has evolved into a blind tasting of two reds and two whites, which are preferably vineyard specific wines (ie straight varietals, and the same variety), from the same vintage. Participants answer a series of questions about the wines by themselves (Appendix 3) and then break into small groups and think about how they would manage their soil and irrigation to produce the fruit that made the wines they tasted (Appendix 4). This session generates enormous discussion and debate as well as providing relaxation and fun for the group. There are two obvious benefits resulting from this session: it focuses participants on end product and how their management affects it, and it incorporates important aspects of adult learning and contributes to group dynamics. The change in the group after this session is obvious as they have more confidence about asking questions of speakers and discussing issues among themselves. Feedback on this session indicates that it has the lowest approval rating of all the sessions (78 %), and general comments on this session indicate higher ambivalence towards this session than the other group session. However there are also some extremely positive comments about this session and the value of it. One reason for the negative comments is due to some participants having no experience with the process of wine tasting and analysis. This exercise can be confronting

for them and they require more personal contact from the facilitator during this session than other more experienced participants. However at the end of the exercise when they see the conflicting opinions about the wines, this has a big impact on how they view the session. Another problem with this session is getting the right wines. If it is impossible to get the wines required, then the session loses its relevance and participants find it difficult to get value from the principles the session tries to promote. It is worth the spending the effort before the workshop trying to track down the right wines for this session.

The field session

The field session of Research to Practice™ workshops is used to show how the theory discussed works in practice in vineyards. For the water management workshop, the field session results in participants completing a small soil survey. One or two soil pits are dug in nearby vineyards and the first day ends with drinks in the vineyard. The soil survey involves participants applying what they learnt in the morning sessions about soils. The survey form they fill out (Appendix 5) leads them through the terms used by soil surveyors, and also gives them experience with some of the equipment that is useful for monitoring pH and EC in vineyard soils. The field session is popular (88% of respondents liked the session) as it reinforces the concepts discussed and shows growers some helpful tools they can use to monitor soil conditions in their own vineyards. When the follow up survey was conducted the soil pit session rated highly as something that they remembered from the workshop that had an impact on their vineyard management.

The major fault of this session is that it is at the mercy of the weather. Soil pits tend to collapse with high rainfall and being outside when it is windy and raining is not pleasant. We have been fortunate to have only very few sessions with these problems, and overcome them by taking some soil samples with us and running participants through the use of electrical conductivity meters and pH meters inside.

The promise

An integral part of the Research to Practice™ model is the promise filled out by participants at the end of the first two days. The promise provides them with an opportunity to plan and implement a new practice in their vineyard. This activity proved very successful with the majority of participants having no difficulty finding something from the workshop that they would like to try out in their vineyard.

The promises from all workshops have been collated and grouped into broad categories (table 3).

Table 3 Summary of the promises made by participants

Promise	Total	Promise	Total
Soil moisture monitoring	223	Monitor salinity	2
Try RDI	88	Permanent cover in mid row	2
Collect soil data, dig pits	72	Renovate cover crops	2
Measure root distribution (calculate RAWs etc)	38	Time Management	2
Irrigation plans	30	Wetting pattern of soil	2
Manage soil structure	29	Wheel track compaction	2
Improve record keeping	25	Business planning	1
Assess water use/scheduling	24	Cab Sav health	1
Try PRD	21	Change from overheads to drip	1
Determine irrigation efficiency	13	Consider and trial new ideas	1
Change irrigation system	10	Drainage	1
Measure irrigation application rates	9	Effects of evaporation and vegetative shading	1
Expand RDI and PRD trials	7	Ensure irrigation supply	1
Improve quality	7	Exploit consultant	1
Measure water quality	7	Gypsum injection trials	1
Mulching	7	Improve drainage	1
Pass on knowledge	7	Improve vine health	1
Continue learning	5	Irrigate to soil type	1
Use gypsum deep ripped	5	Leaf stem water contents and vine health	1
Monitor pH and EC	4	Monitor soil temp and root growth	1
correlate vine and soil water status	3	Monitor test wells	1
Mounding	3	Optimise canopy growth	1
Achieve fruit specifications	2	Photonomy and water stress	1
Evaporation pan use	2	Rectify sandy patch	1
Fertigation	2	Ripe fruit with no disease	1
Improve knowledge of system	2	SAR of water and soil	1
Irrigate after harvest	2	Sub-surface Irrigation	1
Maximise yields	2	Sustainable irrigation	1
Mid row compaction	2		

Table 3 shows that there were quite a variety of promises made by participants, which indicates that all aspects of the workshop were valued. The total number of promises made is higher than the number of participants who attended workshops as some people made multiple promises. Of interest is the promise that rated the highest, soil moisture monitoring. As a practice, soil moisture monitoring can have a significant impact on the water use efficiency and irrigation practices of the industry and it is gratifying to see participants take up this practice enthusiastically. Anecdotal evidence indicates that growers have made significant changes to their irrigation practices as a result of implementing some kind of soil moisture monitoring regime, and this is born out by some of the results of the phone survey discussed further on.

The final day

Integral to the success of promoting changes in practices and the uptake of new research is the third 'report back' day. This day is held following the harvest after the first two days. The timing of this day allows participants to complete their promise and report back on how well the changed practice integrated into their vineyard management.

One problem we have with the third day is the number of original participants who attend. On average about 50 % return for the third day. This is an issue for the Research to Practice™ team and is currently being addressed. We are investigating better advertising of the benefits of returning for the third day and emphasising the importance of it at the first two days and when the information letters are sent to participants notifying them about the third day.

The participants who attend on the third day fill in an evaluation sheet, which indicates what changes they have made during the season. This information is discussed later in the report. General comments about the third day indicate the relaxed atmosphere and ability to interact and participate more is valued very highly. Some people commented that the third day was 'necessary', probably due to the consolidatory nature of the day. Many enjoyed the opportunity to share experiences and the information presented on soil biology.

The future

New Partial Root Zone Drying (PRD) results

New information about PRD and its implementation will be available after this vintage. There are a number of projects in the CRCV which incorporate PRD into a whole of vineyard management system. These projects will start generating valuable information over the next three years and this information will be valuable to the program. It is also important to access commercial implementation of PRD and their experiences and incorporate these into the workshop.

New soil management information

The research of PhD student Andrew Dowley investigating the effects of seasonal soil saturation on grapevine roots. He discovered that saturation results in a significant reduction in root length density, which can seriously impede the water extraction from subsoils during spring. Soil mixing has shown to improve drainage and root survival during winter/spring. The presentation for the workshop will focus on the methods and results of the soil mixing experiments.

Soil management presentations

There are plans to re-arrange the sessions on soil management given on the afternoon of the first day. Feedback indicates that participants are interested in soil management on an issue basis. Individual presentations will be generated on managing compaction, hard setting and crusting, salinity, deep ripping etc and will incorporate all the information currently discussed as well as new aspects about soil management.

Structure of second day

As mentioned earlier feedback from participants has indicated that they are more interested in hearing about the irrigation management strategies earlier in the day. Discussions will be held with various irrigation researchers (Ian Goodwin, Mike McCarthy, Brian Loveys and Peter Dry) on re-arranging the schedule for the second day to accommodate this request.

All presentations and manual

The workshop manual and presentations will be reviewed and updated this year, as the results of recent studies become available. Further information on grapevine growth will be added, the soil moisture monitoring equipment session will be revised to include recently released products and the RDI presentation will be reviewed to include any new information gained from the commercialisation of the method.

The third day

A short introductory presentation covering some of the information covered in the first two days will be developed for the third day. This will help introduce the topic again to participants and focus them on some of the issues that may have arisen during the season. It will also provide participants who have not completed their promise with ideas about other changes they may have made as a result of the workshop.

The workshop delivery

In the first year of the project six pilot workshops were delivered, 17 and 15 workshops were delivered in years 2 and 3, respectively.

Workshop locations

There were a total number of 38 workshops run over the three year life of the project. The total number of participants who filled out enrolment forms was 763. There were also a number of participants who attended as part of their training to become presenters as well as people from Agriculture departments in all states.

Table 4 details the number of workshops and participants in each region. The location of workshops dictated what information from the soils presentations were delivered. For example, in regions where calcareous soils were not present this information was omitted from the workshop. The availability of irrigation water in a region also influenced how the "Irrigation to meet product specification" presentation was given. In areas where water was restricted the focus of this session was at what time of the growing season could managers reduce the amount of irrigation with minimal effect on the end product?

Some of the proposed future changes will enable greater flexibility in the delivery of relevant information to participants of the workshops.

Table 4: Breakdown of number of workshops in each state and corresponding number of participants

State	Number of workshops	Number of Participants
South Australia	16	359
Victoria	9	156
New South Wales	7	132
Tasmania	1	25
Western Australia	4	76
Australian Capital Territory	1	15
Total	**38**	**763**

From table 4 it is obvious that the majority of workshops were held in South Australia. When these numbers are further broken down into regions (table 5) it is significantly obvious that McLaren Vale was a region which participated in the most workshops. There are several reasons for this. The biggest is probably the introduction of a prescribed wells area into the region, restricting the amount of water irrigators are allowed to use from underground sources. This resulted in a reduction of the amount of irrigation water available to irrigators, and in some cases the amount was considerable. Many attended the workshop to learn more about irrigation practices that reduce their water consumption. Another factor contributing to the large response from this region was the support of one of the major wineries in the region. The company viticulturist organised and hosted a number of the workshops as well as contributing to the presentation and general discussion. This input was valuable to the group, as they were able to find out more about the requirements of the company they were selling grapes to.

Table 5 Number of participants and workshops in each region on a state by state basis.

State	Region	Number of workshops	Number of participants
South Australia	McLaren Vale	5	112
	South East	3	56
	Adelaide Hills	2	44
	Barossa Valley	2	32
	Clare Valley	1	25
	Riverland	1	22
	Langhorne Creek	1	30
	Adelaide	1	20
Victoria	Sunraysia	3	60
	North East Victoria	2	33
	Yarra Valley	2	33
	Central Victoria	1	17
	Great Western	1	13
New South Wales	Griffith	3	45
	Cowra	1	14
	Hunter Valley	1	23
	Mudgee	1	31
	Orange	1	19
Western Australia	Margaret River	2	48
	Manjimup	1	12
	Albany	1	16

Workshop Participants

A broad break down of the sectors from which participants came from within the industry is listed in table 6. It is difficult to break down the first category into growers and employees of smaller companies, as this information is not available. Knowing this information would provide some indication of how well we are accessing a sector of the market that has relatively limited access to scientists and technical experts. This information would more importantly indicate what percentage of the owner/growers we are not accessing and help with the development of programs to target these people.

Of significance also is the large attendance by employees of the largest 4 corporate wine companies. Both Southcorp and BRL Hardy hosted workshops, Southcorp specifically for its vineyard managers and technical officers and BRL Hardy for its growers. Some of the smaller wineries also hosted workshops where participants were a mixture of employees and growers, these include Alambie in Mildura and Rosemount in McLaren Vale.

Table 6: Breakdown of origins of participants to the workshop, taken from their enrolment details.

Growers, small companies, contract management	70 %
Corporate employees *(Employees of Southcorp, Orlando, BRL Hardy and Mildara Blass)*	19 %
Others *(Agri-business, TAFE, University and Ag Department Employees)*	11 %

Evaluation of impact

Workshop evaluation

As stated previously, Research to Practice™ workshops are dynamic and change in response to feedback received from participants and speakers. Feedback was sought from participants in the form of evaluation sheets they filled in at the end of the first two days as well as the third day.

The evaluation for the first two days was focussed on the information presented, how relevant and useful it was and whether participants viewed the workshop as good value. The third day evaluation focussed on the changes in practice that participants had made during the previous season. There was also information gathered about how they viewed the process of making, completing and reporting about their promises.

2001 evaluation

As part of the evaluation of the impact attending the workshop had on the management of participant's vineyards, a phone survey was conducted in March 2001. The questions asked were based on the original objectives of the project proposal and are outlined below.

1. Did you change a practice as a result of attending the workshop? List what practices have changed? Was that changed practice part of your promise?

2. Have you expanded your promise or tried other new soil or irrigation management practices since the workshop?

3. What benefits have you observed as a result of attending the workshop? (eg *water savings, improved soil conditions, less erosion, better fruit quality etc. Multiple benefits vs single benefits)*

4. Can you put an economic value on the benefits? Did it cost more or less/ did you make or lose money? What was the driving force behind making the change?

5. Thinking back to the workshops, what was it that made the biggest impact on the way you view your soil and irrigation management?

There were 47 people surveyed from all the regions in which workshops were held. A proportional system was used to determine the number of people surveyed in each region, depending on the percentage of original participants in that region. The survey included participants from the pilot series of workshops in 1997, which made answering the survey questions somewhat difficult as it was so long ago and they had changed quite a few practices since the workshop. Despite this, all respondents to the survey had positive things to say about what they observed. It was difficult for survey participants to put a dollar value on the changes they had made as very few had even thought about the economics of making the changes. Ways of addressing this problem are discussed under objective 4 and 5.

The impact

Objective 1

To provide Australian wine grape growers with a training framework to enable greater uptake of best practice in soil and water management for the production of wine grapes to specification.

The development of the Water Management for Grape Production: Research to Practice™ training workshop was designed to meet objective one. The most significant aspect of the workshop that induced participants to make change and implement best practice soil and water management was the process of making, completing and reporting back on a promise. The feedback obtained from the third day participants indicates an overwhelmingly positive response to this process. Of the participants, 75% indicated that they had changed a soil or irrigation practice after the first two days. When asked for details, the range of changes is quite large, with 15 different changed practices listed. Twenty seven percent of the participants who changed a practice increased their monitoring of soil moisture. Corresponding to this outcome was the percentage (79%) of participants who based their management decisions on the monitoring results. This value is higher than the percentage that made a change, possibly due to some of the participants who ticked "no for the first question already had soil moisture monitoring equipment installed but increased the frequency of monitoring and felt more comfortable with using the information. The results monitoring had on their management decisions is significant, with the following changes occurring:

- changed timing and amount of irrigation
- varied irrigation in response to monitoring information
- changed irrigation to fit grape variety and
- dug holes to determine moisture status.

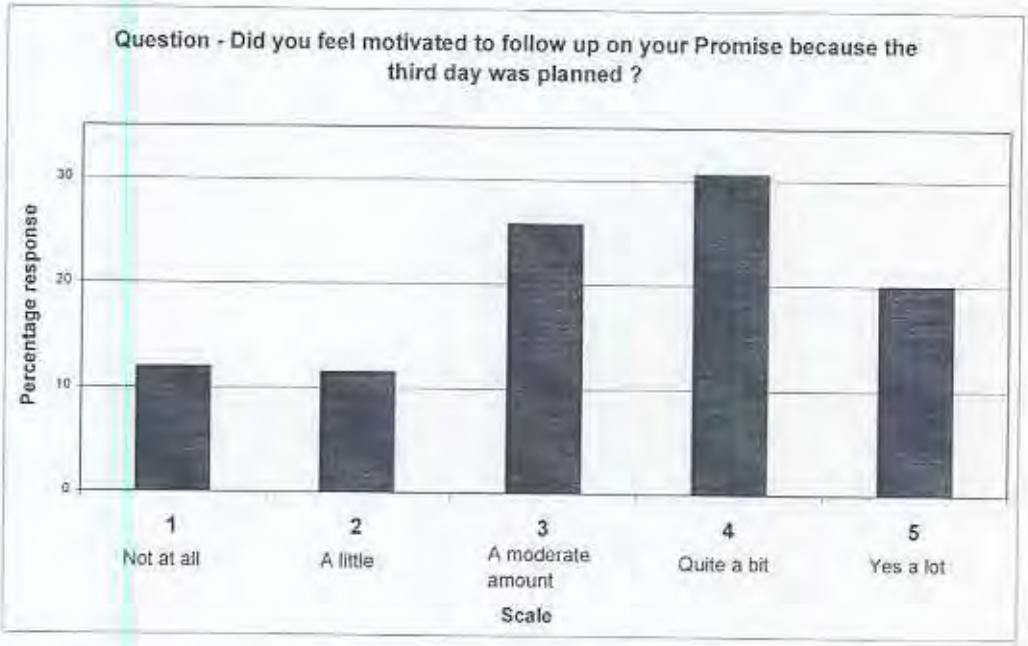
Corresponding to the increase in soil moisture monitoring, 21% of third day participants changed the nature of their water use; within this group the nature of the change varied. Some irrigated using larger volumes less frequently, and some irrigated for shorter periods more frequently. Of the 21%, 17 people irrigated less and used less water and 2 had changed their irrigation practices to suit soil types better.

The impact of the workshop and implementation of a promise is perhaps best summed up by one participants comment on the third day evaluation " Planned when and how much water to put on as opposed to simply turning on the pump whenever"

However, it is not enough just to have an impact on vineyard management immediately after the workshop presentation. Crucial to the success of the objective to "further develop the existing wine industry 'learning' culture of innovation and cooperation to compete" outlined in the Australian wine industry vision 2025 is the continued implementation of best practice and change by vineyard managers. The follow up phone survey conducted in March 2001, asked participants about their changed practices since the workshop. Sixty eight percent of people surveyed had expanded on their promise or tried a new soil or irrigation management technique since the workshop. This indicates that participants of the workshops were able to identify the benefits made by implementing best practice and continued to do so as more information became available or they were in a position to make the changes.

Of interest also is that of those who changed a practice as a result of attending the workshop, 63 % indicated that the changed practice was part of the promise they made at the workshop. Since the main focus of this objective was to provide a framework to enable uptake of best practice, and the information discussed in the workshop was best practice, it is reasonable to assume that the process of filling out a promise impacts on vineyard managers and their inclination to make change. However, information from the evaluation of the third day of the workshop showed that the fact they made a promise was not the only factor that motivated them to make the change. Participants were asked to assess their motivation in keeping their promise with the knowledge that it would be discussed on the third day (figure 4). Half the participants rated their motivation to do the promise due to the third day at 4 and 5, the other half from 1 to 3. This is interesting as it indicates that the report back process is not the major reason for people making changes in management. This attitude probably contributes to the high percentage of phone survey participants who indicated that they had expanded on or implemented new practices since the completion of the workshop.

Figure 4 Assessment by participants of the impact on the third day in motivating them to keep their promise.

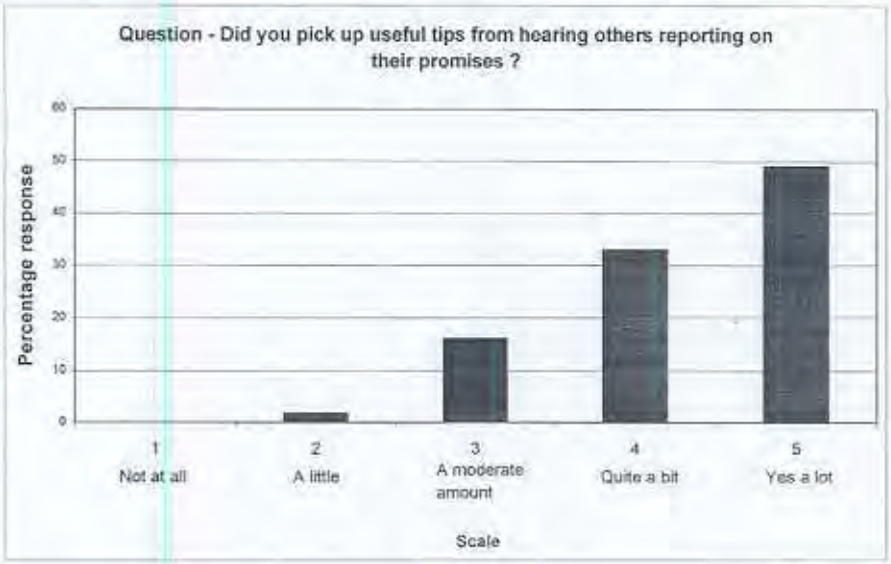


It seems that it could also be assumed that participants (about 50 % from the third day evaluation, figure 4) are gaining enough information in a relevant format at the workshop that they do not need a prompt, like the third day, to make them change a practice or implement a new practice. The processes and format of the Research to Practice™ workshop seem to be successful in providing a certain type of participants with enough information to implement change without needing a follow up day to motivate them. Of this group some of them may not even need the prompt of writing a promise, however the advantage of this activity is that participants leave the workshop with an action plan to achieve over the next season.

Regardless of the motivation the third day has on participants and their incentive to complete their promise, the benefits of the third day cannot be overlooked. Many comments from the evaluations indicate that they value highly the opportunity to share views and experiences with other members of the group. The majority felt they benefited from hearing about the promises of all participants in the report back session (figure 5) and

overall people enjoyed the relaxed atmosphere, the ability to interact and participate more and the good food.

Figure 5 Usefulness of hearing about all participants' promises.



Objective 2

Establish an avenue for improved and broader access to the outcomes of viticultural soil and water R&D in a consolidated, practical training format with a network of quality, commercially supported trainers.

The Water Management for Grape Production: Research to Practice™ workshop was developed by a small group of core researchers. While comment on the content was sought on a wider scale, relatively few people undertook the bulk of the development. It was important that as part of the program, efforts were made to develop and train as many speakers as possible in each state. The demand for the workshop during the three years of funding was very high (a total of 38 workshops) and it was impractical and imprudent to rely on a small group of presenters. Table 7 highlights the people involved in presenting at the workshops. One source of technical speakers was the major wine companies. Quite often these speakers had detailed knowledge of implementing the management strategies in a commercial vineyard. Participants were very receptive to these speakers and the ideas and pitfalls of implementation were a very valuable addition to the session. The other sources of speakers were the state agricultural departments, CSIRO and Universities as well as private consultants.

Table 7: Technical experts and the presentation(s) each delivered at the workshop.

Name	Organisation	Region	Presentation
South Australia			
Mark Skewes	Primary Industries and Resources, SA	Riverland / South East	Irrigation / Soil moisture monitoring equipment
Mike McCarthy	South Australian Research and Development Inst.	Australia	Irrigation
Katherine Boon	Primary Industries and Resources, SA	South Australia	Facilitation
Peter Dry	Adelaide University	Adelaide	PRD
Andrew Dowley	Adelaide University	Australia	Soils
Brian Loveys	CSIRO	Adelaide	PRD
Andrew Press	Southcorp	McLaren Vale	RDI
Stuart McNab	Southcorp	South East	Grape Growth
David Hanson	Southcorp	Padthaway	Soils
Chris Dundon	Mildara Blass	McLaren Vale	Grape Growth
Peter Hayes	Rosemount	McLaren Vale	RDI
Wayne Stewart	Nepenthe Viticulture	Adelaide Hills/Barossa	Grape Growth
Chris Brodie	Wingara	Mildura/Coonawarra	RDI/PRD
Russel Johnstone	Orlando	Nuriootpa	Grape Growth
Sarah Law	BRL Hardy	South East/McLaren Vale	Grape Growth
Derek Cameron	IAMA	McLaren Vale	Soil moisture monitoring equipment
Andrew Skinner	MEA	South Australia	Soil moisture monitoring equipment
Andrew Oliver	Willunga High School	McLaren Vale	Grape Growth
Katie Webster	Consultant	Adelaide	Soil Biology
John Buckerfield	Consultant	Adelaide	Soil Biology
New South Wales/ ACT			
Harry Creecy	NSW Agriculture	Griffith	Grape Growth
Mike Robbins	NSW Agriculture	Orange	Irrigation
Shayne Hackett	NSW Agriculture	Wagga	Grape Growth/RDI/PRD
Norm Cross	NSW Agriculture	Hunter Valley	Irrigation
Tony Somers	NSW Agriculture	Wagga	RDI
Richard Stirzaker	CSIRO	Canberra	Irrigation
Paul Hutchison	CSIRO	Canberra	Soil moisture monitoring equipment
Andrew McLennan	Consultant	Griffith/Wagga	Irrigation
Paul Hudson	Consultant	Griffith	Soil moisture monitoring equipment
Kerry Degaris	MIAWGMB	Griffith	Water quality
Luke Wormald	BRL Hardy	Murrambateman	Grape Growth
Victoria			
Ashley Wheaton	Agriculture Victoria	Tatura	Soils
Ian Goodwin	Agriculture Victoria	Tatura	Irrigation
Megan Hill	Agriculture Victoria	Tatura	Facilitation
Adrian Orloff	Consultant	Shepparton	Soil moisture monitoring equipment
Western Australia			
Diana Fisher	AgWA	Western Australia	Grape Growth
Neil Lantzke	AgWA	Western Australia	Soils
Judy Eastham	University of Western Australia	Western Australia	Soils / Irrigation

Ben McMillen	University of Western Australia	Western Australia	Soil biology
Peter Mollar	Consultant	Western Australia	Soil moisture monitoring equipment
Jim Campbell-Claus	Consultant	Western Australia	RDI
Australia			
Alf Cass	Consultant	Australia	Soils

One of the strengths of the Research to Practice™ to practice program has been the quality of speakers at the workshops. While not every person who has presented at workshops (table 7) has been successful, overall most speakers have been well received and have prepared well for their session. In 1997 and 1998 Agriculture Victoria held Research to Practice™ train the trainer workshops. Current and future presenters were able to spend time talking about the process and philosophy behind Research to Practice™ and some of the specifics from the workshops (both IPM and Water Management at that stage). Presenters brought on board since then are supplied with the presentations and the facilitator of each workshop spends time talking through the presentation with that person. This enables them to ask questions about the presentation and allows the facilitator to provide information on some of the possible questions that might be raised, as well as anecdotes from previous workshops. Presenters are also encouraged to contact the scientist associated with that topic for further clarification and information.

It is planned that more comprehensive speaker's notes will be developed for each presentation before this season commences. Time constraints have limited this process in the past. It is also envisioned that with the commercialisation of the program, there will be further opportunity to run "train the trainer" programs to expand the presenter base.

At this stage the Water Management for Grape Production workshop commercialisation is being handled as part of the strategic plan for the Research to Practice™ (Viticulture) project in program 4 of the CRC for Viticulture. The final draft of the strategic plan is complete. As part of the commercialisation process the following objectives need to be met:

- to increase the accessibility of Research to Practice™ (Viticulture) principles to potential and existing wine and grape industry personnel
- to increase the application of the new vineyard management practices introduced by Research to Practice™ (Viticulture) in Australian vineyards
- continue to develop the value and return on investment for all participants and stakeholders in the Research to Practice™ (Viticulture) project
- to develop the Research to Practice™ (Viticulture) "delivery modules" into self-sustaining units
- to enhance the quality and relevance of CRCV projects by re-enforcing the Research to Practice™ (Viticulture) project as an effective feedback and collaboration mechanism.

Further planning by the Research to Practice™ team is required to ensure these objectives are met.

Objective 3

Integrate the management of the soil resource with irrigation practices.

The importance of integrating soil and irrigation practices in one workshop is perhaps best summed up by the following statement written on the evaluation sheets, 'I didn't expect to talk about soils in a water management course to the extent that it was covered, however I can definitely see that it was necessary'. Feedback from the first two days indicates that many appreciated the information on soils as it added to their irrigation management knowledge. There were great many positive comments about Alf Cass and his style of delivery and the quality of information he presented. His impact on soil viticultural management can not be underestimated.

An important part of the workshop was the accompanying manual. There was great benefit in having both soil and irrigation information together in one folder cannot be underestimated. Many participants indicated that the manual would be a valuable reference after the first two days of the workshop. Feedback from the third day evaluations about the manual indicated that 75 % of participants had used the manual during the season. The responses about the number of times it was used varied from a few times (4 times) to many (every three weeks, 10 times). The purposes participants used the manual for were also varied and included:

- as a reference
- when there was a problem
- information for a TAFE project
- to build a deep ripper
- for the soil and water quality tables
- to spread the message with other growers.

The importance of integrating the soil and irrigation practices continued to impact on participants long after they had attended the workshop. The final question of the phone survey asked participants to indicate what about the workshop had made the biggest impact on them. There were a total of 16 different responses to this question (appendix 6), with the integration of soil and irrigation mentioned by 15% of respondents. It can also be assumed that, as many people made changes to irrigation practices and installed soil moisture monitoring devices, gaining knowledge about their soils was part of the information process that led to the changes.

Objective 4 and 5

Enhance the management capacity and confidence of wine grape growers in improved soil and water management practices.

To improve water use efficiency, product specification and enterprise performance via adoption of 'best practice' soil and water management.

Since objective 4 and 5 are related and it is difficult to extract only the information pertaining to one objective without repetition, they will be addressed together.

Initial indications by participants in the workshop from the evaluation sheets show that many identified information in the workshop that would improve their vineyard operations.

The most popular comments centred on the processes of irrigation scheduling, soil moisture monitoring, RDI and saving water. One person wrote, "I have some valuable data on which to base a revised vineyard irrigation plan" after attending the first two days of the workshop. Other comments included: 'I've noticed some things that we don't do correctly' and 'continues to reinforce best practice and conservation of resources (soils and water)'. All the comments from the evaluations of the workshop regarding the information indicate that the majority of participants learnt something valuable about soil or irrigation management and that as part of a continual process of information gathering many vineyard managers continue to fine tune and improve their practices.

One of the major influences on improved soil and irrigation practices is the installation of soil moisture monitoring equipment. From the summary of the promises made by participants (table 2) is it clear that the importance of this practice was identified. This was translated to the responses from participants who returned to the third day. They were asked whether they monitored water use or soil conditions more often after the initial 2 day workshop, 67 % indicated yes. Many either installed or increased the frequency of their monitoring. Perhaps even more significant was that 78% of participants based their management decisions on the results of their monitoring. The biggest impact of monitoring soil moisture was on irrigation timing and frequency. Changes in irrigation scheduling can have a significant impact on the quality of fruit, resource availability and vineyard sustainability.

Further indication of the impact of the workshop on changes in soil and irrigation management is the results of the phone survey conducted in March 2001. While the number of participants who made changes was discussed in objective one, it is of interest to further investigate what changes were made. From the 47 participants in the survey there were 16 different practices changed or implemented (Table 8). Again the practice with the most significant response was soil moisture monitoring (29%). Other practices, which attracted reasonable attention, included various irrigation practices (RDI, looking at irrigation timing, changing or maintaining irrigation system). There was also reasonable interest in the soil management side of vineyard management with collecting soil data, managing soil structure and mulching/ mid row management rating highly.

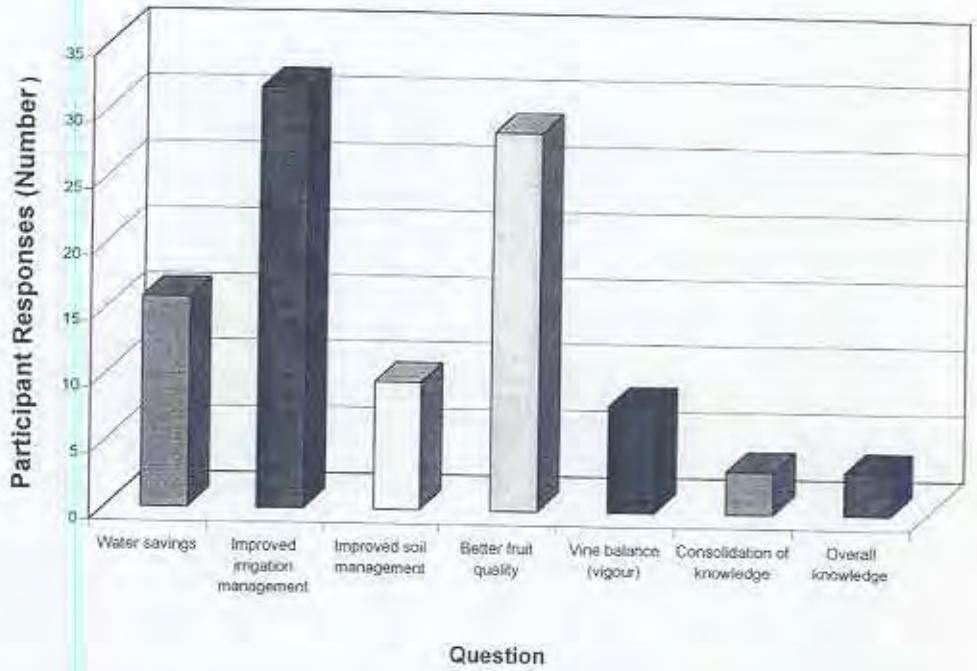
Table 8 Summary of changed practices from participants of the phone survey

Changed practice	Number of respondents
Soil moisture monitoring	24
Mulching/ Mid row management	9
Irrigation timing	7
Collect soil data	7
Regulated deficit irrigation	6
Manage soil structure	6
Modify irrigation system	6
Partial root zone drying	3
Determined irrigation efficiency	3
Maintained irrigation system	3
Developed irrigation plan	2
Improved record keeping	2
Measure application rates	1
Monitor water quality	1
Measure root distribution	1
Reduced water use	1

The fact that many participants in the workshop continue to implement new or changed practices after the workshop indicates that there is a positive effect on their confidence with respect to implementing new ideas. The changes made also appear to be affecting various aspects of vineyard management, sustainability and profitability. Benefits of the changes observed by participants in the phone survey included water savings, improved irrigation and soil management and better fruit quality (figure 5). Improving irrigation and soil management has a significant effect on the water use efficiency of vineyards. Changes to irrigation management also result in better fruit quality, improving the profitability of vineyards in most areas. Integral to improving irrigation management is knowledge about the vine root zone. A key factor for irrigation scheduling is knowing how deep the root zone is. This is highlighted by the number of phone survey participants who collected soil data (table 7) and a comment by one grower in Canberra that you: 'don't need to water past the root zone, it's a waste'. Other comments made by phone survey participants indicate that improved irrigation management made a significant impact on their vineyard management.

Water savings were also a result of changed practices observed by phone survey participants. Anecdotal evidence from workshop participants indicates that quite often changes they had made resulted in irrigation starting later in the season. This saved water and definitely had an influence on vine health as vine roots were water logged for less time. Recent work by Andrew Dowley (discussed in *the future – new soil management issues*) indicates that prolonged water logging in spring can have a detrimental effect on the vine roots and subsequent water uptake when compared with vines which are not water logged. A participant in Orange after they started monitoring soil moisture identified another typical finding by growers. Despite the moisture monitoring indicating that the soil was dry, vines were still active and healthy, indicating that they were accessing moisture from much deeper in the profile than previously thought. Many participants who returned on the third day found this occurrence, and it had a profound effect on their irrigation management. Many participants also expressed surprise at how much they could reduce their irrigation and have a minimal impact on the vineyard. It was encouraging to see growers prepared to reduce irrigation progressively year after year until they found the point of balance. One grower in Sunraysia indicated that they were using 2.5 ML per acre, but that they needed to have really accurate monitoring to be able to achieve this. This grower had also seen the benefits of training and sent personnel on other courses since the workshop. Other participants indicated that they would also be encouraging staff to attend the workshop.

Figure 6 Benefits observed by phone survey participants of changing practices



Of interest and perhaps concern is that an overwhelming number of phone survey participants could not indicate what impact the changed practice had on their vineyard profitability. This is surprising considering nearly half of those asked indicated that fruit quality was the reason they implemented the changes. Only 43% could indicate whether they had made less profit, had no impact on profit or had made more profit from the management changes made. There are a few reasons for the result; one could be that during the workshop there is no focus on profitability factors. It seems that changes need to be made to the promise section to highlight to participants the importance of taking into account the profitability. However, as part of this there need to be some simple tools provided to aid participants in this process. It is important that as part of this development, environmental factors are accounted for as 35 % of responses indicated that water efficiency/ conservation was the main reason for making the changes.

Conclusion

The Research to Practice™ program

The development of the Water Management for Grape Production: Research to Practice™ training workshop provided a platform to deliver the latest research information to the wine grape industry. The workshop design was based on the successful IPM Viticulture: Research to Practice™ workshop and delivered in 21 regions around Australia. The objectives of the project focussed on integrating soil and irrigation management and enhancing the confidence of growers and managers in implementing best practices in these areas.

The workshop program focussed on providing an opportunity for participants to interact with the speakers and with each other, participate in problem solving and field sessions and identify a new or changed practice that were interested in implementing during the season after their workshop. The follow up (third day) of the workshop provided participants with the opportunity to discuss what changes they had made to vineyard management, how these changes had affected their management in the rest of the vineyard and work through any problems they had with implementing the changes.

The response to this format was extremely positive with many participants implementing changes in soil and irrigation practices. The promise made by most participants was for the installation of equipment and implementation of a soil moisture monitoring regime. The impact of this on participants was significant, with water savings and changes to irrigation schedules being the most common outcome from this practice. The inclusion of soil issues was an extremely popular decision, with soil management topics rating the highest as the most liked presentations. Continual improvements planned for this program will only increase the applicability and useability of the information for vineyard managers.

The impact of a Research to Practice™ workshop

Overall the response to the information presented in the workshops and promotion of a promise to implement change was extremely high. The format developed appeared highly successful with a high proportion of participants implementing changes in practices in the years following their attendance at a workshop. The types of changes that occurred were many and varied and included both soil and irrigation management, indicating that all information in the workshop was valued. Many participants were motivated to make the changes they did for reasons other than the fact that a follow up day was planned where their promises were to be discussed. Some of the reasons participants gave for making changes included water conservation irrigation efficiency and fruit quality.

The quality of speakers is also an issue that cannot be underestimated when considering the training framework. Participants were fulsome in their praise for speakers who interacted with them, presented credible information and were realistic with their management options. Alf Cass is an extremely good example of this and many participants commented on how valuable he was to the program. The flip side of this is the speakers who do not perform in a satisfactory manner, and every effort is made to determine speaker suitability before the workshops. Overall a large number of people were involved in the workshop delivery in the three years of the project, and a significant majority were positive influences on participants. Most of the viticultural states of Australia have enough trained presenters to deliver the workshop using in-house people. Critical to the success of the program is the

continued support of wine companies in providing a source of technical speakers and in promoting and hosting the workshops.

Integrating the soil and irrigation management practices had a major impact on some participants. Many growers and managers were unaware of the significance their soil management had on irrigation. This was borne out by some of the comments from participants after the first two days and the enthusiasm they displayed when completing the field exercise. Follow up surveys also indicated that for some participants the information about integrating soil and water management had the biggest impact on them. Other aspects of the workshop that made significant impacts on participants were the opportunity to talk to growers, the soil pit session and information on irrigation scheduling. All of these factors can play an important role in the improvement of water use efficiency and enterprise performance of vineyards. The value to participants of being able to discuss issues with other participants and speakers present was also rated highly in the other evaluation data collected at the workshop. The process of information gathering and instigation of changed practices occurs not only as a result of what participants hear from the workshops as individuals, but also from information they gather when talking to their peers. The majority of participants also consider the manual a valuable reference. The benefits of having soils and irrigation information in one folder are indicated.

Many participants said that they foresaw improvements in their vineyard soil or irrigation management as a result of attending the workshop and comments from the follow up day and phone survey indicated this occurred. A large number of participants started or increased their frequency of monitoring and observed changes in irrigation practices as a result. Many ultimately saved water and saw improvements in vine health and fruit quality. Many participants had continued to make changes to their irrigation and soil management (68%) after the initial workshop.

All these findings indicate that the program was successful at providing a framework for the uptake of new irrigation and soil management strategies. It is also evident that many participants had seen benefits to water use efficiency and product specification from making the initial change and continuing the process. Many appeared more confident about implementing change at the third day as a result of the framework that was provided to give them support.

New topics and research

There is a great deal of interest within the grape growing community in the aspects of organic viticulture and using composts and mulches as part of the vineyard system. As well as water conservation benefits there are implications for nutrition management and environmental systems. There is also considerable interest the biological activity of soil and the impacts this can have on vines. Specifically participants mentioned earthworms and the soil food web.

While there is some information on soil biology and the use of mulches and composts, there is relatively little that relates specifically to vines and the impacts of management changes on vines. Some of the information is being gathered with respect to the nutrition management of these issues, however there needs to be more work on these topics in vineyards to clarify some of the issues

A few participants were interested in judging quality from a winemaker's view as an area of interest. There is considerable work occurring on wine and grape quality and there is a

Quality Research to Practice™ workshop under development. Some critical analysis of what it all means to vineyard managers would be useful. How much of what we know can be manipulated in the vineyard and what affects will that have on the vine are unknowns at this stage.

Frost control was also a popular issue with participants who attended the third day. Again with this topic there needs to be a process of information gathering to work out exactly where the gaps are as well as an education program in relevant regions to ensure growers understand technical aspects of frost.

Generally participants wanted more in depth information on certain topics that are of particular relevance to them. Current CRCV programs like Viticare and the On-Farm Trials project will be able to provide this information.

Future changes to program

Many changes are planned for the Water Management for Grape Production: Research to Practice™ program in the future to ensure it remains at the forefront of the research currently being conducted. Improvements to the delivery of information and the processes involved in that delivery are also planned. The following is a list of issues, changes and new products planned for consideration to maintain the reputation of Research to Practice™ as major source of research information for the Australian wine industry.

- Increasing the number of trained facilitators
- Addressing budgeting issues as part of the Research to Practice™ (Viticulture) strategic plan.
- Commercialising the delivery of Research to Practice™ (Viticulture) workshops
- Evaluating the current format of day 2 in response to participant feedback
- Improving return rate of participants to third day of workshop
- Incorporating new PRD information
- Incorporating new soil management information with respect to reducing water logging in soils in spring
- Evaluate current format of soil presentations used on the afternoon of day one so that a more flexible delivery system can be employed
- Review presentations and workshop manual
- Develop introduction for third day
- Develop more comprehensive speakers notes for presentations
- Determine possibility of running more train the trainer workshops
- Develop some tools for participants to use to determine profitability of changes made, incorporating some form of environmental accounting
- Develop Research to Practice™ update days to showcase latest research information that past participants would not have viewed
- Develop workshop information for delivery at certificate 3 level.

Published Material

Publicity

Victorian Viticulture News
Summer 1997/8 (attached)

Murray Valley Winegrape Grower
Volume 2 Issue 1 January 1998 (attached)

Australian Viticulture – Practical Vineyard Management
Volume 2, Number 1 January/February 1998 (attached)

Riverland Murray Pioneer
1998 (attached)

Ararat Advertiser
September 12, 1998 (attached)
Radio interview for ABC Rural Hour – Ararat

Radio interview Tasmania, December1998

Posters

Appendix 7
10th Wine Industry Technical Conference,
Sydney October 1998
Soil and Water Issues Identified in Six Grape Growing Regions of Australia.
Gayle Grieger, Hugh Armstrong, David Braybrook, Mike McCarthy.

Appendix 8
5th International Symposium on Cool Climate Viticulture,
Melbourne, January 2000
Water Management for Grape Production: Research to Practice™
Gayle Grieger and Hugh Armstrong

Presentations

Appendix 9
7th Community Landcare Conference,
Tanunda, 1998
Recent Innovations in Viticulture Training
Gayle Grieger

Appendix 1: Presentation used to introduce soils the participants.

What do you want from soil when growing grapes ?

What Do You Want ?

- Yield
- Quality
- Sustainability

The Vine Wants ?

Soil Water

Air = Drainage

Root Growth

The Vine Wants ?

Soil Water

Air = Drainage

Root Growth

No Toxics
- Salinity
- Sodicity
- Alkalinity/Acidity
- Aluminium
- Boron
- High Magnesium

The Vine Wants ?

Soil Water

Air = Drainage

Root Growth

No Toxics
- Salinity
- Sodicity
- Alkalinity/Acidity
- Aluminium
- Boron
- High Magnesium

Nutrients
No Pathogens
No Weeds

Undesirable soil qualities

The Soil Factors

Soil Water = Field Capacity (10 kPa) - Wilting Point (1500 kPa)

Air = Drainage

Root Growth

No Toxics
- Salinity
- Sodicity
- Alkalinity/Acidity
- Aluminium
- Boron
- High Magnesium

Nutrients
No Pathogens
No Weeds

Undesirable soil qualities

Colour

Surface soil	Brown	Organic matter high, well aerated
	Pale Grey	Low organic matter, well drained
	Black	Clay/clay soils, swells wet shrinks
Subsoil	Red	Permeable and aerated
	Orange	Less permeable and aerated
	Yellow	Less well drained, may indicate lime
	Pale Mottled Mottled	Poorly drained and aerated, periodic water logging
	Dark Colours	Organic, C, Mn, Fe ?

Manual: What is Soil ? Page 8

The Soil Factors

Soil Water = Field Capacity (10 kPa) - Wilting Point (1500 kPa)

Air = Drainage — Colour, AFP

Root Growth — Strength

No Toxics
- Salinity
- Sodicity
- Alkalinity/Acidity
- Aluminium
- Boron
- High Magnesium

Nutrients
No Pathogens
No Weeds

Undesirable soil qualities

Soil Strength

- Affects root growth through soil
- Determines root volume
- Lowest when the soil is wet, increases as the soil dries
- Measured by crushing a ped or pushing a penetrometer into soil

Manual: What is Soil ? Page 8

Soil Strength

Benchmark: no vine root growth if:

- *stronger than 2 MPa at field capacity*
- *unlikely if difficult to crush by hand when moist or under the heel if dry*

Manual: What is Soil ? Page 9

What are the important properties ?

Soil Water = Field Capacity (10 kPa) - Wilting Point (1500 kPa)

Air = Drainage — Colour, AFP — Texture

Root Growth — Strength

No Toxics
- Salinity
- Sodicity
- Alkalinity/Acidity
- Aluminium
- Boron
- High Magnesium

Nutrients
No Pathogens
No Weeds

Undesirable soil qualities

Soil particle sizes

Texture results from different amounts of the following particles

	Diameter mm	Charges	Surface Area
Gravel	> 2.0	None	Very low
Coarse sand	2.0 - 0.2	None	Low
Fine sand	0.2 - 0.02	None	Low
Silt	0.02-0.002	Some	Mod.
Clay	< 0.002	Many	High-VH.

Manual: What is Soil ? Page 10

Examples of soil texture

	Sand	Silt	Clay %
Sandy loam	75	10	15
Loam	65	10	25
Clay Loam	55	10	35
Clay	45	10	45

What are the important properties ?

Soil Water = Field Capacity (10 kPa) - Wilting Point (1500 kPa)

Air = Drainage — Colour, AFP — Texture

Root Growth — Strength — Structure

No Toxics
- Salinity
- Sodicity
- Alkalinity/Acidity
- Aluminium
- Boron
- High Magnesium

Nutrients
No Pathogens
No Weeds

Undesirable soil qualities

Soil structure



- arrangement of particles to make pores (holes)
- visible structure (macrostructure) gives some indication of invisible structure
- invisible structure (microstructure) is determined by the size and amount of pores

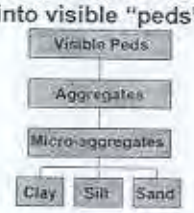
Manual: What is Soil ? Page 14

Soil pore functions - Invisible structure

- Very large pores (Biopores): 0.5 to 5 mm.
  Infiltration of water and inflow of air
- Large pores (Macropores): 0.075 to 0.5 mm.
  Infiltration, drainage, air exchange, softening
- Medium pores (Mesopores): 0.03 to 0.075 mm.
  Flow of water, nutrients towards roots
- Small pores (Micropores): 0.03 to 0.0005 mm.
  Storage of plant available water
- Very small pores: less than 0.0005 mm.
  Hold particles together and make soils hard

Manual: What is Soil ? Page 16

Build-up of soil structure into visible "peds"



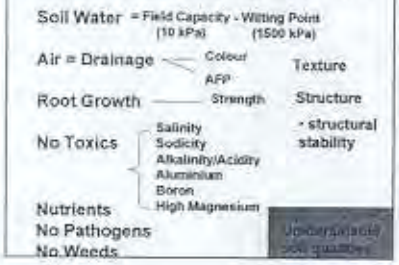
Manual: What is Soil ? Page 14

Visible structure



Manual: What is Soil ? Page 17

What are the important properties ?



Slaking and Dispersion

- Slaking - disintegration of aggregates into micro-aggregates on wetting
- Dispersion - disintegration of micro-aggregates into sand, silt and clay
- Leads to crusting, hardsetting (surface soil) and blocked pores, impeded drainage, waterlogging (subsurface soil).

Manual: What is Soil ? Page 19

Slaking and dispersion test

- Place rainwater in clear container
- Place container on stable surface
- Gently place 3 DRY pea size aggregates into water
- Observe immediate slaking
- Come back in 30 minutes and observe dispersion

Manual: What is Soil ? Page 20

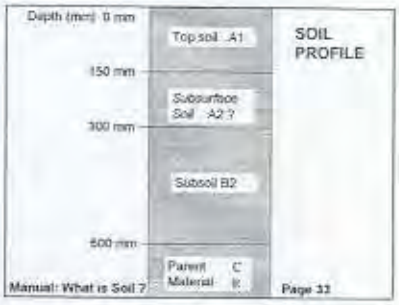
Indicators of structural stability

- No change - macro and micro structure are stable
- Aggregate slakes - unstable macrostructure, insufficient organic matter
- Micro-aggregate disperses - unstable microstructure, high sodium present

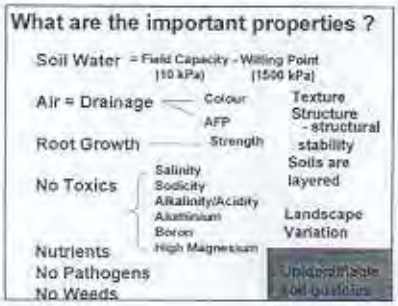
Manual: What is Soil ? Page 22

What are the important properties ?

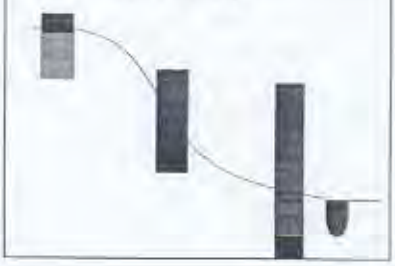




What are the important properties ?



Soil Landscape



Finally

All these factors and properties need to be integrated to develop an optimum irrigation schedule

The end

Appendix 2: Example of the soil case studies used in the workshop

Soil Type 5

Vineyard:
Drip irrigated 2 ML/Ha, high winter rainfall (>600 mm).

Problem:
Low vine vigour, (at 3 years old, no crop), 20-30% mortality on establishment. Poor water infiltration and cover crop establishment. No roots found in mid row.

Soil Properties



A_{11} 0 – 20 cm
Brown, very firm to hard, sandy clay. Massive structure with no roots. Slakes rapidly in water, no dispersion.
$pH_{1:5}$ 5.6 $EC_{1:5}$ 0.08 dS/m

A_{12} 20 – 40 cm
Brown, friable to firm sandy clay loam. Granular structure (20 mm diameter or less). Many roots. Slakes slowly in water, no dispersion.
$pH_{1:5}$ 6.1 $EC_{1:5}$ 0.13 dS/m

B_2 40 + cm
Yellowish brown, hard to very hard medium clay. Blocky structure (50 mm or more), few to no roots, slakes rapidly in water and disperses.
$pH_{1:5}$ 8.3 $EC_{1:5}$ 0.26 dS/m.

Management for an established vineyard

Management for vineyard development

Appendix 3: Form used for wine tasting group session, filled in by individuals

Group Session 1: Product Targets, Managing Vineyards to Meet a Product Specification. Water Management for Grape Production Research to Practice ™

1
Visual/Colour:
Smell/Aroma:
Taste/Flavour:
Other:
Variety:
Yield:
Region:
Ripeness:
Grower's dog's name:
Type of tractor:
Value/Quality/Price/Returns:

2
Visual/Colour:
Smell/Aroma:
Taste/Flavour:
Other:
Variety:
Yield:
Region:
Ripeness:
Grower's dog's name:
Type of tractor:
Value/Quality/Price/Returns:

Appendix 4: Sheet used by small groups for product targets group session

Group Session 1: Product Targets, Managing Vineyards to Meet a Product Specification.
Water Management for Grape Production Research to Practice ™

Wine Number _____

Visual / Colour / Smell / Aroma / Taste / Flavour:

Variety: _____ **Price per bottle $**_____

Which management or vineyard factors do you think may have contributed to the characteristics of the wine?

Irrigation
High Med Low Explain _____

Soil Conditions
Excellent Average Harsh Explain _____
eg Deep, Med, Shallow,

Clay Loam Sand Explain _____

Canopy Management
Shaded Exposed Explain
_____

Crop Load/Yields
High Med Low Yield _____

Ripeness/Baume
Overripe Ripe Under ripe Baume _____

Other Comments:

Appendix 5: Sheets used in field session to describe soil profile

SOIL PROFILE DESCRIPTION SHEET

Date:

Location

Soil type/name:

Landscape position:	Aspect	Slope %

Critical depths:

Effective root depth mm	Drain barrier mm	Root barrier mm	Watertable mm	Pale colors mm	Mottled colors mm	Lime mm

	Examples					
Layer Type	B1					
Depth (mm)	200 - 600					
Colour	Red					
Mottles (colour/size %/ distinctivness)	Few (20%) Faint red 5mm					
Texture	Clay Loam					
Gravel (%)	20					
Structure (type /size/distinctiveness	Prominent Blocky 50 mm					
Hardness	Firm					
Visible Pores	Few					
Roots: fine <2 mm	Abundant					
Roots: coarse>2mm	Few					
Reaction (1 mol/L HCl)	Strong					
Slaking	Yes					
Dispersion	No					
pH 1:5	6.3					
EC 1:5 uS/cm	0.14					
pH field kit	7					

Major Soil Limitations:

Vineyard Characteristics:

	Texture	Ribbon	% Clay	Description
Sands	Sand	0 mm	0-5	Ball will not form
	Loamy sand	5	5	Ball only just holds together
	Clayey sand	5-15	5-10	Sticky, ball holds together, leaves clay stain on fingers
	Sandy loam	15-25	10-20	Ball holds together, feels sandy and spongy
Loams	Silty loam	25	25	Ball holds together,, feels smooth and silky
	Loam	25	25	Ball holds together, feels smooth and spongy
	Sandy clay loam	25-40	20-30	Ball holds together firmly, feels sandy and plastic
	Silty clay loam	40-50	30-35	Ball holds together firmly, feels smooth, silky & plastic
Clays	Clay loam	40-50	30-35	Ball holds together firmly, feels smooth and plastic
	Light clay	50-75	35-40	Ball holds together strongly, feels plastic
	Medium clay	75+	40-50	Ball holds together very strongly, feels like plasticine
	Heavy clay	75+	> 50	Ball holds together strongly, difficult to manipulate

Horizons
A1 - Surface
A2 Subsurface
B – Subsoil
B1, B2, B3
C -Parent Material
R - Rock

Mottles
Distinctiveness
Faint
Distinct
Prominent

Roots
None
Few
Many
Abundant

Pores
10x10mm
None
Few <1
Common 1-5
Many > 5

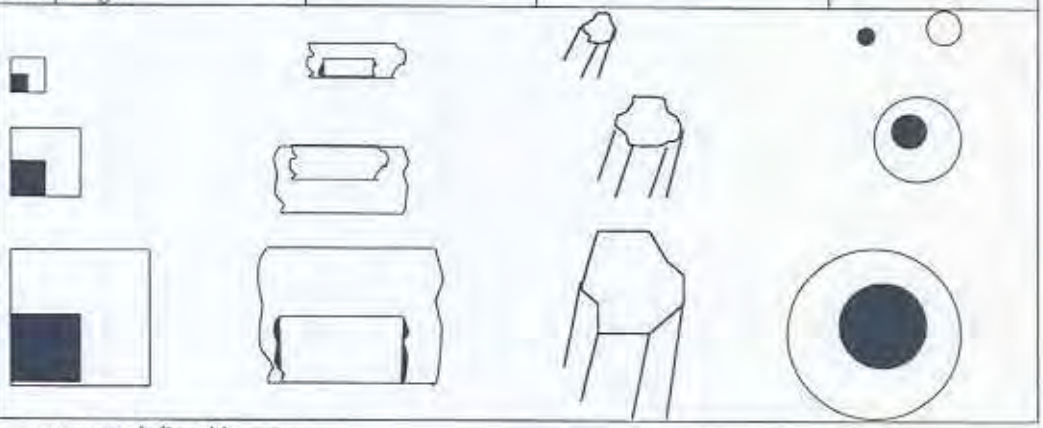
Carbonate	
Calcareous	**Effervescence**
Non-calcareous	None
Moderate	Audible and slightly visible
High	Visible, strong

Colour		
Surface Soil	Brown	Organic matter high, well drained, aerated
	Pale grey	Low organic matter, will slake
	Black	Cracking clay soil, swells & shrinks
Subsoil	Red	Permeable, aerated
	Orange	Less permeable & aerated
	Yellow	Less well drained, may indicate lime
	Pale, bleached	Poorly drained and aerated, periodic water logging
	Dark	Organic C, Mn, Fe?

Hardness		
Dry	Moist	Crush between thumb & finger easily
Loose	Friable	Crush between thumb & finger under force
Hard	Firm	Crush between both hands
Very hard	Very firm	Crush under foot only
Ext. hard	Ext. firm	Not crushed under foot
Rigid	Rigid	

Structure size and shape

Size	Blocky	Platey	Prismatic	Granular
	vertical = horizontal Sharp edges		Vertical > horizontal	Rounded edges
2-5mm				
5-10mm				
10-20mm				



Other structure types not defined by size:
Single grain – sands **Massive**

Appendix 6: Responses to the question from the workshop 'What had the biggest impact on you?'

Impact	Number	Percentage
Combination of soil/water	8	15.
Talking to growers	9	17
Water use sustainability	1	2
Correct soil moisture	4	7
Soil compation & root growth	3	5.5
Salinity	1	2
Soil moisture monitoring	2	4
Soil pits and Q&A	10	19
Target water application (roots)	1	2
Planning	1	2
Irrigation Scheduing	5	9
Partial Rootzone Drying	1	2
Don't Overwater	1	2
Quality of Speakers	3	5.5
Testing water quality	1	2
RDI	2	4

Appendix 7 : Poster presented at the 10th Wine Industry Technical Conference

Soil and Water Issues identified in six grape growing regions of Australia

Gayle Grieger, Hugh Armstrong, David Braybrook, Mike McCarthy.

Introduction.

A pilot series of the workshop Water Management for Grape Production: Research to Practice™ was run in six grape growing regions of Australia. Participants filled in a questionnaire regarding irrigation and soil management practices and problems.

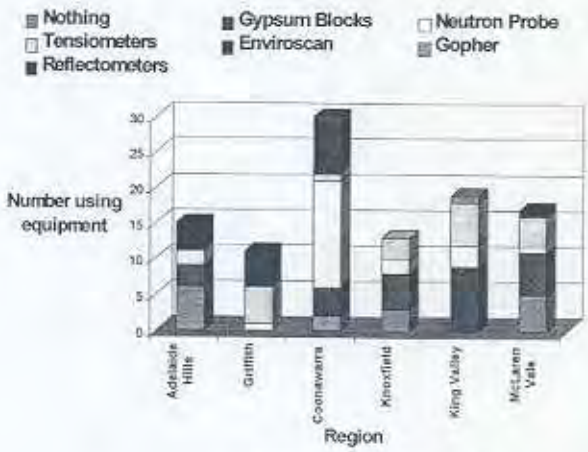


Aim

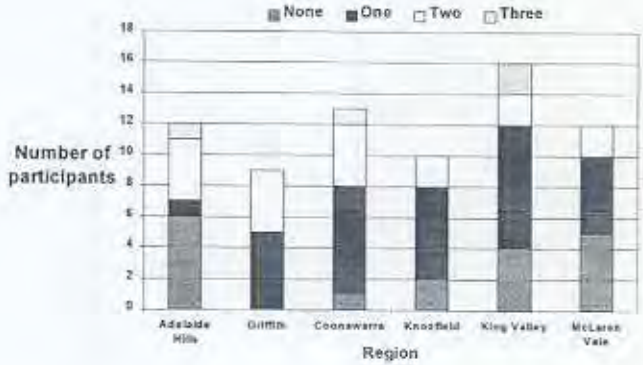
The aim was to gather data about soil and irrigation issues specific to each regions. Allowing these issues to be discussed in detail at each workshop.

Results

A high percentage of participants appeared to be using some form of soil moisture monitoring equipment

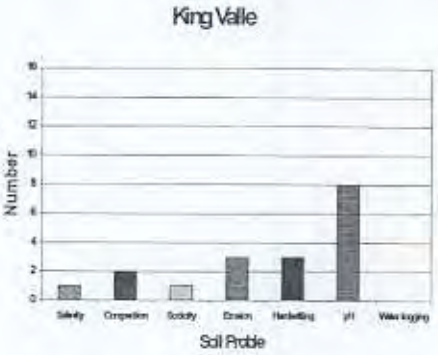


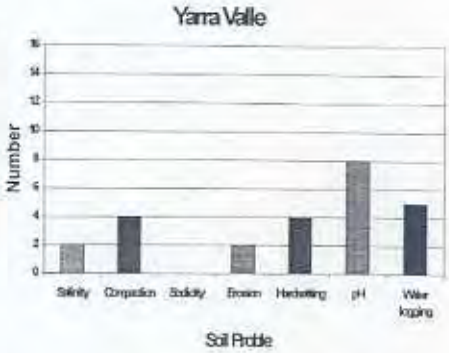
However further investigation indicated that many were using more than one form of soil moisture monitoring equipment



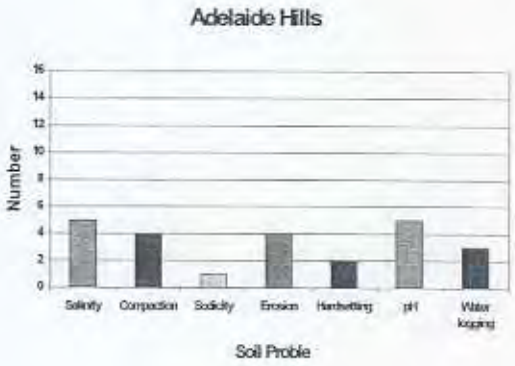
Participants were asked to identify in order what they considered to be their greatest soil problem from the list provided. They also had the opportunity to mention soil issues not in the list.

The King Valley and Yarra Valley participants considered pH to be their biggest soil issue.

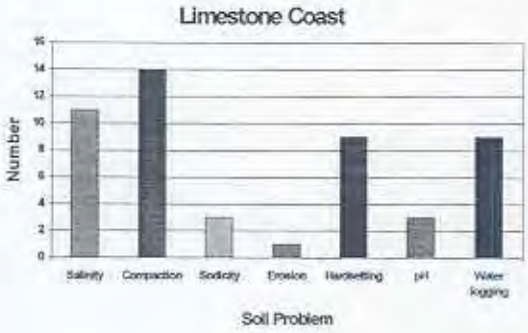


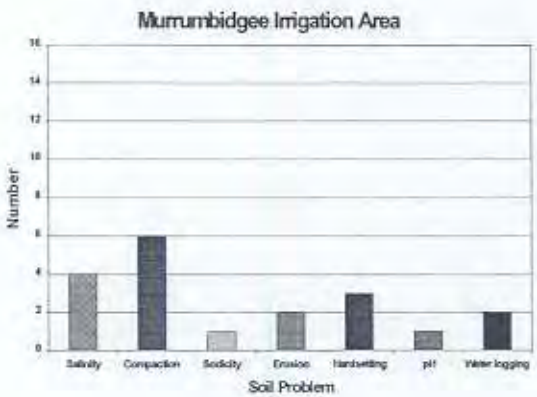


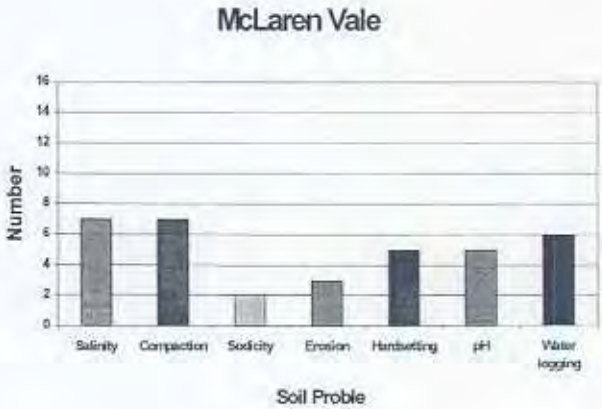
Salinity and pH were considered the greatest soil problems in the Adelaide Hills, followed by compaction and erosion.



The remaining three regions all considered salinity and compaction as major soil problems, followed by hardsetting and waterlogging, and in McLaren Vale pH as well.







Discussion

Each workshop concludes with participants promising to try something new. The top six responses to the promise indicate the importance of monitoring soil moisture and soil health to participants after completing the workshop.

Promise	Number
Soil moisture monitoring	35
Measure root distribution (RAW)	20
Collect soil data (dig pits)	19
Implement regulated deficit irrigation	12
Improve record keeping	11
Irrigation plan	9

Conclusions

Salinity and compaction are perceived as the biggest soil problems in most vineyards.

Soil moisture monitoring is increasing, with many people using more than one system.

Training is required to facilitate management changes.

Acknowledgments
This project was commissioned by the Grape and Wine Research and Development Corporation

Appendix 8: Poster presented at the 5th International Symposium on Cool Climate Viticulture

Water Management for Grape Production: Research to Practice™

Gayle Grieger [1] and Hugh Armstrong[2]

[1] PIRSA Rural Solutions, PO Box 245 Nuriootpa, South Australia, 5355
[2] Cooperative Research Centre for Viticulture, PO Box 154 Glen Osmond, South Australia, 5064

Introduction

Research to Practice™ is a three day workshop designed to promote the uptake of new soil and irrigation management strategies. The concept was developed by the Cooperative Research Centre for Viticulture with the education team at the Institute for Horticultural Development, Knoxfield, Agriculture Victoria. The three day workshop is broken into two days initially then a third (follow-up) day after harvest. Central to the success of the workshop is the commitment of each participant to a promise (or learning contract) at the end of the first two days. This encourages growers to implement something new they gained from the workshop, with the opportunity to discuss the results and any problems at the follow-up day.

Results

The success of this approach is highlighted by the following case studies from a workshop hosted by the Clare Valley Viticulture Landcare Group 19 – 20 October, 1998 (photograph 1. Participants of the Clare Valley workshop completing a soil survey).

Case Study One

Participants: Terry Faulkner (Sevenhill Cellars) and Clark Ingham (Ingham's Skilly Ridge Vineyard).
Promise: The installation and monitoring of gypsum blocks on Ingham's Skilly Ridge Vineyard.

Why make that promise?

Clark had already purchased the gypsum blocks and they were sitting in the shed, the fact that he had to make a promise at the end of the workshop gave him the impetus to install them.
Terry's employer (Sevenhill Cellars) was not ready to install soil moisture monitoring, but he received permission to assist Clark in the installation and monitoring of the gypsum blocks (photograph 2, Terry Faulkner on the bike used to assist in monitoring the gypsum blocks).

What was done?

7 stations of gypsum blocks at two depths (30 and 60 cm) were installed throughout 17 hectares of the vineyard. A data logger was used to collect information from the vineyard and down loaded onto a computer for analysis (photograph 3, Clark Ingham monitoring soil moisture).

Both participants learnt a lot from the installation of the blocks, and Terry was able to use what he had learnt when his employer was ready to install a system and modified the installation to suit his site and soil conditions. Clark and Terry also found the computer program for data interpretation very easy to use and learn (photograph 4, Terry and Clark analysing output from data logger, figure 1 the output from the computer program used to interpret soil moisture).

How did your management change?
Previous irrigation regime was a 10 day cycle for the whole vineyard. When they started monitoring soil moisture, Clark watered when the gypsum blocks indicated. One problem they did encounter was reacting to the gypsum block information too early, and trying to wet too much of the soil each irrigation. This led to over irrigation and increased the yields dramatically in one block. This year Clark feels more confident with the process and what it means and will water back to 150 – 200 kPa instead of field capacity. He will also allow the soils the dry out a lot more before irrigating and thinks he will be using a lot less water this year. The monitoring also indicated that shallow irrigations were less beneficial and as such the irrigation regime has changed over the last few years (Table 1).

Table 1. Change in irrigation management over the last two years.

Year	Irrigation time (hours)	Interval (days)
1997	8	10
1998	12	14
1999*	14-16	25 - 30

*This is how Clark plans to manage his irrigation this year (depending on what the gypsum blocks indicate), he also suffers from a shortage of water this year and will need to ration it fairly carefully.

Clark also had a patch of soil that dried out faster than expected and monitoring in this area increased the management options.

Finally
Clark has installed more gypsum block sites this year and is going to put blocks in at 90 cm in the future as the root zone is deeper than expected. He feels that the gypsum blocks have made management of irrigation on his vineyard a lot easier because he has information on which to base his decisions (photograph 5, Inghams Skilly Ridge Vineyard, Sevenhill, South Australia).

Case Study Two

Participants: Yarn Michalek and Darrin Read – Taylors Wines
Promise: To use less water around the vineyard if possible.

Why make that promise?
The trial was in place and both were interested in installing soil moisture monitoring equipment. By installing it in the trial they also were able to observe the influence of mulch on water retention in soil.

What was done?
Three treatments were applied in winter 1998, and gypsum blocks installed at 3 depths (30, 60 and 90 cm) at each site
1. Straw Mulch (photograph 6, straw mulch under vines).

- 40 (500kg) bales per hectare.
- Set up cost approx. $1600/ha including buying the straw and spreading, freight costs were minimal because of closeness to source.
- Also expect that mulch will persist for 5 years before re-application required.

2. Johnson's "bulk with lucerne" Mulch (photograph 7, Yarn with the Johnson's mulch spread under vines).
   - tonnes per hectare.
   - Set up cost approx. $1380/ha delivered and spread.
   - Expect that re-application will be required after one year.
3. Control
   - bare under vine

Early observations indicated that:

- under Johnson's mulch worm activity and soil friability increased
- under straw mulch there did not seem to be as much worm activity and the soil felt much colder.
- in the control area it was difficult to find worms.

The control was irrigated fortnightly from the end of October to early December, then weekly to harvest and a total of 94 mm of water was applied. The two, mulched blocks were watered twice during the season, once in mid-December and once in mid-February with a total of 13 mm of water applied. There was a reduction in yield in the vines under Johnson's mulch probably due to a lack of soil water. The soil coverage by this mulch is not as extensive as the straw mulch and so these vines dried out faster than the vines with straw mulch.

Infiltration rates for each treatment were measured by observing the number of hours it took for water to reach gypsum blocks at all three depths (table 2).

Table 2, Infiltration times (hours) for water to reach gypsum blocks at three depths (Photograph 8, Darrin Read with the logger used to monitor soil moisture to calculate the infiltration rates).

	Straw	Johnson's	Control
30 cm	4	2	2
60 cm	6	2	4
90 cm	9	4	6

- Under straw it appeared to take longer for the water to infiltrate as the straw acted as a physical barrier
- The Johnson's treatment had the fastest rate of water movement through the profile, reaching 60 cm before the first measurements were taken.

The result of this observation was that irrigation times for areas under Johnson's mulch would be reduced from 24 hours to 16 hours.

How has this trial affected the management of the whole site?

Johnson's mulch and straw mulch have been added to a lot more of the vineyard as a means for conserving water. The irrigation practice on this site has also changed greatly with more critical thought put into the decision to water than before. Darrin's manager indicated that now she has a hard time convincing him to turn the water on, and that he questions decisions about irrigation continually. This has the benefit of making everyone think about their reasons for making a decision and fosters an environment of continual

improvement in water management. This is especially important for Taylor's Wines this year as the low winter rainfall has impacted on their bores and water will be in short supply.

Finally
Both learnt just how important it was to measure and monitor soil moisture, and the importance of conserving water. They also found that they could make significant water savings in mulched vineyards as there was a longer time after bud burst before they started irrigating and under the Johnson's mulch especially, they were able to reduce the irrigation run time and amount. More mulch has and will be added to new areas (photograph 9, Bare under vine management (control treatment). There is also interest in putting in more monitoring sites where there are currently none.

Conclusion
Not every participant who attends the workshop completes a promise and returns on the third day to talk about it. Those that do generally are quite surprised by what they learnt about their vineyard, regardless of what the promise was. For many participants, it starts them on a path of investigation and experimentation to implement new ideas and practices. The above case studies are two examples where vineyard managers and employees have become more critical in evaluating their own practices and implementing change to improve those practices.

The promise and follow up day appear to be very successful in promoting a culture of change and innovation in vineyard practices with a significant proportion of workshop attendees.

Appendix 9: Community Landcare Conference presentation

Recent Innovations in Viticulture Training

Gayle Grieger, Industry Development Officer, Viticulture
Primary Industries and Resources South Australia

Abstract
The Research to Practice™ model was developed to ensure practical applications for research into various aspects of viticulture. The workshops are carefully structured to provide optimum conditions of effective technology transfer. Participants are encouraged to participate in all aspect s of the workshop, and emphasis is placed on their experience in growing grapes. The research results are presented with hints and tips on application to each participants vineyard. Research to Practice™ aims to give participants confidence to make changes in their practices if required.

Introduction
Research to Practice™ was developed by the education and training unit at the Institute for Horticultural Development, Knoxfield, (an institute of Agriculture Victoria which is a business of the Department of Natural Resources). Initially it was developed to provide a vehicle for training in and adoption of Integrated Pest Management (IPM) in Viticulture.

The Grape and Wine Research and Development Corporation and the Cooperative Research Centre for Viticulture provided the majority of funding for the research to practice™ program. Research to Practice™ now contains two workshops; Integrated Pest Management Viticulture and Water Management for Grape Production

What is Research to Practice™
Research to Practice™ is the term used for a training model that was designed to facilitate real change in the practices of participants. Research to Practice™ involves discussion of the options and risks associated with adoption of new management strategies.

Research to Practice™ focuses on the group learning experience. Emphasis is placed on the experience of participants in growing grapes and efforts are made throughout the workshop to get participants to talk about their experiences. A key factor for making learning easier is the standardised format of visual presentations and the workshop manual. Each section of the manual has a similar structure and the presentations follow the manual format. Every effort is made to make the manual and presentations easy to read and understand. All the information presented at the workshop is contained in the manual, this is re-enforced by continual reference to the manual. This also prevents the need for participants to frantically scribble things down with the possibility that they will miss something important.

What to expect in a Research to Practice™ Workshop
A Research to Practice™ workshop runs for three days, with two days initially, then a third day after harvest for follow-up. The workshops consist of general information sessions and specific information sessions. For IPM the specific sessions are pest by pest analyses and for Water Management specific soil and irrigation management issues are covered. Each workshop has group sessions where small groups are formed and an issue discussed. The outcomes of the small groups are then reported back to the whole group for discussion. This enables more issues to be dealt with in the limited time frame. It also allows

participants who are reticent about asking questions in front of their peers the opportunity to have their questions answered in a more informal situation. The group sessions also foster an atmosphere of cooperation and help promote an active learning atmosphere. Another important activity to promote group interaction is the provision of drinks and nibbles at the end of the first day of the workshop. This enables the participants to interact socially with each other as well as workshop presenters and facilitators. There is a noticeable increase in group spirit the next day.

The use of hands on exercises is a very important aspect of effective technology transfer. Allowing participants the opportunity to "try-out" aspects of change while having the safety net of experts on hand is very important. It helps build participant confidence to affect change. For the IPM workshop this involves a session looking at various pests under a microscope and a vineyard walk which re-enforces where to look for various pests. In the Water Management workshop participants spend the majority of the first afternoon in a soil pit in a vineyard. The use of pH and EC meters is demonstrated and participants actually go through the process of measuring pH or electrical conductivity. Participants also analyse a soil profile and connections are made between the soil conditions, grapevine growth and irrigation scheduling.

An important factor of the workshop is the "pledge" all participants make at the end of the second day. Participants are asked to think about some part of their current management strategy that they now feel confident about changing. For IPM this may be monitoring of a particular pest and only spraying when it reaches economic thresholds, instead of the usual spray program, which may have consisted of spraying regularly when conditions for an outbreak occurred. In the Water Management workshop the installation and use of soil moisture monitoring equipment has been a popular pledge. The pledges are documented on a promise sheet and a copy kept by the workshop convenors. The report back session on the follow-up day enables growers to discuss what they tried, the advantages and disadvantages and the next step. This is a valuable session for both growers and scientists as it allows the growers to further clarify and discuss issues, it also provides group support for change as other people in the group may have tried similar things and can add their findings to the discussion. This further promotes the group learning atmosphere and helps growers establish peer networks through which information can be shared. The pledges also help the scientists understand how well the science can be applied in the field as well as identifying gaps in the knowledge which require further research.

Conclusion

Research to Practice™ is about the practical application of new management strategies.

The key to successful adoption of new management techniques is informed growers who have enough information about a subject to feel confident about making change.

SUMMER 1997/98

To the Grapegrower

VICTORIAN Viticulture News

Incorporating the Victorian Grape Grower and Dried Fruits Producer



INSIDE

- ★ PEST & DISEASE CONTROL
- ★ EDUCATION
- ★ REGIONAL UPDATES



LEFT: Yarra Valley vignerons learned how to describe a soil profile at Noralunga Vineyard near IHD Knoxfield in mid-December.

Good soil information a must for growers



ABOVE: Gayle Grieger travelled from South Australia to help supervise a training course for Yarra Valley vignerons with Dr. Alf Cass of the Cooperative Research Centre for Soil and Land Management and Department of Natural Resources and Environment staff Ashley Wheaton and David Braybrook.

GOOD soil management is an essential part of running a productive vineyard, and courses held around the State over summer are giving vignerons a better knowledge of soil characteristics in the vineyard.

Increased knowledge of soil will enable vignerons to suit their soil types to particular grape varieties and vineyard management techniques.

In mid-December Yarra Valley vignerons got their chance to learn more about the physical aspects of vineyard management at a Water Management for Grapevine Production workshop held at IHD Knoxfield, with the practical components of soil science demonstrated at Noralunga Vineyard. A similar workshop was held in the King Valley on January 8 and 9.

Hands-on

A hands-on approach enabled those present to gain an idea of the basic soil profile evaluation and to observe exactly how soil and vine roots interact.

According to Gayle Grieger, Primary Industries and Resources Industry Development Officer, who travelled from South Australia to speak to growers, the seminars involve relaying information to growers simply and easily.

"We are making information applicable to vignerons so they can take it home and use it, and we are tailoring the information to different regions," she said.

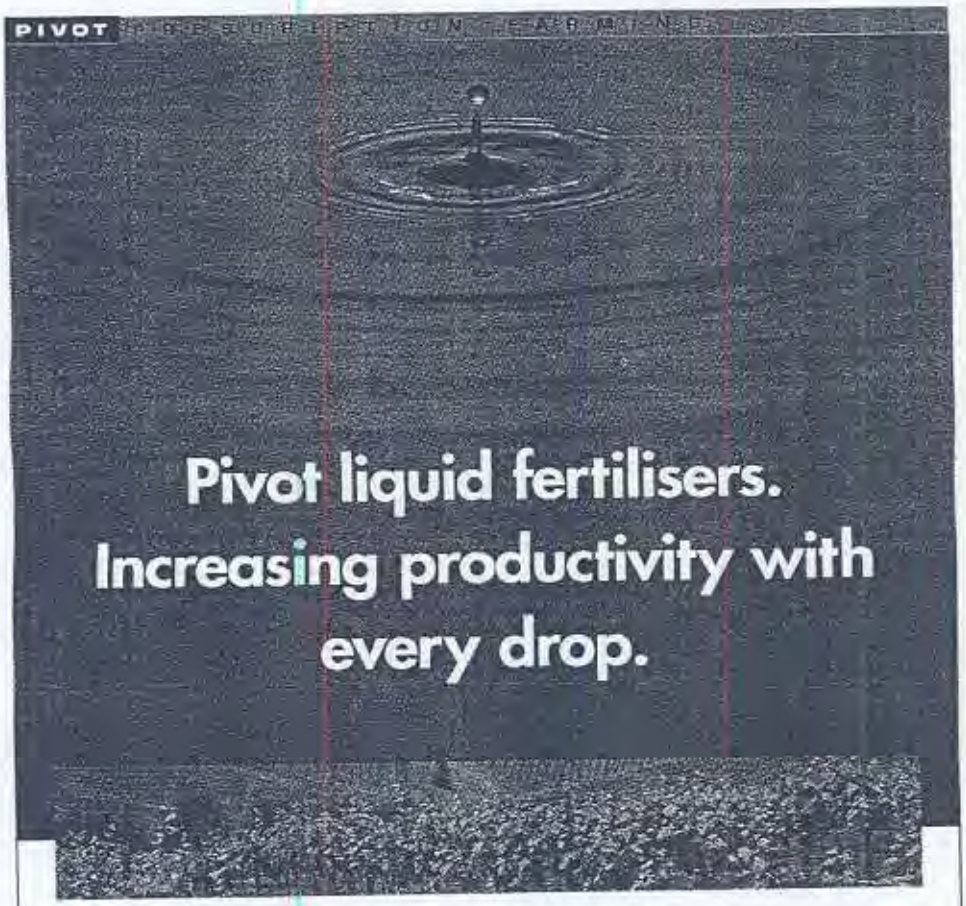
Participants are asked to fill in questionnaires at the commencement of the seminars to give instructors a better idea of their experience and what should be taught during the sessions. Groups are made up of a minimum of 15 people, with a maximum of 25.

Gayle said that a lot of information is packed into the two day workshop, which will be followed by a third day to be held after vintage in order to follow up the vignerons' progress in making improvements to their vineyards.

She said that the seminars are encouraging growers to ask 'What is happening in my vineyard, and what do I have to do to change that?'



Vignerons looked at the chemical, physical and biological aspects of the soil profile of Noralunga Vineyard during a two-day hands-on management course on improving soils.



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MURRAY VALLEY WINEGRAPEGROWER

Volume 4 Issue 1 — Published by Murray Valley Winegrape Industry Development Committee — January 1998

MARKETING ORDER TO BE EXTENDED FOR ONE YEAR.

The Chairman of the MVWIDC, Mr Haydn Farnsworth announced today that both the Victorian and NSW Ministers for Agriculture had decided to extend the period under the existing marketing order for one year, to 30th of June 1999.

The previous issue of this Newsletter identified that growers would be voting in February - March 1998 to renew the marketing order for a further period of four years. This poll has now been deferred for both state governments to review the legislation covering this Marketing Order in respect to National Competition Policy. This review must take place before any legislation (or Marketing Order) can be voted on. It is anticipated that this review will be completed by mid 1998 and a poll of producers to cover a new Marketing Order covering the regional industry levy will take place in early 1999.

WINEGRAPE GROWERS COUNCIL SUPPORTS LEVY INCREASE PROPOSAL

The president of the Victorian Winegrape Growers Council, Mr Brian Englefield has reported that the council members have agreed to support a proposal to increase the regional marketing levy on winegrapes from 90¢ per tonne to $1.20 per tonne. The council members representing the Winegrape Grower Association from Mildura and District, Robinvale and Mid-Murray have reviewed the current financial position of the MVWIDC and its forward budget for the next five years. These financial projections identify the need to provide more regional funds to support the Winegrape Industry Development Committee to continue its role as the Industry Grows in size and significance.

Mr Englefield said that full details of the break up of expenditures incurred in respect to the MVWIDC can be inspected in their annual report and at the annual general meeting in January 1998.

He said it was vital for the regional winegrape industry to be well funded, including the local associations, and the growers council, to ensure issues which may effect the ongoing development of the industry can be addressed. The recent release of the Regional Strategic Development Plan 1997-2003 sets out the action plan summary for the future period and the issues to be addressed.

WESFARMERS FEDERATION INSURANCE

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Water Management Focus

Grape & Wine
Research Development
Corporation

by Hugh Armstrong
Industry Communications and Extension Coordinator

The Grape and Wine Research and Development Corporation Five Year Plan identifies water use efficiency gains of 30% from current levels . The achievement of this goal will be reliant upon regions defining clear performance targets which should include the capacity for increased value and tonnage of grapes produced with less ML of irrigation water per tonne, hectare or dollar .

Growers will be well aware of the pressures to limit the levels of water usage and the ability for water to be transferred between regions and industries . Fortunately the grape industry can demonstrate a competitive position when comparing the value of grapes and wine produced per ML of irrigation water against other crops.

Significant opportunities exist for improving water use efficiency in vineyards, even without major changes to the irrigation system used. The regular use of accurate soil moisture monitoring tools is widely recognised as being the key ingredient and has been directly related to the profit per hectare in a recent study. The importance of visual inspection of vines and soil should not be underrated and should be used to aid more sophisticated tools such as gypsum blocks, neutron probes, capacitance meters or the recently available reflectometry equipment.

The Corporation has supported the development of two techniques for manipulating vine growth and fruit quality; Regulated Deficit Irrigation (RDI) and Partial Rootzone Drying (PRD). Both these techniques have shown great potential for use by growers but require even greater attention to accurate soil moisture monitoring and irrigation system performance .

A recently developed training package : Water Management for Grape Production: Research to Practice ™ also focuses on managing vineyard soil and water resources to produce the desired grape specification. This package is a two day workshop and will be available in the Murray Valley during 1998.

The Grape and Wine Research and Development Corporation would like to wish all industry members a successful 1998 vintage .

EUROPE WINEGRAPE STUDY TOUR 1998

GROWERS ARE ADVISED THAT DETAILS HAVE BEEN FINALISED FOR A STUDY TOUR TO EUROPE IN AUGUST/SEPTEMBER 1998. THIS IS A FIRST GRADE TRIP VISITING LONDON - BRITAIN, PARIS, COGNAC, BORDEAUX, LANGEDOC, BEAUNE, & RIEMS IN FRANCE. ALSO AUSTRIA, GERMANY AND ITALY, WITH THE TOUR FINISHING IN ROME. DURATION OF THE TOUR IS 28 DAYS, AND COST IS $6,300 (APPROX.).

EXPRESSIONS OF INTEREST SHOULD BE MADE WITH G. GREENWOOD (50 213911).

Australian Viticulture

Practical Vineyard Management

Volume 2 Number 1 *January/February 1998*



Official Journal of
WINEGRAPE GROWERS
COUNCIL OF AUSTRALIA INC.

'Research to Practice' theme extends to water management

Following the successful introduction of the Integrated Pest Management: Research to Practice program, which has shown that by working together the various sectors of the industry can translate research results into practical applications, another program has been launched called Water Management for Grape Production: Research to Practice.

This represents the continuing best practice theme of the Grape and Wine Research and Development Corporation involving practising viticulturists and a number of contributing organisations. These organisations include the Cooperative Research Centre for Soil and Land Management, the Cooperative Research Centre for Viticulture, the Institute for Horticultural Development (AgVic), the Institute for Sustainable Irrigated Agriculture (AgVic), Irrigated Crop Management Services (Loxton), New South Wales Agriculture, Primary Industries and Resources SA, and the South Australian Research and Development Institute.

Articles in this section of *Australian Viticulture* are largely drawn from contributors to a pilot program and must be considered in that light. There will, of course, be regional differences which readers will need to take into account. It should also be kept in mind that this presentation is not a complete research to practice package. Nonetheless, it covers many of the 'first step' topics which are worthy of consideration by those who may at a later stage enrol in a program. Essentially these topics are about understanding the nature of our soils and water, along with their relationship with grapevines.

The growth cycle of vines

In temperate Australia, vines are dormant in the winter, with budburst and new growth commencing between late August and late September.

Flowering and fruit set in most areas occur about 8 weeks later, in November or early December. The fruit ripens over the next 10–20 weeks, taking longer in cooler areas. Harvest times therefore range from late January in hotter areas to early May in the coolest regions.

Shoot growth

Shoot growth commences with budburst in early spring. Just before the emergence of green leaves the buds become very furry in appearance as the bud scales open. After budburst there is an initial slow growth of shoots. This is followed by a massive growth of vegetative tissue during late spring which has been termed the 'grand period of growth'. Lateral shoots form at this time too, adding to the general leafiness.

Too much leafiness can make the vine dense and heavily shaded inside with undesirable consequences for initiation, setting, ripening and the occurrence of pests and diseases.

Shoot growth rate rises to a maximum just before flowering and subsequently declines, possibly because of an interaction with developing fruits.

The shoots, and laterals from those shoots, continue to grow until berries are about three-quarter size. As the berries begin to ripen by midsummer shoot growth slows down. The shoots become a brown/orange colour, becoming woody and hardening into canes. This process is known as lignification.

Growth of shoots produces leaves which, by the process of photosynthesis in sunlight, manufacture carbohydrates such as sugar. Carbohydrates are used by the developing shoots, leaves, buds, roots and berries. Vine leaves have an active life of about 70 days, being at their maximum at about 6 weeks after formation and declining steadily thereafter.

A critical leaf area is needed to promote initiation and any trimming of shoots that removes large areas of mature leaves could be detrimental.

After the crop is harvested there is sometimes new shoot growth, and leaves fall as winter approaches.

Post-harvest growth should not be encouraged as it is using up the reserves which have been laid down for the next year. At the same time it is important to retain as many leaves as possible on the vine after harvest as they continue to photosynthesise and support root growth.

Root growth

The roots of mature vines have two periods of active growth. The first starts 3–4 weeks after budburst and continues until sometime after fruit set. The second burst of growth occurs after harvest and coincides with thickening of the trunk, canes and roots when the vine lays down its carbohydrate reserves for the following season.

Root growth and branching are stimulated by moist soil conditions, but excessive soil moisture after budburst can reduce root growth and the production of new roots and can cause root decay in feeder and structural roots.

The presence of an extensive root system is associated with more vigorous shoot growth and yield in young vines as well as mature vines.



Knowing the various growth stages will help refine water management.

Formation of flower buds

The initiation of inflorescences and flowering occur in late spring. The vine flowers and berries set during the 'grand period of growth'. At the same time vines are flowering, the tissue in the buds on the cane is starting to differentiate, with buds becoming potentially fruitful or vegetative for the following season.

Any stress to the vine during this period can affect two crops—it can directly affect the current crop, or indirectly affect the following season's crop.

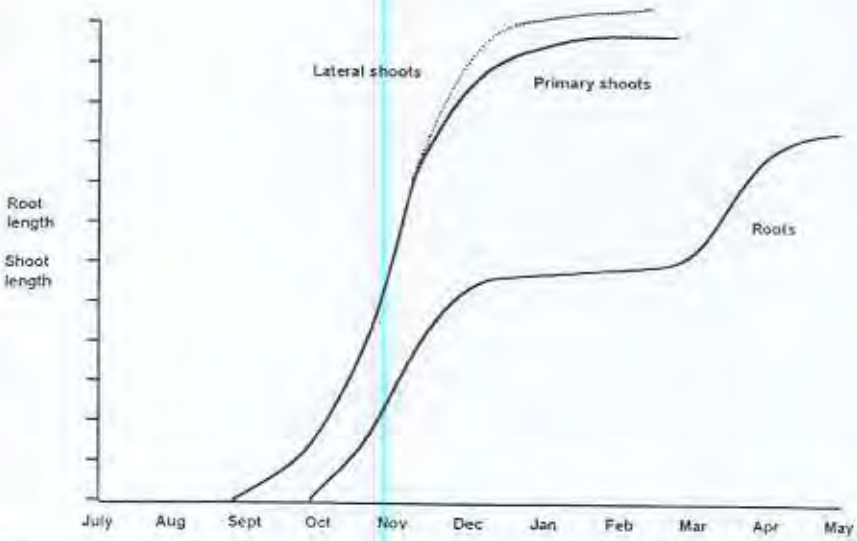
Buds are formed in the axils of leaves as the shoots develop. A bud divides into two, with one bud remaining dormant until the next spring, while the other may develop to form a short or long lateral shoot.

Flowering is promoted by a critical leaf area and by high light intensity. Flowers do not open until 6–8 weeks after the buds burst and leaves appear in spring.

Fruit growth

Fruit development has two distinct cycles. The first cycle, coinciding with the latter part of the shoot growth flush, takes the berries to the hard, green, slow-growing phase. During the second cycle, beginning at veraison, berry ripening processes occur.

Veraison is a sudden and dramatic change in the course of development. At this stage growth accelerates again —the berry begins to soften and grows bigger, glucose and fructose increase, acidity decreases, chlorophyll is lost and the colour develops in red and black varieties. As the berries are ripening the vine's energies are channelled to them. Some bunches form on laterals rather than the main shoots. These are known as second set. Because the second set is produced later in the season, these bunches tend not to ripen in cool climates.



The annual cycle of growth of roots and shoots.

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Knowing characteristics of soil is vital

Getting to know the make-up of soils is a vital early step towards improving irrigation and other aspects of vineyard management.

Grapevines respond to good physical soil conditions by developing vigorous root systems that grow evenly and deeply in the soil. So, anyone selecting a site for a new vineyard needs to carefully consider the physical properties of the soil because most of these properties can't be changed.

With an established vineyard it's advisable that you continue monitoring soil conditions and use the results as indicators of the effects of management and potential problems.

Physical, chemical and biological properties can all affect grapevine growth and production.

Soil composition

Soils generally have five components, namely mineral particles from parent rocks generated by weathering, organic matter, water, air and living organisms.

The type of mineral particles and amount of each component will vary greatly between soils, resulting in a large number of different soil types.

Soil depth

The depth of subsurface soil is important because it influences the supply of nutrient elements. Where the surface layer is thin or where cultivation destroys surface feeding roots (in the top 8 to 15 cm of soil) the supply of nutrients may be limited. Soils as deep as 20 cm or more with fertiliser placed within the layer will usually support vigorous grapevines.

Colour

Colour is the most obvious feature of soil and is a very useful indicator of soil drainage, degree of leaching, organic matter content and the presence of free lime.

Determine soil colour by looking at the surface of a freshly broken aggregate of moist soil and use the following guide to the properties of different coloured soils:

- Generally, light coloured soils reflect heat whereas dark coloured soils absorb and radiate heat so they warm up and cool down readily.
- The colour of the surface of a soil is usually an indicator of its organic matter content—the darker the surface soil, the higher its organic matter content.
- Water penetrates darker coloured, well-managed surface soils more readily than lighter ones. Such

Background to the workshops

by Gayle Grieger, Industry Development Officer (Viticulture)

The 'Water Management for Grape Production' workshops are funded by the Grape and Wine Research and Development Corporation and the Cooperative Research Centre for Viticulture. As with the 'IPM – Research to Practice' program, key presenters are scientists from the various state agencies around Australia. Workshops are accredited through the Institute for Horticultural Development, Knoxfield, and some of the principles developed by their staff to ensure effective transfer of the latest research findings to workshop participants have been transferred to the current workshop series.

A major focus of the workshops is soil management, with the outcomes of current research into soil limitations to grapevine growth being presented in a form that can be readily understood and adopted by grapegrowers. The importance of soil management to ensure optimum root growth and water use efficiency is emphasised.

Workshop participants are also given the latest research findings in irrigation management, in particular some of the new management strategies developed to improve grape quality and reduce irrigation. An important aspect is discussion with participants about problems likely to be encountered when adopting new approaches to irrigation management. Several interactive sessions encourage participants to highlight some of their concerns, and these sessions give the participating scientists valuable information on directions for future research in soil and water management.

Each workshop consists of two days of sessions covering some basic vine, soil and water information and hands-on demonstrations. Using information presented during the two days, participants are encouraged to identify current vineyard management practices that they could improve. The two-day workshop is followed by a third day, three to four months later, where further issues of soil and irrigation management are discussed and feedback is obtained.

To obtain information on each region, participants are asked to answer a questionnaire covering their current soil and irrigation status. Although a major focus of the workshop is on the individual and the impact of their management on their vineyard, the interaction between participants during the workshop ensures they also consider the impact of their management on the region as a whole. This process also provides information to the scientists on the likely success of particular management strategies in each region and identifies the areas requiring further research.

Further workshops are planned in all grapegrowing regions of Australia, commencing in May 1998. Contact Gayle Grieger PIRSA Nuriootpa ph 08 8568 6400 or Hugh Armstrong CRCV ph 08 8303 9405 for additional information.

Soil colour	Indications of soil colour
Red	Indicates good permeability and aeration.
Orange	Indicates good permeability and aeration, with high carbonate levels.
Brown	Indicates good drainage, aeration and the presence of organic matter.
Yellow	Often indicates very high levels of lime and may have fair drainage characteristics.
Grey, green or greyish	Indicates poor permeability and aeration. Mottling may be prominent, indicating waterlogging.
Black	Indicates the presence of well decomposed organic matter or organic matter high in plant nutrients. May indicate poor drainage and poor aeration.

soils are also less subject to erosion.

- Light coloured (near white) subsurface soil indicates that nutrients have been leached and that the soil is periodically waterlogged.

Subsoil colour is a good indicator of how well water and air move through the soil profile. This means that permeability decreases as soil colour changes from red to brown to yellow. This is also indicated by a change from dark to grey. Another observation is that mottled soils are less permeable than unmottled soils.

Texture

Texture refers to the feel of the soil. It is a measure of the amounts of sand, silt and clay that make up a soil. Sand, silt and clay are defined by their particle sizes (see table).

This is probably the most important of all soil properties as it affects erodability and available water capacity.

You can assess texture by how a sample of moist soil (bolus) feels and behaves when it is worked on the palm of the hand to get an assessment of coherence, then pressed out between the thumb and forefinger in an exercise called ribboning.

Assessing soil texture

First you will need

- An amount of soil a little smaller than a golfball from each layer being assessed. If necessary remove gravel from sample
- Some water to moisten the soil.

Then

- Take the soil and moisten it with water, a little at a time, kneading it until it just fails to stick to your fingers.

You will discover

- The sticky point which approximates field capacity for that soil. Sand cannot be moulded and will produce a ribbon less than 5 mm





Plastic buckets and a squeeze bottle are basic equipment for assessing soil types.



A small quantity of soil is moistened in the palm.



The soil is worked into a ball.



The moist soil is ribboned out by working through the thumb and forefinger.

long, whereas a clay loam will be coherent and smooth to work producing a ribbon of 40 to 50 mm .

Characteristics of sand, silt and clay

Sands (2 to 0.02 mm diameter particle size) are easy to work. They allow rapid infiltration and drainage, retain relatively low amounts of water for plant use and are usually low in organic matter and nutrient levels.

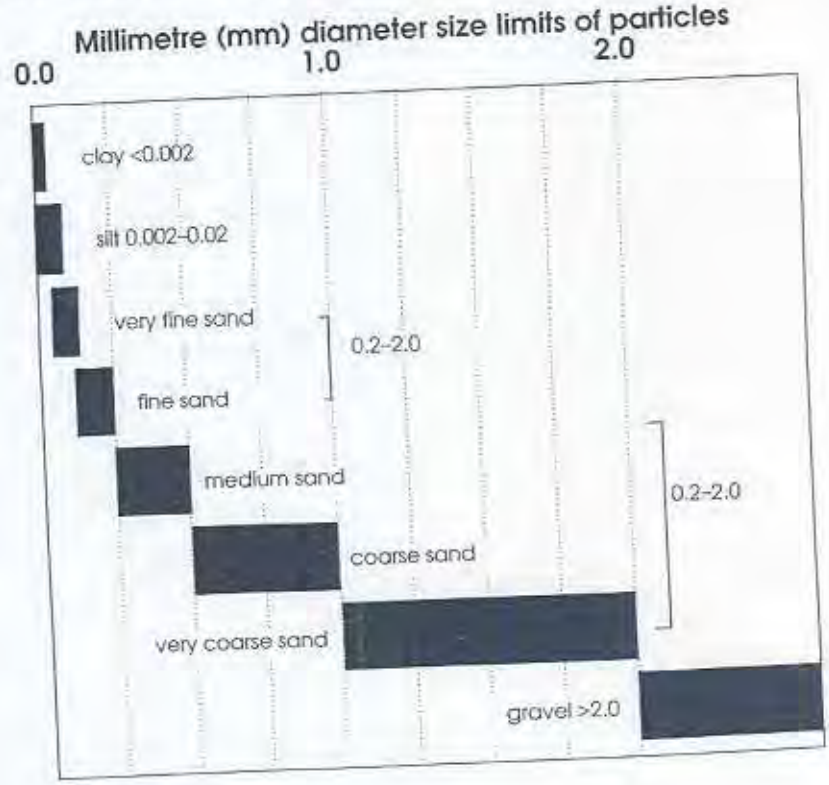
Some sands repel water, resulting in poor water infiltration rates at the soil surface.

Loams/silts (0.02 to 0.002 mm particle size) are easy to cultivate and roots grow well in them. Loams retain enough water for plant use, drain readily and contain nutrients essential for plant development. The composition of loams can vary greatly, causing some to set hard to form crusts, or to become powdery when dry.

Clays (less than 0.002 mm particle size) can be difficult to cultivate. They form hard clods when dry and are sticky when wet. Some clays expand when they are wet and crack when they are dry. Water moves slowly through clays, which can lead to waterlogging. Clay topsoils generally contain more organic matter and nutrients than sands.

Structure

In a well-structured soil, roots can readily penetrate the aggregates and water and air can move freely through the pores, so the soil is rarely saturated with water or starved of oxygen. A well-structured soil resists erosion, allows crop seedlings to emerge easily, and can be worked over a wide range of moisture conditions with little damage. An indication of the structural quality of the soil can be obtained by examining the shape, size and hardness of the visible aggregates or 'peds'. Soils without a well-defined arrangement of aggregates are called 'apedal'. The most favourable peds are



Size of mineral particles.

granular, polyhedral and fine blocky, or peds with rough porous faces.

The consistence (strength) of the aggregates is important. Aggregates that can be broken between thumb and forefinger are loose, soft, friable or firm depending on the bonding between particles. Aggregates that cannot be broken are 'hard' and are often associated with poor physical conditions.



Some common types of soil structure.



Friability

Soil friability describes how easily soil crumbles and stays in its crumbly condition. The more friable the soil the better water and air move through it and the better the grapevine grows.

Most surface and subsurface soils set hard when dry. If this is the case with your vineyard you could consider cultivating when the soil contains optimum moisture, usually the day after a thorough wetting.

Repeated clean cultivation is a problem because it increases the tendency to hardsetting as organic matter is destroyed.

A green manure crop, sod-culture, or pasture phase will provide extra organic matter and reduce hardsetting.

Friability in subsoils largely depends on the size and strength of the aggregates or fragments after soil is disturbed. Friable subsoils allow water and air to move rapidly through the soil, providing a good medium for root growth.

Both sodicity and the content of soft fine carbonates decrease the friability of subsoils, although it is possible to improve friability by applying gypsum directly into the subsoil.

Compacted soils

Soil compaction happens when pressure on the soil pushes soil particles together, restricting root penetration and the supply of oxygen and water. It usually results from mechanical damage. For example, ploughing or using discs or a rotary hoe can cause compaction immediately below the normal tillage depth, forming a plough pan.

Wheel traffic can stop the lateral spread of vine roots out of the vine row. Plough layer compaction could have occurred before vines were planted if the soil was previously used for field crops. This needs to be addressed when developing a new vineyard.

Compaction can increase topsoil erosion because of surface run-off or ponding. When a soil is compacted there is less air space between the pores, restricting the supply of water and oxygen.

Assessing soil compaction

You can check for compaction with a penetrometer. This has a stainless steel cone on the end of a rod which is inserted into the soil and pushed through at a steady rate. A pressure sensor records in pressure units in kilopascals, or some other measure, the force needed to push the rod into the soil. Grapevine roots appear to have an absolute limit beyond which they will not grow.

There is a simple way of estimating compaction in a vineyard. It must be done at field capacity water content (1–2 days after deep penetrating rain).

First you will need a 2.4 mm diameter manganese brazing rod cut to a length of 300 mm with both ends filed flat. Then:

- Push the rod into the soil with the palm of the hand. You will discover that if the rod enters the soil without undue pain to the palm then penetration is relatively good.
- If it is too painful shield the palm with a knife blade and insert the rod again.
- If the rod flexes and does not move into the soil the penetration resistance is too great, indicating poor soil quality with limited capacity for root growth and vine water uptake.

Slaking and dispersion

Slaking and dispersion are the processes by which soil structure breaks down.

Slaking is the breakdown of aggregates into microaggregates. It is a physical process where air from the pores expands as water rushes into the pores. Soils that slake form hardset layers at the surface and may also have surface crusts. You can reduce slaking by increasing the organic matter content of the microaggregates and, particularly, by stimulating biological activity by reducing tillage and maintaining a covercrop or mulch at the surface.

Dispersion is when soil breaks down into individual particles of sand, silt and clay when wet. A dispersive soil is structurally unstable. The clay particles clog the pore spaces, forming a barrier to root growth, and air and water movement. Highly dispersive soils normally erode easily and are likely to cause problems for workability and seedling emergence as a result of crusting.

You can control dispersion by adding gypsum to increase the level of beneficial salts (calcium) at the surface and to displace sodium. Dispersion is also minimised by reduced tillage and trafficking.

It is a good idea to test your soil for slaking and dispersion to assess the need for remediation in developing or improving a vineyard.

Assessing soil slaking and dispersion

First you will need:

- A handful of soil from each layer.
- Shallow, clear, open containers.
- Rain or distilled water.

Then:

- Put a handful of soil from each layer in an open container. Try not to disturb the soil too much when handling it.
- Put the samples in a warm room and let them dry for several days.
- Select from each sample three aggregates or fragments about the size of a pea.
- Place them, equally spaced apart, in a shallow container filled with rain or distilled water. (You can also do the test using irrigation water if you are interested in its effect on structural stability.)
- Watch the aggregates carefully during the first few minutes and note whether they float to the surface or sink, and the rate at which smaller particles break away from the larger sample.
- After 2 hours record whether slaking was complete, partial or did not occur.
- Leave the dish untouched for 20 hours and then assess dispersion. A 'cloudy' or 'milky' halo around the slaked fragments of the aggregate indicates partial dispersion, while the base of the container being completely covered with a layer of clay leaving only a pile of sand where the aggregate was indicates complete dispersion.
- If no dispersion occurred take a small handful of soil, remove any gravel, stones and plant fragments and moisten with rain or distilled water while kneading into a ball of about 40 mm diameter. Add small amounts of water as necessary until the ball of soil just begins to stick to the hand.
- Break the ball of soil open and remove some soil to make 3 pea-size balls and place them in a clear container as described above.
- Watch and record the results.

Results of slaking observations can be interpreted as follows:

- If air dry aggregates float the soil is structurally stable. The bulk density of the aggregates is very low (a very good macro structure quality).
- If air dry aggregates sink but do not slake the soil is structurally stable with good soil macro structure.
- If air dry aggregates sink and slake slowly the macro structure is somewhat unstable to wetting. Organic matter is probably lower than optimum and tilled soil may set hard after rainfall.
- If air dry aggregates sink and slake rapidly the macro structure is unstable. Organic matter is too low and tilled soil will set hard after rainfall.

Results of dispersion observations can be interpreted as follows:

- Type 1. Complete dispersion means very poor microstructure stability. The soil will crust, compact and erode easily. Gypsum needs to be applied.
- Type 2. Partial dispersion means poor micro structure stability. The soil will crust and erode if not protected by surface cover. Gypsum should be applied.
- Type 3. Complete or partial dispersion after remoulding means moderate microstructure stability. The soil structure will deteriorate if careful management is not applied. Crusting, compaction, tillage pans and erosion may be problems under these conditions.
- Type 4. No dispersion after remoulding means good micro structure stability. The soil will not crust or erode readily.

Surface aggregates tend to slake and disperse more readily on wetting by rain or irrigation because tillage damages their structure. As a result, surfaces tend to form either a crust or set hard.

Crusts are shallow packed layers that stop water infiltrating the soil. Most undervine rows which are kept free of weed growth by herbicides are crusted because biological activity such as root growth, growth of earthworm and fauna populations and build up of organic carbon is severely reduced.

Hardset layers are thicker and may reduce infiltration and promote shallow root growth. Many interrow areas can become hardset if they are cultivated too much when establishing and controlling covercrops.

Growers can reduce both crusting and hardsetting by reducing tillage, keeping the soil surface covered at all times by mulch or permanent covercrop, and building up the organic carbon level in the soil.

Impeding layers

An important aspect of soil depth is that of an impeding layer. Impeding layers obstruct both root growth and water movement. Under natural rainfall, grapevines should not be grown in soils with impeding layers as shallow as 1 or 2 metres unless other favourable conditions prevail such as gently sloping and naturally draining topography.

There are several kinds of layers that obstruct root growth and water penetration in grapegrowing soils, namely dense rocks, hardened or semi-hardened accumulations of carbonates, soft calcretes, subsoil clays, claypans, and subsoil clays.

Soil pH

The pH is a measure from 0 to 14 of how acid or alkaline a soil is. A neutral soil has a pH of 7. Soils with a pH of less than 7 are acidic while soils with a pH greater than 7 are alkaline. Most crops prefer neutral pH levels but the desirable range can be between 5.5–8.0. A pH level that is too high or too low can cause nutrient deficiencies or toxicities.

Measuring pH is probably the most common soil test done, and it can be undertaken in the field using a colorimetric pH kit or a pH meter. The meter needs to be calibrated with standard buffer solutions prior to testing each batch of soils, or at least daily. Store buffer solutions in the

refrigerator. The estimate of pH levels in this test is accurate to within 1.5 of a pH unit of the actual pH.

Assessing soil pH levels
(Using a test kit)
First you will need:

- Half a spoon of soil.
- A plate dye.
- Barium sulphate.
- A pH colour chart.

Then:

- Put half a teaspoon of soil on a plate.
- Add enough dye to saturate the sample.
- Sprinkle barium sulphate on to the soil and allow the colour to develop.
- Compare the sample colour with the pH colour card provided.



Handy meters are now available for measuring pH and salinity levels.

Assessing soil pH levels
(Using a pH meter)
First you will need:

- A soil sample.
- Calcium chloride solution.
- A pH meter.

Then:

- Use a 1:5 suspension of soil in calcium chloride solution, and take the reading according to kit instructions.

Phosphorus availability is severely restricted in strongly acidic or alkaline soils, while manganese, zinc, copper and iron become unavailable for plants in highly alkaline soils, commonly resulting in lime-induced chlorosis.

Salinity
Salinity is a measure of the concentration of soluble salts in soil water. The most common soluble salt is sodium chloride. Others include bicarbonates, sulphates, carbonates, calcium, potassium and magnesium. Too many salts in the root zone will damage plant health and reduce yields. A high concentration of soluble salts can even kill a crop.

There are several causes of soil salinity, including:

- Salt from sea spray, which is carried inland by wind or rain and deposited directly on the soil.
- Salts from parent material in the soil layers.
- Saline irrigation water depositing salt in the rootzone.
- Over-irrigation causing shallow water tables to develop, bringing dissolved salts in to the rootzone, especially if there are clay layers in the soil profile.
- Under-irrigation, which can result in a salt build up by not flushing salts down beyond the rootzone.

Soil salinity can be measured using one of two methods to extract the soil solution, the saturation extract (laboratory method) or a 1:5 soil:rainwater extract (field or laboratory method). The electrical conductivity of the sample is measured (EC), preferably in units of deciSiemens per metre (dS/m).

The most accurate and reliable way to assess soil salinity is the saturation extract method which requires laboratory equipment not generally available to grapegrowers. Soils suspected of being saline should be sampled and submitted to a commercial analytical laboratory.

However, other tests can be done in the vineyard using inexpensive equipment and the 1:5 soil:water extraction method.

Assessing soil salinity
First you will need:

- A portable handheld conductivity meter
- A set of glass jars with lids
- A 20 mL kitchen measuring spoon
- A 100 mL measuring jug.

Then:

- Crush 20 g of soil so no big lumps are present.
- Shake the soil in 100 mL of rainwater or demineralised water (i.e. a 1:5 solution), periodically over one hour.
- Let the mixture stand undisturbed for half an hour or a little longer if the suspension is not clear.
- Rinse the electrodes in rainwater or distilled water and dry gently with a tissue.
- Take a reading in the suspension above the soil, making sure the electrodes are fully covered. Take care to minimise electrode contact with soil at the bottom of the jar.

Salinity becomes a problem when surface soils have 0.15% or more total soluble salt or when subsoils contain 0.30% or more. Soils with a content of total soluble salts between these levels must be irrigated with care.

Sodicity
Sodicity refers to the concentration of sodium relative to calcium and magnesium. A high sodium ion content will cause soil clay to disperse and block water passing through the soil pores.

The exchangeable sodium percentage (ESP) is the measure of the sodium content or sodicity of a soil. Sodicity increases with pH.

Most subsoils with strong blocky, angular blocky or columnar structure are probably sodic. Too much exchangeable sodium can affect soil structure and vine health. High levels of exchangeable magnesium have a similar effect.

Many non-sodic soils irrigated with saline water are becoming sodic. The sodium in the saline irrigation water gradually displaces calcium, causing soil structure decline, poor drainage and a general decline in performance.

Dispersion is generally a symptom of sodicity so soils which disperse should have sodicity assessed by laboratory analysis.

Accurate measurement of sodicity in soil can only be done in the laboratory. This is done by either extracting the soil solution or the exchangeable cations (i.e. those attached to the clay particles). The soil solution can either be extracted with the saturation extract procedure or the 1:5 soil:water procedure.

Sodium (Na), calcium (Ca) and magnesium (Mg) are then measured in the extract and the sodicity calculated as the exchangeable sodium percentage (ESP) or the 'sodium absorption ratio' (SAR).

Sodicity hazard	ESP %	Soil structural stability
Non-sodic	0 to 6	Soil microstructure generally stable
Sodic	6 to 15	Soil microstructure susceptible to damage by tillage and trafficking especially when wet
Very sodic	Above 15	Soil microstructure may be damaged spontaneously by irrigation and rainfall (dispersion of clays)

Critical limits for soil sodicity.

Soft carbonates

The soft carbonates, as distinct from hard limestone and calcretes, occur within the fine earth fraction (particles less than 2 mm diameter) of the soil.

They consist of calcium and magnesium carbonates, with calcium predominating, and may affect availability of some nutrient elements, cause lime-induced chlorosis and decrease the permeability of the soil.

Organic carbon

Soil organic carbon (organic matter) is the part of soil which comes from plant, animal and microorganisms in various stages of decay and finally as humus.

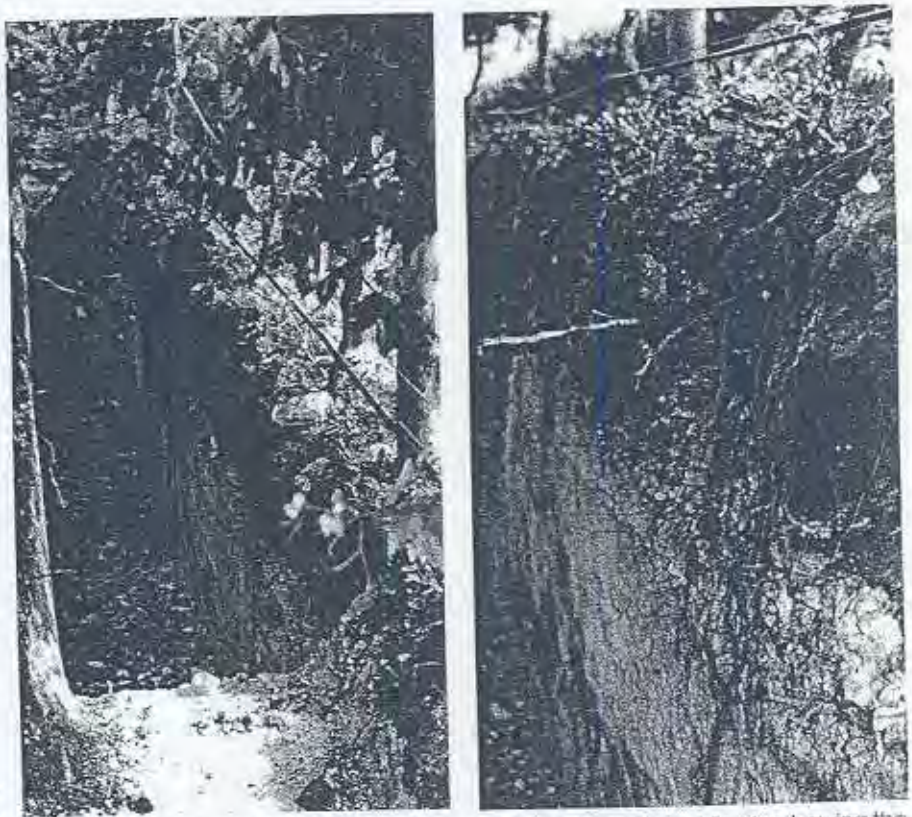
Humus can hold and supply large amounts of essential nutrients for plant uptake. It helps the general functioning of beneficial soil organisms, which assist in stabilising soil structure.

Most natural soils in Australia are low in organic carbon (less than 2%) and soils which have been cultivated often have less than 1%. Subsoils have practically no organic carbon. Soils in cooler, moist climates have higher levels of organic carbon and often better physical properties.

Soils that are regularly cultivated lose organic carbon because every time new surfaces are exposed by tillage, the organic carbon becomes accessible to microorganisms and is oxidised and lost to the atmosphere as carbon dioxide. Traditional 'bare vineyard floor' management has caused a major decline in soil organic carbon. Using herbicides is also likely to decrease levels of organic carbon.

Ways of replacing and building up organic carbon in vineyard soils include minimum tillage and use of properly fertilised, permanent grass interrow and on-row covercrops that are controlled by mowing rather than by spraying with herbicide.

Benefits of organic matter include: assistance in the formation and stabilisation of soil aggregates; slow release of nutrients, particularly nitrogen and phosphorus, in a form that can be taken up by plants; improvement of aeration capacity; and promotion of free-draining to protect against the effects of waterlogging.



Deep pits will allow soils to be sampled from a number of profiles, while also showing the extent of root penetration.

Soil structure and the root system

The part of the grapevine which is immediately affected by soil structure is the root system.

Very often, failure to meet yield or even quality target specifications can be traced to some limitation to root development which results from a physical or chemical problem in the soil.

Soil structure

Poor soil structure is often, but not always, clear to the eye. Compact, hard soil compared to a soft, friable soil presents a contrast that is usually quite obvious. Crusting and hardsetting are clear examples of poor soil structure. Waterlogging in vineyards may also be an indicator of poor soil structure. In particular, vine roots that are confined to shallow depths and which show marked horizontal growth habits are likely indicators of poor structural conditions.



Waterlogging can be an indication of poor soil structure. Exceptions include Coonawarra soils which from time to time will have excess water but have good structure.

Porosity

Soil structure is very much a concept of solid parts plus the spaces called pores. The soil scientists refer to the number of pores (porosity), the range of pore sizes (pore size distribution), and the continuity (connectivity) of pores. A wide range of pore sizes can exist, depending on the history of the soil. For example, one pass of a tractor wheel can compact a clay soil, changing its structure dramatically but not its texture.

Stability

Structural stability depends on a variety of substances that act as 'glues, girders and beams' that hold the arrangement of solid particles in some relatively stable configuration. The resistance of these substances to disturbance like wetting, traffic or tillage determines the structural stability of the soil. Basically this relates to the ability of a soil to retain its porosity and pore size distribution when exposed to some mechanical stress.

Structural quality

Physical factors which are important for plant growth are: sufficient aeration for root respiration; storage of sufficient available water; storage of sufficient nutrients; and a soft, penetrable medium for root growth.

Ideally a soil should have about 25% of the total porosity as large pores, 25% medium pores, 30% small pores, some very large pores and a minimum proportion of very small pores. With this distribution root aeration and available water are expected to be adequate and the soil will be soft and friable for optimum root growth.

Important parameters are total or readily available water, aeration porosity, soil strength within the available water content range and root penetrability of the soil.

Total available water

Total available water (TAW) is the water that may be taken up by plants from field capacity down to the permanent wilting point. Field capacity represents the wettest drained condition of the soil and wilting point represents the driest condition that plants can tolerate. The effective root depth takes account of vertical constraints to root development which may limit the downward growth of roots.

In practice, this depth is defined by the depth of the first physical or chemical (salt, boron, etc.) barrier to root growth. In viticulture, with permanent traffic lanes in vineyards, horizontal constraints need to be taken into account.

Readily available water

Readily available water (RAW) is the water easily taken up by plants between field capacity and the 'refill point' for irrigation. Both total available water and readily available water are critically dependent on the proportion of the total soil porosity distributed as 'water storage pores' (micropores 0.03 to 0.0005 mm diameter).

Air-filled porosity

Air-filled porosity (AFP) is the volume of air present in the soil in relation to the volume of solid and water when the soil is at field capacity (i.e. the wettest condition after a period of drainage has occurred). This quantity represents the minimum volume of air available to the roots. Any soil that has less than 10 to 15% of air-filled porosity is likely to present a limitation to root respiration because of insufficient stored air and because there are also insufficient connected pores to promote exchange of fresh air from the atmosphere.

Strength

One of the main physical factors restricting root growth is high soil strength. Measurement of soil penetration resistance at field capacity using a penetrometer can provide an accurate indication of potential root distribution. Growth of roots in soil is limited by the resistance of the soil to root penetration. Soil strength is strongly dependent on soil water content and bulk density. Soil is weakest when wet and not compact and strongest when dry and compact.

Structural problems

For optimum vineyard management, the potential root depth of soil should be at least 70 cm where irrigated and 100 cm where not irrigated. Potential root depth is defined as soil

depth without physical or chemical barriers to root penetration. If such a barrier exists then it should be ameliorated prior to vineyard development.

Types of physical and chemical barriers to vine root distribution and development are outlined below.

Cracking clays

The mechanism which retards or invigorates vine growth in cracking clays is complex and poorly understood. More and more vineyards are being established on dark coloured (grey, reddish and black) clay soils that crack on drying and swell on wetting throughout the profile and most importantly, right to the surface.

These soils affect vine roots in several ways. Young vines may be slow to establish and high mortality may be observed in the first year after planting. Older vines may show vigour decline with age (8 to 10 years) or they may develop excess vigour.

Factors that explain these observations include: shallow rootzones may be 'waterlogged'—where roots suffer extreme lack of aeration during winter and spring, especially those of recently planted young vines; roots may be damaged by cracking of soil on drying in early summer, especially those of recently planted young vines; young vine roots may have insufficient root-soil contact as a result of large cracks developing in the shallow root zone in summer, and water uptake may be sufficiently impaired to impact on the vine growth; or water availability to vines may generally be limited because of the high clay content and the compact nature of the clays.

In some cracking clay soils, the roots of older vines appear to reach deeper reserves of soil water (and possibly better aeration and nutrition) causing the vines to become excessively vigorous.

Methods to ameliorate cracking clay soils to provide better establishment of young vines include ridging soil into mounds to reduce early mortality in some vineyards, presumably by reducing waterlogging in early spring. Another measure is mulching to reduce desiccation of the surface layer of soil and to avoid development of poor root-soil contact and consequent reduction in water uptake.

Hard rock and saprolite

Extensive hard rock at depths shallower than about 200 to 300 mm and which cannot be disrupted by deep ripping, constitutes a permanent barrier to root growth. However, some terra rossa soils are very shallow but provide ideal vine growth conditions even when effective root depth is less than 200 mm.

Partially and totally weathered rock (saprolite) is less of a restriction than hard rock. Root penetration into partially weathered rock can be improved by deep ripping using tines without wings to minimise the amount of rock fragments brought to the surface. The depth of ripping should be as deep as possible (e.g. 800 mm).

Root penetration and water storage can be improved by ripping with a winged tine but if fragments of hard



saprolite or partially weathered rock are brought to the surface during ripping the wings should be removed or reduced in width.

Cemented pans
Cemented pans are usually formed by the movement of clays, carbonates or other particles into gravel layers and sands which have become cemented, preventing root growth and water penetration. These pans are of variable thickness and may only be a few millimetres thick overlying soft to hard material such as saprolite or partially weathered rock. Even a thin pan will effectively block root growth. If they occur within 800 mm of the surface and are not too thick (<200 mm) cemented pans can be disrupted by deep ripping.

Calcareous clays (carbonate layers)
Calcium and magnesium carbonates ('lime') are often common and important constituents of soils where the annual rainfall is less than 500 mm. The lime may occur in different forms such as fine whitish particles in the soil matrix or as larger fragments of hard nodules or rubble ranging through to continuous limestone sheet rock. The amount and type of calcareous material affects vine rooting depth and different types of calcareous soils will have a greater or lesser effect on vines.

Compact subsoil clays
Poorly structured subsoil layers with a high clay content may restrict root development by confining roots to the surfaces of large peds (sections of soil which cling together to form lumps). Subsoils that are blocky, prismatic or columnar and yellow, grey and brown in colour permit less root growth into the subsoil itself and offer severe root limitations to penetration into peds. In all situations where roots are confined to the surface of hard peds, the question of the efficiency of root function in extracting water and nutrients must arise. In these circumstances, it is likely that a significant fraction of apparent available water may in fact not be accessible.

Shallow impeding subsoil layers can be disrupted by deep ripping and the disrupted aggregate structure stabilised by applying sufficient gypsum and organic matter.

Bleached subsurface sandy layers
Soils with a naturally occurring, compact, dense, light greyish to whitish layer lying below the dark coloured surface soil are common in Australia. The bleached layer usually overlies a hard, impervious clay subsoil at depths of 100 to 1000 mm. The bleached layer varies in texture from sand to clay loam but is always tightly packed, forming an effective root barrier and limiting root depth to the surface soil. South African experience suggest that these layers should be mixed with the surface soil by deep mouldboard ploughing. Amelioration may be improved by incorporating large amounts of organic material during this operation.

Compacted wheel traffic lanes
Soil compaction occurs when soil aggregates are compressed by the weight of heavy machinery, slippage of wheels at the soil surface or the pressure of the base of implement tines being dragged through soil. Compaction of soils that have been ploughed, disced or rotary hoed occurs immediately below the normal tillage depth, forming a plough pan.

Repeated working at the same depth year after year makes the plough pan very pronounced.

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Semillon	11.0	99.69	62.68	65.92	85.62	76.43	
Black Shiraz	2.6	51.65	46.87	48.49	68.46	68.77	
Cabernet	3.7	20.17	27.13	29.69	30.7	28.82	
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Compaction is most severe when the soil is driven over by tractors or tilled when wet but can occur even when the soil is dry. Wheel traffic compaction will stop the lateral spread of vine roots out of the vine row either by mechanical impedance or by reducing aeration, water infiltration and drainage.

Tractor wheel compaction may not be a problem in deep soils, but where a shallow subsoil or compaction layer causes further restriction, roots may be narrowly confined to the vine row, which will limit available water and nutrient reserves.

Hardsetting and crusting soil surfaces

Tillage of soil usually causes structure at the surface to deteriorate. Surface aggregates tend to slake and disperse more readily on wetting by rain or irrigation and lose resistance to disintegration by the mechanical action of raindrop impact. Consequently, surfaces tend to form either a crust or set hard.

Crusts are shallow packed layers, often less than 10 mm thick, that effectively prevent infiltration of water into the soil. Hardset layers are thicker (10 to 300 mm) and may reduce infiltration and cause shallow root growth.

Both crusts and hardset layers reduce seedling emergence. Most undervine rows which are kept free of weed growth by herbicides are crusted because of a severe reduction in biological activity such as absence of root growth, reduction in earthworm and other soil fauna and loss of organic carbon.

Many interrow areas are hardset if repeated and excessive tillage is done to establish and control cover crops.

The adverse effects of these conditions on vine growth relate to the disturbance of water infiltration under the canopy, prevention of vine root growth at shallow depths, and limitations to cover crop establishment and growth. Both crusting and hardsetting may be reduced by minimising tillage, keeping the soil surface covered at all times by mulch or permanent cover crops, and by building up organic carbon in the soil by adding organic matter or maintaining permanent, no-till cover crops.

Toxic elements or salts

The presence of excess salt or other toxic influences such as alkalinity, aluminium, boron or manganese may restrict roots as effectively as a physical barrier. The reason for this is that roots cannot function in a harsh chemical environment and are killed or become dysfunctional.

One of the main problems with chemical barriers to root growth is that, unlike physical barriers, they are not necessarily visible from a field inspection. For this reason assessment of limitations to root growth must be extended to analysis of the chemical condition of the soil. Measurement of pH and electrical conductivity on a 1:5 soil:water extract on all layers down to 2 m or more are the minimum analyses required. However, if other toxic elements are suspected, full laboratory tests should be undertaken.

Effects of salinity and sodicity

Both saline and sodic soils are 'salt-affected' soils. Salinity directly influences vine physiology and berry juice quality. Sodicity adversely affects soil physical properties, reducing the fertility of the rootzone and increasing stress levels on vines. This will decrease yield but not necessarily affect berry juice quality.

Slaking of soil aggregates and dispersion of clays, both processes that are increased by high sodicity, result in a decline in physical fertility. Physically degraded soils which are irrigated with poor quality water tend to accumulate more salts and sodicity tends to increase, causing a downward spiral of fertility.

Sodic soils can, however, be reclaimed successfully. Gypsum is generally applied to soil to correct structural problems caused or increased by a lack of soluble calcium in the soil. With soils that have been positively identified as sodic by chemical analyses, the amount of gypsum to apply can be calculated from the amount of exchangeable sodium present, the depth of the soil to be improved, the level of sodicity desired, and the purity of the gypsum.

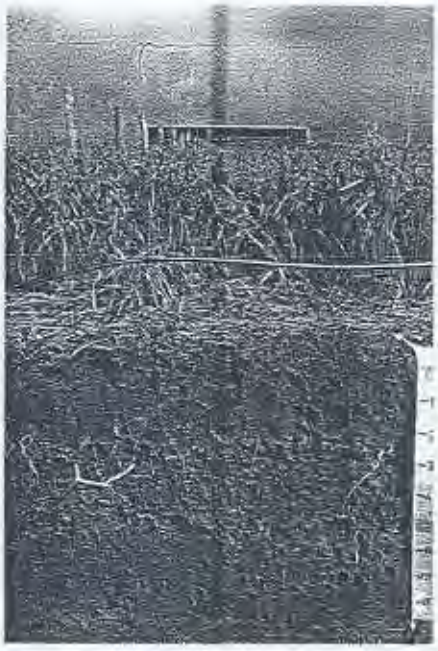
The amount of gypsum needed can be very high, however, and if this is the case then it is probably not practical or desirable to apply the whole amount at once because the rate of gypsum dissolution is low. Unless machinery is available to place it at depth then amounts in excess of 10 t/ha can be applied in later years.



This pit, dug in a Hunter Valley vineyard, has established soil type, root spread, and any impeding layers. While this picture, from Norm Cross (Irrigation Officer NSW), clearly shows the roots, other soil types may not make root outlines so easy to see. This is why the pictures to follow show roots painted with white acrylic paint. These are from the collection of Alf Cass, Research Scientist with the Cooperative Research Centre for Soil and Land Management.



In this saprolitic soil, deep ripping gave some response.



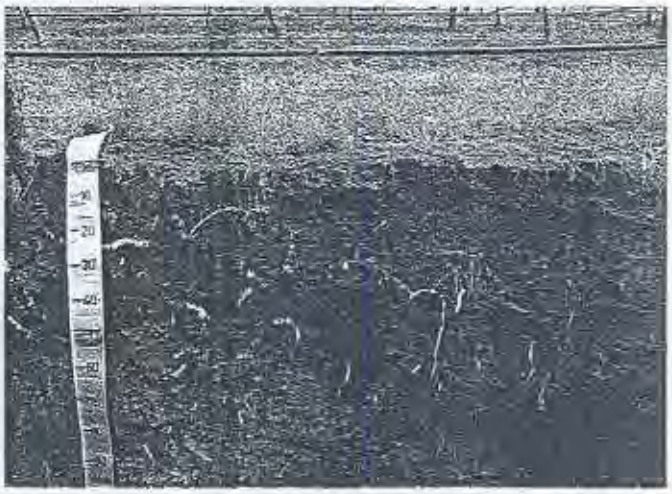
The problem here is a naturally compact subsoil (i.e. it has not been caused by a tractor or other mechanical means). A hard-setting sandy loam sits on top of the compact subsoil.



Horizontal root development like this indicates that the barrier to root penetration must be identified.



Without a deep higher profile, roots in this Terra Rossa soil are obviously dense but the superior soil promotes healthy growth.



High salinity was the cause of the root penetration problem in this soil.



Sand is very easily compacted. In this case the horizontal root growth indicates hard sections created by a tractor.



In this case ideal conditions exist for root penetration. Note the free pattern of root spread.



This picture shows a bleached layer of sandy subsoil where only the odd root has been able to get through.



Branching of roots is evident after deep ripping of an existing vineyard. With this practice, keep traffic off for a year at least to allow roots to re-develop.



Rows were mounded in this vineyard due to shallow soil but roots are still not penetrating far. Because mounds are prone to drying out, mulching is needed for this technique to be effective.

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'Water Management for Grape Production: Research to Practice™' is a training workshop coordinated by the Co-operative Research Centre for Viticulture, with major funding support from the Grape and Wine Research and Development Corporation.

The program is being organised and developed by PIRSA, SA Research and Development Institute, CRC for Soil and Land Management, Agriculture Victoria and NSW Agriculture.

The workshop aims to provide and investigate the most recent techniques for managing vineyard soil and water resources to produce grapes to specification.

Each workshop contains information presented to the group by scientists and industry people with knowledge of the region in which the workshop is being held. Workshop participants are then encouraged to discuss and evaluate the information in the context of their specific vineyard site.

This process has two outcomes; one, it results in vineyard managers and owners thinking about and discussing their current management practices and what they can change. Two, scientists and industry bodies gain a better understanding of how the research results can be implemented, and where the gaps in knowledge are.

Topics

Topics presented and discussed during the workshop include: soil survey and analysis techniques, limitations of soils to grape production, managing soil for optimum grape production, irrigation scheduling, soil moisture monitoring equipment and regulated deficit irrigation.

Several interactive sessions are also included to encourage participants to highlight some of their concerns and problems. This results in valuable feedback from the group about vineyard management issues. Each participant is encouraged to identify something new they can implement in their vineyard to improve soil and/or irrigation management.

The two-day workshop is followed by a third day, after vintage, where further issues of soil and irrigation management are discussed and feedback is obtained on the management changes participants attempted.

Pilot series

A pilot series of workshops has been completed, with workshops held in SA, Victoria and NSW. During the pilot series, the workshops were critically evaluated by scientists, participants and members of the education team at IHD Knoxfield.

The workshop structure and content was developed from the evaluation and is now nearly complete. Each workshop in the pilot series was also used to gain a better understanding of the particular problems associated with grape growing in each region. This was obtained by a questionnaire which participants completed, and through group discussion where various issues were raised.

The information gathered was used to tailor the workshops to be specific to each region.

Feedback from the workshop participants has been extremely positive, with many agreeing that new and interesting information was discussed. All participants also enjoyed the opportunity to discuss management problems in the group session and benefit from the experience of the whole group. The scientists and industry personnel who present sessions and organise the workshops also have gained enormous benefit from talking to participants about management problems.

Further workshops are planned in all grape growing regions of Australia starting in May 1998. Contact Gayle Grieger on (08) 85686400 or Hugh Armstrong, from CRCV on (08) 83039405 for more information.



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Water management course participants examining soil at Seppelt's Great Western winery.

Winemakers on site at soil pit

An excursion to examine a soil pit at Seppelt Winery on Tuesday was the highlight of a two-day water management seminar for winegrowers at Pyrenees House.

Soil scientist Gayle Grieger, industry development officer for viticulture with the South Australian Primary Industries and Resources Department, was the facilitator for the workshop, presented by Grampians Winemakers Association.

The Co-operative Research Centre for Viticulture and the Grape and Wine Research and Development Corporation jointly funded and developed the workshop.

The purpose of the soil pit visit was for winemakers to conduct a mini soil survey, while at the same time learn soil testing methods dealing with texture, structure, pH levels and salinity.

"If the grower knows about testing procedures he or she can get more out of any consultants utilised, and have a greater awareness of the issues and what questions to ask," Ms Grieger said.

Topics covered over the two days included soil suitability, water quality issues and irrigation with wastewater, managing soil structure and moisture monitoring.

Ms Grieger said water supply was a major issue facing Ararat district winegrowers, with most reporting already that dams were not full enough so close to the onset of summer.

Environment manager for Grampians Water Mr David McMaster said the wastewater pipeline to service Ararat vineyards will be put to tender late this year and is expected to be ready for use by the summer of 1999.



A new wine centre for Avoca?

Member for Ripon Mr Stephen Elder has announced a $4250 'Partnerships for Growth' grant for an investigation into the feasibility of establishing a wine and gourmet centre at Avoca.

Pyrenees Shire and Pyrenees Vignerons Association, William Angliss 2000 and the Avoca Chamber of Commerce came up with the proposal.

Mr Elder said if the centre got off the

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