COOPERATIVE RESEARCH CENTRE *for* VITICULTURE

Managing irrigation for grapevines

First Report

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Disclaimer

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Executive Summary

During interviews with grape growers we found their irrigation management was strongly determined by the type of irrigation system they had installed and the extent to which they could utilise soil moisture monitoring equipment. Consequently, we have identified the factors that influencing the adoption of pressurised irrigation systems. The most common reason growers gave for adopting these systems is to save themselves time. This may be time spent irrigating or, in the case of redevelopment, time spent irrigating, spraying, pruning and harvesting. Some growers have found the installation of pipe and riser systems solved their time pressures. Growers are also installing pressurised systems in areas outside the established irrigation districts that are unsuited to flood or furrow irrigation.

The type of pressurised irrigation system chosen by growers depends on their type of grape enterprise, whether they face a frost problem, wether they have access to water on demand and their finances. For example a table grape grower will typically chose under-vine sprinklers so they can grow a cover crop and to minimise disease problems in the vine canopy.

Growers are more likely to adopt soil moisture monitoring if they have converted to a pressurised system and are able to irrigate on demand. Growers in these circumstances are able to take full advantage of monitoring information. These growers are more likely to be motivated to adopt monitoring if they are growing grape varieties where quality parameters are particularly important.

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All errors and omissions remain the responsibility of the authors.

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1.1 Introduction

More precise methods for scheduling irrigation have been developed in recent years. Basically, these methods involve scheduling the timing and length of irrigation by objectively monitoring soil moisture. The major force driving the development of these methods has been the concern of organisations involved in natural resource management to increase the efficiency of irrigation in the horticulture industries.

Best management practices have been identified for vineyard irrigation (see for example, Skewes and Meissner 1997). These practices cover different types of irrigation systems and their management using soil moisture monitoring equipment such as neutron probes and tensiometers. The management of these systems may include practices such as Regulated Deficit Irrigation (RDI), Partial Rootzone Drying (PRD) and Alternate Row Irrigation are advocated. The level of adoption of these practices is variable and many growers are not achieving the benchmarks that have been established.

Our objective in this study is to understand the adoption of irrigation systems and soil moisture monitoring, and to identify and understand the factors that influence irrigation scheduling and management. This knowledge will be used to develop extension strategies promoting more widespread adoption of best management practices.

The study involves three stages. In the first stage we identify the technologies, practices and resources at the farm level that influence the benefits and costs of adopting different types of irrigation systems and management practices. This involves interviews with farmers, extension staff and other relevant experts or specialists. In the second stage, we classify grape growers into adoption segments based on key differences in their endowment of relevant vineyard technologies, practices and resources. In the third stage extension strategies and priorities determined. This involves detailed analysis and interpretation of the study results by the project team in collaboration with research and extension personnel. In this report we describe the findings from the first stage of this study.

For a more detailed description and justification of the study methods see, Kaine and Niall (1999), Kaine and Bewsell (2000), and Kaine and Niall (2001).

monitoring decisions of growers may help to define circumstances in which growers would find these techniques attractive.

1.3 Adoption of pressurised irrigation systems

The adoption of a pressurised irrigation system depends on the benefits this system offers the grape grower. In the interviews with growers it became apparent the attractiveness of a pressurised system depends on:

- The time and labour constraints the grower is under,
- The soils and topography of the block, and
- Whether the block is being redeveloped.

Water allocations were sufficiently large enough in all the districts we visited for water scarcity not to be raised by growers as a problem. Also, growers did not mention the cost of water either as factor in their decision to adopt pressurised systems, or as a factor in decisions to change irrigation management. As one growers stated:

> *"It's a minor cost compared to other costs [for the vineyard]".*

This implies that irrigation water is neither sufficiently scarce nor sufficiently expensive to motivate most growers to conserve water. Hence, efficiency of water use is unlikely to be an issue for most growers unless they face a pressing need to improve their grape quality. Some growers may be interested in saving water if:

- They are experiencing problems with high water tables or salinity which they can influence through irrigation management,
- They are expanding their vineyards and need to save water from their current allocations to irrigate the extra area, or
- They are experiencing problems with the delivery of irrigation water because of problems with the district irrigation distribution system.

We found growers with flood or furrow irrigation have little opportunity to vary their irrigation routine, especially once harvest commences. However, some flood irrigators in the Murrumbidgee Irrigation Area have substantially reduced the amount of time they spend irrigating by laser grading (land forming) and installing pipe and risers.

Pressurised irrigation (overhead sprinklers, under-tree knocker sprinklers, micro-jets and drip)

A number of factors influence the decision about the type of pressurised irrigation system to install. These factors are:

- Crop type. For instance, table grape growers usually chose low-level sprinkler systems. Table grape production requires minimal wetting of the leaf canopy to minimise the incidence of disease and the growing of a cover crop between the vine rows to maintain moderate air temperatures in the vineyard. Hence, both overhead sprinkler systems and micro-irrigation systems such as drip irrigation are unsuitable for table grape production.

- Whether the vineyard is prone to frost. Growers with wine or dried fruit can install overhead sprinkler systems to alleviate problems with frost.

- The availability of irrigation water and the reliability of the district delivery system. In many of the areas we visited growers expressed concern that they regularly experience difficulties obtaining access to water. Delays in the arrival of ordered water or lower than expected delivery volumes were mentioned by a number of growers. Growers with these problems were more likely to choose overhead or low-level sprinklers over drip irrigation. Sprinklers are preferred because they irrigate at higher volumes than drip systems. Consequently, any delay in the arrival of water can be rapidly corrected. This is not possible with drip systems. Such systems entail irrigating more frequently with less water per irrigation than other systems. As one growers stated when talking about the different way drip needs to be managed:

  " What if I didn't get the water and I needed it?"

- The presence of a water table or salinity problem. Growers experiencing problems with high water tables or salinity may be more likely to install pressurised systems such as low-level sprinkler or drip irrigation to minimise the area of the vineyard floor that is watered during when irrigating.

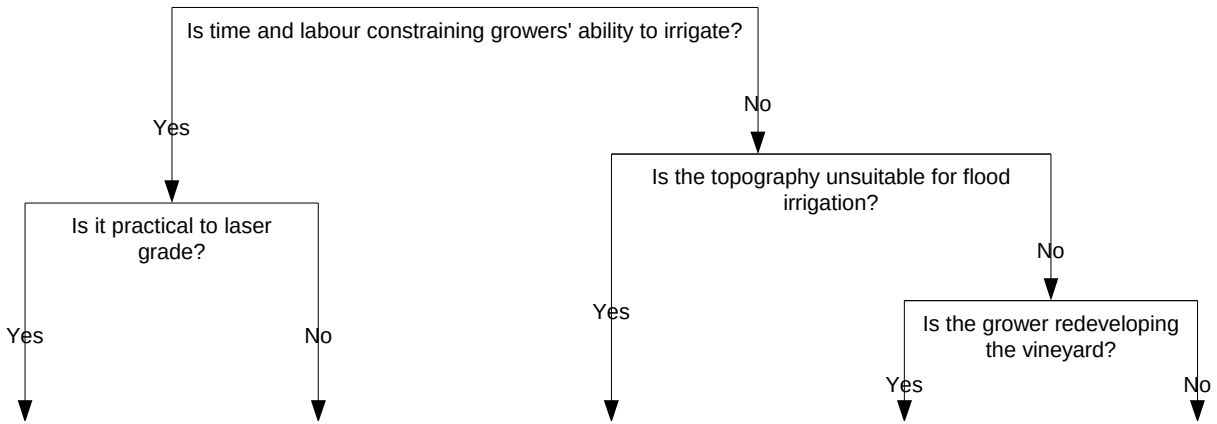
- Financial constraints. Systems such as overhead spray systems usually require a smaller initial capital investment than other systems such as low-level sprinklers and drip irrigation. In some circumstances growers can stage the expenditure involved in installing a fully pressurised irrigation system by first installing pipe and riser system, and then installing low-level sprinklers or drip irrigation at a later date. Some also growers indicated that because of financial constraints they had been forced to install pressurised irrigation in a piecemeal fashion. Overall however, few growers indicated that their financial circumstances had been a constraining factor in their adoption of pressurised irrigation systems.

1.4 Irrigation system segments for wine grapes

1.4.1 Furrow irrigators

The growers in this segment are flood or furrow irrigators. They are not experiencing pressure to reduce the time they spend irrigating. Also, they are not experiencing vine health or disease problems because of high water tables or salinity. Consequently, these growers see no reason to change a system that is working well for them. These growers may, for example, have full-time employment and own a small block that is not practical to convert to pressurised irrigation. The example below illustrates this situation for a grower that has recently replanted to new wine grape varieties.

Darryl and Darlene have a 5.2 hectares vineyard at Merbein South. Until a few of years ago the block was planted with dried vine fruit. Three years ago they pulled out the dried fruit and planted wine grapes. Darryl runs a small business and both he and Darlene are at an age when they want to start slowing down. They saw wine grapes as a good option because they are able to mechanically prune and harvest, once the initial training work is completed. The block is irrigated using pipe and risers. Darryl and Darlene believe the cost involved in converting to a pressurised system would be a great deal for the small area they have, would not be increase the value of their property if they sold it, and would not offer a great deal of savings in labour or time. The current system works well for them. The block is easy to water and Darryl has adopted alternate row irrigation. Darryl is able to drive around on the bike and swap over furrows very easily.



1.4.2 Redeveloper pressure irrigator

The grape growers in this segment are redeveloping their vineyards to reduce the amount of time they spend on a range of farming activities including spraying, pruning and harvesting and irrigating. Growers save time on these activities by planting vines in longer rows that better suit spraying, machine pruning and mechanical harvesting. Generally speaking flood irrigation is not practical with the longer rows. Consequently, vineyard redevelopment usually entails the installing a pressurised irrigation system. For example:

> *Susan and her son Tommy manage 20 hectares of wine grapes in Renmark. The home block is 10 hectares. When her son came home to work on the property they bought the 10 hectares block next door. They have redeveloped the new property, putting in under-vine sprinklers. It was an old, run down block and needed some work to become productive.*

1.4.3 Pressure irrigators

Growers in this segment are not under pressure to spend less time irrigating. These growers have installed a pressurised irrigation system because the topography of their block is not suitable for flood or furrow irrigation. Often, growers in this situation are establishing vineyards in new areas outside the existing irrigation districts. The particular circumstances of the site will dictate the type of irrigation system that is chosen. In the following example a susceptibility to frost at the site prompted the installation of overhead sprinklers.

> *Tony is a horticulturalist for a large corporation that specialises in wine grape production. They have planted 61 hectares to a mixture of red varieties on undulating property just out of Loxton. They pump irrigation water directly from a nearby river into a dam so they can water on demand. They use overhead sprinklers to irrigate the property. The hilly topography meant a pressurised system was essential and overheads give protection from frost.*

Growers in relatively frost free areas that have access to irrigation water on demand from a river or water storage often install drip irrigation.

> *Mel is the manager of a large corporate wine grape, citrus and avocado development on hilly country near Nangiloc. They pump water directly from the*

irrigation, including Mike. Mike believes the soil in the area doesn't suit drip irrigation and Mike finds that with several blocks overheads are easy to check. Also, there is a saving of labour relative to furrow irrigation because you don't irrigate all at once and you can get back on the ground faster because it ground dries out quicker.

1.4.4 Time saving furrow irrigators

Growers in this segment have experienced pressure to reduce the time they spend irrigating. However, in addition to installing a pressurised irrigation system, they also have the option of laser grading and converting to a pipe and riser furrow irrigation system. This allows growers to install some of the infrastructure needed for a pressurised system (such as pumps and mains) without incurring all the expense of full conversion. We believe most of the growers in this segment are from Griffith, where their situation with respect to irrigation water delivery, topography and soil types combine to make this option a practical alternative to a fully pressurised system.

Albert and his son manage 122 hectares of wine grapes in Griffith. The property is split into two blocks, some distance apart. Previously, both properties were furrow irrigated using siphons. They have just converted the home block to a pipe and riser system. They now save enough time on the home block to make irrigating manageable even though the other block is still irrigated with siphons. They plan to convert the other block to pipe and riser as finances allow. They also believe they can easily move to install drip irrigation once market circumstances justify the extra expenditure.

1.4.5 Time saving pressure irrigators

Like the growers in the 'time saving furrow' irrigation segment, the main reason growers in this segment have installed a pressurised irrigation system is to save time irrigating. While there may be other benefits to a pressurised system, these are secondary to the flexibility and labour savings a pressurised system offers. The type of system they choose depends on their circumstances. For example:

Boris manages 41 hectares of vines with his brother in Merbein South. They grow wine grapes with 28 hectares of overheads and the remainder under furrow

storage dam. All 169 hectares of the development are under buried drip irrigation. Currently only two people full time in the vineyard – himself and the farm manager. Mick finds that, with drip irrigation and an automated timer system, they can manage irrigating the entire area between them. All other activities such as spraying, pruning and picking is undertaken by contract labour.

However, some growers have been able to save time and convert to drip because their district irrigation infrastructure has been improved.

Bob and his wife have 16 hectares of dried and wine grapes in Pomona. They bought the block about 20 years ago and it's been on flood up to now. Two years ago district channel system was replaced by a pipe system and Bob is now able to get water on demand. Bob and his wife began to look into installing a pressurised system because they now had a reliable water supply and they were spending so much time flood irrigating. Overheads, low-levels and drip irrigation were all considered but in the end they decided on drip. Bob said "There's no way we could put drip in with the channel system. We would have had to go to low-levels." The few growers in the district who have converted to a pressurised system (before the pipeline went in) have either overheads or low-levels. However drip meant less time on the tractor (no slashing), it was flexible (they can spray and irrigate, pick and irrigate), and it could be automated so that anyone of the family could start it at the pump shed. They have just completed installing the system and Bob and his wife are looking forward to this season!

Some growers have installed their own farm dams so that they can convert to drip irrigation.

Lee runs 32 hectares of wine grapes on a property in Griffith. He has just converted the property over to drip irrigation. Originally it was under furrow but this was taking up a lot of time. Drip offered flexibility and considerable savings in time. Although Lee's property is on a channel he has a dam. Consequently, Lee orders water and then stores it in the dam. From there he can irrigate on demand. He's pleased with how well the vines are looking and although was a bit concerned that the older vines wouldn't adapt they have done well.

Finally, some growers have decided to install overheads instead of drip because of financial considerations.

Jim and his family have just started developing a site out of Merbein, growing wine grapes. The property was set up with overhead sprinklers that eliminate the

1.5 Irrigation system segments for dried vine fruit

1.5.1 Furrow irrigators

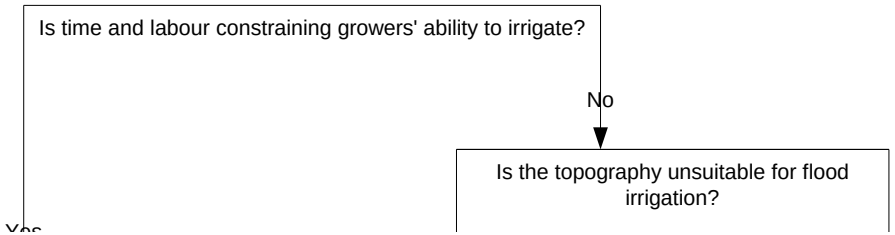
These growers are in a similar position to those growers in the wine grape furrow irrigators segment and the table grape furrow irrigators. They have no pressing reasons to change a system that is working well for them.

> *Luke has a part time job in town, and manages 10 hectares of dried vine fruit at home. The block is furrow irrigated and would generally get watered three to five times over an irrigation season. Luke does not believe it is worth while converting to micro-irrigation. The cost for the pump and equipment would far outweigh any time or labour benefit given the area of vines he has. Currently he is mostly able to irrigate over a weekend (approximately three days). This doesn't interfere with his job and only happens a few times a season.*

1.5.2 Redeveloper pressure irrigator

These growers are redeveloping and putting a pressurised irrigation system in their vineyards to save time across a range of farm activities. For example:

> *Barry has 61 hectares of dried and wine grapes in Merbein. He has been unable to purchase land next to his original block and so the 61 hectares is made up of a couple of blocks spread around the district. All of the dried fruit is under sprinkler irrigation. The wine grapes are furrow irrigated. He has completely changed the layout of the blocks he has converted to sprinklers. From previously short rows, the sprinkler blocks are now laid out in long rows that are much more suited to mechanical harvesting.*



1.5.3 Pressure irrigators

The irrigators in this segment are not under pressure to reduce the time they spend irrigating. They installed a pressurised irrigation system because the topography of their block does not suit flood or furrow irrigation. In this example a frost problem has meant the grower has installed overhead sprinklers.

> *Charlie owns and manages 41 hectares of vines for wine and dried fruit in Wemen. His property is made up of large sandhills, back from the river. The hills and valleys formed by the sandhills create quite a frost problem. The vines are under overhead sprinklers. This allows him to control the frost problem. He also believes the property is just too sandy for drip but would think about under-vine sprinklers given the opportunity financially.*

1.5.4 Time saver pressure irrigators

The primary reason growers in this segment have installed a pressurised irrigation system is to save time irrigating. There may be other benefits but these are secondary. Again, individual circumstances will determine the type of irrigation system chosen. In the following case the grower is in a pumped district where water has to be ordered, so under-vine sprinklers were considered most appropriate.

> *Tom and his wife have a medium sized wine and dried fruit property in Dareton. Their first block, the home block, was under flood irrigation. They converted it early on to overheads to save time. The second block they bought they converted to low-levels, again to save time but also because they thought low-levels had some advantages over overheads. With low-levels they could still grow a cover crop but wind does not affect the low-levels as much. They considered drip and although they were fairly confident they could get water on demand they decided that they wanted to be able to grow a cover crop and drip would not provide any frost protection.*

Other growers, who were also able to obtain water when required, decided to convert to drip irrigation.

> *Leo runs 41 hectares of dried fruit with his brother in Irymple. They have converted it all to trellis drying and mechanically harvesting. With just the two of them this seemed like the best way to manage their time in the vineyard. Wher*

Growers in this segment would be in a similar situation to wine and dried fruit furrow irrigators. We have not interviewed anyone in this segment yet.

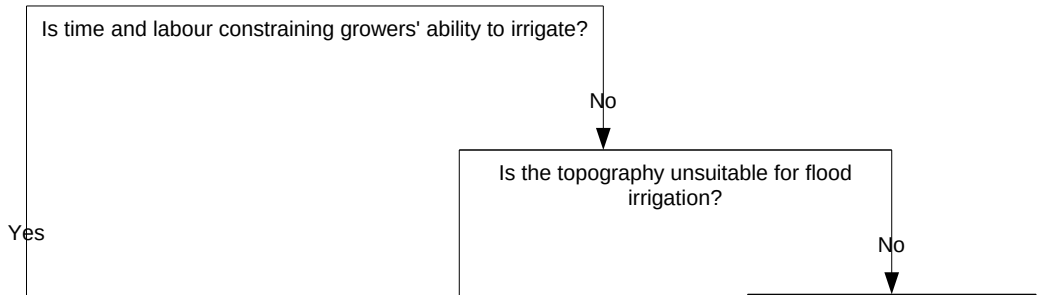
1.6.2 Redeveloper sprinkler irrigators

Growers in this segment are installing pressurised irrigation systems as part of the process of redeveloping their vineyard. In the example below the grower is planting vines in longer rows and converting from overheads to low-level sprinklers. With table grapes low-levels allow a cover crop to be grown without causing the disease problems associated with overheads.

Jack manages 45 hectares of table and wine grapes in Robinvale. He has a mix of overhead and low-level sprinklers. He is gradually redeveloping the property to longer rows and replacing the overheads with low-levels. Jack generally finds the overheads are easier to manage than the low-levels but some varieties do need careful management close to harvest with the overheads.

Since there are more low-level units in a block than overheads Jack has to juggle irrigations. For example, he has to run the overheads on shorter hours so they match the low-levels. However, there is better water distribution and lower losses due to wind with the low-levels. Jack feels "irrigation is just a breeze now [with low-levels compared to flood irrigating]."

Even though Jack pumps water out of a low-pressure pipeline Jack believes the district infrastructure can't support drip irrigation. Jack says, "It's sometimes difficult to get water, it depends on the demand. The problem is it's a 50 year old system designed for flood irrigation."



1.6.3 Sprinkler irrigators

The growers in this segment have installed pressurised systems because of the topography of the land. Generally, these growers have chosen low-level sprinklers because they are less likely to harm the berries, create less of a disease problem and enable the grower to have a cover crop to keep the table grapes cooler and prevent sunburn.

> *Nick runs a 21 hectare table grape development on sand hills near Wemen. They pump water directly from the Murray River on demand. The entire property has under-vine sprinklers. They decided against overheads because of the damage these can do to the berries. As Nick says 'For table grapes it's very important that there are no marks or blemishes. And overheads can create an environment for disease'. Drip irrigation would not allow them to grow cover crops. Cover crops are important because they keep the dust down and keep the vineyard cooler, which again affects the quality of the table grapes. Under-vine sprinklers allow Nick to run the irrigation system to cool the vineyard down and prevent burning of the berries.*

1.6.4 Time saving sprinkler irrigators

Growers in this segment have experienced pressure to reduce the time they spend irrigating. This is the primary reason for growers in this segment to convert to a pressurised system.

> *Rob and Laura manage 20 hectares of table grapes in Robinvale. Originally on flood irrigation, they converted to low-level sprinklers a few years ago because they were less work. Rob says "They're easier to manage and I get better quality grapes." He has also found that he's been able to get a few more years out of his 50 year old vines. "The sprinklers have a rejuvenating effect," he says.*

1.7 Irrigation scheduling and soil moisture monitoring

In general, the installation pressurised irrigation systems is a prerequisite for the adoption of soil moisture monitoring. Since flood irrigation constrains the timing of other vineyard activities such as spraying and harvesting, growers with flood or furrow irrigation must schedule irrigations to fit within these activities. This means that growers on flood or furrow irrigation do not have the managerial flexibility to properly utilise monitoring.

drip irrigation. Consequently, many growers used monitoring, at least for a season or two, to establish irrigation regimes that suited their new systems.

Since pressurised systems deliver relatively small volumes of water another constraint on the use of monitoring is the availability of irrigation water. In pumped districts where water is usually not available on demand and must be ordered growers may not have the capacity in their irrigation supply to respond immediately to soil moisture information. These growers may use monitoring to set up new irrigation routines at regular intervals throughout the irrigation system. However, they will not be able to use monitoring information to tailor their irrigation schedules on the basis of daily information. Consequently, we believe growers will be most likely to adopt and fully utilise soil moisture monitoring if they have the appropriate flexibility in the water supply and vineyard irrigation system. The preconditions for this flexibility are:

- They have a pressurised irrigation system, and
- They have water on demand from a river, storage, pressurised pipe or district channel (that is more or less permanently full over the irrigation season).

The factors that may triggers the use of soil moisture monitoring to help schedule irrigations for growers who meet satisfy these preconditions are:

- Quality issues for all grape types. Increasingly stringent quality requirements, in terms of berry colour for example, may require greater customising of irrigation using soil moisture monitoring.
- A water table or salinity problem or other vine health issue influenced by irrigation. In this instance growers may use monitoring to establish schedules to manage these problems irrespective of the type of irrigation system the grower has.
- Adoption of Regulated Deficit Irrigation (RDI) or Partial Rootzone Drying (PRD). RDI involves reducing water application in order to control vegetative growth on the vine while PRD aims to induce a hormonal response to drought to improve grape quality by reducing water applications at critical times. Objective monitoring of soil moisture can be used to implement these practices.

PRD is a relatively new development and is still undergoing trials. RDI has been available for a number of years now. Growers we spoke with did mention “cutting the water back” during the RDI period often without using soil moisture monitoring. On the whole, growers in irrigation areas where water is not available on demand were cautious about using these techniques. The following example is typical.

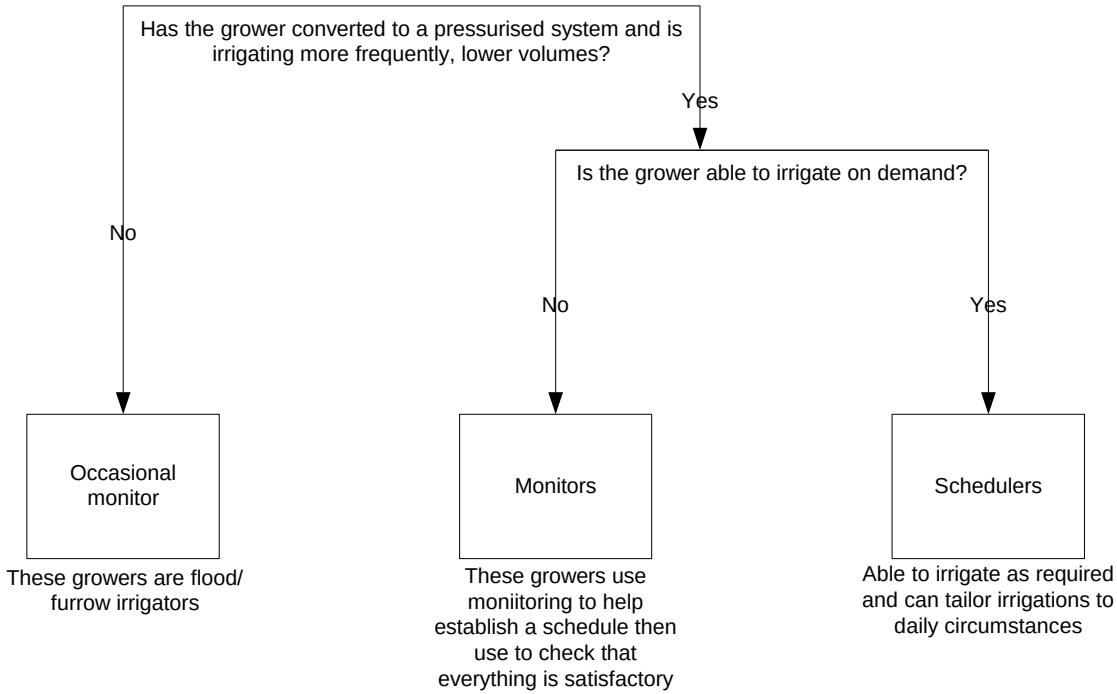
Jack has heard about RDI on wine grapes “but is a bit nervous about it.’

1.8 Soil moisture monitoring segments

The segments for irrigation technologies that have been described already imply there are three potential segments for objective soil monitoring (see figure 4). These are described below:

1.8.1 Monitors

Growers in this segment do not have a pressurised irrigation system. They are flood or furrow irrigating and will only adopt soil moisture monitoring if they have a problem such as high watertables. We did not interview a grower in this segment.



1.8.2 Predictive monitors

This segment consist of growers that have a pressurised irrigation system but do not have access to water on demand (ie continuous, reliable 24 hour access to irrigation water during the irrigation season). The lack of access to water on demand means they are restricted to using monitoring equipment as to check irrigations performance and to help schedule them set irrigation schedules from time to time. They are not in a position to use monitoring to help scheduling on a daily basis.

> *Rob and Laura own their own neutron probe. They started with a consultant when they installed their low-levels, then bought their own probe once they were comfortable with the information they were getting. Rob is not entirely happy with it. He says, "It might be the best system in the world as far as monitoring goes but I haven't got water when I need it." Rob also points out that although he feels he is using water more efficiently, he has not saved any water overall.*

Growers in this segment may use monitoring in blocks with a problem such as the example below.

> *Boris manages 41 hectares of vines with his brother in Merbein South. They grow wine grapes with 28 hectares of overheads and the remainder under furrow irrigation. Boris has tried tensiometers but had problems with them. The only set he uses now is in a block that has lime induced chlorosis and he knows he needs to be careful with the water. For other blocks he knows how much water they need – if he gets it wrong there is obvious run off and pools of water lying around.*

Another example is a wine grape grower for whom quality issues have triggered use of soil moisture monitoring.

> *Tom and his wife have a medium sized wine and dried fruit property in Dareton. Tom has used tensiometers just as a check for a while but found he couldn't rely on them. This year he is installing an EnvironSCAN™ primarily into the wine grapes. Tom has no contract with any wineries and relies solely on the quality of his grapes to be able to sell to the winery. This can mean that grapes he thought he could sell to a winery end up having to be dried, creating lots of extra work. He believes that with an EnvironSCAN™ he would be able to "get the quality" to be able to sell to a winery.*

1.8.3 Scheduler

The third segment encompasses growers who have a pressurised system and are able to water when demand. Often these growers are located outside the pumped irrigation districts. These growers are able to take full advantage of information supplied by soil moisture monitoring equipment. Some growers have adopted monitoring to ensure good crop quality.

> *Nick runs a 21 hectare table grape development in Wemen. They pump water directly from the Murray River on demand. The entire property has under-vine sprinklers. Irrigation scheduling is done with an EnvironSCAN®. Nick still goes out with a shovel to check how things are going, but generally has found the EnviroSCAN® to be quite accurate. He also has a couple of tensiometers as another check. He have a probe in each grape variety, and each probe has a cable running back to the shed where the information is downloaded. Nick also finds that the EnviroSCAN® tells him how far down his fertiliser has gone as it accurately tracks where the water is.*

Another reason to start soil moisture monitoring may be a high watertable, as in this example:

> *Matt manages 20 hectares of wine grapes in Loxton. The water supply infrastructure has just been upgraded and he is able to irrigate when required. All the blocks have overhead sprinklers. Matt began soil moisture monitoring because he was concerned about a high watertable on parts of his property. He started with a neutron probe service run from Loxton but has now bought a gopher so he can take readings and analyse the results himself. He says the gopher was a cheaper option than the neutron probe service, and while it can take a bit of time to read, he needs to be out in the vineyard anyway to check on the crop and vines.*

The installation of a new irrigation system may mean soil moisture monitoring could be useful to manage the change.

> *Bob and his wife have 16 hectares of dried fruit and wine grapes in Pomona. They bought the block about 20 years ago and it's been on flood up to now. Two years ago a pipe system replaced the district channel system their water was delivered through and Bob is now able to get water on demand. This season they have converted to drip irrigation.*

For some growers an important consideration in evaluating the value of soil moisture monitoring is the amount of time it will save on irrigating.

> *John runs 29 hectares of wine grapes just across the river from Mildura in NSW. The whole block is under drip. As John's home is in Mildura when he started looking for a soil moisture monitoring system he liked the Adcon system. He was able to download information from home, there were no cables in the field and they gave good support. 'They didn't just come out, put the system in and leave'. He has been only occasionally surprised by what the probes have told him. Last season Mildura had a couple of inches of rain and he was the only irrigator to start irrigating two days after because the probes told him the rootzone was drying out. He was surprised at how quickly things dried out after the rain.*

1.9 Conclusion

During interviews with grape growers we found their irrigation management was strongly determined by the type of irrigation system they had installed and the extent to which they could utilise soil moisture monitoring equipment. Consequently, we have identified the factors that influencing the adoption of pressurised irrigation systems. We found growers have adopted these systems to save themselves time. This may be time spent irrigating or, in the case of redevelopment, time spent irrigating, spraying, pruning and harvesting. Some growers have found the installation of pipe and riser systems solved their time pressures. Growers are installing pressurised systems in areas outside the established irrigation districts that are unsuited to flood or furrow irrigation.

The type of pressurised irrigation system chosen by growers depends on their type of grape enterprise, whether they face a frost problem, wether they have access to water on demand and their finances. For example a table grape grower will typically chose under-vine sprinklers so they can grow a cover crop and to minimise disease problems in the vine canopy.

Growers are more likely to adopt soil moisture monitoring if they have converted to a pressurised system and are able to irrigate on demand. Growers in these circumstances are able to take full advantage of monitoring information. These growers are more likely to be motivated to adopt monitoring if they are growing grape varieties where quality parameters are particularly important.

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COOPERATIVE RESEARCH CENTRE *for* VITICULTURE

Managing irrigation for grapevines

Second Report

A market segmentation study conducted as a component of the CRCV-MDBC project on 'Development and Adoption of Best Management Practice for Improved Water Use Efficiency and Effectiveness for Irrigated Vines'

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Executive Summary

Our objective in this study was to understand the adoption of irrigation systems and soil moisture monitoring, and to identify and understand the factors that influence irrigation scheduling and management. This knowledge will be used to develop extension strategies promoting more widespread adoption of best management practices.

The study involves three stages. In the first stage we identified the technologies, practices and resources at the farm level that influence the benefits and costs of adopting different types of irrigation systems and management practices. This involved interviews with farmers, extension staff and other relevant experts or specialists. In the second stage of the project we classified grape growers into adoption segments based on key differences in their endowment of relevant vineyard technologies, practices and resources. The findings from this second stage of the study are reported here. In the third stage extension strategies and priorities will be determined. This will involve detailed analysis and interpretation of the study results by the project team in collaboration with research and extension personnel.

In the first stage of this project we found the key factors driving the change from furrow irrigation to pressure irrigation in the grape industry were:

- A desire to spend less time irrigating and to increase flexibility in managing activities in the vineyard,
- A need to redevelop vineyards to longer rows to save time irrigating and harvesting grapes, increasing flexibility in managing activities in the vineyard, and changing grape varieties,
- The topography and soils of the vineyard were not suitable for furrow irrigation, and
- A desire to improve grape and bunch quality.

The key factors influencing the adoption of objective soil moisture monitoring were:

- A need to monitor irrigations more closely as a result of installing drip and microjet irrigation, and
- The availability of irrigation water on demand.

For the second stage of the project approximately 7000 surveys were mailed to grape growers in the Sunraysia, Robinvale, Swan Hill, Riverland and MIA regions. Almost 1900 surveys were returned representing a 44 per cent response rate.

The average age of respondents was 49 with most respondents having some secondary schooling.

vineyards and wished to save time irrigating, increase managerial flexibility and improve the quality of their grapes. The second segment consisted of growers who installed a pressurised system because they were redeveloping their vineyards and wished to save time irrigating and to increase managerial flexibility. These two segments represented 22 per cent of respondents.

The third segment consisted of growers who installed a pressurised system because they wished to save time irrigating, increase managerial flexibility and improve the quality of their grapes. The fourth segment consisted of growers who installed a pressurised system because they wished to save time irrigating and to increase managerial flexibility. These two segments represented 33 per cent of respondents.

The fifth segment was an aggregation of small segments consisting of growers that had installed a pressurised system either because of their topography, because they wished to improve the quality of their grapes, or because they were replanting and may have needed to replace older pressurised systems. The growers in this segment represented 12 per cent of respondents. The sixth segment consisted of growers who had laser graded furrow irrigation. These growers are mostly located in the Murrumbidgee Irrigation Area. This segment represented 10 per cent of respondents. The seventh segment consists of growers who had furrow irrigation. They represented 23 per cent of respondents.

The key factors influencing choice of pressurised system were access to water on demand, type of grapes grown, cost of the system and management of grape quality. There are two aspects to the management of grape quality. One aspect is the overall management of grapevines. The installation of pressurised systems can contribute to better bunch quality and canopy health through the more even distribution of water to the vine and greater control over the timing of irrigations. The second aspect is that, in some circumstances, pressurised systems may be needed to achieve quality targets for wine grapes. For example, achieving colour specifications for red wine grapes.

The frequency of using objective soil moisture monitoring to manage irrigation was highest among growers in the redeveloper segments and declined to a minimum among growers in the furrow irrigation segments.

Approximately 40 per cent of growers that completed the survey used objective soil moisture monitoring to assist them in scheduling irrigations. Some 22 per cent of growers indicated that they used Regulated Deficit Irrigation and 6 per cent indicated they used Partial Root-zone Drying. Approximately 18 per cent indicated they used alternate row irrigation.

Most growers indicated they used soil moisture monitoring to assist them to manage pressurised irrigation systems, especially drip and mini sprinkler systems. There is a greater risk with these

Growers in the third segment had either under vine sprinklers or overhead spray irrigation while growers in the fourth segment had some type of furrow irrigation. These two segments represented 23 per cent and 33 per cent of respondents respectively.

We found that the frequency of use of soil moisture monitoring was highest among growers in the first segment and declined to a minimum among growers in the fourth segment. This was consistent with expectations.

We did not identify any substantive relationship between age and the adoption of pressurised irrigation systems, soil moisture monitoring or other irrigation practices. We did find that growers who had adopted soil moisture monitoring and Regulated Deficit Irrigation were marginally more likely than other growers to have attended a course at a university or college of advanced education.

The results of the survey suggest that the key factors that influence the adoption of pressure irrigation systems and soil moisture monitoring by grape growers are largely related to the production context of the grower.

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We are indebted to the grape growers who participated in the study by being kind enough to complete and return our questionnaires.

All errors and omissions remain the responsibility of the authors.

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Managing Irrigation for Grape Production

1.1 Introduction

The concern of organisations involved in natural resource management over recent years has been to increase the efficiency of irrigation in the horticulture industries. Best management practices have been identified for vineyard irrigation covering different types of irrigation systems and their management using soil moisture monitoring equipment such as neutron probes and tensiometers (Skewes and Meissner 1997). Other irrigation practices such as Regulated Deficit Irrigation (RDI), Partial Root-zone Drying (PRD) and Alternate Row Irrigation are also being advocated. The level of adoption of these practices is variable and there is concern many growers are not achieving the benchmarks that have been established.

Our objective in this study is to understand the adoption of irrigation systems and soil moisture monitoring, and to identify and understand the factors that influence irrigation scheduling and management. This knowledge will be used to develop extension strategies promoting more widespread adoption of best management practices.

The study involves three stages. In the first stage we identify the technologies, practices and resources at the farm level that influence the benefits and costs of adopting different types of irrigation systems and management practices. This stage involves interviews with farmers, extension staff and other relevant experts or specialists. In the second stage we classify grape growers into adoption segments based on key differences in their endowment of relevant vineyard technologies, practices and resources. In the third stage extension strategies and priorities will be determined. This involves detailed analysis and interpretation of the study results by the project team in collaboration with research and extension personnel. For a more detailed description and justification of the study methods see, Kaine and Niall (1999), Kaine and Bewsell (2000), and Kaine and Niall (2001).

In this report we describe the findings from the second stage of this study.

1.2 Findings from the first stage

- A desire to spend less time irrigating and to increase flexibility in managing activities in the vineyard,
- A need to redevelop vineyards to longer rows to save time irrigating and harvesting grapes, increasing flexibility in managing activities in the vineyard, and changing grape varieties,
- The topography and soils of the vineyard were not suitable for furrow irrigation, and
- A desire to improve grape and bunch quality.

We found the type of pressure system that was adopted depended on the availability of irrigation water on demand, the cost of the pressure system, and the managerial requirements of the grower in terms of grape and bunch quality.

The key factors influencing the adoption of objective soil moisture monitoring were:

- A need to monitor irrigations more closely as a result of installing drip and microjet irrigation, and
- The availability of irrigation water on demand.

1.3 Survey questionnaire

On the basis of these key factors we designed a questionnaire in five sections. The first section sought information on some basic vineyard characteristics such as size, tree grape types, and information on length of irrigation season and so on. The second section was designed to elicit information on the irrigation systems used in the vineyard such as type of irrigation system used on each grape type (wine, dried or table), area of vineyard irrigated using each system, method of ordering irrigation water, and so on. Information was also sought in this section on grower's reasons for installing pressure irrigation systems. Respondents were asked to indicate which of the key factors that influence the adoption of pressure irrigation best described their reasons for installing pressure irrigation. In the third section of the survey information was sought on the use of soil moisture monitoring systems. Respondents were asked to indicate which of the key factors that influence the adoption of monitoring best described their reasons for trying or using soil moisture monitoring. In the fourth section growers asked a number of questions about irrigation management including the methods they used to schedule irrigations and whether they used techniques such as Regulated Deficit Irrigation or alternate row irrigation. In the final section growers were asked to supply details about their age, education and financial status.

The questionnaire was printed in the form of a 20 page booklet and mailed with a cover letter explaining the project and providing contact details. Comments on the survey were sought from viticulture research and extension staff. Following revision the survey was piloted with thirty growers from Sunraysia, the Murrumbidgee Irrigation Area and the Riverland. The survey was distributed to growers during winter 2001 with a reminder postcard distributed approximately four

1,164 questionnaires were returned by irrigators who were not grape growers. The number of surveys returned from each region and the area of grapes grown that these surveys represent is reported in table 1.

Table 1: Number of respondents and total area surveyed in each region

	Number of respondents	Area of vines
Sunraysia, Victoria	747	12,074
Sunraysia, NSW	182	2,861
Robinvale	91	2,066
Swan Hill/Nyah	49	1,375
Riverland	523	10,241
MIA	227	4,983
Other/missing	67	-
Total	1886	33,600

Note: Are of vines is in hectares.

Approximately 47 per cent of returns came from grape growers in Victorian Sunraysia and surrounding districts including Robinvale and Swan Hill. Almost 28 per cent of responses were from grape growers in the Riverland and 12 per cent from growers in the MIA. Only ten per cent of responses were from growers in New South Wales Sunraysia.[1] This is illustrated in figure 1 where the responses from each region are shown as a proportion of all responses from grape growers.

The response rates from each region are also shown in figure 1. The response rates varied from a minimum of 22 per cent in New South Wales Sunraysia to a maximum of 44 per cent in the Riverland. Some of this variation may have been due to regional differences in the extent to which the project and the survey were promoted through the media. The response rates for the Sunraysia regions will also be influenced by the fact that surveys were sent to all irrigators in these regions, not only grape growers.

With respect to Victorian Sunraysia, the respondents represent approximately 62 per cent of the grape growing area in that region in 1997, the latest year for which data is available (Argus 1999). Compared to that data, a greater proportion of vineyards in our sample is devoted to wine grape production and correspondingly less to dried grape and table grape production.[2] Also, greater

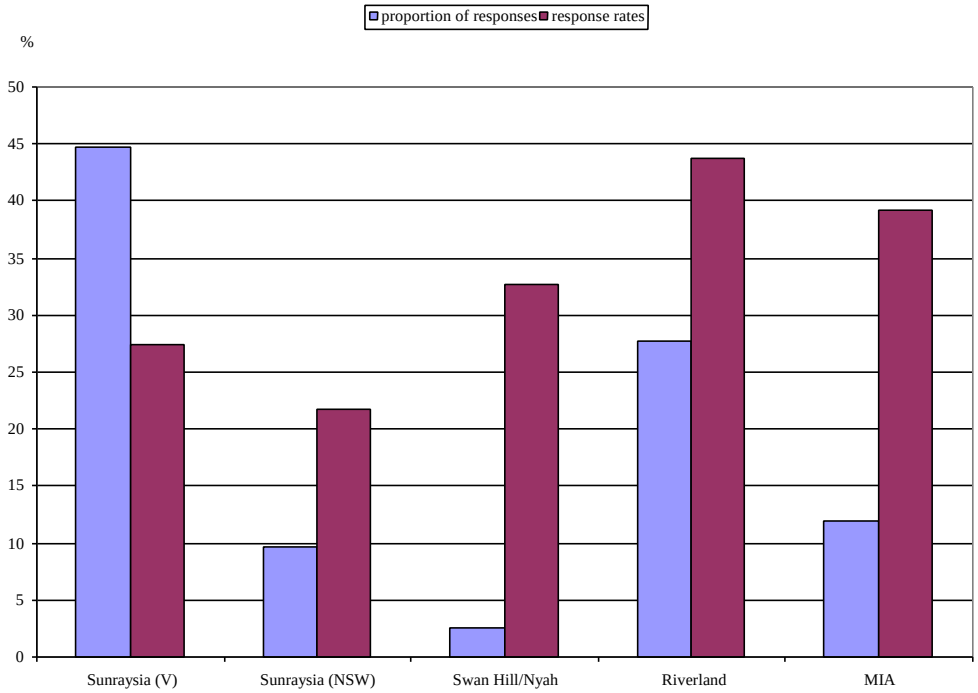


Figure 1: Proportion of responses from each region and response rate for each region.

1.6 General characteristics

The age of respondents varied between 19 and 85 years. The average age of respondents was 49 years, which is slightly lower than the average age for farmers reported by ABARE (2000). Most respondents, over 90 per cent, had some form of formal secondary education. Approximately 12 per cent had undertaken a course at a TAFE, technical or agricultural college while 13 per cent had attended university or a college of advanced education. Approximately 21 per cent of growers in the sample had completed some form of post-school study. These results are similar to those reported by Kilpatrick and Johns (1999).

The majority of growers, approximately 54 per cent, indicated that more than 85 per cent of their income was derived from agriculture. Almost 28 per cent of respondents indicated that less than half their income came from grape growing. Approximately 40 per cent of growers indicated that they were debt free or nearly so. Approximately 35 per cent of growers indicated that their current level of equity was less than 70 per cent. Almost 20 per cent of growers indicated that they had

1.7 Regional characteristics

The proportion of wine grape, dried grape and table grape growers in each of the regions are reported in table 2. In the Riverland and the Murrumbidgee Irrigation Area most growers concentrate on wine production. In Victorian and New South Wales Sunraysia growers produce wine grapes, dried grapes or a combination of both. In the Swan Hill region most growers produce wine grapes, or a combination of wine dried grapes. Finally, in Robinvale most growers produce wine or table grapes, or a combination of both.

The general crop characteristics of the sample are reported in table 3. In the table the average area of vineyards in each region and the average area of wine, dried and table grapes is reported. The average area of vineyards was not significantly different across the regions.[4] However, on average vineyards outside the pumped irrigation districts were four times larger than vineyards inside the pumped districts.[5] Note that most vineyards outside the pumped irrigation districts grew wine grapes. The total area of grapes for each region is in table 4.

Although, the average area planted by grape growers to wine, dried and table grapes in each region was significantly different across regions, this simply reflected the different emphasis in each region on the type of grapes produced.[6] We generally found there were no significant differences across the regions in the average size of vineyards of a particular type. For example, we found no significant differences across the regions in the average area of wine grape vineyards. Nor did we find any significant differences across the regions in the average size of dried grape vineyards.

Table 2: Proportion of wine grape, dried fruit and table grape growers in each region (%)

	Wine	Dried	Table	Wine & Dried	Wine & Table	Other
Sunraysia, Victoria	29.7	31.8	5.8	21.7	3.8	7.2
Sunraysia, NSW	41.8	28.2	1.2	24.1	2.4	2.4
Robinvale	24.4	2.2	34.4	8.9	16.7	13.3
Swan Hill/Nyah	61.7	2.1	2.1	19.1	6.4	8.5
Riverland	90.1	2.8	0.4	5.7	0.6	0.4
MIA	98.1	0	1	0	1	0

Table 3: Average area of vineyard under wine grape, dried fruit and table grapes in each region (ha)

	Wine	Dried	Table	Total
Sunraysia, Victoria	10.8	4.7	1.3	16.8
Sunraysia, NSW	11.8	4.7	0.4	16.8
Robinvale	12.6	2.0	8.4	23.0
Swan Hill/Nyah	18.6	2.5	8.1	29.3
Riverland	19.1	1.0	0.1	20.2
MIA	23.6	0	0.1	23.7

Table 4: Area of vineyard under wine grape, dried fruit and table grapes in each region (ha)

	Wine	Dried	Table	Total
Sunraysia, Victoria	7,776	3,384	914	12,074
Sunraysia, NSW	2,006	796	59	2,861
Robinvale	1,129	182	755	2,066
Swan Hill/Nyah	876	119	380	1,375
Riverland	9,658	522	61	10,241
MIA	4,962	-	21	4,983
Total	*26,407*	*5,003*	*2,190*	*33,600*

However, we did find that table grape vineyards in the Robinvale region were, on average, twice the size of table grape vineyards in Victoria Sunraysia.[7] This difference reflects the greater concentration in the Robinvale region on the production of table grapes. We also found that the average area of wine grape vineyards outside the pumped irrigation districts was five times larger than the average area of wine grape vineyards inside the pumped districts.[8]

In table 5 the average proportion of the vineyard area under different types of furrow and pressure irrigation systems are reported for each region. The proportions are also presented graphically in figures 2 to 7. The proportions were significantly different across regions.[9]

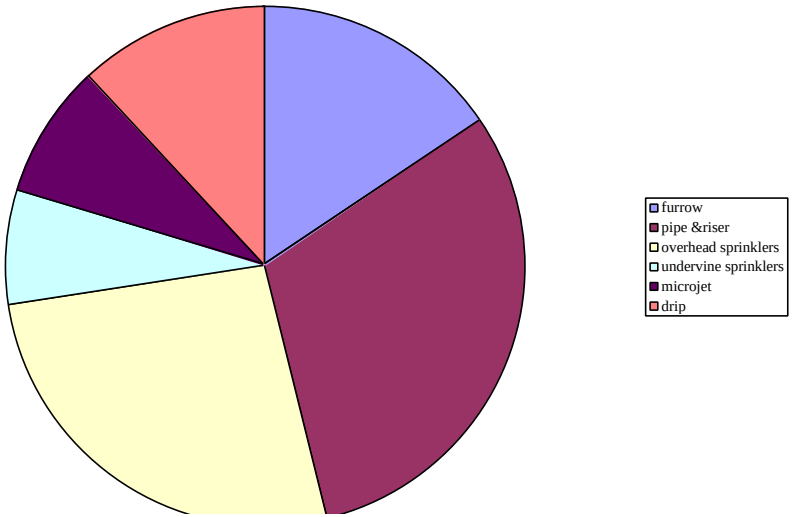
A variety of systems are used in the Sunraysia regions. In Victoria Sunraysia the majority of

The majority of the area in the Robinvale region was irrigated with pipe and riser, overhead sprays and under-vine sprinklers. Pipe and riser furrow irrigation and drip systems predominated in the Swan Hill region.

Table 5: Average proportion of vineyard area under different types of furrow and pressure irrigation in each region (%)

	Furrow	Pipe & Riser	Overhead sprays	Undervine sprinkler	Micro sprinkler	Drip
Sunraysia, Victoria	15.5	30.6	26.3	7.3	8.5	11.8
Sunraysia, NSW	5.7	18.2	27.5	8.2	15.4	25.0
Robinvale	6.5	18.7	23.7	27.6	16.2	7.3
Swan Hill/Nyah	5.5	29.9	7.3	2.4	3.4	51.6
Riverland	2.8	4.9	36.7	4.8	36.3	14.5
MIA	31.0	42.0	1.6	0.2	0.3	24.9

Note: The average proportion of the vineyard area under each type of irrigation system is significantly different across the regions.



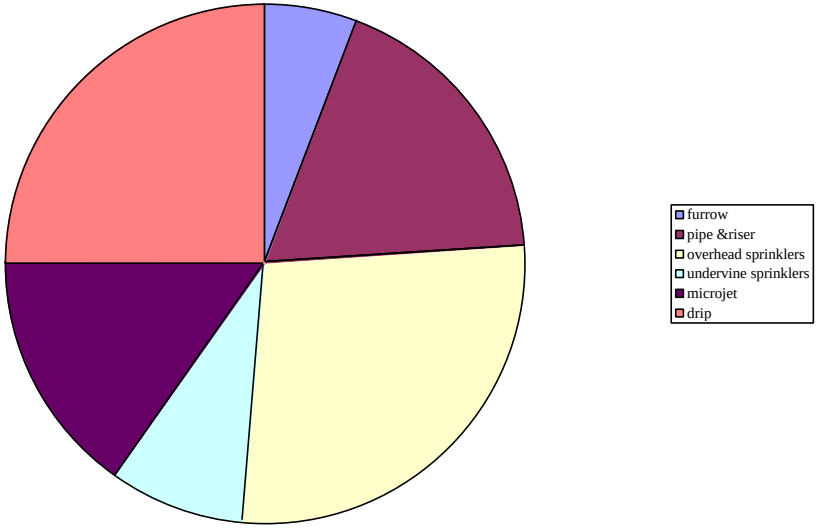


Figure 3: Distribution of irrigation systems in NSW Sunraysia

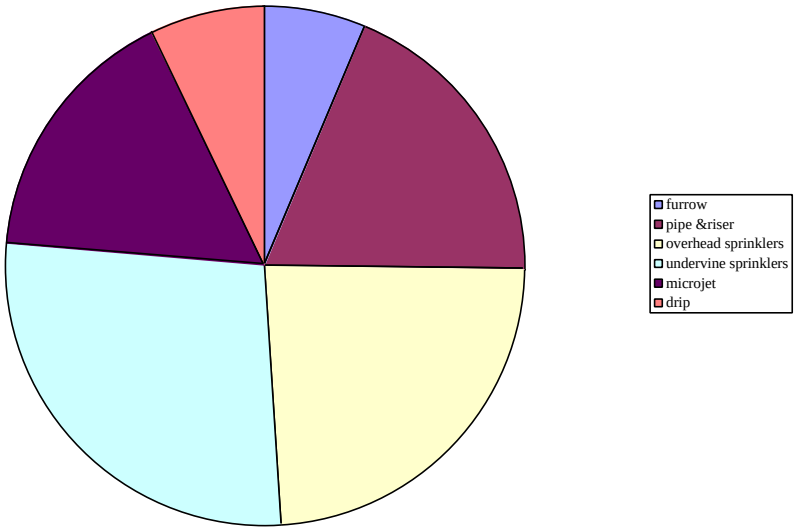


Figure 4: Distribution of irrigation systems in Robinvale

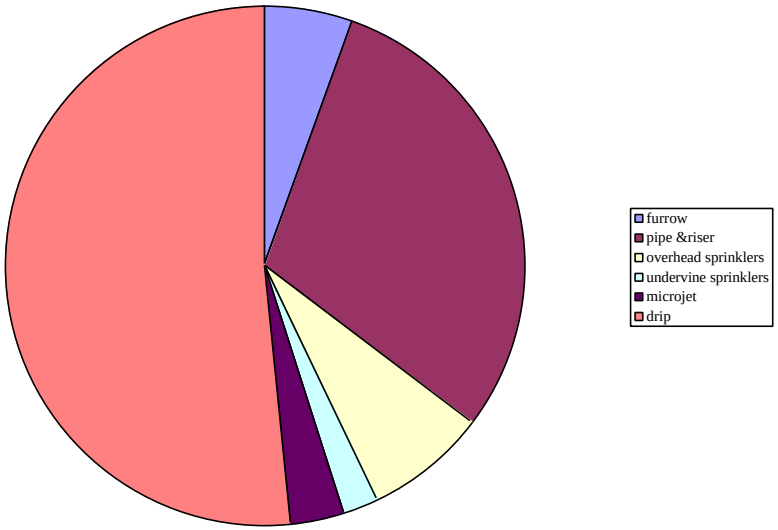


Figure 5: Distribution of irrigation systems in Swan Hill/Nyah

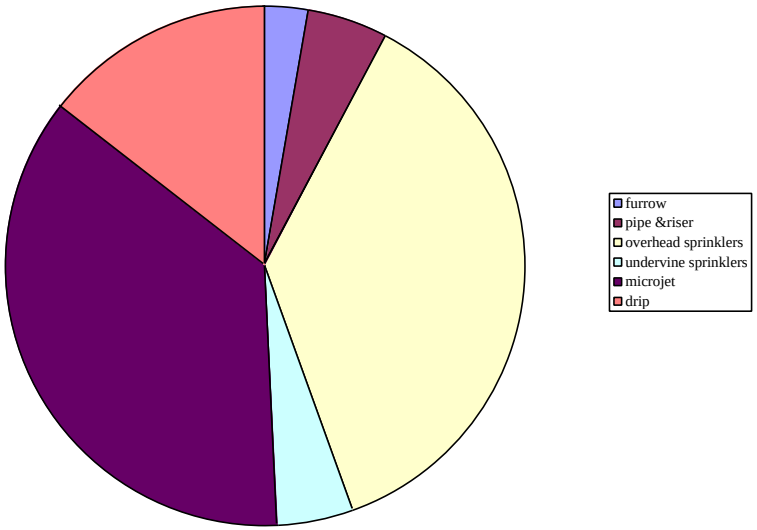


Figure 6: Distribution of irrigation systems in the Riverland

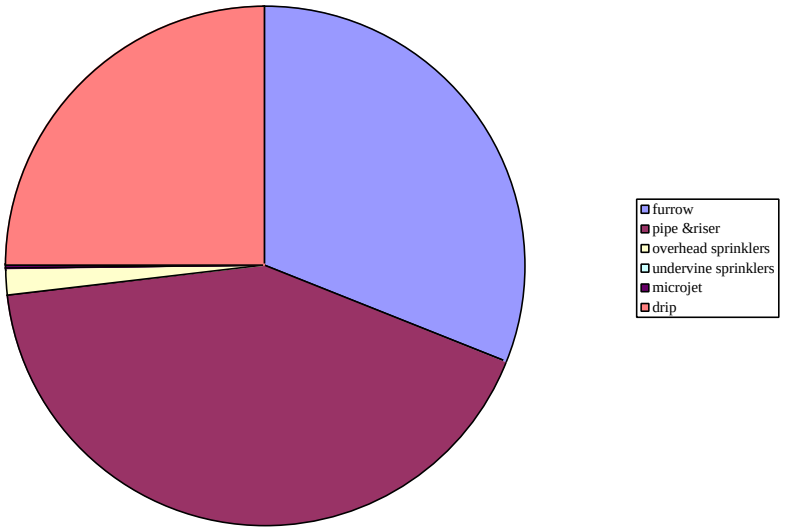


Figure 7: Distribution of irrigation systems in the MIA

In the Riverland most grapes were irrigated with overhead spray and micro sprinkler systems. Only a relatively small proportion of grapes in this region was irrigated with a drip system. Finally, furrow irrigation and pipe and riser irrigation were the predominant systems in the Murrumbidgee Irrigation Area. A relatively high proportion of grapes in this region was irrigated with a drip system.

Vineyards outside the pumped irrigation districts were mostly irrigated by overhead spray or drip irrigation.[10] The predominance of these irrigation systems outside the pumped irrigation districts reflects a need to save time and labour when irrigating the large-scale vineyards and the more variable topography outside the pumped districts.

In short, a mix of furrow irrigation and pressure irrigation systems was used in the Sunraysia regions and Robinvale. In Swan Hill drip irrigation dominated followed by pipe and riser furrow irrigation. Half of the Riverland was under micro sprinklers and drip irrigation with the rest irrigated by overhead sprays. In the Murrumbidgee Irrigation Area irrigation systems were divided between furrow irrigation, pipe and riser irrigation and drip irrigation.

In table 6 the proportion of growers in each region that use recommended practices such as pressure irrigation, quantitative soil moisture monitoring, Regulated Deficit Irrigation and alternate row

	Only					
Sunraysia, Victoria	45.4	13.9	33.6	12.6	5.0	24.9
Sunraysia, NSW	65.3	14.1	50.0	19.4	4.7	10.0
Robinvale	70	13.3	40.0	18.9	3.3	18.9
Swan Hill/Nyah	46.8	6.4	38.3	27.7	2.1	6.4
Riverland	85	12.0	42.2	39.3	4.5	4.5
MIA	20.5	14.3	23.8	16.2	12.9	35.7
Average	**57.2**	**13.2**	**37.0**	**22.2**	**5.6**	**18.0**

Note: Pressure only denotes growers who only had pressure irrigation (including overhead spray irrigation). PAN denotes using evaporation information to schedule irrigation. SMM denotes using quantitative soil moisture monitoring to schedule irrigation. RDI denotes Regulated Deficit Irrigation. PRD denotes Partial Root-zone Drying. ARI denotes alternate row irrigation.

On average, 13 per cent of growers use evaporation information to help them with their irrigation scheduling. The differences across the regions in the proportion of growers using this information were not significant.[12] Almost 40 per cent of growers indicated that they used soil moisture monitoring such as tensiometers or neutron probes to assist them in their irrigation scheduling. This proportion is substantially lower than the adoption rates reported by Fisher et al for Grapecheque participants in northwest Victoria (2001). Growers in New South Wales Sunraysia were more likely than growers in other regions to use soil moisture monitoring while growers in the Murrumbidgee Irrigation Area were less likely than growers in other regions to use monitoring.[13]

Only a very small proportion of growers in any of the regions has attempted Partial Root-zone Drying.

Over twenty per cent of growers indicated they used Regulated Deficit Irrigation and a similar proportion indicated they used alternate row irrigation. Grape growers in the Swan Hill and Riverland regions were significantly more likely to use Regulated Deficit Irrigation than growers in other regions. Growers in the Murrumbidgee Irrigation Area and Victoria Sunraysia were significantly more likely to use alternate row irrigation than growers in other regions.[14]

In figures 8 and 9 the proportion of growers in each region that indicated they received premiums or penalties with respect to quality parameters such as baume, colour and berry size are presented. Growers in the Riverland and the Murrumbidgee Irrigation Area were significantly more likely to receive premiums or discounts for baume than were growers in other regions. Growers in the Riverland were also more likely to receive premiums or discounts for colour than were growers in

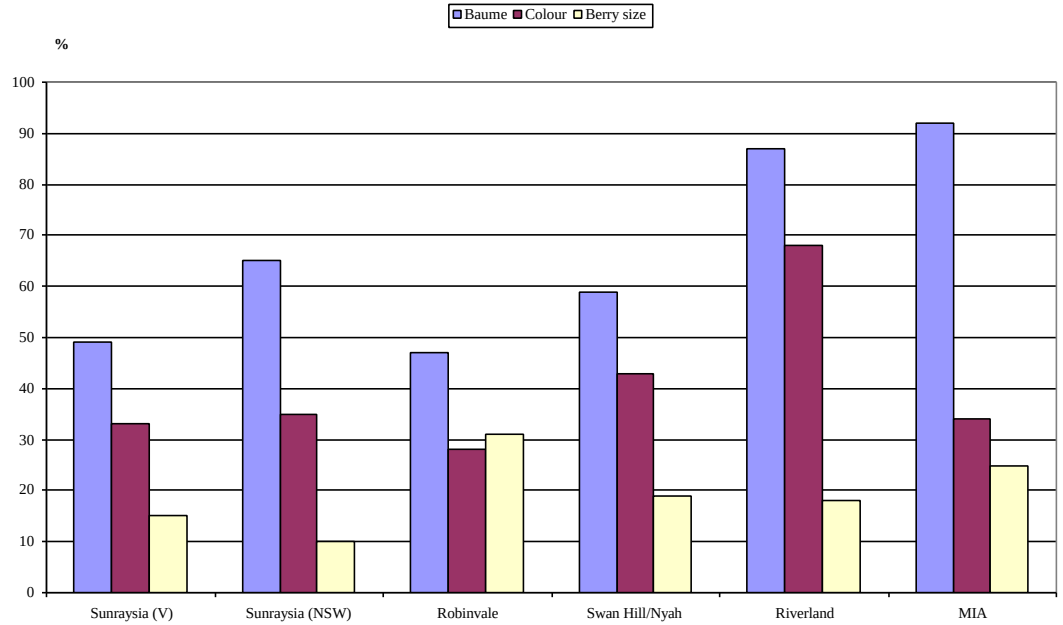
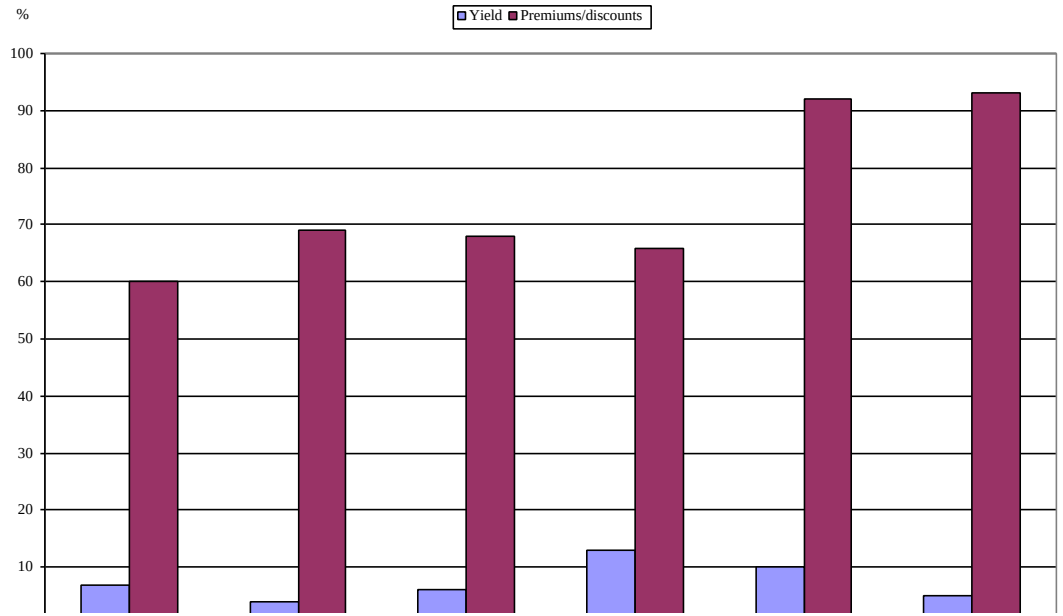


Figure 8: Selected quality parameters by region (a)



1.8 Industry characteristics

In table 7 and figures 10 to 12 the proportion of the area irrigated with each type of irrigation system is presented for wine grape, dried grape and table grape enterprises. In figures 13 and 14 the proportion of the area irrigated with each type of irrigation system is presented for the two main combination enterprises, wine and dried grapes, and wine and table grapes.

There are clear differences in the types of irrigation systems used in each type of enterprise.[16] The main systems used in wine grape enterprises were overhead sprays, micro sprinklers and drip irrigation. In contrast, furrow irrigation and pipe and riser irrigation were predominant in dried grape enterprises. The main systems used in table grapes are under vine sprinklers followed by drip irrigation, overhead sprays and pipe and riser irrigation.

Where a combination of wine and dried grapes are grown, the main irrigation systems were pipe and riser irrigation and overhead sprays (see figure 13). The main systems used in wine and table grape enterprises were overhead sprays, pipe and riser irrigation and micro sprinklers (see figure 14).

Table 7: Average proportion of vineyard area under different types of furrow and pressure irrigation by industry (%)

	Furrow	Pipe & Riser	Overhead sprays	Undervine sprinkler	Micro sprinkler	Drip
Wine	15.5	30.6	26.3	7.3	8.5	11.8
Dried	5.7	18.2	27.5	8.2	15.4	25.0
Table	6.5	18.7	23.7	27.6	16.2	7.3
Wine and dried	5.5	29.9	7.3	2.4	3.4	51.6
Wine and table	2.8	4.9	36.7	4.8	36.3	14.5

Note: The average proportion of the vineyard area under each type of irrigation system is significantly different across the industries.

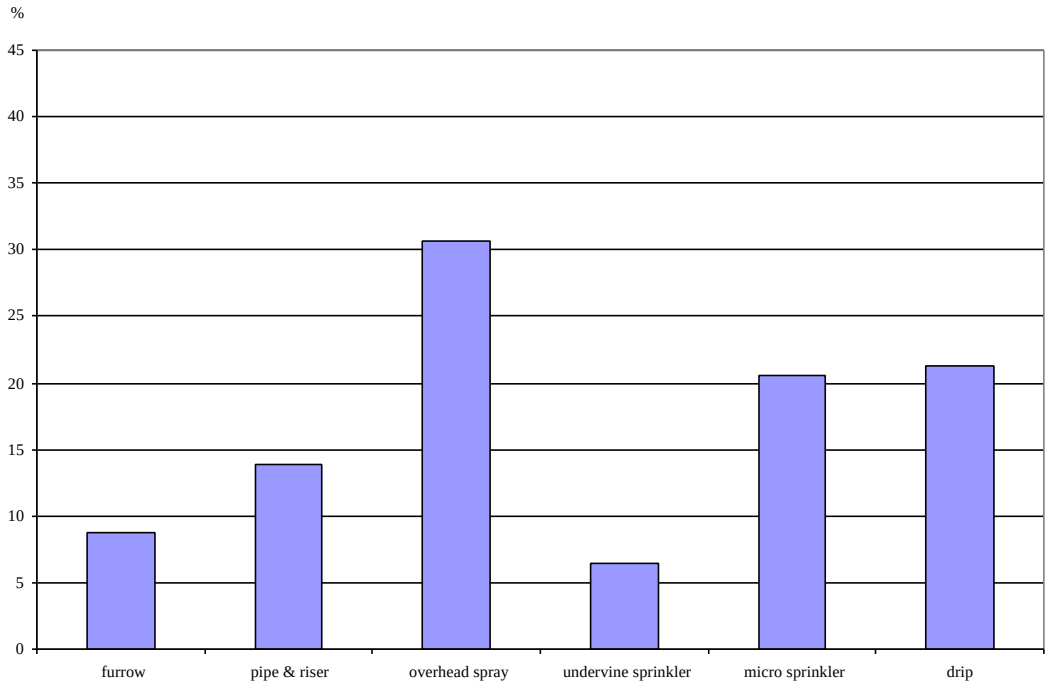
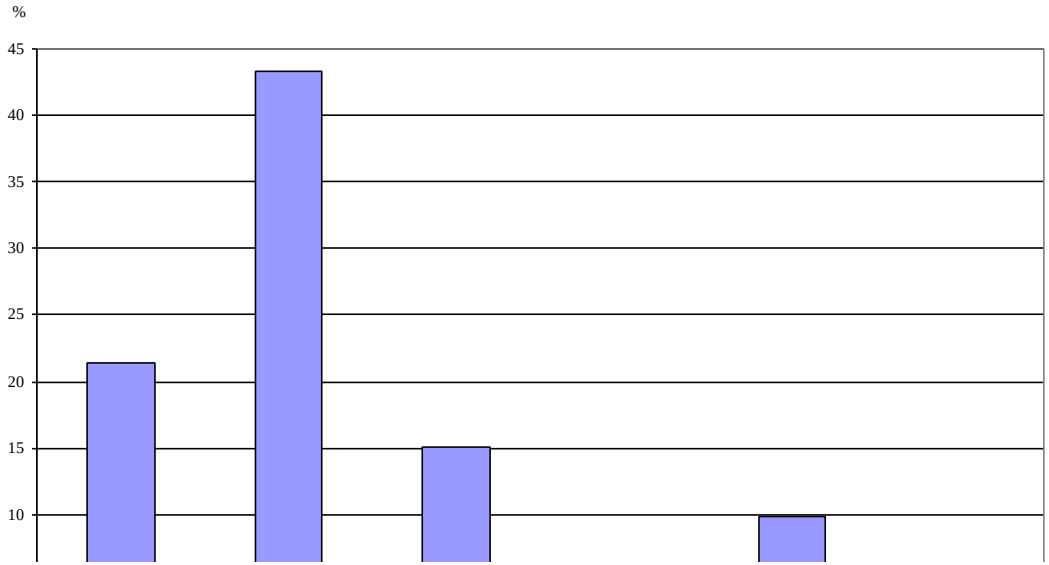


Figure 10: Distribution of irrigation systems in wine grapes



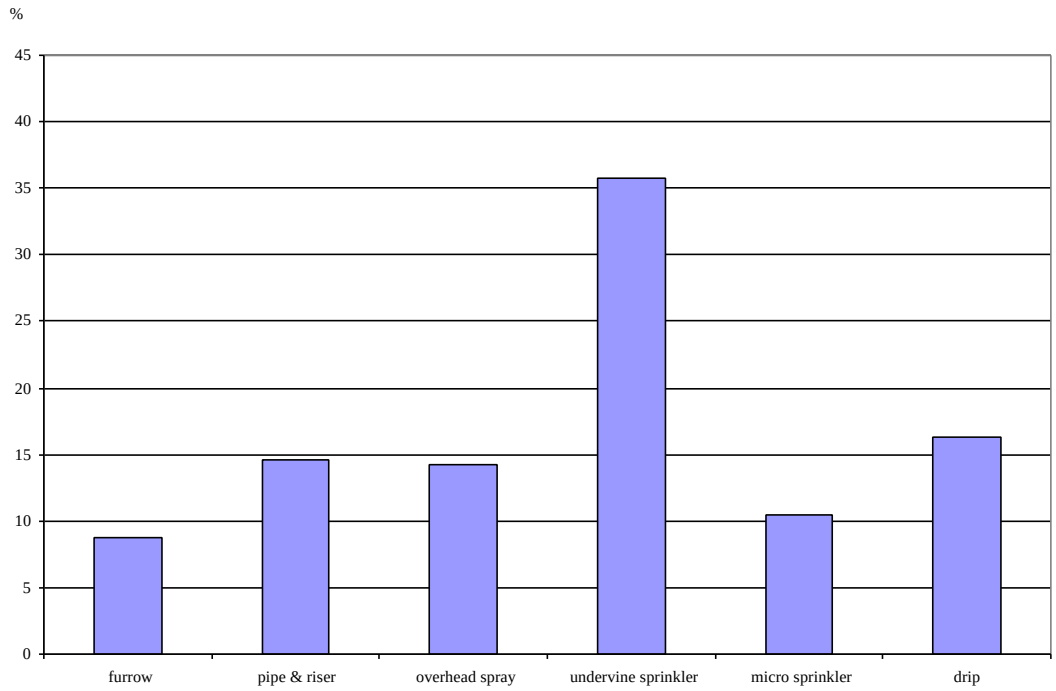
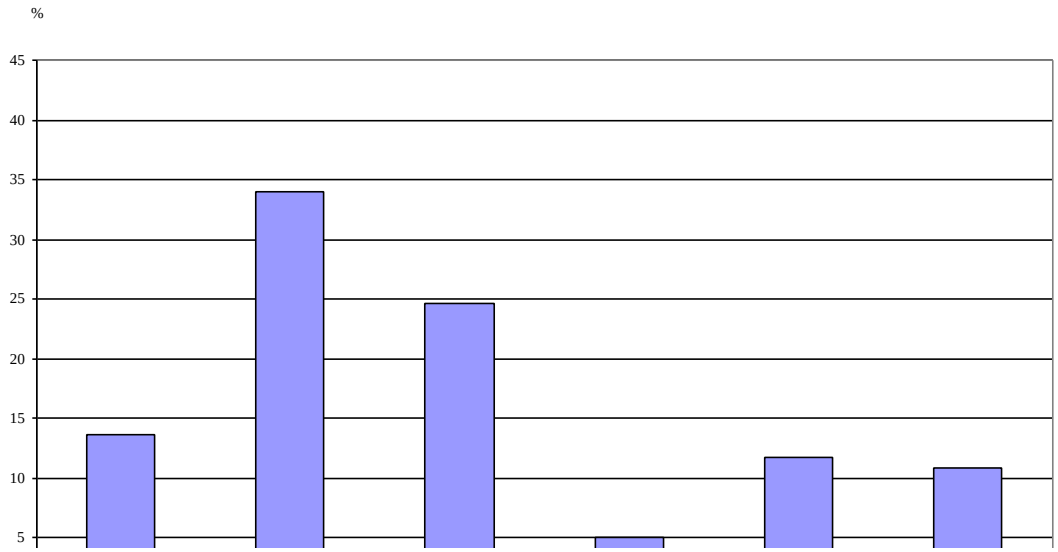


Figure 12: Distribution of irrigation systems in table grapes



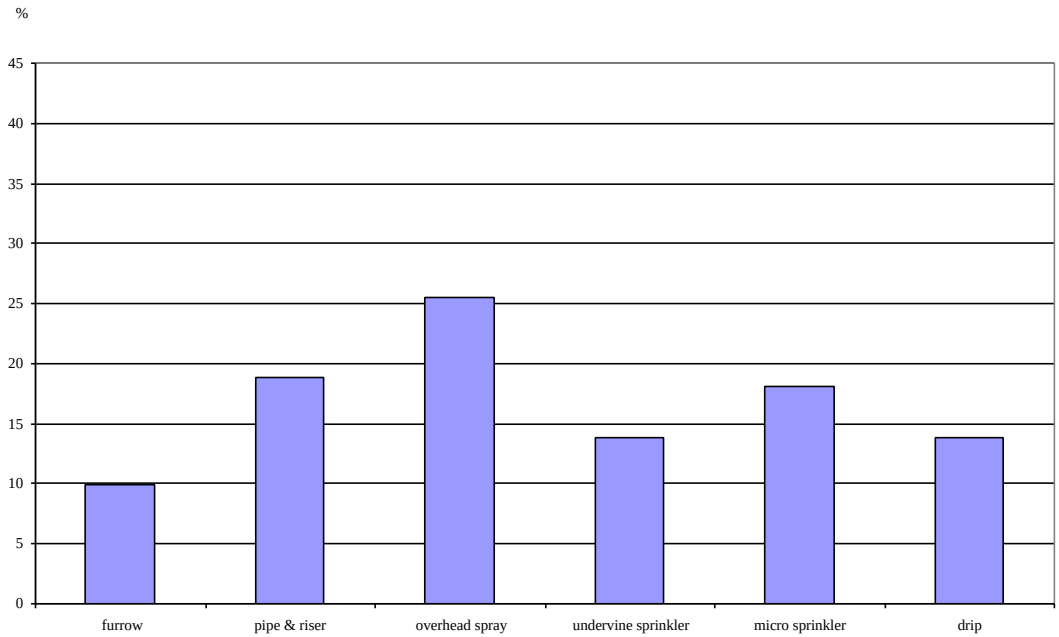


Figure 14: Distribution of irrigation systems in wine and table grapes

In figures 15 and 16 the proportion of growers in each type of grape enterprise that indicated they received premiums or penalties with respect to quality parameters such as baume, colour and berry size are presented. Growers with wine grape enterprises were significantly more likely than other growers to receive premiums or discounts for baume and colour. Growers with table grapes were more likely to receive premiums or discounts for berry size than were other growers. Overall, a significantly higher proportion of growers with wine grapes or table grapes received quality premiums or discounts compared to growers with dried grapes.[17] Note similar differences were also apparent between industries within regions, for example in Sunraysia. In figures 17 and 18 the proportion of growers in Sunraysia for each type of grape enterprise that indicated they received premiums or penalties with respect to quality parameters such as baume, colour and berry size are presented. [18]

In table 8 the proportion of growers in each region that use recommended practices such as pressure irrigation, quantitative soil moisture monitoring, Regulated Deficit Irrigation and alternate row irrigation are reported. A significantly higher proportion of growers with wine or table grapes only used pressurised systems compared to other growers.[19]

The proportion of growers that used evaporation information to help them with their irrigation scheduling was similar across all enterprises.[20] Growers with wine grapes were more likely to have

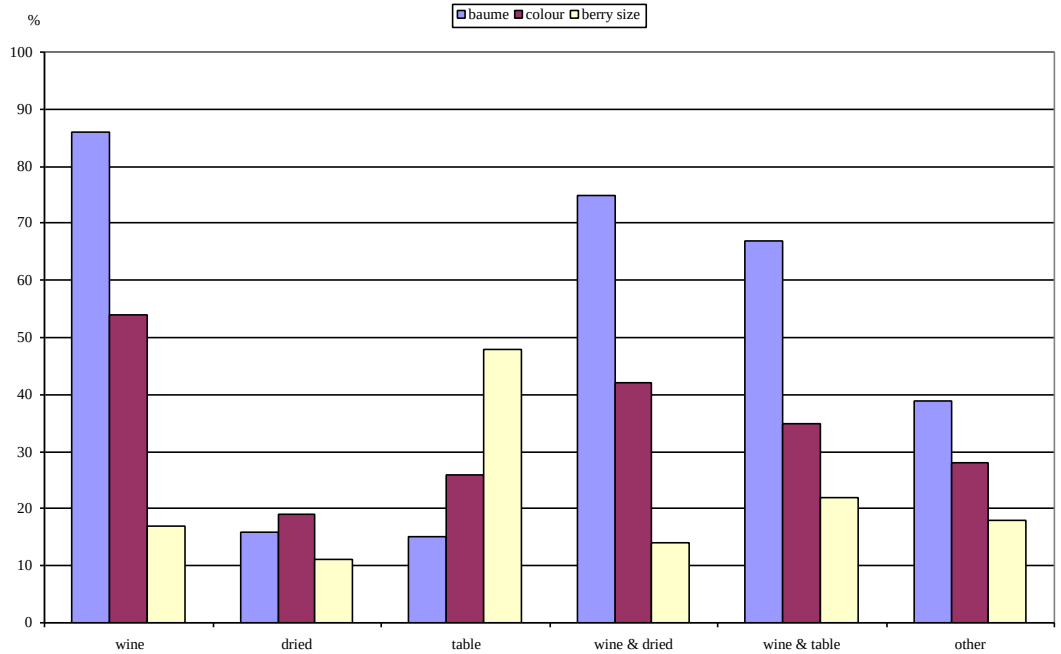
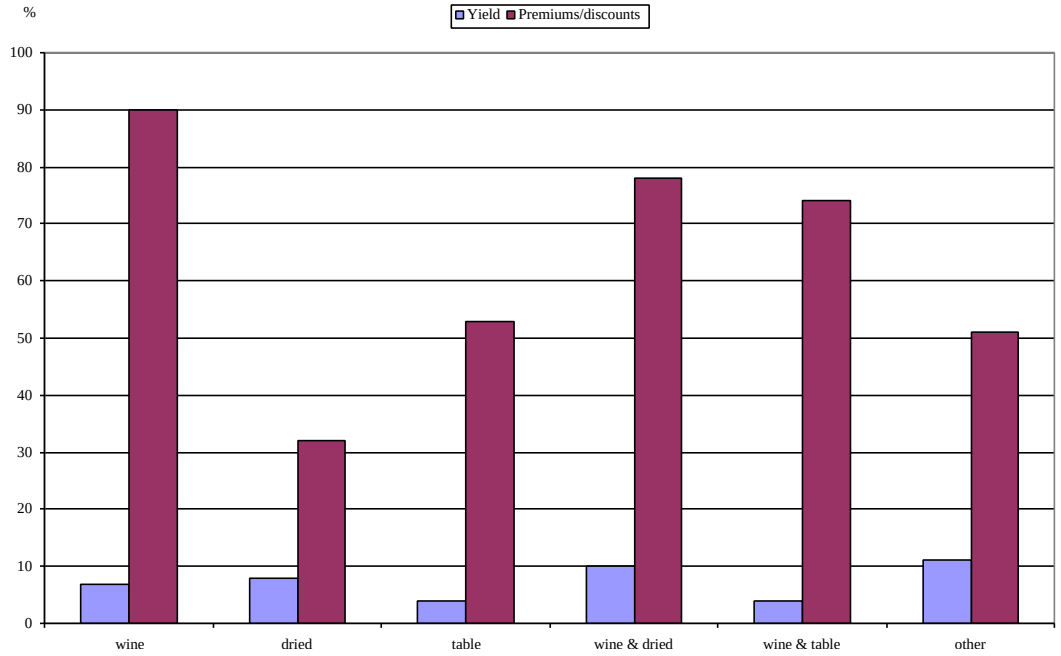


Figure 15: Selected quality parameters by grape enterprise (a)



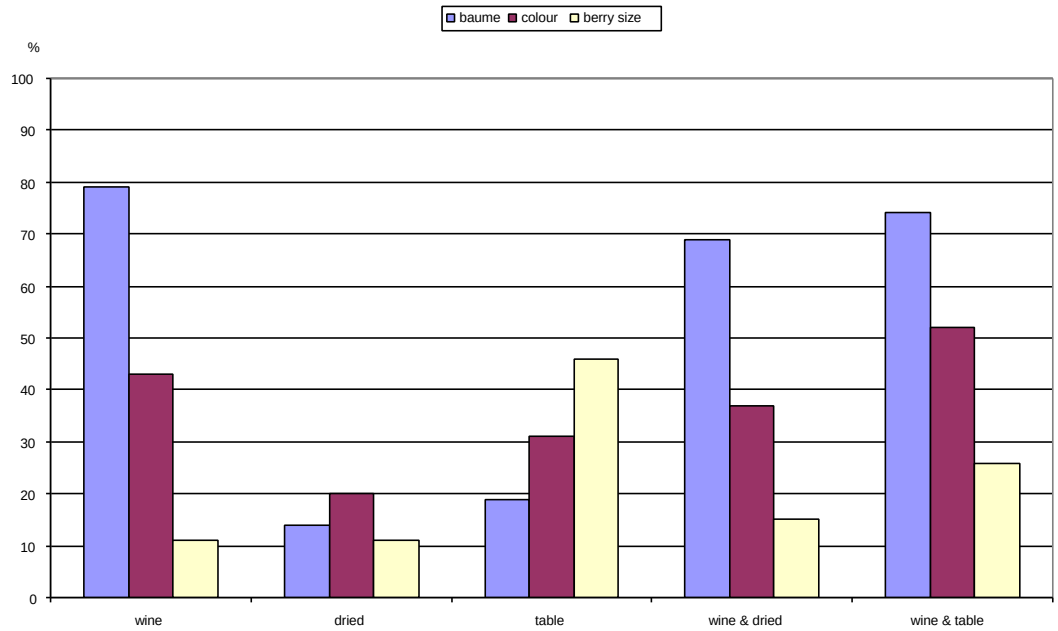


Figure 17: Selected quality parameters by grape enterprise in Sunraysia (a)

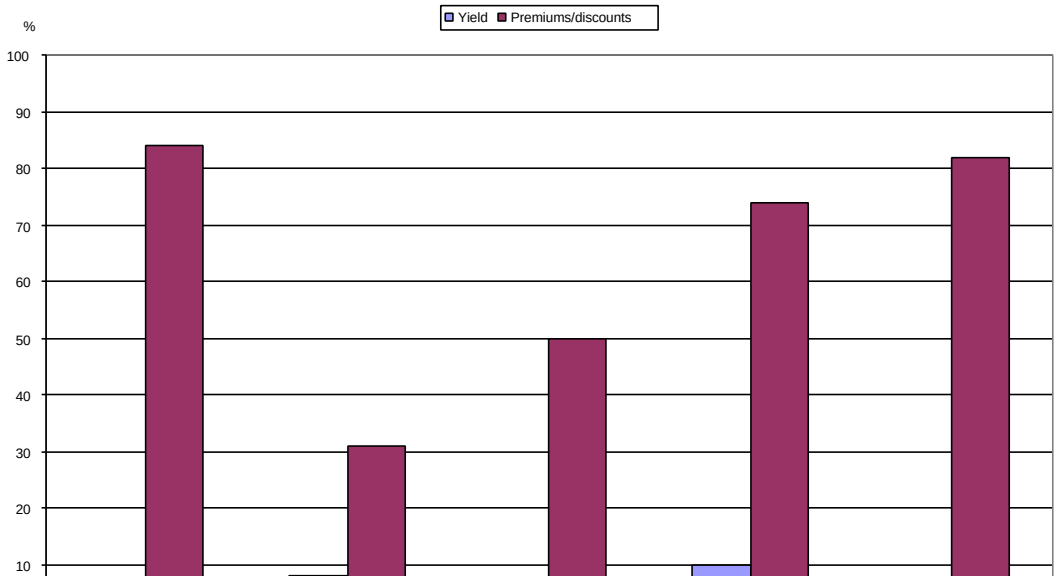


Table 8: Proportion of grape growers in each enterprise type using selected practices and technologies (%)

	Pressure Only	PAN	SMM	RDI	PRD	ARI
Wine	70.3	14.3	43.8	32.1	6.1	12.4
Dried	31.0	12.2	22.4	1.7	3.4	30.6
Table	75.0	2.5	30.0	3.8	7.5	10.0
Wine and dried	34.6	13.2	33.7	16.5	7.0	25.5
Wine and table	64.8	13.0	24.1	22.2	5.6	14.8
Other	33.8	13.5	29.7	8.1	1.4	29.7
Average	**57.2**	**13.2**	**37.0**	**22.2**	**5.6**	**18.0**

Note: Pressure only denotes growers who only had pressure irrigation (including overhead spray irrigation). PAN denotes using evaporation information to schedule irrigation. SMM denotes using quantitative soil moisture monitoring to schedule irrigation. RDI denotes Regulated Deficit Irrigation. PRD denotes Partial Root-zone Drying. ARI denotes alternate row irrigation.

Grape growers with wine grapes were significantly more likely to use Regulated Deficit Irrigation than growers that had other enterprises. Growers with dried grapes were more likely to use alternate row irrigation than other growers.[22]

1.9 Irrigation system characteristics

In figures 19 and 20 the proportion of growers that indicated they received premiums and discounts for grape quality is shown for each type of irrigation system.[23] Growers with overhead sprays, micro sprinklers or drip irrigation were more likely to receive premiums or discounts for baume and colour than growers with other irrigation systems.[24]

In table 9 the proportion of growers with each type of irrigation system that use recommended practices such as pressure irrigation, quantitative soil moisture monitoring, Regulated Deficit Irrigation and alternate row irrigation are reported.[25]

A significantly higher proportion of growers with drip irrigation and overhead sprays used evaporation information to help them with their irrigation scheduling compared to growers with

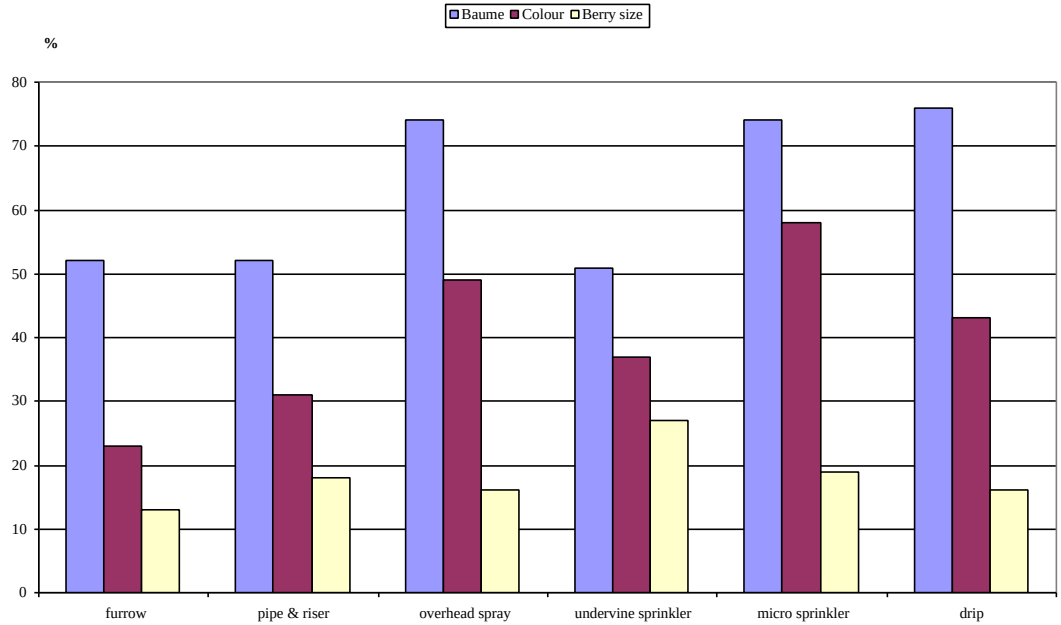


Figure 19: Selected quality parameters by irrigation system (a)

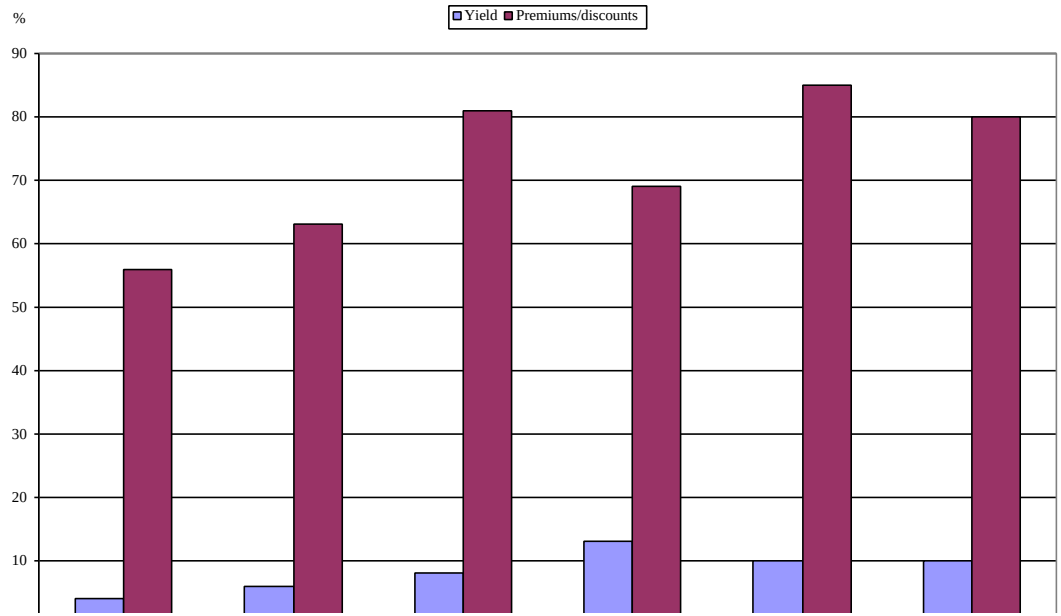


Table 9: Proportion of grape growers of each type of irrigation system using selected practices and technologies (%)

	PAN	SMM	RDI	PRD	ARI
Furrow	6.0	9.0	5.4	6.6	33.5
Pipe & riser	9.8	15.9	4.1	6.0	49.2
Overhead sprays	14.3	35.7	24.8	4.2	0.7
Under vine sprinklers	7.0	39.4	12.7	5.6	1.4
Mini sprinklers	9.7	46.5	34.1	3.2	3.2
Drip	21.7	64.6	36.5	9.0	2.1
Average	**12.0**	**33.2**	**19.3**	**5.7**	**18.5**

Note: Pressure only denotes growers who only had pressure irrigation (including overhead spray irrigation). PAN denotes using evaporation information to schedule irrigation. SMM denotes using quantitative soil moisture monitoring to schedule irrigation. RDI denotes Regulated Deficit Irrigation. PRD denotes Partial Root-zone Drying. ARI denotes alternate row irrigation.

Grape growers with micro sprinklers or drip irrigation were significantly more likely to use Regulated Deficit Irrigation than growers that had other systems. Growers with furrow or pipe and riser irrigation were more likely to use alternate row irrigation than were growers with other systems.[28] The proportion of growers that had attempted Partial Root-zone Drying was similar across irrigation systems.[29] However, there was some confusion about the technique of Partial Root-zone Drying amongst growers.

We also found that, on average, the vineyards of growers that used drip irrigation were approximately twice as large as vineyards of growers that did not. This difference in size was attributable to the fact that these area of wine grapes planted by growers with drip irrigation was three times larger, on average, than the area planted to wine grapes by growers using other irrigation systems.[30] This reflects the fact that the large-scale vineyards that predominate outside the pumped districts produce wine grapes using drip irrigation.

1.10 Irrigation system segments

Through interviews with grape growers, research and extension professionals, and service providers

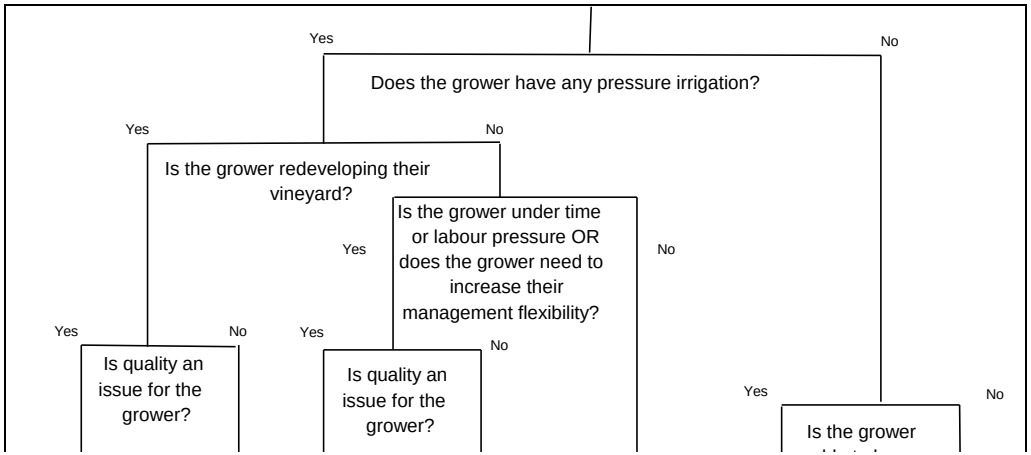
These key factors were present in some degree whether growers were producing wine, dried or table grapes. Consequently, we decided to classify growers into generic segments based on whether they had some form of pressurised irrigation system and their reasons for installing this system. We expected that each of these generic segments would be present in different proportions across the different types of grape enterprise.

We also found the type of pressure system that was adopted by growers depended partly on the availability of irrigation water on demand and the cost of the pressure system. The type of pressure system that was adopted was also partly determined by managerial requirements of the grower in terms of grape and bunch quality. These requirements were related to climate (such as incidence and severity of frost) and to the type of grape enterprise. For example, the need to grow cover crop to control vineyard temperature was a key factor in the decision of many table grape growers to adopt under vine sprinklers rather than micro sprinklers or drip irrigation. Hence, we expected that the variation in the type of irrigation systems used in each of the generic segments would be related to region and type of grape enterprise.

Using the key factors described previously we classified grape growers into seven generic irrigation segments.[31] The formation of the segments is summarised in the classification tree shown in figure 21. Each of the segments is described below.

1.11 Furrow irrigators

The growers in this segment only use furrow irrigation in their vineyards. Some 33 per cent of the growers in this segment have conventional gravity-fed furrow irrigation while the remaining 66 per cent have pipe and riser furrow irrigation.



irrigation and were not planning to redevelop their vineyards. Furrow irrigation has worked well for these growers consequently they have had no reason to change their irrigation system.

The growers in this segment represented 24 per cent of the sample. The growers in this segment are located mainly in Victoria Sunraysia and produce dried fruit and, to a lesser extent, wine grapes (see tables 10 and 11). The vineyards in this segment tend to be smaller, on average, than vineyards in other segments.[32] The total area of grapes grown in this segment is shown by industry in table 12.

1.12 Laser graded furrow irrigators

The growers in this segment are similar to those in the first segment in that they rely on furrow irrigation. The growers in this segment differ in that they have laser graded their vineyards to improve water flow and to reduce the amount of time they needed to spend irrigating. Approximately 39 per cent of the growers in the laser graded furrow irrigation segment have gravity fed furrow irrigation. The remaining 61 per cent have pipe and riser furrow irrigation. These growers were satisfied they were able to meet quality specifications using furrow irrigation and were not planning to redevelop their vineyards. Given that furrow irrigation has worked well for these growers they have had no reason to change their irrigation system.

Virtually all of the growers in this segment produce wine grapes and are from the Murrumbidgee Irrigation Area where their situation with respect to irrigation water delivery, topography and soil types combine to make this option a practical alternative to installing a fully pressurised irrigation system. The growers in this segment represent approximately 10 per cent of the sample. The total area of grapes grown in this segment is shown by industry in table 12.

Table 10: Geographic distribution of irrigation segments

	Sunraysia Victoria	Sunraysia NSW	Robinvale	Swan Hill/Nyah	Riverland	MIA
Time & Quality Redevelopers	34.0	11.6	2.8	3.3	47.4	0.9
Time Redevelopers	38.1	14.4	1.7	2.5	41.5	1.7
Time & Quality Irrigators	31.4	10.0	9.3	4.8	30.7	13.8

Note: Values are the proportion of segment in each region. The proportions are significantly different across regions (χ^2 = 715.1, p=0.00).

Table 11: Industry composition of irrigation segments

	Wine	Dried	Table	Wine & Dried	Wine & Table	Other
Time & Quality Redevelopers	71.6	6.0	0.9	14.9	3.3	3.3
Time Redevelopers	74.6	5.1	1.7	16.1	0.8	1.7
Time & Quality Irrigators	62.4	10.0	9.0	10.0	1.7	6.9
Time Irrigators	49.5	17.1	5.7	18.1	5.7	3.8
Other Pressure Irrigators	65.9	7.0	7.6	13.5	3.2	2.7
Laser Graded Furrow	83.1	7.4	1.4	6.1	1.4	0.7
Furrow	24.1	42.6	4.0	18.3	3.7	7.4

Note: Values are the proportion of segment in each industry. The proportions are significantly different across industries (χ^2 = 379.7, p=0.00).

Table 12: Total area of grapes grown in each segment, by industry.

	Wine (ha)	Dried (ha)	Table (ha)	Total (ha)
Time & Quality Redevelopers	4,012	460	135	4,607
Time Redevelopers	1,934	185	67	2,186

The growers in this segment have installed a pressure irrigation system on some or all of their vineyard. These growers have been redeveloping their vineyards by planting vines in longer rows to reduce the amount of time they spend on a range of farming activities including spraying, pruning, harvesting and irrigating. Generally speaking, the variable topography that characterises most of the regions in the study means that furrow irrigation is not practical on long rows (the exception being the Murrumbidgee Irrigation Area). Consequently, redevelopment of the vineyard usually entails installing some form of pressurised irrigation. The installation of a pressurised system can also increases managerial flexibility in terms of activities such as irrigating, spraying and harvesting. With some pressurised systems, such as mini-sprinklers and drip irrigation, the floor of the vineyard remains dry during irrigations. This means spraying and harvesting can be undertaken while irrigating.

The growers in this segment also indicated that grape quality was a factor in their decision to install a pressurised irrigation system. As described earlier, there are two aspects to the management of grape quality. One aspect is the management of grapevines to achieve better bunch quality and canopy health. The installation of pressurised systems can contribute to this through the potential to achieve a more even distribution of water in the vineyard and through greater control over the timing of irrigations. The other aspect of quality is that, in some circumstances, pressurised systems may be needed to achieve quality targets for wine grapes such as colour specifications for red wine grapes.

The grape growers in this segment represented approximately 14 per cent of the sample. These growers were mostly located in Victorian Sunraysia and the Riverland and produced wine grapes (see tables 10 and 11). The total area of grapes grown in this segment is shown by industry in table 12.

1.14 Time redevelopers

The growers in this segment have installed a pressure irrigation system on some or all of their vineyard. The growers in this segment were redeveloping their vineyards by planting vines in longer rows to reduce the amount of time they spend on activities including spraying, pruning, harvesting and irrigating and to increase their managerial flexibility in the vineyard. Unlike the growers in the preceding segment, none of the growers in the time redeveloper segment indicated that grape quality was a factor in their decision to install a pressurised irrigation system.

The grape growers in this segment represented approximately 8 per cent of the sample. These growers were mostly located in Victorian Sunraysia and the Riverland and mostly produced wine grapes (see tables 10 and 11). The total area of grapes grown in this segment is shown by industry

proportion of growers in this segment are located in the Robinvale region and the Murrumbidgee Irrigation Area. Most of the growers in this segment produced wine grapes. However, a relatively high proportion of growers in this segment produce table grapes (see tables 10 and 11). The total area of grapes grown in this segment is shown by industry in table 12.

1.16 Time irrigators

The growers in this segment have installed a pressure irrigation system on some or all of their vineyard. The main reasons growers in this segment installed a pressurised system was to save time irrigating and to increase managerial flexibility in the vineyard. As with the preceding segment the growers in this segment have either installed a pressurised system in a newly established vineyard or simply converted a long established vineyard from furrow irrigation without changing the vineyard layout (as is the case with redevelopment).

The grape growers in this segment represented approximately 14 per cent of the sample. These growers were mostly located in Victorian Sunraysia and the Riverland. However, a relatively high proportion of growers in this segment are also located in the Robinvale region. Most of the growers in this segment produced wine or dried grapes (see tables 10 and 11). The total area of grapes grown in this segment is shown by industry in table 12.

1.17 Other pressure irrigators

The growers in this segment have installed a pressure irrigation system on some or all of their vineyard. These growers have not been redeveloping their vineyards or been motivated by time pressures to install pressurised irrigation systems. These growers have installed a pressurised irrigation system either because:

- The topography of their block was not suitable for flood or furrow irrigation. Often, growers in this situation are establishing vineyards in new areas outside the existing irrigation districts.
- They were replanting their vineyard to new varieties and needed to replace an existing, possibly outdated, pressure system, or
- They needed to improve grape quality.

Hence, this segment consists of three smaller segments that together represent approximately 12 per cent of responses. These growers were mostly located in Victorian Sunraysia and the Riverland. Note that over 40 per cent of vineyards outside the pumped irrigation districts were in this segment. Most of the growers in this segment produced wine or dried grapes although a relatively high

as the main motivations for installing pressure irrigation. Growers in the time redeveloper and irrigator segments are much more likely to use overhead spray irrigation systems compared to growers in other segments. This is consistent with the greater emphasis in these two segments on saving time as the main motivation for installing pressure irrigation.

Note that the average water right per hectare was similar across the segments.[34]

Table 13: Irrigation segments and irrigation systems

	Furrow	Pipe & riser	Overhead sprays	Under vine sprinklers	Mini sprinklers	Drip
Time & Quality Redevelopers	1.0	-	26.4	10.4	36.8	25.5
Time Redevelopers	-	1.7	41.4	8.6	24.1	24.1
Time & Quality Irrigators	1.0	0.6	19.3	11.9	23.9	43.2
Time Irrigators	0.8	1.6	45.7	11.6	19.4	20.9
Other Pressure Irrigators	0.9	6.0	27.6	8.6	31.9	25.0
Laser Graded Furrow	38.7	61.3	-	-	-	-
Furrow	33.1	62.9	-	-	-	-

Note: Values are the proportion of growers in each segment with each system. Growers with more than one type of irrigation system were excluded from this analysis.

In table 14 the proportion of growers in each segment that use recommended practices such as quantitative soil moisture monitoring, Regulated Deficit Irrigation and alternate row irrigation are reported.

A significantly higher proportion of growers in the time and quality redevelopment and irrigator segments used evaporation information to help them with their irrigation scheduling compared to growers in other segments, especially those in the furrow irrigation segments.[35] The proportion of

proportion of growers that had attempted Partial Root-zone Drying was similar across the irrigation segments.[38]

1.19 Irrigation segments and premiums and discounts for grape quality

The proportion of growers in each segment that indicated they received premiums and discounts for different aspects of grape quality are shown in figures 22 through 26. The differences in the proportions across the segments were significant for baume, colour, berry size and yield.[39]

Table 14: Proportion of grape growers in each segment using selected irrigation practices and technologies
(%)

	PAN	SMM	RDI	PRD	ARI
Time & Quality Redevelopers	17.7	60.9	36.3	7.4	9.8
Time Redevelopers	14.4	49.2	28.8	2.5	11.0
Time & Quality Irrigators	18.6	49.3	33.8	6.9	6.9
Time Irrigators	14.3	42.9	21.9	3.3	6.2
Other Pressure Irrigators	11.4	38.9	25.4	7.0	9.7
Laser Graded Furrow	10.8	12.2	8.1	8.8	48.6
Furrow	7.7	15.1	6.1	5.3	38.6

Note: Pressure only denotes growers who only had pressure irrigation (including overhead spray irrigation). PAN denotes using evaporation information to schedule irrigation. SMM denotes using quantitative soil moisture monitoring to schedule irrigation. RDI denotes Regulated Deficit Irrigation. PRD denotes Partial Root-zone Drying. ARI denotes alternate row irrigation.

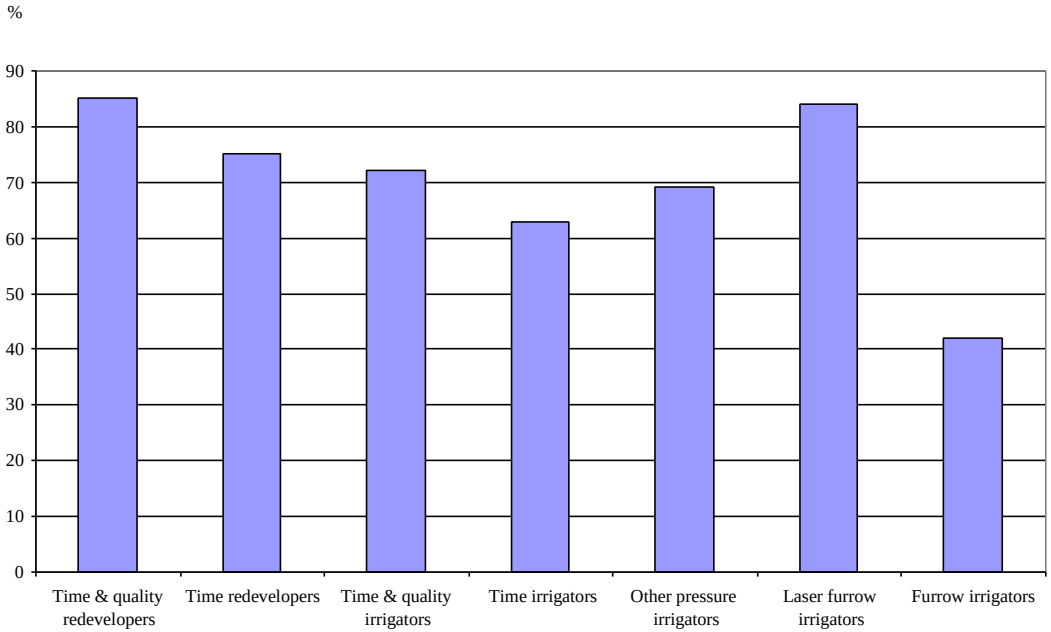
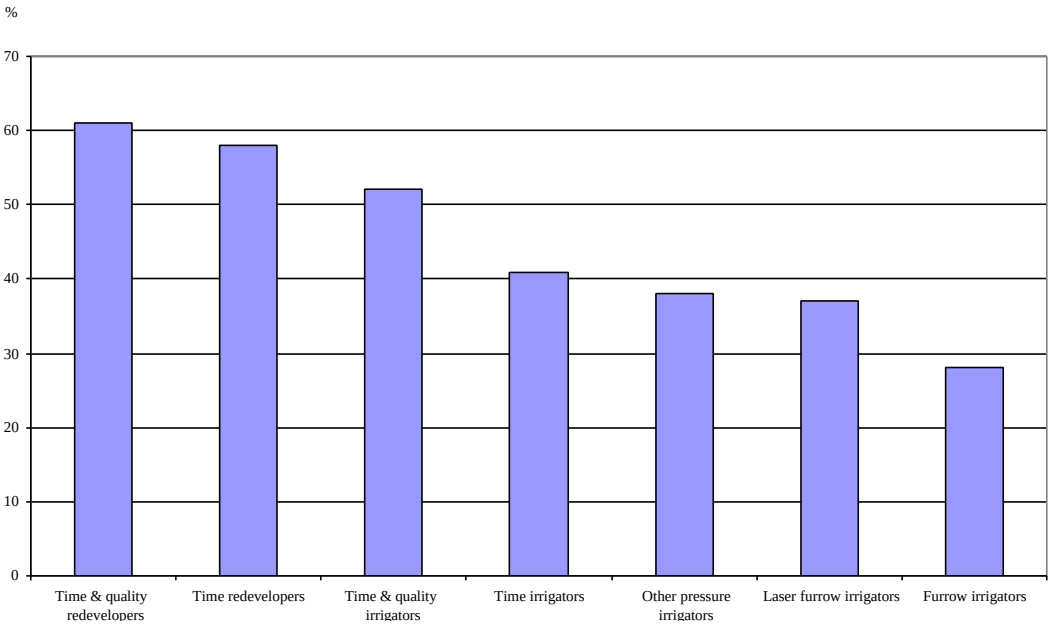


Figure 22: Premiums and discounts for baume by segment



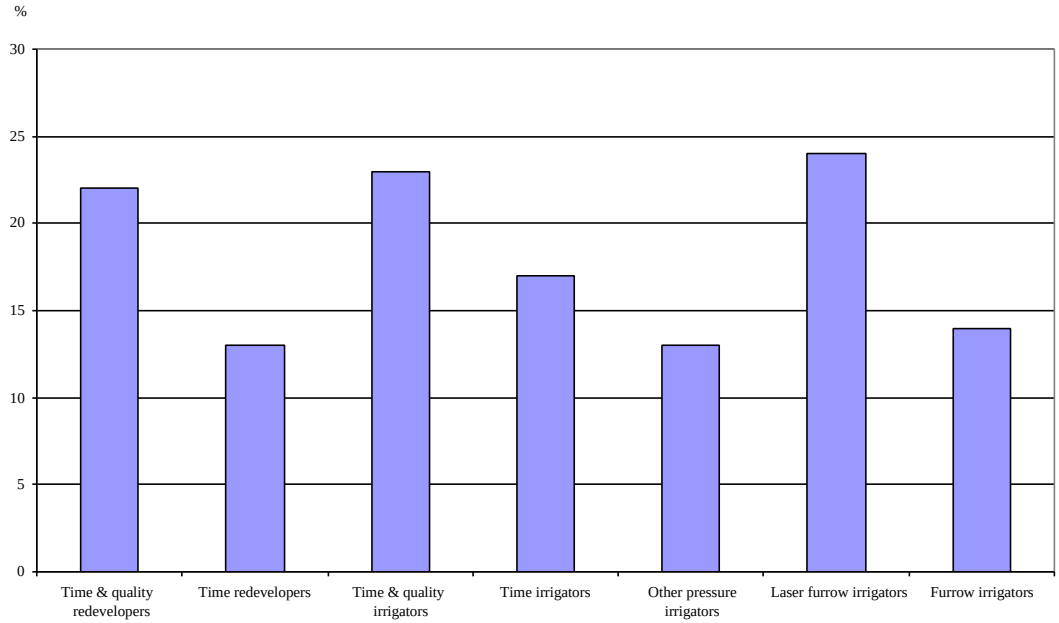
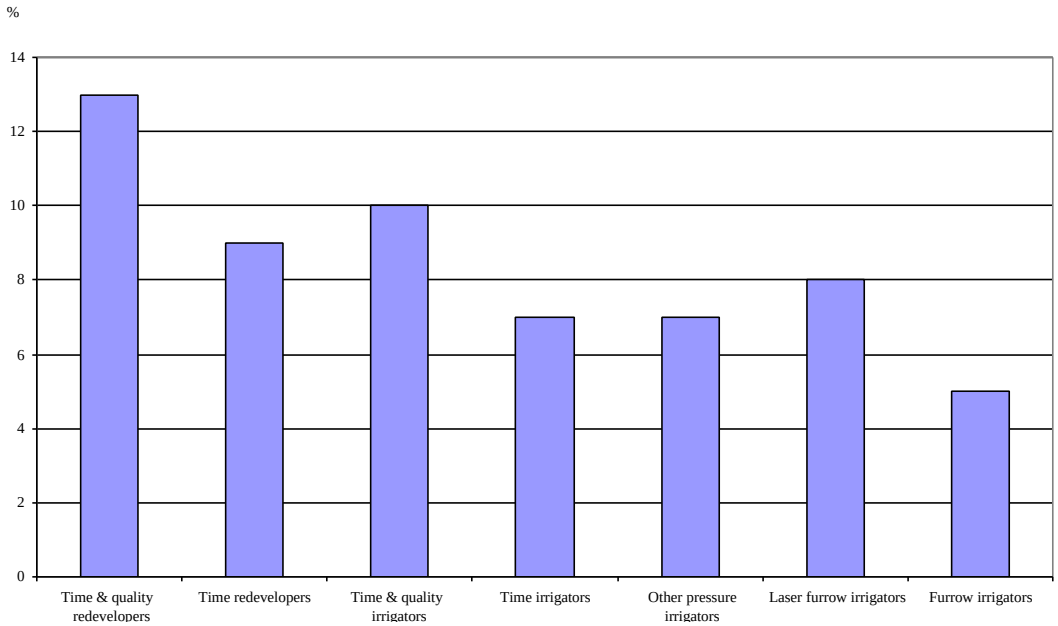


Figure 24: Premiums and discounts for berry size by segment



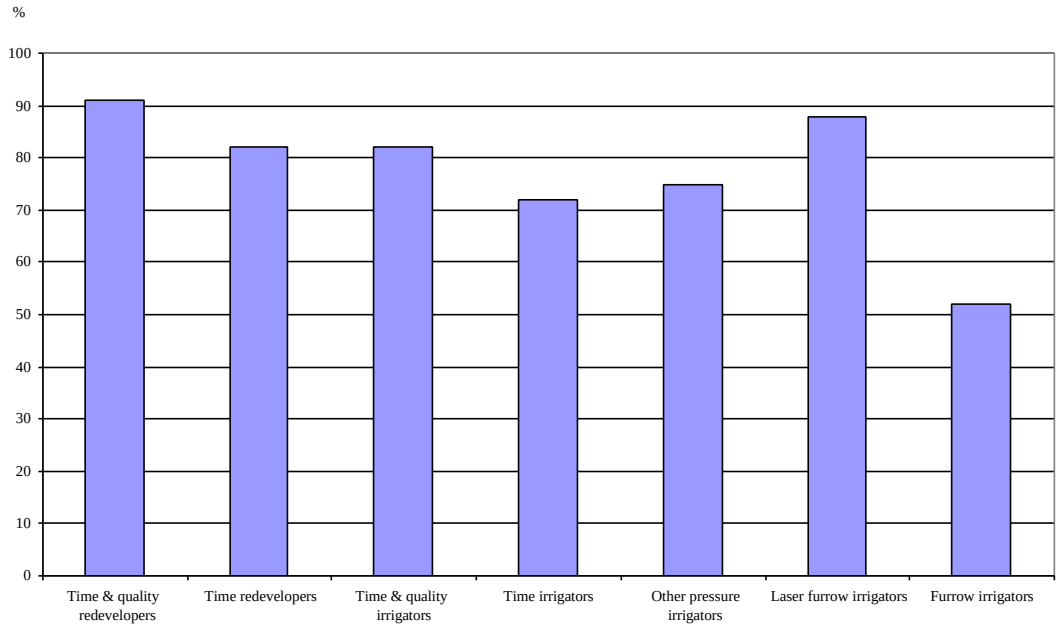


Figure 26: Premiums and discounts for quality by segment

With respect to baume, the proportion of growers that received premiums and discounts was highest among in the time and quality redeveloper segment and the laser graded furrow irrigation segment (see figure 22).

The proportion was lowest among growers in the furrow irrigation segment. The variation in the proportions across the segments partly reflects the importance of wine grape production in the segment and partly reflects the importance of grape quality as a factor in installing pressurised irrigation.

With respect to colour, the proportion of growers that received premiums and discounts was highest among in the time and quality redeveloper segment. The proportion was lowest among in the furrow irrigation segment (see figure 23).

In terms of berry size, the proportion of growers that received premiums and discounts was relatively high among in the time and quality redeveloper and irrigator segments and the laser graded furrow irrigation segment. The proportion was relatively low among growers in the time redeveloper and irrigator segments and the furrow irrigation segment (see figure 24).

With respect to yield, the proportion of growers that received premiums and discounts was highest among in the time and quality redeveloper segment and lowest among growers in the furrow irrigation segment (see figure 25). Similarly, the overall proportion of growers that received premiums and discounts was highest among in the time and quality redeveloper segment and lowest among growers in the furrow irrigation segment (see figure 26).

1.20 Demographic and financial characteristics of the irrigation segments

We found that the average age of growers was significantly different across the segments. However, as the maximum difference between segments in the average age of growers was less than five years we concluded this difference was not meaningful.[40]

In terms of education, a higher than average proportion of growers in the redeveloper segments had undertaken part or all of a degree course at a university or college of advanced education. A lower than average proportion of growers in the furrow irrigation segments had undertaken part or all of a degree course at a university or college of advanced education. The proportions were approximately 18 per cent for the redeveloper segments and 9 per cent for the furrow irrigation segments compared to an average of 12 per cent for the sample as a whole.[41] The relatively small divergence in these proportions from the average for the sample suggests that formal education had

in the next few years. Growers in these segments were also more likely, compared to growers in other segments, to have plans to wind back their vineyard in the near future (see figure 28).[43]

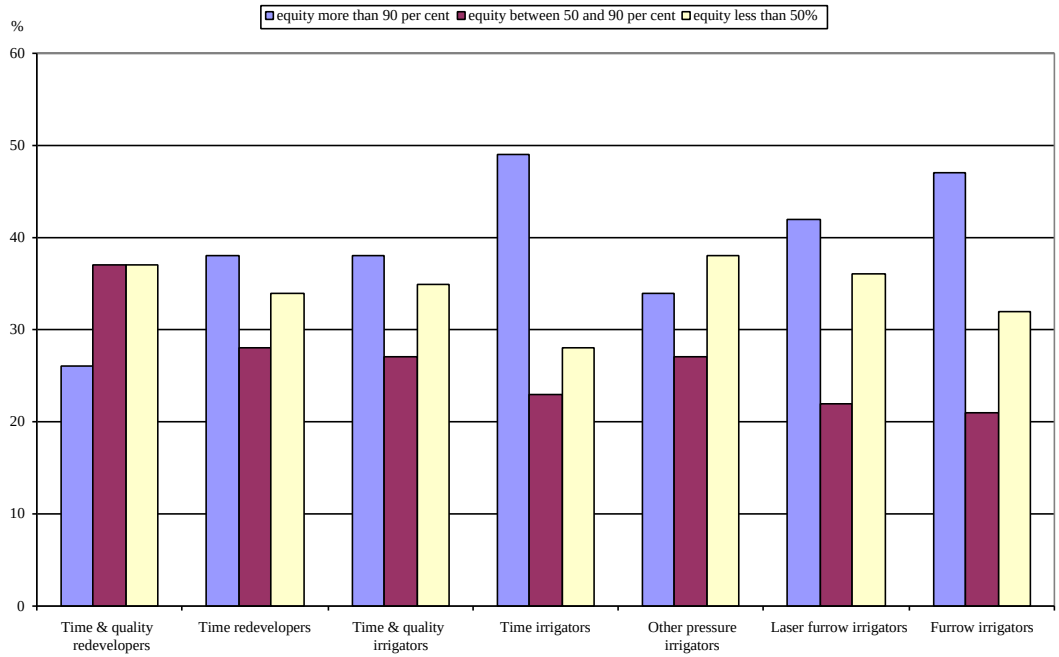
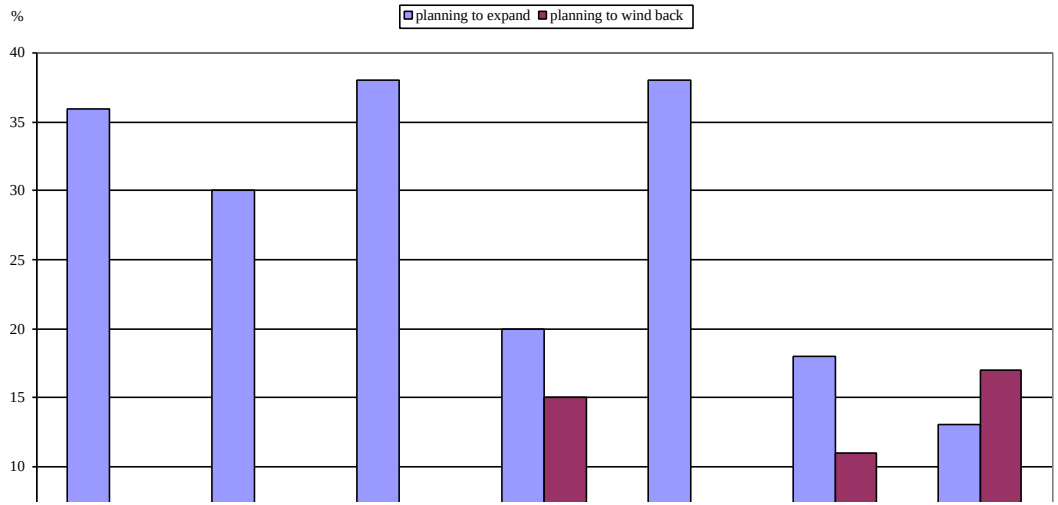


Figure 27: Distribution of farm equity across segments



Finally, growers in the time and quality redevelopment and irrigator segments were more likely to indicate that they had received a redevelopment grant through the Kickstart program compared to growers in other segments.[44]

1.21 Summary of the irrigation segments

The results of the survey indicated that the most common key factors promoting the adoption of pressurised irrigation systems in vineyards were:

- A desire to spend less time irrigating and to increase flexibility in managing activities in the vineyard,
- A need to redevelop vineyards to longer rows to save time irrigating and harvesting grapes and to increase flexibility in managing activities in the vineyard, and
- A desire to improve grape and bunch quality.

We classified grape growers into seven generic segments based on these key factors. We found that most segments were distributed across grape growing regions, however growers in the furrow irrigation segment tended to be concentrated in Victoria Sunraysia while growers in the laser grade furrow irrigation segment were concentrated in the Murrumbidgee Irrigation Area.

We found that the importance of improving grape quality as a factor in adopting pressure irrigation differed across the segments and these differences corresponded with the incidence of premiums and discounts for quality parameters especially colour.

We found that types of irrigations systems used differed across the segments and these differences appeared to correspond with differences across the segments in the type of grapes grown and incidence of premiums and discounts for quality parameters. We also found that the use of objective soil moisture monitoring, Regulated Deficit Irrigation and alternate row irrigation varied across the segments.

Differences were identified across the segments in terms of plans to expand or wind back vineyards, reliance on off-farm income and equity. Demographic differences among the segments appeared marginal.

1.22 Soil moisture monitoring segments

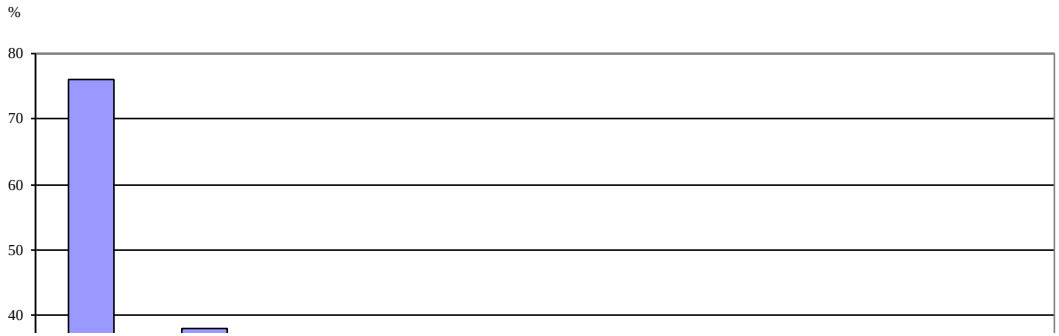
Approximately 40 per cent of the growers that completed the survey indicated that they used

Through interviews with grape growers, research and extension professionals, and service providers we found the key factors influencing the adoption of objective soil moisture monitoring in the grape industry were:

- The installation of a pressurised irrigation system. The value of soil moisture monitoring is limited with furrow irrigation, as these systems have restricted flexibility in terms of the volume and timing with which water is delivered.
- A need to monitor irrigations more closely as the result of irrigating more frequently at lower volumes with pressurised irrigation systems such as mini sprinklers and drip irrigation. There is a greater risk with these systems of subjecting vines to moisture stress because these systems deliver water at particularly low flow rates compared to other systems. Consequently, growers who install these systems rely on soil moisture monitoring to offset this risk.
- A need to monitor irrigations more closely in order to improve grape quality or to control a vigour problem.
- Access to irrigation water on demand.

In figure 29 the statements that growers who responded to the survey selected as best describing their use of soil moisture monitoring are presented. The majority of growers use soil moisture monitoring to routinely help them schedule their irrigations. Less than a quarter of growers use monitoring to manage vigour problems. Approximately a third of growers use monitoring to make sure they meet quality specifications. Nearly a third of growers indicated that they believed water was getting too expensive and monitoring helped them to save water. These results seem reasonably consistent with the findings from the interviews with growers.

We classified growers into four segments with respect to using objective soil moisture monitoring.[46] The segments were formed on the basis of whether or not the grower had installed a pressurised irrigation system, whether that system was a mini sprinkler or drip system and whether the grower had access to irrigation water on demand. The segments are illustrated in figure 30 and are described below.



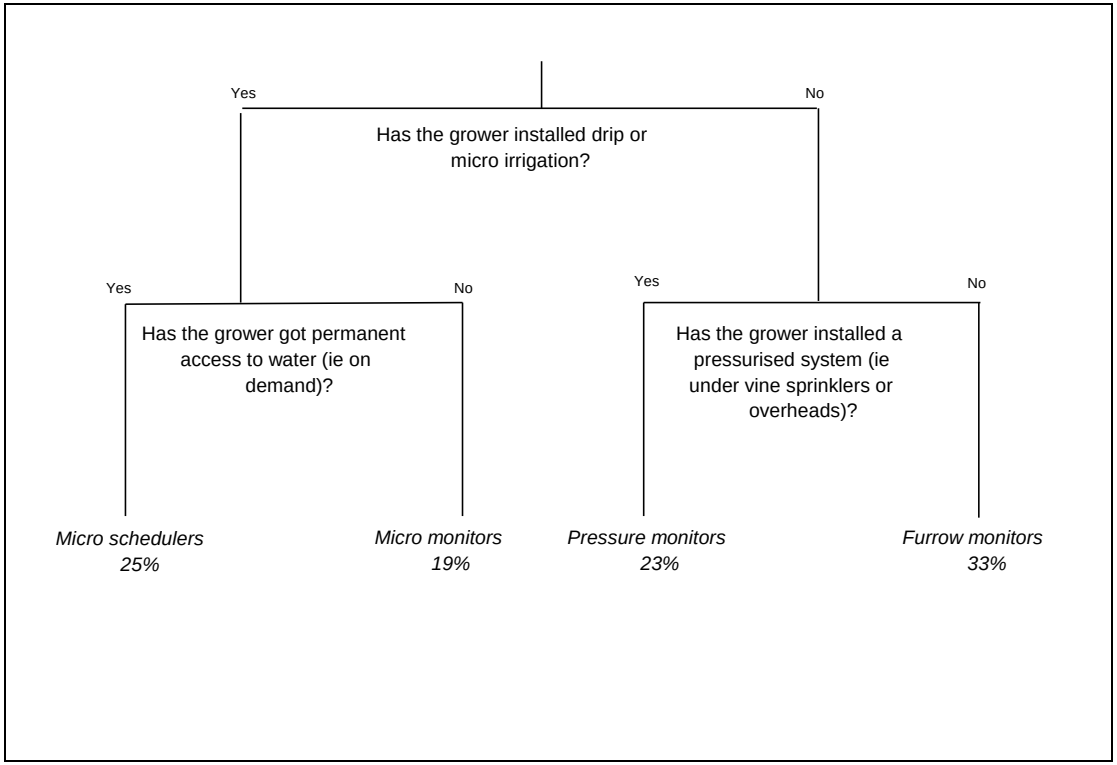


Figure 30: Soil moisture monitoring segments

1.23 Micro scheduling

The growers in this segment had installed either drip or mini sprinkler irrigation and had access to irrigation water on demand. Consequently, these growers were able to take full advantage of information supplied by soil moisture monitoring equipment. We expected that the adoption of soil moisture monitoring would be highest in this segment. Approximately 65 per cent of these growers had some form of objective soil moisture monitoring in their vineyard and most indicated they used their monitoring equipment to help schedule irrigations (see figure 31).

This proportion is lower but approaches the adoption rates reported by Fisher et al for Grapecheque participants in northwest Victoria (2001). Note that the proportion of growers using soil moisture monitoring was significantly different across the segments.[47]

The growers in this segment represented 24 per cent of the sample. The majority of growers in this

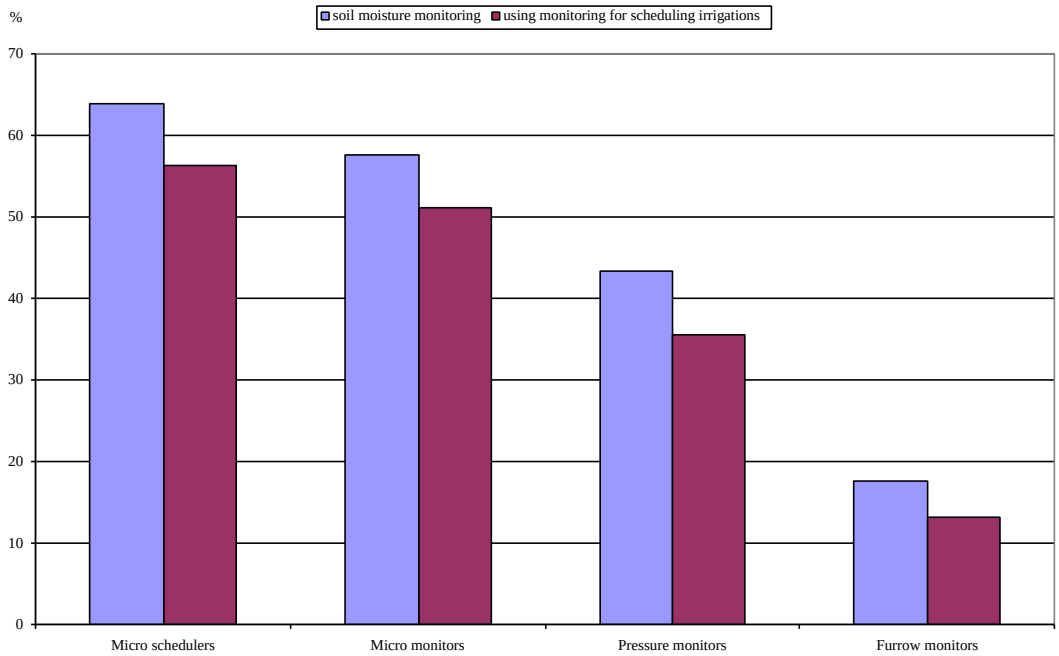


Figure 31: Incidence of soil moisture monitoring by segments

Table 15: Industry distribution of grape growers in the soil moisture monitoring segments
(%)

	Micro scheduling	Micro monitors	Pressure monitors	Furrow monitors
Wine	72.1	69.8	56.9	37.3
Dried	8.7	8.0	11.4	34.9
Table	3.4	3.1	7.5	3.6
Wine and dried	8.3	14.5	16.3	15.8
Wine and table	3.9	2.2	3.1	3.0
Other	3.6	2.5	4.7	5.4

Note: Values are proportion of growers in each monitoring segment. The proportions are significantly different across the segments (χ^2 = 228.0, p=0.00).

Table 16: Geographic distribution of grape growers in the soil moisture monitoring segments
(%)

	Micro scheduling	Micro monitors	Pressure monitors	Furrow monitors
Sunraysia, Victoria	26.0	28.4	48.8	54.7
Sunraysia, NSW	12.9	10.2	11.2	5.4
Robinvale	4.1	4.0	7.9	4.0
Swan Hill/Nyah	6.1	2.2	0.4	2.6
Riverland	38.6	51.5	31.1	4.4
MIA	12.4	3.7	0.6	28.9

Note: Values are proportion of growers in each monitoring segment. The proportions are significantly different across the segments (χ^2 = 1588.5, p=0.00).

Table 17: Irrigation segment distribution of grape growers in the soil moisture monitoring segments
(%)

	Micro scheduling	Micro monitors	Pressure monitors	Furrow monitors
Time & Quality Redevelopers	18.4	23.5	12.2	-
Time Redevelopers	9.7	8.6	9.6	-
Time & Quality Irrigators	28.4	28.7	15.2	-
Time Irrigators	15.3	13.0	20.1	-
Other Pressure Irrigators	23.5	21.0	41.3	-

irrigation supply these growers are restricted in their ability to take advantage of information supplied by soil moisture monitoring equipment. Approximately 58 per cent of these growers had some form of objective soil moisture monitoring in their vineyard and most of these growers indicated they used their monitoring equipment to help schedule irrigations (see figure 31).

The growers in this segment represented 19 per cent of the sample. The majority of growers in the micro monitor segment produced wine grapes and more than half were located in the Riverland (see tables 15 and 16). Most of the growers in this segment were members of the time and quality redeveloper, and irrigator segments or the other pressure irrigator segment (see table 17).

1.25 Pressure monitors

The third segment consists of growers who had higher volume pressurised irrigation systems such as overhead sprays or under vine sprinklers. Some of these growers have access to water on demand. However, we expected a smaller proportion of these growers would have installed soil moisture monitoring as they irrigate with relatively high volume pressure systems. We expected that the adoption of soil moisture monitoring would be lower in this segment than in the micro scheduler or micro monitor segments. This was the case. Approximately 43 per cent of these growers had some form of objective soil moisture monitoring in their vineyard and most of these growers indicated they used their monitoring equipment to help schedule irrigations (see figure 31).

The growers in this segment represented 29 per cent of the sample. While a majority of growers in this segment produced wine grapes, a relatively high proportion of the growers in this segment produced table grapes. Most of the growers in this segment were located in Victoria Sunraysia and the Riverland (see tables 15 and 16). A relatively high proportion of the growers in this segment was located in Robinvale compared to the other segments. Most of the growers in this segment were members of the time irrigator segment or the other pressure irrigator segment (see table 17).

1.26 Furrow monitors

Furrow monitors are the fourth segment. These growers did not have a pressure irrigation system. We expected that the adoption of soil moisture monitoring would be lowest in this segment given that furrow irrigators are severely limited in their ability to adjust their irrigation volumes and timing. Approximately 18 per cent of this segment used soil moisture monitoring (see figure 31).

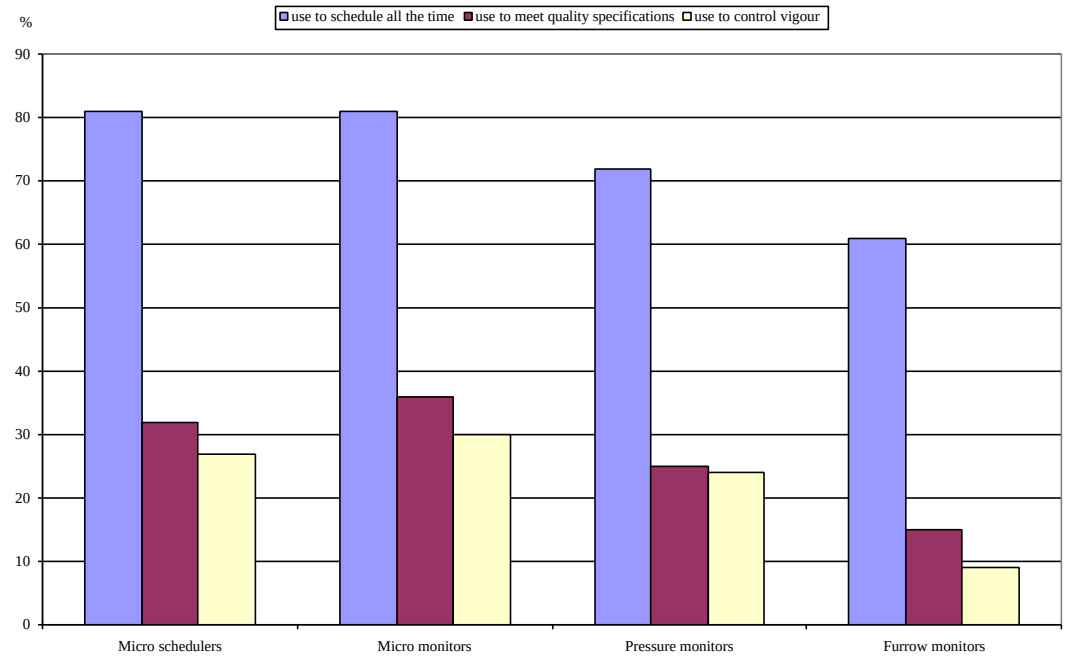


Figure 32: Reasons for using soil moisture monitoring by monitoring segment

We found that a higher proportion of growers in the micro scheduling and micro monitor segments that used monitoring all the time to schedule their irrigations compared to growers in other segments.[48] We also found that the proportion of growers that used monitoring all the time to schedule their irrigations was lowest in the furrow monitoring segments. These results are consistent with the differences in the flexibility of irrigation systems and water supply across the segments.

We found that a higher proportion of growers in the micro scheduling and micro monitor segments that used monitoring to make sure they met quality specifications for grapes compared to growers in other segments.[49] We also found that the proportion of growers that used monitoring to meet quality specifications for grapes was lowest in the furrow monitoring segments. We also found that a lower proportion of growers in the furrow monitor segment used monitoring to control a vigour problem compared to other segments.[50]

Approximately 12 per cent of growers indicated that they had tried but no longer used soil moisture monitoring. Approximately 15 per cent of growers in the micro scheduling and pressure monitor segments had tried but no longer used monitoring compared to 12 and 8 per cent respectively in the micro and furrow monitor segments.[51]

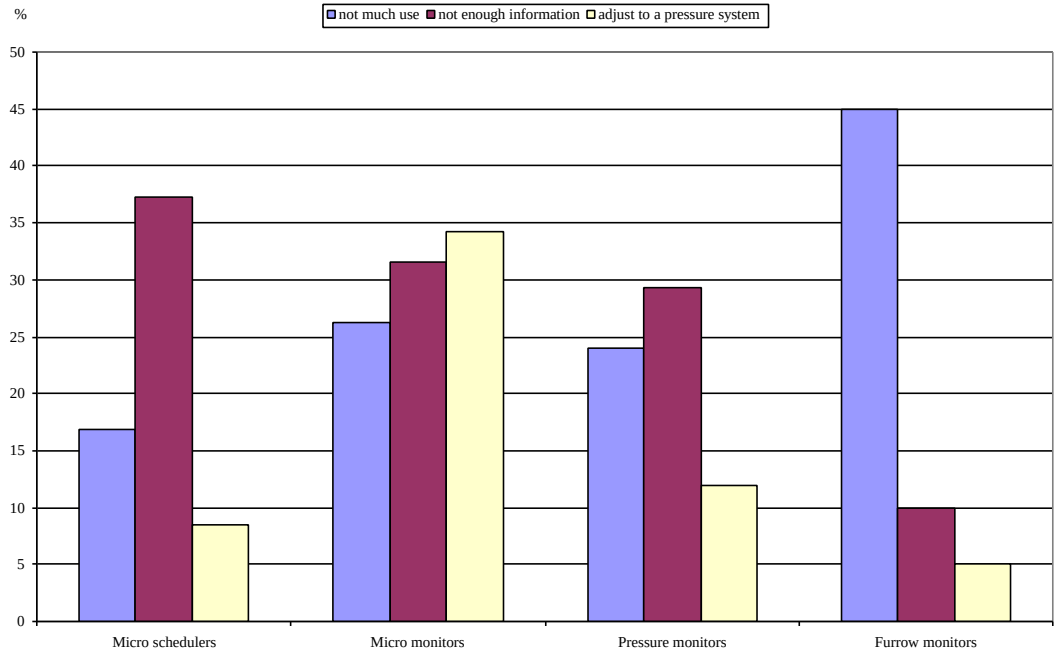


Figure 33: Reasons for no longer using soil moisture monitoring by monitoring segment

We found that growers in the micro monitor segment who no longer used monitoring were more likely to indicate they had used monitoring for a season or two to adjust to pressurised system compared to growers in other segments (see figure 33).[54]

Overall, these results are consistent with the differences in the flexibility of irrigation systems and water supply across the segments.

1.28 Monitoring segments and irrigation management

In table 18 the proportion of growers in each monitoring segment that used recommended practices such as quantitative soil moisture monitoring, Regulated Deficit Irrigation and alternate row irrigation are reported.

A significantly higher proportion of growers in the micro scheduler segment used evaporation information to help them with their irrigation scheduling compared to growers in other segments, especially those in the furrow monitor segment.[55] As discussed earlier the proportion of growers

Table 18: Proportion of grape growers in each monitoring segment using selected irrigation practices and technologies
(%)

	PAN	SMM	RDI	PRD	ARI
Micro scheduling	18.4	63.8	35.7	6.8	6.6
Micro monitors	13.6	57.6	34.3	5.2	9.0
Pressure monitors	13.2	43.3	20.7	4.3	7.5
Furrow monitors	8.6	17.6	4.6	6.2	44.1

Note: PAN denotes using evaporation information to schedule irrigation. SMM denotes using quantitative soil moisture monitoring to schedule irrigation. RDI denotes Regulated Deficit Irrigation. PRD denotes Partial Root-zone Drying. ARI denotes alternate row irrigation.

1.29 Monitoring segments and managing grape quality

As described earlier we found that a higher proportion of growers in the micro scheduling and micro monitor segments used monitoring to make sure they met quality specifications for grapes compared to growers in other segments. We also found that the proportion of growers that used monitoring to meet quality specifications was lowest in the furrow monitoring segments. These differences are consistent with the proportion of growers in each segment receiving premiums and discounts for grape quality (see figures 34 and 35).

Compared to growers in other segments, a higher proportion of growers in the micro scheduling and micro monitor segments received premiums or discounts for baume, colour and yield.[59]

Overall, compared to growers in other segments, a higher proportion of growers in the micro scheduling and micro monitor segments received premiums or discounts (see figure 35).[60] These results are consistent with the proportion of growers in each segment that indicated they used monitoring to make sure they met quality specifications for grapes.

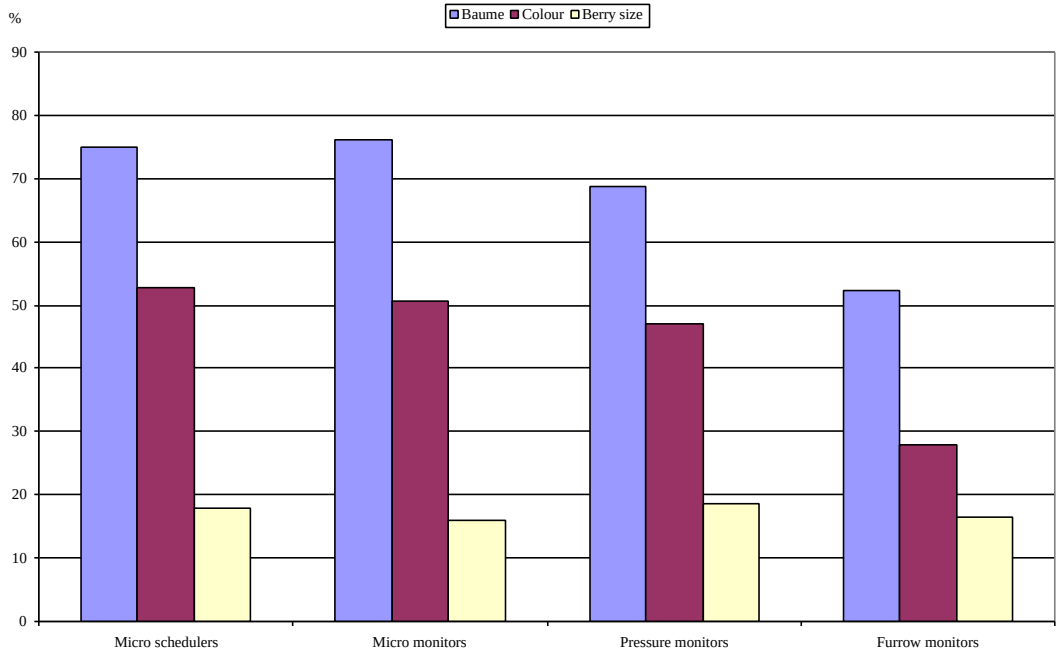
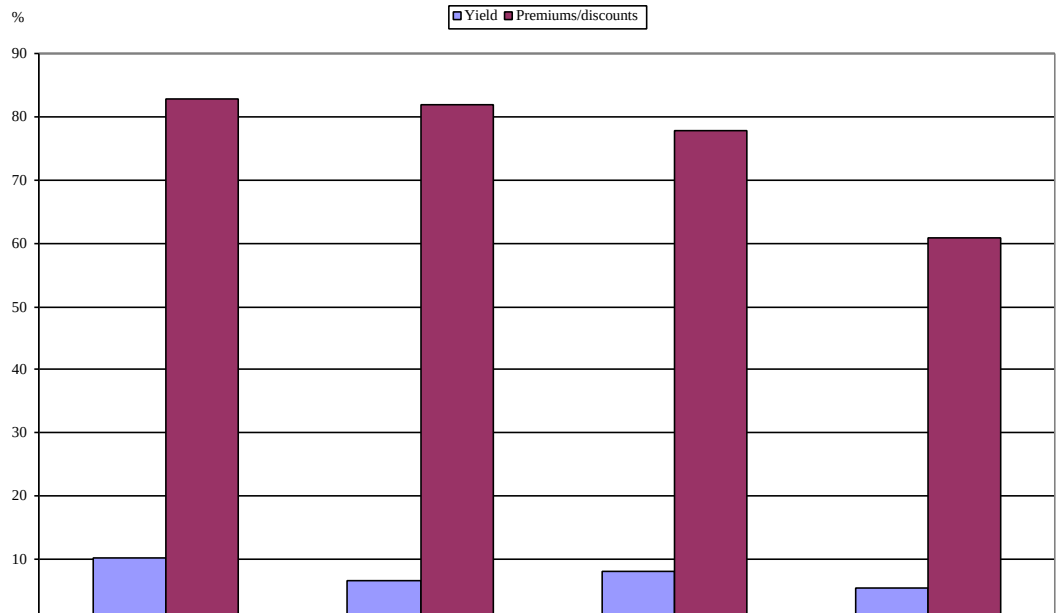


Figure 34: Quality parameters by monitoring segment (a)

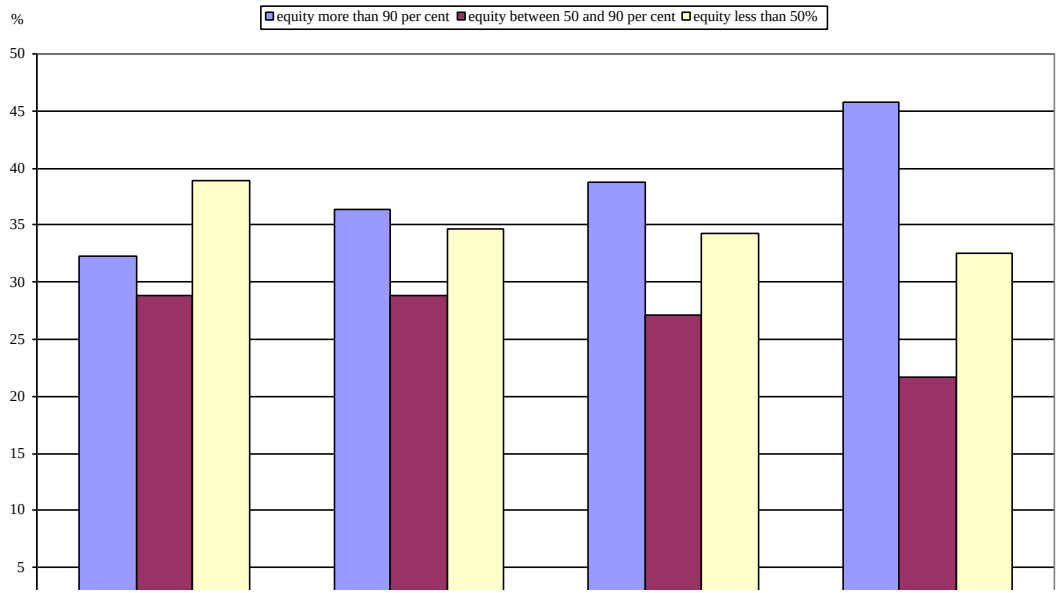


1.30 Demographic characteristics of the monitoring segments

We found that the average age of growers was significantly different across the monitoring segments however this difference was not substantial (less than three years.[61] Compared to growers in the pressure and furrow monitor segments, growers in the micro scheduler and monitor segments were more likely to have undertaken part or all of a degree course at a university or college of advanced education (approximately 17 per cent and 9 per cent respectively).[62] The relatively small divergence in these proportions from the average for the sample as a whole suggests that formal education had a marginal influence of on adoption of soil moisture monitoring.

Although there was no significant difference in the proportion of growers in each segment that were working off farm, growers in the furrow monitoring segment were more likely than growers in other segments to be earning more than 50 per cent of their income from off-farm. Also, a higher proportion of farmers in the furrow monitoring segment were likely to report they were debt free or nearly so compared to growers in other segments (see figure 36).[63]

A relatively high proportion of growers in the pressure and furrow monitor segments indicated that they were planning to redevelop their vineyards in the next few years. However, we also found that the growers in these segments were less likely to have plans to expand their vineyards in the next few years and were more likely to have plans to wind back their vineyard in the near future (see figure 37).[64]



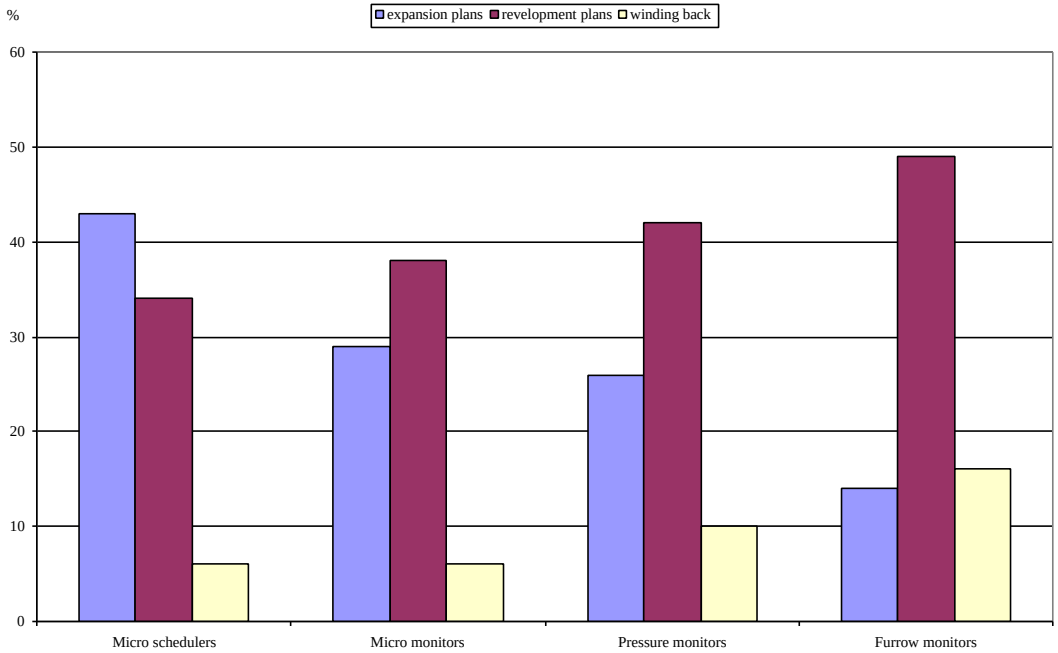


Figure 37: Distribution of plans across monitoring segments

On average, the vineyards in the micro scheduler segment were approximately twice as large as vineyards in other segments. This difference in size was attributable to a larger area planted to wine grapes by growers in this segment.[65] This reflects the fact that the large-scale vineyards that predominate outside the pumped districts produce wine grapes using drip irrigation.

Finally, growers in the micro and pressure monitor segments were more likely to indicate that they had received a redevelopment grant through the Kickstart program compared to growers in other segments.[66]

These results are consistent with those obtained with respect to the irrigation segments in that growers with furrow irrigation exhibited different financial characteristics to growers with pressure irrigation.

1.31 Summary of the monitoring segments

The common key factors influencing the adoption of objective soil moisture were:

- The installation of a pressurised irrigation system

We found that proportion of growers that used objective soil moisture monitoring for routinely scheduling irrigations varied across the segments, as did the proportion of growers that used Regulated Deficit Irrigation and alternate row irrigation.

Differences were identified across the segments in terms of plans to redevelop, expand or wind back vineyard enterprises, reliance on off-farm income and equity. Growers in the micro scheduler segment had vineyards that were approximately three times as large as the vineyards of growers in other segments. Demographic differences among the segments appeared marginal.

1.32

1.33

1.34 Regulated Deficit Irrigation, Partial Root-zone Drying and alternate row irrigation

Approximately 22 per cent of growers indicated they had tried Regulated Deficit Irrigation. Less than 6 per cent of growers indicated they had tried Partial Root-zone Drying while slightly more than 18 per cent indicated they had tried alternate row irrigation.

The majority of growers that had tried Regulated Deficit Irrigation or Partial Root-zone Drying indicated they used these practices to better manage and improve grape quality. Approximately half of the growers that used these practices also used them to manage a vigour problem.

The majority of growers that had tried alternate row irrigation indicated they used this practice to better manage and improve grape quality. Approximately half of the growers that used this practice also used it to reduce water use.

Generally speaking, although we found statistically significant demographic or financial differences between growers that had used Regulated Deficit Irrigation and those that had not, these differences were marginal. Also, we did not find any statistically significant demographic or financial differences between growers that had used Partial Root-zone Drying or alternate row irrigation and those that had not.

One significant and substantial difference that we identified was that growers that had tried Regulated Deficit Irrigation or Partial Root-zone Drying were more likely to indicate they were planning to expand their vineyards. Growers that had tried alternate row irrigation were more likely to indicate they were planning to redevelop their vineyards.[67] These results simply reflect the fact that vineyards with pressure irrigation are at different stage of development compared to vineyards

1.35 Conclusion

Gape growers from Sunraysia Victoria and New South Wales, the Riverland and the Murrumbidgee Irrigation Area were surveyed with respect to irrigation systems and irrigation management and soil moisture monitoring.

The results from the survey confirmed findings from interviews with growers that the most common key factors promoting the adoption of pressurised irrigation systems in vineyards were:

- A desire to spend less time irrigating and to increase flexibility in managing activities in the vineyard,
- A need to redevelop vineyards to longer rows to save time irrigating and harvesting grapes and to increase flexibility in managing activities in the vineyard, and
- A desire to improve grape and bunch quality.

The type of pressurised irrigation system installed by growers depended on wether they had access to water on demand, the type of grapes grown, financial considerations and whether or not grape quality was an issue for the grower.

We classified grape growers into seven generic segments based on these key factors. We found that most segments were distributed across grape growing regions, however growers in the furrow irrigation segment tended to be concentrated in Victoria Sunraysia while growers in the laser grade furrow irrigation segment were concentrated in the Murrumbidgee Irrigation Area.

We found that the importance of improving grape quality as a factor in adopting pressure irrigation differed across the segments and these differences corresponded with the incidence of premiums and discounts for quality parameters especially colour.

We found differences in the type of irrigation systems used across the segments and these differences appeared to correspond with differences across the segments in the type of grapes grown and incidence of premiums and discounts for quality parameters. We also found that the proportion of growers that uses objective soil moisture monitoring, Regulated Deficit Irrigation and alternate row irrigation varied across the segments.

The results from the survey also confirmed findings from interviews with growers that the most common key factors promoting the adoption of objective soil moisture were:

- The installation of a pressurised irrigation system.
- A need to monitor irrigations more closely as the result of irrigating more frequently at lower volumes with pressurised irrigation systems such as mini sprinklers and drip irrigation.

We found that growers that used soil moisture monitoring had relatively large vineyards producing wine grapes compared to growers that did not use monitoring. This reflects the fact that the use of soil moisture monitoring is relatively high among growers with drip irrigation and that the large-scale vineyards that predominate outside the pumped districts produce wine grapes using drip irrigation.

Differences were identified across the irrigation and monitoring segments in terms of plans to expand or wind back vineyards, reliance on off-farm income and equity. Demographic differences among the irrigation and monitoring segments appeared marginal.

In conclusion, the results of the survey suggest that the key factors influencing the adoption of pressure irrigation systems and soil moisture monitoring by grape growers are largely related to the production context of the grower.

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COOPERATIVE RESEARCH CENTRE *for* VITICULTURE

Managing irrigation for grapevines

Third Report - Recommendations for Extension

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Disclaimer

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Executive Summary

In this report we have developed recommendations for extension with respect to irrigation management of grapes. This completes the third phase of the market research in this project. The results of the two previous phases of the market research indicated that there are opportunities to promote efficient water use in viticulture by facilitating the adoption of pressure irrigation systems and soil moisture monitoring.

In the first and second phases of the market research we found that the key factors influencing the adoption of pressure irrigation technologies for most growers are to reduce time spent irrigating; to increase flexibility in managing irrigation, spraying and harvesting activities; and to improve grape quality. The installation of pressure irrigation systems can contribute to improving grape quality through more even distribution of water to the vine and greater control over the timing of irrigations. Pressure systems may also be needed to achieve quality targets for wine grapes, for example, achieving colour specifications for red wine grapes.

Efficient water use was not identified by grape growers as a key factor influencing the adoption of pressure irrigation systems. This suggests that extension activities seeking to increase the adoption of these systems by promoting their advantages in terms of saving water and increasing water use efficiency will not be effective.

We found that, in some regions, the feasibility and attractiveness of micro-irrigation was limited by constraints on timely access to irrigation water and the cost of installing electrical power.

In the first and second phases of the market research we found that the key factors influencing the adoption of soil moisture monitoring were a need to monitor irrigations more closely as a result of installing drip or mini sprinkler irrigation and access to continuously available irrigation water (water on demand). Most growers indicated soil moisture monitoring assisted them to alleviate the risk of stressing vines with drip and mini sprinkler systems. We found that efficient water use was not a factor for most growers in adopting soil moisture monitoring. As more growers install drip and mini sprinkler systems the use of soil moisture monitoring by growers will increase.

Based on the outcomes of these workshops, the validation interviews with growers and the findings from the first and second phases of the market research we recommend:

1. As a high priority, an extension program is developed targeting growers who have installed, or are considering installing, a pressure irrigation system partly because of concerns over achieving grape quality. This program would include:
   - Providing advice and assistance to growers on influencing grape production and quality by utilising specific pressure irrigation systems. This should include different soil types and grape varieties. Collaboration with wineries and suppliers of irrigation equipment and services is recommended in developing this program.
   - Promoting soil moisture monitoring as a technique to effectively manage irrigation for grape quality.

2. As a high priority a program is developed targeting grape growers with furrow irrigation. This program would provide information on managing furrow irrigation to achieve improved grape quality.

3. An extension program about the management of newly installed pressure irrigation systems is developed to facilitate the change from furrow to pressure irrigation.
   - In developing this program it is important to recognise that the information needs of growers will vary. Growers converting vineyards to pressure irrigation will need to adapt mature vines to pressure irrigation systems. Growers that are redeveloping their vineyards to pressure irrigation will need information on irrigating young vines. Collaboration with wineries and suppliers of irrigation equipment in implementing this program is recommended.
   - This program should also include recommendations for using soil moisture monitoring to help establish irrigation schedules for newly installed pressure irrigation systems, especially when installing drip or mini sprinkler systems.

4. A program is developed to provide assistance to all growers in choosing and installing soil moisture monitoring equipment and in interpreting monitoring data.

5. That an assessment is undertaken to investigate the extent to which changes in regional and

Acknowledgments

The Victorian Department of Natural Resources and Environment and the Murray-Darling Basin Commission funded this study. We would like to thank the staff of the Department for their assistance and support, especially Deanne Burrows who arranged the workshops. We would particularly like to thank Rob Walker at CSIRO, Merbein and Anne-Maree Boland at IHD, Knoxfield for their input.

We are indebted to the researchers, extension staff, industry representatives and grape growers who participated in the study.

All errors and omissions remain the responsibility of the authors.

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Background and Introduction

1.1 An outline of earlier work

In previous reports (Kaine and Bewsell, 2001a and Kaine and Bewsell, 2001b) we described the results from the first and second phases of this market research project into the adoption of (a) pressure irrigation systems and (b) soil moisture monitoring in the grape growing industry[1].

In the first, qualitative phase, we interviewed grape growers, industry consultants and extension staff in the Riverland of South Australia, Victoria and New South Wales Sunraysia and the Riverina in New South Wales to identify the factors influencing adoption of pressure irrigation and soil moisture monitoring.

In the second, quantitative, phase a mail survey was sent to grape growers in each of these regions. The data collected in the survey on the distribution of these key factors among growers was then used to identify and quantify market segments for the adoption of pressure irrigation and soil moisture monitoring.

The results were subsequently used to develop recommendations to promote the adoption of pressurised irrigation and soil moisture monitoring. These recommendations are the subject of this report.

1.2 An outline of this report

In this report we describe the process used to develop recommendations to promote the adoption of pressurised irrigation and soil moisture monitoring. In section 2 we outline the market research work relating to the adoption of irrigation systems, giving details on the qualitative and quantitative stages of the work. In section 3 we report on the development of recommendations for promoting the adoption of pressurised irrigation systems, and in section 4 the recommendations are reported.

In section 5 we outline the market research work relating to the adoption of soil moisture monitoring, again giving details on the qualitative and quantitative stages. In section 6 we report on the development of recommendations for promoting the adoption of soil moisture monitoring. The recommendations are reported in section 7. Section 8 concludes this report.

2. Irrigation systems

2.1 Factors influencing the adoption of pressure irrigation systems – qualitative phase

In the qualitative phase of the market research we found that grape growers' propensity to change from furrow irrigation to pressure irrigation depended on a number of key factors. These were:

- A desire to spend less time irrigating and to increase flexibility in managing activities in the vineyard. Furrow irrigation systems are labour intensive, as compared to pressurised systems. Also, as furrow systems wet the ground around the vine rows growers are unable to spray or harvest grapes while irrigating. This problem is avoided with some pressurised systems.
- A desire to save time irrigating and harvesting grapes by redeveloping vineyards to longer rows, thereby increasing flexibility in managing activities in the vineyard, and changing grape varieties,
- The topography and soils of the vineyard were not suitable for furrow irrigation, and
- A desire to improve grape and bunch quality with respect to, for example, increasing uniformity within rows or meeting colour specifications set by a winery.

2.2 Water use and the adoption of pressure irrigation systems

In most instances growers did not identify efficient water use or saving water as a key reason for adopting a pressure irrigation system. This suggests that extension activities seeking to increase the adoption of pressure irrigation systems by promoting their advantages in terms of saving water and increasing water use efficiency will not be effective.

2.3 Market segments for irrigation systems – quantitative stage

In the quantitative phase of the market research a mail questionnaire was distributed to grape growers in the Riverland of South Australia, Sunraysia in Victoria and New South Wales, and the Riverina in New South Wales. We obtained an estimated response rate of approximately 44 per cent[2]. We classified respondents to the survey into seven segments based on whether they had installed a pressure irrigation system and their reasons for installing that system. The segments,

labour irrigating and to increase their flexibility in terms of harvesting and spraying grapes. These growers represented approximately eight per cent of respondents.

- The 'time and quality irrigators' segment. The growers in this segment had installed a pressure system because they wished to save time irrigating and improve the quality of their grapes. This segment represented 19 per cent of the sample.

- The 'time irrigators' segment. This segment consisted of growers who installed a pressure system because they wished to save time irrigating and to increase managerial flexibility. The growers in this segment represented 14 per cent of respondents.

Table 1: Summary of irrigation segments.

	Segment name and percentage of respondents						
	1	**2**	**3**	**4**	**5**	**6**	**7**
	Time and Quality Redevelopers	**Time Redevelopers**	**Time and Quality Irrigators**	**Time Irrigators**	**Other Pressurised Irrigators**	**Laser graded furrow Irrigators**	**Furrow Irrigators**
	14%	**8%**	**19%**	**14%**	**12%**	**10%**	**23%**
Main Location	Vic/NSW Sunraysia	Vic/NSW Sunraysia, Riverland	Vic Sunraysia, Riverland, Riverina	Vic Sunraysia, Riverland	Vic Sunraysia, Riverland	Riverina	Vic Sunraysia
Drivers	Time	Time	Time	Time		Time	
	Quality		Quality		Quality		
	Redeveloping	Redeveloping					
					Topography Changing Variety		
Irrigation System	Pressurised	Pressurised	Pressurised	Pressurised	Pressurised	Furrow Irrigating and Laser graded	Furrow Irrigating
% soil moisture	67	60	57	49	48	18	15

current irrigation system and saw no reason to change. This segment represented 10 per cent of respondents.

- The 'furrow irrigators' segment. This segment consisted of growers who had furrow irrigation. Twenty-three per cent of respondents were in this segment. These growers, along with growers in the previous segment, were satisfied with their irrigation system and saw no reason to change.

The frequency of using objective soil moisture monitoring to manage irrigation was highest among respondents in the redeveloper segments (segments 1 and 2) and declined to a minimum among respondents in the furrow irrigation segments (segments 6 and 7).

2.4 Factors influencing the choice of pressure irrigation system

The key factors influencing choice of pressure system were access to water on demand, type of grapes grown, the cost of the system and management of grape quality.

There are two aspects to the management of grape quality. One aspect is the overall management of grapevines. The installation of pressure systems can contribute to better and more uniform bunch quality and canopy health through the more even distribution of water to the vine and greater control over the timing of irrigations.

The second aspect is that, in some circumstances, pressure systems may be needed to achieve quality specifications for wine grapes. For example, achieving colour specifications for red wine grapes.

2.5 Summary of market research on adoption of pressure irrigation

We concluded from our results that, over time, grape growers will shift from the furrow irrigation segments (segments 6 and 7) into the pressure irrigation segments (segments 1 to 5). This movement will occur in a variety of ways depending on the pressures for change that growers experience as shown in figure 1. Some growers are likely to install pressure irrigation in response to economic and lifestyle pressures to reduce the time they spend irrigating and to increase their managerial flexibility in the vineyard. These growers are represented in figure 1 as shifting from the furrow irrigation segments (segments 6 and 7) into either the time redeveloper (segment 2) or the time irrigator segments (segment 4) depending on whether they redevelop or simply convert

quality redeveloper (segment 1) and the time and quality irrigator segments (segment 3), will develop a need for increasingly specific information on the link between irrigation management and grape quality. These growers are represented in figure 1 as 'shifting' from the time redeveloper segment (segment 2) to the time and quality redeveloper segment (segment 1) or as 'shifting' from the time irrigator segment (segment 4) to the time and quality irrigator segment (segment 3).

On the basis of these conclusions we believe that the adoption of pressure irrigation systems by grape growers might be facilitated by providing:

- Information to growers on selecting and installing pressure systems.
- Information to growers on using pressure irrigation to influence grape quality.

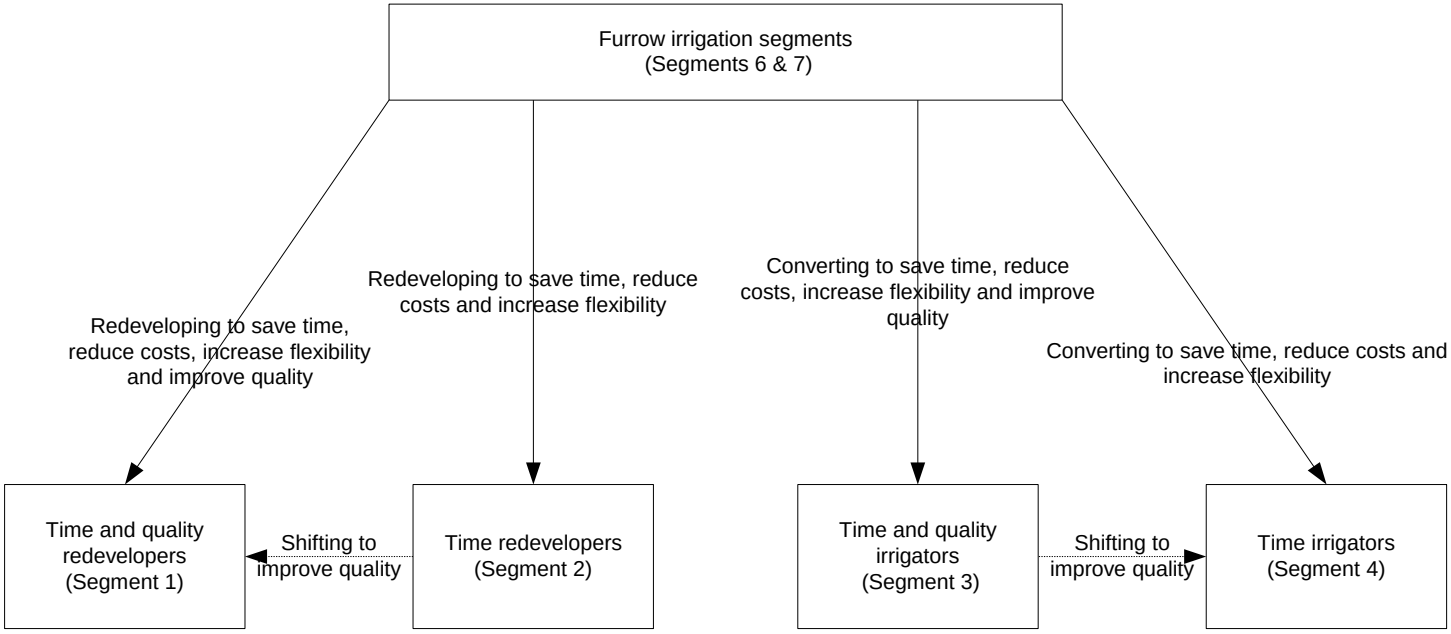

Figure 1: Predicted changes in segment membership

3. Developing extension recommendations for the irrigation systems segments

3.1 Introduction

The recommendations for extension were developed using the results of the two previous phases of the market research. These results were analysed and interpreted in workshops with government agency and industry personnel. Proposals for extension were formulated in these workshops. These proposals were then validated in a final round of interviews with growers from each of the segments in Sunraysia, the Riverland and the Riverina[3]. A total of 15 of these validation interviews were undertaken and the results of these are reported below.

3.2 Interviews with growers

Some of the growers interviewed indicated that they had experienced minor problems in their first season with pressure irrigation. These growers also indicated they had overcome these problems within a season or two through trial and error learning and discussions with other growers and with irrigation equipment suppliers. None of the growers interviewed indicated that they had experienced any long-term problems with pressure irrigation systems. All were satisfied with the design of their current irrigation system and management. These results are consistent with the views expressed by the growers we interviewed in the first stage of the study.

This suggests that the demand by growers for assistance with changing from furrow to pressure irrigation and assistance in obtaining well-designed irrigation systems may be limited. For example from the 'time and quality irrigators' (segment 3):

> *Doug manages 17 hectares of wine grapes just out of Hanwood. He has recently installed drip irrigation. He wanted to increase the flexibility he had to manage the vineyard and he needed to improve the quality of the grapes he grew. Doug had also been experiencing problems with waterlogging and rising watertables because his property has no sub-surface drainage. Since he has installed the drip irrigation system he has been pleased to find that the watertables have fallen.*

didn't have any problems when converting to drip. He talked to other growers and then worked it out for himself!

Although growers were satisfied with their ability to influence grape quality through their irrigation management, most growers expressed concern about achieving quality targets in the future. Growers felt that the parameters used by wineries to specify grape quality would become increasingly complex and precise, placing greater demands on their irrigation management. This suggests demand by growers for information on manipulation of grape quality, for both furrow and pressure irrigation, is substantial and likely to increase in the future.

For example, from the 'time and quality redeveloper' segment (segment 1):

Peter runs an irrigation supplier business as well as managing a 16 hectare block of wine grapes near Renmark. He put the block under drip irrigation from the first planting because he was concerned about meeting the quality specifications set by the winery, particularly for colour. He has found he can get both baume and colour quite early with the drip.

Stephen is a grower in the 'time and quality irrigator' segment (segment 3):

Stephen has 16 hectares of wine grapes on a property out of Paringa. Half of the grapes have overhead sprinklers, the rest drip irrigation. The overhead sprinklers were put in on the original block. When he planted another block he put in drip irrigation. Stephen has found the drip irrigation easier to manage, particularly as he is trying to stress the vines to achieve better quality. This is very difficult with overheads. He gets paid on colour only so it is important to reach the targets set by the winery.

The risks involved in irrigation practices that rely on stressing vines to improve grape quality, particularly with drip and mini sprinkler systems also concerned some growers. This also indicates the demand by growers for information on manipulation of grape quality through irrigation is likely to increase in the future.

George is from the 'time irrigator' segment (segment 4). He is worried about the risks involved in meeting winery specifications:

George manages several blocks totalling 26 hectares of wine and multipurpose grapes in Red Cliffs. The blocks that were under furrow irrigation he has converted to drip to save time. He hasn't converted his other block from overhead sprinklers, although he would like to. The water supply to that block is very unreliable and he can't take the risk that he would get the water when he needed it if he had drip irrigation. This year, because of demands from the winery to achieve specifications he has tried to dry out his Shiraz block. "It was touch and go on occasion," he says. If the water was late, or if anything broke down, he would have been in real

These responses suggest that there may be a role for research agencies to conduct research programs that are intended to identify and quantify the influence of irrigation on a range of parameters that might be used to define grape quality. This research should incorporate different irrigation systems, including furrow, as well as accounting for different soil types and grape varieties. There may also be a role for extension agencies to provide programs to provide advice and assistance to growers on how they can influence grape quality through irrigation scheduling. This applies to the management of furrow irrigation as well as pressure irrigation systems. This assistance could include recommendations to growers on the use of soil moisture monitoring to help establish irrigation schedules.

3.3 Regional infrastructure considerations

The feasibility and attractiveness of micro-irrigation to growers will be influenced by constraints on timely access to irrigation water and the cost of installing electrical power. Where growers do not have access to water on demand their capacity to utilise micro-irrigation can be restricted. Many growers in channel irrigation districts who do not have water on demand may have limited flexibility in adjusting their irrigation management to optimise grape quality. This suggests that regional and district irrigation infrastructure will constrain the adoption of low volume irrigation systems such as drip, mini sprinklers and micro-jets.

Consideration needs to be given to undertaking an assessment of the extent to which changes in regional and district irrigation and power infrastructure may enhance the adoption of low volume irrigation systems such as drip and mini sprinklers.

4. Recommendations for irrigation systems extension

The recommendations outlined below are based on the results of the two preceding phases of the market research and the outcomes of the subsequent workshops and grower validation interviews.

4.1 Recommendation 1

As a high priority an extension program is developed targeting growers who have installed, or are considering installing, a pressure irrigation system in part because, of concerns over achieving grape quality. This program would target growers who are currently in the time and quality redeveloper and the time and quality irrigator segments (segments 1 and 3) and growers moving into those segments in the future. It would demonstrate the link between grape quality and pressure irrigation.

This program would include:

- Providing advice and assistance to growers on influencing grape production and quality using specific pressure irrigation systems. This advice and assistance should account for different soil types and grape varieties. Collaboration with wineries and suppliers of irrigation equipment and services is recommended in developing this program.
- Promoting soil moisture monitoring as a technique to effectively manage irrigation for grape quality.

4.2 Recommendation 2

As a high priority a program is developed for growers in the furrow irrigation segments (segments 6 and 7) providing information on managing furrow irrigation to improve grape quality.

4.3 Recommendation 3

That a program is developed to facilitate the change from a furrow irrigation system to a pressure irrigation system when first installed. In developing this program it is important to recognise that the information needs of growers will vary.

- Growers that are converting vineyards to pressure irrigation will need to adapt mature vines to pressure irrigation systems. This information would be useful to growers moving to the time and quality irrigator and time irrigator segments (segments 3 and 4).
- Growers that are redeveloping their vineyards to pressure irrigation will need information on

4.4 General comments

Given these recommendations we believe there is an important implication for research into irrigation management of grapevines. At this point in time there are no clear guidelines for growers identifying and quantifying the range of parameters that might be used to define grape quality. The influence of irrigation on these is also unknown. We believe research should be undertaken to develop these guidelines for growers, that incorporates different irrigation systems, including furrow, and that accounts for different soil types and grape varieties.

Table 2: Extension recommendations for irrigation systems segments.

	Segments						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Extension program Focus	**Time and Quality Redevelopers**	**Time Redevelopers**	**Time and Quality Irrigators**	**Time Irrigators**	**Other Pressurised Irrigators**	**Laser graded furrow Irrigators**	**Furrow Irrigators**
Managing young vines	X	X					
Managing established vines			X	X	X		
Working with irrigation designers	X	X	X	X	X		
Working with wineries	X		X		X	X	X
Grape quality and irrigation management	X		X		X	X	X

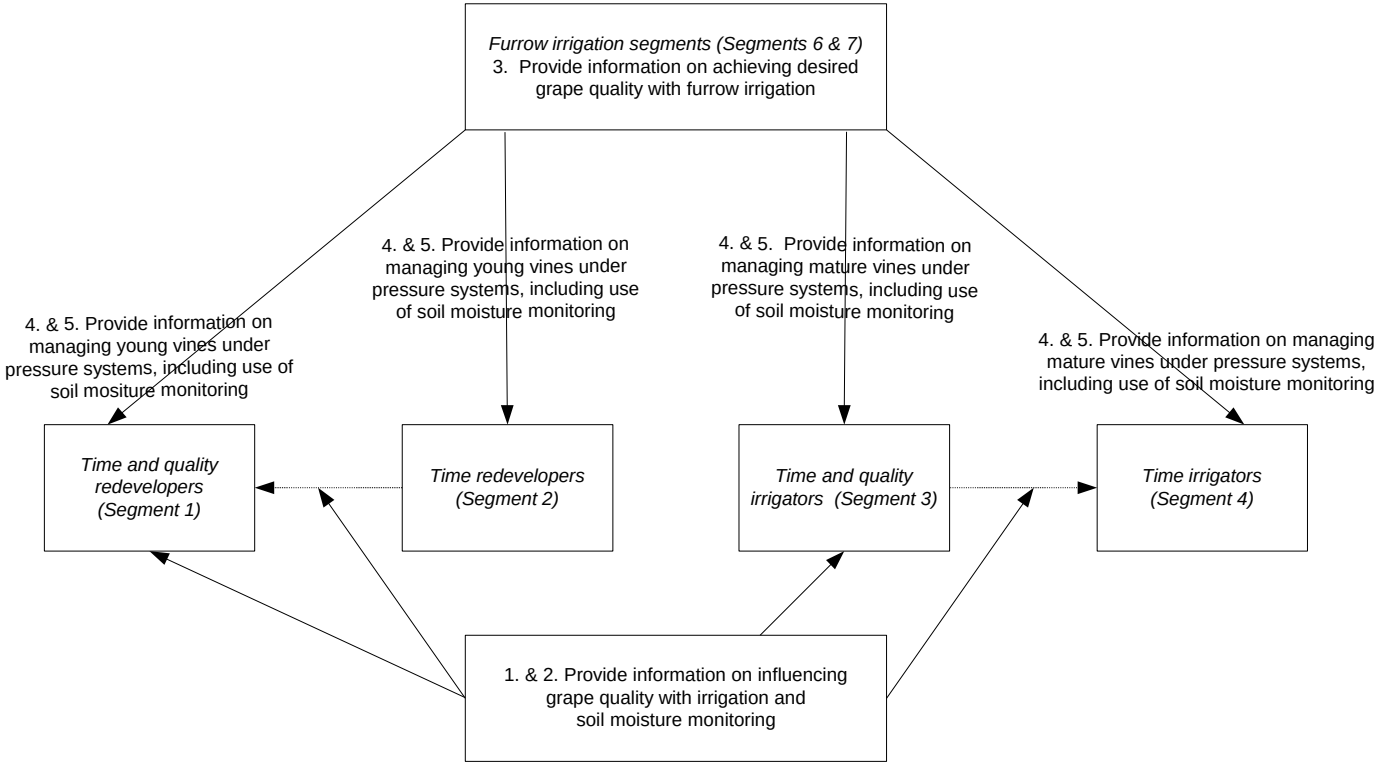

Figure 2: Outline of the recommendations and changing segment membership (numbers denote recommendation)

5. Soil moisture monitoring

5.1 Factors influencing the adoption of soil moisture monitoring – qualitative phase

The first phase of the market research revealed that the propensity of growers' to adopt soil moisture monitoring depended on the following factors:

- A need to monitor irrigations more closely as a result of installing drip or micro- jet irrigation.
- Access to continuously available irrigation water (water on demand).

We found that water use efficiency was not reported as a factor by most growers in adopting soil moisture monitoring. Most growers indicated soil moisture monitoring assisted them to alleviate the risk of stressing vines with pressure irrigation systems, especially drip and mini sprinkler systems. These systems operate at particularly low flow rates compared to other irrigation systems therefore there is greater risk of subjecting vines to moisture stress. Consequently, growers who install these systems tend to rely on access to water on demand and soil moisture monitoring to help alleviate this risk. As more growers install drip and mini sprinkler systems the use of soil moisture monitoring by growers will increase.

5.2 Market segments for soil moisture monitoring – quantitative phase

In the quantitative study we classified respondents into four segments depending on whether they had a pressure irrigation system, if that system was a drip or mini sprinkler system, and whether they had irrigation water on demand. Water on demand was defined as being able to access water within 24 hours. Growers who have on-farm storage, can pump directly from a river, were able to order and obtain water within 24 hours, or had a standing monthly order were defined as having water on demand. The segments, which are summarised in table 3, were as follows.

- The 'micro schedulers' segment. Growers in this segment had installed a drip or mini sprinkler system and could irrigate on demand. These growers are in a position to use objective soil moisture monitoring to adjust their irrigation schedules on a daily basis. This segment represented 25 per cent of growers in the sample.

- The 'micro monitors' segment. These growers had installed a drip or mini sprinkler system but did not have water on demand. Consequently, the growers in this segment are unable to routinely use

We found that the frequency of use of soil moisture monitoring was highest among respondents in the first segment (the 'micro schedulers') and declined to a minimum among respondents in the fourth segment (the 'furrow monitors').

Some growers (29 per cent) indicated that grape quality was one of the factors in their decision to adopt soil moisture monitoring. Generally speaking, growers can use irrigation management to influence quality parameters such as baume and colour by subjecting vines to some degree of water stress. Some growers, especially those with low volume systems such as drip and mini sprinkler irrigation, rely on soil moisture monitoring to assist them in placing vines under the degree of stress necessary to achieve the quality specifications they desire.

5.3 Summary of market research on adoption of soil moisture monitoring

We concluded that the use of soil moisture monitoring will increase over time as more growers install pressure irrigation systems, especially drip and mini sprinkler systems, and as pressure from wineries to produce grapes to specification increases.

Consequently, we believe that soil moisture monitoring may be promoted to grape growers using pressure irrigation systems, especially drip and mini sprinkler systems, as a technique to assist in determining the timing of irrigations. Soil moisture monitoring may also be promoted as a technique to assist in producing grapes to specification. However, we also believe that the adoption of soil moisture monitoring may be limited in areas where growers do not have access to irrigation water on demand.

Table 3: Summary of soil moisture monitoring segments.

	Segments and percentage of respondents			
	1	**2**	**3**	**4**
	Micro Schedulers	**Micro Monitors**	**Pressure Monitors**	**Furrow Monitors**
	25%	**19%**	**23%**	**33%**
Type of Irrigation System	Drip or Micro	Drip or Micro	Undervine or Overhead sprinklers	Furrow Irrigators

6. Developing extension recommendations for the soil moisture monitoring segments

6.1 Introduction

The process used to develop recommendations for extension for soil moisture monitoring was the same as that used to develop recommendations for the irrigation system segments. The proposals for extension of soil moisture monitoring that emerged from the workshop process were included in the validation interviews that were held with growers to assess the extension proposals for irrigation.

6.2 Grower interviews

None of the furrow irrigators (segments 6 and 7) we interviewed were using soil moisture monitoring. All of these irrigators expressed the view that this would change when they converted to a pressure system. For example;

> *Fred has 5 hectares of wine grapes on a property near Griffith. The grapes are under furrow irrigation. Fred doesn't use soil moisture monitoring. A shovel is a good way of checking how the irrigations are going. Once he converts to micro irrigation he will look at high tech systems and decide what is best for him.*

And;

> *Joe has 7 hectares of multipurpose and wine grapes on a vineyard in Red Cliffs. Joe furrow irrigates with pipe and risers. He would like to convert to drip irrigation to save time, and take advantage of the added benefit of saving some water as well, and has investigated installing a new system. However he has not got enough money at present to convert his property. Joe does not use soil moisture monitoring at present. He believes that when he converts to drip he will need to install a system. He has a close friend across the road who has converted from furrow and has soil moisture monitoring, so will get advice from him.*

Most of the growers we interviewed that had a pressure irrigation system used soil moisture monitoring. For example Doug was using soil moisture monitoring to help him achieve the quality

Another example:

> *Russell runs a property growing wine grapes and prunes. He has a total of 40 hectares of grapes, a mix of red and white varieties. Up until this year Russell has furrow irrigated. However he is in the process of converting to drip irrigation. Although he has been achieving the quality specifications demanded by the winery he is keen to eliminate the quality and yield variation within blocks. Unfortunately with furrow irrigation it is very hard to control this variation.*
>
> *For the last couple of seasons the winery has paid for a neutron probe service. The results have been given to Russell and the winery. The winery has been using this information to tell Russell when he is to irrigate his vines, particularly for RDI. Russell says that it has got to the stage with his red wine grapes that he cannot irrigate or fertilise them without getting approval from the winery liaison officer. Russell was very happy with the neutron probe service and information but found it would have been very expensive to continue the service himself. Instead he has installed gypsum blocks. In the future he intends to install a more sophisticated system but the gypsum blocks are proving valuable in the meantime.*

However the problems with water delivery were a concern to some growers. For example:

> *George manages several blocks totalling 26 hectares of wine and multipurpose grapes in Red Cliffs. The blocks that were under furrow irrigation he has converted to drip to save time. George uses a Diviner to monitor soil moisture. He looked around for about three years before deciding on this system. It was a hard decision. He tried tensiometers but didn't like them, and looked at a couple of other systems but thought the after sales service wasn't very good. The results from the Diviner are reinforcing what he is doing. He has good after sales support too.*
>
> *George finds the water supply problems the most frustrating. He says that he often has to water even though he doesn't want to because it's the only time he will get any water. This makes it very difficult to manage his wine grapes in particular.*

These responses suggest that there may be a an important role for extension programs in promoting the use of soil moisture monitoring generally as a technique for managing grape quality.

6.3 Regional infrastructure issues

The attractiveness of soil moisture monitoring to growers depends on their access to water. Where

7. Recommendations for soil moisture monitoring extension

The recommendations outlined below are based on the results of the two preceding phases of the market research and the outcomes of the subsequent workshops and grower validation interviews.

7.1 Recommendation 1

A program is developed to provide assistance to growers in all four monitoring segments in choosing and installing soil moisture monitoring equipment and in interpreting monitoring data.

7.2 Recommendation 2

That an assessment is undertaken to investigate the extent to which changes in regional and district irrigation and power infrastructure may enhance the adoption of low volume irrigation systems such as drip and mini sprinklers

8. Conclusion

The results of this study suggest that there are opportunities to promote efficient water use in viticulture by facilitating the adoption of pressure irrigation systems and soil moisture monitoring by grape growers.

8.1 Irrigation systems

For most growers the key factors influencing the adoption of pressure irrigation systems are to reduce time spent irrigating, to increase flexibility in managing irrigation, spraying and harvesting activities, and to improve grape production and quality. This means the adoption of pressure irrigation systems is largely determined by long term changes in the circumstances of growers such as changes in family composition and enterprise expansion and by commercial pressure from wineries in terms of the specification of grape quality. Consequently, the role of extension in promoting the adoption of pressure irrigation systems is to facilitate the process of changing from furrow to pressure irrigation systems once family and commercial circumstances have prompted growers' to make the change.

We found that, in most instances, growers did not identify more efficient water use or saving water as a key reason for adopting a pressure irrigation system. This suggests that extension activities that seek to increase the adoption of pressure irrigation systems solely by promoting their advantages in terms of saving water and increasing water use efficiency will not be effective.

8.2 Soil moisture monitoring

Interest among grape growers in soil moisture monitoring is primarily motivated by the need to closely manage soil moisture levels to avoid overstressing grapevines when using low volume irrigation systems such as drip, mini sprinkler or micro-jet irrigation. However, growers are becoming increasingly reliant on irrigation practices that involve subjecting vines to water stress to achieve quality targets. This means that the importance of quantitative soil moisture monitoring is likely to increase over time as more growers adopt these types of irrigation management practices, especially growers with micro irrigation systems.

We concluded that the return to efforts to promote the adoption of soil moisture monitoring solely by promoting the advantages of this technology in terms of saving water and increasing water use

9. References

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Appendix A

A.1 Introduction

Facilitated workshops were used to develop recommendations and priorities for extension using the information and perspectives gained from the market research studies and the knowledge and experience of agency staff and industry consultants involved in extension in the grape growing industry. Workshops were held in the Riverland, Sunraysia and the Riverina. Draft recommendations were developed for an extension program using the program logic approach (Mayeske, 1994).

Consumer behaviour theory suggests that growers who were dissatisfied in some way with their irrigation systems or management would be likely to be the most strongly motivated to change their irrigation management. Consequently, in developing recommendations for extension programs, we concentrated on targeting grape growers' who were dissatisfied with their irrigation management. Workshop participants were asked to list the potential problems growers in each irrigation and soil moisture monitoring segment could experience with their irrigation systems and their irrigation management.

Following Mayeske's (1994) program logic approach, the problems that were identified by the participants in the workshops were then categorised into problem trees. The participants then brainstormed solutions to these potential problems. Solution trees were then developed from this information. The resulting problem and solution trees are summarised in appendix B and C.

A.2 Issues identified for irrigation system segments

A number of problems were identified as causing dissatisfaction for growers with furrow or pressure irrigation (see appendix B). The logical response to many of the problems experienced with furrow irrigation, such as a shortage of labour or difficulty controlling vigour, is to install some form of pressure irrigation. Consequently, the problems that were identified in the workshops tended to relate to difficulties either in converting from furrow to pressure irrigation or difficulties in managing pressure irrigation systems once installed. Many of the problems are not segment-specific and have the potential to occur in each irrigation segment. The problems were classified into the following broad categories:

- Managing change. Growers changing from furrow irrigation to pressure irrigation could experience problems in managing micro-irrigation of young vines if they were redeveloping their vineyards or if they were converting established vineyards to micro-irrigation. There is potential for problems to occur with planning and financing the redevelopment or conversion of the vineyard from furrow to pressure irrigation systems.
- Yield and quality issues – irrigation design. This category covered problems that arose as a result of poor irrigation design. Problems could arise in achieving target quality and yield as a result of inadequate pump or system capacity, inappropriate system design for soil type or vine varieties, inadequate drainage and so on.
- Yield and quality issues – irrigation management. This category covers problems such as excessive vigour, improper maintenance, frost, and pest and disease. It also includes yield and quality problems arising from improper scheduling and difficulties in linking irrigation scheduling to management of grape quality.

A.3 Extension proposals for irrigation systems segments

The participants in the workshop believed that extension programs could be directed at assisting growers to manage problems with changing from furrow to pressure irrigation, assisting growers to invest in well designed irrigation systems, and assisting growers with managing the technical problems that can arise with pressure irrigation systems. The participants believed that extension programs addressing these problems could be tailored to the needs of growers in each segment by, for example:

- Providing information on managing young vines under pressure irrigation for growers in both of the redeveloper segments (segments 1 and 2). This information could include recommendations to use soil moisture monitoring to help establish irrigation schedules for newly installed pressure irrigation systems, especially drip and mini sprinkler systems.
- Providing information on managing established vines under pressure irrigation systems for growers in the time and quality segment (segment 2) and the time saving segment (segment 4). This information could also include recommendations and advice about using soil moisture monitoring to help establish irrigation schedules for newly installed systems.
- Work with irrigation designers and growers to overcome any irrigation system design problems. This would include furrow irrigators (segments 6 and 7) who are planning on installing a pressure irrigation system.
- Provide information for growers in all segments on irrigation management particularly emphasising the links between parameters defining grape quality, vigour and irrigation management. Again, this could include advice about using soil moisture monitoring to help establish appropriate irrigation

example, growers might experience problems with siting equipment or with interpreting data. The problem tree that was developed for soil moisture monitoring is reported in Appendix C. The workshop participants believed the problems they identified were likely to be present among growers in all of the monitoring segments.

A.5 Extension proposals for soil moisture monitoring segments

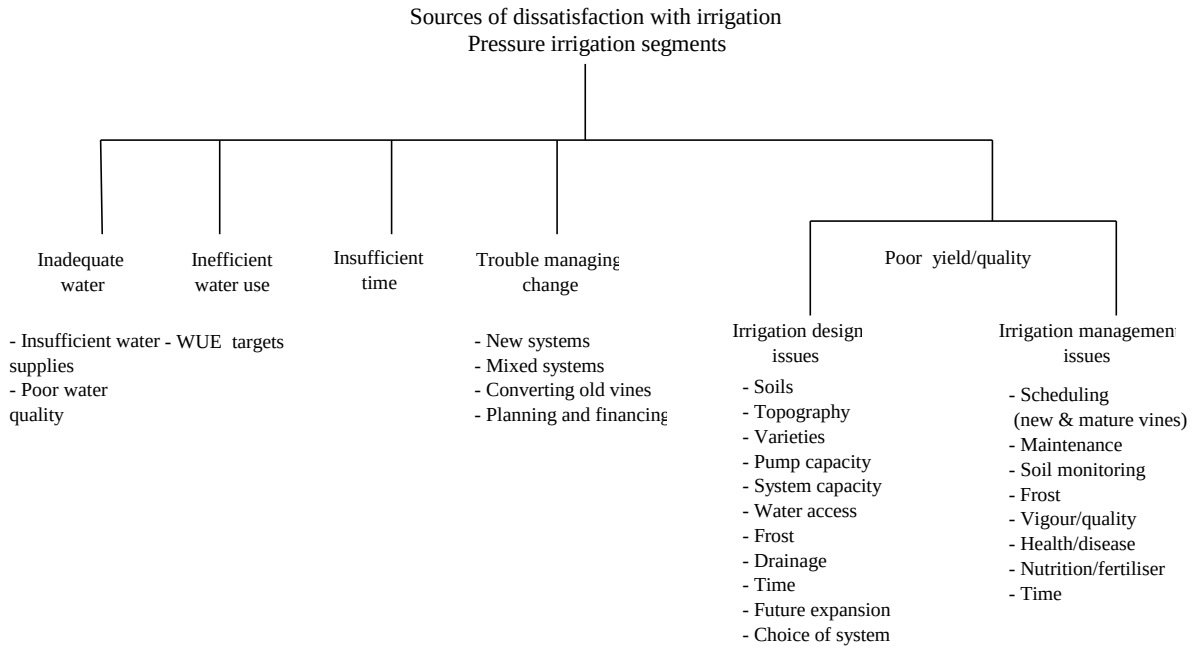
Two extension proposals were developed to respond to these problems. One proposed solution was to provide growers with advice and assistance in siting and calibrating soil moisture monitoring equipment. The other was to provide assistance and advice to growers in using monitoring information when scheduling irrigations to manipulate grape quality and production more effectively. The solution tree for soil moisture monitoring is outlined in Appendix C.

We concluded on the basis of the results for the irrigation segments and the soil moisture monitoring segments that extension agencies could promote soil moisture monitoring to grape growers by:

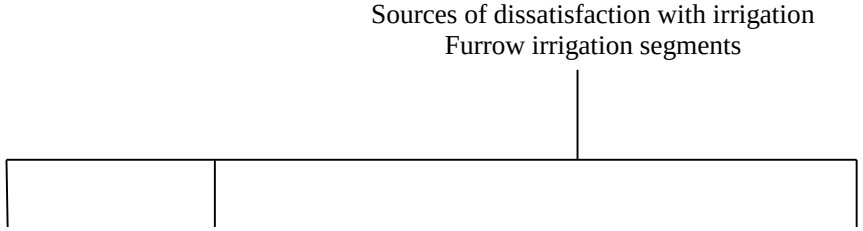
- Promoting soil moisture monitoring as a technique for developing irrigation schedules for newly installed pressure irrigation systems. This applies to growers in all five pressure irrigation segments.
- Providing advice and assistance in siting and calibrating soil moisture monitoring equipment to growers from each monitoring segment.
- Providing advice and assistance in using soil moisture monitoring as a technique for influencing grape production and quality through irrigation management for growers currently in the time and quality redeveloper (segment 1), time and quality irrigator (segment 3) and growers shifting to these segments in the future.

Appendix B

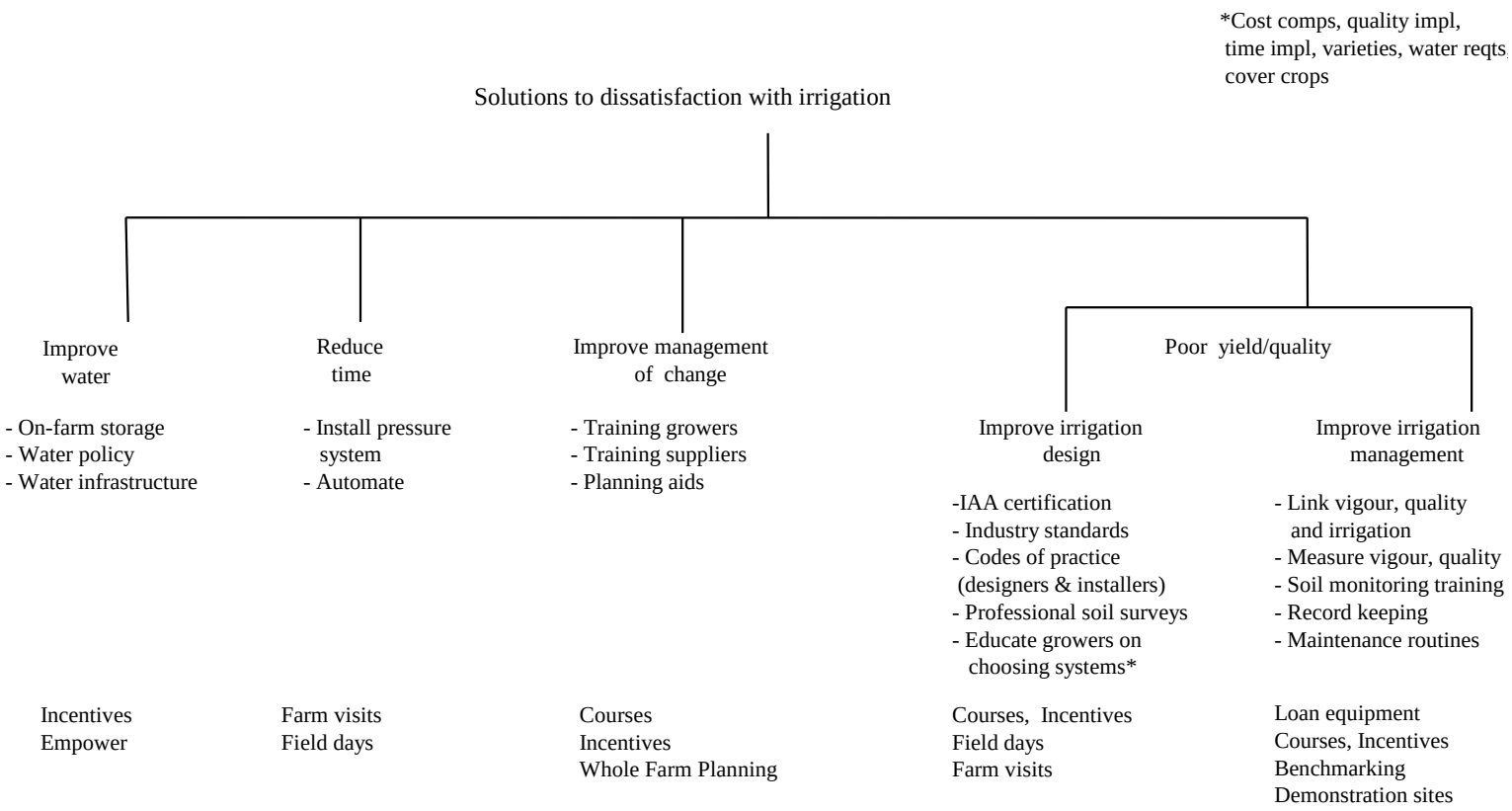
B.1 Problem tree for pressure irrigation systems



B.2 Problem tree for furrow irrigation

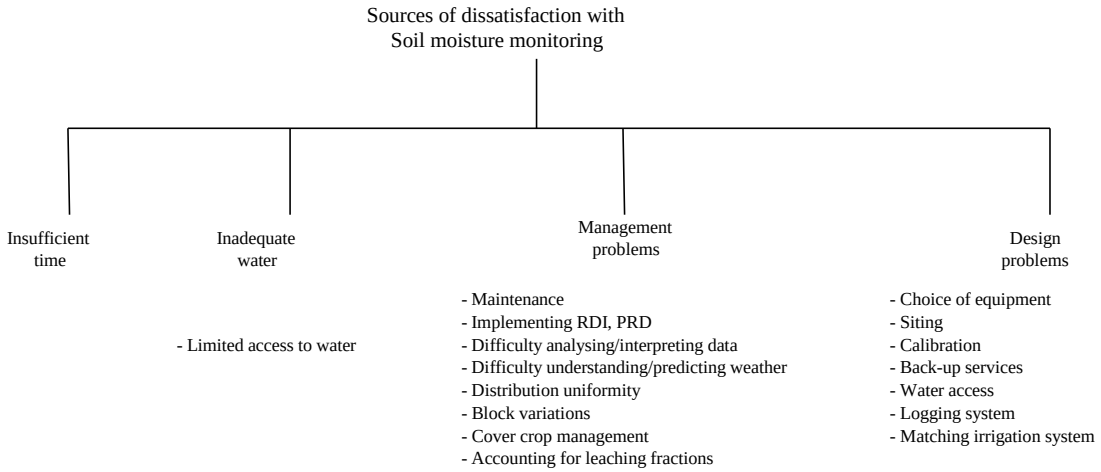


B.3 Solution tree for irrigation systems



Appendix C

C.1 Problem tree for soil moisture monitoring



C.2 Solution tree for soil moisture monitoring