Cooperative Research Centre for Viticulture

Grape and Wine Research and Development Corporation

Australian Society of Viticulture and Oenology Inc.

Vine and Vineyard Water Requirements

Report on the workshop held at the Waite Campus, Adelaide University, 3 September 2002, to review and scope needs on efficient water use in viticulture.

Final Report to GWRDC

Project Nº GWR 02/02d

The CRC *for* Viticulture is a joint venture of these core participants

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Vine and Vineyard Water Requirements

GWRDC Project Code GWR 02/02d

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Vine and Vineyard Water Requirements

Increasing vineyard water use efficiency is a major goal of the wine industry. Strategic water management to increase grape quality is similarly an industry priority. Precise knowledge of vine and cover crop water requirements, soil evaporation and 'leakiness' are fundamental to achieving water use efficiency. Traditional approaches for estimating vineyard water requirements are based on use of pan evaporation data and crop coefficients. Soil moisture monitoring, using anything from visual assessment to sophisticated soil moisture sensors, has also been widely adopted as an irrigation scheduling tool over the last decade. Such approaches generally arrive at estimates of evapotranspiration (ET), which is a composite of actual vine and cover crop transpiration and soil evaporation. The advent of sap flow sensing technologies that enable the direct measurement of vine transpiration has suggested vine transpiration values in a range equivalent to 0.5 to 2.0 megalitres per hectare per season (depending on canopy size etc) which is lower than expected relative to traditional methods of measurement. Furthermore, we know that deficit irrigation technologies such as PRD and RDI have the capacity to significantly modify vine water use through physiological changes. The impact of this on vine water use needs to be considered in developing meaningful crop factors.

The key questions addressed at the workshop were as follows:-

The accuracy of current estimates of vine transpiration, cover crop transpiration and soil evaporation.

Knowledge gaps

Research required to fill the gaps

Prioritisation of the research needs

Structuring the research, regionally and nationally

Extension of current and new information

In addition to addressing these questions, the workshop was designed to assist the Grape and Wine Research and Development Corporation (GWRDC) in the identification and prioritisation of research aimed at further enhancing water use efficiency in Australian wine grape vineyards. These proceedings contain the papers presented at the workshop and a summary of the discussions that followed the formal presentations.
The workshop was held at the Waite Campus, Adelaide University on 3 September 2002.

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Papers Presented

Vine and vineyard water requirements: an industry perspective

Richard Hamilton

Traditional approaches for measuring vine and vineyard water requirements

Ian Goodwin

Micrometeorological approaches to estimating vineyard water requirements: Review and latest insights

Helen Cleugh

Grapevine water use in New Zealand: Experiences with sap-flow devices

Steve Green, Brent Clothier, Bryan Jardine, Marc Greven, Sue Neal, Horst Caspari, Bartolo Dichio, Peter Davidson, Damian Martin, Greg Dryden and Murray Neal.

Physiological control of vine water use

Brian Loveys

Evaporation from the grapevine canopy and soil surfaces

Isa A. M. Yunusa

Using Granier sap flow sensors to determine grapevine transpiration

Ping Lu, Isa A.M. Yunusa and Rob Walker

Sapflow measurements can underestimate vine water use by up to 40%: A comparison of gravimetric and sapflow measurements of vine transpiration

Mark Gibberd and Rob Walker

Peach transpiration using heat pulse velocity

Ian Goodwin

Using gas exchange chambers to measure vine water use

Paul Petrie, Michael Trought, G. Stanley Howell, Graeme Buchan and John Palmer

Estimates of vineyard soil water evaporation (Es) and factors that affect it

Rob Stevens

Vine and vineyard water requirements: status and future directions

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Overview

This is a summary of discussions following presentation of formal papers at the workshop. The full proceedings of the workshop will be published separately to this report.

Summary

Workshop participants acknowledged the push for increased water use efficiency in Australian irrigated cropping systems and the part to be played in this by the grape and wine industry. While it was acknowledged that significant scientific gains had been made due to the advent of new equipment, such as sap flow monitors, there remains conjecture as to the range of actual values for grapevine water use. There is also a clear and necessary distinction to be made between actual vine water use and vineyard water requirements. There is increasing evidence to suggest that soil (water) evaporation can be a significant component of vineyard evapotranspiration or ET. Workshop participants felt there is a clear need for a coordinated approach to resolve the relative magnitudes of, and factors influencing actual vine water use and other components of ET (the sum of actual vine water use, cover crop water use and soil evaporation), to enable the scope for increased water use efficiency through management of the components of ET to be accurately determined. From an industry perspective, there is also clear need for knowledge and tools that enable understanding and management of optimum levels of soil moisture in the zone of principal root volume for meeting winemaker specifications for grape composition and wine quality and, of course, grower profitability.

Within the context of meeting winemaker specifications for grape composition and quality, the priority issues identified at the workshop were as follows:

1. Develop a coordinated approach to determination of total vineyard water requirements.
2. Develop a coordinated approach to characterise the components of vineyard water use:
    - Vine transpiration
    - Cover crop transpiration
    - Soil evaporation
    - Drainage
3. Define and characterise vapour pressure deficit (VPD) or humidity effects on stomatal control of transpiration, and its interaction with soil moisture deficit effects.
4. Redefine crop coefficients for closer matching of irrigation scheduling to vine water requirements, taking into account all components of vine water use.
5. Validate the water requirements/water use module of VineLOGIC (Godwin et al. 2002) with best available data sets and develop real time irrigation scheduling capacity.
6. Assess remote sensing approaches for vineyard canopy area estimation and potential to integrate with vine water use models.

Introduction

The purpose of this paper is to overview the discussions that occurred during the workshop session of the meeting. The participants were asked to address the following questions:-

- The accuracy of current estimates of vine transpiration, cover crop transpiration and soil evaporation
- Knowledge gaps
- Research required to fill the gaps

- Structuring the research, regionally and nationally
- Extension of current and new information

The accuracy of curre nt estimates of vine transpiration, cover crop transpiration and soil evaporation

It was noted from the papers presented that *actual* water use by 'typical' grapevines was in the range 5-15 litres/vine/day (equivalent to approximately 0.6-1.8 mm/vine/day for standard spacings about 2.3 m x 3.3 m). It was also noted that the number of such studies was limited and that the vines used had canopy sizes of approximately 40% ground cover. Noting also the difficulty and potential inherent errors in scaling-up from water use measurements on a few vines to total water use values per hectare, these limited data equated to actual *vine* water uses in the range 1–2 megalitres per hectare. There was considerable discussion as to whether values at the lower end of this range were realistic, particularly in the light of research in other countries which indicates water use for well-watered vines of approximately 40% ground cover of 7 mm/d or 42 l/vine/d (for a spacing of 2 m x 3 m (Stevens 2002)).

These data can be compared with results from a benchmarking study of 42 wine grape properties in the Sunraysia area (Giddings et al. 2002). The study, involving a wide range of wine grape varieties and several irrigation systems, revealed irrigation applications in the range 2–9 megalitres per hectare with an average of approximately 6 megalitres per hectare across all properties. The lower values were generally obtained with drip-irrigation. In a similar benchmarking study conducted in the Murrumbidgee Irrigation Area (MIA) by McCaffery and Tijs (2002) irrigation applications for drip irrigated vines were in the range 1.5–4.0 megalitres per hectare and for furrow irrigated vines, values were in the range 4–6.5 megalitres per hectare. There are clearly instances of irrigation applications in both Sunraysia and the MIA which are near values obtained for actual water use by vines. It should be noted also that a water balance study in a flood irrigated vineyard of 50 year-old Sultana vines by Yunusa et al. (1997) the total vineyard ET was 6.2 mega litre per hectare, with vine water use being 1.2 megalitre per hectare, cover crop water use of 2.1 megalitre per

hectare and soil evaporation of approximately 3 megalitres per hectare. Thus, depending on the circumstances of the particular vineyard, irrigation applications of 1.5–2.0 megalitres per hectare may be insufficient, in that while the vine's water needs may (or may not) be met, there would be insufficient replacement water to cover that used by cover crops or lost to the atmosphere by soil evaporation. It was also clear from the meeting that the literature varies widely in values for soil evaporation e.g. 16–77% of ET (see papers by Helen Cleugh and Rob Stevens, this proceedings). With such diversity in reported values, participants found it difficult to reach a conclusion with respect to typical vineyard ET and component values. It was strongly concluded that more work was needed to resolve this issue. This included the need to develop standardised protocols for use of sap flow devices. For example, sap flow probes need to be inserted pre-dawn when vine transpiration is zero or negligible. This is necessary to avoid embolisms due to air being sucked into xylem vessels when wounding occurs under conditions of transpirational flow. Careful attention also needs to be paid to wound or calibration factors and the depth of probe insertion, depending on the system being used. Thermal gradients may also be an issue in some situations.

With respect to cover crop water use, very few data were presented. The handbook "Cover Cropping in Vineyards" by Ingels et al. (1998) reports data by Meisinger et al. (1991), which demonstrated that 136 litres of water were required to produce 0.5 kg of above ground (cover crop) dry matter. Participants concluded there was a need to assess and make use of broad acre crop models (with respect to water use) and modify these for use in vineyards.

Knowledge Gaps

The group noted that few irrigators use crop factors for irrigation scheduling. The general feeling was that crop factors provided a simple approach to irrigation scheduling but that the traditional recommended values were relatively inflexible. Irrigators using deficit or strategic irrigation techniques such as Regulated Deficit Irrigation (RDI) or Partial Rootzone Drying (PRD) need to use reduced crop coefficients and although there are suggested values for RDI (see paper by Goodwin,

this proceedings) there is little available information for users of PRD. There is also a need to account for effective canopy cover in setting appropriate coefficients. Thus it was concluded that there is a need to re-define crop coefficients for closer matching of irrigation scheduling to vine water requirements.

The widespread use of soil moisture monitoring for irrigation scheduling purposes prompted the observation that such devices provide "point measurements" and unless there are many point measurements in a vineyard it is difficult to account for the high variability in soil type and soil water holding capacity in most vineyards. It was suggested that remote sensing techniques could be explored as a means of linking measured variations in canopy area to estimates of variable water requirements throughout the vineyard (this being based on the known correlation between vine water use and vine total canopy area). In this context also, it was noted that while vine water use is generally correlated with canopy area, interception of solar radiation is also a factor.

The ability of the grapevine to maintain transpiration rates under widely differing ambient conditions was noted. This applies particularly to differences in vapour pressure deficit. The need to characterise stomatal response to atmospheric humidity under conditions of adequate rootzone moisture was identified as an important area for future research.

Given the complexity of the issues involved, specifically vine genotype, management, atmospheric, site and soil factors, the need to capture such variability in models was identified. Regarding models for vine water use, estimations of the volume of soil that water is easily or readily extracted is the biggest limitation to successful model development. Data on the spatial and temporal distribution of roots are needed to overcome such potential limitations. It was noted that VineLOGIC (Godwin et al. 2002) provides an excellent starting point, but improvements will be needed, specifically on an enhanced vineyard soils module and an improved simulation of trickle irrigation.

Soil temperature effects on vine transpiration and total water use was noted as an area for which little information was available. For example, in New Zealand it

has been noted that vines preferentially extract water from roots in the surface soil layers. Potential cooling effects of irrigation on surface roots is another issue for which little information is available.

Few data are available in Australia from vines in lysimeters. Lysimeters were seen to be another option for calibrating values obtained by sap flow devices and for measuring total ET. The potential to link with overseas groups involved in lysimeter-based vine water use work was noted. It was also noted that insufficient data are available on sub-surface irrigation methods and the extent of reductions in soil evaporation under such set-ups.

Research required to fill the gaps

The six priority issues were further sub-divided into three groups:

1. Priority issues (1) and (2)
2. Priority issues (3) and (4)
3. Priority issues (5) and (6)

Group one was seen to be the main area for immediate attention. This was centered around a re-evaluation of total vineyard ET and its component parts. A micro-meteorological approach was seen to be critical, perhaps focused on two sites. The sites would need to be large and uniform, given the requirement for a 300–400 m zone or fetch surrounding the location of key sensing devices. Use of the same variety (e.g. Shiraz) at both sites was seen to be an advantage. There would be a high capital cost associated with equipping the sites, which for the micro meteorological component could then be partially managed remotely by telimetry. Studies on the components of ET (vine transpiration, cover crop transpiration and soil evaporation) would require further capital costs and technical help, as these components are more site intensive with respect to data collection. Collaboration with international experts in sap flow devices would have obvious benefits with respect to world's best practice in this field. The strong view of industry was that measurements of grape composition and yield were key drivers, and these would also need to be included.

Group two issues, specifically issue (3), were also identified for attention at a workshop on partial rootzone drying held on 4 October, 2002 at the Waite Campus, Adelaide. The issue of VPD or humidity effects on stomatal control of transpiration, and its interaction with soil moisture deficit effects, will potentially be addressed as an initiative of that workshop. The issue of re-definition of crop coefficients is also likely to be addressed through other avenues, but close linkage with research to address the Group one issues (above) would be desirable.

Group three issues were centered around modeling and remote sensing approaches. The obvious link in this case would be to other projects. For example the sites used to address the Group one issues should be set up in a way that enables data to be used either for algorithm development or validation purposes. The CRCV VineLOGIC project is an obvious linkage. Similarly, the CRCV precision viticulture project would provide an obvious linkage with respect to remote sensing or aerial estimates of canopy size variability and hence water use variability within a vineyard.

Structuring the research regionally and nationally

From an industry perspective, a key issue is the production and crop quality targets that are required of today's growers. This is a major driver in relation to the question of vine and vineyard water requirements. Thus any new research will need to be integrated with measures of yield and quality to provide a background for future work. The range of issues to be addressed is potentially quite large and thus a package of activities will be required with components potentially being addressed in a stepwise manner. For example, highest priority would have to be re-addressing the basic questions of vineyard ET and its component parts in vineyard set-ups that meet industry requirements with respect to maximising transferability of outcomes. For growers, researchers and extension providers, confidence in values for 'typical' vine water use, cover crop water use and soil evaporation will provide a clear pathway forward for best management of vineyards to meet wine company quality targets, and grower profitability and sustainability targets.

Site selection and set-up will be key issues and require industry input. However, it is clear that one of at least two potential sites would need to be in the warm-irrigated regions and structured in a way that results will have maximum transferability throughout the warm regions.

Extension of current and new information

Overall it was felt there were insufficient data on actual vine water use and soil evaporation to develop a major extension program at this stage. More research was clearly required to develop confidence in values for 'typical' vine water use and soil evaporation. However, there was a view that even if soil evaporation was at the low end of the range of reported values, there would be an advantage in promoting the use of mulches, provided mulches did not introduce negative impacts with respect to yield and grape quality. There is also the issue of lack of data on effectiveness (with respect to reductions in soil evaporation) of various mulches, which is an issue for future research. Furthermore, one needs to be mindful of the issue raised by Cleugh (this proceedings), that reductions in soil evaporation may increase the vapour pressure deficit of within canopy air and the possible effect that this may have on vine transpiration.

In pursing the understanding of vine water use in the context of whole of vineyard water requirements, participants felt that there would be advantages in involving people with an interest in developing simple tools for irrigation scheduling. While it was acknowledged that existing sap flow sensors will not be suitable for scheduling due to lack of robustness, some limitations also exist within existing soil moisture monitoring devices, and so the potential still exists to develop improved plant-based devices as scheduling tools.

In this regard, we need to decide how much error is acceptable within the decision-making process. There is also the need to move beyond point source measurements and develop systems that take account of the variability that exists within vineyards. Most growers are currently using tools that measure relative changes and trends in (plant/soil) water status instead of absolute values. It is acknowledged that such devices have led to major improvements in water use

efficiency i.e. despite possible imperfections in an absolute sense, the decision making processes are still sound, and as a result, substantial changes in practices and improvements in irrigation have resulted. Thus the way forward is to continue the promotion of scheduling and monitoring tools, including a review of current crop coefficients in relation to current grower production and grape quality targets.

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