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Grapevine management guide 2016–17

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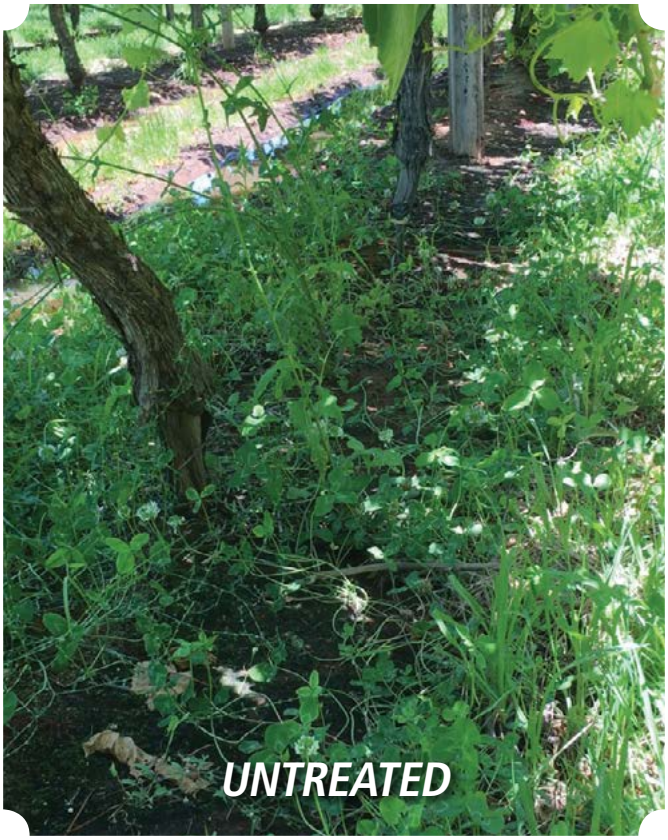

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Grapevine management guide 2016–17

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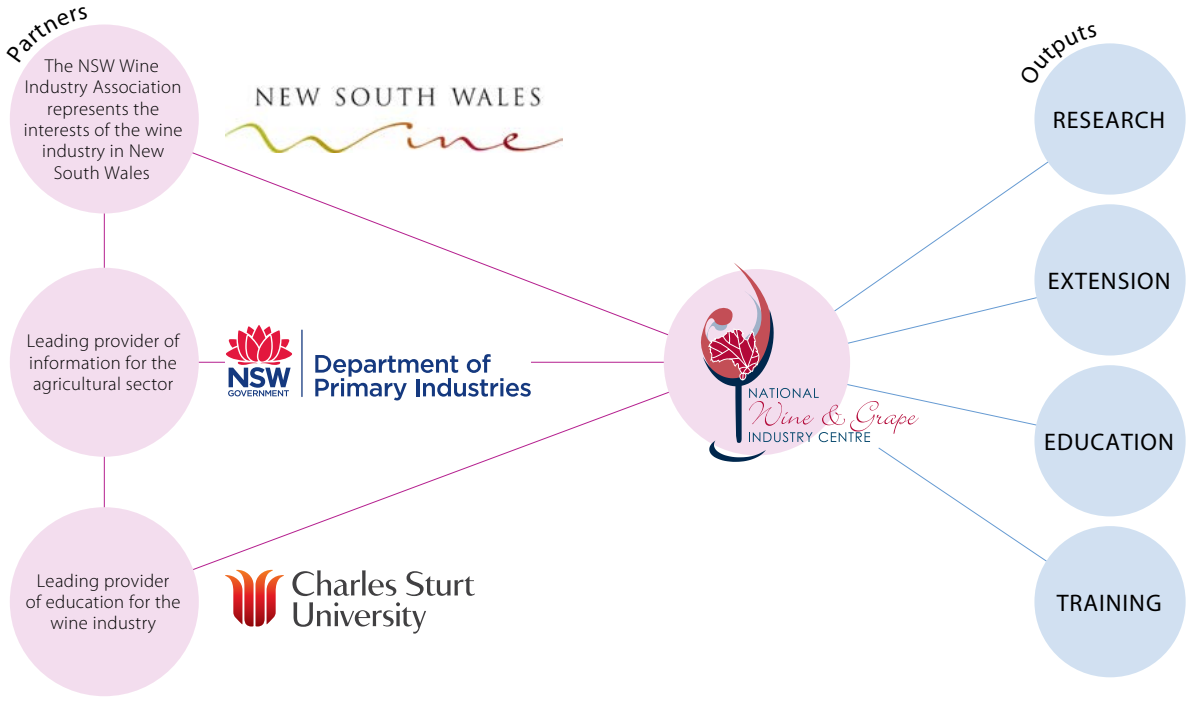
The National Wine and Grape Industry Centre delivers high value research, education, training and extension to the Australian Wine Industry.



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Acknowledgments

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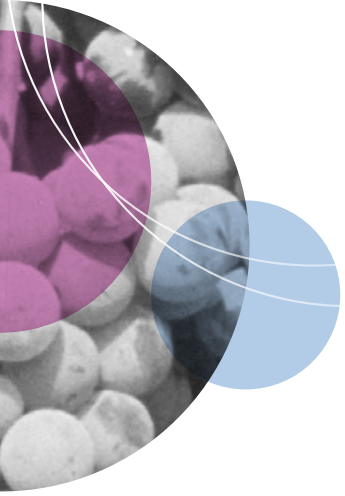

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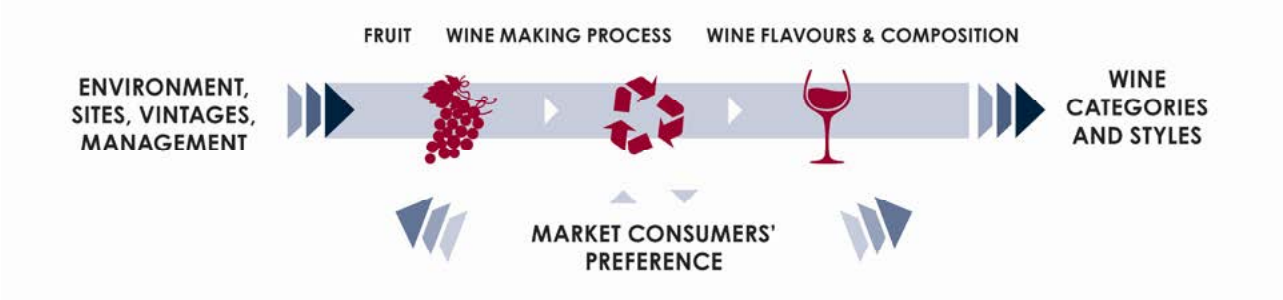

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Foreword

Driving innovation to enhance winegrape production in NSW

As the Development Officer – Viticulture (DOV), It is with great pleasure that I welcome you to the Grapevine management guide 2016–2017.

My role as DOV is primarily to support capacity building and industry growth through adopting new information and technologies that will deliver benefits to NSW winegrowers through expert advice and assistance. As you will see in this year's guide, keeping up with advances in this area is a job in itself. The developments in app[lication]s, robotics, drones and lasers are fast becoming essential tools in vineyard operations; this year's guide explores their creation and use.

The Skills Development Program continues to provide resources for industry with my colleague Adrian Englefield further expanding the weather station network with new systems now installed in Hilltops and the Southern Highlands all freely available on the AWRI website. These new systems are being bolstered with the inclusion of four new regions now contributing in our seasonal VineWatch bulletins including the Murray Valley, New England, Hilltops and Southern Highlands. This initiative now covers the majority of NSW wine regions and is well accepted by industry as the go-to reference for up-to-date information across the growing season.

Our efforts in delivering the Wine Australia regional program on behalf of industry continue this vintage with trials underway across seven sites in five regions exploring manipulation of ripening and disease management through cultural, biological and chemical means. This information will be reported directly back to industry through the Spring Vine Health Field Day workshops, which cover seven regions across the state.

With the recent finalisation of the NSW RD&E strategy 2016–21 borne out of industry-wide input at the Innovator's Forum, industry now has a clear focus and goal to meet its strategic objectives across four themed areas with specific RD&E concepts to be undertaken from these. NSW DPI will help to deliver both high quality research and extension to the state's wine industry.

The Grapevine management guide 2016–2017 is one of NSW DPI's flagship publications. Such publications are a crucial means of packaging information for producers, and as such, I recommend this current edition to you.

Feedback please

NSW DPI wants to make sure that the information we're providing is what you need to make your business grow. We would like to receive any feedback that you care to offer – good, bad or indifferent. This will help us to make future editions even more useful.

Please contact me with your suggestions by mail, phone or email.

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Future projects

Current research at NWGIC

Dr Gregory Dunn, Leader, Viticulture DPI NSW & Deputy Director, National Grape and Wine Industry Centre (Wagga Wagga)

The National Wine and Grape Industry Centre (NWGIC) at Wagga Wagga is an alliance between Charles Sturt University (CSU), DPI NSW and the NSW Wine Industry Association that conducts research in a range of projects spanning the continuum from the grapevine to the wine and on to the consumer. These projects are mainly co-funded by the Australian Grape and Wine Authority (AGWA) and often involve collaboration with other R&D providers across Australia. In addition to these research projects, post graduate students and visiting scholars conduct other smaller studies. Major research themes and current projects are:

Vine health and biosecurity

- Practical management of grapevine trunk diseases – Dr Sandra Savocchia, email: ssavocchia@csu.edu.au
- Understanding fungicide resistance in powdery and downy mildew – Dr Sandra Savocchia, email: ssavocchia@csu.edu.au
- Determining thresholds for bunch rot contamination of grapes and techniques to ameliorate associated fungal taints – Professor Chris Steel, email: csteel@csu.edu.au
- Evaluating and demonstrating new white and red disease-resistant varieties for the Riverina – Dr Bruno Holzapfel, email: bruno.holzapfel@dpi.nsw.gov.au
- Brassica biofumigation of black foot fungi in vineyard soil – Dr Melanie Weckert, email: melanie.weckert@dpi.nsw.gov.au
- Entomopathogenic fungi as potential biocontrol agents of grape phylloxera – Dr Sandra Savocchia, email: ssavocchia@csu.edu.au

Vine quality and yield

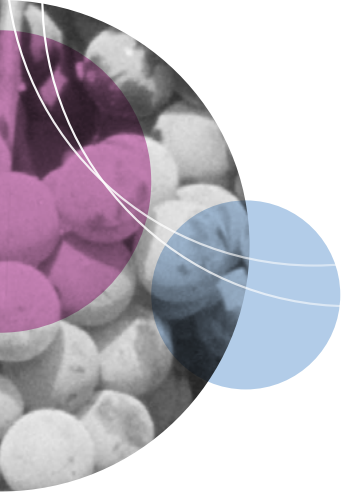
- Improved yield prediction for the Australian wine industry using real time image capture and analysis – Associate Professor Gregory Dunn, email: gregory.dunn@dpi.nsw.gov.au
- Improving industry capacity to manage yield and wine quality relationship through understanding the influence of vine carbon balance and berry composition – Dr Bruno Holzapfel, email: bruno.holzapfel@dpi.nsw.gov.au

Fruit and wine composition and style

- Fruit and wine composition and sensory profile: sequential harvest, searching for the sweet spot in Australian regions – Dr Leigh Schmidtke, email: lschmidtke@csu.edu.au
- The sugar potassium nexus within the grape berry – Dr Suzy Rogiers, email: suzy.rogiers@dpi.nsw.gov.au
- Cell death in the grape berry – Dr Suzy Rogiers, email: suzy.rogiers@dpi.nsw.gov.au
- Low alcohol wine and sequential harvest – Dr Leigh Schmidtke, email: lschmidtke@csu.edu.au
- Metal ion speciation: understanding its role in wine development and generating a tool to minimise wine spoilage – Dr Andrew Clark, email: aclark@csu.edu.au

Wine and consumers

- Objective measures of Australian sparkling wine style and quality – Professor Anthony Saliba, email: asaliba@csu.edu.au
- Characteristation of wine avoiders and how to transition avoiders to consumers – Professor Anthony Saliba, email: asaliba@csu.edu.au



Introduction

Associate Professor Greg Dunn,
NSW DPI Viticulture Research Leader

Australian farmers have a long and proud history of innovating and being early adopters of innovation. This, underpinned by world class R&D, has enabled Australian agriculture to remain at the forefront of world agriculture. Considering the unpredictable weather, periodic water shortages and ancient soils that form the basis of our agriculture, this has been no mean feat.

Society is in the midst of a technology revolution particularly, but not restricted to, communication. For instance, many industries have been revolutionised by the ability to rapidly capture, analyse and transmit images. Technological options to improve management are rapidly increasing. There is also enormous potential for robotics and synthetic biology to affect agriculture.

This issue of the *Grapevine management guide* focuses on some of the emerging technology relevant to vineyards. Among other things, the guide has a closer look at the use of unmanned aerial vehicles in vineyards, as well as the plethora of smart device apps that are appearing. The guide complements this year's Spring Vine Health workshops, which also concentrated on technology in vineyards.

I hope you enjoy reading the 2016–17 *Grapevine management guide* and find it useful.

App alert

Viticulture apps – identification and assessment

Tony Hoare, Viticulturist

App name	App Icon	Subject	updated	platform	Cost	Link
BOM		Weather + short-term forecast	Real-time	Android & iPhone	Free	http://www.bom.gov.au/app/
CliMate		Historical data, analysis, trends and forecasting	Real-time	iPhone & iPad	Free	http://www.australianclimate.net.au/
AWRI Dog book		Registered chemicals for vineyard use	regularly	Android, iPhone, iPad & iPod touch	Free	https://goo.gl/pzOfCn
MyPest-Guide Grapes		Pest identification and control options	regularly	Android, iPhone & iPad	Free	https://goo.gl/cc7PUk
PestGenie		Farm safety, chemicals and spray records	regularly	Android, iPhone, iPad & iPod touch	Subscription	https://goo.gl/zNy5WM
PMapp		Assesses powdery mildew infection levels	Last update Dec 2015	Android, iPhone, iPad & iPod touch	Free	https://www.adelaide.edu.au/news/news82342.html
Viticanopy		Vine balance assessment	Last update Oct 2015	Android under development iPhone, iPad & iPod touch	Free	https://www.adelaide.edu.au/news/news81346.html
Fit Vine		Assess vine planting material	Last update Oct 2014	iPhone, iPad & iPod touch	Free	https://itunes.apple.com/us/app/fit-vine/id928430666

Vineyard apps – current apps and their evaluation

It would seem there is an app[lication] for everything these days, and vineyards are not exempt.

Viticultural apps have been emerging over the past few years to assist growers in their daily management operations. Apps allow growers to have the convenience of being able to make vineyard management decisions or collect data using a smart phone device. Data is then in a ready-to-export format for sharing, and record keeping is easier and more accessible. The instant availability from online sources, especially specialised apps, allows growers to make decisions quickly, based on accurate and up-to-date information. Many of the best apps are available for free and others are at a low cost considering their benefits. I have road tested a few currently available apps and discuss their benefits below.

The advent of apps has made many vineyard management decisions easier through having immediate access to information and the ability to store and analyse data. The convenience is only matched by the cost of many of these apps many of which are free. I encourage you to at least trial these apps, which will not leave you out of pocket and can actually increase your bottom line. All apps evaluated can easily be downloaded at either the **Google play store** (https://goo.gl/bkNIOG) or **iTunes** (https://goo.gl/2wdv0A).

Bureau of Meterology (BOM) Weather

This new, free app is guaranteed to be a favourite of many Australian vineyards. The app has all the benefits of the old, trusty website, which was an essential planning tool for vineyard activities when trying to work around the weather. The app has allowed the information previously available on the BOM website to be even more close at hand on mobile devices. The app prompts the user to make available their current location and then provides current weather data, a six day forecast and immediate link to radar information on climate, especially impending rainfall. The app allows the user to enter multiple sites from around Australia for links to weather information by simply tapping a star icon.

CliMATE

This free app is a valuable tool for evaluating climate information historical records. It allows the user to pinpoint their geographic location and then access both historical and predictive weather information for that location. The most relevant weather parameters are available for analysis as well as seasonal trends, which is a great tool for making weather reliant management decisions, particularly regarding irrigation decisions or evaluating pest and disease pressure. The app allows the user to be an expert on local weather, which will definitely help with timing management decisions and allocating resources. With water acquisition, security, cost and availability constantly changing in relation to growing climate variability and extreme fluctuations, this app is a very useful tool for water budgeting.

Dog book

The Australian Wine Research Institute (AWRI) guide of *Registered Agrochemicals for use in Viticulture* is available as a free app. This replaces the need for the printed version released each year that advises winegrape growers of agrochemicals available for use in viticulture and their withholding periods. The app has made it easier to navigate the guide on a mobile device, which provides fast and convenient access to the information. It is important to use the update prompt to check for changes and additions to the guide during the season. The benefit of this app is that growers have the information in the palm of their hand when spraying to avoid any potential issues associated with chemical usage compliance.

MyPestGuide Grapes 1.1.

This free app is a useful tool for identifying common pest and diseases of vineyards. Although developed by the Department of Agriculture and Food, Western Australia (DAFWA), the identification component of the app is relevant to other Australian winegrape growing regions. It is user friendly, which has easy to follow prompts to identify an unknown pest or disease in vineyards. This is done by firstly identifying the damage caused to the vine or fruit and then narrowing it down to a number of pests or diseases that could be the cause. Detailed information is then available for each of the potential pests and diseases including a description, life cycle, damage, and control options. The app allows the user a greater degree of confidence in identifying a pest or disease issue for assessing economic thresholds and implementing targeted control measures, both of which will help to maximise fruit yield and quality.

PestGenie

PestGenie has been around for some time and is now available as a mobile app via subscription. It provides a database of 7 million chemicals including their labels and safety data sheets (SDS). The benefit of this is that all compliance documents for vineyard chemical users can be found in one concise site. Additional features include a crop protection expert facility to select the most appropriate disease control method, spray diary and chemical inventory.

PMapp Version 1.0.4.

This free app is designed to help collect and assess data on powdery mildew (PM) infection. It is emphasised in the app background information that it is not a decision support tool. Developed as a collaboration between the University of Adelaide and Industry and Wine Australia, the app has provided a field data collection template that replaces the need for the old-fashioned manual version. Whilst the app has the disclaimer to not be a decision support tool, it is by design a tool to assess PM incidence and severity. This app is very relevant due to the disease's widespread incidence in vineyards, and the winery thresholds for low levels of infection. Powdery mildew remains a major risk in many Australian vineyards and this app is a particularly useful tool to assess your PM prevention strategies or the incidence and severity of a PM infection. Therefore, this app will help growers to be more confident in their understanding of levels of PM damage, provide an accurate infection assessment tool for negotiating potential downgrades, and protect wineries from taking compromised fruit from the vineyard.

Viticanopy

This free app allows the user to assess vineyard balance by measuring parameters that are associated with vine balance. Vine balance has been shown to have a direct correlation to wine quality. Growers can now easily assess the parameters of vine balance, vine leaf area index, canopy porosity and canopy architecture in the field using a handheld device. This has replaced the previous assessment tools that were expensive, destructive and relied on a high degree of expertise. Now anyone can assess their vine balance information to help make decisions to about adjustments during the season to maximise fruit quality. The concept of vine balance has been based on some quantitative and some qualitative measures that require a certain level of expertise to interpret. This app allows the user to easily obtain an assessment of canopy density and quantifies the information so measured responses can be applied for ongoing assessment. This can only benefit attaining maximum fruit and wine yield and quality.

Fit Vine

The National Wine and Grape Industry Centre has developed this free app as a tool to identify and assess vine planting material. The app is a useful tool to give growers the confidence to self-assess vine planting material quality to help ensure that industry standards are observed. This not only benefits the grower but also the Australian wine industry on the whole. There is renewed enthusiasm for planting and replanting vineyards in Australia. The release of this app is well timed and should avert any potential issues with planting material quality for growers.

The Fit Vine app

A field tool for assessing grapevine planting material

Helen Waite

The last thing I expected to do when I embarked on my PhD research was to develop an app, but that is exactly what came to pass. A PhD is a voyage of discovery into the unknown that can turn up unexpected results and take some unexpected twists and turns. It was one of those unexpected turns that led ultimately to developing an app designed to help nurseries and viticulturists assess the health and fitness of grapevine planting material.

It all began in 2012 when I was invited to give two master classes in the WineSkills program in England. There had been significant issues with poor establishment and planting material failing that had seriously affected the fledgling English wine industry, and it was felt that my expertise could be of benefit to UK viticulturists. The master classes took the form of introductory talks and discussions, followed by practical workshops where the participants dissected sample vines and completed a guided evaluation of all aspects of vine quality. On both occasions, the participants commented on how much they had learned and how enjoyable helpful the master classes had been.

Back in Australia I also knew that although nurseries and viticulturists are very aware of how graft transmitted viruses affect the health of planting material, awareness of other equally important aspects of vine health and quality is low. This is most likely because young vines can appear strong and healthy at first glance. However, serious trunk diseases can also be transmitted in apparently symptomless planting material. These diseases severely debilitate young vines causing vine failure and poor establishment resulting in increased costs, delayed cropping and unproductive vineyards. Trunk diseases transmitted in infected planting material are also the main cause of the syndrome known as 'young vine decline' in the vines that survive. Other defects such as poorly-healed graft unions and weak root systems can also significantly affect the establishment and survival of young vines, increase their susceptibility to stress and reduce grape yield and quality.

Clearly it is better to not plant compromised vines, but the lack of data detailing the affects from poor vine establishment and performance on vineyard productivity has meant that many people do not regard vine quality as important.

How then to raise awareness of the importance of quality planting material and the attributes that differentiate good and poor material?

I knew that master class workshops would not reach most of the people who would find them useful. The information needed to be presented in a format that could be used without support, was readily accessible and easy to use in the field.

With the help of Ken Appleby who very generously donated his IT expertise to the project, I used the check list I had developed for the master classes in England as the starting point to construct a vine quality calculator in Excel spread sheet format. The calculator assesses all aspects of vine quality including internal and external features of young vines and accompanying documentation. It also included descriptions and explanations of the characteristics of good and poor vines. We christened the spread sheet Fit Vine because it calculates the fitness of planting material as a means of gauging vine quality and thus their capacity to establish and create healthy, productive and long lived vineyards.

We sent the Fit Vine spreadsheet to a variety of people who tested it and gave us feedback that helped us refine it and improve its functionality and accuracy. Once we were satisfied that it was the best we could make it, we made it available as a free download from the NWGIC web site. Nevertheless, it was a relatively unsophisticated tool and was not well suited to use in the field.

To make it a more useful and user friendly tool, Fit Vine needed to be in a more sophisticated format and easily accessed for use in the field when vines are delivered just before planting. This was where the app concept came in. Almost everybody owns a mobile phone or iPad and although reception in rural areas can be erratic, I felt that if Fit Vine could be turned into an app for mobile devices, it would be much more accessible and useful.

The next challenge was how to fund the app's development. After trying the usual sources open to researchers without success, Professor Alain Deloire, the (former) director of the National Wine and Grape Industry Centre at Charles Sturt University, Wagga Wagga, very generously agreed to fund its development.

Thus began my relationship with an app production company. Think mature aged scientist and young gun app developer. It could have been a recipe for disaster, but was a very happy and productive working relationship, that, after a modicum of hard work and a lot of fun, resulted in the publication of the Fit Vine app.

Because it was designed to be used in the field, we had to make the app self explanatory. That meant presenting the vine assessment as a series of illustrated weighted yes/no questions and providing directions for the sequential dissection of sample vines. At the suggestion of Brandon the app developer, we decided to make a short one minute video showing the sequence of steps in vine dissection. That meant writing the script and filming it on my iPhone so that it could be turned into the animation that is part of the app. I also had to find photographs to illustrate the assessment criteria. I had a reasonably good collection that covered most of the defects seen in young vines and only had to take a few more.

Finally the app was ready. Brandon sent me a test copy that I used to assess a real batch of vines, and once we had ironed out a few minor issues it was ready to go live to industry around the world via the Apple store. There are versions for iPhones and iPads and it is free to download. Industry feedback so far has been positive, but as with all new concepts, if the resources became available, there are some minor changes I would make to improve the function of the app, such as having a separate evaluation for vines on own-roots. There is also a facility for feedback from users under the section 'How to use this app'.

Developing the app was a lot of fun. I learned some new IT skills and Brandon learned something about grapevines.

Smartphone app to assess berry and bunch characteristics

Dr Suzy Rogiers, Principal Research Scientist, NSW DPI Wagga Wagga

Grape growers are facing challenges in optimising yield and harvest dates due to hotter, drier seasons compressing harvests. Having real-time access to data on the following characteristics will help growers and winemakers to make better decisions during harvest:

- berry volume
- berry dehydration (yield loss)
- bunch and vineyard variability
- white grape berry skin colour.

A team at Charles Sturt University's National Wine and Grape Industry Centre (NWGIC) led by Professor Alain Deloire is developing an android, smartphone-based, real-time imaging tool to help growers make decisions related to harvest.

Figure 2: Prototype app running on android phone. After an image is taken in the vineyard, the app calculates berry volume and provides information on the number of berries per size category.

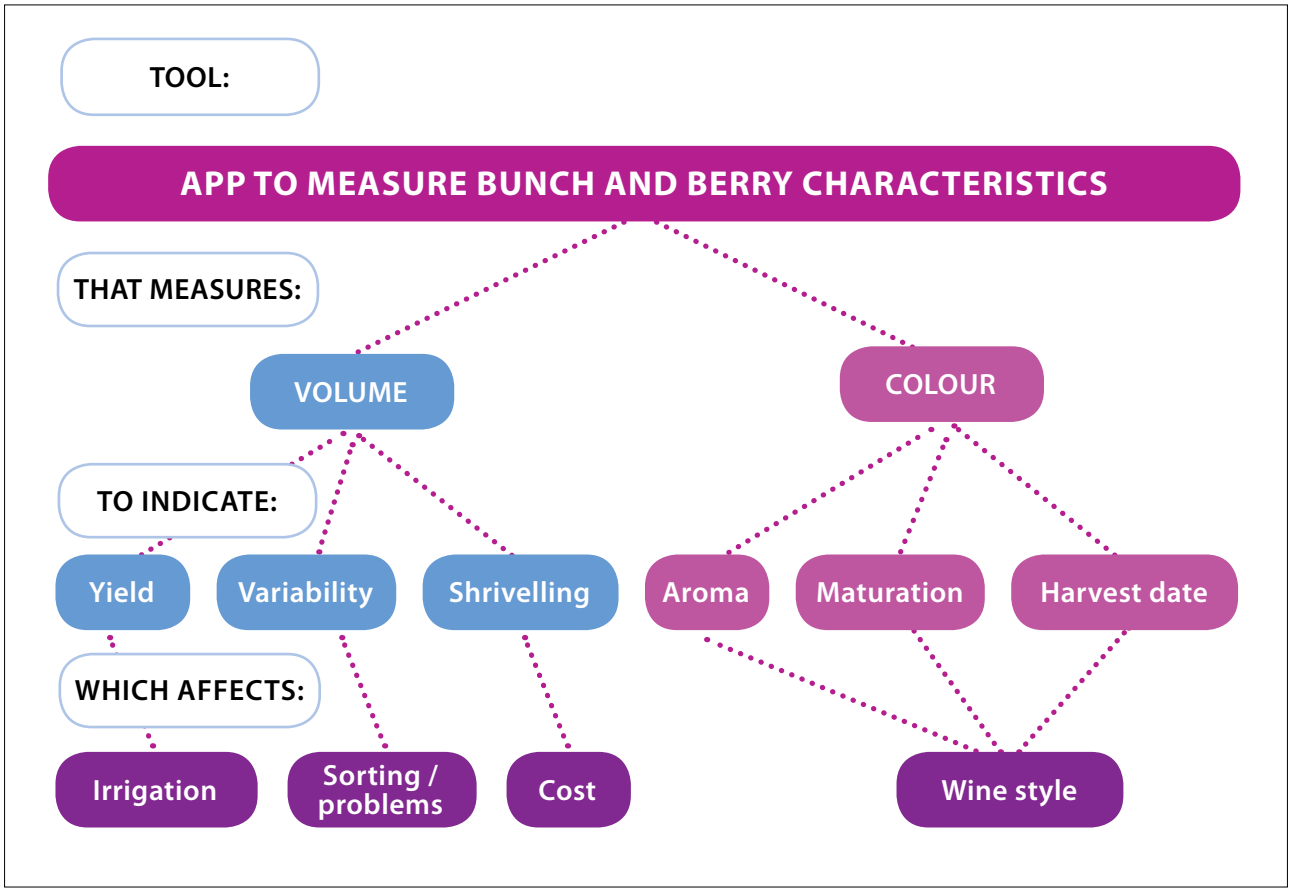


Figure 1: Overview of the app's functions and relevance to the wine industry

To use the app, a grower or winemaker takes a photo of grape bunches in the vineyard. The app will then calculate berry size and assess berry colour against a standard. Information will be provided on potential yield, the range of berry volume classes on any particular date and the extent of variability within a bunch and across the vineyard. The app will also provide information on the onset and extent of berry shrivel within the block. Together with other indicators, the information can be used to make decisions on irrigation, cultural practices when appropriate (e.g. canopy manipulation), the requirement for sorting in the winery and the optimal time to harvest particular wine styles.

Berry colour is a new and important indicator, notably for white variety ripening, because a relationship exists between berry skin colour and the berry's aromatic potential, mainly pyrazines versus thiols. In conjunction with other indicators, berry colour has the potential to be very useful for profiling berry maturation and selecting the most appropriate harvest dates for specific white cultivars.

Industry involvement

Professor Lisa Given at Charles Sturt has been leading user-focused trials of the initial app prototype (Version 1). Focus group discussions have been held with grape growers and winemakers in NSW and ACT to explore the app's functionality and visual design. This research is part of a Linkage Grant funded by the Australian Research Council with 11 wine industry partners, including Wine Australia and the Australian Wine Research Institute.

Future work (January to April 2017)

- Calibration in the vineyard of the V1 prototype app in collaboration with selected or volunteer wine industry partners
- Improvement of V1 according to user needs and practical interest
- Testing of users' experiences with the system, to ensure simple and robust operation.

The app is scheduled for release in 2018.

Acknowledgments

The project brings together expertise from Charles Sturt University's Intelligent Analytics & Sensing (IAS) Research Group and CM3, a research unit in Machine Learning and Machine Vision.

This project is funded by Wine Australia, NWGIC, CM3 and an ARC Linkage Grant on Information Seeking & Research Adoption in the Wine Industry

Further reading

Deloire A. 2012. New method to determine optimal ripeness for different white wine styles. *Practical Winery and Vineyard Journal*. Fall 2012, pp. 2–5.

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Dr Leigh Schmidtke: lschmidtke@csu.edu.au

Prof. Lisa Given: lgiven@csu.edu.au

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New tools of the trade

Rapid determination of grapevine nutrient and reserve status

Bruno Holzapfe[1,3], **Jason Smith**[4] **and Leigh Schmidtke**[1,2]

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[2] School of Agricultural and Wine Sciences, Charles Sturt University Wagga Wagga, Australia

[3] New South Wales Department of Primary Industries, Wagga Wagga, Australia

[4] Hochschule Geisenheim University, Germany

Why do we assess?

The ability to rapidly measure grapevine nutrient and carbohydrate status is important for making informed and timely decisions on vineyard input requirements. Assessing grapevine nutrient status is critical for verifying whether fertiliser is required and then if the application was effective.

It is recommended that about 100 petioles are collected from a vineyard or a management unit from the opposite leaves of basal bunches at flowering (50% cap fall). The analytical nutrient results are compared with recommended standard ranges. The interpretation of mineral nutrient concentrations reflects the relationship between mineral nutrient content in petioles at that time and vine performance.

Determining petiole nitrogen (N) at veraison provides a reasonable prediction of final yeast assimilable nitrogen (YAN) levels at harvest and can provide an opportunity for adjustments to post-veraison vineyard fertiliser programs. This approach is aimed at optimising YAN levels at harvest, as a strong correlation between veraison petiole and harvest juice N has been observed. The measurements of petiole N at flowing relate more to vine productivity, while the measurements at veraison relate to grape composition, with both providing information about vineyard fertiliser management.

Rapidly assessing N and carbohydrate reserves in the perennial structure of vines can also support making more informed vineyard management decisions. As early N demand in spring cannot be met by root uptake alone, stored N reserves before dormancy are required to support shoot growth in the following season. Similarly, grapevines use stored carbohydrates from the perennial tissues to support new root and shoot growth in spring. These carbohydrates are stored as starch and as free sugars, with the total concentrations and amounts varying within and between growing seasons, size and age of grapevines and between the perennial parts (Figure 1).

The total amount of carbohydrate reserves stored by dormant grapevines ranges between 0.52 kg/vine and 2.2 kg/vine. Commonly, 50% or more is stored in the root system. Generally up to half of the total stored carbohydrates and N are mobilised in spring to support initial shoot growth and canopy development, with the maximum allocation of carbohydrates to shoots reached at the 8–10 leaf stage. These carbohydrate and N reserves are usually refilled at the end of the growing season or earlier through assimilated production (leaves) and nutrient uptake (roots). The cropping level will determine the replenishment required after harvest.

Knowing the perennial reserves at harvest can help manage them after harvest to an appropriate level, by ensuring a functional canopy and N application to elevate both N and starch if necessary. In cooler climates without an effective replenishment period after harvest, more appropriate yield levels need to be achieved so that the carbohydrate levels at harvest are sufficient for the next season. N reserves that might be insufficient in winter and N application might be considered in spring. Reserves measured during dormancy would provide information on carbohydrate and N status for the following season. Common methods to determine nutrient and reserves status are costly

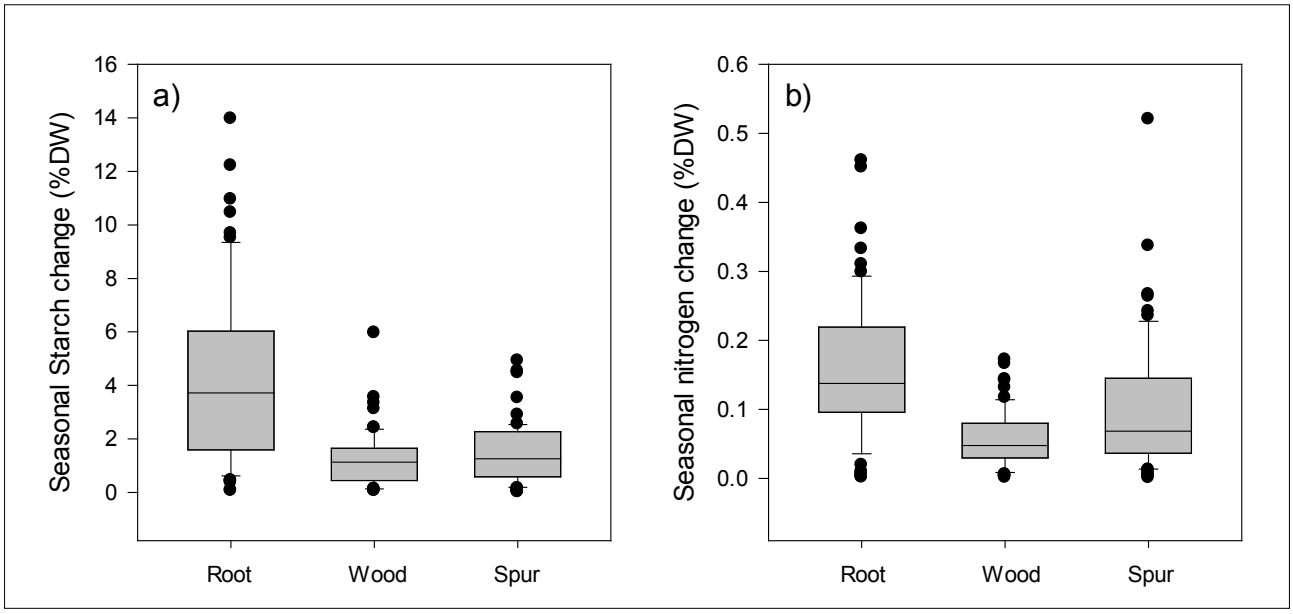

Figure 1. Magnitude of inter-seasonal changes in over-wintering starch (a) and N concentrations (b) in various grape tissues.

and often too slow for timely adjustments to nutrient application and vineyard management – therefore more rapid assessments are required.

How it works

Samples of grapevine trunk wood or petioles are collected and dried before being finely ground to a powder. A small sample of the powder is placed onto the sample measuring diamond or crystal of an attenuated total reflectance Fourier transform infrared spectrometer (ATR-FTIR). The measurement with an ATR-FTIR analyser is taken by shining an infrared light through a series of mirrors so that the laser is reflected onto the surface of the powder. The laser penetrates the powder and chemical bonds in the powdered sample absorb a small amount of the laser light at very specific wavelengths that depends on the sample composition. A comparison of the amount of laser light that is directed onto the sample and the quantity of light that is reflected back to a detector via a series of mirrors is used to quantify the light absorbed by the sample. This provides an infrared spectra of the sample between wavelengths 2,500–25,000 nm or wave number 4000–400 cm^{-1}, which is sometimes referred to as a spectral fingerprint (Figure 2). Each sample can be measured in about 60 seconds once placed onto the ATR surface and can provide a rapid and reasonably accurate tool for measuring grapevine nutritional status. The development of robust and useful calibrations for routine use requires the Infrared spectra of the sample and the composition of the analyte of interest to be simultaneously measured for several hundred or thousand samples. By using multivariate regression and machine-learning algorithms the amount of light absorbed by the sample can be related to the composition of the sample.

Does it work?

Relating a spectral fingerprint of a sample to the composition of the sample is relatively straight forward, but can be prone to errors. Such errors arise from:

- interference of the non-uniform distribution and sized particles of sample that absorb and reflect light differently
- instrumental variations caused by changes in temperature and humidity
- lack of sensitivity i.e. the compounds that we are interested in might not actually absorb enough light at the wavelengths that we are using to ensure accurate calibration.

This is especially true if the compounds we are trying to measure are inorganic molecules such as those in petiole analysis. Instrumental calibration drift can occur over time as seasonal variations in samples can also affect the accuracy of the method.

Finally, calibration errors arising from the traditional methods of analysis are also a part of the mathematical relationships used to correlate the infrared fingerprint to sample composition. If the traditional method used to determine the concentration of a compound has large analytical errors, an infrared spectral correlation of this method will also have the additive errors of the analytical technique and those errors associated with the infrared method briefly described above.

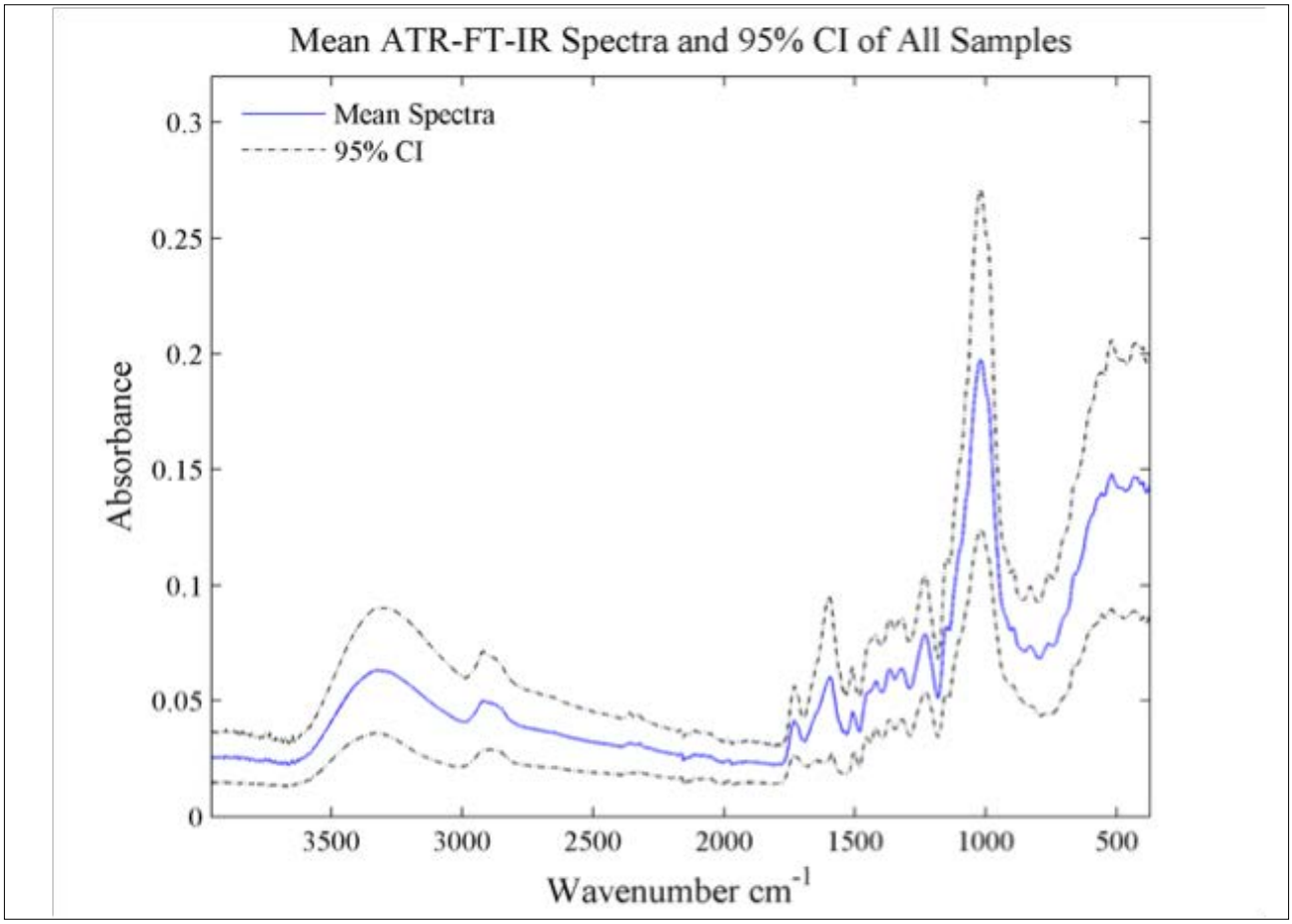

Figure 2. Infrared spectral properties of the sample are based on organic bonds (eg. C-H, dipole), the typical wavelength for mid infrared is 2,500–25,000 nm or wave number 4000–400 cm^{-1}.

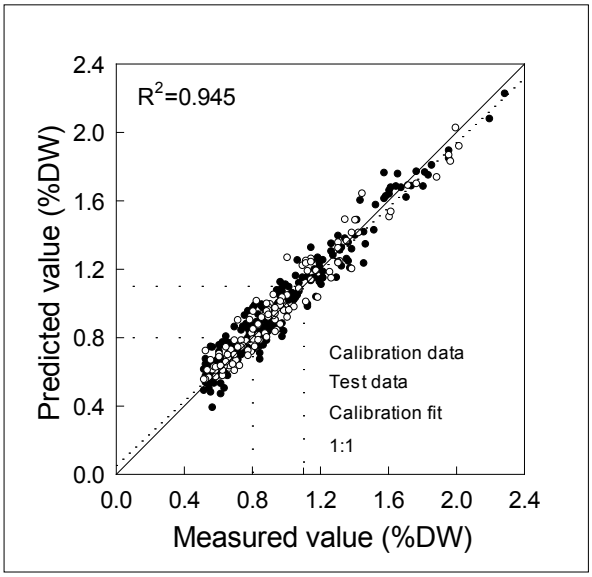

Figure 3. Regression plot for the prediction of petiole N by infrared spectroscopy, the adequate concentration is 0.8–1.1 (%DM) for this macronutrient.

So, to judge how well using infrared measures on sample composition can be used to make decisions for vineyard management, it is useful to consider what analytical level or value of measurement is required to make those decisions that affect vine performance. In measuring petiole samples for macronutrients, the analytical range in which a management decision should be made to correct a nutrient deficiency is well within the limits of precision for the infrared measurement. Figure 3 clearly shows the suggested values for vine management and the calibration performance of the infrared spectral regressions. It is more difficult to make such a judgement when measuring the level of vine wood non-structural carbohydrates and N, rather the nutrient concentrations of petioles. This is not due to poorly correlated calibration algorithms or poorly suited samples for this type of measurement, but rather there are insufficient levels of information on how to relate vine starch and N to overall plant performance.

Recent research (Smith & Holzapfel 2009; Holzapfel & Smith 2012) shows the importance of winter carbohydrate levels for early canopy development and vine productivity. In addition, starch and N varied considerably between vineyards and seasons, which opens up the opportunity to develop

standards for the carbohydrate and N reserve status. This approach will help to optimise vineyard management, together with more frequent macro nutrient assessment of petiole levels, to enhance vine performance and grape composition.

References and further reading

Holzapfel, B. & Treeby, M. (2013). Vineyard and winery indicators of Shiraz must fermentation behaviour. *Vitis 52*, 97–104.

Holzapfel, B.P. & Smith, J.P. (2012). Developmental stage and climatic factors impact more on carbohydrate reserve dynamics of Shiraz than cultural practice. *American Journal of Enology and Viticulture* 63, 333–342.

Holzapfel, B.P., Smith, J.P., Field, S.K. & Hardie, W.J. (2010). Dynamics of Carbohydrate Reserves in Cultivated Grapevines. *Horticultural Reviews* 36, 143–211.

Schmidtke, L.M., Smith, J.P., Müller, M.C. & Holzapfel, B. (2012). Rapid Monitoring of grapevine reserves using ATR-FT-IR and chemometrics. *Analytica Chimica Acta* 732, 16–26.

Smith, J., Quirk, L., Müller, M., Schmidtke, L. & Holzapfel, B. (2011). Variation in starch and nitrogen reserve storage by grapevines and measurement by ATR-FT-IR spectroscopy. Proceedings of the XVIIth International Symposium GiESCO, Asti – Alba, Italy, August 29 – September 2, 263–266.

Smith, J.P. & Holzapfel, B.P. (2009). Cumulative response of grapevine (Vitis vinifera L.) to late season perturbation of carbohydrate reserve status. *American Journal of Enology and Viticulture* 60, 461–470.

Smith, J.P., Schmidtke, L.M., Müller, M.C. and Holzapfel, B. P. (2014). Measurement of macronutrient concentrations in grapevine petioles by ATR-FT-IR spectroscopy. *Australian Journal of Grape and Wine Research* 20, 299–309.

Using remotely piloted aircraft for vineyard management

Amy Steiger, GIS Manager for the Cardno South Coast office

Remotely piloted aircraft systems (RPAS), also known as an unmanned aerial vehicle (UAV), unmanned aircraft system (UAS) or drones, are revolutionising critical data capture, offering aerial mapping solutions that are fast, accurate, and inexpensive. They can be a crucial business tool to provide cost-effective and accurate data for vineyard management.

This technology is particularly applicable to winemakers and grape growers, collecting valuable information that can be compared year after year, which helps with decision making about crop management. Key applications include identifying variations in plant health or plant stress, smarter planning for irrigation, fertiliser and pesticide delivery, as well as being able to track plant density and distribution.

There are two platform types for remotely piloted aircraft: fixed wing or multi-rotor aircraft. They each have their own advantages and limitations and the results required will determine the best platform for the job at hand. A multi-rotor UAV only needs a small area for take-off and landing, can hover and usually has the ability to capture video footage. Fixed wing UAVs are often lighter, can cover large areas quickly and are ideal for aerial mapping.

Cardno is global company, certified in Australia by the Civil Aviation Safety Authority (CASA) to provide aerial surveying services for commercial projects. Operations are also offered in New Zealand and the United States. Our pilots are surveyors and spatial analysts who undertake field capture and data interpretation. Fresh advances in aerial technologies allow unique multi-sensor flight packages that greatly increase efficiency; completing what used to take days in the field with a single flight mission.

The primary platform our pilots use is the Sensefly eBee, which is a fixed wing aircraft. The eBee can be completely autonomous and is designed as an aerial mapping tool, providing high quality and detailed outputs. Additional environmental

Figure 1. Drone type EBEE RTK ready for take off.

sensors such as thermal, near infrared (NIR), red edge and multi-spectral can be integrated into this single, fixed wing platform for optimum utility.

Capturing data with a multi-spectral or near infrared camera gives insight into crop health beyond what is visible to the eye, such as vine development and stress analysis. These different sensors can help to identify diverse factors influencing the growth potential of vineyards and can help to tailor actions to optimise overall productivity and yield .

Acquiring information from a plane or satellite is often referred to as remote sensing. Remote sensing can provide insights for harvesting, planning and site/crop management such as:

- the early stages of growth
- identifying targeted soil sample locations
- recommended vine spacing
- evaluating plant health and potential crop yields.

The key benefits from using RPAS for vineyard management include:

- Rapid deployment – reduced time and cost to collect valuable field datasets, ability to capture current information and cover large areas quickly that may be remote or rugged.
- Efficiency of cost – increased efficiency through streamlined inspections, planning for irrigation, fertiliser distribution and pest control.
- New visibility – ability to obtain a bird's eye view to help understand key trends and relationships, and monitor changes through time.

Cardno has been a certified operator in Australia since September 2014 focusing primarily on surveying, but more recently expanding into aerial photo interpretation and remote sensing. We take a holistic approach to RPAS through integrating GIS, remote sensing and surveys to provide clients with a complete and precise aerial mapping service. We are able to provide detailed interpretation of the results to assist growers and winemakers improve crop quality and yield.

The demand for remote sensing services is growing rapidly as more clients seek the ease and relative safety of remote observation. RPAS allow service providers to pursue advanced efficiencies and streamline operations to lower costs and reinforce client satisfaction.

About the author: Amy Steiger is the GIS Manager for the Cardno South Coast office and has been a UAV pilot since 2014. Amy has worked as a consultant in spatial sciences, environmental and scientific consulting for almost 10 years.

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Key functions of PHDS include:

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New online tool to identify best rootstocks

Based on recent research, Wine Australia has released a free online tool to help winegrape growers determine the rootstocks that will best suit their vineyard.

The **Grapevine Rootstock Selector** takes the user through a series of questions about their vineyard:

- How would you describe your region's climate?
- During a drought, how much irrigation water are you likely to have?
- What is your desired level of vine vigour?
- What is the salt content of your soil?
- How does the soil drain at your site?
- What is the pH of your soil?
- Do you need rootknot nematode-tolerant rootstocks?

that allow growers to identify a small number of appropriate rootstocks (Figure 1).

The Grapevine Rootstock Selector brings together knowledge from Australian and international research about the specific characteristics of different rootstocks and is based on a tool first developed in 2002 by Yalumba Nursery.

Wine Australia developed the Grapevine Rootstock Selector in conjunction with Nick Dry of Yalumba Nursery, and Dr Rob Walker and Peter Clingleffer of CSIRO. It draws on published, peer-reviewed research by respected Australian and international research organisations on how the rootstocks perform.

Wine Australia General Manager Research, Development and Extension Dr Liz Waters said the tool helps to share the insights gained from rootstock research in a simple format.

'This work distils the comprehensive research in this area into a useable tool that allows grape growers to choose specific rootstocks suited to their individual vineyard's conditions', Dr Waters said.

'The tool provides growers with research-backed information before they talk to their local nursery about different rootstocks.

'Planting rootstocks is an excellent way to manage known risks to vine health and supports long-term vineyard sustainability. Research has shown that certain rootstocks have the potential to help improve resilience and efficiency in the vineyard, for example, some are highly suited to low-water environments.

'The Grapevine Rootstock Selector has gathered the relevant research literature into one place, to help growers who may be considering rootstocks to see what might be the best options for their vineyard.

The criteria used in the Grapevine Rootstock Selector were selected as they confer directly to important information about the planting site. The rootstock attributes are supported by published research, but have not been weighted. That is to say, if one reference or ten references support the presence of an attribute, the Grapevine Rootstock Selector will pick them the same.

Selecting appropriate rootstock is critical for success in your vineyard (see the article: A field tool for assessing grapevine planting materials page 7).

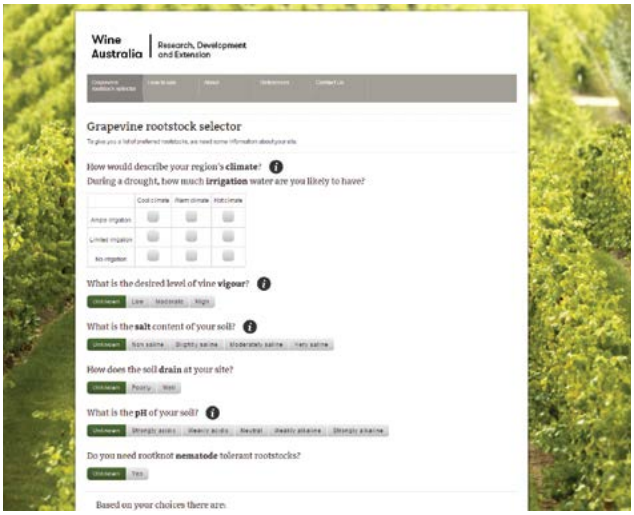

Figure 1. A screen shot of the rootstock selector website.

Satellite and drones for water and nitrogen decisions

Author: Toni Somes

Innovative growers could soon be using data from drones and satellites to make better-informed farm-management decisions as the technology becomes increasingly more affordable and refined for agriculture.

GRDC-funded research by Deakin University's Centre for Regional and Rural Futures (CeRRF) has been investigating drones and satellite technology for monitoring crop performance to improve nitrogen use and water management decisions.

Irrigation engineer Dr John Hornbuckle, who has led the research, says advances in aerial data collection, combined with software improvements and satellite accessibility, meant there was now an unprecedented level and depth of information available for use on-farm.

'Information collected from drone and satellite-based platforms can now be used to gain new insights into the effects of water and nitrogen management on plant growth,' Dr Hornbuckle says. 'From there growers can develop strategies to maximise yields across the farm, based on analysing the best and worst-performing areas.'

Speaking at a recent GRDC Update in southern New South Wales, Dr Hornbuckle said the automation and simplification of data collection from drones and satellites was increasing the uptake of the technology by growers.

'In the past 18 months, there has been a significant increase in the use of drones globally and this has been driving innovation including the collection of high-resolution agricultural data. Additionally, new satellite data from the recently launched Sentinel 2 satellite, which incorporates a range of (lightwave) bands more suited to monitoring canopy nitrogen content, namely red edge bands, has become freely available across Australia.

Figure 1. Associate Professor John Hornbuckle believes data collected via drones and satellite platforms has the capacity to improve on-farm cropping decisions. PHOTO: Cox Inall Communications

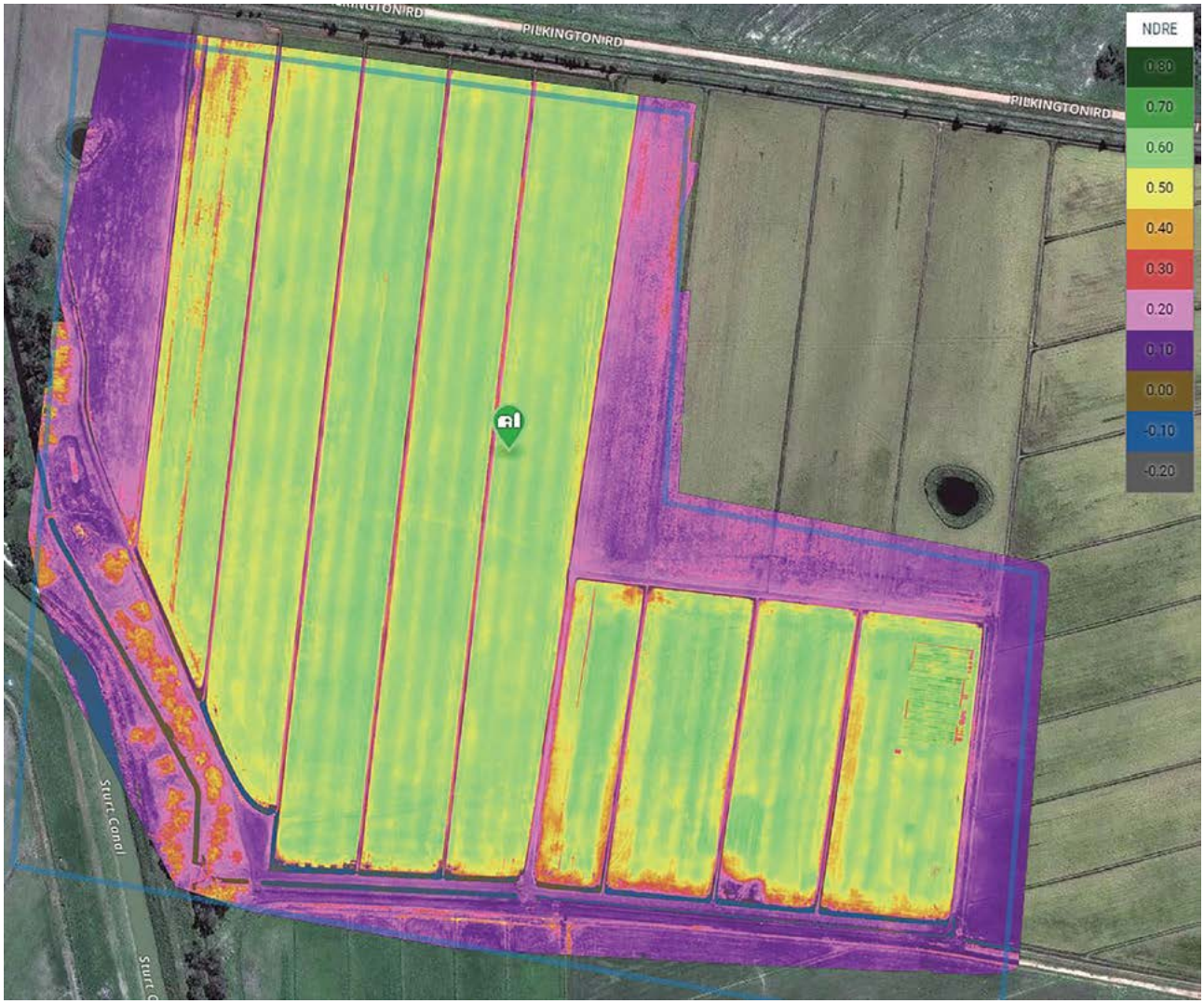

Figure 2. High-resolution multispectral drone data, in this case NDRE, shows the impact of non-uniform top-dress spreading. The non-uniform spreading pattern can be seen running up and down the bays. IMAGE: John Hornbuckle

'These two rapidly changing monitoring platforms offer the potential for grain growers to gain insights into their crops' performance, which had previously been unavailable for everyday growers.'

Drone data

Dr Hornbuckle says low-cost, drone-based platforms have taken off worldwide, with global drone companies releasing drones suited to agricultural monitoring costing under $2000. He says this is coupled with advances in developing apps, which allowed fully automated drone flights to collect very high-resolution aerial data (sub 5-centimetre pixels) and process the information.

Drones kitted out with multi-spectral and thermal cameras are now collecting aerial data, such as normalised difference vegetation index (NDVI) and/or normalised difference red edge (NDRE) data, which has proved useful in monitoring variability issues associated with water and nitrogen in crops.

Satellite data

Dr Hornbuckle says freely available satellite data from the Landsat and Sentinel platforms also collected multi-spectral data, which could be used for irrigation water management when combined with on-ground weather station networks.

IrriSAT, developed by Dr Hornbuckle and research partners CSIRO and the New South Wales Department of Primary Industries, with funding from the Cotton Research and Development Corporation, is now available as a cloud-based app using Google Earth to provide irrigators with water management information to help with irrigation scheduling and crop productivity benchmarking.

The IrriSAT app provides access to IrriSAT crop water use data, which, coupled with weather and crop water use forecasts, can enable irrigators to track their soil-moisture deficit and better manage irrigation schedules, as well as identify and investigate water use differences within and between paddocks.

Using drones for nitrogen management

'One of the major advantages of using a low-cost drone platform is the ability to take images when you want. You don't have to wait for a scheduled plane flight or a satellite overpass,' Dr Hornbuckle says.

'If you want an image before, during or after an irrigation, you can collect this data on the spot. The second major advantage is the high resolution of these images compared with traditional satellite or plane-based platforms. In contrast to traditional free satellite images, which generally are low resolution, drone-based data is generally around 5 to 10cm, allowing individual plant data to be collected, (with) potential benefits for identifying weeds and allowing impacts of events such as soil compaction from wet harvests to be seen in collected images. Additionally, cloud cover does not obscure image capture, which is sometimes an issue with satellite imagery.'

Using satellite data for water management decisions

Dr Hornbuckle says decisions on irrigation scheduling were well suited to more coarse-resolution satellite data, as generally irrigation systems in broadacre production systems were unable to deliver variable water requirements at an individual plant level.

'IrriSAT automatically combines both satellite data and on-ground weather station data and provides this information back to growers through a cloud-based interface,' he says.

'This information is automatically updated daily and provides daily crop water use information to growers, which can be used for irrigation scheduling and tracking total crop water use across a growing season.'

More information:

John Hornbuckle, Centre for Regional and Rural Futures, Griffith, 0429 862 920, j.hornbuckle@deakin.edu.au

Acknowledgement: Reproduced from GRDC's GroundCover™ Newspaper, Issue 125 – Northern Region, p43 (Writer: Toni Somes).

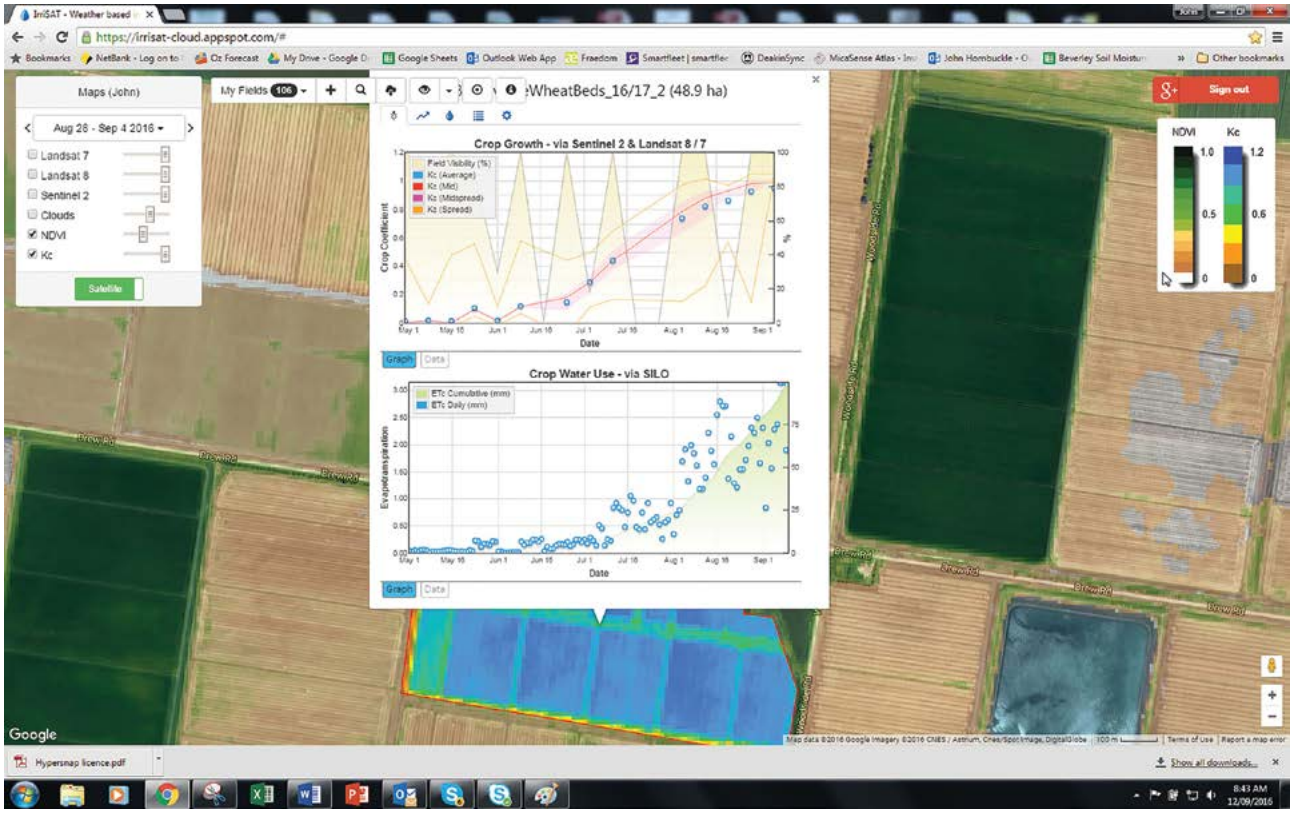

Figure 3. IrriSAT showing crop water use variability across bays in a field and total field water use. IMAGE: John Hornbuckle

Case study: Automated lasers for bird control – Summerhill Road Vineyard

Anthony McDougall, Summerhill Road Vineyard, Bungendore, Australia

Product: Agrilaser Autonomic

Reason: Grape damage due to birds

In use since: March 2016

Summerhill Road Vineyard is located within the Canberra district. We grow Riesling, Sauvignon Blanc, Merlot and Pinot Noir grapes. The vineyard was planted in 1996 and we took over the vineyard three years ago.

This was part of a dream to transition from my current role as an IT architect to realise my passion for wine and country living. As with all transitions I have tried to apply my existing knowledge in developing technology solutions and connecting this with what I am learning through viticulture studies at CSU and the day-to-day running of our vineyard, this is what resulted in my trialling lasers as an alternative to netting.

Our vineyard is planted over a relatively small area – 8 acres – making protecting grapes from birds a critical requirement to ensure the quality of grapes and achieve a high yield. Birds, such as starlings, cockatoos, currawong, crows, rosellas and wattlebirds, damage the grapes. Without any bird control, this can lead to a significant reduction of crops (1–2 tonne per week) and increased risk of disease (reducing the quality of the fruit).

Historically, birds have been controlled with netting. The vineyard was 100% netted as lower cost options such as using gas guns are not practical given the vineyard is situated close to neighbours, including a number of horse farms, resulting in approximately $4,000 in annual labour costs. The nets that we inherited are 15–20 years old, full of holes and degraded from sun damage. The result is that I am faced with needing to replace the nets at an estimated cost of $20 k, depending on the density of the nets, or finding an alternative.

It was at this point I decided I would start with replacing a portion of the nets to maintain the vineyard, and look for a better long-term solution. My first attempt was using drones and bird humming wire, which were somewhat successful. However, the drone is required to be under the control of a person (even when running via GPS waypoints) and so requires a commitment to fly regularly to deter the birds. This was fun in the initial stages, but when the drone happened to decide it was time to descend rapidly (aka crash), I realised a replacement for nets needed to be robust and reliable. This ruled drones out as a viable option in the short term.

Partway through the 2016 vintage, a colleague of mine with whom I had been talking about the issues with bird control and my trials with drones, sent me a link to new laser technology (Figure 1) that was developed out of the Netherlands for controlling birds in airports. It had been adapted to agriculture and used successful in blueberry farms and getting some significant traction in Europe and America. It had undergone trials in similar environments, but as it hadn't been deployed in a commercial sense in a vineyard it was a world first and exciting to work with a cutting-edge technology.

Figure 1. Mounted Agrilaser ready for positioning in any outdoor situation.

How does the technology work?

The principal behind the technology is based on using a high-powered laser that the birds perceive as a large stick. The birds perceive the laser in the canopy as a physical threat and treat the area as unsafe. The laser is combined with a heavy-duty pivot and tilt security camera and software for programing the unit so that it has continuous movement throughout the controlled area.

The unit is programmed by setting waypoints and times when the program should be active. This way, the laser can be directed to the areas where it is required and avoid shining outside the area to be controlled. As it is automated, it is able to repel birds whenever required which, in a vineyard environment, is from just before the sun rises until soon after sunset (Figure 2).

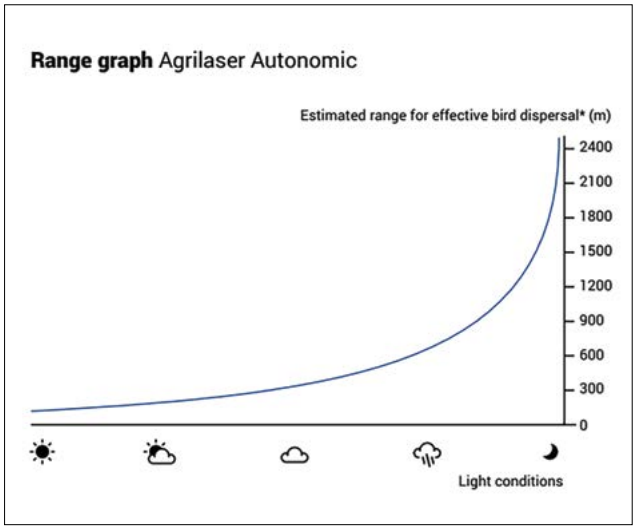

Figure 2. The graph highlights the effective range of the Agrilaser under different light conditions.

The laser is able to repel birds from a range of approximately 300 m to 2.5 km, depending on the time of day and the terrain. Based on the area of a circle, this is able to protect and area upwards of 28 ha.

Trial details

The trial was conducted in the last five weeks of our vintage – from early March until the start of April 2016.

The reason why it was such a late trial is that the Agrilaser Autonomic hadn't been previously used in Australia and I wasn't aware of the technology until February. So after a few emails to the manufacturer and the local reseller that had been doing lots of work with airports, I was able to have a unit delivered from the Netherlands to run a trial before completing our harvest.

We completed the initial setup (Figure 3.) in a few hours, including programming, to protect our Sauvignon Blanc and Merlot blocks. After setting up the Agrilaser Autonomic, the bird reduction was obvious, even after only a few days. The reduction continued over the following weeks.

Figure 3. Setting up the Agrilaser in a mounted position for greater coverage.

After 2–3 weeks, the birds simply wouldn't nest in any of the surrounding trees and spent very little time in the vineyard. Based on my observation, one of the key reasons that the laser is effective not only in the immediate area of the vineyard, is because it can be directed to the surrounding trees, ensuring the birds no longer sit in the trees to plan an attack, or build up a large flock capable of causing significant damage to the vineyard (Figure 4.). It was interesting to watch how the laser affected the flocks of starlings that would spend time in and around the vineyard. Initially they shifted from using the trees as a launching point to using a grassed area next to the vineyard. I adjusted the waypoints in the laser to include the grassed area and within a few days the flock never returned.

Figure 4. Agrilaser at work in the vineyard.

In relation to a reduction in bird activity, it wasn't a 100% control of all birds. Based on my observation and review using some time-lapse cameras and general observation, it appeared to be around an 80–90% reduction in birds. It also seemed that the birds that still visited the vineyard were in small numbers of 5–10 and appeared to be scout birds rather than a large flock capable of doing significant damage.

The one species that appeared more resistant than others was the wattlebirds. Being the first time this technology has been used it isn't clear if this is because the laser wasn't deployed until after the grapes had already started ripening or perhaps the way the birds move through the vineyard underneath the canopy, which could mean that they are less affected by the laser as it is directed to the top of the canopy. However, it did still reduce them, which was evidenced while I was preparing for harvesting. I adjusted the laser and noted a much larger flock arrived unexpectedly, at which point I returned the laser to the normal program, which deterred the large wattlebird flock.

When it came to the end of the end of the trial, the laser had some residual impact, but after turning it off for a week the water birds and other wildlife returned to the dams. This appeared to show there is some safety in the event of a short-term failure – after a few days without the laser I would expect very little residual impact. The good thing, however, is that this also means the beneficial birds over winter are not deterred and continue to keep the bugs down while the vineyard is dormant.

Expectations for 2017

Our focus this year will be getting the laser deployed well in advance of when the birds start becoming a problem and having it running over all three of our blocks by deploying it on an extended able pole raised to approximately 5 m. Based on this, we will do the setup in mid-December so we can monitor the bird activity with a plan to delay and, if practical, avoid netting entirely.

Results

- 80–90% less birds
- immediate effect after installation that seemed to continue to improve during the five-week trial
- capacity for significant savings in labour and capital replacement costs over netting
- works fully autonomically and autonomously
- allows a more flexible grape harvest and maintenance – able to access vineyard with tractors and equipment right up to picking.

Should I water the dirt or the plant?

Alec Downey B.Sc. (For) Head of Plant Science Applications & Research, ICT International Pty Ltd

Adjunct Senior Lecturer, School of Plant Biology, University of Western Australia

Many irrigators have experience in soil moisture monitoring technologies, whether it be manually measured neutron probes, automated capacitance-based sensors or even simple gypsum blocks to measure soil water potential. By definition, these technologies attempt to measure the moisture in the soil, but it is an indirect measurement as they do not actually measure water.

In the past – soil moisture sensors

The neutron probe (Figure 1.) most closely measures water as it reads the hydrogen (H) atoms in the soil. Water has two hydrogen atoms (H2O) and hydrogen is the most rapidly changing element in the soil over a short temporal scale of days to weeks.

Capacitance probes infer a change in moisture content by recording a change in amplitude of a given electrical signal frequency passed through an electrical circuit that sits adjacent to the soil. The signal's change in amplitude is then used to calculate a change in dielectric constant that must then be calibrated for the given soil type to determine a change in moisture content.

A gypsum block detects a change in soil pore water potential or pressure, which can then be passed through an empirical table for a given soil classification to determine a general soil water content range.

The issue with all of these techniques is that they are relatively small, static points in space that are used to indirectly determine soil moisture content for that given point, from which all other heterogeneous points within the soil are referenced, and irrigation decisions made from. Again, the neutron probe has the largest sphere of influence at approximately 30 cm diameter around the point of measurement. Capacitance probes and gypsum blocks must be in intimate contact with the soil, with absolutely no air gap, and have a functional sphere of influence of approximately 2 mm around the point of measurement or 0.000000002 m^3. This is hardly representative of the moisture content of

Figure 1. Neutron probe being used in a vineyard

Figure 2. Sap flow meter installed on a vine

even 1 m^3 of soil, much less 10,000 m^3 or one hectare metre (or ha3), being the volume of soil 1 m deep across a hectare. This volume typically represents the depth from which plants access water, more commonly referred to as the plant's active root zone.

But what else can we do?

Using soil moisture sensors has always been ultimately to determine the water use rate or grape vine requirement. This has been done indirectly by measuring the water content on day 1 and subtracting the soil water content measured on day 2. The difference, or the change in water content between the two values is considered the vine's water use. This calculation makes no allowance for evaporation, lateral subsurface movement or lateral drainage, or vertical drainage through the soil. Such assumptions about vine water use can often lead to over irrigation, and on other vines, under irrigation.

Ultimately, the best way to determine the water use requirements of the vine is to directly measure the vine's volumetric water use. This can be done non-destructively, and continuously every 10 minutes of the day and night using a sap flow meter.

In the future – plant-based monitoring

The plant is the world's most sophisticated transducer or sensor ever developed. Using an extensive network of kilometres of tap root, lateral roots and fine root hairs, the vine can explore many cubic meters even tens of cubic meters of soil from which to access its daily water use requirements. The vine then integrates this large volume of soil into a single measurable value of water use through the stem. This is supplied to the canopy for the exchange of water for carbon so that the vine can photosynthesise and grow.

The canopy then integrates all of the environmental factors acting upon the vine such as the:

- amount of sunlight received;
- ambient temperature; relative humidity;
- vapour pressure deficit (VPD); and
- wind speed.

to regulate the demand of water required to operate at its maximum capacity under the conditions.

As the environmental factors rarely remain constant, the vine's water use rate changes accordingly. The rate at which the vine water-use rate changes depends upon the variability in the environment. Typically, within 10 minutes of any environmental parameter changing, such as sunlight from a cloud coming or going, and/or temperature changes, the plant will change its rate of water use.

A sap flow meter (Figure 2.) provides the ability to continuously monitor these changes in water use supply and demand. And, because the vine is exploring large volumes of soil and integrating the available soil moisture across anything up 36 m^3 of soil, each measurement is very accurate and representative of a larger proportion of the whole block or land management unit.

What does the plant tell me?

Sap flow meters have traditionally been the domain of the scientific researcher. However, with the development of new principles of measurement and integration of new technology, sap flow meters are now sufficiently robust and straight forward to be routinely used as would any other tool in commercial horticulture and viticulture.

A pilot sap flow study by the Murray Valley Winegrowers Inc. in Mildura, lead by chairman Brian Englefield, has demonstrated the value of using sap flow meters to monitor plant water use requirements. The plant will tell you when it has enough water simply by reviewing the shape of the daily water use curve. At night, under fully hydrated conditions, the vine will not use any water. As sunlight hits the canopy the 'green factory' readily and continuously trades water for carbon to enable photosynthesis. As the sun sets, water use declines retuning to zero water use throughout the night as shown in Figure 3.

However, when a vine is exhibiting signs of water stress, the daily water use curve becomes asymmetrical with water use not reaching zero at night (Figure 4). This plant response shows that water has been taken from within the capacitive water storage tissues, or the vine's sap wood, to meet the day's evaporative demand. The elevated night water use shows water being taken from the soil to rehydrate the water-conducting tissues, or sap wood, ready for the day ahead.

The plant can withstand these sorts of excessive water use requirements for only a short period of a day, perhaps two or even three days at a time. If the plants daily water use needs cannot be regularly supplied from the soil, then the daily water use rate will steadily decline, indicating a water deficit stress on the vine that ultimately will affect yield and fruit quality.

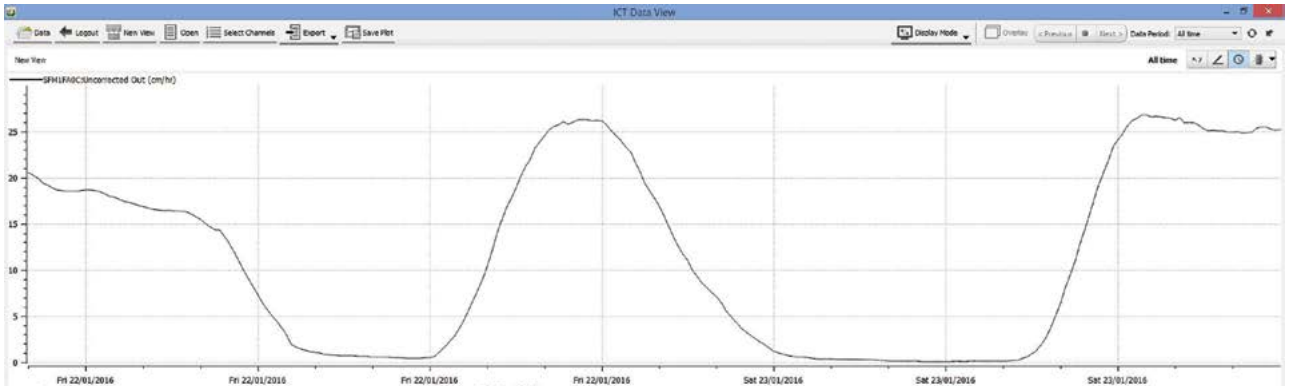

Figure 3. Characteristic Daily Water Use curve of a vine exhibiting no signs of water deficit stress.

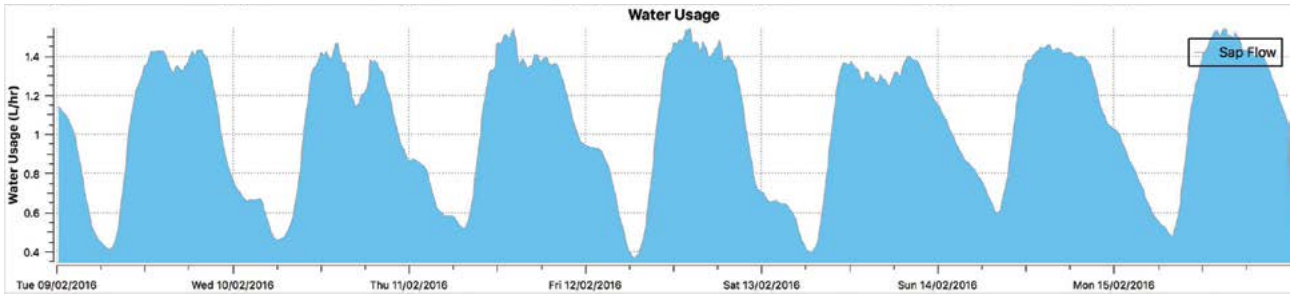

Figure 4. An example of a daily water use curve over a 7-day period in which the vine exhibits water deficit. Most night water use does not reach zero and in fact, for the majority of the night, hourly water use rate is as high as 0.5 L/hr or 1/3 the midday maximum rate.

Primarily, sap flow will tell the irrigation manager how much water the vines are using and when they are using it. This information is provided in a simple summary table (Figure 5), (the time scale for which can be adjusted by the user from daily, weekly, fortnightly, monthly or yearly) that shows the:

- individual vines water use
- extrapolated water use per hectare based on the vine planting density
- total water use for the entire irrigation block based on the total number of hectares.

The data is expressed in litres of water per hour (L/hr) as well as litres per day (L/day) and also millimetresof water per day.

This provides the irrigation manager both the volume of water needed to be applied and/or the number of hours the irrigation system needs to be run in order to deliver the millimetres of water through the irrigation system to meet the vine's water use needs. By interpreting the daily vine water use curve, the optimum irrigation timing can also be evaluated and matched to achieve the optimum delivery efficiency and uptake by the vine.

Conclusion

So should I water the dirt or the plant? It's clear that the dirt or the soil is heterogeneous or highly variable and soil moisture sensors indirectly infer plant water use from a very small and unrepresentative proportion of the vineyard. Directly monitoring the vine using a sap flow meter provides a very direct and accurate measurement of vine water use that represents a significant proposition of the vineyard. Therefore, irrigation scheduling decisions should always be based on the plant and not the dirt!

Then watch your viticultural costs reduce and your profits rise!

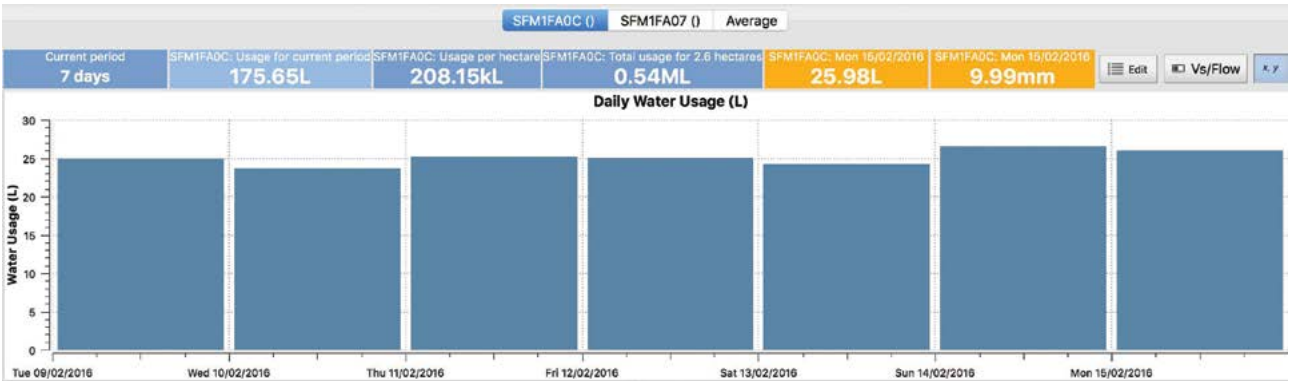

Figure 5. The vine water use summary shows the volume of water in litres and mm required to apply through the irrigation system.

Innovation in vineyard IPM and biocontrol release technology

Paul Jones and Dan Papacek, Bugs for Bugs

info@bugsforbugs.com.au

Why take a softer 'integrated' approach?

There are many good reasons to move away from synthetic chemicals as the mainstay of pest control and look instead at taking a softer integrated approach.

Concerns about worker, consumer and environmental safety are important factors driving a shift towards reduced reliance on pesticides, but there are also very practical reasons for growers to look beyond the spray tank for solutions to manage difficult pests in the vineyard. Withdrawn pesticide products and insecticide resistance issues have left growers with a much smaller selection of viable spray options in their pest control toolkit. There is also increasing awareness of how insecticides can cause ongoing problems when a broad-spectrum spray targeted at one pest disrupts a biological control using other pests, resulting in secondary pest-flare.

With the availability of an increasingly comprehensive range of selective chemistry that is soft on beneficials, it is easier now than ever before to implement effective integrated pest management (IPM) in the vineyard. IPM is an approach that aims to achieve good quality and high yields with minimal pesticides. The focus is on biological and cultural controls, and when chemicals are required, soft products that will have minimal impact on the key biocontrol agents are favoured over disruptive, broad-spectrum products.

The imperative to use available chemistry judiciously in order to slow the development of resistance is another good reason to use an IPM approach. By relying on biological and cultural controls as the first line of defence, we can reduce the need for insecticide applications and slow resistance development to the valuable IPM compatible products currently available.

Biological solutions for vineyard pests

Most insects and mites have natural enemies. An abundance of predators and parasites occur naturally in Australian vineyards, and in an IPM strategy these powerful allies are conserved (by minimising broad-spectrum insecticide applications) and encouraged (through cultural practices) to play a key role in controlling pests.

Sometimes a little extra help is needed. It can be worthwhile to supplement natural populations of beneficials with strategic releases of mass-reared biocontrol agents.

Bugs for Bugs is one of Australia's leading biocontrol producers and we are actively researching and developing biocontrol solutions for difficult vineyard pests. We have a long history supporting grape growers to develop and implement effective IPM strategies, and supplying predators and parasitoids to this industry.

We produce a range of beneficial organisms that can help control major vineyard pests including mealybugs, scale insects, light brown apple moth and other caterpillar pests. We are currently also working with AeroBugs to develop improved drone-based biocontrol release strategies that have the potential to increase the efficiency and effectiveness of biocontrol delivery into vineyards.

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Cryptolaemus and lacewings for mealybug and scale control

Figure 1. Long tailed mealybug and sticky honeydew on grape bunch (photo by Dan Papacek).

Mealybugs and scale insects are becoming increasingly important pests of vineyards in many grape-growing regions across Australia (see Figure 1). They feed by sucking sap, but this alone rarely causes economic damage. They are a problem because they excrete honeydew, which contaminates leaves and bunches, leading to the development of sooty mould. This reduces photosynthesis and can cause bunches to rot.

Mealybugs and scale insects are difficult to control with pesticides. This is largely due to their waxy covering, their habit of infesting sheltered plant parts, and the consequent difficulty in achieving effective spray coverage. They also readily develop resistance to pesticides.

Instead of relying on chemicals to manage these pests, we suggest growers use cultural practices to encourage natural enemies and reduce pest pressure. If extra help is needed, we recommend strategic releases of two excellent native biocontrol agents:

1. ladybird *Cryptolaemus montrouzieri*

2. green lacewing *Mallada signata*.

Cryptolaemus are very efficient natural enemies of mealybugs. They have been exported to many other countries and are recognised as powerful predators of mealybugs. The larvae look very much like mealybugs and are often confused with them. Adult beetles and young larvae feed on mealybug eggs and young stages, while the large larvae can also feed on adult mealybugs (Figure 2).

Figure 2. Cryptolaemus adult (above, photo by Denis Crawford) and larva (below, photo by Dan Papacek) feeding on mealybugs.

In addition to mealybugs, Cryptolaemus will also feed readily on many species of soft scales, including grapevine scale.

Cryptolaemus are supplied both as larvae and adults. We recommend larvae for treating hotspots, or a combination of larvae and adults to ensure both rapid hotspot clean-up and optimal coverage and establishment across the vineyard.

After release, larvae should start feeding immediately. It will take around two weeks for them to complete their development (at 25 °C). They will pupate nearby and adult beetles should emerge to continue the cycle in another 2–3 weeks. Significant control is possible within one generation of Cryptolaemus (about four weeks). However, high pest populations can take longer to control and we usually suggest two releases a fortnight apart. Our recommended release rates vary depending on the economic importance of the pest being targeted and the severity of the infestation.

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Green lacewing larvae are generalist predators that feed on a wide range of vineyard pests including mealybugs, scale insects, caterpillars and mites. We have seen excellent results from green lacewings released in vineyards that have persistent scale and mealybug problems. Boosting natural populations of green lacewings early in the season can enhance biological control of these difficult pests and contribute to the control of various mite and caterpillar pests.

Lacewings are despatched as eggs and should hatch into the larval stage during transit. Eggs are packed with shredded paper and wheat husks, with a small quantity of sterilised moth eggs for food. Upon arrival, larvae can be distributed by sprinkling the wheat husks and shredded paper onto the vines. It is best to release larvae into pest hotspots to ensure they have an immediate food supply.

We recommend two or three releases 10–14 days apart to improve lacewing establishment in the field. Larvae usually take about 12 days to develop before they pupate. After this time, there will be few lacewing larvae in the field, as it takes a further 16 days before adults emerge and lay eggs. Once again, the recommended release rate will vary depending on the economic importance of the pests being targeted and the infestation severity.

For best results, Cryptolaemus and lacewings should be released before pests have built up to high and damaging levels. It is also worth noting that ants like to feed on honeydew and they encourage the development of mealybug and scale colonies by interfering with natural enemies. Controlling or reducing ant numbers can help to establish beneficials and make a big difference to the success of biological control.

Trichogramma for light brown apple moth control

Figure 3. Trichgramma carverae on light brown apple moth egg mass (photo by Denis Crawford).

The light brown apple moth (LBAM, Epiphyas postvittana) is a native leaf-roller with a wide host range. This species does not survive well at high temperatures so it is typically a problem in cooler areas or during mild summers.

In vineyards, LBAM feed on grapevine foliage and fruit (Figure 3). Feeding within the bunches can reduce crop yield, but more importantly it increases the risk of infection by Botrytis and other bunch-rotting fungi.

Removing other broadleaf hosts, such as capeweed and clover in and around the vineyard is an important cultural control that can significantly reduce the overwintering LBAM population and contribute to improved management. Cultural practices and naturally occurring biological control agents might be sufficient in some instances, but in areas where pressure is high or seasonal conditions favour the pest, additional control measures are often required.

The parasitoid wasp *Trichogramma carverae* is recognised as the best available natural enemy of LBAM. This minute wasp lays its eggs into the LBAM egg mass. Parasitised egg masses turn black as the wasp larvae inside devour the developing LBAM caterpillars. After pupating within the LBAM egg mass, adult Trichogramma wasps emerge and females proceed to parasitise more LBAM eggs.

The advantage of this natural enemy is that it provides optimal crop protection by controlling the pest in the egg stage. However, Trichogramma wasps are very sensitive to insecticides and are best suited to those crops grown organically or under an IPM strategy.

Monitoring regularly for moth eggs is essential in order to determine the best time for release and the release rate. Trichogramma should be released when moths are active and laying eggs. Local history and pheromone traps provide a good guide to moth activity timing. Peak egg laying usually occurs just after a peak in the number of moths caught in pheromone traps.

Trichogramma are despatched in the form of parasitised moth eggs, housed in cardboard capsules. The more Trichogramma applied, the quicker the pest is controlled. However, economics will also dictate the number released. Experience overseas and in Australia suggest that regular releases of Trichogramma at variable rates, according to pest pressure and plant development, is appropriate.

To establish a continuous Trichogramma population in the field, it is necessary to make two releases between five and seven days apart. The wasps only live for that period in the field and it takes approximately nine days for any attacked eggs to produce a wasp. Thus seven days after the original release, all the original wasps will have died. It will take a further 2–5 days before their offspring emerge.

A second release will ensure that there are still adults present while the first generation completes its development.

Innovative biocontrol release technology

Manual distribution of biocontrol agents over large areas in field crops can be very labour-intensive and therefore costly. Bugs for Bugs has been working closely with AeroBugs's founder Nathan Roy to develop more efficient ways to deliver biocontrol agents, using unmanned aerial vehicles (UAVs, or drones) (Figure 4).

Nathan is a former strawberry grower and he is passionate about biological control, having seen the benefits on his own farm. Having recognised that labour costs associated with manually distributing beneficials are a considerable barrier to adoption, he set about developing improved release methods.

The result of Nathan's R&D efforts is his patented drone release technology, which enables efficient targeted distribution of our beneficials, and ensures that they arrive safe and sound in the crop.

AeroBugs are Australia's first operators accredited to use UAVs for this purpose, and the results have been excellent. So far, the technology has been successfully used to distribute predatory mites and parasitoid wasps in strawberry, melon, sweet corn and tomato crops.

This technology offers improved biocontrol distribution and considerable cost-savings compared with traditional manual distribution. There is potential to use this technology in vineyards, particularly for the release of Trichogramma, and we look forward to working with AeroBugs and interested growers to trial this approach.

Figure 4. AeroBugs drone delivering beneficials to a melon crop (photo by Dan Papacek)

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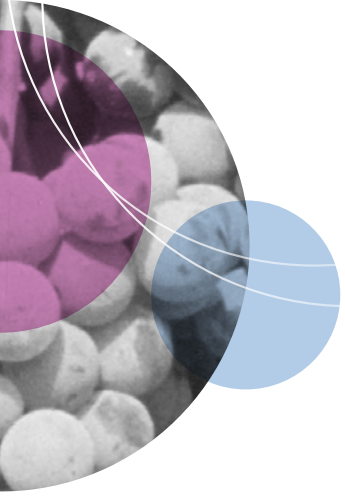

Appendices

Appendix 1: 'Off label' grapevine permits

All agricultural and veterinary products sold in Australia must be registered for use by the Australian Pesticides and Veterinary Medicines Authority (APVMA). Therefore, in most states, registered products must only be used for those approved purposes that are stated on the label. However, situations do arise whereby chemicals are needed for a use not specified on the label.

In such instances an 'off-label' permit may be obtained through the APVMA Permits Scheme. Such permits allow chemicals to be used legally in ways that are different to the uses specified on the product label and/or allow limited use of an unregistered chemical.

The following table lists the current off-label permits issued for grapevines in various situations. It is essential that you read the conditions attached to the permit before using the chemical. For example, the permit might have a restriction on permitted uses and states in which it is current. It is advisable to contact your winery or grape purchaser before applying any chemical covered by an off-label permit.

Permits can be downloaded from the APVMA website (https://portal.apvma.gov.au/permits).

'Off label' grapevine permits

Permit No.	Description	Expiry date
PER81443	Clothianidin/table grapes/fruit fly.	31-Oct-18
PER81476	Ethephon/sultana, sunmuscat, Sunglo Or Carina Grapes grown for drying/cordon bunch removal.	31-Dec-18
PER14683	Trichlorfon/stone fruit & guava/Mediterranean fruit fly.	31-May-17
PER14661	Fipronil/table grapes/termite species	31-Dec-17
PER14492	Acramite miticide/table grapes/two spotted mites	31-Oct-20
PER13944	Ammonium nitrate and calcium nitrate/grape vines (for dried fruit production)/chemical cordon bunch removal	31-Mar-18
PER13859	Dimethoate/orchard cleanup fruit fly host crops/fruit fly	31-Jul-24
PER13424	Sulphur dioxide & carbon dioxide/table grapes/redback spiders	31-Mar-17
PER13378	Torque miticide (fenbutatin-oxide)/table grapes/rust mite & two-spotted mite	30-Sep-17
PER13253	Maldison/table grapes/Queensland and Mediterranean fruit fly	31-May-21
PER12439	Trichlorfon/table grapes/fruit fly	31-May-21
PER11748	Sodium metabisulfite/table grapes (packaged)/phylloxera	31-Oct-24

Contact your winery/grape purchaser before applying any 1A, 1B, 2B or 3A insecticide.

Table 1. Post-emergent herbicides registered in NSW for use in vineyards. Read the product label before use.

Chemical (Poisons Schedule)	Trade names	Herbicide Group	WHP days	Rates	Weeds controlled	Comments
2.2-DPA present as the sodium salt 740 g/KG (s5)	Dalapon 740 SP	J	7	10 kg/Ha	Kikuyu, Couch, Johnsons grass	Vines must be at least 4 years old. DO NOT exceed 10 kg/ha per year. Do not allow applications to contact green tissue and buds of vines. Apply as a direct spray into vine rows. Half rate at 10–14 day intervals will improve weed control and minimise risk to vines.
Amitrole 250 g/L (S5)	Sabakem Amitrole 47	Q	56	4–12 L/ha	Broadleaf weeds and grasses	Apply when weeds are small and making active growth. Repeat application may be necessary in 6–8 weeks. Apply as directed spray to weeds only. Use higher rates for larger or more tolerant weeds.
Amitrole + Paraquat (S7)	Alliance – 250 g/L Amitrol + 125 g/L Paraquat	Q+ L	Not required when used as directed	3–4 L/ha or 400 mL per 100 L as a spot spray	Young seedling plants only of: annual ryegrass (including glyphosate resistant biotypes), brome grass, barley grass, capeweed, Indian hedge mustard, turnip weed; volunteer cereals – barley, oats, triticale, wheat, wild oats; wild radish. Plus: barnyard grass (max. early tillering), bladder ketmia, cowvine, cranesbill, dove's foot, dwarf amaranth, fleabane (max 6 leaf), field peas, goosefoot, marshmallow, medics, mignonette, Paterson's curse, soursob, speedwell (not ivy-leaf), stonecrop, storksbills, sub. clover; thistles – artichoke, milk/sow, spear, stemless, variegated; three cornered jack, volunteer cotton, volunteer canola (including Roundup Ready® varieties), wireweed, wild lettuce	Spray young weeds during late winter to spring–summer as required. Use higher rate for spring application. Can be combined with residual herbicides for longer-term control. Does not require additional wetter unless spraying at high volume. Where Amitrole + Paraquat is mixed with water at less than 400 mL/100 L of water, add 100 mL Shirwet® 600 or 60 mL BS1000 per 100 L of spray. Spot spray rate assumes a total volume of 1000 L/ha. For lower water volumes increase dilution rate as below: - water volume 250 L/ha: use 1.6 L/100 L - water volume 500 L/ha: use 800 mL/100 L - water volume 750 L/ha: use 530 mL/100 L.
	Para-Trooper, Paraglide 10 g/L Amitrol + 250 g/L Paraquat			1.7 L/sprayed ha	Annual weed control	If fat hen or *Portulaca* spp. is present and Imtrade Para-Trooper herbicide rate is less that the ratio 800 mL/100 L, add 120 mL Imtrade Wetter 1000 per 100 L spray mix.
Carfentrazone-ethyl 240 g/L (S%)	Carfentrazone 240 EC, Elevate, Hammer 400 EC, Nail 240 EC, Spotlight Plus	G		25–75 mL/ha plus recommended label rates of knock-down herbicides. Spot spray 10 mL/100 L plus recommended label spot spray rates of knockdown herbicides	Australian crassula/stonecrop, cape weed, chickweed, common storksbill (maximum 4 leaves), doublegee/spiny emex/three cornered jack, marshmallow, Paterson's curse, sub. clover, wild radish, *Crassula* spp, Bifora, *Bifora testiculata, Arctotheca calendula*, chickweed, *Stellaria media, Erodium cicutarium, Malva parviflora, Echium plantagineum*	Apply as a tank mix with glyphosate paraquat. Adding Spotlight Plus to knockdown herbicides will increase the speed at which treated broadleaf weeds in general develop visible symptoms (compared with results achieved with knockdown herbicides applied alone) and might improve final control of broadleaf weeds, including certain hard-to-kill weeds (marshmallow in particular). Using higher rates and full soil disturbance might improve control of marshmallow in particular. Use the lower rates on younger plants or plants growing under good conditions and the higher rates on older plants or plants growing under less optimum conditions. The lower rate might only provide suppression of cape weed, wild radish, common storksbill and doublegee under poor growing conditions. Application to hardened weeds or drought-stressed weeds, especially under summer conditions might cause only localised injury to weed foliage, which might not enhance final weed control.

Chemical (Poisons Schedule)	Trade names	Herbicide Group	WHP days	Rates	Weeds controlled	Comments
Diflufenican 25 g/L Bromoxynil 250 g/L (S5)	Bentley, Colt, Cougar, Difluken B, Jaguar	C + F	Not required when used as directed	500 mL–1 L	Certain broadleaf weeds in cover crops.	Apply during vine dormancy only. Avoid contact with vines. Particular care should be taken if applied in late autumn or early spring, when vines might not be fully dormant. Apply from early post-emergence and when weeds are actively growing.
Diquat 200 g/L (S6)	Reglone, Diquat 200, Desiquat, Dia-Kill 200, Ozcrop diquat 200	L		150 L + 1.4 L Agral in 700 L water/ha plus 1.6 L/ha Paraquat 250 (S7)	Capeweed	Apply as a directed spray under trees or vines. Under most conditions, Gramoxone 250 at 1.6–3.2 L/ha or Spray.Seed 250 at 2.4–3.2 L/ha will give effective control of grasses and broadleaf weeds in orchards, but where heavy infestations of cape weed occur Diquat 200 should be added to Gramoxone 250 at the rate of 1.5 L/ha. For inter-row or around butts use high-volume applications. Gramoxone 250, Spray.Seed 250 and Diquat 200 have no effect on brown bark, but care should be taken when spraying
Diquat + Paraquat (S7)	agVantage Di-Par 250, Agmate Paraquat & Diquat 250 Sl, Spalding Exocet 250, Spray.Seed 250	L	7	Boom 2.4–3.2 L/ha Spot spray 240–320 ml/100 L	Most annual grasses and broadleaved weeds.	For spot spraying and when volume of water applied exceeds 200 Lha add a wetter at 120 mL/100 L of additional water. Thoroughly wet plant foliage. Use the high rate for dense, more established weed growth. Repeat treatment on regenerated green perennial weeds (such as paspalum and docks) while plants are weakened from previous treatment. Addition of at Oxyflurofen 240 ml/ha will improve control of small flowered mallow, evening primrose and other weeds sensitive to Oxyflurofen. Refer to the Oxyflurofen product label.
2,2-DPA-sodium 740 g/kg	Agspray Atlapon Dalapon 740 SP, Propon	J	7	Boom: 10 kg per sprayed hectare	Couch, Kikuyu, Johnsons grass	Vines must be at least 4 years old. DO NOT exceed 10 kg/ha per year. Apply as a direct spray into vine rows. Half rate at 10–14 day intervals.
Fluazifop-P 128 g/L (S6)	Fusilade Fort,	A	28	1.65 L/ha 2.5 L/ha 3.3 L/ha or 6.6 L/h	Growing actively at 5-leaf to early tillering: annual (Wimmera) ryegrass, barley grass, barnyard grass, brome grasses, crowsfoot grass, Johnson grass, liverseed grass, prairie grass, summer grass (crabgrass), wild oats. Growing actively at 5-leaf to early tillering, innocent weed and stinkgrass growing actively at 3–5-leaf stage, foxtail (TAS) seedlings (*Setaria* spp.), pigeon grass young vegetative growth (3–6 leaves per shoot) when actively growing. Established plants of couch grass, English couch (rope twitch), water couch, Johnson grass, paspalum, bent grass and kikuyu grass.	Apply in not less than 200 L/ha. Direct the spray to the base of the vine. Young growth is most susceptible at 5 leaves to early tillering when actively growing. Higher rates might be required for more advanced plants. Suppression only beyond the 5-leaf stage. Use the higher rate for well-established infestations or where greater control is required in one season. Or consider a double knock of Spray.Seed followed by Fluazifop-P when fresh growth has emerged – may be necessary for couch control. Note: Tank mixes of Fluazifop-P are not recommended, and there should be a minimum of 3 days before any other herbicide is applied. Fluazifop-P does not control winter grass or silver grass.
				20–80 ml/10L	Wide range of grasses.	Use the higher rate for well-established infestations or where greater control is required in one season.

Chemical (Poisons Schedule)	Trade names	Herbicide Group	WHP days	Rates	Weeds controlled	Comments
Fluazifop-P 112 g/L (S6)	Fuzilier, Rootout 212	A	28	1 L/ha	Growing actively at 5-leaf to early tillering: annual (Wimmera) ryegrass, barley grass, barnyard grass, brome grasses, browsfoot grass, Johnson grass, liverseed grass, prairie grass, summer grass (crabgrass), wild oats	Apply in not less than 200 L/ha. Direct the spray to the base of the vine.
				1–5 L/ha	Growing actively at 3–5-leaf stage: foxtail (TAS) seedlings (*Setaria* spp.), pigeon grass. Young vegetative growth (3–6 leaves per shoot) when actively growing.	
				Spot spray at 12.5–100 ml/10L	Wide range of grasses see label	Use the higher rate for well-established infestations or where greater control is required in one season.
Glufosinate-ammonium (S5)	Basta, Biffo, Cease, Exile, Exonerate, Exonerate200 SL, Fascinate 200 SL, Faster-TG 200, Fiestar, Glufosinate 200, Glufosinate- Ammonium 200, Muster, Kelpie	N	Not required when used as directed	1–5 L/ha The recommended rate of use is determined by the following criteria: -Weed species -Weed stage of growth -Weed density -Climatic conditions	**Annual weeds** *Amaranthus* spp., apple of Peru, Argentine peppercress, awnless barnyard grass, barley grass, barnyard grass, billy goat weed, bitter cress, black bindweed (buckwheat), bladder ketmia, bordered panic, brome grasses), calopo, caltrop burr, cape weed, sub. clover,, cobbler's peg, common storksbill, crowsfoot grass, dead nettle, dwarf crumbweed, fat hen, flax-leaf fleabane, fumitory, green crumbweed, lesser canary grass, liverseed grass, medics (annual), milk thistle, mint weed, New Zealand spinach, Patterson's curse, peanuts, pigweed, pinkburr, potato weed, prairie grass, prickly lettuce, red Natal grass, ryegrass (annual), saffron thistle, St. Barnaby's thistle, sago weed, scarlet pimpernel, setaria, sheep thistle, silver grass, sorghum/ sudax, square weed, stagger weed, star of Bethlehem, summer grass, thickhead, three cornered jack, tomato, Townsville stylo, turnip weed, variegated thistle, wheat, wild carrot, wild gooseberry, wild mustard, wild oats, wild radish, wireweed **Perennial weeds** Blady grass, cape tulip, centro, clover glycine, couch grass, cynodon, cow pea, giant sensitive plant, greenleaf, Johnson grass, *Paspalum* spp, perennial bindweed, shamrock, sida weed, silver leaf desmodium, siratro, stink grass, white clover, white eye, willow herb.	Apply as a directed or shielded spray. Refer to the label for details on specific application methods. **Warnings** Do not allow spray or spray drift to contact desirable foliage or green (uncalloused) bark. Refer to the label for instructions on how to avoid potential crop damage and protect crops, native and other non-target plants. Glufosinate-ammonium may be used around trees/vines less than 2 years old provided they are effectively shielded from spray and spray drift. **Weed species** Apply the appropriate rate to control the least susceptible weed present as per the lists of weeds controlled in the label's tables. **Weed stage of growth** Use the lower rate when weeds are young and succulent (grasses: pre-tillering; broadleaves: cotyledons to 4-leaf) or the population is very sparse. A median rate should be used for medium sized plants (grasses: tillering; broadleaves: 4-leaf to advanced vegetative) and the high rate should be used when weeds are mature (grasses: noding–flowering; broadleaves: budding–flowering). **Climatic conditions** Best results are achieved when applied under warm humid conditions (temperatures below 33 °C with a relative humidity above 50%). Control will be reduced and/ or slower under cold conditions. Good results will be achieved under most other conditions, however, poor results can occur under hot, dry conditions. Weeds that have been hardened or stunted in growth due to stressed conditions should be treated at the maximum rate. For weed density, coverage and perennial weeds see the label.

Chemical (Poisons Schedule)	Trade names	Herbicide Group	WHP days	Rates	Weeds controlled	Comments
Glyphosate 360 g/L present as ipa and/ or mono-ammonium salts (S5)	Accencis 360, Banish 360, BioChoice 360, Country Glyphosate 360, Glyphosate 360 SL, Glister 360, Glyphosate 360, Aquatic 360, Pestmaster Aqua-Tech 360, Roundup Biactive, Sanos 360, SquareDown 360, Weedmaster Duo, Wipe-Out 360, Wipe-Out Bio	M	Not required when used as directed	Annual weeds: Boom: 2–3 L per sprayed hectare Perennial weeds: Boom: 3–9 L per sprayed hectare. Weed-wiping equipment: 1 L mix: 2 L water.	Broad spectrum. Hard-to-kill perennials (couch, paspalum, etc.) require higher rates. Use low rates where weeds are less than 15 cm high	Apply as a directed or shielded spray or using wiper equipment. Do NOT apply as a spray near or vines less than 3 years old unless they are effectively shielded from spray and spray drift. Do NOT allow wiper surface to contact any part of the vine. Do NOT allow spray or spray drift to contact green bark or stems, canes, laterals, suckers, fresh wounds, foliage or fruit.. Do NOT allow wiper equipment to contact vines.
Glyphosate– ipa/mas 450 g/L (S5)	AllOut 450, ClearUp 450, Eradicator 450, Glister 450, Glymont 450,Glyphos classic 450, Glyphosate 450, Glyphosate 450 CT, Glyphosate 450 SL	M	Not required when used as directed	Annual weeds: Boom: 1.6–2.4 L per sprayed hectare Perennial weeds: Boom:2.43–4.8 L per sprayed hectare.		
Glyphosate ipa/mas 540 g/L (S5)	Credit, Sickle 540	M	Not required when used as directed	Annual weeds: Boom: 1.35–2 L per sprayed hectare Perennial weeds: Boom:2–4 L per sprayed hectare.		
Glyphosate-ipa 432 g/L + carfentrazone-ethyl 7.2 g/L (S5)	Broadway	M + G	Not required when used as directed	850 mL–2.5 L/ha	Australian crassula/stonecrop, cape weed, chickweed, common storksbill (max. 4 leaves), doublegee/spiny emex/three cornered jack, marshmallow, Paterson's curse, sub. clover, wild radish	Using higher rates and full soil disturbance can improve control of small, flowered mallow in particular. Use the lower rates on younger plants or, plants growing under good conditions, and the higher rates on older plants or plants growing under less optimum conditions. When using Broadway Herbicide as a spot spray, apply in sufficient water (minimum 500 L/ha) to thoroughly wet all weed foliage to the point of run-off. Adding standard rates of a non-ionic surfactant might improve weed control. DO NOT allow spray or spray drift to contact green bark or stems, canes, laterals, suckers, fresh wounds, foliage or fruit.

Chemical (Poisons Schedule)	Trade names	Herbicide Group	WHP days	Rates	Weeds controlled	Comments
Haloxyfop 520 g/L (S6)	Verdict , Haloxyfop, Jasper, V Agro- Essence, Convict, Exert, Firepower, Haloxyfop, Haloxyken, Hermes, Recon	A	Not required when used as directed	Annual grasses: 200 mL ha; perennial grasses: couch, Rhodes, slender rats tail 400–800 mL/ha *Paspalum* spp	Perennial grasses: couch, Rhodes grass, slender rats tail grass, buffel grass, green panic, Johnson grass, kikuyu, *Paspalum* spp., *Setaria* spp. Annual grasses: annual ryegrass, barley grass, barnyard grass, brome grass, crowsfoot grass, lesser canary grass, liverseed grass, Mossman river grass, paradoxa grass, summer grass, volunteer cereals, wild oats	Spray should be directed to base of vine. Avoid contact with fruit and foliage. When using perennial rates, annual grasses are also controlled. Spot spray: Use 25 mL to 50 mL/100 L of water. Use higher rate on late tillering mature grasses.
Haloxyfop 130 g/L (S6)	Asset, Gallant. Judgement,	A	Not required when used as directed	Annual grasses: 800 m L ha Perennial grasses: Couch: 1.6–2.3 L/ha Paspalum, Johnson grass: 0.8–1.6 L/ha		
Oxyfluorfen 240 g/L plus a glyphosate product at its recommended label rate	Goal, Point Herbicide, Striker	G+M	Not required when used as directed	75 mL/ha plus a glyphosate product at its recommended label rate.	Refer to the glyphosate product label (such as Ripper™ 480, Roundup®, Roundup CT®, PowerMax®, Touchdown® or Touchdown HiTech®).	Adding Oxyfluorfen to glyphosate products will improve knockdown and increase the speed at which treated weeds develop visible symptoms of phytotoxicity (compared with results achieved with glyphosate applied alone) and give control of annual nettles, (*Urtica* spp.), barley grass, Paterson's curse, small-flowered mallow and storksbill. For glyphosate rates, refer to the appropriate label. DO NOT apply the tank mix of glyphosate and Oxyfluorfen near trees or vines less than 3 years old unless they are effectively shielded from spray and spray drift.
Oxyfluorfen 240 g/L ha plus a paraquat or diquat/paraquat		G+L		250 mL/ha plus a paraquat or diquat/ paraquat product at its recommended label rate.	Refer to label of the paraquat or diquat/paraquat products (such as Spray.Seed® or Tryquat® 200).	Adding Oxyfluorfen in a tank mix with a paraquat or diquat/paraquat product will improve control of small flowered mallow, evening primrose and other weeds sensitive to Oxyfluorfen. For the paraquat or diquat/paraquat product rate, refer to the appropriate label.
Paraquat 135 g/L + Diquat 115 g/L (S7)	Spray Seed 250, Blowout, Brown Out 250, Combik 250, Di-Par 250, EOS, Kwicknock 250, Paraquat/ Diquat, Paraquat + Diquat 250, Pre-Seed 250, Revolver, Scorcher 250, Speedy 250, Spray & Sow, Spray Out 250	L	Not required when used as directed	Spot spraying: 240–320 mL/100 L. Add 170 mL Agral or 100 mL BS1000 per 100 L Boom: 2.4–3.2 L/ha. If volume of water applied exceeds 200 L/ha, add 200 mL Agral or 120 mL BS1000 per 100 L of additional water.	Broad spectrum. For rapid kill of a wide range of annual grasses and broadleaf weeds.	Thoroughly wet plant foliage. Use the high rate for dense, more established weed growth. Repeat treatment on regenerated green perennial weeds (such as paspalum and docks) while plants are weakened from previous treatment. Adding Spark at 250 mL/ha will improve control of small-flowered mallow, evening primrose and other weeds sensitive to Spark. Note: Spot spray rate assumes 1000 L water/ha. For lower water volumes increase dilution rate as below: - water volume 250 L/ha: use 960 to 1280 mL/100 L - water volume 500 L/ha: use 480 to 640 mL/100 L - water volume 750 L/ha: use 320 to 430 mL/100 L - OR Measure how much spray is required to cover an area of 100 m^2 using your normal application volume. - Your dilution rate is 24–32 mL of Paraquat + Diquat 250 in this volume.

Chemical (Poisons Schedule)	Trade names	Herbicide Group	WHP days	Rates	Weeds controlled	Comments
Paraquat (S7)	Gramoxone 250, Nuqua 250t, Explode250, Nuquat 250, Paradox 250, Para-Ken 250, Para-Ken 334, Paraquat 250, Paraquat 250 SL, Shirquat® 250, Sinmosa 250, Sprayquat 250, Spraytop® 250 SL, Uniquat 250	L	Not required when used as directed	Knapsack: 50 mL Paraquat plus 30 mL non-ionic wetter/15 L (add 30 mL diquat if cape weed is present). Boom: 1.7 L/ha Add diquat if cape weed is present. See label for rates.	Broad-spectrum annual weed control. Most active against grasses. See label for rates at increased wetting agent where fat hen and *Portulaca* spp. are present.	Spray as necessary for control of annual weeds. Avoid contacting crop foliage. Apply soon after weed emergence and before weeds reach 15 cm in height. Use spraying pressure less than 240 kPa. Repeat sprays as required. Paraquat 250 will not harm vines with mature brown bark. Use the higher rate for dense weed growth. If product rate is less than 400 mL/100 L, add 100 mL Agral or 60 mL BS1000/100 L of spray mix.
Pine oil (S6)	BioWeed	unspecified	0	1L/ 4 L water	Broad-spectrum nonselective weed control. Claims in advertising to act as a pre-emergent and weed seed killer (not on label).	This product does not work in the same manner as a petrochemical herbicide and failure to change your approach to application can lead to disappointing results. Ensure that all weed foliage is totally covered with spray as pine oil is a contact spray only. Partial coverage will only give partial control. Use a foaming nozzle or spraying tips that apply 2 L/minute. A water volume of 600 L/ha is recommended or 1 L BioWeed™ to 4 L water.
Quizalofop-P-ethyl 100, 200, 250 & 480 g/L (S6)	Conquest Atomic Selective Herbicide, Elantra, Elantra Xtreme, Leopard, Leopard 200 EC, Quinella 100 EC, Quinella Upgrade, Quiz, Quizalofop-P-ethyl 200 EC, Sextant, Tiger.	A	Not required when used as directed	See label for directions	Selected post-emergent systemic grass control. See label for details to control awnless barnyard, crowsfoot, paspalum, Johnson grass and likuyu.	Apply when weeds are actively growing. Use a minimum of 800 L of prepared spray/ha. Thoroughly wet target weeds (especially well established clumps) without causing run off. Repeated sprays might be necessary for perennial grass species. Always add a surfactant/wetting agent at the recommended rate. Check label for details.
Quizalofop-P-tefuryl 120 g/L (S6)	Pantera, Buzzard, Quizalofop-P-Tefuryl	A	Not required when used as directed	125–250 mL/100 L	Awnless barnyard grass, crowsfoot grass, kikuyu, paspalum, Johnson grass.	Apply when weeds are actively growing. Use minimum of 800 L of prepared spray/ha. Thoroughly wet target weeds (especially well established clumps) without causing run off. Repeated spraying might be necessary for perennial grass species. Always add a surfactant/wetting agent at the recommended rate. Check label for details.

Table 2. Residual herbicides registered in NSW for use in vineyards: Long-term pre-emergent control of a range of weeds depending on rate, soil and moisture. Read label before use.

Chemical	Trade names	Herbicide Group	WHP days	Rates	Weeds controlled	Comments
Dichlobenil 67.5 g/kg (S6)	Casoron G	O	Not required when used as directed	60–90 kg/ha	Annual grasses and broadleaf weeds.	**For bearing and non-bearing vines** Spread granules evenly over the soil of the area to be treated. Remove existing weeds by hand, desiccation or cultivation. Use a higher rate on heavier soils.
Isoxaben 750 g/kg (S5)	Gallery 750	O	Not required when used as directed	375–750 g/ha	Amaranth, bittercress, black nightshade, cape weed, clover, fat hen, flatweed, hedge mustard, mallow, milk thistle, Paterson's curse, plantain, scarlet pimpernel, wild radish, wireweed. Isoxaben has negligible activity on grasses	Apply to weed-free, even soil surface. Needs 12.5 mm moisture via rainfall or irrigation within 21 days of application to be activated. Mix with pendimethalin or oryzalin to provide additional grass weed control.
Napropamide 500 g/kg (Unscheduled)	Devrinol WG	K	Not required when used as directed	4.5 kg/ha for light to medium soils, 6.7 kg/ha for heavy clay soils apply in 500–1000 L of water/ha as a band spray.	Annual ryegrass, barnyard grass, crowsfoot grass, innocent weed, liverseed grass, pigweed, potato weed, redshank, sowthistle, stinkgrass, summer grass, winter grass.	Soil must be free of weeds and trash and must have a fine tilth Apply at 500–1000 L of water/ha. Apply as a directed band spray, avoiding contact with fruit or foliage. In irrigated areas apply in early spring and follow with sprinkler irrigation to 5 cm soil depth within 10 days of application. In non-irrigated winter rainfall areas, apply late autumn/winter and mechanically incorporate, within 10 days. If rainfall exceeds 20 mm during this 10-day period, mechanical incorporation will be unnecessary.
Norflurazon 800 g/L (Unscheduled)	Zoliar 800 DF, Zoliar DF	F	Not required when used as directed	2.5 kg/ha	Annual ryegrass, barley grass, blackberry nightshade, brachiaria caltrop, cape weed, chickweed, common sowthistle, dandelion seedlings, curled dock seedlings, false caper seedlings, fat hen, Indian hedge mustard, spiny burgrass, medic, hedge mustards, paspalum, Paterson's curse, plantain seedlings, portulaca, prairie grass, prickly lettuce, great brome, scarlet pimpernel, shepherd's purse, silver grass, skeleton weed seedlings, sorrel seedlings, soursob, stinkgrass, stinking roger, sub. clover, summer grass, three-cornered jack, variegated thistle, wild oats, wild radish, wild turnip, winter grass, wireweed, witch grass, yellow weed, Yorkshire fog grass.	Apply using a boom spray to bare ground before weed emergence. Apply as a directed spray in 300–500 L water/ha Avoid contact with foliage or fruit. An application in early autumn will give winter weed control, or in early to mid-spring will give full summer weed control. Not recommended for grapes grown in sand or loamy sand soils with less than 1% organic matter and pH greater than 7.5, as veinal chlorosis might occur. Do not apply to nursery stock.
				5.0 kg/ha	Couch grass+, dandelion, curled dock, false caper, Johnson grass+, skeleton weed, sorrel, soursob + = suppression only	
				1.25 kg/ha ZOLIAR plus	Pigweed (*Portulaca*)	
				1.9 kg/ha ZOLIAR + 2.0 L/ha Simazine 500 g/L	Barnyard grass, clammy goosefoot, cobbler's pegs, green pigeon grass, redroot amaranth, summer grass, wireweed.	
Oryzalin 500 g/L (Unscheduled)	Surflan 500, Flowable Oryzalin Stonewall, Accensi Oryzalin, Ospray Oryzalin, Agricrop Prolan, Sharp Shooter, Rygel Oryzalin, Genfarm Oryzalin	D	Not required when used as directed	4.5 L/ha:up to 4 months' weed control 6.8 L/ha: 6–8 months' weed control Use 200–450 L water/ha	Grasses: barnyard grass, guinea grass, love grass, paradoxa grass, pigeon grass, spiny burr (gentle Annie/innocent weed), summer grass, crabgrass Broadleaf weeds: deadnettle, fat hen, fumitory, *Portulaca* (pigweed), sowthistle, wireweed (hogweed) *Brassica* spp., blackberry nightshade, caltrop, paddymelon, silver leaf. Nightshade controls many annual grasses and broadleaf weeds	Suitable for nurseries and newly planted and established vineyards. For best results, if irrigation or rain is not expected within 21 days after application, then mechanically incorporate into the top 2.5 cm of soil. Soil must be free of weeds, of good tilth, and firm.

Chemical	Trade names	Herbicide Group	WHP days	Rates	Weeds controlled	Comments
Oxyfluorfen 240 g/L (S5)	Goal, Point Herbicide, Striker	G	Not required when used as directed	Weed-free soil: 3–4 L/ha	Before germination: Amsinckia, barley grass, barnyard grass, blackberry nightshade, bladder ketmia, burrgrass, caltrop, cape weed, chickweed, crowsfoot grass, deadnettle, fat hen, giant pigweed, liverseed grass, lovegrass, pigeon grass, pigweed, prickly lettuce, red Natal grass, redshank, ryegrass, *Sesbania* pea, shepherd's purse, small flowered mallow, soursob, sow thistle, starburr, stinkgrass, summer grass, thornapple, white eye, wild mustard, wild radish, wireweed. Seedlings: Amsinckia, bellvine, cape weed common, cotula, crowsfoot grass deadnettle, groundsel, liverseed grass, pigweed, potato weed, redshank, shepherd's purse, sow thistle, stinging nettle, stinkgrass, wild radish.	Weed-free soil: apply to freshly worked, weed-free soil. Use the higher rate when longer residual control is required (up to 4 months). Where grass weeds are expected to be a major problem, or when control of a wider weed spectrum is required, mix the lower rate with 4.5 L Oryzalin 500 per treated hectare. Use the higher rate when longer residual activity (up to 4 months) is required. When young seedling grasses and/or broadleaf weeds are present, apply as a tank mix with certain post-emergent herbicides to produce both knockdown and residual control. A non-ionic surfactant should be used in the spray mixture at 100 mL/100 L. Mature, established weeds must be eliminated by mechanical or chemical means before application. See label for more details.
				Emerged weeds present (4–6 leaf stage)		Do not apply oxyfluorfen once bud swell has occurred. Use the higher rate when longer residual control is required (up to 4 months). When young seedling grasses and/or broadleaf weeds are present, apply as a tank mix with glyphosate or paraquat or diquat/paraquat to obtain both knockdown and residual control. A non-ionic surfactant such as BS-1000 should be used at 0.1% v/v. Where weed growth is large and dense, weeds must be eliminated before applying Oxyfluorfen, using chemical or mechanical means.
Pendimethalin (S5)	Argo 440EC, Cronos 440EC, Cyclone 330 EC, Fist 330, Panida Grande, Pendimethalin 330, Pendimethalin 330EC, Rifle 330, Rifle 440, Romper 440 EC, Stomp 440	D	Not required when used as directed	See label for directions	Annual ryegrass, asthma plant, barnyard grass, chickweed, caltrop, cobbler's Pegs, crowsfoot grass, deadnette, dwarf amaranth, fat hen, deadnettle, green amaranth, pigeon grass, pigweed, prickly lettuce, sowthistle, spotted medic, stinking roger, summer grass, winter grass, wireweed	Do not apply pendimethalin to grapevines after bud swell. Precaution: pendimethalin or pendimethalin plus simazine are likely to affect the emergence and growth of green manure crops if they are sown into the treated band within 12 months of application. Use the higher rate on medium to heavy textured soils and the lower rate on light textured soils. Use a directed spray avoiding spray contact with green bark, fruit and foliage. If applied to freshly transplanted trees or vines, soils should be compacted before pendimethalin application to avoid contact with roots. Pendimethalin must be incorporated by a minimum of 5 mm of rainfall or spray irrigation as soon as possible but no later than 10 days after application or weed control can be reduced. For best results, soil surface should be free of weeds, surface litter and clods at the time of application. If small weeds are present at the time of application, pendimethalin should be tank mixed with a knockdown herbicide at the recommended rate. Crop damage and/or reduced weed control can result if pendimethalin is not incorporated successfully.

Chemical	Trade names	Herbicide Group	WHP days	Rates	Weeds controlled	Comments
Simazine 500 g/L (Unscheduled)	Simazine 500, Simazine 500 Flowable, Simazine 500 SC, Gesatop 500 SC	C	Not required when used as directed	Boom 2.3–4.5 L/ha. Use 2.3 L/ha on sandy alkaline soils and 4.5 L/ha on heavy soils. In first year of use split applications are preferred.	Annual weeds and grasses: annual ryegrass, annual thistles, barley grass, bindy-eye, brome grass, cape weed, chickweed, common sowthistle, creeping oxalis, fat hen, geranium, ivy-leaf speedwell, nettles, potato weed, Powell's amaranth, redroot amaranth, redshank, shepherd's purse, slim amaranth, wild mustard, wild oats, winter grass, wireweed (not TAS) and suppression of soursob.	NOTE: most of the 500 g/L and 600 g/L products labels state 'grapevines must be established for 3 years' but please check the label. In the first year a split application is preferred. Normally apply to bare, moist soil before weed emergence. Damage might result from using high rates on sandy soils that are low in organic matter. Mechanical incorporation is not necessary, but for best results 13 mm rain or sprinkler irrigation is required within 2 weeks of application to give herbicide activity in soil.
Simazine 600 g/L (Unscheduled)	Gesatop 600 SC	C	Not required when used as directed	Boom: 1.9–3.8 L/ha Use 1.9 L/ha on sandy alkaline soils and 3.8 L/ha on heavy soils. In first year of use, split applications are preferred.		
Simazine 900 g/kg (Unscheduled)	Simazine 900 WDG, Simazine 900 WG, Simazine 900DF, Simanex 900 WG, SimaPhos 900, Simaquest 900 WG	C	Not required when used as directed	1.25 kg/ha for light soil 2.5 kg/ha for heavy soil		As for above BUT NOTE: most of the 900 g/L products labels state 'for vines established more than 12 months of age' or similar, but please check the label. In the first year split applications are preferred, e.g. use 2.2 kg/ha in July or August and 2.2 kg/ha in October. Warning: do not use on excessively sandy soils, as crop damage might occur.
Trifluralin 480 g/L (S5)	Trigen 480, Triflurex, Trifluralin 480, Tango 480	D	Not required when used as directed	1.2 L/ha for light soils 1.7 L/ha for medium soils 2.3 L/ha for heavy soils	Annual ryegrass, barnyard grass, canary grass, caltrop, crab grass, spiny burr grass, pigweed, redroot, redshank, summer grass, soil surface wild oats, winter grass, wireweed. From seed only: Columbus grass, guinea grass, Johnson grass, liverseed grass.	Mechanically incorporate into soil. New plantings: apply during pre-plant cultivation. Apply to established crops in spring after weeds and green manure crop has been ploughed into ground. Refer tp label for a suitable method of incorporation.

Table 3. Chemical desuckering: Non-selective post-emergent 'knockdown' herbicides registered in NSW for use in vineyards. Read the product label before use.

Chemical (Poisons Schedule)	Trade names	Rates	Weeds controlled	Comments
Carfentrazone-ethyl 240 g/L (Unscheduled)	Spotlight Plus	300 mL/100 L sprayed to point of run-off. A minimum volume of 50 L of spray solution per km of vine row (both sides sprayed) is recommended.	Controls unwanted suckers (water shoots) arising from the main stem or trunk.	Applying Spotlight Plus to suckers (water shoots) arising from the main stem will result in rapid burn down and extended regrowth control. Any regrowth might be less vigorous but could need a repeat application for season-long control. Suckers arising from pruned stubs or roots might be less well controlled. More vigorous varieties and grafted vines on vigorous rootstocks might need several applications depending on the growth conditions. Preferably apply with a fully shrouded sprayer designed for the purpose and targeting the basal 60 cm of the trunk. Air-induction, off-centre nozzles such as AirMix OC or similar are preferred to minimise the production of fine, driftable droplets. The optimum nozzle configuration is to have nozzles pointing forwards and backwards to ensure all surfaces of the shoots are sprayed. Use sufficient spray volume to ensure that the spray solution thoroughly wets the foliage and stems of unwanted suckers to the point of run-off.

The Australian Wine Research Institute

Agrochemicals registered for use in Australian viticulture

AN ESSENTIAL REFERENCE WHEN GROWING GRAPES FOR EXPORT WINE

16/17

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Contents

Growing grapes for export wine?… choose the right chemical

Governments around the world set limits for the amount of residue of a fungicide, insecticide or herbicide that is legally allowed in a food, such as grapes or wine. These limits for agrochemicals are commonly referred to as MRLs (maximum residue limits), and for Australia they are listed in the Australian New Zealand Food Standards Code.

Over the past year, Australian wineries have exported wine worth more than $1.96 billion, mostly to countries that have MRLs vastly different to, and sometimes lower than, those set by our own government. In fact, some chemicals commonly used by Australian grapegrowers do not have MRLs in some of our major export markets. Often this is because grapes are not grown commercially in these countries and, therefore, there is no need to register products for use on grapes. As a result no MRL is set, which means that the importing country will either not allow any detectable residue of the agrochemical in wine, or only permit 'safe' amounts of it.

To ensure that wine meets these requirements, it is necessary to restrict the application of certain chemicals or to avoid their use altogether. Since 1991, some wineries have provided their grapegrowers with a list of recommended fungicides and insecticides and the associated 'export harvest interval' (the minimum number of days between the last application and harvest). The export harvest interval is sometimes much longer than the withholding period stated on the chemical label, and it has been calculated to minimise the likelihood of residues affecting fermentation, affecting sales of the wine and to reduce the exposure of the public to agrochemicals.

The following tables list the preferred agrochemicals for use in the production of grapes for export wine, and any restriction on their use, for the 2016/2017 season. Some biological control agents are also listed. The recommendations have been developed to satisfy the lowest MRL for any of Australia's major wine markets after considering available data on the persistence of the chemical, both on grapes and through winemaking. Many of these data were gathered as a result of a large, multi-agency research effort, funded by Wine Australia and the Dried Fruits Research and Development Council. A list of current MRLs and supporting information can be obtained by visiting the AWRI's website: www.awri.com.au, or by contacting the AWRI helpdesk on telephone (08) 8313 6600.

If you are a member of the Australian wine industry and would like to receive email notices from the AWRI on technical issues, including agrochemicals, please visit www.awri.com.au to subscribe to eBulletins.

1 AGROCHEMICALS REGISTERED FOR USE IN AUSTRALIAN VITICULTURE

AWRI Agrochemical search app and online search facility

The AWRI agrochemicals online search facility and agrochemical search app allows the user to rapidly access information contained in the current *Agrochemicals registered for use in Australian viticulture* booklet (often called the 'Dog Book'). These tools also contain additional information derived from the AWRI database i.e. they allow the user to search for products registered for use on targets that are not listed in the Agrochemical booklet. Visit www.awri.com.au/agrochemicals/ or scan the QR code below to download the app.

Apple iTunes  Google play 

Frequently asked questions

Why does The Australian Wine Research Institute recommend that the application of some products (for example Scala) be restricted to before 80% capfall?

The recommendations in the tables have been developed to satisfy the lowest maximum residue limit (MRL) for any of Australia's major wine markets after considering available data on the persistence of the agrochemical, both on grapes and through winemaking.

In the case of Scala (pyrimethanil), it is known that if it is sprayed onto grapes after 80% capfall, residues might be detectable in the resultant wine. Some of the markets to which Australia exports wine have a very low MRL for pyrimethanil, or alternatively, have not announced their position on the course of action they would take if pyrimethanil was detected in wine. To ensure that Australian wine meets MRLs set by all of these markets, the 80% capfall restriction is suggested.

Are there exceptions to these restrictions?

Yes. Products may be used closer to harvest than the suggested restriction period in consultation with the winery/grape purchaser.

A winery may choose to ignore the restriction if the wine made from the grapes will be sold in Australia alone, or to an export market that has an MRL greater than the expected residue or if the market otherwise permits residues of the agrochemical. In this case, the label withholding period is the minimum delay that should be observed between spraying the grapes and harvest.

Can I use a product that is not listed?

Yes. Provided that it is in consultation with your winery and used according to the label specifications.

Important points

- GRAPEVINE GROWTH-STAGE CAN BE VARIABLE ACROSS A BLOCK. WHEN ASSESSING GRAPEVINE PHENOLOGY FOR THE PURPOSE OF APPLYING AGROCHEMICALS, BASE THE ASSESSMENT ON THE **MOST ADVANCED VINES** IN THE BLOCK TO MINIMISE THE POSSIBILITY OF RESIDUES AT HARVEST.
- To accurately identify the grapevine growth stage, use the chart on page 13. For more information consult Coombe, B. 1995. Adoption of a system for identifying grapevine growth stages. *Aust. J. Grape and Wine Res.* 1:104-110. The chart can also be downloaded from the AWRI website.
- Ask your winery if they have specific chemical recommendations. These might differ from the recommendations suggested below.
- When spraying, ensure that the amount of chemical applied never exceeds the rate specified on the manufacturer's label (unless otherwise specified).
- If you are unable to keep to these recommendations, or if you need to spray closer than 30 days before harvest, contact your winery or The Australian Wine Research Institute for advice.
- Avoid spraying some types of foliar fertilisers closer than 60 days before harvest, as wine quality might be affected.
- Always read the label on the chemical container. The products mentioned in the table might not necessarily be registered for use in your state.
- Keep a record of agrochemical applications. Some wineries might not accept delivery of grapes without receipt of a signed spray diary from the producer. An industry-accepted spray diary template can be downloaded from the AWRI agrochemical website www.awri.com.au/industry_support/viticulture/agrochemicals/
- These recommendations have been developed as a general guide and assume that the wine will be sent to a range of overseas markets, each with differing MRLs. If you only sell wine in Australia, or to only a few countries, contact The Australian Wine Research Institute to discuss how the recommendations might differ. The AWRI can also provide advice regarding the persistence of a chemical on grapes or through winemaking, and MRLs for most major export destinations.

How to use the following table

Active constituent	Activity group	Some registered products	Restriction on use
Grouped alphabetically within each restriction	Australian agrochemical codes	List of some chemical products available	The recommended withholding period

Recommendations

Active constituent	Activity group	Some registered products	Restriction on use
BLACK SPOT			
captan[1]	M4	Captan, Captan 800 WG, Captan 900 WG, Captan WG	Not recommended for use on grapes destined for export wines.
captan[1] + metalaxyl	M4 + 4	Duplex WG	
benalaxyl + mancozeb	4 + M3	Galben M	Use no later than 80% capfall.
metiram	M3	Polyram DF	
thiram	M3	Thiragranz, Thiram 800 WG	
ziram	M3	Ziragranz, Ziram DG, Ziram Granuflo	
chlorothalonil	M5	Applonil 720, Barrack 720, Barrack Betterstick, Bravo 720, Bravo Weather Stik, Cavalry Weatherguard, Cheers 720, Cheers 720 Weathershield, Chemtura Chlorothalonil, Chlornil 720 SC, Chloro 720, Chloronil Pro, Chlorothalonil 720, Chlorothalonil 900 WG, Conan Sticks 720SC, Echo 720, Echo 900 WDG, Elect 500, Fung-o-nil 500, Unite 720, Whack 720, Whack 900 WG	Use no later than E-L 29, berries pepper-corn size (4 mm diameter).
copper hydroxide + mancozeb	M1 + M3	ManKocide DF	Use no later than 30 days before harvest.
copper oxychloride	M1	Copper Oxychloride WP, Oxydul DF	
dithianon	M9	Delan 700 WG, Dinon 700 WG, Dragon 700 WG	
mancozeb	M3	Choice Mancozeb 750 WG, Dithane Rainshield Neo Tec, Fortuna Globe 750WG, innova Mancozeb 750, Kencozeb 750DF, Mancoflo, Mancozeb 750 DF, Mancozeb 750 WG, Mancozeb DF, Manic WG, Manzate DF, Manzeb, Penncozeb 750DF, Sinozeb Xtend 750 DF, UniZeb 750 DF	
BOTRYTIS BUNCH ROT*			
boscalid[1]	7	Filan	Not recommended for use on grapes destined for export wines.
captan[1]	M4	Captan, Captan 800 WG, Captan 900 WG, Captan WG	
captan[1] + metalaxyl	M4 + 4	Duplex WG	
fenhexamid	17	Teldor 500 SC	Use no later than 80% capfall.
fenpyrazamine	17	Prolectus	
pyrimethanil[2]	9	Predict 600SC, Protector 400SC, Pyrus 400 SC, Scala 400 SC	
azoxystrobin	11	Affix 250SC, Amistar 250 SC, Avior 800 WG, Azaka, Azoxystrobin 250, Azoxystrobin 250 SC, Azoxystrobin 500 WG, Connect 800 WG, Mirador 250 SC, Spartacus 250 SC, Spartacus 500WG, Supernova 250SC	Use no later than E-L 29, berries pepper-corn size (4 mm diameter).

* Review resistance management strategies on pages 23 to 26.

1. Contact your winery or grape purchaser prior to the application of any captan or boscalid spray.
2. Apply no more than 800 g active per hectare (maximum 2 L of 400 SC and 1.33 L of 600SC formulations).

Active constituent	Activity group	Some registered products	Restriction on use
BOTRYTIS BUNCH ROT* *(CONT.)*			
chlorothalonil	M5	Applonil 720, Barrack 720, Barrack Betterstick, Bravo 720, Bravo Weather Stik, Cavalry Weatherguard, Cheers 720, Cheers 720 Weathershield, Chemtura Chlorothalonil, Chlornil 720 SC, Chloro 720, Chloronil Pro, Chlorothalonil 720, Chlorothalonil 900 WG, Conan Sticks 720SC, Echo 500SC, Echo 720, Echo 900 WDG, Elect 500, Fung-o-nil 500, Unite 720, Whack 720, Whack 900 WG	Use no later than E-L 29, berries pepper-corn size (4 mm diameter).
tebuconazole + azoxystrobin	3 + 11	Custodia	
cyprodinil[3]	9	Solaris 300 EC	Use no later than E-L 29, berries pepper-corn size (4 mm diameter). Do not use within 60 days of harvest.
cyprodinil + fludioxonil[3]	9 + 12	Switch	
potassium salts of fatty acids	U1	Ecoprotector	Use no later than 14 days before harvest.
hydrogen peroxide + peroxyacetic acid (suppression only)	M + M	Peracetic Acid, Peratec, Peratec PLUS, Peroxy Treat	Use no later than 7 days before harvest.
iprodione	2	Aquaflow 500 SC, Chief 250 Liquid, Chief Aquaflo, Corvette Flowable, Corvette Liquid, Ippon 500 Aquaflo, Ipral 250, Iprine 250, Iprine 500, Iprodex 250, Iprodione 250, Iprodione Aquaflow 500, Iprodione Liquid 250, Rovral Aquaflo, Rovral Liquid, Shelby 250, Sindon 500 SC, Sinpro 500 SC, Subscribe, Transact	Use no later than 7 days before harvest. Consult your winery/ grape purchaser before spraying within 30 days of harvest.
DOWNY MILDEW*			
captan[4]	M4	Captan, Captan 800 WG, Captan 900 WG, Captan WG	Not recommended for use on grapes destined for export wines.
captan[4] + metalaxyl	M4 + 4	Duplex WG	
phosphorous acid[4]	33	Agri-Fos 600, ChemPhos 400, Phospot 400, Phospot 400 pH 7.2, Phospot 600, Dominator 600, Fungacid 600, Fungi-Fos 400, Fungi-Fos 400 pH 7.2, Grow-Phos 600, Phos Phyt 400, Sprayphos 400, Sprayphos 600, Sprayphos 620, Throw Down, Throw Down 600	
ametoctradin + dimethomorph	45 + 40	Zampro	Use no later than 80% capfall.
benalaxyl + mancozeb	4 + M3	Galben M	
dimethomorph	40	Acrobat SC, Downright, Sphinx	
metiram	M3	Polyram DF	
oxadixyl + propineb	4 + M3	Rebound WP	

* Review resistance management strategies on pages 23 to 26.

3. Do not apply Solaris 300 EC or Switch at both flowering and growth stage E-L 29.
4. Contact your winery or grape purchaser prior to the application of any captan or phosphorous acid spray.

Active constituent	Activity group	Some registered products	Restriction on use
DOWNY MILDEW* *(CONT.)*			
zineb	M3	Zineb	Use no later than 80% capfall.
mandipropamid	40	Revus	Use no later than E-L 26 (capfall complete).
azoxystrobin	11	Affix 250SC, Amistar 250 SC, Avior 800 WG, Azaka, Azoxystrobin 250, Azoxystrobin 250 SC, Azoxystrobin 500 WG, Connect 800 WG, Mirador 250 SC, Spartacus 250 SC, Spartacus 500WG, Supernova 250SC	Use no later than E-L 29, berries pepper-corn size (4 mm diameter).
chlorothalonil	M5	Applonil 720, Barrack 720, Barrack Betterstick, Bravo 720, Bravo Weather Stik, Cavalry Weatherguard, Cheers 720, Cheers 720 Weathershield, Chemtura Chlorothalonil, Chlornil 720 SC, Chloro 720, Chloronil Pro, Chlorothalonil 720, Chlorothalonil 900 WG, Conan Sticks 720SC, Echo 500SC, Echo 720, Echo 900 WDG, Elect 500, Fung-o-nil 500, Unite 720, Whack 720, Whack 900 WG	
tebuconazole + azoxystrobin	3 + 11	Custodia	
amisulbrom + tribasic copper sulphate	21 + M1	Amicus Blue	Use no later than E-L 31, berries pea-size (7 mm diameter).
trifloxystrobin	11	Flint 500 WG (suppression only)	
pyraclostrobin	11	Cabrio, Cabrio WG	Use no later than E-L 31, berries pea-size (7 mm diameter). Do not use within 63 days of harvest.
copper ammonium acetate	M1	Cop-IT	Use no later than 30 days before harvest.
copper ammonium complex	M1	Copperguard, Liquicop	
copper cuprous oxide	M1	Ag Copp 750, Nordox 750 WG, Red Copper WG	
copper hydroxide	M1	Blue Shield DF, Champ Dry Prill WG, Flo-Bordo, Hydrocop, Kocide Blue Xtra, Kocide Opti, Vitra 400 WG	
copper hydroxide + mancozeb	M1 + M3	ManKocide DF	
copper octanoate	M1	Tricop	
copper oxychloride	M1	Copper Oxychloride, Copper Oxychloride 500 WP, Copper Oxychloride WP, Coppox WG, Coppox WP, Neoram 375 WG, Oxydul DF, Uni-Guard 500 WP	
copper sulphate tribasic	M1	Bordeaux WG, Cuprofix Disperss, Tri-Base Blue, Tribasic Liquid	
copper sulphate tribasic + mancozeb	M1 + M3	Copman DF, Novofix Disperss	
dithianon	M9	Delan 700 WG, Dinon 700 WG, Dragon 700 WG	

* Review resistance management strategies on pages 23 to 26.

Active constituent	Activity group	Some registered products	Restriction on use
DOWNY MILDEW* *(CONT.)*			
mancozeb	M3	Choice Mancozeb 750 WG, Dithane Rainshield Neo Tec, Fortuna Globe 750WG, innova Mancozeb 750, Kencozeb 750DF, Mancoflo, Mancozeb 750 DF, Mancozeb 750 WG, Mancozeb DF, Manic WG, Manzate DF, Manzeb, Penncozeb 420 SC, Penncozeb 750DF, Sinozeb Xtend 750 DF, UniZeb 750 DF	Use no later than 30 days before harvest.
metalaxyl - M + copper hydroxide	4 + M1	Ridomil Gold Plus	
metalaxyl - M + mancozeb	4 + M3	Ridomil Gold MZ WG	
metalaxyl + copper oxychloride	4 + M1	Axiom Plus, Copper Plus, Medley Plus, Metalaxyl + Copper Oxychloride WP, Zeemil Plus	
metalaxyl + mancozeb	4 + M3	Axiom MZ 720, Max MZ, Maxyl, Medley MZ, Metal-Man MZ 720, Zeemil 720WG, Zeemil MZB 720 WP	
sulfur + copper oxychloride	M2 + M1	Mildex WG	
hydrogen peroxide + peroxyacetic acid (suppression only)	M + M	Peratec PLUS	Use no later than 7 days before harvest.
EUTYPA DIEBACK			
cyproconazole + iodocarb	3 + 28	Garrison Rapid	Dormancy spray only.
fluazinam	29	Emblem	
tebuconazole	3	Gelseal, Greenseal	
Trichoderma herzianum	NA	Vinevax Bio-Implants, Vinevax Wound Dressing	
PHOMOPSIS CANE AND LEAF SPOT			
captan[5]	M4	Captan, Captan 800 WG, Captan 900 WG, Captan WG	Not recommended for use on grapes destined for export wines.
captan[5] + metalaxyl	M4 + 4	Duplex WG	
fluazinam	29	Emblem, Gem[6], Shirlan[6]	Dormancy spray only.
metiram	M3	Polyram DF	Use no later than 80% capfall.
copper sulphate tribasic + mancozeb	M1 + M3	Novofix Disperss	Use no later than 30 days before harvest.
dithianon	M9	Delan 700 WG, Dinon 700 WG, Dragon 700 WG	
mancozeb	M3	Choice Mancozeb 750 WG, Dithane Rainshield NeoTec, Fortuna Globe 750WG, innova Mancozeb 750, Kencozeb 750 DF, Mancoflo, Mancozeb 750 DF, Mancozeb 750 WG, Mancozeb DF, Manic WG, Manzate DF, Manzeb, Penncozeb 420 SC, Penncozeb 750DF, Sinozeb Xtend 750 DF, UniZeb 750 DF	

* Review resistance management strategies on pages 23 to 26.

5. Contact your winery or grape purchaser prior to the application of any captan spray.

6. Gem and Shirlan have a 32 day re-entry period.

Active constituent	Activity group	Some registered products	Restriction on use
POWDERY MILDEW*			
boscalid[7]	7	Filan	Not recommended for use on grapes destined for export wines.
hexaconazole	3	Viva	Use no later than 80% capfall.
metrafenone	U8	Vivando	
spiroxamine	5	Prosper 500 EC	
sulfur, present as elemental or crystalline sulfur	M2	Dusting Sulphur, Dusting Sulphur 900	Use no later than 12 weeks before harvest.
azoxystrobin	11	Affix 250SC, Amistar 250 SC, Avior 800 WG, Azaka, Azoxystrobin 250, Azoxystrobin 250 SC, Azoxystrobin 500 WG, Connect 800 WG, Mirador 250 SC, Spartacus 250 SC, Spartacus 500WG, Supernova 250SC	Use no later than E-L 29, berries pepper-corn size (4 mm diameter).
sulfur + tebuconazole	M2 + 3	Unicorn 745WG	
tebuconazole	3	Buzz Ultra 750WG, Folicur 430 SC, Laguna Xtreme 800 WG, Launch, Orius 430 SC, Zolo 430 SC	
tebuconazole + azoxystrobin	3 + 11	Custodia	
cyflufenamid	U6	Flute 50 EW	Use no later than E-L 31, berries pea-size (7 mm diameter).
paraffinic oil	n/a	BioPest	
pyriofenone	U8	Kusabi 300 SC	
trifloxystrobin	11	Flint 500 WG	
pyraclostrobin	11	Cabrio, Cabrio WG	Use no later than E-L 31, berries pea-size (7 mm diameter). Do not use within 63 days of harvest.
penconazole	3	Azotic, Delos, Pearl, Ruby 100EC, Topas 100 EC	Use no later than E-L 31, berries pea-size (7 mm diameter). Do not use within 60 days of harvest.
tetraconazole	3	Domark 40ME, Mettle 40ME	
quinoxyfen	13	Legend, Quinfen 250 SC	Use no later than E-L 34 (before commencement of veraison). Do not use within 42 days of harvest.
triadimefon	3	Slingshot, Triadimefon 125	Use no later than 35 days before harvest.
triadimenol	3	Allitron, Bayfidan 250 EC, Citadel, Triadimenol 250 EC, Tridim 250 EC	

* Review resistance management strategies on pages 23 to 26.

7. Contact your winery or grape purchaser prior to the application of any boscalid spray.

Active constituent	Activity group	Some registered products	Restriction on use
POWDERY MILDEW* *(CONT.)*			
copper ammonium acetate	M1	Cop-IT	Use no later than 30 days before harvest.
copper ammonium complex	M1	Copperguard, Liquicop	
myclobutanil	3	Mycloss Xtra	
proquinazid	13	Talendo	
sulfur, present as elemental or crystalline sulfur	M2	Chemtura Sulphur WG, Cosamil, Cosavet WG, David Grays Sulphur Spray, Flosul 800, GranuSulf 800 WG, InnoSulph 800 WG, Kendon Sulphur, Kumulus DF, Microsul WG Elite, Microthiol Disperss, Notion, Rutec Sulfur, Solo 800WG, Sulfostar DF, Sulfur 800 WG, Sulgran WG, Sulphur 800 WG, Thiovit Jet, Top Wettable Sulphur, Uni-Shield, Wettable Sulphur	
sulfur + copper oxychloride	M2 + M1	Mildex WG	
hydrogen peroxide + peroxyacetic acid (suppression only)	M + M	Peratec PLUS	Use no later than 7 days before harvest.
potassium bicarbonate	M2	Ecocarb	
AUSTRALIAN PLAGUE LOCUST			
Metarhizium anisopliae var. *acridum*	n/a	Green Guard SC, Green Guard SC Premium	Use no later than 7 days before harvest.
BUD MITE			
sulfur, present as polysulfide	M2	Lime Sulphur	Apply as near as possible to budburst.
sulfur, present as elemental or crystalline sulfur	M2	Chemtura Sulphur WG, Cosamil, Cosavet WG, GranuSulf 800 WG, InnoSulph 800 WG, Kumulus DF, Microsul WG Elite, Microthiol Disperss, Notion, Solo 800WG, Sulfostar DF, Sulfur 800 WG, Sulgran WG, Sulphur 800 WG, Thiovit Jet, Top Wettable Sulphur, Uni-Shield, Wettable Sulphur	Use no later than 30 days before harvest.
BUNCH MITE			
sulfur, present as polysulfide	M2	Lime Sulphur	Apply as near as possible to budburst.
sulfur, present as elemental or crystalline sulfur	M2	Chemtura Sulphur WG, Cosamil, Cosavet WG, GranuSulf 800 WG, InnoSulph 800 WG, Microsul WG Elite, Sulfur 800 WG, Sulgran WG, Sulphur 800 WG, Thiovit Jet, Wettable Sulphur	Use no later than 30 days before harvest.

* Review resistance management strategies on pages 23 to 26.

Active constituent	Activity group	Some registered products	Restriction on use
GARDEN WEEVIL			
indoxacarb	22A	Avatar	Use no later than E-L 31, berries pea-size (7 mm diameter). Do not use within 56 days of harvest.
GRAPE LEAF BLISTER MITE			
paraffinic oil	n/a	Heavy Paraffinic Dormant Spray Oil	Dormancy spray only.
petroleum oil	n/a	Stifle, Vicol Winter Oil	
sulfur, present as polysulfide	M2	Lime Sulphur	Apply as near as possible to budburst.
sulfur, present as elemental or crystalline sulfur	M2	Chemtura Sulphur WG, Cosamil, Cosavet WG, David Grays Sulphur Spray, Flosul 800, GranuSulf 800 WG, InnoSulph 800 WG, Kendon Sulphur, Kumulus DF, Microsul WG Elite, Microthiol Disperss, Notion, Rutec Sulfur, Solo 800WG, Sulfostar DF, Sulfur 800 WG, Sulgran WG, Sulphur 800 WG, Thiovit Jet, Top Wettable Sulphur, Uni-Shield, Wettable Sulphur	Use no later than 30 days before harvest.
GRAPE LEAF RUST MITE			
sulfur, present as polysulfide	M2	Lime Sulphur	Apply as near as possible to budburst.
sulfur, present as elemental or crystalline sulfur	M2	Chemtura Sulphur WG, Cosamil, Cosavet WG, Flosul 800, GranuSulf 800 WG, InnoSulph 800 WG, Kendon Sulphur, Kumulus DF, Microsul WG Elite, Microthiol Disperss, Notion, Rutec Sulfur, Solo 800WG, Sulfostar DF, Sulfur 800 WG, Sulgran WG, Sulphur 800 WG, Thiovit Jet, Top Wettable Sulphur, Uni-Shield, Wettable Sulphur	Use no later than 30 days before harvest.
GRAPEVINE MOTH			
chlorantraniliprole	28	Altacor	Use no later than 80% capfall.
spinetoram	5	Delegate	Use no later than E-L 31, berries pea-size (7 mm diameter).
emamectin	6	Proclaim, Warlock	Use no later than E-L 31, berries pea-size (7 mm diameter). Do not use within 56 days of harvest.
indoxacarb	22A	Avatar	
Bacillus thuringiensis subspecies *aizawai*	11	Bacchus WG	May be used until harvest.
Bacillus thuringiensis subspecies *kurstaki*	11	Delfin, DiPel DF	
Trichogrammanza carverae	n/a	Trichogramma parasitic wasp	

Active constituent	Activity group	Some registered products	Restriction on use
GRAPEVINE SCALE[8]			
paraffinic oil	n/a	Bioclear, BioPest, Heavy Paraffinic Dormant Spray Oil, Trump Spray Oil	Dormancy spray only.
petroleum oil	n/a	All Seasons White Oil, D-C-Tron Plus Spray Oil, Sacoa Summer Spray Oil, Stifle, Vicol Summer Oil, Vicol Winter Oil	
spirotetramat (suppression only)	23	Movento 240 SC	Use no later than E-L 18.
LIGHT BROWN APPLE MOTH			
chlorantraniliprole	28	Altacor	Use no later than 80% capfall.
methoxyfenozide	18	Prodigy	
spinetoram	5	Delegate	Use no later than E-L 31, berries pea-size (7 mm diameter).
emamectin	6	Proclaim, Warlock	Use no later than E-L 31, berries pea-size (7 mm diameter). Do not use within 56 days of harvest.
indoxacarb	22A	Avatar	
Bacillus thuringiensis subspecies *aizawai*	11	Bacchus WG,	May be used until harvest.
Bacillus thuringiensis subspecies *kurstaki*	11	Delfin, DiPel DF	
tetradecenyl acetate + tetradecadienyl acetate	n/a	Isomate LBAM Plus Pheromone, MD LBAM Corto, MD LBAM Flex Pheromone, MD LBAM Pheromone	
Trichogrammanza carverae	n/a	Trichogramma parasitic wasp	
MEALYBUG[9]			
paraffinic oil	n/a	Bioclear, BioPest, Trump Spray Oil	Dormancy spray only.
spirotetramat	23	Movento 240 SC	Use no later than E-L 18.
buprofezin	16	Applaud, Scale & Bug, Strident	Use no later than 80% capfall.
MEDITERRANEAN/QUEENSLAND FRUIT FLY			
A baiting program that does not target fruit or foliage is recommended.			
Control options for fruit fly are subject to APVMA permit conditions.			
Contact your winery or grape purchaser prior to any 1A, 1B, 2B or 3A insecticide.			

8. Some group 1B insecticides are registered for grapevine scale. Contact your winery or grape purchaser prior to any 1B insecticide application.

9. Consult product label, registration may apply to specific mealybug species.

Active constituent	Activity group	Some registered products	Restriction on use
SNAIL			
copper complex	n/a	Escar-go, Socusil	Dormancy spray only.
metaldehyde	n/a	Meta (pellets), Metarex Snail and Slug bait, Pestmaster Snail and Slug pellets, Slug Out (bait), Slugger Slug and Snail pellets	Ground application only. Use no later than 7 days before harvest.
iron EDTA complex	n/a	Multiguard Snail and Slug Killer	Ground application only. May be used until harvest.
TWO SPOTTED MITE			
petroleum oil	n/a	Stifle	Dormancy spray only.
sulfur, present as polysulfide	M2	Lime Sulphur	Apply as near as possible to budburst.
sulfur, present as elemental or crystalline sulfur	M2	Chemtura Sulphur WG, Cosamil, Cosavet WG, GranuSulf 800 WG, InnoSulph 800 WG, Microsul WG Elite, Sulfur 800 WG, Sulgran WG, Sulphur 800 WG, Thiovit Jet	Use no later than 30 days before harvest.
etoxazole	10B	ParaMite	Use no later than 21 days before harvest
WINGLESS GRASSHOPPER			
indoxacarb	22A	Avatar	Use no later than E-L 31, berries pea-size (7 mm diameter). Do not use within 56 days of harvest.
Metarhizium anisopliae var. *acridum*	n/a	Green Guard SC, Green Guard SC Premium	Use no later than 7 days before harvest.

Growth stage description

GROWTH STAGE ASSESSMENTS ARE **NOT** AN AVERAGE ACROSS THE VINEYARD. BASE ALL GROWTH STAGE ASSESSMENTS ON THE **MOST ADVANCED VINES** IN THE BLOCK.

Budburst: When the first green tips are visible (E-L 4).

E-L 18: 14 leaves separated, flower caps still in place, but cap colour fading from green.

5% capfall: E-L stage 19-20; flowers have just begun to open and the first caps have lifted and fallen off. No developing berries present.

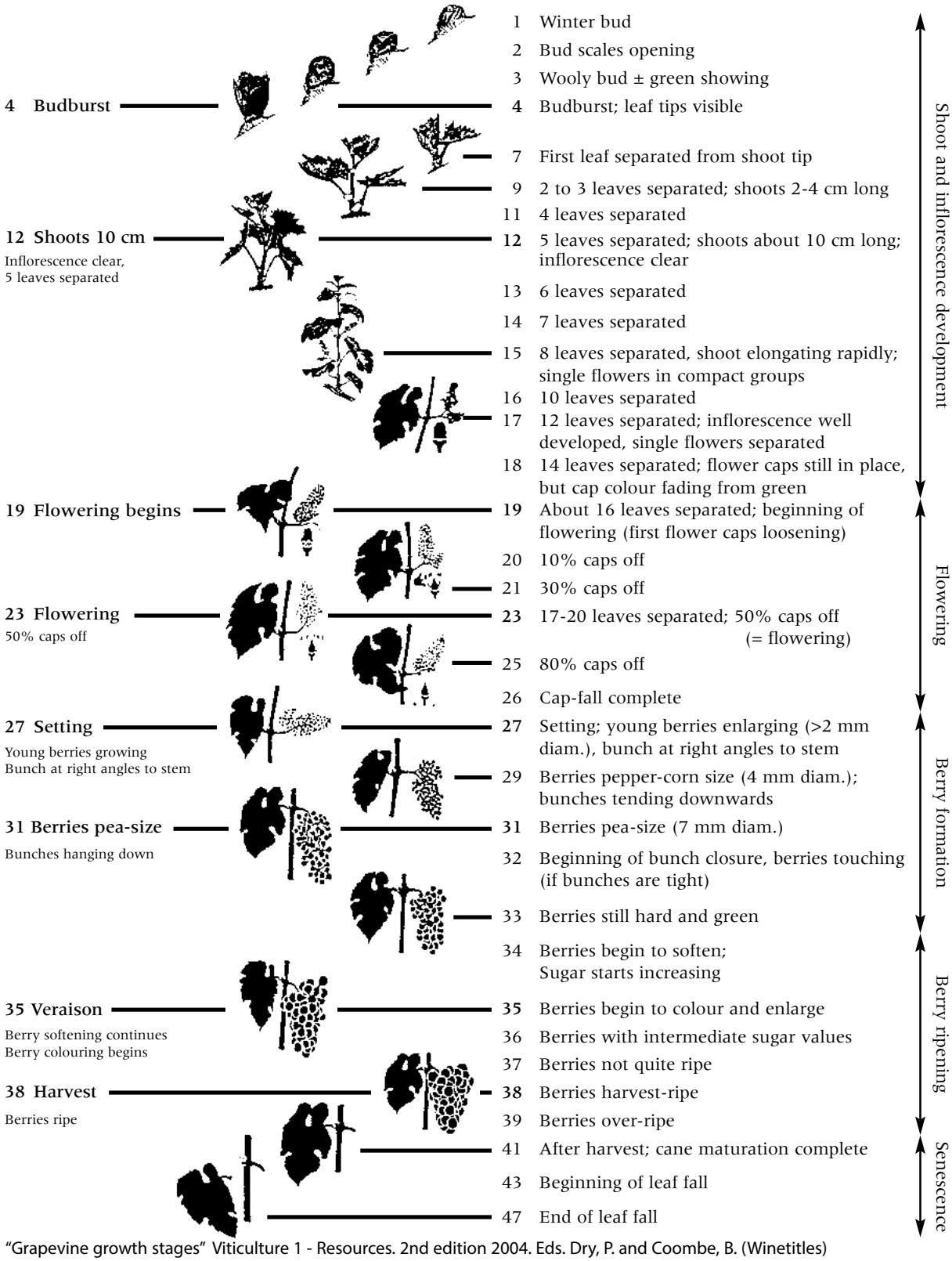
80% capfall: E-L stage 25; 80% of caps have just lifted and the largest berries are no more than 2 mm in diameter.

E-L 29: Just after berry set, berries peppercorn size (4 mm diameter); bunches tending downwards.

Pre-bunch closure: E-L stage 31; berries have reached pea-size (7 mm diameter); bunches hanging down**.**

Veraison: E-L stage 35; when 50% of berries begin to soften and sugar starts increasing.

Grapevine growth stage table



"Grapevine growth stages" Viticulture 1 - Resources. 2nd edition 2004. Eds. Dry, P. and Coombe, B. (Winetitles)

Agrochemicals registered for use in Australian viticulture

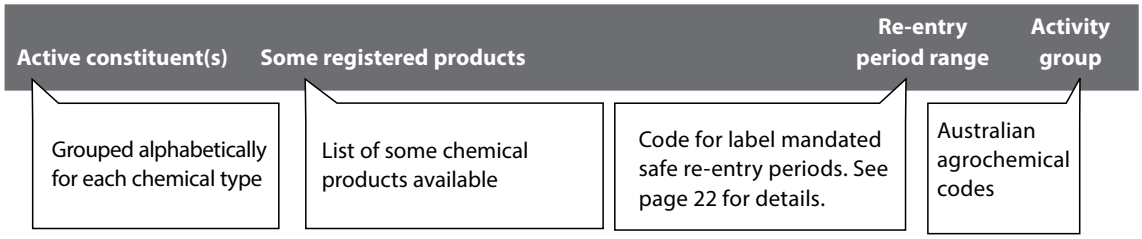
The following products are registered by the Australian Pesticides and Veterinary Medicines Authority for use in wine-grape production in Australia. Always read the label on the chemical container as the products listed in the table might not necessarily be registered for use in your state.

To avoid the development of chemical resistance, it is necessary to know how the product works. Most chemicals have been allocated an 'activity group' based on their mode of action. The activity group appears on the product label as a number (or letter and number) for fungicides, a letter for herbicides and a number and letter or only a letter in the case of insecticides and miticides. Sometimes the resistance management strategy is also shown on the label. Management strategies to avoid the development of fungicide resistance have been published by CropLife Australia, and are described on page 23. More information regarding activity groups can be found on the CropLife Australia website: www.croplifeaustralia.org.au

In the past, the export restriction on use for many of the insecticides listed in the table below has not been provided. Due to international pressures, the use of agrochemicals belonging to chemical groups such as the organophosphates and carbamates is not encouraged. The recommended restriction on use for all 1A, 1B, 2B, 4A and 4C insecticides listed in this booklet is 'Use no later than 80% capfall'. In addition, it is recommended that any 3A insecticides that are not restricted to use during dormancy only (label withholding period), should not be used later than 80% capfall. However, it is essential that you contact your winery/grape purchaser prior to the application of any 1A, 1B, 2B, 3A, 4A or 4C insecticide.

The CropLife resistance management strategies on page 23 are a guide only and do not endorse particular products, groups of products or cultural methods in terms of their performance. Always follow the product label for specific use instructions. While all effort has been taken with the information supplied in this document, no responsibility, actual or implied, is taken for the day to day accuracy of product or active constituent specific information. Readers should check with the Australian regulator's (APVMA) product database for contemporary information on products and actives. The database can be sourced through www.apvma.gov.au. The information given in the resistance management strategies is provided in good faith and without any liability for loss or damage suffered as a result of its application and use.

How to use the following table



Active constituent(s)	Some registered products	Re-entry period	Activity group
FUNGICIDE			
ametoctradin + dimethomorph	Zampro	*	45 + 40
amisulbrom + tribasic copper sulphate	Amicus Blue	g	21 + M1
azoxystrobin	Affix 250SC, Amistar 250 SC, Avior 800 WG, Azaka, Azoxystrobin 250, Azoxystrobin 250 SC, Azoxystrobin 500 WG, Connect 800 WG, Mirador 250 SC, Spartacus 250 SC, Spartacus 500WG, Supernova 250SC	* - l	11
benalaxyl + mancozeb	Galben M	*	4 + M3
boscalid	Filan	*	7
captan	Captan, Captan 800 WG, Captan 900 WG, Captan WG	* - i	M4
captan + metalaxyl	Duplex WG	d	M4 + 4
chlorothalonil	Applonil 720, Barrack 720, Barrack Betterstick, Bravo 720, Bravo Weather Stik, Cavalry Weatherguard, Cheers 720, Cheers 720 Weathershield, Chemtura Chlorothalonil, Chlornil 720 SC, Chloro 720, Chloronil Pro, Chlorothalonil 720, Chlorothalonil 900 WG, Conan Sticks 720SC, Echo 500SC, Echo 720, Echo 900 WDG, Elect 500, Fung-o-nil 500, Unite 720, Whack 720, Whack 900 WG	*	M5
copper ammonium acetate	Cop-IT	*	M1
copper ammonium complex	Copperguard, Liquicop	*	M1
copper cuprous oxide	Ag Copp 750, Nordox 750 WG, Red Copper WG	*	M1
copper hydroxide	Blue Shield DF, Champ Dry Prill WG, Flo-Bordo, Hydrocop, Kocide Blue Xtra, Kocide Opti, Vitra 400 WG	*	M1
copper hydroxide + mancozeb	ManKocide DF	*	M1 + M3
copper octanoate	Tricop	*	M1
copper oxychloride	Copper Oxychloride, Copper Oxychloride 500 WP, Copper Oxychloride WP, Coppox WG, Coppox WP, Neoram 375 WG, Oxydul DF, Uni-Guard 500 WP	*	M1
copper sulphate tribasic	Bordeaux WG, Cuprofix Disperss, Tri-Base Blue, Tribasic Liquid	*	M1
copper sulphate tribasic + mancozeb	Copman DF, Novofix Disperss	* - b	M1 + M3
cyflufenamid	Flute 50 EW	*	U6
cyproconazole + iodocarb	Garrison Rapid pruning wound dressing	*	3 + 28
cyprodinil	Solaris 300 EC	*	9
cyprodinil + fludioxonil	Switch	*	9 + 12
dimethomorph	Acrobat SC, Downright, Sphinx	*	40

Active constituent(s)	Some registered products	Re-entry period	Activity group
FUNGICIDE *(CONT.)*			
dithianon	Delan 700 WG, Dinon 700 WG. Dragon 700 WG	*	M9
fenhexamid	Teldor 500 SC	*	17
fenpyrazamine	Prolectus	*	17
fluazinam	Emblem, Gem, Shirlan	* - n	29
hexaconazole	Viva	*	3
hydrogen peroxide + peroxyacetic acid	Peracetic Acid, Peratec, Peratec PLUS, Peroxy Treat	*	M + M
iprodione	Aquaflow 500 SC, Chief 250 Liquid, Chief Aquaflo, Corvette Flowable, Corvette Liquid, Ippon 500 Aquaflo, Ipral 250, Iprine 250, Iprine 500, Iprodex 250, Iprodione 250, Iprodione Aquaflow 500, Iprodione Liquid 250, Rovral Aquaflo, Rovral Liquid, Shelby 250, Sindon 500 SC, Sinpro 500 SC, Subscribe, Transact	*	2
mancozeb	Dithane Rainshield Neo Tec, Fortuna Globe 750WG, innova Mancozeb 750, Kencozeb 750DF, Mancoflo, Mancozeb 750 DF, Mancozeb 750 WG, Mancozeb DF, Manic WG, Manzate DF, Manzeb, Penncozeb 420 SC, Penncozeb 750DF, Sinozeb Xtend 750 DF, UniZeb 750 DF	*	M3
mandipropamid	Revus	*	40
metalaxyl - M + copper hydroxide	Ridomil Gold Plus	*	4 + M1
metalaxyl - M + mancozeb	Ridomil Gold MZ WG	*	4 + M3
metalaxyl + copper oxychloride	Axiom Plus, Copper Plus, Medley Plus, Metalaxyl + Copper Oxychloride WP, Zeemil Plus	*	4 + M1
metalaxyl + mancozeb	Axiom MZ 720, Max MZ, Maxyl, Medley MZ, Metal-man MZ 720, Zeemil 720 WG, Zeemil MZB 720 WP	* - m	4 + M3
metiram	Polyram DF	*	M3
metrafenone	Vivando	*	U8
myclobutanil	Mycloss Xtra	*	3
oxadixyl + propineb	Rebound WP	*	4 + M3
paraffinic oil	BioPest	*	unspecified
penconazole	Azotic, Delos, Pearl, Ruby 100EC, Topas 100 EC	*	3
phosphorous acid	Agri-Fos 600, ChemPhos 400, Phospot 400, Phospot 400 pH 7.2, Phospot 600, Dominator 600, Fungacid 600, Fungi-Fos 400, Fungi-Fos 400 pH 7.2, Grow-Phos 600, Phos Phyt 400, Sprayphos 400, Sprayphos 600, Sprayphos 620, Throw Down, Throw Down 600	*	33
potassium bicarbonate	Ecocarb	*	M2
potassium salts of fatty acids	Ecoprotector	*	U1

Active constituent(s)	Some registered products	Re-entry period	Activity group
FUNGICIDE *(CONT.)*			
procymidone	Fortress 500, Metapris, Procymidone 500, Proflex 500, Sumisclex 500	k	2
proquinazid	Talendo	*	13
pyraclostrobin	Cabrio, Cabrio WG	*	11
pyrimethanil	Predict 600 SC, Protector 400SC, Pyrus 400 SC, Scala 400 SC	*	9
pyriofenone	Kusabi 300 SC	*	U8
quinoxyfen	Legend, Quinfen 250 SC	*	13
spiroxamine	Prosper 500 EC	*	5
sulfur + copper oxychloride	Mildex WG	*	M2 + M1
sulfur + tebuconazole	Unicorn 745WG	f	M2 + 3
sulfur, present as elemental or crystalline sulfur	Chemtura Sulphur WG, Cosamil, Cosavet WG, David Grays Sulphur Spray, Dusting Sulphur, Dusting Sulphur 900, Flosul 800, GranuSulf 800 WG, InnoSulph 800 WG, Kendon Sulphur, Kumulus DF, Microsul WG Elite, Microthiol Disperss, Notion, Rutec Sulfur, Solo 800WG, Sulfostar DF, Sulfur 800 WG, Sulgran WG, Sulphur 800 WG, Thiovit Jet, Top Wettable Sulphur, Uni-Shield, Wettable Sulphur	*	M2
tebuconazole	Buzz Ultra 750WG, Folicur 430 SC, Gelseal, Greenseal, Laguna Xtreme 800 WG, Launch, Orius 430 SC, Zolo 430 SC	* - g	3
tebuconazole + azoxystrobin	Custodia	*	3 + 11
tetraconazole	Domark 40ME, Mettle 40ME	*	3
thiram	Thiragranz, Thiram 800 WG	*	M3
triadimefon	Slingshot, Triadimefon 125	*	3
triadimenol	Allitron, Bayfidan 250 EC, Citadel, Triadimenol 250 EC, Tridim 250 EC	*	3
Trichoderma harzianum	Vinevax Bio-Implants, Vinevax Wound Dressing	*	unspecified
trifloxystrobin	Flint 500 WG	*	11
zineb	Zineb	*	M3
ziram	Ziragranz, Ziram DG, Ziram Granuflo	*	M3

Active constituent(s)	Some registered products	Re-entry period	Activity group
HERBICIDE			
2,2-DPA-sodium (dalapon-sodium)	Dalapon 740 SP	*	J
amitrole + ammonium thiocyanate	Amitrole T	*	Q
amitrole + paraquat	Alliance, Para-Trooper	* - h	Q + L
bromoxynil + diflufenican	Bentley, Colt, Cougar, Difluken B, Jaguar, Kelpie DFF + Brom MX	*	C + F
carfentrazone-ethyl	Artillery, Carfentrazone 240 EC, Carfentrazone-ethyl 240, Elevate, Hammer 400 EC, Nail 240 EC, Nail 600 EC, Spotlight Plus	*	G
dichlobenil	Casoron G	*	O
diquat	Desiquat, Dia-Kill 200, Diquat 200, Reglone	*	L
diquat + paraquat	Blowout, Brown Out 250, Combik 250, Di-Par 250, EOS, Kwicknock 250, Paradym 250, Paraquat + Diquat 250, Paraquat/Diquat, Pre-Seed 250, Revolver, Scorcher 250, Speedy 250, Spray & Sow, Spray Out 250, Spray Seed 250, Spraykill 250, Uni-Spray 250	*	L + L
fluazifop-P	Fusilade Forte, Fuzilier, Resilience, Rootout 212	*	A
flumioxazin	Chateau	*	G
glufosinate-ammonium	Basta, Biffo, Cease, Exile, Exonerate, Exonerate200 SL, Fascinate 200 SL, Faster-TG 200, Fiestar, Glufosinate 200, Glufosinate-Ammonium 200, Kelpie G-FOS 200, Sky-7th 200	*	N
glyphosate-ipa	AllOut 450, Banish 360, BioChoice 360, ClearUp Glyphosate 450, Envirospray 360, Eradicator 450, Eradicator 540, Eraze 360 Bi-aquatic, Eraze 510 Bi-aquatic, Gladiator, Glister 360, Glister 450, Glymount 450, Glyphos classic 450, Glyphosate 360, Glyphosate 360 SL, Glyphosate 450, Glyphosate 450 CT, Glyphosate 450 SL, Glyphosate 510, Glyphosate 510SL, Glyphosate CT, Ken-Up 450 CT, Ken-Up Aquatic 360, Ken-Up Gold 500, Knockout 450, Knockout Blow 510, Nugget, Pestmaster Aqua-Tech 360, Pestmaster Glyphosate CT, Raze, Rico Glyphosate 450, Roundup, Roundup Biactive, RoundupCT, Sanos 360, Sanos 450, Sickle 540, SquareDown 360, Wipe-Out 450, Wipe-Out Bio	*	M
glyphosate-ipa + carfentrazone ethyl	Broadway	*	M + G
glyphosate-ipa + mas	Banish 360 Sync, Credit, Weedmaster Duo	*	M + M
glyphosate-mas	Bazooka Dry 800 SG, ClearUp 700 Bio-Dri, ClearUp 700 Dri Broadacre, ClearUp 840 Dry-Flo, Gladiator Dry 680 WG, Glister 680 SG, Glyphos 700 SG, Glyphosate 680, Glyphosate 700, Glyphosate 700SG, Glyphosate 875, Ken-Up Dry 680 WG, Roundup Ready Plantshield	*	M
glyphosate-mea	Clear Up 450 SL, Glyphosate 450 SL	*	M

Active constituent(s)	Some registered products	Re-entry period	Activity group
HERBICIDE *(CONT.)*			
glyphosate-potassium salt	Cotton Glyphosate 495, Firebolt, Gladiator Optimax, Glyphosate 540K, Glyphosate K-Tech 500SL, Max Out 540, Roundup PowerMAX, Roundup Ultra MAX, Touchdown Hitech, Warlord 540 Hi-Load, Wipe-Out Accelerate	*	M
glyphosate-potassium salt + ipa	Weedmaster Argo	*	M + M
glyphosate-potassium salt + mas	Weedmaster Dual Salt Technology	*	M + M
haloxyfop-R methyl ester	Asset, Convict, Exert 520, Firepower, Haloxyfop 520, Haloxyfop 520 EC, Haloxyfop 900EC, Haloxyken 520, Hermes 520, Jasper 520, Recon 520, Verdict 520	*	A
isoxaben	Gallery 750 DF	*	O
napropamide	Devrinol WG	*	K
norflurazon	Zoliar DF	*	F
oryzalin	Cameo 500, Oryzalin 500, Prolan 500, Surflan 500	*	D
oxyfluorfen	Cavalier, Convert 240 EC, Crossbar 240, GoalTender, Gowel 240 EC, Ox 240, Oxen 240EC, Oxyfan 240 EC, Oxyfluorfen 240 EC , Point, Striker	*	G
paraquat	Explode250, Gramoxone250, Nuquat 250, Paradox 250, Para-Ken250, Para-Ken334, Paraquat 250, Paraquat 250 SL, Shirquat250, Sinmosa 250, Sprayquat250, Spraytop250SL, Uniquat 250	*	L
pendimethalin	Cronos 440EC, Fist 330, Panida Grande, Pendimethalin 330, Pendimethalin 330EC, Rifle 440, Romper 440 EC, Stomp 440	* - b	D
pine oil	BioWeed	*	unspecified
quizalofop-P-ethyl	Atomic Selective Herbicide, Elantra, Elantra Xtreme, Leopard, Leopard 200 EC, Quinella 100 EC, Quinella Upgrade, Quiz, Quizalofop-P-ethyl 200 EC, Sextant, Tiger Gold 250	* - j	A
quizalofop-P-tefuryl	Pantera	b	A
simazine	Gesatop 600 SC, Gesatop Granules 900 WG, Kelpie S-Zine 900WG, Simagranz, Simanex 900 WG, SimaPhos 900 WG, Simaquest 900 WG, Simazine 500 Flowable, Simazine 900 DF, Simazine 900 WDG, Simazine 900 WG	*	C
trifluralin	Trampoline 480, Tricon Flexi 480, Triflur X, Trifluralin 480, Trifluralin 480 EC, Triflurasip 480, Trilogy, Trilogy 600, Uni-Try	*	D
INSECTICIDE			
alpha-cypermethrin	Alpha Duo 100, Alpha Duo 100 EC, Alpha Duop 100, Alpha Forte 250 SC, Alpha-Cyper 100 EC, Alpha-Cypermethrin 100, Alpha-Cypermethrin 100 EC, Alpha-Scud Elite, Astound Duo, Chieftain Duo 100EC, Dictate Duo 100, Dominex Duo, Ken-Tac 100, Mascot Duo, UniChoice 100 EC	* - b	3A

Active constituent(s)	Some registered products	Re-entry period	Activity group
INSECTICIDE *(CONT.)*			
azinphos-methyl	Gusathion 200 SC	*	1B
Bacillus thuringiensis subspecies *aizawai*	Bacchus WG	*	11
Bacillus thuringiensis subspecies *kurstaki*	Delfin, DiPel DF	*	11
bifenthrin	Arrow 100 EC, Astral 250 EC, Bifenthrin 100, Bifenthrin 100 EC, Bifenthrin 250 EC, Bifenthrin Ultra 300 EC, Bifentin 100EC, Bi-Thrin 100EC, BiFendoff 100, Disect 100 EC, Tal-Ken 100, Talstar 250 EC, Venom 100 EC	*	3A
buprofezin	Applaud, Scale & Bug Insecticide, Strident	*	16
carbaryl	Bugmaster Flowable, Carbaryl 500 Flowable, Carbaryl 500 SC, Cricket and Grasshopper Killer Bait	c	1A
chlorantraniliprole	Altacor	*	28
chlorpyrifos	Chlorban 500EC, Chlorpos 500EC, Chlorpyrifos 500, Chlorpyrifos 500 EC, Cyren 500 EC, Cyren 500 WP, Generifos 500 EC, Kensban 500, Lorsban 500 EC, Lorsban 750 WG, Strike-Out 500 EC, Strike-Out 500 WP, suSCon Green	*	1B
clothianidin	Samurai (bare soil application only)	*	4A
copper complex	Escar-Go, Socusil	*	unspecified unspecified
diazinon	Diazinon	*	1B
dicofol	Miti-Fol EC	*	UN
dimethoate	Danadim, Dimethoate, Dimethoate 400, Dimethoate 400EC, Saboteur	*	1B
emamectin	Proclaim, Warlock	a	6
esfenvalerate	Sumi-Alpha Flex	*	3A
etoxazole	ParaMite	*	10B
fenitrothion	Fenitrothion 1000, Fenitrothion 1000 EC	*	1B
fipronil	Albatross 200 SC, Amulet Cue-Lure, Cannonball 200SC, Fipronil 200SC, Regal 800 WG, Regent 200SC	*	2B
indoxacarb	Avatar	*	22A
iron EDTA complex	Multiguard Snail and Slug Killer	*	unspecified
maldison (malathion)	Fyfanon 440 EW, Hy-Mal, Maldison 500	*	1B
metaldehyde	Meta (pellets), Metarex Snail + Slug bait, Pestmaster Snail + Slug pellets, Slug Out (bait), Slugger Slug + Snail pellets		unspecified
Metarhizium anisopliae var. *acridum*	Green Guard SC, Green Guard SC Premium	c	unspecified
methidathion	Suprathion 400 EC	*	1B

Active constituent(s)	Some registered products	Re-entry period	Activity group
INSECTICIDE *(CONT.)*			
methiocarb	Mesurol Snail and Slug Bait		1A
methomyl	Electra 225, KDpc Metho, Landrin 225, Lannate L, Marlin, Methomyl 225, Nudrin 225, Seneca, Sinmas 225	* - c	1A
methoxyfenozide	Prodigy	*	18
paraffinic oil	Bioclear, BioPest, Heavy Paraffinic Dormant Spray Oil, Trump Spray Oil	*	unspecified
petroleum oil	All Seasons White Oil, D-C-Tron Plus Spray Oil, Sacoa Summer Spray Oil, Stifle, Vicol Summer Oil, Vicol Winter Oil	*	unspecified
pyrethrins + piperonyl butoxide	Py-Bo Natural Pyrethrum	*	3A
spinetoram	Delegate	*	5
spinosad	Naturalure Fruit Fly Bait Concentrate	*	5
spirotetramat	Movento 240 SC	*	23
sulfoxaflor	Transform	*	4C
sulfur, present as elemental or crystalline sulfur	Chemtura Sulphur WG, Cosamil, Cosavet WG, David Grays Sulphur Spray, Flosul 800, GranuSulf 800 WG, InnoSulph 800 WG, Kendon Sulphur, Microsul WG Elite, Microthiol Disperss, Notion, Rutec Sulfur, Solo 800WG, Sulfostar DF, Sulfur 800 WG, Sulgran WG, Sulphur 800 WG, Thiovit Jet, Top Wettable Sulphur, Uni-Shield, Wettable Sulphur	*	M2
sulfur, present as polysulfide	Lime Sulphur	*	M2
tetradecenyl acetate + tetradecadienyl acetate	Isomate LBAM Plus Pheromone, MD LBAM Corto, MD LBAM Flex Pheromone, MD LBAM Pheromone		unspecified
trichlorfon	Dipterex 500 SL, Lepidex 500, Tyranex 500 SL	*	1B
Trichogrammanza carverae	Trichogramma parasitic wasp		unspecified
PLANT GROWTH REGULATORS			
Contact your winery or grape purchaser prior to the application of any plant growth regulator.			
chlormequat[10]	CC-77, Cycocel 77A, Getset	*	unspecified
cyanamide	Cyan, Dormex, Duomax HC520	*	unspecified
ethephon[10]	E-Phon, Ethephon 480, Ethephon 720, Ethephon 720 SL, Ethrel 720, K-Ethephon, Promote 720, Promote 900	e	unspecified
gibberellic acid	Gala, GBR Acid, GBR Acid 200SG, Gibb 100, Gibb 200, Gibber, N-Large, ProGibb SG	*	unspecified
methyl esters of fatty acids	Waiken	b	unspecified

10. For grapes destined for export wine, the use of chlormequat or ethephon is not recommended.

Re-entry period

The re-entry period is the minimum amount of time that must pass between when a pesticide is applied to an area and when that area can be entered without protective clothing and equipment.

Re-entry periods are set to protect people from exposure to agrochemicals that can occur by inhalation or skin contact if they enter an area without proper protective equipment.

The agrochemical label provides information on the re-entry period and any protective clothing or equipment that must be used if the re-entry period is not met. Different products from the same activity group may have different re-entry requirements.
The advice provided in these tables lists the range (from least stringent to most stringent) of re-entry periods for the active constituent.

Where the re-entry period specifies a range of days, the shorter period relates to low exposure activities and the longer period to higher exposure activities. Check the label for details.

This advice is intended as a guide.
Consult each product label for re-entry period directions.

*	Do not enter until the spray has dried
a	8 hours
b	12 hours
c	1 day
d	1 to 16 days depending on vineyard activity being performed
e	2 days
f	4 to 23 days depending on vineyard activity being performed
g	5 days
h	5 to 23 days depending on vineyard activity being performed
i	7 days
j	8 days
k	9 to 24 days depending on vineyard activity being performed
l	9 to 27 days depending on vineyard activity being performed
m	15 to 33 days depending on vineyard activity being performed
n	32 days

Chemical resistance management strategies

What is 'chemical resistance'?

Chemical resistance is the inherited ability of an organism, be it a disease, weed or insect, to survive doses of an agrochemical that would normally control it. Resistance may develop after frequent use of one chemical or chemicals from the same activity group. Incorrect chemical use, such as under- or over-dosing or application at the wrong time in the life cycle of the target, can also promote resistance.

How does resistance develop?

Any population might contain a very small number of individuals that are naturally able to survive the application of a particular chemical. If the same chemical or chemicals from the same activity group are used repeatedly and exclusively, the susceptible individuals continue to be removed, and those with natural resistance survive and multiply to essentially dominate the population. The chemistry then 'fails' in the field.

It has been observed in vineyards that despite several herbicides being used over a season, they are often applied at the same time each season. As such, the weed species peculiar to that time are treated with the same herbicide each year, therefore promoting resistance.

Resistance countering measures

Manage unwanted pathogens, weeds and insects using non-chemical means when possible.

When using chemicals, get the most out of them by:

- timing them to when the target is most susceptible
- using the correct dose
- adding suitable adjuvants
- applying when the conditions are right.

Minimise chemical selection pressure by not overusing chemicals from the same activity group. CropLife Australia maintains Resistance Management Strategies for fungicides, insecticides and herbicides. These are available at www.croplifeaustralia.org.au.

Fungicide resistance status

Resistance to fungicides is a serious problem worldwide and Australia has not been spared. Resistance to many of the commonly used fungicides now exists.

CropLife Australia incorporates two initiatives in fungicide resistance management which ensure the best control with least risk of developing resistance. These are:

1. All fungicides have been classified by activity group, which appears as a number or letter and number code on the fungicide product label

2. Strategies have been developed for the use of fungicides in crops where resistance by a particular organism is already evident or considered a risk. See pages 25 - 27.

The advice given in the CropLife strategies is valid at the time of going to print. Current versions of the strategies are available from the CropLife Australia.
Phone 02 6273 2733 Email: info@croplife.org.au Website: www.croplife.org.au.

CropLife disclaimer

The strategies on pages 25 - 27 are guide only and do not endorse particular products, groups of products or cultural methods in terms of their performance. Always follow the product label for specific use instructions. While all effort has been taken with the information supplied in this document no responsibility, actual or implied, is taken for the day to day accuracy of product or active constituent specific information.
Readers should check with the Australian regulator's (APVMA) product database for contemporary information on products and actives. The database can be sourced through www.apvma.gov.au. The information given in this strategy is provided in good faith and without any liability for loss or damage suffered as a result of its application and use. Advice given in this strategy is valid as at 10 June 2016.

Downy mildew

Fungicide activity groups: Group 4 (phenylamide); **Group 11** (quinone outside inhibitor); **Group 40** (carboxylic acid amide); **Group 45** (quinone outside inhibitor, stigmatellin binding type) fungicides

1. Apply **all** these fungicides preventatively, **Group 4** fungicides should be applied before the first sign of oilspots or as soon as possible after an infection period.
2. Mixtures - co-formulations or tank mixes with label rate of alternative mode of action.
3. Apply a maximum of two consecutive applications of any one group.
4. Start preventative disease control sprays using **non-Group 4** protectant fungicides, typically when shoots are 10-20cm long. Continue spraying at intervals of 7-21 days depending on disease pressure, label directions and rate of vine growth.
5. Limit the use of **Group 4** fungicides to periods when conditions favour disease development. Always apply **Group 4** fungicides in mixture.

	Group			
	4	**11**	**40**	**45(40)**
Max. number of consecutive applications	2	none	2	2
Max. number of solo sprays	none	2	2 (50%)	none
Max. number of sprays per season	4-mix	2	4-mix (50%)	4-mix
Areas of higher agronomic risk	mix	mix	mix	mix

6. **Group 40** - do not apply as the last spray of the season.
   Group 40 - apply a maximum of 50% of the total number of downy sprays.
7. **Group 11** - If applied alone, do not make consecutive applications.
8. **Group 11** - apply a maximum of 2 sprays per season, including in mixtures.

Powdery mildew

Fungicide activity groups: Group 3 (DMI); **Group 5** (Amines); **Group 7** (SDHI) **Group 11** (quinone outside inhibitor) and combinations of **Group 3**; **Group 13** (Aza-napthalenes); **Group U6** (Phenyl-acetamide); **Group U8** (Actin disruptors)

1. Apply **all** these fungicides preventatively.

2. Consecutive applications include from the end of one season to the start of the next.

3. Mixtures - co-formulations or tank mixes with label rate of alternative mode of action.

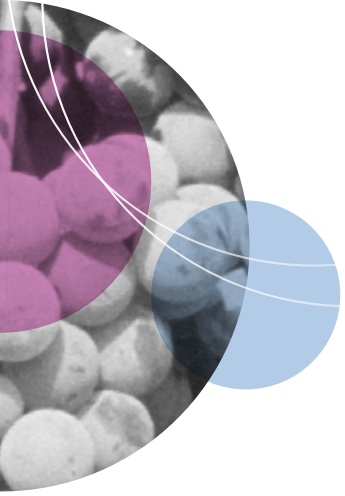
	Group						
	3	**5**	**7**	**11 (3)**	**13**	**U6**	**U8**
Max. number of consecutive sprays	2	2	none	see below	2	2	2
Max. number of sprays per season	3	3	3	2	3	2	4

4. **Group 11** - where these fungicides have been routinely used for many seasons, field research indicates there in an increased risk of powdery mildew resistance. To ensure effective powdery mildew control in these circumstances, either use alternative modes of action or apply in mixtures.
   Group 11 - If applied alone, do not make consecutive applications.
   Group 11 - apply a maximum of two sprays per season, including mixtures

Grey mould (Botrytis bunch rot)

Fungicide activity groups:
Group 2 (dicarboximide); **Group 7** (SDHI - succinate dehydrogenase inhibitors); **Group 9** (anilinopyrimidine) and combinations with **Group 12** (phenylpyrroles); **Group 11** (quinone outside inhibitor) and combinations with **Group 3**; **Group 17** (hydroxyanilide)

1. If three or fewer bunch rot sprays are applied in a season, use no more than one spray from the same fungicide group during the season, for any **Group 2** or **9** (including combinations with **Group 12**), **11** (including combinations with **Group 3**), **17** or **7** fungicides.
2. If four or more bunch rot sprays are applied in a season, use no more than two sprays from the same fungicide group during the season, for any **Group 2** or **9** (including combinations with **Group 12**), **11** (including combinations with **Group 3**), **17** or **7** fungicides.
3. DO NOT apply more than two consecutive sprays from the same fungicide group, for any **Group 2** or **9** (including combinations with **Group 12**), or **17** fungicides, including from the end of one season to the start of the following season.
4. DO NOT apply consecutive sprays of **Group 7** fungicides, including from the end of one season to the start of the following season.
5. DO NOT apply more than two sprays per season of **Group 11** (including combinations with **Group 3**) fungicides. If two consecutive applications of **Group 11** (including combinations with **Group 3**) fungicides are used, then they must be followed by at least the same number of applications of fungicide(s) from a different group (s) before a **Group 11** (including combinations with **Group 3**) fungicide are used again, either in the current or following season.
6. If a **Group 11** fungicide is used solo, it should only be used in strict alternation with fungicides from a different cross-resistance group.
7. If resistance to a fungicide group has been detected, only use that fungicide group in mixtures or in strict alternation with fungicides with a different cross resistance group. A fungicide group that has been applied as the final application of the season should not be the first fungicide in the following season.
8. DO NOT apply fungicides curatively.
9. Late season fungicide treatments should be applied before Botrytis infection reaches unacceptably high levels in the vineyard.



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