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Grapevine management guide 2014–15

NSW DPI MANAGEMENT GUIDE

Compiled by Darren Fahey

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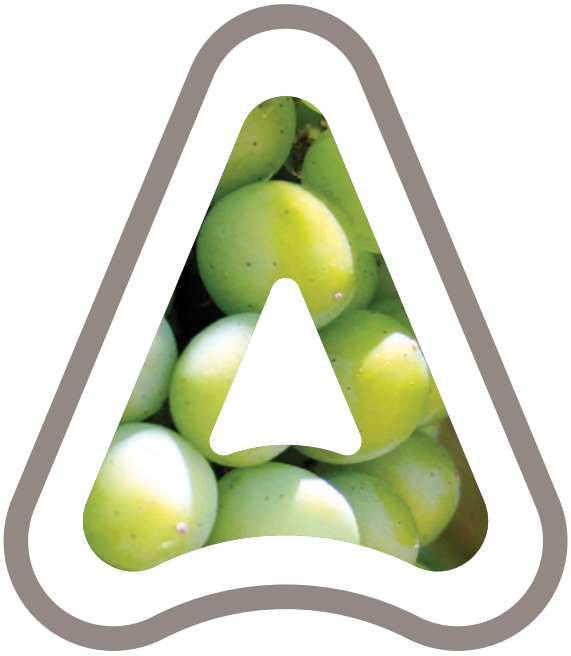

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NSW DPI MANAGEMENT GUIDE

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Main cover photo: Static chambers monitoring nitrous oxide emissions in Hunter Valley Semillon vines at Braemore Vineyard September 2014. Inserts: left to right; Early infloresence on Semillon vines Hunter Valley September 2014; One of ten new weather stations positioned across Mudgee and Griffth, this station is located in the McWilliams Hanwood vineyard, August 2014.

Disclaimer

The information contained in this publication is based on knowledge and understanding at the time of writing (October 2014). However, because of advances in knowledge, users are reminded of the need to ensure that the information upon which they rely is up to date and to check the currency of the information with the appropriate officer of the Department of Trade and Investment, Regional Infrastructure and Services or the user's independent adviser.

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- NSW Department of Primary Industries
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- Murray Valley Wine Grape Growers Inc.
- Grape and Wine Research and Development Corporation
- NSW Wine Industry Association
- South Australian Research and Development Institute.
- Phylloxera and Grape Industry Board of South Australia
- Australian Grape and Wine Authority

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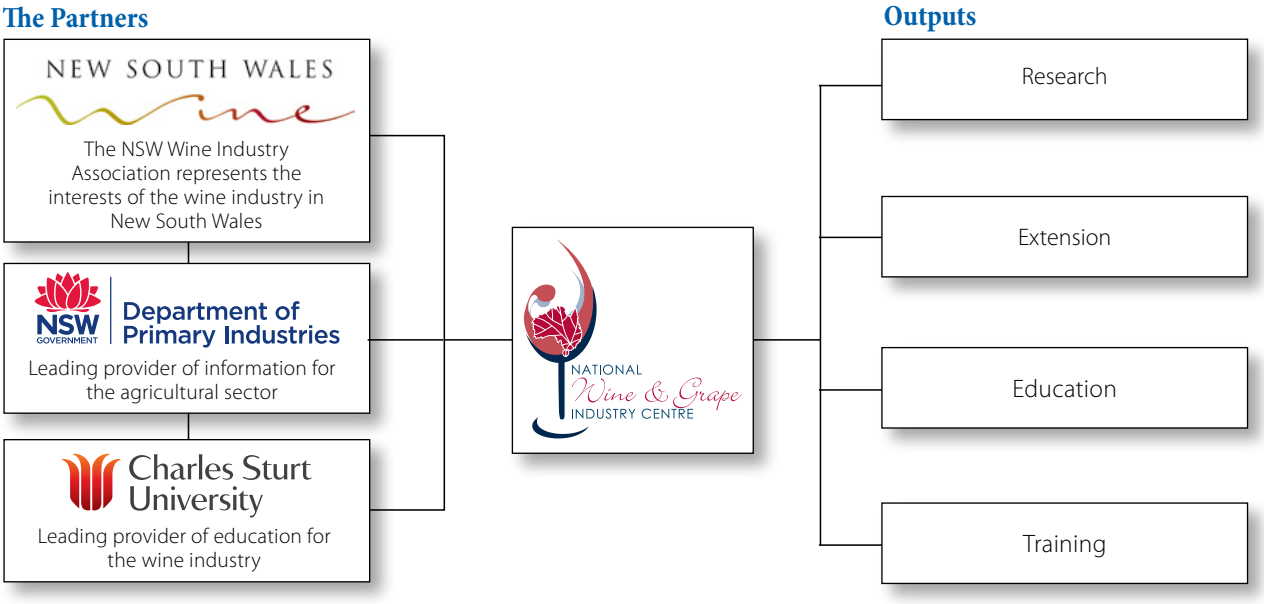
The National Wine & Grape Industry Centre delivers high value research, education, training and extension to the Australian Wine Industry.
Schematic diagram of the role of the the National Wine and Grape Industry Centre



Contents

Foreword

What's new?

As the newly appointed Development Officer – Viticulture (DOV) It is with great pleasure that I welcome you to the *Grapevine Management Guide 2014–2015*.

My appointment as DOV is part of a collaborative extension model between the NSW Government and the State's wine industry, which will deliver benefit to NSW winegrowers through expert advice and assistance.

My role as DOV is primarily to support capacity building and industry growth through the adoption of new information and technologies. I will be responsible for coordinating the delivery of the DPI's Skills and Development program currently being undertaken by the Australian Wine Research Institute, further information on this program can be found on 'page 44.

Moreover, in consultation with industry specifically tailored research programs to meet regional needs will be developed to enhance the profitability and sustainability of the State's wine industry.

Also as DOV I will be responsible for working within NSW DPI R&D programs to deliver projects with practical outcomes to industry.

The Grapevine management guide 2014–2015 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.

Darren Fahey
Development Officer – Viticulture
NSW DPI

Farewell to Jason Cappello

After many years with NSW DPI Jason Cappello, Development Officer – Viticulture, has left the department to broaden his career as Horticultural Agronomist with MIA Rural Services.

Amongst Jason many achievements he compiled the *Grapevine Management Guide 2013–14*.

We thank Jason for his contribution to this publication and the NSW wine and viticulture industry during his many years of service with NSW DPI and wish him well in his new role.

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, fax or email.

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Current research at NWGIC

GREG DUNN, LEADER – VITICULTURE, NSW DPI, WAGGA WAGGA

The centre conducts research in a range of projects that span 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 other R&D providers across Australia. In addition to these research projects, other smaller studies are conducted by post graduate students and visiting scholars. Major research themes and projects are listed below.

Vine health and biosecurity theme

- Practical Management of grapevine trunk diseases: contact Dr Sandra Savocchia, ssavocchia@csu.edu.au
- Understanding fungicide resistance in powdery and downy mildew: contact Dr Sandra Savocchia, ssavocchia@csu.edu.au
- Determination of thresholds for bunch rot contamination of grapes and techniques to ameliorate associated fungal taints: contact Professor Chris Steel, csteel@csu.edu.au
- Brassica biofumigation of black foot fungi in vineyard soil: contact Dr Melanie Weckert, melanie.weckert@dpi.nsw.gov.au
- Entomopathogenic Fungi as Potential Biocontrol Agents of Grape Phylloxera: contact Dr Sandra Savocchia, ssavocchia@csu.edu.au

Vine quality and yield theme

- Improved yield prediction for the Australian wine industry using real time image capture and analysis: contact Associate Professor Gregory Dunn, 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: contact Jason Smith, jasmith@csu.edu.au
- The role of potassium in sugar unloading into grape berries with the objective to manage berry sugar accumulation from a viticultural perspective and identifying the instigators of cell death in the berry mesocarp cells and understand the implications on berry composition: contact Dr Suzy Rogiers, suzy.rogiers@dpi.nsw.gov.au
- Evaluating and demonstrating new disease resistant varieties for the Riverina: contact Dr Bruno Holzapfel. bruno.holzapfel@dpi.nsw.gov.au

Fruit and wine composition and style theme

- Fruit and wine composition and sensory profile: sequential harvest, searching for the sweet spot in Australian regions: contact Dr Leigh Schmidtke lschmidtke@csu.edu.au or Professor Alain Deloire, adeloire@csu.edu.au
- Metal ion speciation, understanding its role in wine development and generating a tool to minimise wine spoilage: contact Dr Andrew Clark, aclark@csu.edu.au
- Low alcohol wine and sequential harvest: contact Dr Peter Torley, ptorley@csu.edu.au

Wine and consumers theme

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

Winegrape nutrition and fertiliser application for sustainable production

BRUNO HOLZAPFEL, JONATHAN HOLLAND and MICHAEL TREEBY, NSW DPI, WAGGA WAGGA

Bruno Holzapfel, Research Scientist – Viticulture
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In a nutshell

A 'vineyard system' is defined as the grapevines and that part of the soil profile exploited by roots (the 'rootzone').

Nutrients are removed from vineyard systems through losses below the rootzone, and when grapes are harvested and taken away from the vineyard.

The availabilities of mineral nutrients to vine roots are influenced by soil characteristics, soil moisture, the form that the particular mineral nutrient is present as, the vineyards cropping history and how much, when and how fertilisers and soil amendments are applied.

Different fertilisers and soil amendments have different characteristics that influence why, when and how they are used in vineyards.

Qualitative and quantitative assessments of vine nutrient status can used to determine the suitability of vineyard fertiliser/soil amendments programs.

Introduction

Mineral nutrition is a major part of grape production, impacting on all aspects vine growth, berry development and maturation and ultimately juice composition as it relates wine making. Most of the influence of mineral nutrition is on berry composition is indirect, through altered growth and yield level. However, nitrogen application does directly affect the composition of nitrogenous compounds in the must and therefore the fermentation process and the wine produced. Mineral nutrients are divided into macro-nutrients, which are present in plants at concentrations expressed as %, and micro-nutrients, which are present in concentrations expressed as parts per million (ppm) or mg/kg.

Macro-nutrients include nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulphur (S). Micronutrients include iron (Fe), copper (Cu), manganese (Mn), zinc (Zn), boron (B) and molybdenum (Mo). Sodium (Na) and chlorine (Cl), which are often present at % levels in plant tissue, are generally considered to be micronutrients.

Aluminium (Al), selenium (Se), nickel (Ni) and cobalt (Co) are all considered to be essential micronutrients as well, but for the most part don't cause any issues and needn't be considered further. Likewise, silicon (Si), which is considered beneficial and facilitating disease defence mechanism, but not essential, doesn't need to be considered further as well.

The various macro- and micro-nutrients have functions and roles that impact on vine development and grape composition.

Vineyard nutrient balance

A summary of vineyard mineral nutrient dynamics and balance is presented in Figure 1. The mineral nutrient requirements of grapevines vary according to the variety, whether the vines are growing on a rootstock, and on what rootstock that is, vine age and production levels. There is no single 'recipe'.

All mineral nutrients are removed by the crop, but the removal of some, e.g. N and K, is on a much larger scale than the removal of others, e.g. Fe and Mn.

Some nutrients [e.g. N in the nitrate (NO_3^-) form] can be lost below the rootzone by leaching, and can also be lost to the atmosphere by a process known as denitrification.

Most of the biomass (shoots and leaves) produced annually by grapevines remains in the vineyard and releases mineral nutrients back to the soil as it breaks down. The rate of release is dependent on the materials' carbon:nitrogen (C:N) ratios; wood has a high C:N ratio and breaks down slowly (months – years), and leaves have a low C:N ratio and breaks down quickly (weeks – months). The same principal applies to cover crops; oats and rye corn, for example, break down slowly (months), and faba beans breaks down quickly (weeks). Breakdown of organic matter will also be influenced by temperature and moisture, and the degree of contact between the organic matter and the soil.

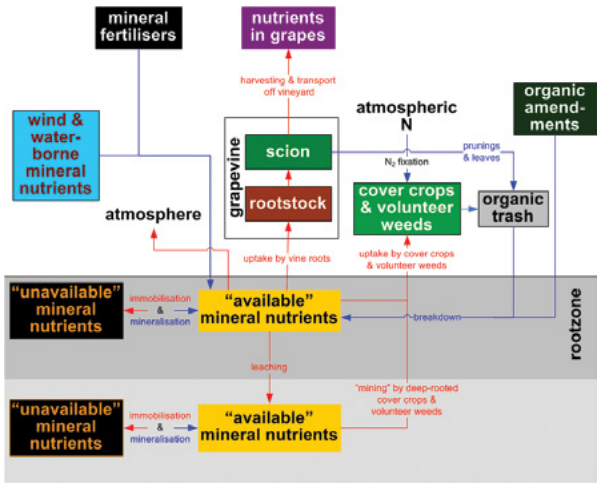

Figure 1. *The vineyard mineral nutrient balance (modified from Bauer, 1992).*

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Immobilisation and mineralisation within the rootzone are two processes working in opposite directions; immobilisation removes nutrients from the available pool, and mineralisation puts them back; this is particularly important for P.

Soil fertility

Mineral nutrients exist in soils in organic and inorganic forms in the soil solution, and bound up in organic matter. Soil fertility simply means the capacity of a soil to keep plant roots well supplied with mineral nutrients in the inorganic form. Mineral nutrients bound up in organic material and in organic forms are not available for uptake by plant roots. Inorganic forms are the major source of mineral nutrients for plants. Crop production on highly fertile (i.e. high levels of mineral nutrients in inorganic form) soils requires little if any supplementary mineral nutrient supply. Crop production on an infertile soil generally requires considerable supplementary mineral nutrient supply. Grapevines are no different.

Soil tests use various chemical extraction methods to estimate the amount of available nutrients; in other words, soil tests 'measure' soil fertility. The results correlate reasonably well with the amounts of nutrients taken up by most annual crops, and hence have some application in estimating the fertiliser needs of annual crops. The correlation is not as strong for perennial crops because of the longer period of nutrient uptake, the greater volume of soil explored and the amount of mineral nutrients stored in the vine or tree from one season to mobilised and used in the next season. Nonetheless, soil tests can be useful in diagnosing poor vine growth and performance, and are useful in the pre-planting phase of a vineyard development.

The characteristics of the rootzone (depth, texture, pH, moisture, aeration and organic matter) have a considerable influence on the processes that govern the actual availability of mineral nutrients to vine roots.

Soil depth and texture are important in determining the soil's ability to hold water and supply water to vine roots. Depth and texture are also important because water brings some mineral nutrients to vine roots and water is needed by soil micro-organisms to grow and breakdown soil organic matter for energy. The mineral nutrients in organic matter and in organic forms must be released and/or mineralised into soluble inorganic forms before they can be absorbed by plant roots. This process is facilitated by micro-organisms as they breakdown organic matter for energy, and they themselves die and decompose. Adequate organic matter is obviously critical here, as is soil temperature, aeration and moisture are also critical here. The upshot is that rates of mineralisation are greater in warm moist free-draining soils with reasonable levels of organic matter compared to dry cold soils with poor drainage and low levels of organic matter.

Mineral nutrient availability is strongly dependent on the soil pH, and this is simply a chemistry issue because inorganic mineral nutrients change form as the pH changes. Optimum soil pH range for grapevines is thought to be around 5.5 to 8.0 (Figure 2). Outside of this range excesses of certain elements and deficiencies of others become important. For example, soil with a pH less than 5.5 is likely to contain an excess of aluminium ions. In contrast, deficiencies of iron, manganese and copper are induced under alkaline soil conditions (pH greater than 8.0). The use of lime-tolerant rootstocks negates this problem to some extent.

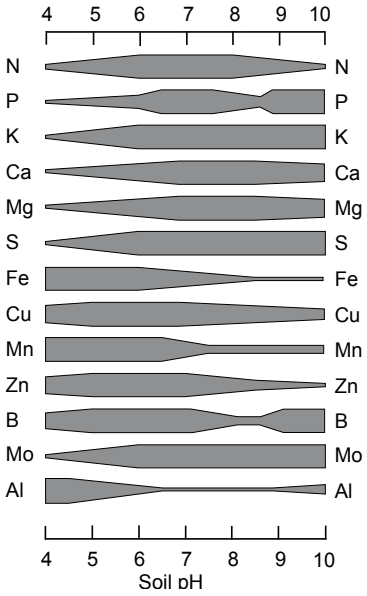

Figure 2. *Relationship between soil pH and nutrient availability (adapted from Lucas and Davies 1961).*

Nutrient function

Nitrogen, Mg and S form part of the chlorophyll, which uses sunlight to convert carbon dioxide (CO_2) and water to produce sugars. Nitrogen and S are components of proteins, which do all the work in the cell. Enzymes, which catalyse metabolic and catabolic reactions, are proteins. Calcium and B perform rolls in plant cell walls, which provide the mechanical strength to hold the inner the thin membrane and cell contents, and giving plants some mechanical strength. Phosphorus is involved in storing and releasing energy, and is a vital structural ingredient of the membrane around each cell. Potassium is involved in carbohydrate metabolism and transport, and the regulation of water movement.

Root growth and the uptake of nutrients from the soil solution require energy from stored or recently assimilated carbohydrates. Macro and micro nutrients are essential for plant growth, because of their roles in metabolic functions and structural components. Nitrogen is one of the most important macro nutrients and the seasonal N accumulation varies between the different vegetative and reproductive parts of the grapevine (Figure 3).

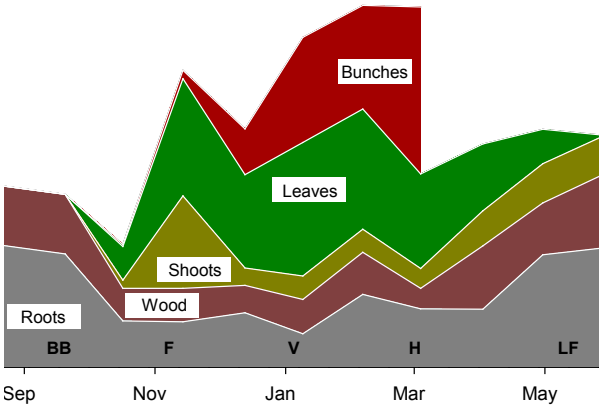

***Figure 3**. Seasonal N accumulation (relative) in a 10 year old Shiraz vineyard (Riverina).*

Iron, Mn, Zn and Cu are involved in the CO_2 assimilation process, and in plant defence mechanisms against stress such as heat. Iron and Mo play significant roles in the conversion of NO_3^- into a useable form where it finally ends up in proteins etc.

Several nutrients have an important role in the vegetative and reproductive development of grapevines. Shoot growth in spring is influenced by the availability of N, P and K and micro nutrients. Sufficient supply of B and Cu ensures cane maturation and a good supply of N and Fe avoids premature leaf fall. Nitrogen and P are important for inflorescence initiation and development, while the supply of the micro nutrients Zn, B and Mo are important for fruit set. Berry growth is influenced by N availability after fruit set and K and Mg are important nutrients during the berry ripening process.

The nutrient composition of grapes influences the winemaking process, and the wine produced from these grapes. The supply of the macro nutrients N, P and K alter the must composition, excessive K results in high juice pH and low colour in the ferment and wine. The amounts of nitrogenous compounds present in the must as amino acid and ammonium have a critical role in the fermentation process and the final wine composition. The timing of N application and the seasonal water supply influences amino N concentration in the juice.

Assessing nutrient status

Assessing grapevine nutrient status is important for verifying the assessing whether the vineyard fertiliser is achieving what it is supposed to be doing: ensuring that vine productivity isn't limited by mineral nutrient supply. Both qualitative information (i.e. appearance of the vines vigour-wise and any leaf symptoms) and quantitative information (i.e. nutrient concentrations in a standard tissue sampled at a standard time) are needed. Visual deficiency (or toxicity) symptoms generally are only become apparent after the productivity declines.

Shoot vigour and deficiency or toxicity symptoms on leaves are important indictors of vine nutrient status. Most macro-nutrient deficiency symptoms appear first on the older leaves (except N and S), while most micro-nutrient deficiencies appear on the younger leaves (the exception is Mn) (Table 1). The difference between the occurrences of deficiencies in leaves of different ages relates to the mobility of the nutrient within the vine.

***Table 1.** Visual symptoms of nutrient deficiencies in grapevines used to make qualitative assessments of vine nutrient status (adapted from Nicholas 2004).*

	Symptoms (leaf, growth)	Location
Macronutrient		
N	Overall leaf yellowing, growth reduction	all leaves, first youngest leaves
P	Interveinal areas yellow/pale green, growth reduction	Older leaves
K	Leaf curling, interveinal areas/ margin yellow	Older leaves
Mg	Yellow or red leaf interveinal areas/ margin	Older leaves
S	Overall leaf yellowing	Most leaves, first youngest leaves
Micronutrients		
Fe	Interveinal arreas yellow, stunted growth	Young trees
Mn	Interveinal areas pale green	Older/mid-shoot leaves
Cu	Small young leaves, interveinal areas yellow, stunted growth	Young leaves
Zn	Interveinal areas pale green, stunted growth	Young leaves
B	Interveinal areas pale green, stunted shoots, shoot tips die	Young parts

The interpretation of mineral nutrient concentrations in the petioles sampled from leaves from leaves opposite the basal bunch at 50% capfall (EL stage 23) is based on a comparison with nutrient standards that reflect the relationship between mineral nutrient content in petioles at that time and vine performance (Table 2). Other interpretative standards exist for other parts of the vine sampled at other times, but the most robust are the petioles at flowering standards. It is recommended that about 100 petioles are collected from a cross a management unit (i.e. a single variety, a variety on a particular rootstock or an area irrigated from a single valve basal bunches at flowering (50% cap fall) and compare the analytical nutrient results to the recommended standards.

Fertilisers and their application

The seasonal pattern of nutrient demand and uptake by grapevines influences the application timing of most fertiliser. Typically, fertiliser is applied during the main periods of root growth in the spring and autumn. This is particularly relevant to the supply of nitrogenous fertilisers, which shouldn't be supplied until late spring, and the autumn application should be modest to avoid re-stimulating shoot growth and having leaves remain on the vine beyond autumn, but sufficient to allow sufficient uptake and storage of N to support spring growth the following season.

An exception to this generalisation is P supplied as single- or double-strength super phosphate. Phosphate (PO_4^{3-}), which is the form of P taken up by plants, is so sparingly soluble and moves so slowly down the soil profile, that application anytime of the year will have the same effect: small amounts of PO_4^{3-} moving slowly down the profile with each irrigation and significant rainfall event.

The various N, P and K fertilisers available vary in concentration and solubility (and hence speed of nutrient availability) and often contain more than one macro-nutrient. Selection depends upon many factors (e.g. effect on soil pH, suitability for delivery by fertigation, cost per unit nutrient, the need for rapid result where a deficiency is obvious etc.). Ease of spreading is also a consideration, and here inorganic fertilisers have an advantage of organic fertilisers, which tend to be more voluminous and of variable and lower macro-nutrient content. Obviously, applying fertiliser through a drip irrigation system is significantly easier than broadcasting fertiliser, but the higher solubility and purity needed for fertigation comes at a cost. Several alternative fertilisers (e.g. organic and bio-dynamic products) claim a range of nutritional benefits associated with their use, but Australian experience with these materials is limited, and as a consequence there is little information available to assist their use on Australian vineyards.

An important consideration for users of organic fertilisers is that mineral nutrients in those materials need to be released and/or transformed into available forms by the breaking down of the material in the soil. This is not a rapid process for materials with a high C:N ratio, and if conditions aren't conducive to microbial activity in the soil then that breakdown process may be quite prolonged. A material that was being used to correct a chronic N deficiency, for example, would need to have a low C:N ratio to ensure that the N in the material was mineralised reasonably quickly.

Grape growing regions differ in the mineral nutrition issues that are important because soils and climate varies from region to region. For instance, soils with a low pH would need amelioration in the form of lime addition, which improve the availability of several nutrients. However, this measure is most appropriate prior to planting a vineyard. Generally, grape production in Australia can be separated into warm (irrigated) and cool (supplementary irrigation) regions. Warm regions tend to problems with deficiencies of Zn, and Fe to a lesser extent, while deficiencies of B are more likely in cool regions with higher rainfall.

As indicated earlier, there is no 'recipe' to suit all vineyards, and, accordingly, it is difficult to estimate how much fertiliser needs to be applied. As a general rule, provided that irrigation is managed to avoid excessive mineral nutrient loss through run-off or leaching, and pruned canes remain in the vineyard after pruning, the main loss of nutrient from a vineyard will be in the fruit harvested and moved off-site. A reasonable approach and starting point to simply replacing what has been removed, therefore, is to estimate the amount of mineral leaving the vineyard in the grapes given the yield. For example, a tonne of fruit removes about 2 kg N; a yield of 20 t/ha would require a replacement of approximately 40 kg N/ha. That amount of N fertiliser can be the basis of the annual application needed — mindful of the other considerations around timing and not leaching NO_3- down the profile etc. – and can then be adjusted upwards or downwards by conducting plant tissue analysis on petioles collected at flowering and comparing the concentrations of mineral nutrients in the petioles with the standard ranges, as described above. Assessing nutrient (especially N) concentrations in winter spurs is a useful indication of the amount of nutrients in reserve that the vine has available to support spring growth (Table 2).

Table 2. *Recommended adequate ranges of petiole nutrient levels for grapevines at flowering (Robinson et al. 1990) and spur concentrations at dormancy and fruit nutrient content of Chardonnay grapes (Riverina).*

	Macronutrients						Micronutrients				
	N	P	K	Ca	Mg	S	Fe	Mn	B	Zn	Cu
	(% DW)						(mg/kg)				
Petiole concentration	0.9–1.1*	0.25–0.50	1.8–3.0	1.2–2.5	>0.4	–	>30	30–60	35–70	>26	6–11
Spur concentration	0.59	0.08	0.44	0.4	0.13	0.04	95	26	71	22	–
	(kg/t)						(g/t)				
Fruit content	2.13	0.33	3.34	0.33	0.15	0.17	1.2	2.4	13.2	8.3	–

* 0.9 to 1.25% N for vines grafted onto Ramsey.

Conclusions and recommendations

Current best practice is to determine the soil nutrient status before the establishment of a vineyard and supply the necessary nutrients to avoid early poor vine growth. Subsequently, it is recommended to analyse petioles at flowering annually to determine vine nutrient levels and modify fertiliser programs to bring the next season's petiole results into the optimum range. In addition, soil samples should be taken every 2–3 years to assess soil nutrient levels. Maintaining accurate records of yields and petiole and soil sample results is important to pick up trends. This information, together with visual observations of vine growth can greatly assist vineyard nutrient management. Selection of mineral nutrient source (i.e. inorganic vs organic, readily soluble vs sparingly soluble, high analysis vs low analysis, multi-nutrient vs single nutrient) needs to be on the basis of compatibility with the vineyard's production philosophy, the vineyard's delivery system and the response speed needed. The timing and amount of fertiliser applied should be undertaken in accord with vine demand, yield and grape quality targets, mindful of the need to avoid losses through leaching and waterlogging.

Acknowledgments

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Monitoring vine water status

Part 1: Some physiological principles

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In a nutshell

- Moving toward precision irrigation is a way to optimise the use of available water resources while improving the consistency of fruit quality
- Combining measures of vine water status and soil moisture will provide information to manage irrigation appropriately
- Limited tools are available to measure vine water status, the pressure chamber is currently among the most efficient

Introduction

Water is a precious resource and the efficient application of irrigation water to vineyards is a necessary objective for environmental sustainability and vineyard profitability. Furthermore, the judicious use of water is an important 'lever' used to influence fruit and wine composition. Reduced water allocations and rising power costs provide additional incentive to implement irrigation programs that maximise water use efficiency. Balanced against these factors are the water needs of the vine, and the impact of water availability on growth and berry development. Monitoring of vine and soil moisture status provide practical methods by which irrigation strategies can be refined to suit production and fruit quality requirements of a vineyard.

What do we have in the tool box?

Direct visual observation of grapevine canopies is a simple method for monitoring the water status of the vine. Actively growing shoot tips carrying firm, turgid tendrils indicate that the vine water status is adequate. A decrease or cessation in shoot growth along with the wilting of tendrils or leaves indicate a water deficit. In some varieties, leaves may also orient away from the sun's direct rays under water constraints. The burning of leaf margins or the withering and dehiscence of the shoot tip indicate that the vine has received a significant amount of water stress.

These visual symptoms are helpful and can be used as a straight forward stress index that is based on the fact that growth is one of the most sensitive processes to water status. However, precision irrigation is better managed using techniques that measure vine water status directly, or indirectly via other processes that depend on vine water status (Table 1). These measured parameters are time dependent and can vary rapidly through the day, therefore knowledge of the processes

Functional apex

Necrosis of apex

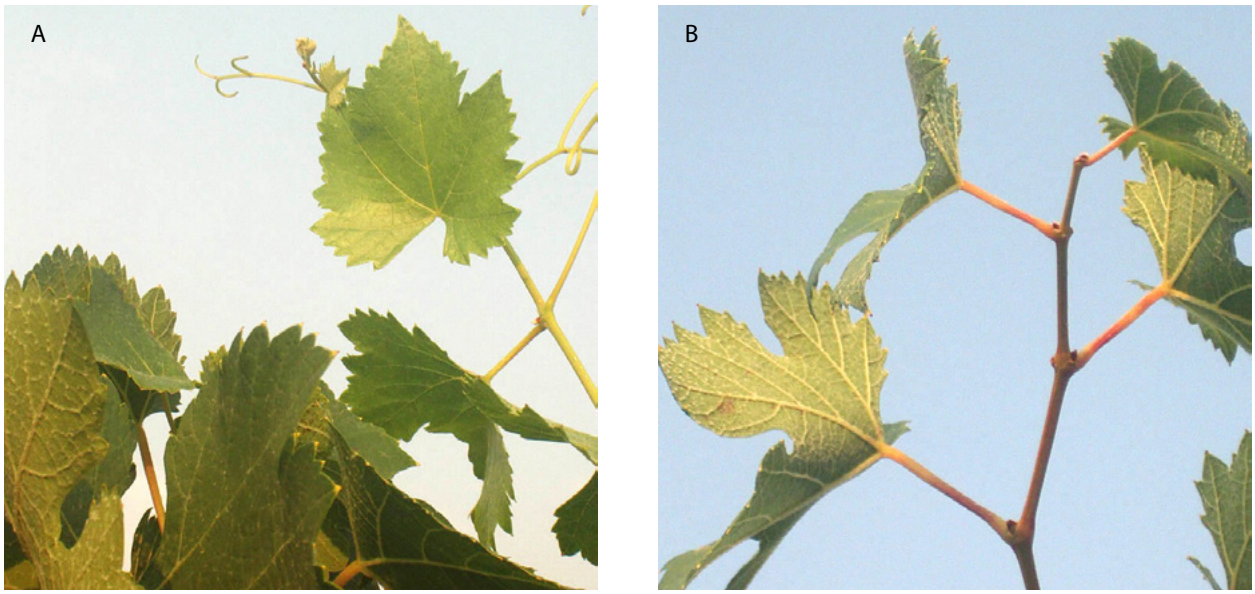

Figure 1. *Example of two extreme situations of vine water status. (A) Well-watered vine with functional apex, and (B) a vine under water stress with the apex dead and missing. Other visual signs can be used to give an indication of vine water status and the reader is referred to Smart, 2003 for further information.*

being monitored is needed to avoid potential pitfalls. Only three of the techniques listed below measure water status directly in the strict sense: the pressure chamber (also called Scholander pressure chamber), and leaf/stem psychrometers both measure water potential, while turgor patch clamp probes measure leaf turgor pressure. The other techniques listed measure processes such as growth, transpiration or swelling and shrinking that respond to vine water status, but in a variety dependent way. Some of these are already in practical use by the industry, while others are limited to the scientific community as the instruments are either complex or the results require significant post-collection data processing and interpretation. A number of new methods are under development, and several of these show potential as future irrigation management tools. For further information on NIR spectroscopy see DeBei *et al*. 2011, the leaf patch clamp pressure probes see Zimmerman *et al*. 2009, and infrared thermography see Jones *et al*. 2002.

Table 1. *Plant based options to measure vine water status directly or indirectly*

Practical	Scientific	Under development for industry use
Visual canopy characteristics (effect of water status on growth)	Sapflow sensors (sap flow velocity)	NIR Spectroscopy (calibrated to water potential or water content)
Pressure chamber (leaf or stem water potential)	Stomatal conductance (porometer or IRGA)	Dendrometers (trunk diameter)
	Leaf relative water content (measured by weighing and comparing to fully hydrated leaves)	Leaf patch clamp pressure probes (leaf turgor)
	Psychrometer (leaf or stem water potential)	Infrared thermography (leaf temperature)

This list does not include the indirect soil-based or climate-based methods for assessing vine water requirements. Soil-based instruments measure the volumetric soil water content (using neutron probes or time domain reflectometry) or soil water tension (using tensiometers or psychrometers). These instruments require the precise installation procedures including the correct positioning and can be useful once calibrated with plant based vine water status measurements. Soils are heterogeneous in terms of structure and depth which will affect the water holding capacity and the development and depth of the root system. This addresses the question of the number of probes which are needed to monitor irrigation and the relationship between soil moisture and the vine water status. The accuracy of the vine water management will depend on the level of precision of the water measurement. This decision belongs to the growers and wineries as to the most appropriate method for their situation.

The climate-based approach calculates the evapotranspiration (ET) and this includes evaporation from the soil and transpiration from the plant.

A reference ET (ET_0) refers to the ET from a hypothetical crop surface such as grass grown without any water stress. This can be measured using pan evaporation or calculated using the Penman-Monteith equation which integrates temperature, humidity, wind speed and solar radiation. However, the ET_0 needs to be adapted to grapevines and this is achieved by multiplying ET_0 by a crop coefficient (K_c) so that $ET_c = ET_0 \times K_c$. K_c is dependent on variety, climate, canopy size (developmental stage) as well as canopy architecture. Planting density and the soil type also need to be considered. Because of the use of generic crop coefficients, exclusively using a climate based method for scheduling irrigation can lead to substantial accumulation of errors resulting in over or under watering. Therefore, it is recommended to use this approach conjunction with some other soil or plant measurements.

In a nutshell

- Vine water status and irrigation has to be managed according to the developmental stage of the vine
- Root and leaf function regulate vine water status
- Soil properties and climate (temperature) impact on vine water status

Managing water status according to the developmental stage of the vine or fruit

The budburst to flowering period is a very active period of shoot and root growth, and it is important that vines start the season with high soil moisture. Winter rainfall may be sufficient to refill the profile, but if a dry winter is forecasted, irrigation leading into dormancy is advised. At the very least, vines should be irrigated several weeks before budburst if soil moisture has not been replenished over winter. Water constraints through budburst will result in uneven and reduced spring shoot growth that impact on canopy size for the remainder of the season. As the spring progresses, water constraints will also prevent normal flower development and therefore will have a negative impact on crop potential during the current and the following season. Fruit set is highly sensitive to any water constraints and therefore it is recommended that water be applied if soil moisture is low through this period. Between fruit set and veraison, vine water status can be regulated depending on the desired outcome. No water constraints should be applied to achieve maximum fruit growth, however if smaller fruit and reduced shoot growth are desired a limited amount of water constraint can be applied. Reduced shoot growth can lower canopy density and thus increase light exposure and air circulation around the fruiting zone. If, however, the water deficit is too great, leaf dehydration will occur and berry development may slow. Important flavour precursors also accumulate in the fruit during the pre-veraison

period and this process is sensitive to water deficits. Sugar accumulation into the berries between veraison and harvest is highly dependent on healthy, functioning leaves, bunch microclimate and vine water status. During the post-harvest period, vines are able to rebuild their carbohydrate reserves in preparation for the following season if the temperatures are adequate and the vines are not dehydrated.

Root and leaf functioning control vine water status

Variety differences in the ability to withstand water stress can vary according to rooting volume and depth, the efficiency and ability to conduct water through the vascular tissues, and stomatal control of water loss from the canopy. Stomata are microscopic pores on the underside of grapevines leaves that allow gas exchange between the leaf and the atmosphere. When the stomatal pores are open, carbon dioxide is able to enter the leaf to supply photosynthesis but at the same time water escapes and, if not controlled, the vine may become water stressed. Some varieties such as Semillon do not close their stomata sufficiently when the evaporative demand is high (Rogiers *et al*. 2012) and therefore they require more water to prevent leaf and fruit damage. These varieties are called anisohydric, and are "optimistic" in the sense that water supply is needed in the short term if the vine is not to suffer damage. Other varieties such as Grenache close their stomata sooner with water stress and therefore they are able to conserve water and maintain their hydrated state for longer. These varieties are called isohydric, and are "pessimistic" in the sense that water supply is not necessarily required in the short term. Irrigation scheduling must therefore take into consideration these variety differences with careful monitoring and management of the anisohydric varieties that may rapidly develop water stress. Isohydric varieties may be somewhat more tolerant in the short term, however, heat waves may require high transpiration to allow leaf cooling and the more anisohydric Shiraz can increase transpiration by opening stomata under high temperature if the vine is well supplied by water. Furthermore, avoiding north-south row orientation in very warm viticultural regions will prevent the burning of the western side of the canopy in the late afternoon. Variety/rootstock combinations will also impact on how much water is required

To maintain a desired vine water status, knowledge of soil and climate matter

When scheduling irrigation it is important to consider the combined effects of soil water holding capacity, canopy size and evapotranspiration on vine water status. Under high evapotranspiration (warm, dry days) the water applied must balance that which is lost from the vines through transpiration and evaporation from the soil. If water supply does not match demand, vine water status will progressively decline to the point that growth and photosynthesis are inhibited and leaves lose the ability to cool through transpiration. For this reason irrigation, and maintaining vine water status through heat events, is critical. Nocturnal water loss through the stomatal pores on the leaves can also be significant on warm and windy nights, sometimes up to 10% of whole day water loss. Again there are variety differences in how much water can be lost during the night. Similar to daytime water use, Semillon loses more water during the night than Grenache (Rogiers *et al*. 2009).

In a nutshell

- Important fruit compounds are derived from the vine leaf (sugar, potassium) and root (water, minerals) and depend on the vine water status
- Most of the major compounds involved in fruit quality are biosynthesized prior to veraison by the berry itself but are dependent on vine water status (tannin, aromatic precursors, organic and amino acids)
- Important compounds are accumulated (potassium, nitrogen, water, sugar) from veraison to harvest and are highly influenced by vine water status

Berry metabolism and composition is regulated by water and temperature

Complex and, often, poorly understood processes occurring in the grapevine during berry growth and development (i.e. from flowering to veraison and veraison to ripening-harvest) contribute to final fruit composition. Berry development typically follows a double sigmoid growth pattern (Figure 2) consisting of two distinct growth phases separated by a lag phase (Coombe 1992). Important compounds such as tannin, amino and organic acids as well as those responsible for aroma, for example methoxypyrazines in cultivars including Sauvignon Blanc, Cabernet Sauvignon and Merlot, are biosynthesised during the first growth period. Other compounds are biosynthesised from veraison

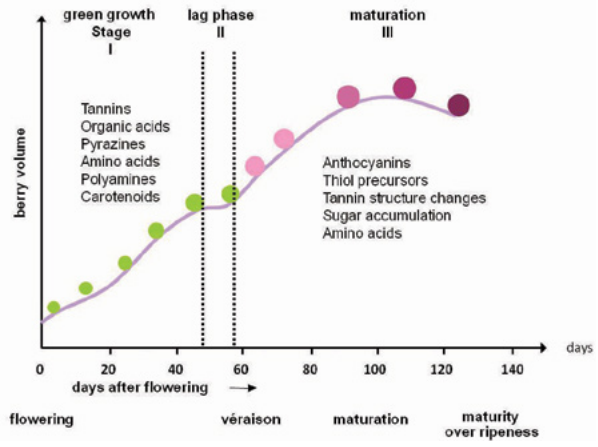

Figure 2. *Examples of organic compound accumulation and change during the fruit development.*

(berry softening) to harvest (Figure 1). Important compounds such as water, minerals, nitrogen and sugar are imported from the vine (leaf and root) to the fruit and one of the main drivers of vine and fruit metabolism is water.

Some varieties such as Shiraz can undergo visual signs of weight loss (seen as shriveling) during the later stages of ripening. This phenological stage of development is accompanied by the concentration of the existing sugars in the fruit and other changes in flavours and aromas. Depending on the desired wine style, shriveling can be a positive or negative process during late ripening.

The extent of shriveling is dependent on the amount of water entering the berry through the vascular system in comparison to the amount that is lost through the skin. The loss of water through the skin, and thus shriveling, is greater in exposed fruit, especially when the evaporative demand is high. Interestingly Shiraz berries do not loose water from the skin any faster than other varieties that do not shrivel, therefore the difference seems to lie in the way water is supplied to the berry late in ripening. Rain and irrigation can to some extent reverse the shriveling trend and temporarily increase the fresh weight of berries. This is dependent, however, on many factors such as maximum berry size, the degree of shriveling, the amount of water applied, the humidity and the number of days after the onset of weight loss.

Monitoring vine water status

Part 2: A detailed example using the pressure chamber

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In a nutshell

- The pressure chamber is the tool most commonly used to measure the vine water status
- Leaf water potential (LWP) has allowed us to establish reliable thresholds of vine water status
- Stem water potential remains the simplest way to assess vine water status and to give recommendations on irrigation (when, how much and for how long)

Plant water status can be measured directly by several different methods using the pressure chamber. Assessments are required on each particular block and at several locations within the block if the soil is heterogeneous. Typically there is significant variation in vine water status across a block. While we cannot remove this heterogeneity, we can deal with in a practical manner. In the first instance, it is suggested to map out the heterogeneity across the block using methods such as NDVI and/or soil electrical conductivity surveys. If more precise data are required, it could be recommended to follow this up with detailed vine stem water potentials to map out the wet and dry areas of the block. Depending on the size and the number of vineyards, several pressure chambers (or soil probes) may be required if the block is large since leaf and stem water potential vary significantly during the day. Using these comprehensive maps, choose extreme and average sections which can then be used as indicators of how to manage the rest of the block and to save on time and labour.

Leaf water potentials (LWP)

Measurements are carried out using a pressure chamber (Figure 1) according to the technique described by Scholander (1965). Leaf water potentials are reference measures of vine water status and have enabled solid reference thresholds of vine water status to be established, mainly with the predawn leaf water potential (PLWP) (Carbonneau,1998; Carbonneau *et al.*, 2004) and with the stem water potential (SWP) (Choné *et al.*, 2001). PLWP is mainly used for research purposes and practically speaking SWP is recommended. In addition these methods have demonstrated the importance of water constraint and deficit on vine functioning according to (i) developmental stage; (ii) duration of water constraint or deficit and (iii) its intensity/level (Myburgh, 2007; Deloire *et al.*, 2005, 2004; Ojeda *et al.*, 2002; 2001; Van Leeuwen *et al.*, 2004; Naor *et al.*, 1997; Myburgh *et al.*, 1996; Van Leeuwen and Seguin, 1994).

This reliable, validated tool is conducive to appropriate sampling at the plot level.

Figure 1. *Example of a pressure chamber used to measure leaf water potential.*

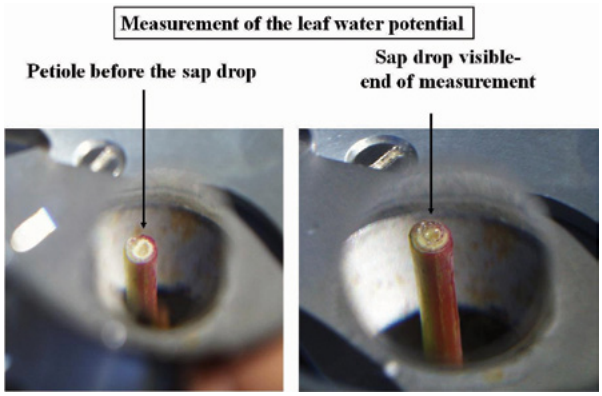

Figure 2. *The leaf water potential is obtained by pressurising a leaf with a neutral gas (such as nitrogen or air). When the sap drop is visible it is the end of measurement and the pressure is read on the pressure gauge. The duration of the measurement is less than a minute.*

Three cardinal measures of water potential

Pre-dawn leaf water potential (PLWP)

This data is obtained by measuring the leaf water potential by means of a pressure chamber (Scholander *et al.*, 1965). It estimates the capacity of the cells to retain water by pressurising a leaf with a neutral gas. The less free water there is in the plant, the greater the pressure required to cause it to exude. The result is expressed in bar or MPa, always as a negative value. The measurement of predawn leaf water potential (PLWP; ψ_{plwp}), is performed before sunrise, when the stomata of the plant are closed and when the grapevine has been able to equilibrate its water potential with wettest layer of the soil. PLWP is mainly used for research purposes only. Threshold values for $PLWP_{plwp}$ have been proposed by

Carbonneau (1998), which makes it possible to evaluate the degree of water deficit experienced by the plant (Tables 1 and 2). The approximate values are the result of 20 or more years of observations in many vineyards of different cultivars. The PLWP is the reference for most cultivars in interaction with the terroir unit. Table 3 gives some indication on possible reasoning of PLWP, vine physiology and berry ripening.

Table 1. *Predawn leaf water potential and grapevine water status (according to Carbonneau, 1998). The physiological and biochemical vine requirements to these thresholds will depend on the cultivar, the phenological stage and the duration of the water deficit. (1 bar = 0.1 MPa = 100 KPa). This is mainly used for research purposes and is unlikely to be used in practical situations.*

Classes	Predawn leaf water potential (Ψplwp, MPa)	Level of water constraint or stress
0	0 MPa ≥ ψ_{plwp} ≥ –0.2 MPa	No water deficit
1	–0.2 MPa > ψ_{plwp} ≥ –0.4 MPa	Mild to moderate water deficit
2	–0.4 MPa > ψ_{plwp} ≥ –0.6 MPa	Moderate to severe water deficit
3	–0.6 MPa > ψ_{plwp} ≥ –0.8 MPa	Severe to high water deficit (= stress)
4	< –0.8 MPa	High water deficit (=stress)

Table 2. *The following table proposes simplified thresholds of pre-dawn leaf water potentials. The physiological and biochemical vine requirements to these thresholds will depend on the cultivar, the phenological stage and the duration of the water deficit (1 bar = 0.1 MPa = 100 KPa) (From Deloire and Heyns, 2011).*

Predawn leaf water potential (Ψ_{plwp}, MPa)	Level of water constraint or stress
0 to –0.3	Little or no water deficit (for most cultivars)
–0.3 to –0.6	Moderate to severe water deficit (depending on the cultivar)
< –0.6	Water stress (for most cultivars; irreversible cell damage)

Table 3. *Threshold values of pre-dawn leaf water potentials (Y_{plwp}, MPa) and possible consequences for vine functioning. It should be noted that the threshold values can vary amongst different grape cultivars (Ojeda et al., 2002; Williams and Araujo, 2002; Deloire et al., 2005).*

Y_{plwp} (MPa)	Vegetative growth	Berry growth	Photosynthesis	Grape ripening
0–0.3	normal	normal	normal	normal
–0.3 to –0.5	reduced	normal to reduced	normal to reduced	normal or stimulated
–0.6 to –0.9	reduced to inhibited	reduced to inhibited	reduced to inhibited	reduced to inhibited
< –0.9	inhibited	Inhibited	total inhibition	partial or total inhibition

Midday leaf water potential (MLWP)

The midday leaf water potential (MLWP) allows the measurement of plant water status during the day. It is a method which enables the measurement of a short term hydric response (for example on an hourly basis) of the vine in reaction to a change in the root water absorption and the leaf transpiration (interaction soil water content x climate x leaf transpiration x cultivar). The leaf water potential is not really recommended due to high variability between measurements.

Stem water potential (SWP)

The stem water potential (SWP) is measured on leaves which are bagged with both a plastic sheet and an aluminium foil at least 30 minutes before measurement (Myburgh, 2010). The bagging of the leaves prevents transpiration and their water potential reaches equilibrium with water potential in the stems. Stem water potential values are highly correlated with transpiration (Choné *et al*., 2001). They are particularly accurate for revealing small water deficits, or water deficits on soils with heterogeneous soil water potential (in interaction with the vine rooting). Stem water potential is generally measured between 11h00 and 15h00. The stem water potential is stable and sensitive, which means that 4 to 6 bagged leaves are enough to get correct information on a vine water status for a specific homogeneous situation. The relationships between the SWP and the PLWP plateaus beyond –0.6 to –0.8 MPa of PLWP (Sibille *et al*., 2007; Williams and Araujo, 2002), which means that the SWP is difficult to use beyond a certain level of water deficit (YSWP < –1.4 MPa). Nonetheless, Table 4 gives some useful reference values for most cultivars. For excellent information on SWP thresholds see Choné *et al*. and Lovisolo *et al*. 2010.

Table 4. *Stem water potential (measured between 11.00 and 15.00h), and possible relationship to the level of vine water deficit. The table proposes thresholds for most cultivars. Recommended vine water status* according to phenological stages: budburst – flowering: classes 0 to 1; pea size – véraison: classes 1 to 2; véraison – harvest: classes 1 to 4 according to the desired yield and style of wine. Class 5 has to be avoided (From Deloire and Heyns, 2011).*

Classes	SWP (Ψ_{SWP}, MPa)	Level of vine water deficit
0	≥ –0.6	Zero water deficit
1	–0.7 to –0.9	Mild to moderate water deficit
2	–1.0 to –1.2	Moderate water deficit
3	–1.2 to –1.4	Moderate to important water deficit (according to cultivar)
4	–1.4 to –1.6	Strong to severe water deficit (according to cultivar: possible plant and cell damage)
5	< –1.6	Severe water deficit (stress: plant and cell damage).

* The recommendations have to be considered in the context of soil type, depth and water content, cultural practices, climate and cultivars.

For practical use in vineyards using data from water potentials measured by the pressure chamber, several factors must be taken into account, i.e. (a) the diversity and heterogeneity of plots (which involves sampling); (b) the time taken to carry out the measurements (1–2 min per leaf and 4–6 leaves used for an average measurement; the number of measurements per plot is variable according to the heterogeneity of the situation); (c) labour costs; (d) the size of the vineyard (the time taken to move among plots); (e) the pre-dawn leaf water potentials are carried out just before daybreak which limits the sampling period to about two to four hours; and (f) extreme temperatures just before or during the day of measurement could influence leaf water potential

results for specific cultivars (example of heat wave). As a very general indication, an irrigation of 12 mm could increase the stem water potential measured during the middle of the day (Ψ_{SWP}) by –0.4 MPa, 12 to 24 hours after the irrigation event. The irrigation programme has to be calibrated according to commercial targets of the yield and the desired style of wine. The amount of water, which will be applied will depend on the soil type and water content, the potential evapotranspiration and the cultivar (drought sensitive versus drought tolerant variety; Schultz, 2003). The duration of the irrigation will depend on the irrigation system (water flow rate of the drippers) and the number of drippers per m^2 or hectare. The irrigation programme has to be calibrated and established according to the recommendations provided in this article (one season could be enough for the calibration). A pressure chamber is therefore needed to begin the calibration. If the 'site by cultivar' combination is 'stable', the irrigation programme could be reproduced from one year to another. However the programme will have to take into account unpredictable climatic variables such as heat waves. Changes in soil water content can also be monitored with soil probes and morphological observations could be used in parallel with the pressure chamber.

Table 5. *Stem water potential as indicators of vine water status.*

Vigour	Safe window	Moderate to high water constraints	Water stress (Avoid)
0 to –0.6 to –0.9 MPa	–0.6 to –1.1 MPa	–1.1 to –1.4 MPa	Values more extreme than –1.4 MPa

* Values closer to 0 indicate that the vine is more hydrated.

In a nutshell

- It is recommended to avoid water constraint from budburst to the end of flowering
- From berry set to veraison (early berry softening), if a water constraint is applied, it is recommended to avoid high constraint and stress to preserve the fruit metabolism and composition (quality)
- From veraison to harvest, the irrigation program will depend on the desired yield and concentration of sugars and other fruit components (severe water stress has to be avoided)
- Irrigation is required before a heat wave

Examples of irrigation strategies

Vineyards and vine irrigation should be managed according to the production goals and the phenological stages:

- Bud break to flowering
- Flowering to the very beginning of veraison (berry softening)
- Veraison (very beginning of berry softening) to harvest

Table 6 provides some examples of possible irrigation strategies using the information on vine water status.

Other morphological indicators (growth and necrosis of the apex, leaf shrivelling, and tendril angle) and/or physiological indicator (berry sugar accumulation) could be used in parallel of measuring vine water status.

Table 6. *Examples of irrigation options at the various developmental stages of the vine. Other options could be chosen according to yield, fruit quality/composition and potential wine style goals.*

Developmental stage	Stem water potential (MPa)*	Predawn leaf water potential (MPa)*	Purpose
Budburst to fruit set	0 to –0.6	0 to –0.3	Avoid water deficits as flowers and fine roots are developing during this stage. Fruit set is very sensitive to any water stress
Fruit set to early veraison (start of berry softening)	0 to –0.6	0 to –0.3	To prevent inhibition of canopy and fruit growth and metabolism avoid water constraints
	–0.7 to –0.9 or –1.0 to –1.2	Regulated deficit irrigation (RDI) at –0.3 to –0.5	To achieve a reduction in vigor and fruit size trying to avoid perturbation of fruit metabolism (more extreme values than shown here will result in the inhibition of important compounds: tannin, aromatic precursors, organic and amino acids)
Veraison to harvest	0 to –0.6	0 to –0.3	Avoid any water constraints to prevent the inhibition of fruit growth
	–0.7 to –0.9 or –1.0 to –1.2	–0.3 to –0.5	To manage fruit volume (more extreme values than shown here will affect leaf functioning and result in slowed sugar and anthocyanins)
Post-harvest	0 to –0.9	0 to –0.5	To replenish vine carbohydrate reserves, water stress has to be prohibited to avoid inhibition of photosynthesis

* Values closer to 0 indicate that the vine is more hydrated.

Summary in a nutshell

- There are various ways to practically assess soil moisture and vine water status including soil probes, the pressure chamber and morphological indicators.
- The decision on which tool/method to use and how to manage irrigation belongs to the growers and the winery but training to use decision making tools is often required/ recommended.
- Cost, labor, practicality and efficiency should be considered prior to choosing a method or a tool.
- Irrigation management needs to consider practical goals such as yield, fruit quality/ composition and desired/potential wine style
- While new tools or technologies are under development, the above considerations will still apply when they become available.

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Nitrogen nutrition and grape and wine production

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In a nutshell

- Vineyard nitrogen (N) supply elevates berry N and yeast assimilable N (YAN)
- N mobilisation from other annual and reserve tissues is an important contributor to N in grapes
- Petiole N and early YAN concentrations can predict final YAN levels at harvest
- Assessment of must YAN levels prior to fermentation is important to determine additional yeast requirements
- The final wine flavour characteristics are influenced by amounts and composition of YAN in the must

Introduction

The nitrogen supply in the vineyard affects the N status of vines, which affects the form and concentration of nitrogenous compounds in must. During berry ripening, mobilisation of N from vine storage organs often moves to the bunches and alters the amount of N in the grapes The total berry N content increases during maturation, with the majority of N and amino acids present in the flesh and the skins. Arginine and proline are often the most dominant amino acids in the must (Figure 1A), with the later usually accumulated at the end of the berry ripening process and can not be utilised by the yeast. Ammonium (NH_4) is another important N containing compound in the must, but the concentration declines during berry maturation. Free assimilable amino N (FAN) increases during this period and is therefore influenced by harvest date (Figure 1B).

Primary amino acid N or α amino (FAN) and ammonium N (NH_4) are classified as yeast assimilable N (YAN), having a critical role in the fermentation process. Low YAN levels result in slow (or stuck) fermentation, while high levels lead to fast or boiling ferments. In addition, YAN levels and composition influence aroma and flavour characteristics, this is due to the production of desired/undesired compounds during the fermentation and consequential presence in the wine. A range of 250 to 350 mg/L is seen as the optimum YAN level in the must and required additions are often made with di-ammonium phosphate (DAP) in the winery when YAN levels are insufficient to sustain fermentation. However, it is important to know the YAN levels prior to the addition of DAP, to avoid rapid fermentations and the development of undesired compounds in the wine.

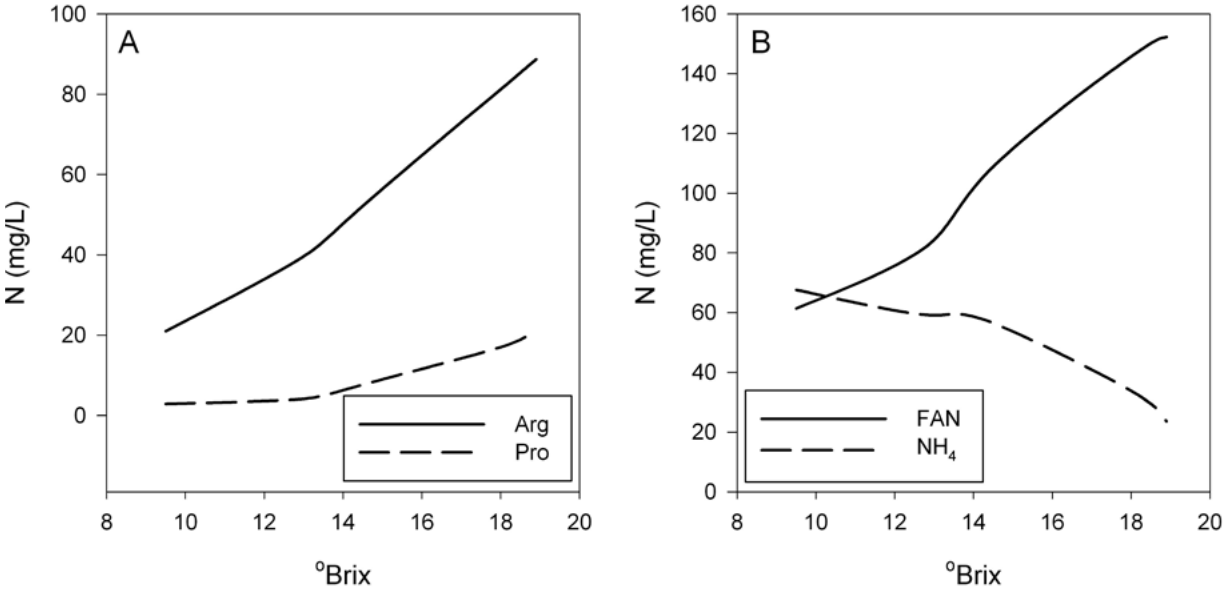

Figure 1. *Changes in Riesling juice N concentration of arginine (Arg) and proline (Pro), from veraison to harvest (A). The changes of yeast assimilable N (B) in free assimilable amino acid N (FAN) and ammonium (NH4) from veraison to harvest (Müller et al. unpublished data)*

Vineyard N supply and must N

The main factors, other than seasonal and environmental, for N uptake are the amount of water and N fertiliser applied to a vineyard, both of which play a major role in the growth and development of vines. The amount applied is usually based on petiole N Levels (or N status) at flowering and by considering the production level (N removal). The N status of the vine does relate to berry N, but low N supply can also reduce cluster initiation, fruit set and berry size. The timing of N application is also critical for influencing vine growth and yield and on the N directed towards the berries. An N application between bloom and veraison results in higher berry N compared to an application after harvest (Figure 2A). Application during the post-harvest period usually enhances early development and yields in the following season. Reduced water supply in the form of partial rootzone drying (PRD) can lower berry YAN concentrations, while regulated deficit irrigation (RDI) can lead to a slight increase of must YAN (Figure 2B).

The application method is also important, foliar application and fertigation being the most effective. Urea sprays applied at rates between 5 to 50 kg/ha (concentration less than 4%) around veraison can considerably increase berry YAN levels at harvest. N applied through the fertigation system from bloom to veraison has also shown to be very effective in elevating juice amino N. Soil applied N is less effective, with the N form in the fertiliser or N to C ratio in organic fertilisers determining the rate of uptake.

Assessment and prediction YAN

The YAN levels could be predicted by petiole levels measured at veraison, to allow for adjustments of N supply in the period of berry development, also considering the potential yield (Figure 3A). However, an application might be necessary during early berry development and this would be indicated by N measures at flowering. Testing the level of N in the petiole at veraison provides the opportunity for further adjustments that might be required to reach an optimum YAN level at harvest.

Veraison petiole values of about 0.5N %DW for red grapes correlate with about 100mg N/L FAN. The contribution of NH_4 in the must has also to be considered, since YAN levels of 100mg N/L for red and 150 mg N/L for white musts are seen as a minimum requirement for low risk fermentation. However, the optimum concentrations for white grape must are in the range of 250 to 350 mg N/L. The range for red grape must is not defined, but is likely lower since the YAN in the skins can be utilized during the wine making process. Because of the connection between petiole N and must FAN, the petiole N concentrations also have a strong relationship with the sugar consumption during fermentation (Figure 3B).

Final YAN levels can also be predicted by assessing those more than a month prior at harvest, by direct determination in the juice during berry maturation. Such a prediction will provide early information on N addition requirements in the winery, but this would make it difficult to make adjustments in the vineyard. The use of veraison petiole N can provide additional information for optimising YAN levels in the vineyard; these assessments are more feasible with cheaper techniques available to determine the N concentrations.

Must YAN and fermentation

It is most reliable to determine yeast assimable amino (YAN) levels close to harvest, as harvest maturity influences the nitrogenous compounds in the berry. In addition, the harvest procedure and the transport

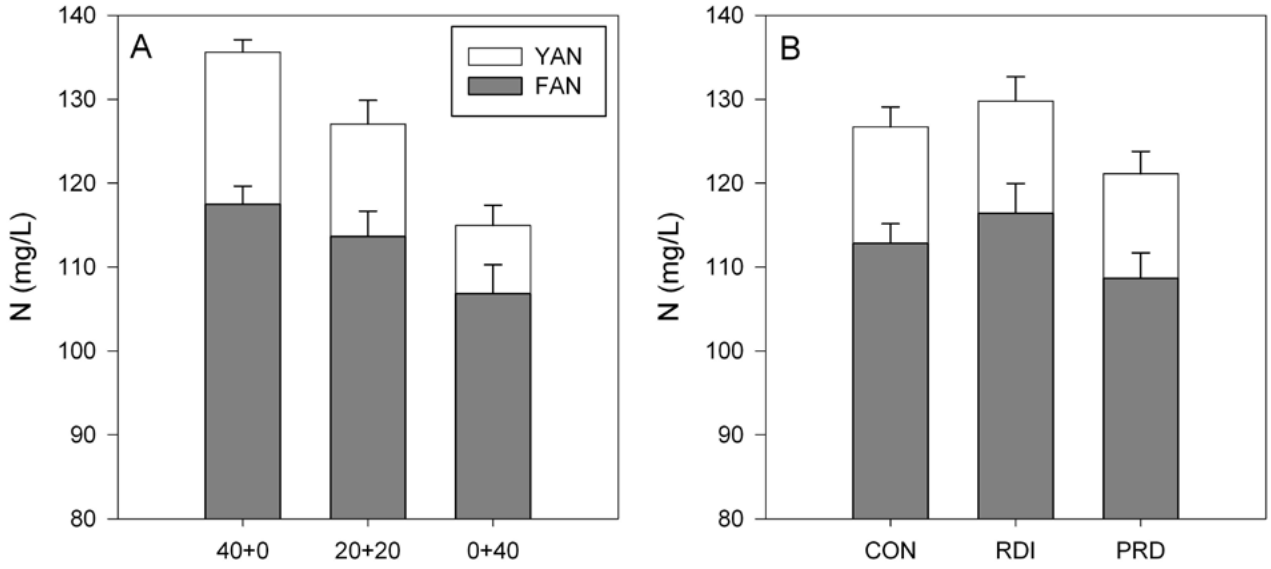

Figure 2. *The influence of N timing with an application rate of 40 kg/ha (A) and irrigation management (B) in a Shiraz vineyard on free assimilable amino (FAN) and total yeast assimilable N (YAN) (Holzapfel et al. unpublished data).*

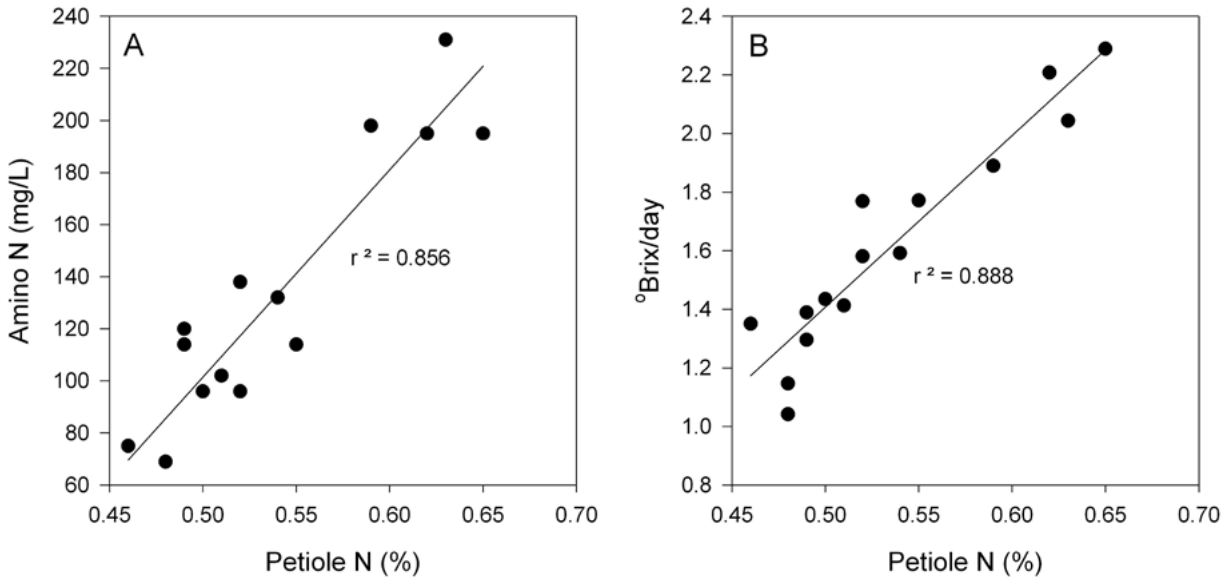

Figure 3. *Relationship between petioles N at veraison and assimable amino N at harvest (A) and daily sugar consumption in the fermenting Shiraz must (B) (adapted from Holzapfel and Treeby 2007 and 2013).*

can reduce must YAN concentrations due to microbial growth. YAN in the must is composed of free a amino N (FAN) and ammonium (NH_4), with the minimum requirements for yeast being about 100 or 150 mg N/L of must for the completion of fermentation, for red and white grapes respectively. The yeast utilised first the NH_4 and then the primary amino N, with the preference of utilisation also varying between the various amino acids. The amount of YAN (and also sugar levels) in the must influences the fermentation rate; musts with low levels are associated with sluggish and stuck ferments, while musts with high levels ferment too fast (Figure 4).

The amount of YAN present in the must impacts on the compounds produced during the fermentation process. Low N must results in elevated levels of thiols in the wine and higher alcohols and lower amounts of esters and long chain volatile fatty acids. In contrast, high N must leads to an increase in ethyl acetate, acetic acid and volatile acidity. Higher concentrations of urea, ethyl carbamate and biogenic amines in the wine have also been observed in wines produced from high YAN musts. In addition, the composition of the FAN is also important for wine composition, since the various amino acids provide C-skeletons for certain flavour compounds produced during the fermentation process, impacting on the sensory profiles of the wines produced.

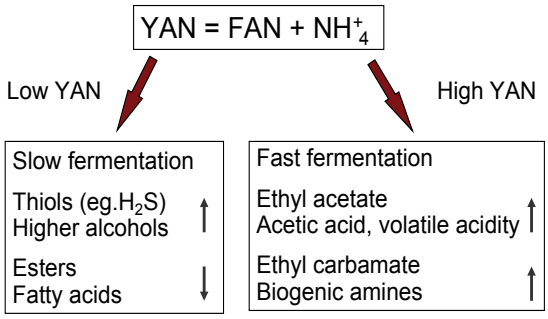

Figure 4. *Juice yeast assimilable N (YAN) levels and the wine making process.*

Impact on wine characteristics

The aromas and flavours in wine are influenced by four major sources, with the compounds formed by the yeast during the fermentation being one of them. The yeasts vary in their requirements for N, ranging from very low to extreme. Therefore it is important to measure the YAN levels in the winery to determine the requirements for N additions to the must prior fermentation. These levels can be assessed for instance enzymatically for NH4 and with the o-phthaldaildehyde/N-acethyl-cysteine reagent (NOPA) for α-amino N.

The amount of YAN is not only important for the fermentation rate, but also for compounds produced during the process. For instance, deficiencies results in undesired thiols (hydrogen sulfide), being produced from S containing amino acids, while must with balanced YAN levels are high in desired aroma compounds such as terpenes and esters. To optimise fermentation and the produced compounds during the process inorganic or organic N is added to the must, being in from of DAP or α-amino N or a mixture of both. The issue with the inorganic N is that that the yeast is using this form with preference to the amino acid N. Therefore it is better to add a complete nutritional supplement to musts that are YAN deficient.

The required N additions to the must should only be based on must YAN levels, but also should take into account the fermentation conditions (e.g. yeast and temperature) and consider wine style targets. As indicated above, the N compounds present in the must influence the volatile compounds and therefore the aroma profile of the wine (fermentation bouquet). The flavour is also affected by the production of non-volatile compounds (eg. polyols). In addition, the remaining N after the alcoholic fermentation has an important role for the secondary fermentation (malolactic) and microbial stability of the wine.

Conclusions and recommendations

N supply and N status is closely related to must amino acid composition and amounts, being crucial for the formation process and wine aroma and flavour. The vineyard adjustments to achieve an optimum YAN level at harvest can be based on petiole N status at bloom and veraison. The later can be particularly helpful in making prediction of YAN levels at harvest, allowing additional N applications if required during berry ripening. However, it is important to monitor the YAN levels in the incoming must to the winery, for determining required adjustments for the wine making process. Insufficient YAN must levels can be enhanced by adding inorganic or organic N in the winery. However, it is best to use DAP and other supplements only for fine tuning the must, while the grape amino-N content should be optimized in the vineyard for maximising wine flavour and aroma.

Acknowledgments

The authors would like to thank the past and current staff of the National Wine and Grape Industry Centre (NWGIC) and all industry collaborators who contributed to this paper.

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AWRI website. www.awri.com.au/

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Colour in red grapes

AN EXCERPT FROM RIVERINA GRAPE QUALITY PARAMETERS AND THEIR EFFECT ON WINE PRODUCTION BOOK
COURTESY OF THE AUSTRALIAN WINE RESEARCH INSTITUTE, MARK KRSTIC

The colour of red grapes is often used as a measure of relative quality of grapes, especially in some inland regions such as the Riverina. Growers have been encouraged to undertake practices that will improve the intensity of colour of red wine grapes, especially for Cabernet Sauvignon, Merlot, and Shiraz. Some wineries provide incentives through their grape pricing. The red colour in grapes comes primarily from a group of phenolic compounds known as anthocyanins. These coloured anthocyanin compounds are found in the skins of all red varieties – this is why these varieties are fermented on skins for the production of red wine. There are a few varieties such as Rubired and Alicante Bouschet that have redcoloured flesh in berries. Levels of anthocyanins may be measured quantitatively in grapes by a range of laboratory techniques – most commonly via spectroscopy methods (e.g. Iland *et al.* 2004) and recorded in units of milligrams per gram berry fresh weight (mg/g) or milligrams per berry fresh weight (mg/berry).

Winery expectation

Winery expectations vary significantly depending on grape variety and growing season temperatures, especially post veraison. In berries, anthocyanin formation is optimal between 17–26°C. This means that intense colour tends to be more difficult to achieve in extremely hot and extremely cold regions. It also means that a warm region will normally have better colour intensity in a cooler than average season. Ranges of typical colour values for different regions can be found in Table 1.

Additional processing steps required

Some wineries may impose a minimum harvest colour standard – that is, red grapes must achieve a minimum colour level before being acceptable for harvest – as winemakers seek to make wellcoloured red wines from purchased red wine grapes. A small number of wineries may have a payment schedule linked to anthocyanin concentration (mg/g) in red winegrapes.

Wineries tend to stream grapes of similar colour/quality together during intake. Wines with low colour may need to be blended with wine of higher colour to produce

Table 1. *Typical colour ranges for red grape varieties from several Australian grapegrowing regions.*

Growing region	Average colour (mg/g)	Range (mg/g)
Cabernet Sauvignon		
Murray Valley	0.9–1.2	0.4–2.0
Riverland	0.9–1.2	0.4–2.1
Riverina	0.8–1.1	0.3–1.9
Coonawarra	1.4–1.7	0.9–2.8
Shiraz		
Murray Valley	1.2–1.5	0.4–2.3
Riverland	1.1–1.6	0.4–2.3
Riverina	1.1–1.4	0.4–2.1
Coonawarra	1.5–1.8	0.9–3.0
Merlot		
Murray Valley	0.9–1.3	0.4–2.0
Riverland	0.7–1.3	0.4–2.0
Riverina	0.8–1.2	0.3–1.9
Coonawarra	1.4–1.8	0.9–2.7

Note: these levels are a guide only and will vary from season to season depending on growing conditions (primarily temperature), vineyard management practices and cropping levels.

Figure 1. *Ruby Cabernet – MOG level 0 (Source: Krstic et al. 2003)*

wines of acceptable quality standards to be incorporated into branded products.

Sometimes, potassium metabisulfite (PMS) may be added to loads of harvested grapes in the field. While this may prevent oxidation, it can also be responsible for 'bleaching' red wine grapes. Care should be taken to ensure fieldadded PMS is spread out evenly across the load and not concentrated in some parts of the load.

Financial impact on winery

Anthocyanins may be readily oxidised, either in the presence of oxygen or facilitated by the enzyme laccase (found in botrytisinfected fruit). This leads to the formation of yellow brown pigmented quinones and other undesirable phenolic compounds. In this event, significant additional processing may be required in the winery to remove these compounds with fining agents or pasteurization to remove/inactivate the laccase enzyme.

Impact on wine quality

Inability to meet the minimum colour levels will detrimentally affect wine quality – wines will be too light in colour and can be linked (in hot inland regions) to reduced desirable flavor and aroma compounds. In hot inland regions, high grape colour/anthocyanin levels are targeted – but in cooler regions, the relationship between grape colour and wine quality is not as strong.

Causes

Low colour: Generally, anthocyanin levels in wine grapes increase throughout grape maturity. When vines are over cropped, harvested early or out of balance there may be a delay in maturity and reduced colour. Colour formation also requires mild temperatures, so a very hot growing season or overexposed bunches will result in low colour formation. Alternatively, a cold or wet season reduces the development of colour in the berries and the presence of laccase from some bunchrot fungi may lower anthocyanin levels. Excessive irrigation and nitrogen nutrition can also produce poorly coloured fruit.

High colour: Colour is commonly a desirable trait in red grapes however excessive levels may be caused by severely shriveled grape berries. This fruit may contain 'cooked' or 'jammy' flavours which are undesirable in final wines.

Avoidance

Excessive bunch exposure as well as too much shading may also affect the rate and uniformity of colour development. Balanced vines which do not exhibit excessive vigour are best equipped to produce grapes with good colour. Excessive irrigation and nitrogen, as well as the presence of laccase causing bunchrot fungi are factors that have been associated with poor colour.

Further reading

Iland, P., Bruer, N., Edwards, G., Weeks, S. and Wilkes, E. (2004) *Chemical analysis of grapes and wine: techniques and concepts*. Patrick Iland Wine Promotions Pty Ltd, Adelaide, Australia.

Krstic, M.P., Moulds, G., Panagiotopoulos, B. and West, S. (2003). Growing Quality Grapes to Winery Specifications. *Winetitles*, Adelaide, Australia.

Major agrochemical 'Dog Book' updates for 2014–15

MARCEL ESSLING, SENIOR VITICULTURIST, THE AUSTRALIAN WINE RESEARCH INSTITUTE, ADELAIDE

The AWRI publication *Agrochemicals registered for use in Australian viticulture 2014/2015* ('Dog Book') is now available. This agrochemical update summarises the major changes in the 2014–2015 'Dog Book' compared with the previous version.

Timing chemical application to growth stage

The following statement is emphasised on page 3 to better meet target withholding periods and satisfy export market maximum residue limits (MRL).

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.

Footnotes

Footnotes are now printed at the bottom of the page where they appear.

Active constituents and targets

TEBUCONAZOLE + AZOXYSTROBIN

APVMA 66541

Custodia has been granted registration by the Australian Pesticides and Veterinary Medicines Authority (APVMA) for control of Botrytis and downy mildew in grapevines. Custodia is a Farmoz Pty Ltd product. It contains the active constituents tebuconazole and azoxystrobin. It should be used as a protectant treatment only. Restriction on use for export grapes: Use no later than 80% capfall.

Resistance management strategy: Do not apply more than two consecutive sprays of Custodia. Do not apply more than two sprays of Custodia per season. Do not use Custodia curatively.

SULFOXAFLOR

APVMA 64101

Transform has been granted registration by the APVMA for control of longtailed mealybug in grapevines. Transform is a Dow AgroSciences product. It contains the active constituent sulfoxaflor.

Restriction on use for export grapes: Use no later than 80% capfall.

Resistance management strategy: Do not apply consecutive applications of products from the same mode of action group (Group 4C).

Notes: Transform should not be used more than twice per season.

CYPROCONAZOLE + IODOCARB

APVMA 47914

Garrison Rapid Pruning Wound Dressing has been granted registration by the APVMA for control of eutypa dieback in grapevines.

Garrison Rapid Pruning Wound Dressing is a Chemcolour Industries Australia Pty Ltd product. It contains the active constituents cyproconazole + iodocarb.

Restriction on use for export grapes: Not required when used as directed.

Notes: Dormant spray. Apply on the same day as pruning. Do not apply during the growing season.

Botrytis bunch rot

The active constituent cyprodinil was listed for *Botrytis* bunch rot. A withholding period of 'Use no later than E-L 29, berries peppercorn size (4 mm diameter). Do not use within 60 days of harvest' applies. Until now the fungicide cyprodinil was only available in co-formulated form with fludioxonil.

Grape leaf blister mite

The active constituent paraffinic oil was listed for grape leaf blister mite. A restriction on use of 'Dormant spray only' applies.

Grapevine scale

Listings of 1B insecticides registered for grapevine scale were removed from the 'recommendations' section of the 'Dog Book'. A footnote stating 'Some group 1B insecticides are registered for grapevine scale. Contact your winery or grape purchaser prior to any 1B insecticide application' was added.

Grapevine growth stage description

More detail has been added to the grapevine growth stage descriptions.

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

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% caps have just lifted and the largest berries are no more than 2 mm in diameter.

E-L stage 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.

The grapevine growth stage table from Viticulture 1 – Resources. 2nd edition 2004. Eds Dry, P. and Coombe, B. (Winetitles) is now published in full on page 13 of the 'Dog Book'.

Insecticide

Following a review by the APVMA, dimethoate is registered for aphids, jassids, mites, thrips, and Queensland fruit fly in viticulture. Follow label directions and contact your winery or grape purchaser prior to any 1B insecticide application.

Label restriction on use: Do not use after flowering commences (E-L 19).

Resistance management

For fungal pests where resistance is an issue, the following statement has been added to the bottom of the page: 'Fungicide resistance in this pathogen has been reported. Review resistance management strategies on page 22 and follow the directions'.

The powdery mildew resistance management strategy has been updated to include Group U6 (phenyl-acetamide) fungicides.

This information is provided to inform the Australian grape and wine sector of agrochemical information, and should not be interpreted as an endorsement.

Update on phylloxera detection methods

In 2013 a four year trial commenced between Plant Biosecurity Collaborative Research Centre, Australian Grape and Wine Authority, South Australian Research and Development Institute, New South Wales Department of Primary Industries, Department of Environment and Primary Industries – Victoria, University of Adelaide, and Rho Environmetrics to develop a DNA sampling tool for the detection of phylloxera in soil using molecular techniques.

Background

At present, surveillance for phylloxera relies on aerial imagery to identify weak vines followed by a process of digging and inspecting vine roots by skilled inspectors. This has several limitations including costs, not all vines with low vigour are phylloxera infested or phylloxera may be present but its effects are not recognised. Furthermore, the National Phylloxera Management Protocol (NPMP) does not have an endorsed maintenance protocol to demonstrate area status for phylloxera.

Research approach

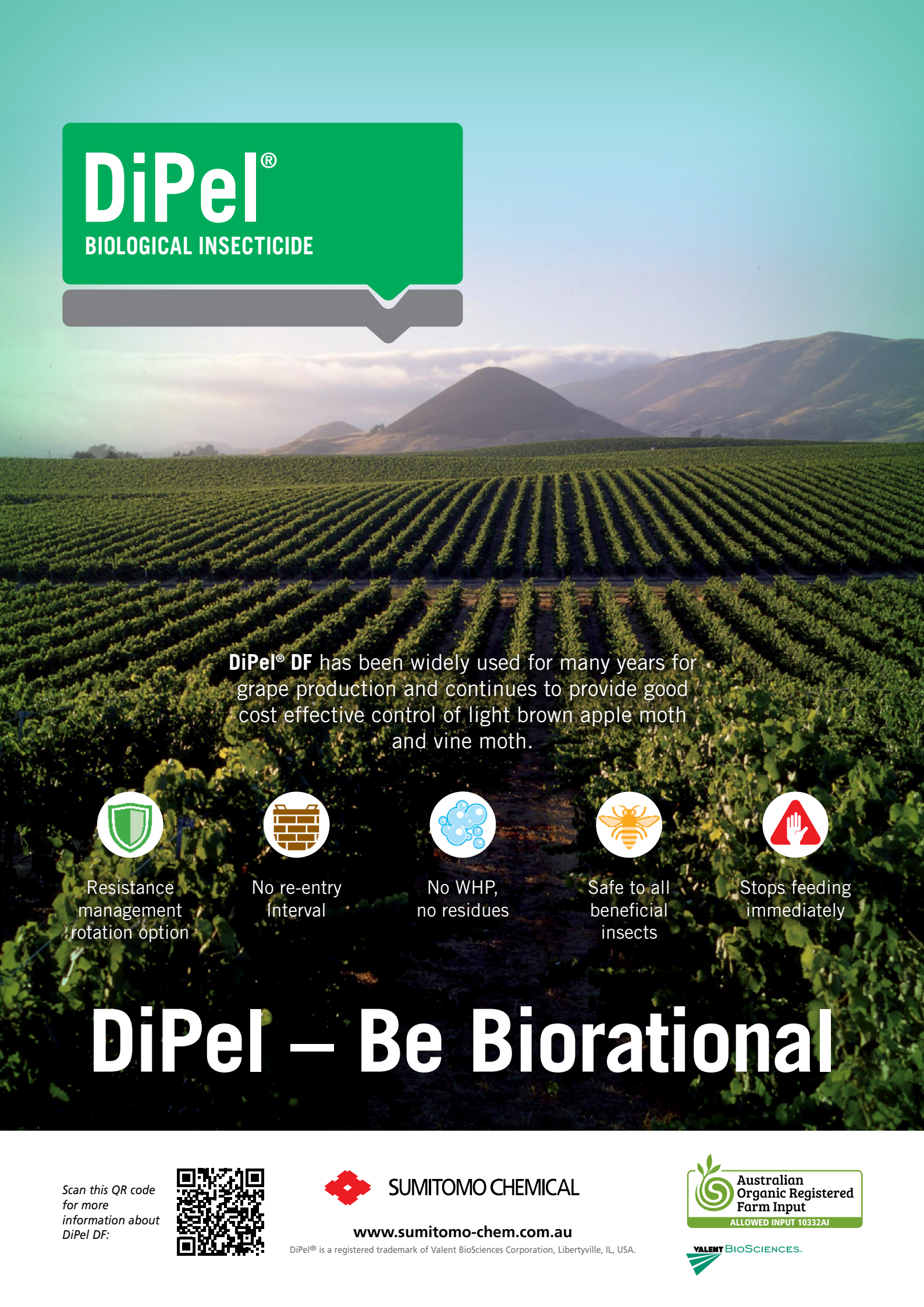
This project builds on previous research assessing the most appropriate sample location to achieve detection. In addition, research is evaluating the effect of different soil types, seasonal impacts, transport and impact of storage on sample integrity. Once the sampling matrix has been prepared, the protocol will be tested by growers to determine the accuracy and assess the robustness of the protocol.

Industry benefit

Using a DNA testing technique, the presence of Phylloxera can be detected in soil samples in a cheap and efficient manner. This project will develop a sampling method that can be easily and quickly carried out in the vineyard toprovide the most accurate sample for diagnostic analysis. It considers seasonal conditions, soil type and will greatly assist in phylloxera status surveillance.

Follow the link to access PMZ maps across Australia
https://maps.phylloxera.com.au/virtual/pmz

For more information on this project contact:
Alan Nankivell
Chief Executive Officer
Phylloxera and Grape Industry Board of South Australia
www.phylloxera.com.au



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VALENT BIOSCIENCES

NSW Grapevine pest and disease guide

COURTESY OF THE AUSTRALIAN WINE RESEARCH INSTITUTE

This leaflet was produced by the Australian Wine Research Institute as part of the delivery of the New South Wales Department of Primary Industries, Viticulture Skills Development Program.

The pests and diseases contained in this leaflet, left uncontrolled in the vineyard, pose a threat to grape production. Correct identification is essential for effective control of pests and diseases and for the detection of new exotic pests and diseases which have been introduced to the state.

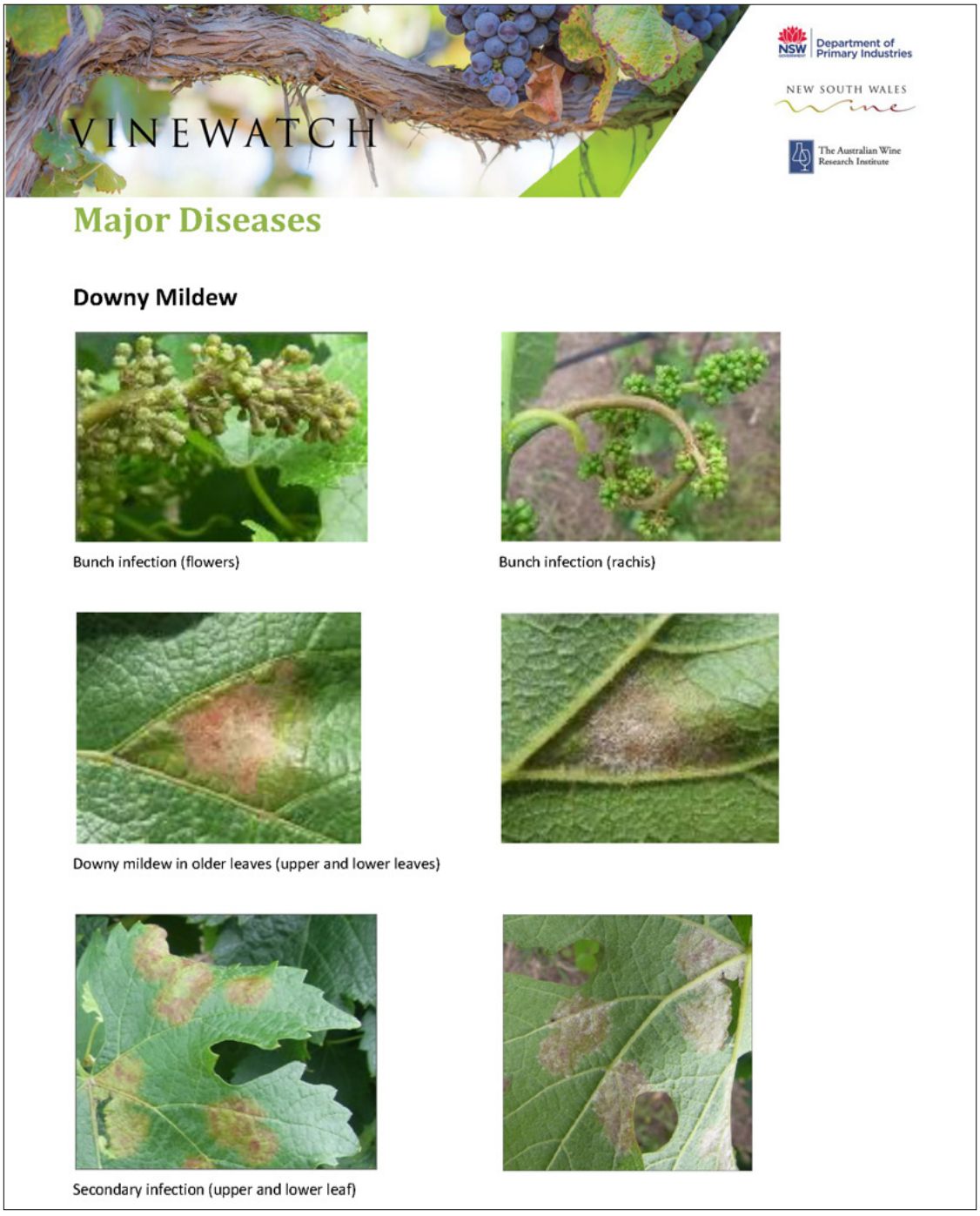
Additional sources of information for the identification and control of grapevine pests and diseases can be found at the back of the leaflet.

If you think you may have an exotic pest or disease, or an outbreak of phylloxera, please call the Exotic Plant Pest Hotline 1800 084 881.

All images in the NSW Grapevine pest and disease guide, unless the source is otherwise labelled, were provided by Dr Richard Hamilton.

Go to www.awri.com.au

The following is an example page from this book.



Tocal College – specialised training to rural industries

RTO NUMBER 91166

Tocal College is a leading Australian Provider of specialised training to rural industries. It consists of CB Alexander Campus at Paterson and the Murrumbidgee Rural Studies Centre at Yanco, with education staff also located at Camden, Gosford, Tamworth and Wagga Wagga.

Tocal offers adult education through delivery of PROfarm short courses and external courses and through skills recognition (life experience) programs.

Skills Recognition (Life Experience) Program

Skills recognition is sometimes referred to as Recognition of Prior Learning (RPL). Skills Recognition gives formal credit for the knowledge and abilities you have already gained through life, in formal course work at recognised institutions, or by attending workshops and short courses.

Skills recognition is available for a range of qualifications, including the nationally recognised Diploma in Horticulture and the Diploma of Agriculture. It reduces the number of units you need to study to complete these qualifications. Skills recognition gives you a flying start and allows you to build knowledge and skills gained through short courses towards a full qualification.

PROfarm Short Courses

The PROfarm program consists of over 100 specialist courses in agriculture, conservation and land management, natural resource management, farm business management and other rural industry areas.

Courses range in length from one to five days and are designed to meet the needs of farmers, primary industries, agribusiness and the community. The courses focus on real-world issues and are delivered throughout New South Wales by specialist extension and education staff of NSW Department of Primary Industries. For details see www.profarm.com.au

External Courses

Tocal College offers external courses at diploma and advanced diploma level in agriculture and in conservation and land management. These courses provide the opportunity for specialisation in areas such as integrated weed management, farm business management and vertebrate pest management.

Tocal's external courses feature a blend of skills recognition (see above), online study and short course study units. These courses also provide a pathway to the B.Agrifood Systems at UNE.

Traineeships

The College provides industry traineeships in agriculture, horticulture, irrigation and wine industry operations. Trainees are expected to attend training on a part time basis.

CB Alexander Campus, Paterson
Phone: 1800 025 520 Email: info@tocal.com Web: www.tocal.com
Postal: The Principal, Tocal College, Paterson NSW 2421

Murrumbidgee Rural Studies Centre, Yanco
Phone: 1800 628 422 Email: mrsc@industry.nsw.gov.au

Other College Centres for PROfarm Courses
Camden/Sydney basin: (02) 4640 6333 Tamworth/Northern NSW: (02) 6763 1100

Herbicides for use in vineyards

BRUCE BROWNE, CHEMICALS OFFICER, BIOSECURITY NSW, NSW DPI, ORANGE

Herbicide groups (see following tables)

- High Risk: Groups A
- Moderate Risk: Groups C–Q

Remember:

- Read and follow the label directions of registered herbicide products before using.
- Calibrate spraying equipment and provide sufficient agitation of herbicide in tank, especially when using
  WP – wettable powder
  WG – wettable granules
  DF – dry flowable
  SC – suspension concentrate.
- Consult the label for recommendations for use of wetting agents.
- Practice herbicide-resistance minimisation strategies.

Check withholding periods of herbicides before use, as well as rainfast times.

Table 3 lists post-emergent herbicides registered in NSW for use in vineyards. Table 4 lists the residual herbicides registered for use in vineyards, and Table 5 shows non-selective post-emergent herbicides registered for grapevine sucker control in vineyards.

Remember: Read the product label before using a herbicide.

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

Group	Chemical	Trade names	Rates	Weeds controlled	Comments
Q	250 g/L amitrole + 220 g/L ammonium thiocyanate	Amitrole T **No longer marketed**	4–12 L/100 L water	Broadleaf weeds and grasses	Apply when weeds are small and making active growth. Repeat application may be needed in 6–8 weeks. Apply as a directed spray to weeds only. Use higher rates for larger and more tolerant weeds.
J	740 g/kg 2,2-DPA-sodium	Agspray Atlapon Dalapon 740 SP	Boom: 10 kg per sprayed hectare	Annual and perennial grasses including couch, paspalum	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 to 14 day intervals.
G	240 g/L carfentrazone-ethyl	Spotlight Plus NAIL™ 240 EC Hammer ®	–25 75mL/ha plus recommended label rates of knock-down herbicides Spot spray 10 mL/100 L plus recommended label spot spray rates of knockdown herbicides	Small-flowered mallow and certain other broadleaf annual weeds	Apply as a tank mix with Gladiator, Roundup PowerMAX or other glyphosate products or with Spray Seed, Shirquat, Nuquat or other paraquat products. Addition of 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 may improve final control of broadleaf weeds, including certain hard-to-kill weeds (marshmallow in particular). The use of higher rates and full soil disturbance may 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 may only provide suppression of capeweed, wild radish, common storksbill and doublegee under poor growing conditions.
N	200 g/L glufosinate-ammonium	Basta	1.0–5.0 L/ha	Annual and perennial weeds	Apply as a directed or shielded spray. Refer to the label section **Application** for specific information on application methods. **Warnings:** Do not allow spray or spray drift to contact desirable foliage or green (uncalloused) bark. To avoid potential crop damage, refer to the label sections on **Application Equipment and PROTECTION OF CROPS, NATIVE AND OTHER NON-TARGET PLANTS.** Basta may be used around trees or vines less than 2 years old provided that they are effectively shielded from spray and spray drift.
M	360 g/L glyphosate – ipa	Roundup Glyphosate 360	Annual weeds: Boom: 2–3 L per sprayed hectare Perennial weeds: Boom: 3–9 L per sprayed ha 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 trees 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 tree, vine or palm. Avoid painting out stumps with this product, as injury resulting from root grafting may occur in adjacent trees. **Citrus fruit, nuts, olives, pome fruit and vineyards.** 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. For residual control of annual weeds, glyphosate may be tank-mixed with certain residual herbicides. See label for directions.
M	360 g/L glyphosate (present as ipa and mono-ammonium salts)	Weedmaster Duo	See label for directions	See label for directions.	See label for directions
M	450 g/L glyphosate – ipa	Various	See label for directions.	See label for directions.	See label for directions.

Group	Chemical	Trade names	Rates	Weeds controlled	Comments
M	540 g/L glyphosate – ipa/mas	Credit	See label for directions.	See label for directions.	See label for directions.
A	130 g/L haloxyfop-R-methyl	Asset	Annual grasses: 800 mL/ha Couch: 1.6–3.2 L/ha Paspalum, Johnson grass: 0.8–1.6 L/ha	Wide range of annual and perennial grasses (couch and paspalum)	Direct the spray to the base of trees or vines at any growth stage, but make sure contact with fruit and foliage is avoided. See product label Directions for Use table for rates. Couch grass (established): Use the higher rate if couch is at the late tillering mature stage. Paspalum/Johnson grass: Use the lower rate when weed is in the vegetative to early tillering stage. Higher rate required at the late tillering stage. Annual grasses: Use the lower rate when weed stage is from 2-leaf to early tillering.
A	520 g/L haloxyfop-R-methyl	Verdict 520	Annual grasses: 200 mL/ha Perennial grasses: Couch, Rhodes, slender rats tail 400–800 mL/ha Paspalum, kikuyu, buffel, Johnson, Setaria 200–400 mL/ha	See label for additional plants 2-leaf to tillering Established stands	Spray should be directed to base of vine. Avoid contact with fruit and foliage. Spot spray: use 25–50 mL/100 L (high rate on late-tillering mature grasses). Verdict 520 rates are to be used with spraying oil or non-ionic wetter, according to label directions. When using perennial rates, annual grasses are also controlled.
Q + L	250 g/L amitrole 125g/L paraquat	Alliance	See label for directions	See label for directions	See label for directions.
L	250 g/L paraquat	Gramoxone, Nuquat Paraquat	Knapsack: 50 mL Paraquat plus 30 mL non-ionic wetter/15 L (add 30 mL diquat if capeweed is present) Boom: 1.7 L/ha. If product rate is less than 400 mL/100 L, add 100 mL Agral or 60 mL BS1000/100 L of spray mix. Add diquat if capeweed 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. In bananas apply soon after weed emergence and before weeds reach 15 cm in height. Use spraying pressure less than 240 kPa. Avoid chemical contact with roots and peepers near the pseudo stem. Repeat sprays as required. Gramoxone 250 will not harm trees or vines with mature brown bark if this product is sprayed. Use the higher rate for dense weed growth.
L	200 g/L diquat	Reglone, Diquat	1.5 L + 1.4 L Agral in 700 L water/ha plus 1.6 L/ha Gramoxone 250	Capeweed	Apply as a directed spray under trees or vines. Under most conditions Gramoxone 250 at 1.6 to 3.2 L/ha or Spray.Seed 250 at 2.4 to 3.2 L/ha will give effective control of grasses and broadleaf weeds in orchards, but where heavy infestations of capeweed occur Reglone 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 Reglone have no effect on brown bark, but care should be taken when spraying around trees to avoid spray contacting green bark or plant material.

Group	Chemical	Trade names	Rates	Weeds controlled	Comments
L	135 g/L paraquat + 115 g/L diquat	Spray.Seed 250 Herbicide	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 see label.	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 Spark at 250 mL/ha will improve control of small-flowered mallow, evening primrose and other weeds sensitive to Spark. Refer to the Spark label. **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 to 32 mL of Spray.Seed 250 in this volume.
A	128 g/L fluazifop-P	Fusilade Forte	1.65 L/ha	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.	Apply in not less than 200 L/ha. Direct the spray to the base of the vine Withholding period: 4 weeks. Young growth is most susceptible at 5 leaves to early tillering when actively growing. Higher rates may be required for more advanced plants. Suppression is only beyond the 5-leaf stage.
			2.5 L/ha	Growing actively at 5-leaf to early tillering: Innocent weed and stinkgrass.	
			3.3 or 6.6 L/ha	Growing actively at 3- to 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.	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 Fusilade when fresh growth has emerged – may be necessary for couch control. **Note:** Tank mixes of Fusilade are not recommended, and there should be a minimum of 3 days before any other herbicide is applied. Fusilade does not control winter grass or silver grass.
A	100 g/L quizalofop-P-ethyl	Simcap Targa, Leopard 100	125–250 mL/100 L	Selected post-emergent systemic grass control. For details on control of awnless barnyard, crowsfoot, paspalum, Johnson grass and kikuyu, see label.	Avoid spraying stressed weeds. Consult label for withholding periods and wetting agents.
A	200 g/L quizalofop-P-ethyl	Leopard 200	65–125 mL/100 L	Selected post-emergent systemic grass control. For details on control of awnless barnyard, crowsfoot, paspalum, Johnson grass and kikuyu, see label.	Avoid spraying stressed weeds. Consult label for withholding periods and wetting agents.
C + F	25 g/L diflufenican 250 g/L bromoxynil	Jaguar	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 may not be fully dormant. Apply from early post-emergence and when weeds are actively growing.

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.*

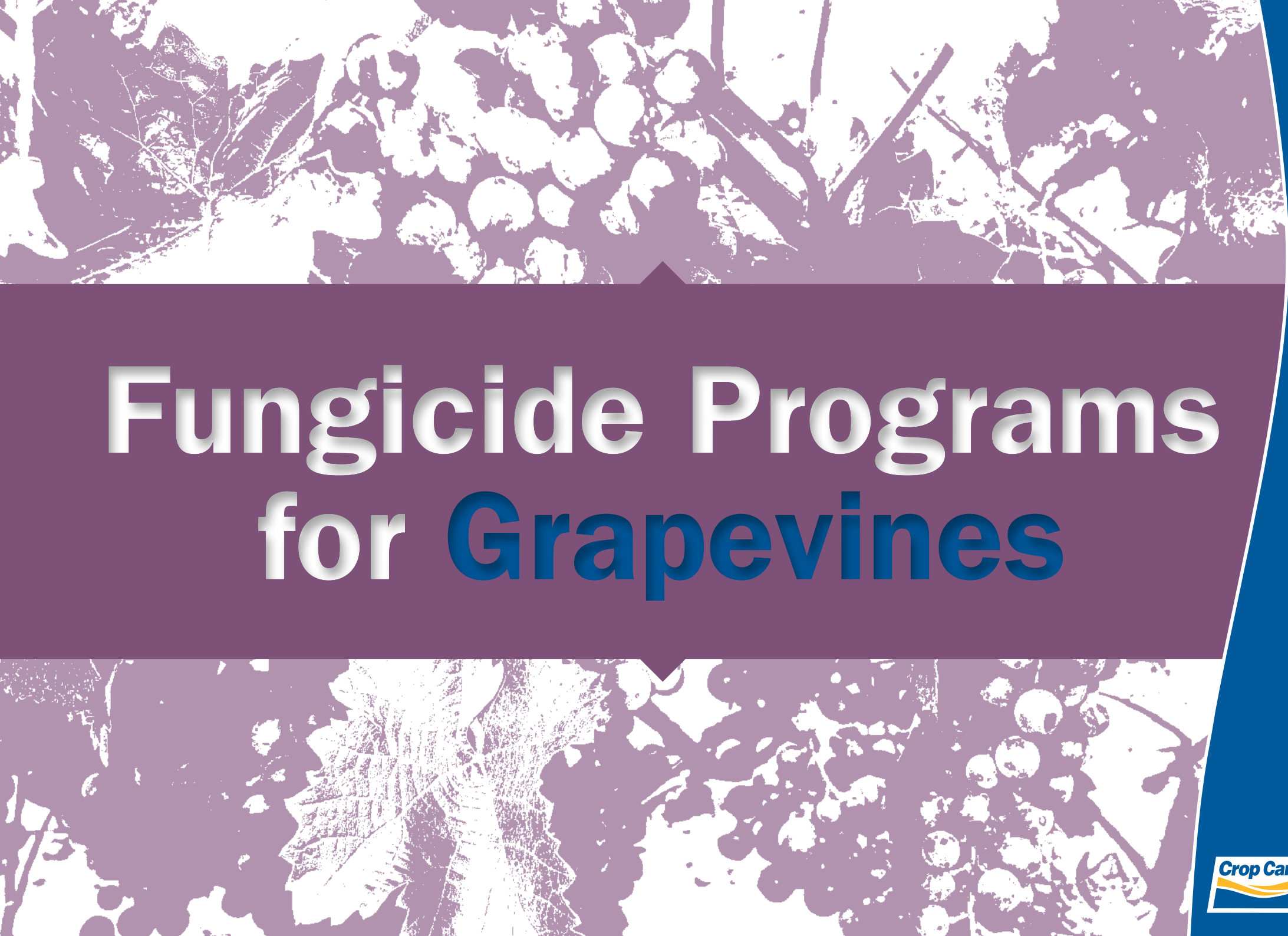
Group	Chemical	Trade names	Rates	Weeds controlled	Comments
C	500 g/L simazine	Various	Boom 2.3–4.5 L/ha. Use 2.3 L/ha on sandy alkaline soils and 4.5 L/ha on heavy soils. In first year of use, split applications are preferred.	Annual weeds and grasses.	Grapevines must be established for 3 years. In the first year a split application is preferred. Normally apply to bare, moist soil before weed emergence. Damage may result from using high rates on sandy soils 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.
C	600 g/L simazine	Gesatop 600 SC	Boom: 1.9 to 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.	Annual ryegrass, annual thistles, barley grass, bindy-eye, brome grass, capeweed, 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, turnips (not NSW), wild mustard, wild oats, winter grass, wireweed (not TAS) and suppression of soursob.	As for above
C	900 g/kg simazine	Various	1.25 kg/ha – light soil 2.5 kg/ha – heavy soil	As for above.	As for above. Use on vines 2 years or older. 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 may occur.
D	500 g/L oryzalin	Surflan 500 Flowable Oryzalin	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.	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.
K	500 g/kg napropamide	Devrinol WG	4.5 kg/ha – light to medium soils 6.7 kg/ha – 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 in 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.
O	67.5 g/kg dichlobenil	Casoron G	60–90 kg/treated hectare (2 m × 5 km)	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 higher rate on heavier soils.
O	750 g/kg isoxaben	Gallery 750	375–750 g/ha	Broad-spectrum residual broadleaf weed control. See Gallery 750 label for full weed list.	Apply to weed-free, even soil surface. Needs moisture via rainfall or irrigation within 21 days of application to be activated. Mix with pendimethalin or oryzalin to provide additional grass weed control.

Group	Chemical	Trade names	Rates	Weeds controlled	Comments
D	330 g/L pendimethalin	Various	9–12 L/ha	Annual grasses and broadleaf weeds. See label for simazine rates when controlling caltrop, cobblers peg, curious weed and stinking Roger. Do not use simazine on alkaline soils.	Do not apply after vines after bud swell. Use low rate on light-textured soils. Use the higher rate on medium to heavy textured soils and the lower rate on light textured soils. Use a directed spray, avoiding contact with green bark, fruit and foliage. If applied to freshly transplanted trees or vines, soil should be compacted before application of pendimethalin herbicide to avoid contact with roots. Pendimethalin herbicide must be incorporated by a minimum of 5 mm of rainfall or spray irrigation as soon as possible and no later than 10 days after application, or weed control may 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 herbicide should be tank mixed with a knockdown herbicide at the recommended rate. Caution: Use of simazine mixtures could lead to crop damage on vines younger than 3 years of age. Refer to the simazine label. DO NOT apply simazine mixtures to alkaline soils.
D		440 g/L pendimethalin		Stomp	
A	120 g/L quizalofop-P-tefuryl	Pantera	125–250 mL/100L	Control of Kikuya	
G	240 g/L oxyfluorfen	Goal, Point Herbicide, Spark, Striker	Weed-free soil: 3–4 L/ha	Before germination: Wild radish, giant pigweed, thornapple, starburr, capeweed, blackberry nightshade, sour sob, caltrop, bladder ketmia, shepherd's purse, wild mustard, redshank, small-flower mallow, deadnettle, sow-thistle, fat hen, pigweed, prickly lettuce, chickweed, *Amsinckia*, wireweed, ryegrass, barnyard grass, summer grass, liverseed grass, barley grass, burrgrass, crowsfoot grass, stink grass, pigeon grass, lovegrass	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 Surflan 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.
	Refer Kenup label	Apply as a tank mix with Kenup	75 mL/ha plus certain knockdown herbicides. See label for directions.	Seedlings: Small-flowered mallow, deadnettle, stinging nettle, *Amsinckia*, sowthistle, shepherd's purse, redshank, wild radish, capeweed, pigweed, stink grass, crowsfoot grass, liverseed grass.	
D	480 g/L trifluralin	Various	1.2 L/ha – light soils 1.7 L/ha – medium soils 2.3 L/ha – heavy soils	Annual grasses and certain broadleaf weeds. Does not control established weeds.	Mechanically incorporate into soil. New plantings: apply during pre-plant cultivation. Established vines: apply during spring

Group	Chemical	Trade names	Rates	Weeds controlled	Comments
F	800 g/L norflurazon	Zoliar DF	2.5 kg	Annual ryegrass, barley grass, blackberry nightshade, *Brachiaria* (green summer grass), caltrop, capeweed, chickweed, common sowthistle (milk thistle), dandelion seedlings, curled dock seedlings, false caper seedlings, fat hen†, Indian hedge mustard, innocent weed (spring burrgrass), medic, hedge mustards, paspalum, plantain seedlings, pigweed (*Portulaca*), prairie grass, prickly lettuce, great brome (ripgut brome), salvation Jane, scarlet pimpernel, shepherd's purse, silver grass, skeleton weed seedlings, sorrel seedlings, soursob†, stinkgrass, stinking Roger, subterranean clover, summer grass (crabgrass), three-cornered Jack (doublegee, spiny emex), variegated thistle, wild oats, wild radish, wild turnip, winter grass, wireweed, witch grass, yellow weed, Yorkshire fog grass. † Suppression only.	Apply using a boom spray to bare ground before weed emergence. Apply as a directed spray in 300 to 500 L water/ha. Avoid contact with foliage or fruit. An application in early autumn will give winter weed control, or in early to midspring will give full summer weed control. Notes: For grapes only: 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 may occur. Do not apply to nursery stock. Do not use more than 5 kg/ha each year.
			5.0 kg	Couch grass†, dandelion, curled dock, false caper, Johnson grass†, skeleton weed, sorrel, soursob. † Suppression only.	
			1.25 kg Zoliar DF + 2.0 L Simazine 500 g/L	Pigweed (*Portulaca*).	
			1.9 kg Zoliar DF + 2.0 L Simazine 500 g/L	Barnyard grass, clammy goosefoot, cobbler's pegs, green pigeon grass, redroot amaranth, summer grass, wireweed.	

Table 5. *Chemical desuckering: Non-selective post-emergent 'knockdown' herbicides registered in NSW for use in vineyards. Read the product label before use.*

Group	Chemical	Trade names	Rates	Weeds controlled	Comments
G	240 g/L carfentrazone – ethyl	Spotlight Plus	300 mL/100 L sprayed to point of run-off. A minimum volume of 50 L of spray solution per kilometre of vine row (both sides sprayed) is recommended.	Control of unwanted suckers (water shoots) arising from the main stem or trunk.	Application of Spotlight Plus to suckers (water shoots) arising from the main stem will result in rapid burn down and extended control of regrowth. Any regrowth may be less vigorous but may need a repeat application for season long control. Suckers arising from pruned stubs or roots may be less well controlled. More vigorous varieties and grafted vines on vigorous rootstocks may 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.



Fungicide Programs for Grapevines

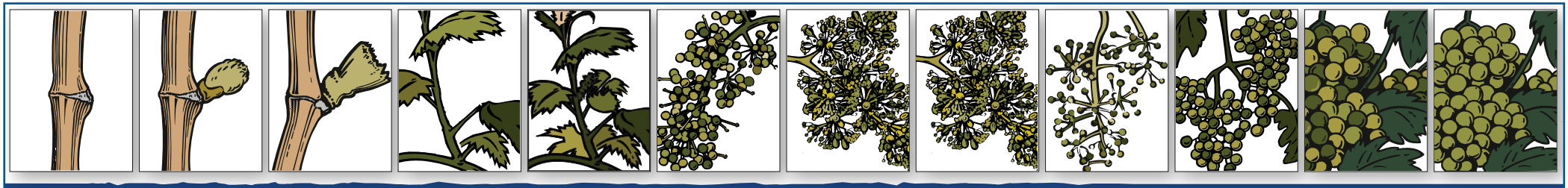
Crop Care

Fungicide Program for Grapevines

Cool/Wet Climates

Margaret River, Coonawarra, Yarra Valley, Mudgee/Orange, Hunter Valley and Stanthorpe

Phomopsis, Black Spot, Powdery and Downy Mildew, and Botrytis Rot Control



	Dormant	Woolly Bud	Bud Burst	3-4 Leaves Separated	8 Leaves Separated	Flowering Begins	10% Capfall	80% Capfall	Fruit Set	Pre-Bunch Closure	Veraison	Pre-Harvest
	E-L1	E-L3	E-L4	E-L11	E-L15	E-L19	E-L20	E-L25	E-L27	E-L31	E-L35	E-L37
	Shoot and inflorescene development E-L1 to E-L18					Flowering E-L19 to E-L26			Berry formation E-L27 to E-L33		Berry ripening E-L34 to E-L39	
PRODUCT	Emblem	Dragon + Sulphur x2		Captan + Legend[1]	Barrack + Flute	Supernova + Protector 400 + Powdery Mildew Product	Corvette + DMI	Dragon + Viva + Switch	Sulphur + Liquicop or Duplex[2] x3	Captan + Protector 400	Corvette	Sulphur + Liquicop
TARGET DISEASE	Phomopsis	Phomopsis, Mites, Black spot		Phomopsis, Black spot, Powdery mildew, Downy mildew		Botrytis, Downy mildew, Powdery mildew	Botrytis, Powdery mildew	Botrytis, Downy mildew, Powdery mildew	Powdery mildew, Downy mildew	Downy mildew, Botrytis	Botrytis	Downy mildew, Powdery mildew

Resistance:
All uses comply with CropLife recommendations for fungicide resistance management.

Suggested total volumes for dilute spraying:

- Dormant..... 200L/ha
- Wooly bud to early flower..... 500L/ha
- Late flower to pre-bunch closure 750-1,000L/ha
- Bunch closure to vintage..... 1,000-1,500L/ha

Withholding Periods:
All suggestions comply with AWRI recommendations, provided the last **Captan** spray is at least 30 days before harvest and the last **Corvette** spray is at least 7 days before harvest.

[1] Information on the IPM compatibility of **Legend** is not available.

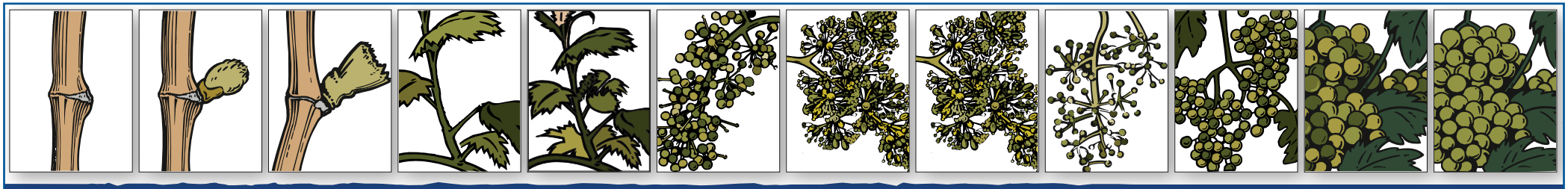
[2] Use **Duplex** instead of **Liquicop** if there has been an infection period for downy mildew and/or downy mildew infection is detected in the vineyard. Do not apply more than two consecutive sprays of **Duplex**.

Fungicide Program for Grapevines

Warm/Dry Climates

Barossa, Riverland, Sunraysia, Murrumbidgee Irrigation Area (MIA) and Inland Queensland

Phomopsis, Black Spot, Powdery and Downy Mildew, and Botrytis Rot Control



	Dormant	Woolly Bud	Bud Burst	3-4 Leaves Separated	8 Leaves Separated	Flowering Begins	10% Capfall	80% Capfall	Fruit Set	Pre-Bunch Closure	Veraison	Pre-Harvest
	E-L1	E-L3	E-L4	E-L11	E-L15	E-L19	E-L20	E-L25	E-L27	E-L31	E-L35	E-L37
	Shoot and inflorescene development E-L1 to E-L18					Flowering E-L19 to E-L26			Berry formation E-L27 to E-L33		Berry ripening E-L34 to E-L39	
PRODUCT	Emblem	Dragon + Sulphur x2		Captan + Legend[1]		Supernova + Corvette + Powdery Mildew Product	Captan + Legend[1]		Sulphur + Liquicop or Duplex[2] x3	Captan	Corvette	Sulphur + Liquicop
TARGET DISEASE	Phomopsis	Phomopsis, Mites, Black spot		Phomopsis, Black spot, Powdery mildew, Downy mildew		Botrytis, Downy mildew, Powdery mildew	Botrytis, Downy mildew, Powdery mildew		Powdery mildew, Downy mildew		Botrytis	Downy mildew, Powdery mildew

Resistance:
All uses comply with CropLife recommendations for fungicide resistance management.

Suggested total volumes for dilute spraying:

- Dormant..... 200L/ha
- Wooly bud to early flower..... 500L/ha
- Late flower to pre-bunch closure 750-1,000L/ha
- Bunch closure to vintage..... 1,000-1,500L/ha

Withholding Periods:
All suggestions comply with AWRI recommendations, provided the last **Captan** spray is at least 30 days before harvest and the last **Corvette** spray is at least 7 days before harvest.

[1] Information on the IPM compatibility of **Legend** is not available.

[2] Use **Duplex** instead of **Liquicop** if there has been an infection period for downy mildew and/or downy mildew infection is detected in the vineyard. Do not apply more than two consecutive sprays of **Duplex**.

Fungicide Program for Grapevines

Spray Guidelines

The spray program for warm dry climates is designed to give you the best options for disease control throughout the season in districts such as Barossa, Riverland, Sunraysia, Murrumbidgee Irrigation Area (MIA), Hunter Valley and Inland Queensland grape growing regions.
The spray program for cool wet climates is designed to give you the best options for disease control throughout the season in districts such as Margaret River, Coonawarra, Yarra Valley, Mudgee/Orange and Stanthorpe grape growing regions.
In both situations the number of sprays needed will vary with disease pressure and the diseases present.
The programs provided are for conditions of high disease pressure. Important factors considered when preparing these programs are outlined below.

Strategic Coverage: The viticulture industry has become more focused on good phomopsis control, thanks to research over recent years, which has identified different strains with different pathogenicity, the importance of pruning methods and effective fungicides. The importance of early season control of this disease is supported by pre-budburst application of Emblem®. This is followed by applications of Dragon® and Captan between budburst and pre-flowering. These two fungicides have been shown to be very effective as protectant fungicides against phomopsis.
Another example is the control of Botrytis with a balance between high value systemic products at critical times of the crop/disease life cycle. In this case the highly effective bunch rot fungicides Protector 400® and Corvette® are recommended in cool wet climates at the critical stages of 80% capfall, pre-bunch closure and pre harvest. Where Botrytis pressure is much lower or the stage of the crop/disease life cycle is less critical, the protectants Barrack® and Captan are recommended.

Mode of Action: To reduce the chance of fungicide resistance developing, a range of modes of action are recommended for control of diseases. Fungicides are also recommended at times of the disease life cycle where they will be most effective according to their mode of action.
For example, for powdery mildew control we recommend the protectant fungicide sulphur (Group M2) for early and late sprays. Before, during and after flowering, which are the critical periods for powdery mildew control, we recommend 1 spray of Flute® (Group U6), 2 sprays of Supernova® (Group 11), 1 DMI (Group 3) spray and 1 Legend® (Group 13) spray, so that (5) modes of action products are recommended for powdery mildew control.

Fungicide Resistance Management: The maximum number of sprays as recommended by CropLife is always adhered to so as to minimise the risk of the development of fungicide resistance. In some cases the number of sprays of a product in the program may be less than the recommended maximum, but never more.
Relatively cheap and effective fungicide options such as DMI, copper and sulphur are included. However, reduced effectiveness of some DMI's has been reported and we have therefore restricted the number of DMI sprays to one, depending on climate, and introduced products from different modes of action for powdery mildew control. A maximum of 1 or 2 dicarboximides (depending on the total sprays for this disease) are recommended by CropLife for Botrytis control in vines. Therefore two applications of Corvette® are recommended in our programs.

Integrated Pest Management: The effect of fungicides on biological control agents such as predatory mites is carefully considered. Fungicides which are known to have an adverse affect are generally not included in the spray program unless there is no alternative product with a better IPM profile.
Captan and Dragon control a wide spectrum of diseases (phomopsis cane and leaf blight, downy mildew and black spot) and at the same time have excellent IPM profiles. Some other protectant fungicides such as those based on mancozeb are known to have a damaging affect on a range of predatory mites which assist in the management of bud mite and rust mite in vines. We **do not** recommend them.

Withholding Period: Withholding requirements for export wines, as recommended by the Australian Wine Research Institute (AWRI) have been strictly adhered to.
Although Barrack has a 7 day withholding period in Australian grapes, MRL's do not exist in some important overseas wine markets and therefore it is not recommended past 80% capfall as recommended by the AWRI.

Cost Effectiveness: Where there are 2 alternative products or product combinations that will fulfil a similar role, the one, which costs less, is recommended.
Several products are registered for protective and post infection control of downy mildew, but these are generally more expensive than straight protectants. We only recommend these products (e.g. Crop Care's new Duplex®) where there has been a downy mildew infection and curative activity is required. Otherwise we recommend the protectant copper product Liquicop®.

Crop Effects: Where a large number of sprays of a product may have an adverse affect on vines or the environment, the total sprays are reduced (or sometimes eliminated) and another product with similar activity is recommended.
For example copper products used throughout the season will cause a bronzing of leaves of many varieties and may result in pollen sterility at flowering. We recommend our copper product Liquicop only after flowering and later in the season after earlier sprays of Dragon, Barrack and Captan.

For more information, please contact your local Technical Sales Representative.

Customer Service (Australia-wide):
1800 111 454
www.cropcare.com.au

® Barrack, Dragon and Supernova are registered trademarks of Crop Care Australasia
® Captan, Corvette, Duplex, Emblem, Flute, Legend, Liquicop and Protection 400 are registered trademarks

Crop Care

DASLABS
Diagnostic & Analytical Services

Plant Health Diagnostic Service

Helping to improve the health and profitability of your vineyard

■ DIAGNOSIS ■ IDENTIFICATION ■ SURVEILLANCE

The **Plant Health Diagnostic Service (PHDS)** provides an essential link in protecting the health and improving the profitability of crops, pastures and nursery enterprises. Our laboratories are staffed by specialist pathologists, mycologists and entomologists - experts in a wide range of crop, pasture and horticultural pests and diseases – who can provide plant pathogen and insect identification.

Our specialist plant pathologists and entomologists have the backing of the **Agricultural Scientific Collections Unit**, which houses Australia's largest collection of agriculturally significant insects, fungi, plant bacteria and viruses.

Our Plant Health Diagnostic Services staff are supported by the Department of Primary Industries advisory service, providing a complete plant health package for your business.

Available services

Key functions of PHDS include:

- Botrytis monitoring of grape bunches and experience in diagnosing woody trunk diseases;
- diagnosis of winegrape disease and disorders, including bacteria, fungi, and nematodes;
- determining the presence of specific grapevine viruses
- identification of insect and mite problems;
- active surveillance for emerging and exotic diseases;
- timely and efficient delivery of results to the client.

We can assist you to:

- save expenditure on unnecessary or incorrect chemical usage;
- ensure your produce achieves best quality and, therefore, best market price;
- implement best practice pest and disease control.

Diagnostic and Analytical Services

Elizabeth Macarthur Agricultural Institute (Menangle)
Phone: (02) 4640 6327
Private Bag 4008
NARELLAN NSW 2567
Email: emai.phds@industry.nsw.gov.au

Orange Agricultural Institute
Phone (02) 6391 3980
1447 Forest Road
ORANGE NSW 2800
Email: orangeai.phds@industry.nsw.gov.au

For more information, you can contact our Customer Service Unit on 1800 675 623 or visit our website at:
www.dpi.nsw.gov.au/aboutus/services/das

NATA WORLD RECOGNISED ACCREDITATION

NSW GOVERNMENT Department of Primary Industries

12168 06/13

NSW Viticulture Skills Development Program

In a first for NSW, pest and disease early warning systems have been deployed in two NSW wine regions, Mudgee and the Riverina. The systems are based on an array of fully automated weather stations that have been strategically placed to account for variations in factors such as altitude and aspect across the regions. Eventually growers will have real time access to the weather data and pest and disease alerts. These systems are part the NSW Viticulture Skills Development Program, an initiative funded by DPI NSW and in partnership with the NSW Wine Industry Association. The skills development program is a five year program that allows NSW WIA to determine regional information and development needs for its 14 diverse wine regions. The new weather data will, among other things, allow the prediction of downy mildew infection periods as well as other parameters (e.g. delta T for spray drift calculations and degree days for vine growth data) that are useful for vineyard management.

For the first 12 months of the program the Australian Wine Research Institute (AWRI) has been contracted to deliver the Viticulture Skills Development program. Leading national experts are contributing to the workshops and field days in Griffith, Mudgee, Canberra, Orange, the Sunraysia and the Hunter Valley.

Other activities include:

- Vine health field days in selected regions
- Vine nutrition workshops in selected regions
- Demonstration trials on the use of mulch in vineyards and alternative approaches to manage Botrytis
- A module on running experiments in vineyards
- Pest and disease surveys
- Rootstock and clone surveys
- A fortnightly newsletter (Vinewatch) issued throughout the season

More details can be found here:

If you have any questions, please contact Mardi Longbottom on (08) 8313 6600 mardi.longbottom@awri.com.au

or Darren Fahey on (02) 6933 2961 darren.fahey@dpi.nsw.gov.au

Figure 1. *A newly installed weather station at Logan Wines, Mudgee.*

NSW Department of Primary Industries

NEW SOUTH WALES Wine

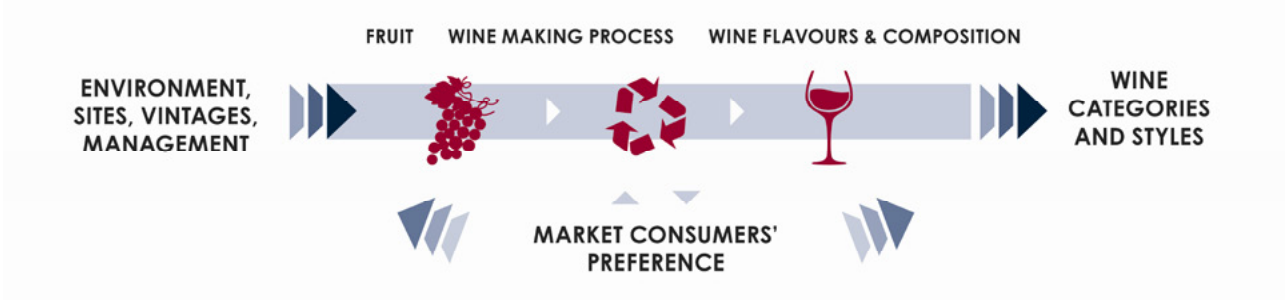
The Australian Wine Research Institute

NATIONAL Wine & Grape INDUSTRY CENTRE

World Class Research Facilities


Expertise in Vine to Wine, Sensory and Consumer Research


Integrated and Comprehensive Research Programs
Helping to lead the Australian Wine Industry in the 21st Century



National Wine and Grape Industry Centre,
McKeown Drive, Charles Sturt University, Wagga Wagga NSW 2678
www.csu.edu.au/nwgic nwgic@csu.edu.au

Appendix 1
Internet sites for wine and grape industries

Internet services include:

- Electronic mail (email)
- World Wide Web (www)
- Internet relay chat (IRC) groups.

Listed are some of the web sites accessible to wine and grape industries. To access the sites, enter the address into a browser window, or go to the NSW Department of Primary Industries website, www.dpi.nsw.gov.au, and search for 'grapes'.

General weather sites

www.bom.gov.au

Bureau of Meteorology is the national meteorological authority for Australia, providing meteorological, hydrological and oceanographic services. The web site features education, publications, news, weather forecasts, warnings and observations, other weather services, climate services, and hydrology services.

www.bom.gov.au/watl/index.shtml

Water and land information is a service of the Bureau of Meteorology. It provides detailed weather services for agriculture and natural resource managers, including national rain forecast maps and frost potential maps.

www.longpaddock.qld.gov.au

Ten-day precipitation outlook for Australia and New Zealand viewed through two 5-day charts and precipitation percentage of normal chart.

http://wxmaps.org/pix/aus.vv.html

This site presents Global Forecast System medium-range 7-day forecast maps of vertical velocity and rainfall for Australia and NZ.

Organic agriculture sites

www.ofa.org.au

Organic Federation of Australia is the peak Australian organic producers' industry body. Site includes an organic directory, information forums and events.

www.ifoam.org

The International Federation of Organic Agriculture Movements is the international umbrella body for national organic producer groups.

Australian organic certification and grower groups

www.nasaa.com.au

The National Association for Sustainable Agriculture (Australia) provides certification services for Australian producers; these services are also suitable for export markets.

www.organicgrowers.org.au

Organic Growers Australia Certified Ltd (OGA) is Australia's first certification service to specifically cater for the needs of the smaller organic producer.

www.demeter.org.au

The Biodynamic Research Institute is the grower association and certifier for biodynamic producers in Australia. Certified bio-dynamic producers use the Demeter biodynamic label on produce.

www.organicfoodchain.com.au

Organic Food Chain is a company that certifies producers under its own label, as well as to export standards.

Wine industry organisations

www.wineaustralia.com

The Australian Wine and Brandy Corporation web site features newsletters, statistics, vintage reports, publications, contacts, exporting, promotion, geographical indications (wine zones and regions) and a register of protected names. The link to www.wineaustralia.com provides statistical information and an interactive wine tasting challenge (BYO bottle).

www.gwrdc.com.au

The Australian Grape and Wine Authority is the body responsible for investing in grape and wine research and development on behalf of the Australian wine industry and community. The web site features information on grape and wine research, newsletters, research applications, contacts and the National Vine Health Steering Committee.

www.awri.com.au

The Australian Wine Research Institute provides research, development and extension services. The web site features industry services, links, agrochemicals, information resources, wine exporting, publications, wine and health and research projects.

www.crcv.com.au

The Cooperative Research Centre for Viticulture promotes cooperative scientific research and is a joint venture between the viticulture industry and research and education organisations. The web site features information on research programs, education and training, Viticare, AusVit, publications and links.

www.asvo.com.au

The Australian Society of Viticulture and Oenology Inc. serves the interests of practising winemakers and viticulturists by encouraging the exchange of technical information. Activities include seminars, a newsletter, and industry awards.

www.nswwine.com.au

The NSW Wine Industry Association Inc. (NSWWIA) represents the wine regions of NSW. Committees formed since the Association began cover Research and Development, Education and Training, Licensing, Tourism and Promotion, and Water and Resources. The web site provides information on activities of the Association, promotion opportunities and events. See the list of regional associations at www.nswwine.com.au/pages/NSW-Wine-Regions.html

www.csu.edu.au/nwgic

The National Wine and Grape Industry Centre was formed by bringing together the resources of the NSW Department of Primary Industries, Charles Sturt University, and the NSW Wine Industry Association. This unique initiative helps the industry to maintain its internationally competitive edge through research, education, training and extension. The web site contents include courses available, a contact page and research topics.

www.phylloxera.com.au

The Phylloxera and Grape Industry Board of South Australia web site provides information about the Board, phylloxera, research results, rootstocks, other pests, young vine management, news, statistics and links to other web sites.

www.avia.org.au

The Australian Vine Improvement Association is made up of participating Vine improvement groups throughout Australia.

Government sites

www.dpi.nsw.gov.au

NSW Department of Primary Industries is a leading provider of information for profitable, sustainable food and fibre industries. The web site features horticulture, animals, field crops and pasture, pests, diseases and weeds, natural resources and climate, farm business, trade, research, advisory and education services, community services, corporate information, employment, news, media, a bookshop and links.

www.daff.gov.au

The Australian Government Agriculture Portal provides all government services and information under the one web site.

www.agric.wa.gov.au

Department of Agriculture and Food, Western Australia.

www.depi.vic.gov.au

Victorian Department of Environment and Primary Industries.

www.pir.sa.gov.au

Department of Primary Industries and Resources South Australia.

www.daff.qld.gov.au

Queensland Primary Industries and Fisheries within the Department of Employment, Economic Development and Innovation.

www.dpipwe.tas.gov.au

Tasmanian Department of Primary Industries, Parks, Water and Environment.

www.csiro.au

Commonwealth Scientific and Industrial Research Organisation.

www.workcover.nsw.gov.au

WorkCover Authority of NSW looks at all relevant issues pertaining to safety in your business enterprise.

www.daff.gov.au/biosecurity

DAFF Biosecurity manages quarantine controls at our borders to minimise the risk of exotic pests and diseases entering the country. DAFF Biosecurity also provides import and export inspection and certification to help retain Australia's highly favourable animal, plant and human health status and wide access to overseas export markets.

www.austrade.gov.au

Austrade (Australian Trade Commission) provides export and investment services to Australian companies and international buyers and investors in 94 locations worldwide. It is the official trade and investment facilitation agency of the Australian Government. Some of the web site features are trade events, useful links, publications, industry and country information and information on exporting and investment.

www.abs.gov.au

Australian Bureau of Statistics is Australia's official statistical organisation. The web site features media releases, news, statistics, education resources, census data, products and services.

www.daff.gov.au/abares

Australian Bureau of Agricultural and Resource Economics (ABARE) is a professionally independent applied economic research agency. It provides stakeholders in Australia's rural and resource industries with up-to-date public policy analysis and commodity forecasts. The web site features ABARE data, commodity analyses, agricultural surveys, economics, media releases, conferences, publications, related links and feedback.

www.customs.gov.au

Australian Customs and Border Protection Service is a statutory authority that services the government, the business community and the people of Australia. Some features of the web site are: a business guide to customs, media and publications, customs tax reform, customs notices, importing goods into Australia, links to other sites, Minister's Home Page, and customs forms.

www.efic.gov.au

The Export Finance and Insurance Corporation helps Australian exports to compete internationally by providing insurance and finance facilities to support their overseas contracts. The web site contains customer service, country information, environment policy, news, publications and market watch.

Journals

www.winetitles.com.au

Publisher of *Australian Viticulture.*

www.winebiz.com.au

Publisher of *Australian & New Zealand Grapegrower & Winemaker.*

Pest, disease and pesticide information

www.awri.com.au/industry_support/viticulture/agrochemicals/

A comprehensive list of Agrochemicals registered for use in Australian viticulture. It also lists current MRLs, Fungicides Resistance Management Strategies and off-label grapevine permits.

www.cropwatch.com.au

CropWatch SA provides grapegrowers in the Riverland, McLaren Vale, Mildura, Swan Hill and Robin Vale areas with timely information on the potential risks of important diseases and pests like downy mildew, powdery mildew, black spot and light brown apple moth. It has an interactive disease diagnosis page based on Ausvit's *The Australian and New Zealand Field Guide to Diseases, Pests and Disorders of Grapes.*

www.apvma.gov.au

The Australian Pesticides and Veterinary Medicines Authority (formerly National Registration Authority) operates the Australian system that evaluates, registers and regulates agricultural and veterinary chemicals. The web site includes a PUBCRIS database, which contains details of registered agricultural and veterinary chemical products.

Education and training

www.dpi.nsw.gov.au/education

NSW Department of Primary Industries is a provider of short courses and education and training through the Murrumbidgee Rural Studies Centre at Yanco and the CB Alexander Agricultural College at Paterson ('Tocal'). For more details see below, and see the NSW Department of Primary Industries web site for information on short courses.

www.csu.edu.au/nwgic

National Wine and Grape Industry Centre (NWGIC). Through Charles Sturt University (CSU) the NWGIC provides higher education to the Australian Wine

Industry. CSU provides undergraduate and postgraduate programs in Winegrowing, Wine Science, Food Processing and Food Science.

www.tocal.nsw.edu.au

CB Alexander Agricultural College or 'Tocal' is a part of the NSW Department of Primary Industries. The site contains details of full-time and part-time courses for school leavers who want to pursue careers in agriculture. It also has details of external courses in agriculture and natural resource management, short courses, coming events and education resources for sale.

www.uws.edu.au

The University of Western Sydney. Some web site features are: search engine, learning, research, academic publications, Internet support, library, news, colleges and schools.

www.tafensw.edu.au

NSW Department of Education and Communities, Technical and Further Education (TAFE NSW). Web site features include courses and careers, campuses and institutes, flexible study options, getting started at TAFE and news.

USA sites

www.tablegrape.com

The California Table Grape Commission gives a guide to fresh table grapes, including recipes, cooking tips and nutritional information.

www.nysaes.cornell.edu

New York State Agricultural Experiment Station has researchers and extension educators working to develop good farming, food storage and processing practices. Web site features departments, information, news, press releases.

www.universityofcalifornia.edu

The University of California develops and promotes the use of integrated pest management. The web site features information, education, publications, programs and a directory.

http://wineserver.ucdavis.edu

The Department of Viticulture and Oenology, University of California, Davis is a research and educational institution. The web site features wine and grape information, programs, research, newsletters, courses and links.

New Zealand sites

www.lincoln.ac.nz

Lincoln University Centre for Viticulture and Oenology is an internationally renowned university specialising in commerce and management, primary production, natural resources, science, engineering and social science. The web site features departments, information, news and press releases.

www.massey.ac.nz

Massey University Laboratory for Wine Microbiology is a leader in the fields of sciences, design, social sciences, education and business. The web site features research and library information, business and community information, and links.

French sites

www.montpellier.inra.fr

The Montpellier INRA Centre is a leader in wine research and a major teaching site for southern France.

German sites

www.campus-geisenheim.de

The Geisenheim Research Centre is one of the oldest research institutions in the areas of viticulture, oenology, wine technology and beverage research, horticulture and landscape architecture in Germany.

www.genres.de

The Grape and Vine Variety Catalogue web site features an online search, a database and links. Links to an English language page of the German site.

Other overseas sites

www.arc.agric.za

The South African Institute for Research in Viticulture and Oenology (Agricultural Research Council) promotes the agricultural and related sectors through research, technological development and transfer. Web site features are strategic plan, events, products, opportunities and links.

www.brocku.ca/ccovi/

Brock University's Cool Climate Oenology and Viticulture Institute. This Canadian web site features research, academic programs, background and links.

Appendix 2
Where to buy your planting material

Approved sources for purchasing cuttings in NSW, Victoria and South Australia

Vine improvement organisation	Address and Email	Mobile	Telephone	Facsimile
MIA Vine Improvement Society Contact: Leo De Paoli	PO Box 486, YENDA NSW 2681 miavis@bigpond.com	0412 699 476	(02) 6968 1202	–
Victorian and Murray Valley Vine Improvement Association Contact: Gary Thomas Orders accepted at any time	PO Box 5051, MILDURA VIC 3502 www.vamvvia.org.au vamvvia@bigpond.com	0418 997 730	(03) 5022 8499	(03) 5021 4833
Riverland Vine Improvement Committee* Contact: David Nitschke Preference given to orders received by 31 May	PO Box 292, MONASH SA 5342 www.rvic.org.au info@rvic.org.au	0407 974 149	(08) 8583 5366	(08) 8583 5504
Australian Vine Improvement Association Inc. Contact: Gary Thomas	PO Box 5051, MILDURA VIC 3502 www.avia.org.au	0418 997 730	(03) 5022 8499	(03) 5021 4833

Nurseries supplying rootlings from approved sources

The nurseries listed are recognised for using material sourced from vine improvement organisations. However, they may use material obtained from other sources. This information is provided to inform the Australian grape and wine sector of nursery supplier information, and it should not be interpreted as an endorsement. Buyers should check the source of the material they intend to purchase to ensure it meets their needs.

New South Wales

Nursery Name	Address and Email	Mobile	Telephone	Facsimile
Adro Grafted Vines*	PO Box 539, GRIFFITH 2680 adrografted@bigpond.com	0428 447 246	(02) 6964 4288	(02) 6964 4288
Binjara Vine Nursery Pty Ltd*	PO Box 75, EUSTON 2737 www.binjara.com.au justin@binjara.com.au	0417 148 429	(03) 5026 1661	(03) 5026 1050
Hanwood Grafted Vines	PO Box 55, HANWOOD 2680 lndepoli@dragnet.com	0412 699 476	(02) 6963 0247	(02) 6963 0247
Mallee Point Nursery*	PO Box 438, YENDA 2681 malleepoint@bigpond.com	0428 690 208	(02) 6968 1086	(02) 6968 1786
Sunraysia Nurseries*	PO Box 45, GOL GOL 2738 www.sunraysianurseries.com.au sales@sunraysianurseries.com.au	–	(03) 5024 8502	(03) 5024 8551

Victoria

Nursery Name	Address and Email	Mobile	Telephone	Facsimile
Ausvine Nursery	PO Box 243, MILDURA 3502 niutta1@bigpond.com.au	0429 950 031	(03) 5021 0068	(03) 5021 0068
Boulevarde Nurseries	PO Box 816, IRYMPLE 3498 www.boulevarde.com.au info@boulevarde.com.au	–	(03) 5024 9000	(03) 5024 6692
Binjara Vine Nursery Pty Ltd*	See NSW details			
Freck's Vine Nursery	PO Box 1161, RED CLIFFS 3496 freck94@bigpond.com	0412 947 426	(03) 5024 2885	(03) 5024 2885
KC Vines & Rootstocks*	PO Box 1054, MILDURA 3502 www.kcvines.com.au info@kcvines.com.au	0407 309 961	(03) 5024 8812	(03) 5024 8834
Fussy Britches Nursery	PO Box 5033, MILDURA 3502 fussbrit@iinet.net.au john@fussybritches.net.au ICA-37 accredited	0428 502 588	(03) 5023 4370	–
Revs Nursery Pty ;Ltd	PO Box 498, IRYMPLE 3498 revsnursery@bigpond.com	0429 873 114	(03) 5024 5986	(03) 5024 6596
Sunraysia Nurseries*	See NSW details			

* Vine Improvement Nursery Association Accredited.

South Australia

Nursery Name	Address and Email	Mobile	Telephone	Facsimile
Adelaide Hills Vine Improvement Inc*	C/- Box 38, KANGARILLA 5157 www.adelaidehillsvineimprovement.org davidc@adelaidehillsvineimprovement.org	0422 644 825	(08) 8383 7532	–
Barossa Vine Improvement*	PO Box 293, NURIOOTPA 5355		(08) 8562 2011	(08) 8562 4410
Fleurieu Vine Nursery	3 Clemens Road, LANGHORNE CREEK 5255 gd.warren@bigpond.com	0429 676 014	(08) 8537 3286	–
Glenavon Nurseries Pty Ltd*	101 South Bremer Rd, LANGHORNE CREEK 5255 www.glenavon.com.au	0417 883 826	(08) 8537 3207	(08) 8537 3250
Golding Vine Nursery	C/- Box 700, LOBETHAL 5241 darren@goldingwines.com.au	0413 942 272	(08) 8389 5120	(08) 8389 5290
Langhorne Creek Vine Improvement*	C/- PO, LANGHORNE CREEK 5255	0439 373 450	(08) 8537 3450	(08) 8537 3450
Orchard Fruits Nursery	PO Box 1716, LOXTON 5333 www.pippos.com	0418 815 655	(08) 8584 5544	(08) 8584 5544
RVIC Nursery	PO 292, MONASH 5345 www.rvic.org.au	0407 974 149	(08) 8583 5366	(08) 8583 5504
Ramco Wine Group	Box 889, NURIOOTPA 5355 s.curtis@ramcowinegroup.com	0400 742 603	(08) 8541 9013	–
River Murray Nursery	PO Box 995, LOXTON 5333 rivermurraynursery@yahoo.com.au	0428 819 540		–
Yalumba Nursery*	PO Box 10, ANGASTON 5353 www.yalumbanursery.com ndry@yalumba.com	0411 487 495	(08) 8568 7700	(08) 8568 7710
Vinewright*	PO Box 180, MOUNT PLEASANT 5235 www.vinewright.com.au plwright@vinewright.com.au	0438 682 345	(08) 8568 2385	(08) 8568 2345

Tasmania

Nursery Name	Address	Mobile	Telephone	Facsimile
Woodlea Nursery*	49 Whish-Wilson Rd, SCOTTSDALE 7260 www.woodleanursery.com.au info@woodleanursery.com.au	0447016744	(03) 6352 7262	(03) 6352 7252

Western Australia

Nursery Name	Address	Mobile	Telephone	Facsimile
Viticlone Supplies*	Box 202, DUNSBOROUGH 6281 www.viticlonesupplies.com viticlone@netserv.net.au	0418 946 901	(08) 9755 2030	(08) 9755 2030

* Vine Improvement Nursery Association Accredited.

Note: Check with the respective authorities that all certificates are obtained for planting material to enter your state. Written consent is required to introduce grapevine material, regardless of its origin, into the proclaimed phylloxera exclusion area.

Quality planting stock is the best investment a grower can make to establish a long-lived and productive vineyard.

Producers wanting to purchase new vine material should refer to the *Grapevine management guide* 2012–2013 article 'Quality planting stock: it's your business' on pages 27–32, written by Helen Waite.

Appendix 3
Agrochemicals registered for use in Australian viticulture 2014–15

COMPILED BY MARCEL ESSLING AND MARDI LONGBOTTOM
REPRODUCED COURTESY OF THE AUSTRALIAN WINE RESEARCH INSTITUTE

Always read the label

Users of agricultural (or veterinary) chemical products must always read the label, and any Permit before using the product, and strictly comply with the directions on the label and conditions of any permit.

Users are not absolved from compliance with the directions on the label or the conditions of the Permit by reasons of any statement made or omitted to be made in this publication.

The product trade names in this publication are supplied on the understanding that no preference between equivalent products is intended and the inclusion of a product does not imply endorsement by the NSW Department of Primary Industries over any other equivalent product from other manufacturers.

Some of the chemical use patterns quoted in this publication are approved under Permits issu ed by the Australian Pesticides and Veterinary Medicines Authority and were in force at the time the publication was prepared. Persons wishing to use a chemical in a manner approved under Permit should obtain a copy of the relevant Permit from APVMA.

They must read all the details, conditions and limitations relevant to that Permit and must comply with the details,conditions and limitations prior to use.

Permits

Some of the chemical use patterns quoted in this publication are approved under permits issued by the Australian Pesticides and Veterinary Medicines Authority (APVMA) and were in force at the time the publication was prepared.

Persons wishing to use a chemical in a manner approved under permit should obtain a copy of the relevant permit and approved use pattern from the supplier of the product at point of sale and must read all the details, conditions and limitations relevant to that permit, and must comply with the details, conditions and limitations prior to and during use.

Below is a list of the key permits currently related to Viticulture in NSW. This information was obtained from the APVMA website, accessed on 29 September 2014.

Permit No.	Description	Expiry date	Condition of use and restriction on use for export wine grapes
PER14680	Naturalure fruit fly bait concentrate	31 Mar 2019	South Australia – PIRSA direction required
PER14556	Fipronil meat bait European Wasp	31 Mar 2019	Tasmania only – baits to be prepared under direction of Wine Industry Tasmania at specific locations
PER13841	Lebaycid Insecticide Spray (fenthion) Fruit fly – all species	30 Oct 2014	Use no later than 80% capfall
PER13840	Leybacid Insecticide Spray (fenthion) Mediterranean fruit fly	30 Oct 2014	Use no later than 80% capfall
PER13674	Lebaycid (fenthion) Queensland Fruit Fly	30 Oct 2014	Use no later than 80% capfall
PER13565	Hy-Mal Insecticide Fruit Fly	30 Sep 2014	Refer to page 2 of permit. Use no later than 80% capfall
PER12770	Glyphosate / Grapevine removal/destruction / Phylloxera South Australia only	31 Dec 2016	Apply to cut stumps only

AWRI

The Australian Wine Research Institute

Agrochemicals registered for use in Australian viticulture 14/15

A must for grapegrowers and winemakers exporting wine

Compiled by Marcel Essling and Anne Lord

Updated 31 May 2014

Disclaimer

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The information in this publication is current as at 31 May, 2014. The AWRI is not responsible for ensuring that you receive any further updates of this publication.

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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 $1.76 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 before 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 pesticides.

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 2014/2015 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 the Grape and Wine Research and Development Corporation 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 Marcel Essling 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 the AWRI website www.awri.com.au to subscribe to eBulletins.

AWRI Agrochemical search app and online search facility

The AWRI agrochemicals online search facility and agrochemcial 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.

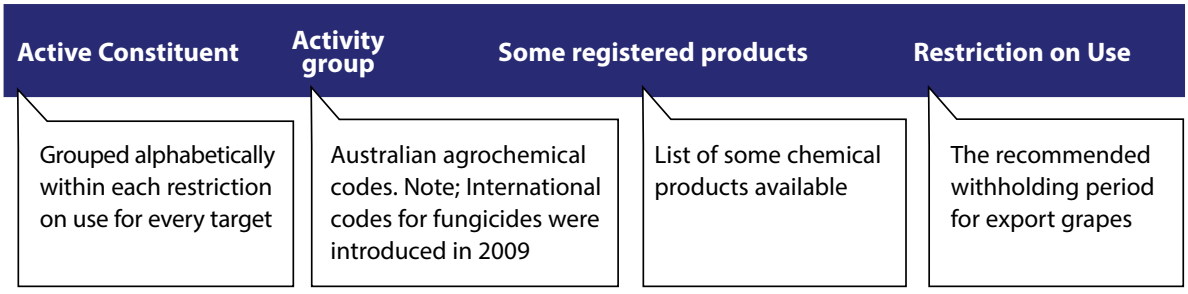
Can I use a product that is not listed?

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 www.awri.com.au/agrochemicals/.
- 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/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. We 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



Recommendations

Active Constituent	Activity group	Some registered products	Restriction on Use
BLACK SPOT			
benalaxyl + mancozeb	4 + M3	Galben M	Use no later than 80% capfall.
chlorothalonil	M5	Applonil 720, Barrack 720, Barrack Betterstick, Bravo 720, Bravo Weather Stik, Cavalry 720 SC, Cavalry Weatherguard, Cheers 720, Cheers 720 Weathershield, Chemtura Chlorothalonil, Chloronil Pro, Chloro 720, Chlornil 720 SC, Chlorothalonil 720, Chlorothalonil 900 WG, Echo 720, Echo 900 WDG, Elect 500, Fung-o-nil 500, Unite 720, Whack 720, Whack 900 WG	
metiram	M3	Polyram DF	
thiram	M3	Thiragranz, Thiram DG, Thiram 800 WG	
ziram	M3	Ziragranz, Ziram DG, Ziram Granuflo	
captan	M4	Captan, Captan 800 WG, Captan 900 WG, Captan WG	Use no later than 30 days before harvest.
captan + metalaxyl	M4 + 4	Duplex WG	
copper hydroxide + mancozeb	M1 + M3	ManKocide DF	
copper oxychloride	M1	Copper Oxychloride WP, Oxydul DF	
dithianon	M9	Delan 700 WG, Dragon 700 WG	
mancozeb	M3	Choice Mancozeb 750 WG, Dithane Rainshield Neo Tec, innova Mancozeb 750, Kencozeb 750DF, Mancoflo, Mancozeb 750 DF, Mancozeb 750 WG, Mancozeb DF, Mancozeb DG, Manfil, 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.
azoxystrobin	11	Amistar 250 SC, Avior 800 WG, Azoxystrobin 250 SC, Azoxystrobin 500 WG, Connect 800 WG, Mirador 250 SC, Spartacus 250 SC, Supernova 250SC	Use no later than 80% capfall.
chlorothalonil	M5	Applonil 720, Barrack 720, Barrack Betterstick, Bravo 720, Bravo Weather Stik, Cavalry 720 SC, Cavalry Weatherguard, Cheers 720, Cheers 720 Weathershield, Chemtura Chlorothalonil, Chloronil Pro, Chloro 720 Chlornil 720 SC, Chlorothalonil 720, Chlorothalonil 900 WG, Echo 500SC, Echo 720, Echo 900 WDG, Elect 500, Fung-o-nil 500, Unite 720, Whack 720, Whack 900 WG	
fenhexamid	17	Teldor 500 SC	
pyrimethanil	9	Predict 600 SC, Protector 400SC, Pyrus 400 SC, Scala 400 SC	

* Fungicide resistance in this pathogen has been reported. Review resistance management strategies on page 22 and follow the directions on page 24.

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

Active Constituent	Activity group	Some registered products	Restriction on Use
BOTRYTIS BUNCH ROT* *(CONT.)*			
tebuconazole + azoxystrobin	3 + 11	Custodia	Use no later than 80% capfall.
cyprodinil[2]	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[2]	9 + 12	Switch	
captan	M4	Captan, Captan 800 WG, Captan 900 WG, Captan WG	Use no later than 30 days before harvest.
captan + metalaxyl	M4 + 4	Duplex WG	
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	Use no later than 7 days before harvest.
iprodione	2	Aquaflow 500 SC, Chief Aquaflo, Chief 250 Liquid, Corvette Flowable, Corvette Liquid, Fungol 500, Ippon 500 Aquaflo, Ipral 250, Iprine 250, Iprine 500, Iprodione 250, Iprodione Aquaflow 500, Iprodione Liquid 250, Rovral Aquaflo, Rovral Liquid, 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*			
phosphorous acid[3]	33	Agri-Fos 600, ChemPhos 400, Country Phospot 400, Country Phospot 400 pH 7.2, Country Phospot 600, Dominator 600, Fungacid 600, Fungi-Fos 400, Fungi-Fos 400 pH 7.2, Phos Phyt 400, Sprayphos 400, Sprayphos 600, Sprayphos 620, Throw Down, Throw Down 600	Not recommended for use on grapes destined for export wines.
ametoctradin + dimethomorph	45 + 40	Zampro	Use no later than 80% capfall.
azoxystrobin	11	Amistar 250 SC, Avior 800 WG, Azoxystrobin 250 SC, Azoxystrobin 500 WG, Connect 800 WG, Mirador 250 SC, Spartacus 250 SC, Supernova 250SC	
benalaxyl + mancozeb	4 + M3	Galben M	
chlorothalonil	M5	Applonil 720, Barrack 720, Barrack Betterstick, Bravo 720, Bravo Weather Stik, Cavalry 720 SC, Cavalry Weatherguard, Cheers 720, Cheers 720 Weathershield, Chemtura Chlorothalonil, Chloronil Pro, Chlornil 720 SC, Chlorothalonil 720, Chlorothalonil 900 WG, Echo 500SC, Echo 720, Echo 900 WDG, Elect 500, Fung-o-nil 500, Unite 720, Whack 720, Whack 900 WG	

* Fungicide resistance in this pathogen has been reported. Review resistance management strategies on page 22 and follow the directions on page 24.

2. Do not apply Solaris 300 EC or Switch at both flowering and growth stage E-L 29.

3. Contact your winery or grape purchaser prior to the application of any phosphorous acid spray.

Active Constituent	Activity group	Some registered products	Restriction on Use
DOWNY MILDEW* *(CONT.)*			
dimethomorph	40	Acrobat SC, Downright, Sphinx	Use no later than 80% capfall.
metiram	M3	Polyram DF	
oxadixyl + propineb	4 + M3	Rebound WP	
tebuconazole + azoxystrobin	3 + 11	Custodia	
zineb	M3	Zineb	
mandipropamid	40	Revus	Use no later than E-L 26 (capfall complete)
trifloxystrobin	11	Flint 500 WG (suppression only)	Use no later than E-L 31, berries pea-size (7 mm diameter).
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.
captan	M4	Captan, Captan 800 WG, Captan 900 WG, Captan WG	Use no later than 30 days before harvest.
captan + metalaxyl	M4 + 4	Duplex WG	
copper ammonium acetate	M1	Cop-IT	
copper ammonium complex	M1	Copperguard, Liquicop	
copper cuprous oxide	M1	Ag Copp 750, Nordox 500, Nordox 750 WG, Norshield WG, Red Copper WG	
copper hydroxide	M1	Blue Shield DF, Champ Dry Prill WG, Cung Fu 350 SC, 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 WP, Copper Oxychloride 500 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, Dragon 700 WG	

* Fungicide resistance in this pathogen has been reported. Review resistance management strategies on page 22 and follow the directions on page 24.

Active Constituent	Activity group	Some registered products	Restriction on Use
DOWNY MILDEW* *(CONT.)*			
mancozeb	M3	Choice Mancozeb 750 WG, Dithane Rainshield Neo Tec, innova Mancozeb 750, Kencozeb 750DF, Mancoflo, Mancozeb 750 DF, Mancozeb 750 WG, Mancozeb DF, Mancozeb DG, Manfil, 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 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.
PHOMOPSIS CANE AND LEAF SPOT			
fluazinam	29	Emblem, Gem[4], Shirlan[4]	Dormancy spray only.
metiram	M3	Polyram DF	Use no later than 80% capfall.
captan	M4	Captan, Captan 800 WG, Captan 900 WG, Captan WG	Use no later than 30 days before harvest.
captan + metalaxyl	M4 + 4	Duplex WG	
copper sulphate tribasic + mancozeb	M1 + M3	Novofix Disperss	
dithianon	M9	Delan 700 WG, Dragon 700 WG	
mancozeb	M3	Choice Mancozeb 750 WG, Dithane Rainshield NeoTec, innova Mancozeb 750, Mancoflo, Mancozeb 750 DF, Mancozeb 750 WG, Mancozeb DF, Manfil, Manzate DF, Manzeb, Penncozeb 420 SC, Penncozeb 750DF, Sinozeb Xtend 750 DF, UniZeb 750 DF	
POWDERY MILDEW*			
boscalid[5]	7	Filan	Not recommended for use on grapes destined for export wines.

* Fungicide resistance in this pathogen has been reported. Review resistance management strategies on page 22 and follow the directions on page 24.

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

5. 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.)*			
azoxystrobin	11	Amistar 250 SC, Avior 800 WG, Azoxystrobin 250 SC, Azoxystrobin 500 WG, Connect 800 WG, Mirador 250 SC, Spartacus 250 SC, Supernova 250SC	Use no later than 80% capfall.
hexaconazole	3	Viva	
metrafenone	U8	Vivando	
spiroxamine	5	Prosper 500 EC	
tebuconazole	3	Folicur 430 SC, Laguna Xtreme 800 WG, Orius 430 SC, Zolo 430 SC	
tebuconazole + azoxystrobin	3 + 11	Custodia	
sulfur, present as elemental or crystalline sulfur	M2	Dusting Sulphur, Dusting Sulphur 900	Use no later than 12 weeks before harvest.
cyflufenamid	U6	Flute 50 EW	Use no later than E-L 31, berries pea-size (7 mm diameter).
paraffinic oil	n/a	BioPest	
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	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	Use no later than E-L 34, (before commencement of veraison). Do not use within 42 days of harvest.
fenarimol	3	Rubigan SC	Use no later than 35 days before harvest.
myclobutanil	3	Mycloss Xtra	
triadimefon	3	Slingshot, Triad 125, Triadimefon 125, Triadimefon 125 EC	
triadimenol	3	Allitron, Bayfidan 250 EC, Citadel, Triadimenol 250 EC, Tridim 250 EC	
copper ammonium acetate	M1	Cop-IT	Use no later than 30 days before harvest.

* Fungicide resistance in this pathogen has been reported. Review resistance management strategies on page 22 and follow the directions on page 23.

Active Constituent	Activity group	Some registered products	Restriction on Use
POWDERY MILDEW* *(CONT.)*			
copper ammonium complex	M1	Copperguard, Liquicop	Use no later than 30 days before harvest.
proquinazid	13	Talendo	
sulfur, present as elemental or crystalline sulfur	M2	Barmac Wettable Sulphur, Brysulf 800 WG, Chemtura Sulphur WG, Cosamil, Cosavet WG, David Grays Sulphur Spray, GranuSulf 800 WG, InnoSulph 800 WG, Kendon Sulphur, Kumulus DF, Microsul WG Elite, Microthiol Disperss, Notion, Rutec Sulfur, Stollers Flowable Sulphur, Sulfostar DF, Sulfur 800 WG, Sulgran WG, Sulphur 800 WG, Thiovit Jet, Titan Sulphur 800 WG, 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	Barmac Wettable Sulphur, Brysulf 800 WG, Chemtura Sulphur WG, Cosamil, Cosavet WG, GranuSulf 800 WG, InnoSulph 800 WG, Kumulus DF, Microsul WG Elite, Microthiol Disperss, Notion, Sulfostar DF, Sulfur 800 WG, Sulgran WG, Thiovit Jet, Titan Sulphur 800 WG, 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	Barmac Wettable Sulphur, Brysulf 800 WG, Chemtura Sulphur WG, Cosamil, Cosavet WG, GranuSulf 800 WG, InnoSulph 800 WG, Microsul WG Elite, Sulfur 800 WG, Sulgran WG, Thiovit Jet, Titan Sulphur 800 WG, Wettable Sulphur	Use no later than 30 days before harvest.

* Fungicide resistance in this pathogen has been reported. Review resistance management strategies on page 22 and follow the directions on page 23.

Active Constituent	Activity group	Some registered products	Restriction on Use
GARDEN WEEVIL			
esfenvalerate	3A	Sumi-Alpha Flex	Foliar spray only. Use no later than 80% capfall.
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	Dormant spray only.
petroleum oil	n/a	Caltex Winter Spray Oil, 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	Barmac Wettable Sulphur, Brysulf 800 WG, Chemtura Sulphur WG, Cosamil, Cosavet WG, David Grays Sulphur Spray, GranuSulf 800 WG, InnoSulph 800 WG, Kendon Sulphur, Kumulus DF, Microsul WG Elite, Microthiol Disperss, Notion, Rutec Sulfur, Stollers Flowable Sulphur, Sulfostar DF, Sulfur 800 WG, Sulgran WG, Thiovit Jet, Titan Sulphur 800 WG, 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	Barmac Wettable Sulphur, Brysulf 800 WG, Chemtura Sulphur WG, Cosamil, Cosavet WG, David Grays Sulphur Spray, GranuSulf 800 WG, InnoSulph 800 WG, Kendon Sulphur, Kumulus DF, Microsul WG Elite, Microthiol Disperss, Notion, Rutec Sulfur, Stollers Flowable Sulphur, Sulfostar DF, Sulfur 800 WG, Sulgran WG, Thiovit Jet, Titan Sulphur 800 WG, 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 indoxacarb	6 22A	Proclaim Avatar	Use no later than E-L 31, berries pea-size (7 mm diameter). Do not use within 56 days of harvest.
Bacillus thuringiensis subspecies *aizawai*	11	Bacchus WG	May be used until harvest.

Active Constituent	Activity group	Some registered products	Restriction on Use
GRAPEVINE MOTH *(CONT.)*			
Bacillus thuringiensis subspecies *kurstaki*	11	BioCrystal Kurstaki, Delfin, DiPel DF	May be used until harvest.
Trichogrammanza carverae	n/a	Trichogramma parasitic wasp	
GRAPEVINE SCALE [6]			
paraffinic oil	n/a	Bioclear, BioPest, Heavy Paraffinic Dormant Spray Oil, Trump Spray Oil	Dormant spray only.
petroleum oil	n/a	All Seasons White Oil, Caltex Summer Spray Oil, Caltex Winter Spray Oil, D-C-Tron Plus Spray Oil, Sacoa Summer Spray Oil, Stifle, Vicol Summer Oil, Vicol Winter Oil	
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	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	BioCrystal Kurstaki, Delfin, DiPel DF	
tetradecenyl acetate + tetradecadienyl acetate	n/a	Isomate LBAM Plus Pheromone, MD LBAM Flex Pheromone, MD LBAM Pheromone	
Trichogrammanza carverae	n/a	Trichogramma parasitic wasp	
MEALYBUG [7]			
paraffinic oil	n/a	Bioclear, BioPest, Trump Spray Oil	Dormant spray only.
buprofezin	16	Applaud, Clap, Scale & Bug	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.			

6. Some group 1B insecticides are registered for grapevine scale. Contact your winery or grape purchaser prior to any 1B insecticide application.
7. 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	Dormant spray only.
metaldehyde	n/a	Meta, Metarex, Pestmaster, Slug Out, Slugger	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	Dormant spray only.
sulfur, present as polysulfide	M2	Lime Sulphur	Apply as near as possible to budburst.
sulfur, present as elemental or crystalline sulfur	M2	Barmac Wettable Sulphur, Brysulf 800 WG, Chemtura Sulphur WG, Cosamil, Cosavet WG, David Grays Sulphur Spray, GranuSulf 800 WG, InnoSulph 800 WG, Kendon Sulphur, Kumulus DF, Microsul WG Elite, Microthiol Disperss, Notion, Rutec Sulfur, Stollers Flowable Sulphur, Sulfostar DF, Sulfur 800 WG, Sulgran WG, Thiovit Jet, Titan Sulphur 800 WG, Top Wettable Sulphur, Uni-Shield	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

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

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.

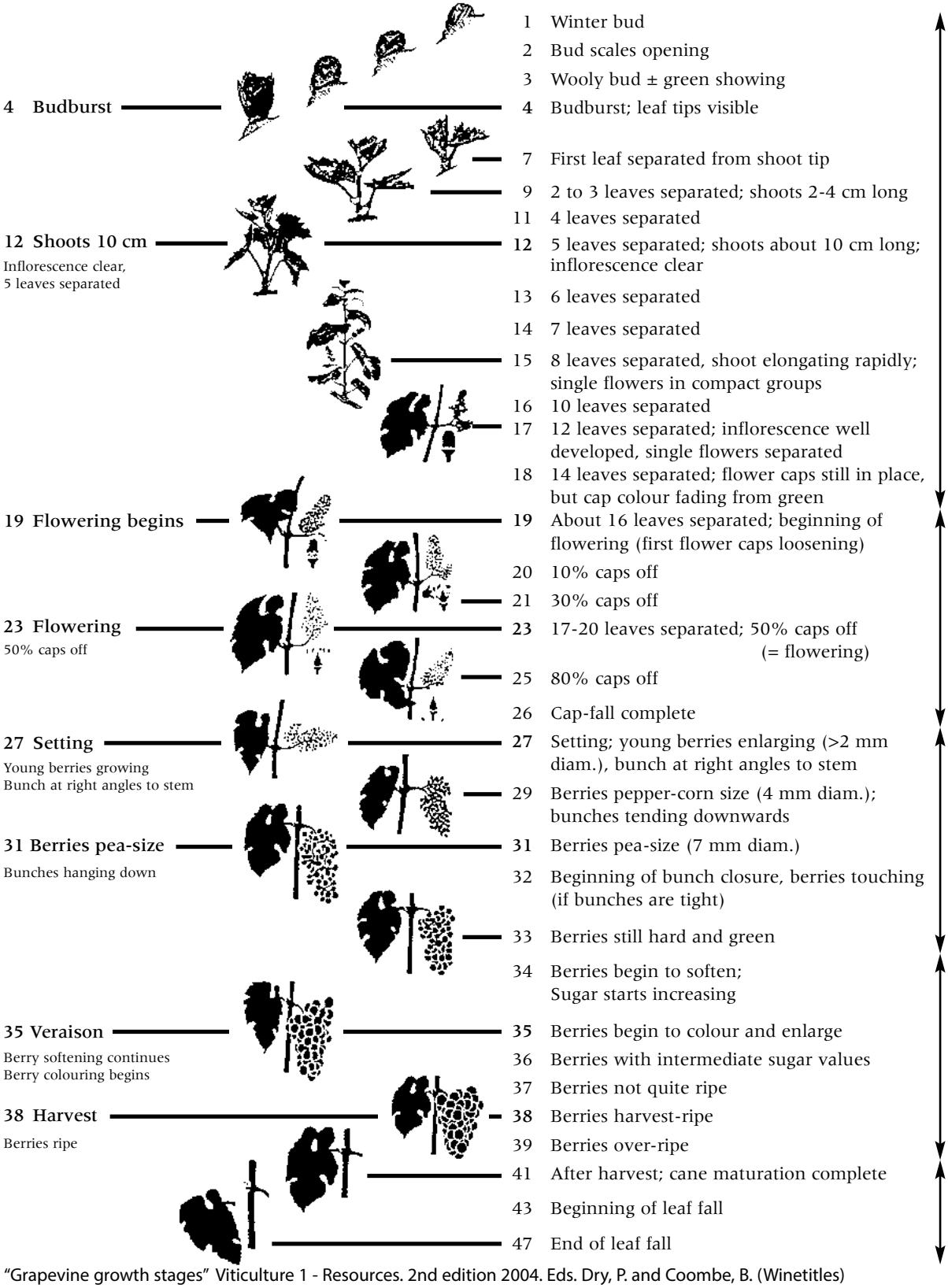
80% capfall: E-L stage 25; 80% of caps have just lifted and the largest berries are no more than 2 mm in diameter.

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

Pre-bunch closure: E-L stage 31; Berried 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

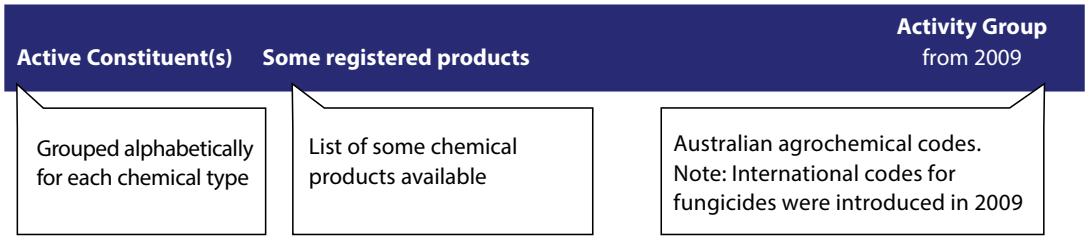
The following products are registered by the Australian Pesticides and Veterinary Medicines Authority for use in wine grape production in Australia. Always read the label on the chemical container as the products listed in the table might not necessarily be registered for use in your State.

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 22. 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 22 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	Activity Group from 2009
FUNGICIDE		
ametoctradin + dimethomorph	Zampro	45 + 40
azoxystrobin	Amistar 250 SC, Avior 800 WG, Azoxystrobin 250 SC, Azoxystrobin 500 WG, Connect 800 WG, Mirador 250 SC, Spartacus 250 SC, Supernova 250SC	11
benalaxyl + mancozeb	Galben M	4 + M3
boscalid	Filan	7
captan	Captan, Captan 800 WG, Captan 900 WG, Captan WG	M4
captan + metalaxyl	Duplex WG	M4 + 4
chlorothalonil	Applonil 720, Barrack 720, Barrack Betterstick, Bravo 720, Bravo Weather Stik, Cavalry 720 SC, Cavalry Weatherguard, Cheers 720, Cheers 720 Weathershield, Chemtura Chlorothalonil, Chloronil Pro, Chloro 720, Chlornil 720 SC, Chlorothalonil 720, Chlorothalonil 900 WG, 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 500, Nordox 750 WG, Norshield WG, Red Copper WG	M1
copper hydroxide	Blue Shield DF, Champ Dry Prill WG, Cung Fu 350 SC, 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 WP, Coppox WG, Coppox WP, Copper Oxychloride 500 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	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	Activity Group from 2009
FUNGICIDE *(CONT.)*		
dithianon	Delan 700 WG, Dragon 700 WG	M9
fenarimol	Rubigan SC	3
fenhexamid	Teldor 500 SC	17
fluazinam	Emblem, Gem, Shirlan	29
hexaconazole	Viva	3
hydrogen peroxide + peroxyacetic acid	Peracetic Acid, Peratec, Peratec Plus	M + M
iprodione	Aquaflow 500 SC, Chief 250 Liquid, Chief Aquaflo, Corvette Flowable, Corvette Liquid, Fungol 500, Ippon 500 Aquaflo, Ipral 250, Iprine 250, Iprine 500, Iprodione 250, Iprodione Aquaflow 500, Iprodione Liquid 250, Rovral Aquaflo, Rovral Liquid, Sindon 50 SC, Sinpro 500 SC, Subscribe, Transact	2
mancozeb	Choice Mancozeb 750 WG, Dithane Rainshield Neo Tec, innova Mancozeb 750, Kencozeb 750DF, Mancoflo, Mancozeb 750 DF, Mancozeb 750 WG, Mancozeb DF, Mancozeb DG, Manfil, 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 MZB 720 WP	4 + M3
metiram	Polyram DF	M3
metrafenone	Vivando	U8
myclobutanil	Mycloss Xtra	3
oxadixyl + propineb	Rebound WP	4 + M3
paraffinic oil	BioPest	unspecified
penconazole	Topas 100 EC	3
phosphorous acid	Agri-Fos 600, ChemPhos 400, Country Phospot 400, Country Phospot 400 pH 7.2, Country 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, Throwdown 600	33
potassium bicarbonate	Ecocarb	M2
potassium salts of fatty acids	Ecoprotector	U1

Active Constituent(s)	Some registered products	Activity Group from 2009
FUNGICIDE *(CONT.)*		
procymidone	Fortress 500, Metapris, Procymidone 500, Proflex 500, Sumisclex 500	2
proquinazid	Talendo	13
pyraclostrobin	Cabrio, Cabrio WG	11
pyrimethanil	Predict 600 SC, Protector 400SC, Pyrus 400 SC, Scala 400 SC	9
quinoxyfen	Legend	13
spiroxamine	Prosper 500 EC	5
sulfur + copper oxychloride	Mildex WG	M2 + M1
sulfur present as polysulfide	Lime sulphur	M2
sulfur, present as elemental or crystalline sulfur	Barmac Wettable Sulphur, Brysulf 800 WG, Chemtura Sulphur WG, Cosamil, Cosavet WG, David Grays Sulphur Spray, Dusting Sulphur, Dusting Sulphur 900, GranuSulf 800 WG, InnoSulph 800 WG, Kendon Sulphur, Kumulus DF, Microsul WG Elite, Microthiol Disperss, Notion, Rutec Sulfur, Stollers Flowable Sulphur, Sulfostar DF, Sulfur 800 WG, Sulgran WG, Thiovit Jet, Titan Sulphur 800 WG, Top Wettable Sulphur, Uni-Shield, Wettable Sulphur	M2
tebuconazole	Folicur 430 SC, Greenseal, Laguna Xtreme 800 WG, Orius 430 SC, Zolo 430 SC	3
tebuconazole + azoxystrobin	Custodia	3 + 11
tetraconazole	Domark 40ME, Mettle 40ME	3
thiram	Thiragranz, Thiram DG, Thiram 800 WG	M3
triadimefon	Slingshot, Triad 125, Triadimefon 125, Triadimefon 125 EC	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	Activity Group from 2009
HERBICIDE		
2,2-DPA-sodium (dalapon-sodium)	Atlapon, Dalapon 740 SP	J
amitrole + ammonium thiocyanate	Amitrole T	Q
amitrole + paraquat	Alliance, Para-Trooper	Q + L
bromoxynil + diflufenican	Barracuda, Bentley, Colt, Cougar, Difluken B, Jaguar	C + F
carfentrazone-ethyl	Carfentrazone 240 EC, Elevate, Hammer 400 EC, Nail 240 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, Paraquat/Diquat, Paraquat + Diquat 250, 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, Rootout 212	A
glufosinate-ammonium	Basta, Biffo, Cease, Exile, Exonerate, Exonerate200 SL, Fascinate 200 SL, Faster-TG 200, Fiestar, Glufosinate 200, Glufosinate-Ammonium 200, Sky-7th 200	N
glyphosate-ipa	AllOut 450, Banish 360, BioChoice 360, ClearUp Bio 360, ClearUp 450, Country Glyphosate 360, Glyphosate 360 SL, Envirospray 360, Eradicator 450, Eradicator 540, Gladiator, Glister 360, Glister 450, Glymount, Glymont 450, Glyphos classic 450, Glyphosate 360, 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 CT, Raze, Ripper 480, Roundup, Roundup Biactive, RoundupCT, Sanos 360, Sanos 450, Sickle 540, SquareDown 360, Wipe-Out 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, Nugget Dry 680 WG, Roundup Ready, Roundup Ready Plantshield, Weedmaster Dry	M
glyphosate-mea	Clear Up 450 SL, Wipe-Out Plus	M
glyphosate-potassium salt	Firebolt, Gladiator Optimax, Glyphosate 495 K Salt, Glyphosate 540, Glyphosate K-Tech 500SL, Max Out 540, Roundup Attack, Roundup PowerMAX, Touchdown Hitech, Warlord 540 Hi-Load, Wipe-Out Accelerate	M

Active Constituent(s)	Some registered products	Activity Group from 2009
HERBICIDE *(CONT.)*		
glyphosate-potassium salt + mas	Weedmaster Argo, Weedmaster Dual Salt Technology	M + M
haloxyfop-R methyl ester	Agro-Essence, Asset, Convict, Exert 520, Firepower, Haloxyfop 520, Haloxyfop 520 EC, Haloxyken 520, Hermes 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, Goal, GoalTender, Gowel 240 EC, Ox 240, Oxen, Oxyfan, 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	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
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, Tiger Gold 250, Triflen 480	A
quizalofop-P-tefuryl	Pantera	A
simazine	Gesatop 600 SC, Gesatop Granules 900 WG, Simagranz, Simanex 600 SC, Simanex 900 WG, SimaPhos 900, Simaquest 900 WG, Simazine 500, Simazine 500 Flowable, Simazine 500 SC, Simazine 900 DF, Simazine 900 WDG, Simazine 900 WG, Simazine 900DF	C
trifluralin	Tricon Flexi 480, Triflur X, Triflur Xcel, Trifluralin 480, Trifluralin 480 EC, Triflurasip 480, Trilogy, Trilogy 600, Uni-Try	D

Active Constituent(s)	Some registered products	Activity Group from 2009
INSECTICIDE		
alpha-cypermethrin	Alpha Duo 100, Alpha Duo 100 EC, Alpha Duop 100, Alpha Forte 250 SC, Alpha-Cyp 100 Duo, Alpha-Cyper 100 EC, Alpha-Cypermethrin 100, Alpha-Cypermethrin 100 EC, Alpha-Scud Elite, Astound Duo, Chieftain Duo 100EC, Dictate Duo 100, Dominex Duo, Fastac Duo, Ken-Tac 100, Mascot Duo, UniChoice 100 EC, Unitox 100EC	3A
azinphos-methyl	Gusathion 200 SC	1B
Bacillus thuringiensis subspecies *aizawai*	Bacchus WG	11
Bacillus thuringiensis subspecies *kurstaki*	BioCrystal Kurstaki, Delfin, DiPel DF	11
bifenthrin	Arrow 100 EC, Astral 250 EC, Bifenthrin 100, Bifenthrin 100 EC, Bifenthrin Ultra 300 EC, Bifentin, Choice BiFendoff 100, Disect 100 EC, Out of Bounds, Tal-Ken 100, Talstar 100 EC, Talstar 250 EC, Venom 100 EC	3A
buprofezin	Applaud, Clap, Scale & Bug Insecticide	16
carbaryl	Bugmaster Flowable, Carbaryl 500 Flowable, Carbaryl 500 SC, Cricket and Grasshopper Killer Bait	1A
chlorantraniliprole	Altacor	28
chlorpyrifos	Chlorpos, Chlorpyrifos 500, Chlorpyrifos 500 EC, Country Chlorpyrifos 500, 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	unspecified
diazinon	Country Diazinon 800, Diazinon	1B
dicofol	Miti-Fol EC	UN
dimethoate	Dimethoate	1B
emamectin	Proclaim	6
esfenvalerate	Sumi-Alpha Flex	3A
etoxazole	ParaMite	10B
fenamiphos	Assassinator 400, Country Fenamiphos 400, Fenamiphos 400, Fenamiphos 400EC, Nemacur 400	1B
fenitrothion	Fenitrothion 1000, Fenitrothion 1000 EC	1B
fipronil	Albatross 200 SC, Amulet Cue-Lure, Cannonball 200SC, Regal 800, 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 and Slug bait, Pestmaster Snail and Slug pellets, Slug Out (bait), Slugger Slug and Snail pellets	unspecified

Active Constituent(s)	Some registered products	Activity Group from 2009
INSECTICIDE *(CONT.)*		
Metarhizium anisopliae var. *acridum*	Green Guard SC, Green Guard SC Premium	unspecified
methidathion	Supracide 400, Suprathion 400 EC	1B
methiocarb	Mesurol Snail and Slug Bait	1A
methomyl	Electra 225, KDpc Metho, Lannate L, Marlin, Methomyl 225, Nudrin 225, Sinmas 225	1A
methoxyfenozide	Prodigy	18
paraffinic oil	Bioclear, BioPest, Heavy Paraffinic Dormant Spray Oil, Trump Spray Oil	unspecified
petroleum oil	All Seasons White Oil, Caltex Summer Spray Oil, Caltex Winter Spray 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
sulfoxaflor	Transform	4C
sulfur, present as elemental or crystalline sulfur	Barmac Wettable Sulphur, Brysulf 800 WG, Chemtura Sulphur WG, Cosamil, Cosavet WG, David Grays Sulphur Spray, GranuSulf 800 WG, InnoSulph 800 WG, Kendon Sulphur, Kumulus DF, Microsul WG Elite, Microthiol Disperss, Notion, Rutec Sulfur, Stollers Flowable Sulphur, Sulfostar DF, Sulfur 800 WG, Sulgran WG, Thiovit Jet, Titan Sulphur 800 WG, 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 Flex Pheromone, MD LBAM Pheromone	unspecified
trichlorfon	Dipterex 500 SL, Lepidex 500	1B
Trichogrammanza carverae	Trichogramma parasitic wasp	unspecified
PLANT GROWTH REGULATORS		
chlormequat	Cycocel 77A, Getset	unspecified
cyanamide	Cyan, Dormex	unspecified
ethephon	Country Ethephon 480, Ethephon 720, Ethephon 720 SL, Ethrel 720, K-Ethephon, Promote 720, Promote 900	unspecified
gibberellic acid	Gala, GBR Acid, GBR Acid 200SG, Gibber, N-Large, ProGibb SG	unspecified
methyl esters of fatty acids	Waiken	unspecified

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 which 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 ensures 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; and

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 following page.

The advice given in the CropLife strategies is valid at the time of going to print. Current versions of the strategy are available from the CropLife Australia website: www.croplifeaustralia.org.au.

Powdery mildew

Fungicide activity groups: Group 3 (DMI); **Group 5** (amine); **Group 7** (carboxamide); **Group 11** (quinone outside inhibitor); **Group 13** (quinoline), **Group U6** (phenyl-acetamide); **Group U8** (actin inhibitor)

1. **DO NOT** apply more than two consecutive sprays of a **Group 3** or **Group U6** fungicide.
   DO NOT apply more than three **Group 3** sprays per season.
   DO NOT use **Group 3** fungicides curatively.
2. **DO NOT** apply more than two consecutive sprays of a **Group 5** fungicide.
   DO NOT apply more than three **Group 5** sprays per season.
3. **DO NOT** apply consecutive sprays of **Group 7** fungicides, including from the end of one season to the start of the following season.
   DO NOT apply more than four **Group 7** sprays per season.
4. Apply **Group 11** and other systemic fungicides preventatively.
5. **DO NOT** apply more than two sprays per season of **Group 11** or **Group U6** fungicides.
6. Where **Group 11** products have been routinely used for many seasons, field research indicates there is an increased risk of powdery mildew resistance to **Group 11** fungicides occurring. To ensure continued protection against powdery mildew in these circumstances, either abstain from using Group 11s or mix **Group 11** fungicides with a registered rate of a compound from an alternative chemical group for the control of powdery mildew in grapes.
7. Alternatively, if applied alone, **Group 11** fungicides should be used in strict alternation with fungicides from an alternative chemical group for the control of powdery mildew.
8. **DO NOT** apply more than two consecutive sprays of a **Group 13** fungicide.
   DO NOT apply more than three **Group 13** sprays per season.

Downy mildew

Fungicide activity groups: **Group 4** (phenylamide); **Group 11** (quinone outside inhibitor); **Group 40** (dimethomorph)

1. Start disease control sprays using a protectant or non-phenylamide fungicide and continue spraying at 7-21 days depending on disease pressure and rate of grapevine growth, typically when the shoots are 10 cm (E-L 12 stage) or longer.

When conditions favour disease development, apply two consecutive sprays of a **Group 4** product. **DO NOT** apply more than two consecutive sprays of a **Group 4** product. **DO NOT** apply more than four sprays of a **Group 4** product per season.

2. **DO NOT** apply more than three consecutive sprays of a **Group 40** fungicide, and no more than a total of six sprays per season.

DO NOT apply more than two sprays per season of **Group 11** fungicides. If two consecutive applications of **Group 11** 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** fungicide is used again, either in the current or following season.

3. Apply **Group 11** fungicides preventatively.

4. Apply a maximum of two consecutive applications in alternation with fungicides from a different MOA group with satisfactory efficacy against the target pathogen/s.

Grey mould (Botrytis bunch rot)

Fungicide activity groups: **Group 2** (dicarboximide); **Group 9** (anilinopyrimidine); **Group 12** (phenylpyrroles); **Group 17** (hydroxyanilide); **Group 7** (carboxamide)

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**), **Group 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**), **Group 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**), **Group 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. Late season fungicide treatments should be applied before Botrytis infection reaches unacceptably high levels in the vineyard.

The proven power trio against powdery mildew

Powdery mildew can have a devastating impact on the value of both table and wine grapes. Our powerful trio of fungicides provides the foundation for a cost-effective control program right through the season. To find out more, visit our website or contact your local Bayer CropScience representative.

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When it comes to controlling diseases like powdery mildew, downy mildew, phomopsis and black spot, BASF fungicides have been setting the standard for years. BASF's global innovations make it possible for viticulturists to grow quality grapes for people to enjoy their favourite wine.

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