

# THE BAROSSA GROWERS GUIDE





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## FOREWORD

The Barossa Viticulture Technical Group (BVTG) was established in 2002 by a number of local growers and corporate employees. The purpose of this group is to provide viticultural technical support to the regions grape growers by promoting best practice viticulture. This support is provided through technical seminars and field trips. In July 2008 the BVTG became a sub-committee of the Grape Barossa committee, which reports directly to the Barossa Grape and Wine Association Board. The mission statement of the BVTG is,

*The Barossa Viticulture Technical Group is committed to the regional development of viticulture practices that ensure the environmental and economic sustainability of the Barossa grape-growing region. This commitment will be implemented through the facilitation and coordination of regionally specific research and development projects, workshops, and the clear and precise dissemination of information to wine industry stakeholders*

First awarded in 2006, the BVTG announced in July 2009 the renaming of the Barossa Young Viticulturist Fellowship Award to the Geoff Knights Viticulture Innovation Award, in honour of the late Geoff Knights (1945 – 2009) whom was a founding member of the BVTG. The Geoff Knights Viticulture Innovation Award is aimed at providing a grower, viticulturist or industry participant with the opportunity to explore an innovative viticultural idea or topic through study, travel or a project that can deliver benefits to the Barossa wine industry. The award is also a great opportunity for individuals to further their knowledge and careers, and seeks to involve such people in regional organisations and the Barossa's future.

As recipient of the 2006 Barossa Young Viticulturist Fellowship Award, my project concept of a Barossa Growers Guide originally

started with the idea of creating a generic spray diary for Barossa grape growers, especially those growers that do not deliver to any of the major wineries. The grower handbooks and spray diaries issued to growers by the major wine companies ensure that these growers are kept up-to-date with current industry regulations, and best management practices pertaining to agrochemical application, and pest and disease management.

It is my view that such information should be readily available to all growers, especially information on changes to agrochemicals registered for use in Australian Viticulture. Although this information can be found at [www.awri.com.au/agromemicals](http://www.awri.com.au/agromemicals), it is imperative that growers consult with their grape purchaser as they may have different withholding periods and/or agrochemical restrictions because MRL's (maximum residue limits) change from market to market depending on what country the winemaker is exporting to.

It is vital for growers to maintain accurate records in all facets of their business, however particularly with spray information. Growers that are currently out of contract or are selling grapes on the spot market should keep records for their vineyard on aspects such as yield history and spray programs as this may enable them to sell their grapes more readily. If a grape purchaser knows the vineyard inputs for the past growing season, they can make an informed decision on purchasing the grapes - besides the fact that it looks professional.

The information provided in this Barossa Growers Guide may change over time as future research discovers new and alternative methods. For this reason, this guide has references to reliable web sources for you to access the latest information.

**Adrian Hoffmann**

# INTRODUCTION

## The past:

With a grape growing history dating back to 1842, the Barossa is recognised as Australia's most famous wine region.

The first vines were planted in the region in 1842. English gentry sponsored the development of a commercial wine industry in the 1850's and 1860's but the real growth took place from the 1880's onwards. Entrepreneurial English and Lutheran settlers built wineries and commenced selling their wines to the vast market place of wine consumers in London. Although some growers did make wine for their own use, the majority sold grapes to the established wineries. The Barossa's strength and success has come from this specialisation. Its pool of expert grapegrowers have a blend of inherited knowledge of the land and its climate, passed down through the generations.

In 1997 two regions were identified in the Geographic indication Barossa zone: Barossa Valley (BV) and Eden Valley (EV), along with some additional buffer land.

The Barossa Valley (often called the Valley Floor) stretches from Williamstown in the south almost to Kapunda and Truro in the north and averages less than 400 metres above sea level. The red brown soils are more fertile than those in the Eden Valley, rainfall is up to 50% less and temperatures are up to 2 degrees warmer than in the Eden Valley.

The Eden Valley encompasses land from Truro in the north to Mount Pleasant in the south and is generally between 400 metres and 600 metres above sea level, with most winegrowing country located in the higher, cooler, wetter sections of the region. Soils are generally rocky and acidic, winter rainfall is abundant, temperatures are cooler and the growing season is longer.

These striking differences in topography, geology and climate create characteristic and contrasting wine styles.

## The present:

The business of growing grapes and making wine has continued to be a strong part of the identity of the region to this day. Boasting thousands of hectares of prime vineyards, these provide the highest quality grapes for the region's renowned range of premium, super premium and ultra premium wines. The Barossa is home to some of the oldest productive Shiraz vines in the world. Shiraz has pride of place because this is the birthplace of one of the world's greatest wines - Penfold's Grange.

Now with 150 wineries ranging in size from small wine production, to names with world-wide reputations, the Barossa comprises 755 vineyards of varying sizes.

Barossa's share of Australia's national winegrape vineyard area is around 7% (10,992 Ha BV and 2,264 Ha EV) and produces on average around 4% of the national crush. (approximately 60,000 tonnes in 2009). Shiraz, Cabernet Sauvignon and Grenache are the main red varieties, and Chardonnay, Semillon and Reisling the main white varieties.

## The future:

With so many years of tradition and culture, the Barossa stands strong, paying tribute to old world traditions whilst looking toward the future.

Grapegrowers in the region have produced crops of very high quality over many years and are in an excellent position to face the challenges of years to come due to the support of the superb research institutions in the valley, and the presence of important wine companies which lead the path to sustainable high quality viticulture.

This guide will assist grapegrowers to find independent sources of information to grow high quality wine grapes sustainably into the future.

# QUALITY GRAPES

## What is grape quality?

It is the suitability for a certain purpose. Good communication with the grape purchaser will ensure that quality targets are met for the intended wine style.

A great deal of work has been undertaken within Australia and overseas to help improve grape quality, and has been communicated widely through books e.g. (1) various workshops ([www.AWITC.com.au](http://www.AWITC.com.au)) and seminars ([www.ASVO.com.au](http://www.ASVO.com.au))

The next big step is the production of fruit attributes that support the development of exactly those wine attributes that are required by consumers. As consumers seem to preferentially buy by brand, variety and region ([www.winepreferences.com](http://www.winepreferences.com)), the development of recommendations for all varieties on a regional basis must be encouraged.

An example is the Communication guide for McLaren Vale Grapegrowers and wineries (McLaren Vale Grape, Wine and Tourism Association) which devised quality descriptors for common varieties of the region.

## How to assess grape quality?

Sugar concentration (by refractometry), titratable acidity and pH (laboratory analysis of juice), colour (visual), and Berry Sensory Assessment (2) and see Table 1) can be done by grapegrowers.

In the picking bin the absence of negative specifications like biological or environmental contaminants can be visually assessed (Australian Winegrape Load Assessment posters at [www.ASVO.com.au/order/](http://www.ASVO.com.au/order/)).

Grapes are classified as a 'food'. They are subject to the Australian and New Zealand Food Authority (ANZFA) food standard code ([www.Anzfa.gov.au](http://www.Anzfa.gov.au)). As with any other 'food', wine grapes should be clean, fresh, ripe and flavoursome.

## Where to sample for grape quality assessments?

It is critical that the method used produces results representative of the whole vineyard.

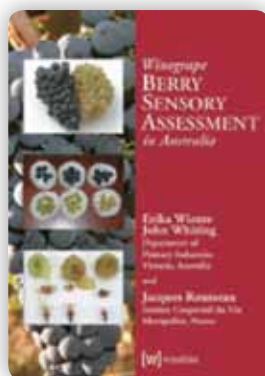
The most common approach involves randomly sampling bunches from various positions within the whole vineyard regardless of any knowledge about the spatial variation in vine performance. In some cases, the number of samples taken is determined statistically in an attempt to achieve an acceptable degree of error.

Zonal-based sampling however, with the help of PV technology (see below) allows that the number of samples allocated to each zone is proportionate to the zone area (or vine number) relative to the total area of the block.

In recent years, berry sensory assessment has been routinely included in pre-vintage grape evaluation in particular for aroma development and phenolics in skins and seeds (2).

Desirable traits for Barossa region grapes are listed in **Table1**, but this is only semi-objective and the underlying phenolics will change in the winemaking process.

- (1) Krstic, M., Moulds, G., Panagiotopoulos, B. and West, S. Growing quality grapes to winery specifications, Winetitles 2003.
- (2) Winter, E. Whiting, J. and Rousseau, J. Winegrape Berry Sensory Assessment in Australia, Winetitles 2004.



## QUALITY GRAPES (CONT.)

TABLE 1: PREFERRED AND NON-PREFERRED FRUIT QUALITY DESCRIPTIONS FOR BAROSSA GRAPES

	Preferred	Non preferred
<b>Berry firmness</b>	turgid berries with good plasticity	hard berry
<b>Pulp consistency</b>	balanced juice to pulp ratio, no release of juice when squashed.	too dry, gelatinous pulp which adheres to skin and seeds
<b>Sugar/acid balance</b>	balanced sugar to acid that displays freshness and vibrancy.  <i>acid levels are very important</i>	acid dominance (sourness) without sugar or flavour fullness, sugar dominance (especially sickly sweet) and without enough acid to balance it.
<b>Herbaceous/fruity balance</b>	low herbaceousness, intense fruitiness	very herbaceous with lack of fruitiness
<b>Skin chewiness</b>	crunchy and fresh, easy to chew into small pieces	hard to chew or shrivelled, slippery, too soft and flabby.
<b>Skin aroma</b>	not too acidic or herbaceous, fruity	bitter, herbaceous and no fruity taste
<b>Tannin intensity and astringency</b>	<b>Shiraz</b> moderate intensity, fine-grained, elegant <b>Cabernet Sauvignon</b> slightly higher naturally, fine grained <b>Grenache</b> slightly lower naturally, fine grained <b>Chardonnay</b> low intensity with a very fine silky structure, almost non-existent.	<b>Red varieties</b> intensity too high or too low  astringency too grippy, rough and aggressive  <b>Chardonnay</b> smaller & stressed berries may be too tannic to balance the freshness of the fruit.
<b>Seeds</b>	colour dark brown cracking like coffee beans, toasted flavours not astringent low tannic intensity	any green spots soft or almond like herbaceous flavours very astringent highly tannic

Source: **Winter, E. Whiting, J. and Rousseau, J.** Winegrape Berry Sensory Assessment in Australia, Winetitles, 2004.

### Explanations:

Turgid = fully hydrated, not soft or lacking water

Herbaceous = taste of a grass blade or tendril

Flabby skins = no firm structure, leading to an easy collapse of the fruit in the mouth.

Tannin intensity = high when many tannin molecules affect the salivary proteins in the mouth and it is hard to slide the tongue over the roof of the mouth.

Tannin astringency = grippy, coarse grain feeling with difficulties to resalivate the mouth.

Fine grained tannins = soft feeling in all parts of the mouth.

## Enhancing quality through Precision Viticulture

The term 'Precision Viticulture' (PV) encompasses the use of a range of technologies that allow viticulturists and winemakers to make more informed, targeted management decisions in the vineyard. Precision viticulture uses Global Positioning Systems (GPS) and Geographical Information Systems (GIS), as well as tools for measuring vineyard attributes at high spatial resolution (e.g. Remote Sensing, Yield Monitoring and Soil Sensing).

The acquisition of such data has been shown to improve the uniformity in fruit quality through either the differential harvesting/processing of wine grapes or the differential application of vineyard inputs.

PV recognises that the productivity of vineyards can be spatially variable. For example, yield variation across a single vineyard block is typically 8 to 10-fold (equivalent to 2-20 t/ha). Variation in fruit quality appears to follow a similar pattern to the variation in grape yield and some key soil properties.

With PV, vineyard management is targeted to 'zones' of similar performance. These zones are managed differently, rather than uniformly over large areas when spatial variability is not recognised.

PV uses novel technologies to characterise the vineyard with the aim to:

- locate zones which have similar (or dissimilar) characteristics
- produce quantitative data on how these zones perform

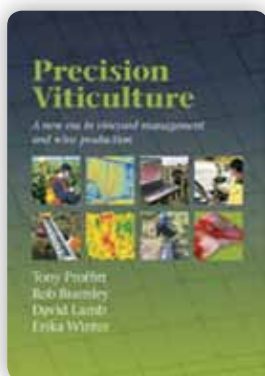
- use the data to understand the reasons for the differences in performance
- implement or improve a PV based management plan.

This process should ideally be repeated over several years with the aim of increasing production efficiency, profitability and/or sustainability.

The cyclic nature of the process further allows using spatial data collected over a number of years to predict likely outcomes in the future.

PV technologies and associated tools have been successfully applied in Barossa vineyards. A number of Australian case studies have been documented (1) and include:

- Selective harvesting and the opportunities to increase profitability
- Plant cell density related irrigation management
- Targeted management of vineyard inputs (e.g. irrigation water, pruning)
- Sampling (e.g. crop yield forecasting).
- Management of vineyard natural resources and environmental sustainability (e.g. salinity).



(1) Proffitt, T., Bramley, R., Lamb, D. and Winter, E. Precision Viticulture, A new era in vineyard management and wine production. Winetitles, 2006.

## Increasing quality through modern viticultural practice

Novel technologies have been developed for many aspects of grapegrowing ([www.CRCV.com.au](http://www.CRCV.com.au)) including for the purpose to:

- monitor water requirements and water use efficiency
- apply correct amounts of water
- measure nutritional balance
- measure soil water relations
- measure aerial environmental variables
- monitor bunch temperatures
- assess root and canopy density
- measure vigour and yield
- estimate yield

### Water

It is important to use modern soil moisture tools to adapt irrigation to water availability, climate and plant demand for best grape quality outcomes and to assess the usability of recycled water (1).

### Soils

The soil is the basis for grapevine growth and performance. Soil fertility, structure and texture should be maintained and improved. This can be achieved by a range of soil amelioration and inter-row cultivation methods (2). This includes management of salinity and acidity and the use of precision viticulture for zonal management.

### Block setup

It may be necessary to trial varying row and vine spacing and trellis options (3) so that the setup is best suited to the site. This includes taking care of adjacent vegetation.

### Vines

Develop varietal and regional recommendations to measure and apply nutrition, irrigation, and plant biomass allocation in roots, shoots and fruit to achieve balanced sustainable vines with

quality fruit. This includes PV tools to identify vineyard variability and new tools to measure plant stress.

**Vine health:** Experiment and communicate regional recommendations for integrated disease, pest and weed management (4) with improved methods of identification, prevention, biological and chemical control (5). Identify opportunities for pre-emptive and incursion management and to strengthen bio-security ([www.wfa.org.au/biosecurity.aspx](http://www.wfa.org.au/biosecurity.aspx)).

**Canopy:** Measure bunch-zone temperatures and experiment with trellis structure, leaf density, leaf positioning, shoot positioning, fruit location to ensure optimal exposure with minimal heatloads and good ventilation (6).

- (1) **Nicholas, P.** Soil, irrigation and nutrition. Winetitles, 2004.
- (2) **Ingels, C. A., Bugg, R. L., McGourty, G. T and Christensen, L. P.** Cover cropping in Vineyards: A Grower's Handbook. Winetitles, 1998.
- (3) **Smart, R. and Robinson, M.** Sunlight into wine. A handbook for winegrape canopy management. Winetitles, 1992.
- (4) **Nicholas, P., Magarey, P. and Wachtel, M.** Diseases and Pests. Winetitles, 1994
- (5) **Bernard M., et al.** Guidelines for Environmentally Sustainable Wine Grape Production in Australia: IPM adoption self-assessment guide for growers, The Australian and New Zealand Grapegrower and Winemaker, pp 24-35, March 2007
- (6) **Winter, E., Lowe, S. and Bulleid, N.** Bunchzone temperature monitoring throughout ripening and grape and wine quality of Shiraz in NE Victoria. Australian Viticulture 11 (1) pp 48-53, 2006.

## Improving accuracy of yield predictions

### Crop Estimation

The ability to supply the grape purchaser with accurate crop estimates is critical for grape streaming into wine products and optimum utilisation of winery capacity (1).

For grape growers, accurate yield estimates can help to make decisions on crop thinning, irrigation, harvest organisation and other management inputs. It will also give an early indication of tonnages and hence potential returns.

Problems that can arise when yield predictions are not done correctly:

- Penalties may be imposed, as the grape purchaser may need to make alternative plans for the parcel of fruit.
- Over supplied fruit may be rejected.

*Note: If you are unsure about current methods for grape maturity sampling and/or crop estimation, contact your grape purchaser.*

### How many bunches and from where?

Crop forecasting is often based on a random sampling approach whereby samples are taken from various positions within whole vineyard blocks regardless of, and generally in the absence of, any knowledge about the spatial variation in vine performance.

*Note: High variability in bunch weights means that you will need to collect more samples to ensure increased accuracy in your estimates.*

In some cases, the number of samples taken is determined statistically in an attempt to achieve an acceptable degree of error. Whilst this approach to crop forecasting has improved in recent years with the introduction of better statistical sampling protocols, the spatial variation commonly seen in vineyards suggests that Precision Viticulture methods can offer an improved sampling approach. When using zonal-based sampling, it is recommended that a proportional allocation of samples to the different zones is adopted. Where one zone is dominant, it may be possible to confine sampling to a single zone.

### When to assess potential yield?

The following table is adapted from Dunn and Martin, Crop Forecasting Manual, 2003.

Timing	Activity	Comments
Six weeks after budburst	Count bunches	knowing the number of bunches after budburst at this time together with a historical bunch weight at harvest allows you to calculate an estimated yield.
Post fruit-set	Count bunches and count berries	Counting bunches at this time (pea size berries) may give a more accurate estimate than the first bunch count just after budburst. Knowing the average number of berries per bunch, and the historical berry weight at harvest allows fine tuning of the bunch weight estimates.
Pre-harvest (2 weeks before harvest)	Weigh bunches	This is the time when the most accurate crop estimate can be made. However, performing crop estimates through the season allows for crop management decisions (e.g. crop thinning).

(1) **Dunn, G.M., Martin, S.R. and Petrie, P.R.** Managing yield variation in vineyards. Proceedings of the Australian Wine Industry Technical Conference, 24-29 July 2004, Melbourne, Australia, pp 51-56, 2005.

## SUSTAINABLE VINEYARDS

### What is sustainability?

Sustainability is an economic, social, and environmental concept in which human activity is conducted so that society and its members are able to meet their needs and express their greatest potential in the present, while preserving biodiversity and natural ecosystems, and planning and acting for the ability to maintain these ideals indefinitely.

*(Brundtland Commission, Our Common Future, Oxford University Press, 1987).*

For the Australian wine industry the key priority areas of sustainability have been described in “Sustaining Success - the Australian Wine Industry’s Environment Strategy. (South Australian Wine and Brandy Industry Association, 2002,).

At a National level the Australian Wine Industry Stewardship (AWIS) and EntWine environmental schemes are coordinated by the Winemakers’ Federation of Australia ([www.wfa.org.au/awis](http://www.wfa.org.au/awis)).

#### Environmental goals:

- **Water use efficiency and water quality.** The current Soil and Water Project [www.gwrdc.com.au](http://www.gwrdc.com.au) addresses these issues for several regions
- **Management of liquid and solid waste products,** including treated timber vineyard posts
- **Reduction of agrochemical use and adoption of IPM strategies,** and maintaining and enhance natural ecological systems and to protect **biodiversity**
- Managing conflicting **land-use decisions** between vineyards and local communities and other industries (Australia’s regional arrangements for natural resource management [www.nrm.gov.au](http://www.nrm.gov.au))

- Managing predicted greenhouse gas-induced **climate change** on viticulture. This includes modelling of regional effects, carbon footprint and life cycle analyses of grapegrowing and assessment of novel adaptation strategies.

The Australian Government is intensifying the partnership with businesses to integrate greenhouse issues into business decision making and to accelerate the uptake of energy efficiency. [www.climatechange.gov.au/resources/industry.html](http://www.climatechange.gov.au/resources/industry.html)

### What is a carbon footprint?

A carbon footprint is the total amount of CO<sub>2</sub> and other greenhouse gases emitted over the full life cycle of a product or service. It is expressed as tonnes of CO<sub>2</sub> equivalents, which accounts for the different global warming effects of different greenhouse gases.

A carbon Footprint calculator for the wine industry is available from [www.wfa.org.au/carbon\\_calculator.aspx](http://www.wfa.org.au/carbon_calculator.aspx)

### What is a lifecycle analysis?

During the life cycle of a product (e.g. wine) all impacts on the environment are measured, like the energy required to produce and transport the grapes, wine, its production aids and packaging materials and the waste disposal steps for all substances involved.

### Social goals:

Sustainability cannot be upheld without promoting a learning culture. This involves a skills audit across all sectors identifying the number of people and range/levels of skills likely to be required in the future, as well as assessing the adequacy of current training and on-the-job induction. The Taking Stock and Setting Directions Report WGGGA 2006 is a good resource in this regard [www.wgga.com.au/industry/tssd/](http://www.wgga.com.au/industry/tssd/)

**Economic goals:**

To improve efficiency while adding value through quality of the grapes delivered. The new Australian Wine Grape Sector Strategic Plan, implemented by WGGGA, will include an industry structural reform program and financial management tools for grower decision making and new grower business models.

## Integrated Pest and Disease Management (IPM)

**What is IPM?**

*It aims at integrating methods from:*

- **Chemical sprays** – which consider best practice and environmental safety
- **Cultural practices** – which reduce or prevent pests and diseases
- **Biological control** – which uses plants and animals to fend off pests and diseases
- **Ecological engineering** – which aims to enhance beneficial invertebrates and maximise their contribution to biological control.

IPM in vineyards has been proven to result in long-term vineyard health, and at the same time underpin the required crop quality and yield.

Work at Plant Health Australia (2) is ongoing to identify opportunities for pre-emptive and incursion management, and to strengthen biosecurity.

The National Vine Health Steering Committee and the Australian Vine Improvement Association (3) have developed recommendations for the provision of clean planting material.

Information on agrochemicals in viticulture; their resistance risk, their applicability at certain plant stages (MRL's) is available from the AWRI website.

Guidelines setting minimum standards for European sustainable grape production were developed by the International Organisation for Biological and Integrated Control (4). Australian guidelines for IPM in sustainable wine grape production were published in 2007 (1).

It is anticipated that these will serve as a technical reference for enhancing IPM implementation in viticulture in Australia.

**Prerequisites:**

To adopt IPM practices it is important to:

**Understand the disease or pest**

- how to recognise them
- their life cycles
- where the problem comes from

**Know what the conducive factors are**

- what are the environmental conditions that favours them
- what are the plant stages or conditions that support them

**Keep good records about the history of the vineyard**

- what was the problem in past years
- how has it been treated in the past

**Decide what risk of crop loss or damage can be tolerated**

- what are the risks for this and further year's crops
- what are the risks for the vines

**Learn about the ecosystem of the vineyard**

- what else lives there (e.g. bacteria, fungi, invertebrates and other plant beneficial's).

**Consider the impact of activities on the ecosystem**

- what do my management practices do to ecosystems
- how does this affect the disease and pest spectrum

## SUSTAINABLE VINEYARDS (CONT.)

### Chose an IPM strategy

- what is suited to the site/ vines/ climate/ environment and economic situation

(1) **Bernard M. et al.** Guidelines for Environmentally Sustainable Wine Grape Production in Australia: IPM adoption self-assessment guide for growers, The Australian and New Zealand Grapegrower and Winemaker, 518 (March), pp 26-36, 2007.

(2) [www.wfa.org.au/biosecurity](http://www.wfa.org.au/biosecurity)

(3) [www.planthealthaustralia.com.au/go/phau/strategies-and-policy](http://www.planthealthaustralia.com.au/go/phau/strategies-and-policy)

(4) [www.iobc.ch/IOBCGrapes.pdf](http://www.iobc.ch/IOBCGrapes.pdf)

### Stepwise implementation of IPM

To build healthy populations of beneficial predators and parasitoids in vineyards, and to enhance the service they provide, a range of steps may be adopted (1):

#### Step I:

- Monitor pests and diseases, and use insecticides only at key times when monitoring indicates a spray is economically justified, and there are no other alternatives
- Minimize sprays which have toxic properties to beneficials In IPM programmes, it is undesirable to use agrochemicals which have toxic and other deleterious effects to natural predators. Toxic broad-spectrum products should be avoided and substituted with 'softer' products that target the same pest/disease
- Use fungicides according to infection period or monitoring (rather than calendar-based) which generally results in reduced spray frequency and lower overall toxic exposure of natural enemies
- Using cultural supporting measures such as increasing canopy aeration through good

canopy management to reduce disease pressure. As a result of lower damage to beneficials, sprays applied for one pest/disease do not lead to pesticide-induced outbreaks of another pest, and the cost of such secondary outbreaks is reduced. It is especially important to minimise toxic sprays early in the season, as damage to bio-control at this time has the most significant consequences which may last the rest of the season.

#### Step II: Step I and monitor beneficials

- Monitoring pests and beneficials every 7-10 days over the growing season and use this data to decide when, or when not to spray. This often leads to significant reduction in insecticide use.

#### Step III: Steps I-II and encourage beneficials inside the vineyard

- Allowing grass swards to flower in every second inter-row by alternate row mowing provides pollen for predatory mites, and habitat/shelter for insect predators and spiders living and reproducing in long grass, such as brown lacewings and damsel bugs, but its use can be limited by frost or drought.
- Under-vine mulching using composted/fermented marc, composted green waste, or mowing grass with side-throw slashes to place grass under vines. This reduces water evaporation losses and runoff, improves soil structure and water holding capacity, and increases soil microbial activity.
- Providing nectar for beneficials by inter-row plantings. Beneficial insects and predatory mites can be encouraged by inter-row and under vine management. The emphasis is on providing a supplementary food source in the form of high quality, easily accessible nectar and pollen, shelter from summer heat and low humidity, and over-wintering hosts and shelters.

#### **Step IV: Steps I-III and release of beneficials (if required)**

- Augmenting low numbers of key beneficials by releases. This is most likely to be effective where releases are made in the early stages of pest infestation (or even preventatively) into crops which have a history of recurrent problems with a particular pest. Releases are only recommended when required, based on monitoring and IPM-specialist advice once Steps I-III are adopted, or to introduce a key beneficial species absent from a vineyard or a region. In many vineyards however, Step IV is often not needed, and where releases are made they are generally not needed on an ongoing basis. Relatively few species are available for release, thus successful vineyard IPM relies on systematic enhancement of naturally present species (Steps I-III).

#### **Step V: Steps I-IV and encouraging beneficials at a regional level**

- Improving the wider landscape in order to enhance biological control. Such initiatives follow on from long-term overseas studies (e.g. on lacewings and parasitoids and their movements) of their landscape requirements in recognition of the large spatial scale on which populations of many pests and

beneficials operate. Overseas studies show that native vegetation reserves, including roadside verges and headlands are a source of beneficials, and that generally, the more complex the landscape and the larger the vegetation remnant, the higher the utility to bio-control. To best aid natural bio-control, regional landscape modifications need be based on research and give specific benefits to key beneficials.

**(1) Bernard M., et al.** Guidelines for Environmentally Sustainable Wine Grape Production in Australia: IPM adoption self-assessment guide for growers. The Australian and New Zealand Grapegrower and Winemaker, pp 24-35, March 2007.

# MAJOR PESTS AND DISEASES IN BAROSSA VINEYARDS

## POWDERY MILDEW (UNCINULA NECATOR, ERYSIPHE NECATOR)

### Brief summary of symptoms for powdery mildew (PM)

**Leaf:** Yellow-green blotches up to 10 mm wide on the upper side and dark veins on the lower side progressing to fungal growth and ash grey spores (Figure 1), later leaves may blacken and fall off. Young diseased leaves crinkle and die.

Figure 1.



Photo Credit. Peter Magarey

**Buds & Shoots:** Buds infected in the previous season produce “flag shoots“ with distorted leaves curling upwards. Ash-grey patches 3-10 mm wide spreading until shoot is covered, leads to stunting and oily grey blotches which turn red-brown on lignified canes (Figure. 2). They may die back in winter from the tip onwards.

Figure 2.

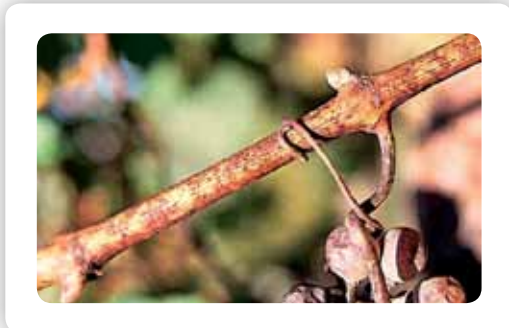


Photo Credit. Peter Magarey

**Bunch:** Powdery ash grey growth on berries or stalks, progressing to web-like scars, splitting

and desiccation or rotting (Figure 3). Note: The use of a hand lens is highly recommended.

Figure 3.



Photo Credit. Peter Magarey

### Economic impact

Powdery mildew is generally considered the most significant disease in Barossa vineyards

- Early season onset is more damaging as many cycles of PM can manifest.
- Splitting of berries can lead to infection with other fungi
- Diseased berries can cause off-flavour in wine at infection levels as low as 3-5% and may lead to rejection or deduction in grape price
- Untreated PM is a source of infection for other vineyards.

### Disease cycle

**Spring:** Cleistothecia (fungal resting bodies, visible with a hand lens) on plant material on the vineyard floor or in the cracks of the vine bark produce ascospores after rain (min. 2.5 mm) or overhead irrigation when temperatures are above 10°C. Ascospores infect lower leaves of shoots, often with a single grey spot. After 5-10 days these infections grow to colonies on the leaf surfaces and produce conidiospores which can spread to neighbouring vines by wind. Under favourable conditions may cause infection within 24 hours. Some newly emerging shoots may carry dormant fungal hyphae from infection in the bud the previous season. These

are called “flag shoots” and visibly “flag” the presence of the disease with stunted growth and grey appearance. They produce conidiospores which are dispersed by wind.

**Summer:** Ascospores and conidiospores can both spread and infect leaves, new buds and young berries every 5-10 days. Favourable conditions are mild cloudy weather, 20-30°C, 40% relative humidity (no free water needed) sheltered position of disease from direct sunlight. Shaded canopies and stressed plants contribute to susceptibility.

**Mid-Summer to Autumn:** Cleistothecia are formed. Leaving stalks and canes in the vineyards will increase infection potential.

**Winter:** Over-wintering occurs either as fungal growth in diseased buds or as yellow spore-bearing resting bodies (cleistothecia). They turn black when mature on over-wintering plant parts left on the vine or ground.

### Sources of infection

In most years, weather conditions are favourable for the development of grapevine powdery mildew in the Barossa.

**Infected buds and flag shoots:** Powdery mildew can over-winter as dormant hyphae in diseased buds which have generally been infected before the bud scales have turned brown. In the following spring, these diseased buds produce diseased and deformed shoots termed ‘flag shoots’. Fungal hyphae on these flag shoots produce conidiospores which are easily spread by wind to neighbouring shoots and vines. The production of spores takes around 5-10 days depending on temperature. The incidence of over-wintering infected buds that produce flag shoots in spring appears to be mostly related to the severity of disease on vines in the previous season(s). Infected buds and flag shoots often

appear on the same vines or panels every year.

**Cleistothecia:** Cleistothecia should not be a significant source of inoculum if powdery mildew has been well controlled in the previous seasons. They are formed on the surface of diseased leaves, stems and berries from mid-summer through to autumn (Fig. 4).

Figure 4.



Photo Credit. Peter Magarey

They are washed onto cordons and spurs and overwinter on the bark around the vine crown and cordon.

In the next season, temperature (10-30°C) and wetness (rainfall of 2.5 mm or more) promote ascospore release from cleistothecia.

Spores germinate at leaf temperatures between 6° to 33°C; the optimum temperature for growth is 25°C.

At 21° to 30°C, rapid germination and mycelium growth takes place. During favorable temperature periods, the time between spore germination and production of spores by the new colony takes only 5 days. These spores may have a changed genetic make up and may carry resistance to fungicides.

High temperatures that do not harm the plant can harm the fungus; spores and mildew colonies can be killed at extended durations

## MAJOR PESTS AND DISEASES IN BAROSSA VINEYARDS (CONT.)

of temperatures above 33°C. The fungus is destroyed completely when air temperatures rise above 35°C for 12 hours or more if colonies are directly exposed to UV light. Note that this rarely occurs inside a dense vine canopy.

### Conditions that promote PM

**Environmental conditions** include:

- sheltered vineyard sites, vineyards in hollows
- mild cloudy weather with low to moderate UV light
- relative humidity above 40%
- temperature during plant susceptible periods 20-30°C for long hours.

**Vine microclimate** features include:

- dark dense parts of canopy
- unaerated parts of vine.

**Susceptible plant stages** are:

- periods of rapid canopy growth (due to the presence of tender tissues)
- early berry development (before they become resistant to infection).

**Varietal susceptibility** differs:

- Particularly susceptible are eg. Verdelho, Chardonnay, Traminer, Riesling and Pinot Noir.
- Less susceptible are Shiraz and Grenache.

The duration of active vegetative growth will influence risk of PM development, therefore vineyard sites (e.g. deep fertile soil), management practices (e.g. high nutrient and irrigation) or climatic conditions that promote ongoing foliar growth increase the risk of powdery mildew.

Berries become resistant to infection at around 4-6 weeks after flowering (or approximately 13-15 weeks after bud burst).

- (1) **Nicholas, P. Magarey, P. and Wachtel, M.** Diseases and Pests. Winetitles, 1994.

- (2) **Magarey, P. MacGregor, A.M., Wachtel, M. F and Kelly, M.C.** The Australian and New Zealand Field guide for diseases, pests and disorders of grapes. Winetitles, 1999.

### Monitoring for Powdery Mildew

#### Disease modelling

A number of vineyards and regional information providers use various disease models that indicate when conditions are most conducive for disease spread.

The Gubler-Thomas (1) model uses temperature data to calculate a daily PM risk index that ranges between 0-100. High values (>60) indicate that temperature conditions are conducive for sporulation and infection.

*Note: Whilst the model can indicate when conditions are most favourable to the spread of PM, the time and nature of the first infection for the season plays an equally important role.*

#### Standard method to quantify disease

The incidence of powdery mildew on vines can be determined with a high level of confidence using the method described by Emmett and Wilkins (in 2).

*Note: Using this method the presence of disease can be reliably detected when incidence of diseased vines is as low as 2%, provided 200-300 vines were monitored.*

The method encompasses the following steps:

- examine 200-300 vines at 1-2 week intervals
- slowly walk along vine rows and inspect each side of the vines (up to 30 seconds per vine).
- inspect the inner foliage and the upper and lower surface of randomly selected leaves
- mark infection sites with tape for later recognition
- inspect more thoroughly on vines where powdery mildew was detected last time

*Note: Systematic monitoring is recommended if no disease history is available for a site.*

### Targeted Detection Monitoring

As symptoms of infection are difficult to detect at low levels, this approach involves focusing monitoring efforts on potential or known ‘hot-spots’ examining:

- susceptible varieties
- end panels
- dense canopies
- previously infected vines
- close to other sources of infection (e.g. neighbouring unsprayed vines).

If any powdery mildew is detected (using hand lens) a systematic number-based sample as described above is taken to quantify powdery infection on foliage and fruit.

*Note: While targeted monitoring can be more cost effective, broader monitoring should be undertaken at regular intervals*

### Harvest assessments

Assessment of incidence and severity of PM on bunches in picking bins according to assessment guidelines (2).

Post-harvest monitoring of vines

Use a hand lens to check suspect patches on leaves for fungal growth or cleistothecia. Cleistothecia are more likely to be present where powdery mildew is well established.

### Winter monitoring

Tag and record any areas where scarring is most evident as this will provide another “hot-spot” to concentrate monitoring efforts the following season.

- (1) **Gubler, W.D. and Thomas, C.** Control of grapevine powdery mildew using the U.C. Davis risk assessment model. Abstracts, 3rd International workshop on grapevine downy and powdery mildew. SARDI research report series no 22. p. 46, 1998.
- (2) **Krstic, M., Moulds, G., Panagiotopoulos, B. and West, S.** Growing quality grapes to winery specifications. Winetitles, 2003.

## Management of Powdery Mildew

### Cultural management options

Powdery mildew severity on grapevines can be reduced in some seasons by vine management that produces open vine canopies, e.g. through:

- trellising and training
- pruning,
- trimming
- shoot removal,
- water and fertilizer management
- vigour reducing cover crops.

*Note: Preventing primary infection and epidemic development when plants are susceptible early in the season will lower the risk of crop loss.*

Reduction of inoculum levels

If infection was present in the previous season it is important to:

- remove bunch remnants when pruning
- avoid excessive vine stress to prevent susceptibility and lack of plant internal defence
- remove flag shoots and practice good vineyard sanitation when disposing of PM affected plant parts.

### Organic and biodynamic options

Several non-sulphurous fungicides have been tested in Australia. These include fungal and bacterial preparations, sodium salts, silicate compounds, compost teas, vegetable and mineral oils and dairy byproducts. Milk and whey convey control for PM through free oxygen radicals which are produced when the droplets are exposed to sunlight. They destroy the fungal hyphae and conidia. Additionally, a natural antimicrobial compound in milk (lactoferrin) ruptures the fungal conidia. However, it is recommended to check with your grape purchaser before using these products.

These alternative fungicides are sometimes suggested for use under conditions of low disease pressure, as they are not as effective as sulphur. Most of these alternatives are also

## MAJOR PESTS AND DISEASES IN BAROSSA VINEYARDS (CONT.)

non-systemic and non-fumigant and would therefore require very thorough coverage for good disease control.

### Biological control organisms

Biological control organisms with known activity against PM are not yet registered in Australia (1) but include:

- *Ampelomyces* sp. (e.g. AQ10® USA)
- *Acremonium* sp. *Cephalosporium* sp.
- *Cladosporium* sp. *Gliocladium* sp.
- *Fusarium* sp
- *Penicillium* sp
- *Tilletiopsis* sp.
- *Trichothecium* sp
- *Bacillus subtilis* (e.g. Serenade®USA)

*Bacillus subtilis* helps prevent the powdery mildew from infecting the plant, with some effect in killing the powdery mildew organism, but is not as effective as the oils or sulfur in controlling it.

[www.ipm.ucdavis.edu/PMG/GARDEN/FRUIT/grapes.html](http://www.ipm.ucdavis.edu/PMG/GARDEN/FRUIT/grapes.html)

### Chemical management options

A current list of chemicals is available on the AWRI website and an updated booklet “Agrochemicals registered for use in Australian Viticulture”, is printed each year by the Australian Wine Research Institute [www.AWRI.com.au/industry\\_support/viticulture/agrochemicals/agrochemical\\_booklet/](http://www.AWRI.com.au/industry_support/viticulture/agrochemicals/agrochemical_booklet/)

*Note: Growers should always contact their grape purchaser/s (or potential purchaser/s) before applying any agrochemicals in their vineyard as their recommendations may vary to those given by the AWRI each year.*

**Preventive fungicides** must be applied early season before the disease gets established.

**Curative fungicides** can be used with thorough monitoring and decreased spray numbers. They need to be applied immediately after detection

of symptoms and repeated as recommended. This approach also requires excellent spray coverage.

- (1) **Bernard M., et al.** Guidelines for Environmentally Sustainable Wine Grape Production in Australia: IPM adoption self-assessment guide for growers, The Australian and New Zealand Grapegrower and Winemaker, pp 24-35, March 2007.

### Timing of Chemical management

**Dormancy/Pre-budburst:** No sprays are recommended for powdery mildew during the dormant period. While lime sulphur is used in some countries to reduce the number of viable cleistothecia it is not recommended for use against PM in Australia. If the main source of disease carry-over is from infected buds, then any dormant application of fungicides will not be effective.

**Early season:** As powdery mildew is difficult to detect at low levels, protectant sprays are generally used early-season. However, if PM is detected through field monitoring, a chemical with post-infection activity should be applied.

*Note:* Applying early season sprays will be of benefit as the canopy is relatively small and open and the best coverage and control can be achieved.

**Flowering and fruitset:** It is recognised that the most important period for the control of PM is from pre-bloom to 4 weeks after flowering, when conditions promote rapid disease development and spread. Disease-prone vineyards may require further sprays at two to three week intervals from berry set to berry softening. Infections that continue to develop on bunch stems may affect wine quality, so a spray program beyond berry softening may be warranted under high disease pressure.

*Note: Poor spray application or coverage is*

often implicated in powdery mildew outbreaks

**Pre-harvest and harvest management:** If powdery mildew is detected on bunches prior to harvest, a detailed survey of affected blocks should be conducted assessing incidence and severity on bunches and spatial distribution in the block.

*Note: It may be necessary to avoid harvesting in the worst affected areas, or if hand harvested pickers can be instructed to not take severely infected bunches, or drop the worst affected fruit onto the ground*

**Post-harvest:** Post-harvest sprays are usually not needed unless new growth on young vines needs to be protected for as long as possible in late summer/early autumn. They can prevent the formation of cleistothecia if they are applied before the fungus can develop sufficiently to cover the foliage.

*Note:* A strategic spray program should be implemented if there has been a recent history of disease or the vineyard has the potential for disease pressure.

In strategic spray programs, sprays are applied according to:

- monitoring of plant growth stages
- monitoring of disease activity
- knowledge of disease behaviour
- estimates of the likelihood of crop damage
- mode of action and withholding periods of chemicals

*Note: Withholding periods of fungicides for national and export end use may differ. Check recommendations of your grape purchaser (which are governed by the destination of the wine) before spraying the crop*

## Chemicals for PM

### Sulphurs

The activity of Sulphur (a Group Y fungicide) is merely protective and results from two mechanisms: a killing activity when powdery mildew spores come in direct contact with the sulphur particles and secondly degeneration of spores from sulphur vapours which occur under suitable environmental conditions. The sulphur fungicides are less active in humid and cool conditions (<math>17^{\circ}\text{C}</math>), because vaporisation which contributes to their effectiveness is moisture and temperature dependent. Sulphur vapours are active above  $17^{\circ}\text{C}$ , with the optimal range being  $25\text{-}30^{\circ}\text{C}$ , but highly concentrated vapours may damage young vine growth in hot and humid weather. The higher label rate is generally required for cool conditions whereas the lower label rate is used in hot conditions and with small amounts of plant surface that can be well covered. Dusts are not as rain-fast and they cannot be tank mixed with most other fungicides or pesticides. They are harmful to beneficials and residues on grapes will negatively affect the winemaking process.

### Potassium bicarbonate (Group Y)

Has only eradicant activity. Requires direct contact with the fungus organism for control. May therefore need more frequent application than sulphur to achieve the same level of control (increasing energy use, costs and soil compaction). Use in situations of low disease pressure, such as early in the season or in vineyards where powdery mildew has previously been well controlled. Mostly applied in conjunction with Synerrol horticultural oil.

*Note:* Should not be mixed with organophosphorus-type pesticides or other chemicals that are susceptible to alkaline decomposition. Wrong doses of potassium bicarbonate can injure the plant due to the alkaline properties.

## MAJOR PESTS AND DISEASES IN BAROSSA VINEYARDS (CONT.)

### Copper ammonium acetate (Group Y)

Liquicop copper fungicide has been extended for the control of powdery mildew on grapevines.

### Demethylation inhibitors (DMI)

The demethylation inhibitor (DMI) fungicides need to be used strategically. While they have some curativity they will be most effective if applied before infection is expected to occur. They belong to the Croplife Group C and have included the development of low levels of resistance to this group of chemistry.

### Morpholines

E.g. Prosper belongs to the Group E fungicides. A restriction to the number of uses applies.

### Strobilurins

These chemicals need to be applied before powdery mildew spores are dispersed, because these treatments have limited post-infection effect. They belong to Group K.

### Phenoxy Quinolines

E.g. Legend Fungicide, is a **Group M Fungicide**, which interferes with spore germination and infection process formation. It is said to have a unique surface mobile vapour activity - outstanding protectant disease control on fruit and foliage and that the activity is not affected by temperature thus it may be safely applied in high temperatures without causing

crop damage; furthermore the efficacy against mildew is not affected by cool temperatures.

### Resistance Management

Chemicals like sulphur and copper have multisite activities. This means they kill fungi in many ways. Single-site activity fungicides are highly effective but fungi can develop resistance. This means they find ways of substituting the chemical pathways that should kill them with some modified molecules, and subsequently live. To still have a good effect with fungicides, those prone to resistance buildup should be sprayed in alternation with fungicides of a different mode of action.

Alternating fungicide spray groups must be well thought through, taking into consideration the mode of action (preventative or curative), the alternation of Croplife Australia fungicide groups, the resistance status of the fungus, compatibility of substances with other products (caution with mixing some DMI's and copper), their national or international withholding periods and the safety of plants and animals, including beneficials.

Below is the Croplife Australia Powdery mildew fungicide Resistance Management Guideline: [www.croplifeaustralia.org.au/default.asp?V\\_DOC\\_ID=1953](http://www.croplifeaustralia.org.au/default.asp?V_DOC_ID=1953).

Fungicide activity group(s)	Resistance Management Strategy
<b>Group C (DMI)</b>	1. DO NOT apply more than two consecutive sprays of a Group C fungicide. DO NOT apply more than three Group C sprays per season. DO NOT use Group C fungicides curatively.
<b>Group E (morpholine)</b>	2. DO NOT apply more than two consecutive sprays of a Group E fungicide. DO NOT apply more than three Group E sprays per season.
<b>Group K (strobilurin)</b>	3. DO NOT apply more than three sprays per season of Group K fungicides. If 2 or 3 consecutive applications of Group K 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 K fungicide is used again, either in the current or following season. DO NOT use Group K fungicides curatively.
<b>Group M (phenoxy quinoline)</b>	4. DO NOT apply more than two consecutive sprays of a <b>Group M</b> fungicide. DO NOT apply more than three <b>Group M</b> sprays per season.

## DOWNY MILDEW (PLASMOPARA VITICOLA)

### Brief summary of symptoms

**Leaf DM** - primary infection: Small yellow "oilspots" (Fig. 1) on upper side of leaves (may be as infrequent as one per 50 m of vine row). They will extend to 5cm diameter and may cover the leaf surface. After a warm and humid night, sporulation (secondary infection) becomes visible in the form of white downy growth on the underside of the spots (Fig. 2).

Figure 1. – primary infection



Photo Credit. Peter Magarey

Figure 2. – secondary infection



Photo Credit. Peter Magarey

The spots later dry out in the centre and become brown with an outer ring of yellow active fungi. Infection of the oldest leaves will be tapestry-like brown and confined to smaller veins. Severely infected vines can become defoliated. Note: DM primary infection may look like spray damage from herbicides or damage from sucking insects.

These leaf symptoms however will not develop white downy mildew on the underside of the leaf

**Shoot DM:** Oily brown patches may occur on green stems, tendrils and petioles which become dry and fall off.

**Bunch DM:** At and near flowering and up to pea size berries are very susceptible. After warm wet nights white downy sporulating masses will show on diseased bunches. Later, bunch stalks may turn brown and have an oily appearance and can desiccate. Larger than pea size berries are resistant but when previously infected they harden, turn purple, then brown, shrivel and fall.

### Where to look

- In areas which are low lying or where vines are sheltered or shaded

### Economic impact

- Severe leaf infection can lead to premature leaf fall reducing yields and fitness of the vine, which may lead to over-exposure of bunches and may reduce the winter hardiness of buds.
- Total crop loss had been experienced if severe infection has not been controlled at flowering.
- Untreated DM is a source of infection for other vineyards.

### Disease cycle

The fungus can survive for several years as resistant spore-bearing oospores in old infected leaf material in the soil.

**Primary infection:** When the weather conditions are warm and cloudy or when temperature remains **10°C or more and there is at least 10 mm of precipitation over a 24-hour period** with rainsplash for the last 4 hours, spores are splashed from soil to the foliage. If the spores remain wet for long enough, infection takes

## MAJOR PESTS AND DISEASES IN BAROSSA VINEYARDS (CONT.)

hold. Depending on the temperature following infection, oilspots will appear 5-15 days later.

**Secondary infections:** Spores are produced under the oilspots after warm (at least 13°C, optimum 20-25°C) and wet nights (2-3 hours at >98% RH) and at least 4 hours darkness. The second generation spores are carried by wind or rain to adjacent foliage where they germinate and cause a new generation of oilspots. This can happen extremely rapidly, 50 oilspots can produce 100,000 new oilspots within 50 m radius of the canopy.

- (1) **Nicholas, P. Magarey, P. and Wachtel, M.** Diseases and Pests. Winetitles, 1994.
- (2) **Magarey, P. MacGregor, A.M., Wachtel, M. F and Kelly, M.C.** The Australian and New Zealand Field guide for diseases, pests and disorders of grapes. Winetitles, 1999.

### Monitoring for Downy Mildew

**Modelling:** Disease models are based on the 10:10:24 rule (1), but also consider detailed aspects of rainfall, air temperature, relative humidity and leaf wetness. Data measured at central weather stations can be used to indicate whether conditions have been favourable for primary and secondary infection by DM.

*Note: The alerts from a regional weather station may not be totally representative for your site and your potential "hotspots"*

**Monitoring:** Downy mildew develops in very specific moisture and temperature conditions. With careful monitoring of these conditions and frequent field assessments, the disease can be kept in check if the following points are considered:

- Sample when weather conditions indicate potential for a new generation of oilspots.
- Inspect 200 vines, initially examining leaves and later also bunches

- Check outer leaves plus the inside of the canopy where less light penetrates.
- Use a hand lens to check suspect patches on leaves (resting spores will not be visible).
- Orientate leaves at an angle to the sun to make DM easier to identify on the surface of leaves
- Mark infection sites to allow later assessments of disease spread and the effectiveness of control treatments.
- Monitor every 1-2 weeks once disease conditions occur.

A simple 'desk-top' test for downy mildew can be conducted to verify monitoring results: Seal suspect leaves and bunches in a lightly moistened plastic bag (not wet, 3-5 drops of water per cm<sup>2</sup> of bag surface is enough). Incubate overnight in the dark at 20-25°C. If primary infection is present, fresh white down on the undersides of leaf oilspots will be obvious the next morning. Berries greater than 5 mm will not produce spores, but the downy spore structures will be visible on any infected bunch and berry stems.

*Note: Occasionally other oilspot like symptoms can be found on vines and are sometimes referred to as sunspots. They are caused by permanent sun damage. Other similar symptoms may result from spray drift from herbicides such as paraquat. All these cases can be eliminated through the incubation method.*

### Managing Downy Mildew

#### Preventive management practices

Producing open canopies to increase light and air circulation and penetration of sprays with shoot thinning, bunch thinning, trellising, leaf removal and vigour reducing cover crops.

#### Organic and biodynamic options

The only organically acceptable fungicides registered for downy mildew control are protectant in action. No eradicant fungicides are currently available to organic producers.

International research efforts are seeking alternatives to copper as an agricultural input. For downy mildew control, the alternatives being investigated include plant extracts, biological control with other micro-organisms, and substances that trigger the vines' natural immune system. To date, none of these alternative approaches have provided economically effective control.

#### **Biological control**

Organisms with known activity against DM but no commercial registration are *Fusarium* spp, *Bacillus* spp *Pseudomonas* spp. and *Trichoderma* spp.

#### **Chemical management practices**

**Conservative:** Ensure vines have a protective cover of allowable fungicide before each rainfall and/or overhead irrigation event that is likely to create suitable conditions for infection. To achieve this, use weather forecast services.

**Higher risk:** Waiting for confirmation of a primary infection period, then ensure that a thorough cover spray of allowable eradicant fungicide is applied before each subsequent rainfall and/or overhead irrigation event that is likely to create suitable conditions for infection. Accurate confirmation of a primary infection requires the use of a disease prediction service based on vineyard weather data.

This strategy will not prevent development of oilspots from the first primary infection. It is intended to prevent spores from these oilspots creating further infections, in the event that secondary infection conditions occur.

*Note: For this higher risk approach to succeed, spray equipment and access to the vineyard must be available when needed.*

**Very high risk:** Waiting until symptoms of downy mildew are evident in the vineyard. Not recommended, and may increase resistance buildup.

### **Chemicals for Downy Mildew**

**Chlorothalonil, metiram and zineb are Group Y** protectant fungicides that should be present on the leaves before spores land on their surfaces.

Copper products (Group Y) are protectants thus must be present as a layer of fine crystals on the leaves. Prolonged wetting of copper treated foliage may increase the likelihood of copper injury to the plant. There are increasing concerns about the environmental effects of copper (may kill soil bacteria). At present, the Australian organic standards allow a maximum of 8 kg/ha of copper to be applied annually.

**Benalaxyl or oxadixyl are Group D** eradicant fungicides and have been known to be faced with fungal resistance and thus are sold in mixtures with mancozeb or propineb, respectively. Strict resistance management strategies (see below) are to be adhered to.

**Dimethomorph** based **Group X** fungicides are curative and can be applied up to 5 days after infection.

**Strobilurins** are Group K fungicides are best used early in the life cycle of the disease

It is important to adhere to the Croplife Australia resistance management strategy recommendations.

[www.croplifeaustralia.org.au/default.asp?V\\_DOC\\_ID=1953](http://www.croplifeaustralia.org.au/default.asp?V_DOC_ID=1953).

## MAJOR PESTS AND DISEASES IN BAROSSA VINEYARDS (CONT.)

Fungicide activity group(s)	Resistance Management Strategy
<b>Group D</b> (phenylamide)	1. Start disease control sprays when the vine shoots are approximately 20 cm long and continue spraying at intervals of 7–21 days using a protectant or non-phenylamide fungicide.
<b>Group K</b> (strobilurin)	2. When conditions favour disease development, apply two consecutive sprays of a <b>Group D</b> product. DO NOT apply more than two consecutive sprays of a <b>Group D</b> fungicide. DO NOT apply more than four sprays of a <b>Group D</b> product per season.
<b>Group X</b> (dimethomorph)	3. DO NOT apply more than three sprays per season of <b>Group K</b> fungicides. If two or three consecutive applications of <b>Group K</b> 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 <b>Group K</b> fungicide is used again, either in the current or following season.
	4. DO NOT apply more than three consecutive sprays of a <b>Group X</b> fungicide, and no more than a total of six sprays per season.

## BOTRYTIS (BOTRYTIS CINEREA)

### Brief summary of symptoms

**Leaf Botrytis:** Areas of yellow or dead brown tissue between veins may show white spores.

**Stem Botrytis (shoot blight):** Rotting brown wilting stems usually girdled at point of infection.

**Flower Botrytis:** Rotting inflorescences or dead flower parts turn brown.

**Latent Botrytis:** Invisible infection of inner parts of flowers, this infection will lay dormant (latent) and will only break out after veraison.

**Fruit-stalk Botrytis** often goes unnoticed and may in mid-summer lead to slip-skin Botrytis

**Slip-skin Botrytis** occurs where the fungal mass under the skin allows the skin to slide freely over the pulp when touched.

**Botrytis bunch rot (grey mould)** can be recognised by berry discolouration, collapse and the presence of grey spore masses Fig.1.

Figure 1.



Photo Credit. Peter Magarey

**Botrytis noble rot** is also *Botrytis cinerea* but only develops into noble rot under conditions of cold nights and hot days leading to restricted fungal growth which concentrates flavours and also adds some fungal aromas (relevant to some wine styles).

### Disease cycle

**Autumn/Winter:** Black resting bodies (Sclerotia) are formed under cold temperatures and nutrient stress in late autumn on leaves on the ground, stems, bunch stalks and remnants of berries if still in the vineyard or in adjacent vegetation. Sclerotia are frost resistant and live for many years.

**Spring:** With warm wet conditions the resting bodies produce spores which are transported in the air. When landing on moist plant parts they germinate, penetrate the cell walls, preferably where there is dead, damaged or soft tissue.

*Note: Flowers can be infected invisibly and harbour latent Botrytis.*

**Summer:** The fungal body can grow inside various plant parts and – with sufficient nutrition and moisture – will produce millions of spores which may infect other plant parts. The fungal spores start growing mycelia on the tissue surface which introduces the oxidative enzyme laccase into the plant cells.

Laccase targets defence related phenolics and facilitates the destruction of the plant tissues. All phenolics in berries including the red colour compounds can be oxidised to brown coloured compounds. However Botrytis very often enters plant tissues in spots of wounding, thin tissue, berry split or insect damage and thrives on dead cells.

Infected bunches will spread rot if conditions are warm (ideal is 15-20°C) and wet (15-20 h above 96% RH). Bunch rot creates entry points for other fungal infections that may cause bad aromas or health concerns (1, 2).

*Note: On dry material spores cannot germinate and on healthy tissue they face competing fungi, bacteria and plant internal resistance compounds.*

## MAJOR PESTS AND DISEASES IN BAROSSA VINEYARDS (CONT.)

### Economic impact

- Yield and/or quality loss
- Secondary fungal or bacterial infections
- Loss of colour and shelf life of wine
- Undesirable flavours and aromas in wine

**Nicholas, P. Magarey, P. and Wachtel, M.** Diseases and Pests. Winetitles, 1994.

- (2) **Magarey, P. MacGregor, A.M., Wachtel, M. F and Kelly, M.C.** The Australian and New Zealand Field guide for diseases, pests and disorders of grapes. Winetitles, 1999.

### Sources of infection

- Botrytis is not specific to grapevines
- Most of Botrytis inoculum comes from within the vineyard itself.
- Botrytis mycelia can also over-winter in the cane tissue and in dormant buds.
- Important sources of over-wintering Botrytis are fruits stalks or mummies left in the vineyards after machine harvesting.
- Botrytis spores have been shown to be spread by Light brown apple moth larvae

### Conditions that promote Botrytis

Botrytis is an excellent example for the complex interaction between

- Site and environmental factors
- Plant and microclimatic factors
- Pathogen factors

Identifying the key factors associated with disease outbreaks can be difficult because of this triangular relationship. Also the intensity of each factor may be different in each season.

#### Site, regional climate

Record or obtain data on:

- history of bad weather events (wet/humid around flowering and prior to harvest)
- Low-lying or sheltered blocks or sections of blocks and their Botrytis history

- Sections of vineyard with limited airflow and water drainage
- Unfavourable row orientation against prevailing airflow
- history and current damage from birds, LBAM etc
- Presence of other plants harbouring Botrytis within and around the vineyard.

#### Soil and canopy microclimate

Management practices where leaf, flower and berry wetness may be prolonged are unfavourable.

Check:

- Canopy size and configuration
- Areas of bunch zone congestion
- Crowding of shoots around trellis posts
- High soil moisture throughout the season
- Longer periods of bunch wetness in low lying un-aerated locations
- Botrytis on exposed versus shaded fruit.

#### Varietal susceptibility

While all varieties are susceptible, those that are particularly prone to Botrytis infection and damage tend to have thin-skinned berries and large, tight bunches.

Susceptible varieties include Chardonnay, Sauvignon Blanc, Pinot Noir, Semillon, Riesling and Traminer.

#### Susceptible tissues before flowering:

Botrytis can infect young shoots and leaves when damaged through wind, hail, rubbing of bunches against wires, sunburn, mechanical damage e.g. leaf blowing, shoot trimming and chemical damage.

#### Susceptible tissues at flowering:

Botrytis infection can occur when spores are present, humidity is high and spores land on the abscission wounds at the base of flowers during cap-fall. Botrytis can enter and become established as a small point of infection in developing berries but this infection does

not spread due to plant internal resistance processes (latent infection). Latent infections usually are dormant until post veraison but may come alive through damage to the berry surface (in particular at the point of pedicel attachment). Botrytis may also infect dead flowers and debris in the inflorescence and lead to the rot of the complete inflorescence in bad weather conditions.

#### **Susceptible tissues post veraison:**

At this stage berries are susceptible for Botrytis rot from inside (latent infection) or outside (caused by spores or mycelial spread). The degree of Botrytis damage will be governed by the environment, plant susceptibility, and the amount and aggressiveness of the pathogen.

#### **Pathogen factors**

Botrytis quantity and aggressiveness will be high under the following conditions:

- high amount of inoculum due to over wintering sources
- high amount of latent infection
- fungicide resistant populations of Botrytis.

### **Monitoring for Botrytis**

#### **Disease models**

Making decisions about the need for fungicide application over the flowering period should be influenced by the incidence of weather conditions (or other sources of wetness and humidity such as overhead irrigation) conducive for infection by Botrytis. A number of climate-based disease models have been developed for Botrytis bunch rot but none are currently validated for Australian conditions.

#### **Pre Flowering and flowering damage assessment**

- Monitor as many shoots as possible for onset of damage.

#### **Post veraison damage assessment**

- Assess at least 30 vines in the most susceptible varieties/spots and record Botrytis frequency

(how many bunches out of 100 have any infection) and severity (what percentage of bunches are rotten).

- Use a scheme to reliably assess percentage of rot on bunches.

#### **Botrytis inoculum levels**

- If Botrytis is suspected but not visible samples may be collected into zip-lock plastic bags (do not cross contaminate samples) and incubated with a wet filter paper in the bag at 20°C for 3-10 days. Each bunch can then be assessed for the presence of Botrytis. However, access to a dissecting microscope is required as Botrytis may be difficult to distinguish from other fungi that are likely to develop on incubated bunches.

*Note: This may yield Botrytis that possibly would not have caused a big outbreak*

- To assess latent Botrytis, the bags with green bunches must be put in a freezer overnight to break down plant internal defence.

*Note: You will not get a valid monitoring result if the sample has been sprayed with a botryticide.*

#### **Botrytis resistance testing**

Fungicide resistance has been an issue for a number of groups of chemicals used against Botrytis. If a problem in controlling Botrytis has occurred where fungicide resistance could be a possible issue or where previous fungicide use patterns have increased the risk of resistance development it may be worth having tests performed by a diagnostic laboratory.

### **Managing Botrytis**

#### **Cultural management options - site modification and matching varieties to sites**

- If replanting is an option, focus on less susceptible varieties with loose bunches and thick skins, however they may be later-maturing and increase risk of unfavourable conditions pre-harvest.

## MAJOR PESTS AND DISEASES IN BAROSSA VINEYARDS (CONT.)

- Select appropriate rootstocks to avoid excessive vegetative growth and dense canopies.

### Vineyard management practices

Options should be worked out each season according to the risk factors, weather and other pests and diseases, considering:

- **Generating more uniform vines** and crops by differentially managing the blocks for input
- **Managing vine vegetative growth** including reducing soil water and N input or possibly using cover-crops to compete with vines for water and nutrients
- **Producing open canopies** to increase air circulation for improved moisture evaporation and penetration of sprays with e.g. shoot thinning, bunch thinning, trellising, leaf removal in the bunch zone
- **Producing loose, well dispersed bunches** using vine management techniques e.g. appropriate pruning and thinning practices, irrigation strategies
- **Avoiding mechanical tissue and berry damage** from management practices
- **Minimising berry scarring from** powdery mildew and pests (e.g. LBAM or birds)
- **Avoiding berry sunburn** with canopy management options
- **Fostering firm skins** (Calcium sprays after set may toughen skins)
- **Avoiding drought stress** to prevent berry shrivel, and avoid berry splitting by watering before heavy rainfall
- **Avoiding overcropping** as delayed ripening may expose grapes to wet weather
- **Removing bunch remnants** (and perhaps trash on the vineyard floor) when pruning if infection was present in the previous season

*Note: Assessing the potential impact of cultural methods can be difficult due to the various other factors that contribute to berry infection and disease development each season.*

### Biological management options

**Mulching:** Organic mulches maybe used to enhance biological degradation of vine debris to reduce levels of *B. cinerea* primary inoculum the following season. Mulch types such as anaerobically and aerobically fermented grape marc, inter-row grass clippings and shredded office paper, may reduce sporulation.

**Oils:** Plant-based oils may be effective in managing *B. cinerea*, but high concentrations can be toxic to the plant, and applications may not be appropriate after veraison when they could significantly alter the flavour of the wine.

**Teas:** An extract of *Equisetum arvensis* applied as a spray during susceptible times may create a barrier of Silica to prevent penetration of the spores into the vine tissue.

**Trichoderma sprays:** *Trichoderma harzianum* is a commercially available fungal organism that can colonise plant parts and prevent *Botrytis* from taking hold. The spore solution must be viable (check storage prehistory), sprayed preventively in sufficiently concentrated solution, and may need to be re-applied if hot weather has decreased *Trichoderma* populations, or if wet weather is predicted.

**Plant defence stimulants:** Plant growth regulators such as salicylic acid,  $\beta$ -aminobutyric acid and jasmonic acid may induce a direct physiological vine defence response to disease, whereas chemical components of the extracts from composts, seaweed, fish and micro-organisms, either induce a direct response through elicitor-active chemicals or through simulation of microbial attack. There are limitations to the use of these compounds as all plant defence stimulants change vine physiology, an affect which can have negative effects on vine development.

## Chemical management options

### Timing of chemical management

**Flowering:** Fungicides applied at early flowering (i.e. 10% capfall) are aimed at protecting the flower structures from infection as the cap falls to protect the abscission wounds, which are ideal infection sites. If a protectant is applied, newly generated wounds will not be protected. Spraying at late flowering (i.e. 80% capfall) must be performed with a curative fungicide to control latent infections that may have occurred during the flowering period. They will also protect flowers from new infections.

Periods of high humidity or rainfall are required to initiate spore release and infection. Therefore assessing the need to spray should be based on the weather conditions over the duration of flowering.

*Note: Utilising fungicides with dual activity against other diseases may reduce the build-up of Botrytis within vineyard (e.g. Captan or chlorothalonil) but are not effective enough to be solely relied upon for good Botrytis control.*

**Pre bunch-closure:** The recommendation to spray at this stage is often based on the limited potential to achieve adequate coverage once bunches have closed up, and also that many fungicides cannot be applied after bunch closure due to MRL requirements overseas. These sprays may reduce the build-up of Botrytis on “trash” (e.g. stuck caps, aborted berries, leaf material) inside the bunch and – if a curative chemical is used - may still reduce some of the latent infection that occurred at flowering. While berries are basically resistant to Botrytis infection at this stage, any damage to the berry surface during this time can enable Botrytis to infect. It is therefore important to ensure that potential causes of damage are minimised. Fruit stalks (pedicels) are often a source for later formation of “slip skin” Botrytis. Good spray cover inside bunches is required to prevent this infection.

*Note: Botrytis control during ripening is limited by the ability to achieve adequate spray coverage within a developing bunch. In vine trellising systems where there is a defined bunch zone it may be advisable to target a higher proportion of the spray volume at this zone.*

**Pre-harvest:** Spray strategies must take into account the changing weather, changing ripening of berries, changing disease spread and quality specification and destination of the fruit. If Botrytis incidence is low and severity is high, pickers can be instructed to drop severely infected bunches in the case of handpicking. For machine picking consider avoiding picking the worst affected areas. If Botrytis incidence is high and severity is low (eg very little Botrytis is developing in many bunches), it is advisable to discuss options with the grape purchaser, such as the application of curative fungicides or those that may reduce the spore viability thus the rate of spread to other berries and bunches.

*Note: The application of late sprays requires water as a carrier and this introduces additional moisture to the canopy.*

### Chemicals for Botrytis management

A current list of chemicals is available on the AWRI website and an updated booklet “Agrochemicals registered for use in Australian Viticulture”, is printed each year by the Australian Wine Research Institute (see [www.AWRI.com.au/industry\\_support/viticulture/agrochemicals/agrochemical\\_booklet/](http://www.AWRI.com.au/industry_support/viticulture/agrochemicals/agrochemical_booklet/)). Note: Growers should always contact their grape purchaser/s (or potential purchaser/s) before applying any agrochemicals in their vineyard as their recommendations may vary to those given by the AWRI each year.

**Preventive surface active botryticides** like eg. chlorothalonil (**Group Y**) rests on the plant surfaces and kills Botrytis spores. They must be applied with good spray coverage before the time of infection is expected. Hydrogen peroxide and peroxyacetic acid, and PMBS (not

## MAJOR PESTS AND DISEASES IN BAROSSA VINEYARDS (CONT.)

a registered botryticide), are only effective for a few days to dry up spores, but do not kill the mycelium.

**Translaminar fungicides** are best used in a preventative program.

Fenhexamid eg Teldor (**Group J**) is also best used preventatively. It is absorbed to 75% into the waxy layer of the cuticle, with the remainder moving through into the plant tissue.

Boscalid, e.g. Filan (**Group G**) also exhibits foliar absorption, and translocates into the plant tissues where it inhibits spore germination and germ tube elongation.

Azoxystrobin e.g. Amistar (**Group K**) has a preventative effect on Botrytis, but other group K fungicides are less suited for Botrytis control. *Note: Fungicides with Botrytis side effects may not be effective enough to prevent a disease in wet conditions.*

Fludioxonil (**Group L**) is part of the product Switch and is surface active. It is combined with cyprodinil (**Group I**) which can penetrate deeply into plant tissue. Although it is a combination product it should not be applied at flowering and pre bunch closure as this will represent two consecutive sprays (see below).

**Curative fungicides** can kill mycelium, latent Botrytis and spores (when germinated). Pyrimethanil (e.g. Scala) and Cyprodinil are curative.

For Botrytis control it is particularly important to avoid resistance build-up by alternating botryticides with different modes of action (Croplife Australia recommendations below). [www.AWRI.com.au/industry\\_support/viticulture/agrochemicals/agrochemical\\_booklet/](http://www.AWRI.com.au/industry_support/viticulture/agrochemicals/agrochemical_booklet/)

Fungicide activity group(s)	Resistance Management Strategy
<b>Group A</b> (benzimidazole)	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 <b>Group A, Group B, Group I</b> (including combinations with <b>Group L, Group J</b> or <b>Group G</b> fungicides.
<b>Group B</b> (dicarboximide)	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 <b>Group A, Group B, Group I</b> (including combinations with <b>Group L, Group J</b> or <b>Group G</b> fungicides.
<b>Group I</b> (anilinopyrimidine), and combinations of <b>Group I and Group L</b> (phenylpyrroles)	3. DO NOT apply more than two consecutive sprays from the same fungicide group, for any <b>Group A, Group B, Group I</b> (including combinations with <b>Group L</b> ) or <b>Group J</b> fungicides, including from the end of one season to the start of the following season.
<b>Group J</b> (hydroxyanilide)	4. DO NOT apply two consecutive sprays of <b>Group G</b> fungicides, including from the end of one season to the start of the following season.
<b>Group G</b> (anilide)	5. Late season fungicide treatments should be applied before botrytis infection reaches unacceptably high levels in the vineyard.

## LIGHTBROWN APPLE MOTH (EPIPHYAS POSTVITTANA)

### Symptoms and appearance

Scale-like and pale blue-green egg masses of Light brown apple moth (LBAM) can be found on the upper surface of leaves (1). Black egg masses indicate parasitism by *Trichogramma* sp. wasps, and are found mainly late in the growing season. First instar larvae are approximately 1.6 mm long, and final instar larvae range from 10-18 mm and are medium green with a darker green central stripe. Young larvae are most easily found in shoot tips, but also in the overlap between older leaves. Older larvae form feeding shelters by rolling and webbing leaves and bunches with silk. Feeding damage and webbing can also be seen on flower stems and bunch stalks, which can result in shrivelled berries. Flying adults are active at dusk and dawn when conditions are calm, but are easily superficially confused with other moths, unless trapped in species-specific pheromone traps

Note: Adult vine moths are easily distinguished from LBAM by its large size as distinctive black and cream wing colouring. Vine moth larvae are far larger, and have black and white stripes and red spotting.

### Male and Female LBAM adult moths



Photo Credit Greg Baker

### Economic impact

- Occasional damage to vines around budburst from over-wintering LBAM

- Webbing in flowers or rolling of leaves hinder spray penetration
- Yield loss to up to 10% in susceptible varieties
- Rejection of grapes due to infection of wounded berries with *Botrytis* or *Aspergillus*

### Life cycle

**Spring:** Moths emerge from pupae, and after mating, females lay eggs in masses of 20-50 on the upper surfaces of leaves. First instar caterpillars hatch after 1-3 weeks (depending on temperature), crawl to the top of the shoot and go through 5 or 6 growth stages (instars). Most first instar caterpillars however never survive to 5-6th instar stage; the greatest LBAM mortality occurs at the 1-2 instar stage.

**Summer:** There are usually 2 generations of LBAM during the summer. It is important to observe when the first flight occurs in spring to track the progression of future generations throughout the growing season by sampling larvae in the canopy.

**Autumn:** Eggs are often laid in remaining bunches, vine understorey and in neighbouring broad leaf vegetation like cape weed and dock, clover or medic if predatory insects are not present to control these in the mid-row. In alternately mowed vine rows, designed to provide habitat for beneficial insects, numbers of beneficial brown lacewings, damsel bug, earwigs and other predators are often very high, and very few LBAM larvae can survive there.

**Winter:** LBAM over-winters as pupae (tough brown resting structure).

### Monitoring

- Examine vine shoots weekly for 2-5 instar caterpillars (and for egg-masses) from leaf expansion onwards inspecting 50 leaves per panel (3-4 vines) on 20 panels
- Examine shoot from tip to bottom at top sides of leaves. Use a hand counter for leaf number

## MAJOR PESTS AND DISEASES IN BAROSSA VINEYARDS (CONT.)

and a sheet for pest records. Check also for beneficials. A summary of a LBAM monitoring method used in commercial IPM consulting may be found in (1).

*Note: Scout for larvae mainly because egg-mass counts generally do not correspond to numbers of older caterpillars which do the damage.*

→ Traps or pheromone lures should be used to indicate flight times and thus key times to especially monitor canopy for larvae. Broadcasts of ‘regional LBAM alerts’ may also be used but these have little relevance to individual vineyard LBAM larval numbers.

*Note: Alerts disregard the large variations in LBAM from vineyard to vineyard, and deciding when to spray based on male counts results in unnecessary insecticide use, as male trap counts can be very high early in the season whilst larval infestations of vine canopies remain negligible. Such sprays can damage beneficials present in high numbers at this time.*

### Management of LBAM

#### Biological control

**Parasitoids** lay their eggs into LBAM larvae or eggs. A commonly found parasitoid is *Dolichogenidea tasmanica*, but many different larval parasitoid wasp species make up the beneficial complex of LBAM, including larval and egg parasitoids like native *Trichogramma* sp (2).

#### Biological control available for release

***Trichogramma carverae*:** Release this LBAM egg-parasitoid only if naturally present bio-control is enhanced by a nectar resource. *T. carverae* alone is usually not able to achieve LBAM control.

Note: Spray program for other pests and diseases must exclude sprays toxic to these parasitoids (for further information see 3, 4).

#### Vineyard management practices

**Avoiding alternative hosts:** Surrounding vegetation should consist of non-host plants which also support

natural predators and parasites.

**Alternate row mowing** of grass swards allowing grass to flower, provides pollen food source and shelter from heat and low humidity for beneficials.

**Flowering buckwheat strips** 1 in every 10 rows - provide high quality nectar for parasitoids and for predators whose adult life stages feed on nectar and pollen (5).

#### IPM compatible chemical management

Lists of chemicals are available in the booklet “Agrochemicals registered for use in Australian Viticulture”, published each year by the Australian Wine Research Institute (see [www.AWRI.com.au](http://www.AWRI.com.au)).

Mimic® (Tebufenozide) is an insect growth regulator which must be eaten by the caterpillars to work. *Bacillus thuringiensis* is a bacterial larvicide. Both should be used based on monitoring results (threshold is more than 8 caterpillars per 50 shoots or 4 caterpillars per 50 bunches). Spraying should occur before caterpillars reach 3-5 mm and build feeding shelters.

Indoxacarb (Avatar®), Spinosad (Success®) and Emamectin (Proclaim®) may be used within an IPM strategy, but each kills some of the beneficials active on LBAM or other vineyard pests. Decision on choice and timing should be based on monitoring beneficial species.

*Note: The use of Lorsban® (Chlorpyrifos) or other registered pyrethroids, carbamates or organophosphates will disrupt beneficial populations.*

**Pheromone ties:** Disrupting the mating of moths provides an alternative to applying chemical sprays.

*Note: The expense is only warranted in vineyards with a history of high LBAM populations. Pheromone ties are not sufficiently effective in treating smaller areas or high LBAM infestations and they also need to be used from the start of the season.*

(1) **Nicholas, P. Magarey, P. and Wachtel, M.** Diseases and Pests. Winetitles, 1994.

- (2) **Bernard, M., Carter V., Semeraro L. and Wratten S. D.** Beneficial insects in vineyards: Parasitoids of LBAM and grapevine moth in South-East Australia. *The Australian and New Zealand Grapegrower and Winemaker*, 513 (October) pp 19-26, 2006.
- (3) **Bernard, M., Horne, P. A., Papacek, D., Altmann, J., Jacometti, M. A., Wratten, S. D., Evans, K., Weppler, R., Herbert, K. S., Powell, K. S., Rakimov, A. and Kourmouszis, T.** Guidelines for Environmentally Sustainable Wine Grape Production in Australia: IPM adoption self-assessment guide for growers. *The Australian and New Zealand Grapegrower and Winemaker*, pp 24-35, March 2007.
- (4) **Bernard, M., et al.**, Beneficial insects in vineyards: Parasitoids of LBAM and grapevine moth in South-East Australia, *Australian and New Zealand Grapegrower and Winemaker*, 511 (October), pp 19-26, 2006.
- (5) **Bernard, M. and Wratten, S. D.** Enhancing beneficial insects and mites in vineyards: providing nectar, pollen, and shelter in vine rows. *The Australian and New Zealand Grapegrower and Winemaker*, 519 (April), pp 33-34, 2007.

# MAJOR PESTS AND DISEASES IN BAROSSA VINEYARDS (CONT.)

## GRAPE BUD MITE (COLOMERUS VITIS)

### Symptoms and appearance

Typical early season symptoms of bud mite damage can include dead buds and shoot tips, zigzagged shoot growth on an angle from one node to the next, shortened and compressed lower shoot internodes, and increased development of lateral shoots, that may result in a ‘witches broom’-like effect.

*Note: Bud mite infestations are usually only patchy; high bud mite numbers and more uniform distribution of damage symptoms indicate a history of a long-term disruption of biological control agents of bud mite*

*Note: Bud mite can also cause ‘winter bud necrosis’ and bud failure, which may be mistakenly attributed to restricted spring growth syndrome (RSG) (2).*

Bud mite are tubular worm-like microscopic organisms (approx. 0.2 mm long), and so can only be adequately seen with a dissecting microscope at 25-40 x magnification. They have two pairs of tiny legs at the head region, barely visible at 40 x mag.

### Economic impact

- Loss of vigour and poor shoot development in the next year
- Yield loss with high infestations

### Life cycle

**Spring:** Bud mites move from over-wintering buds directly into the protective shelter of newly forming buds within a month of budburst. As the shoot grows, they are ‘carried upward’ by the growing shoot, living under the scales at the base of each leaf stem.

*Note: Bud mites spend almost their entire life-cycle inside vine buds. They do not migrate along canes or move out to feed on the leaves like the rust mites. Bud mite cluster together, along with eggs and cast-off skins inside buds where they feed through the growing season.*

**Summer:** Depending on temperatures, eggs can hatch in 5-25 days.

**Winter:** Adult mites over-winter inside dormant buds, in greatest numbers in 0-4 node buds closest to bases of shoots, but they can also be found in buds further up the shoot. They often live inside the primary bud, and if this bud is destroyed by bud mite, typically secondary buds develop. Many secondary buds can be a sign of bud mite infestation.

*Note: Bud mites have a relatively restricted movement but can spread to a vineyard via poorly sanitised vine cuttings.*

### Where to look

Where mites have been a problem in previous seasons, and/or in blocks where chemical controls have been applied which may negatively impacted predatory mite populations.

### Monitoring

- Locate clusters of damage symptoms in the vineyard and tag.
- Collect healthy-looking un-burst buds from these vines early October (normal-looking buds as if in bud-swell). Dissect and examine for bud mite. Seek expert identification of bud mite. DPI NSW, Yanco, or DPI Vic Knoxfield can carry out specialist identification

*Note: Do not collect damaged buds with white-bleached exposed hairs. These are long-dead, rotten inside, and past the point when the cause can be diagnosed.*

## Management of Bud Mite

### Biological control

Predatory mites provide long-term preventative control of rust and bud mite and other pest mites. Key species in Australian vineyards are *Typhlodromus dossei*, *T. dorenae*, *Euseius victoriensis*, and *Galendromus occidentalis*. Numbers of naturally present predatory mites may be estimated by checking at least 4 x 25 randomly collected leaves, prior to carrying out any predatory mite releases. Leaves are examined under a microscope at 6-10 x magnification, and predatory mites are counted. Seek instruction in how to recognise predatory mites.

Some other control agents are predatory thrips e.g. *Haplothrips victoriensis* feeding on rust mite and two spotted mite (3).

*Note: Spray program must exclude sprays toxic to predators (e.g. lime sulphur, chlorpyrifos, dithiocarbamates, benzimidazoles and synthetic miticides) to achieve lasting biological control of bud mite and rust mite (4).*

#### Biological control available for release

*Euseius victoriensis* and *Galendromus occidentalis* are commercially available from Biological Services and Fruit Doctors, Loxton, SA. Note: Only release where predatory mite numbers at flowering are very low/absent or release without assessment where repeated broad-spectrum pesticide use occurred in previous years.

#### Vineyard management practices

Alternate row mowing will provide grass pollen as a supplementary food source for predatory mites.

#### Sanitation

Do not allow contaminated equipment, vines, grapes, or winery waste near uninfected vineyards. Use certified planting material, or sanitise dormant cuttings with hot water treatment.

#### IPM compatible chemical management

Diagnose bud mite presence before spraying (the spray against bud mite is not a routine annual spray). Use wettable sulphur (no oil) immediately after node-1 bud-burst (i.e. at node-2 rosette), 1-2 weeks after node-2 bud-burst with high spray volume to run-off. This spray is timed precisely to the very brief time when bud mite is exposed on newly developing shoots and before it moves inside newly developing bud primordia. This spray timing is essential in order to achieve bud mite control. (Spray volume of approx. 0.5 L per vine was

Recommended for extremely highly infested vineyards in South Africa, but carefully achieved point of run-off should be sufficient).

Note: Mis-timed sprays or highly concentrated wettable sulphur provide no additional control benefit, and damage beneficial bud mite predators.

Reduced damage symptoms following spraying will not be evident until the following spring, because damage in the current spray season was already caused before sprays were applied.

*Note: ‘Woolly bud’ spray against rust mite does not work against bud mite. Lime sulphur has no effect on bud mite and is very toxic to all beneficial insects and mites.*

- (1) **Bernard M., Carew M., Hurst P., Horne P. and Hoffmann A.**, Grapevine bud mite, RSG, and blister mite: an emerging story, *The Australian and New Zealand Grapegrower and Winemaker* 464, pp 41-48, 2002.
- (2) **Bernard M. B., Horne, P. A. and Hoffmann, A. A.** Eriophyoid mite damage in *Vitis vinifera* (grapevine) in Australia: *Calepitrimerus vitis* and *Colomerus vitis* (Acarina: Eriophyidae) as the common cause of the widespread ‘Restricted Spring Growth’ syndrome. *Experimental and Applied Acarology* 35, pp 83-109, 2005.
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## MAJOR PESTS AND DISEASES IN BAROSSA VINEYARDS (CONT.)

### GRAPE RUST MITE (CALEPITRIMERUS VITIS)

#### Symptoms

**Spring damage:** Newly unfolding leaves display a crinkled appearance and with high rust mite infestations may also show yellow, necrotic spots. Newly unfolding shoots can be temporarily stunted and exhibit delayed growth, this applies particularly to varieties that are slow to grow away during cool spring conditions such as Cabernet Sauvignon, or Sauvignon Blanc.

Rust mite spring damage is most pronounced in early spring up to about 6-8 leaf stage, and in cold temperatures and vine varieties which require higher temperatures for early shoot extension. Vines recover even under high infestations, and leaf crinkling is not visible (other than as minor residual symptoms near the centre of mature leaves) as the season progresses.

*Note: The reason for temperature dependence is explained by the observation that large numbers of mites (up to 1,500-2,000 per spur in severe infestations) feed on a small leaf surface area of green tissue when cold temperatures in spring slow down shoot extension. The resulting damage is therefore greater than damage which may be caused to fast growing shoots where mites spread over a larger surface area. This may be one reason why spring rust mite damage was misdiagnosed as Restricted Spring Growth Syndrome (RSG) in Australia and parts of the USA in the past (but not in other parts of the world).*

**Summer/autumn damage:** The outer epidermal leaf layer shows masses of microscopic feeding scars when examined under a high magnification microscope. The accumulation of this damage eventually results in the typical summer leaf bronzing symptoms and may also lead to some leaf stomata collapse. The upper leaf surface turns yellow-brown in white vine varieties and red-brown in red varieties. With extremely high infestations (e.g. 3000 mites per leaf) the upper leaf surface can turn purple-black regardless of vine variety, berries and bunch stems can be scarred (but this

is usually not visible to the naked eye). Premature leaf fall may expose bunches to direct sunlight and a potential over-heating.

*Note: Summer damage occurs if infestations continue through the season, and is not simply a result of a sudden late infestation, as it is often assumed.*

#### Appearance

Grape rust mite (RM) is about 0.2 mm long, worm-like and very similar in appearance to grape bud mite except that rust mite is wider and diamond shaped at the head region when examined under a microscope, whereas bud mite is more tubular. Unlike bud mite, rust mite is found on vine leaves throughout the growing season.

*Note: To see both mites, at least a 25-40 x magnification and a bright light source are needed.*

The adult stages of rust mite and bud mite may be superficially distinguished from each other in this way but generally only by those trained to observe the differences:

**rust mite:** creamy-yellow to orange colour;

**bud mite:** stark white colour

**rust mite:** wider at the head than the tail;

**bud mite:** equally narrow at both ends.

*Note: To identify these mites to species level, slide mounting and staining procedures specific to this mite group must be used, and slide-mounted specimens identified under a compound microscope at 300-1000 x magnification, by a taxonomist.*

Grape rust mite consists of 2 morphologically distinct forms, the summer female (protogyne) and identical summer male, and the overwintering form, the winter female (deutogyne).

The winter female is the only form that overwinters, and that migrates to and from the canopy to winter shelters. Sprays are directed at this form during its spring migration from winter shelters before it lays eggs and gives rise to the first spring generation of protogynes and males.

### Economic impact

- To date there is no evidence that grape rust mite causes yield losses. However, when vine varieties such as Sauvignon Blanc or Cabaret Sauvignon (that require higher temperatures for shoot extension in early spring) have been heavily infested for several years, shoot quality may be reduced, making pruning difficult.
- Summer leaf bronzing damage may lead to closure or collapse of leaf stomata, due to cell damage in the leaf epidermis. This can affect the leaves' gas exchange and photosynthesis, thus could theoretically lead to slower fruit ripening.

*Note: Effects on ripening are impossible to study in severely bronzed vines, because it occurs uniformly across vine blocks and controls are not available for experimental study. There is no effect on ripening of only moderately bronzed vines as chlorophyll in the palisade leaf cell layer is not impaired.*

### Life cycle

**Winter:** Winter females are found inside the thick bark of cordons (approx. 95% of over-wintering population is found here), and only about 3-5% is found under the outer scales of over-wintering buds.

*Note: Rust mites enter buds to over-winter only in late summer, therefore do not penetrate deep inside the bud and, unlike bud mite, do not damage bunch primordia.*

**Spring:** Winter females begin to emerge from winter shelter in response to day-length and temperature. This is not governed by the vine, and mites do not feed at this time.

In Australia, spring migration was studied over 3 years, and in different regions was always found to coincide with Chardonnay woolly bud, irrespective of vine varieties.

*Note: This is therefore the optimal time to spray, if spray control is required, as at this time the winter female population is exposed to sprays,*

*but feeding on new season green tissue has not occurred, and the eggs of the first rust mite spring generation have not yet been laid.*

**Summer:** Summer females and males are found predominantly on leaves, hidden under fine leaf hairs.

Fertilisation takes place via males depositing minute sperm-containing structures on vine leaves, from which sperm is collected by females. Eggs develop from larvae to adults in about 6 days (but this varies greatly with temperature and humidity). The number of generations in a season can vary from 3-12 and more.

### Where to look

- Use late summer bronzing assessments to decide if a woolly bud spray is needed the following spring. Check particularly blocks with history of damage the previous season damage occurred.
- In blocks where chemical controls have been applied for mites or other pests which may have negatively impacted on predatory mite populations.

*Note: Rust mites migrate around the vineyard by wind, machinery, clothing, and also by hitchhiking on flying insects.*

### Monitoring

- Record severity of summer leaf bronzing from mid to late January to decide if spraying is required the following spring.
- Monitor shoots in early spring up to 6-10 separated leaves, to see if spring damage is present. Also check effectiveness of sprays in this way.

*Note: Trapping of mites at the woolly bud stage with a specialist double sided sticky tape is the most reliable method for determining rust mite numbers, but it is very time intensive and is therefore really only suitable for research purposes, or the enthusiast. Moreover, when trapping rust mite in spring it is already past the required time for woolly bud sprays. Trapping*

## MAJOR PESTS AND DISEASES IN BAROSSA VINEYARDS (CONT.)

of rust mite on sticky traps for monitoring would therefore need to be done in summer (from mid Jan onwards), to trap the autumn migration of rust mite.

### Management of Rust Mite

#### Biological control

Predatory mites provide very effective preventative control of rust and bud mites. Releases of additional predatory mites may be used to augment low predatory mite numbers in the vineyard, however where sprays toxic to predatory mites are minimised, additional releases may not be required.

#### Vineyard management practices

Alternate row mowing will provide grass pollen as a supplementary food source for predatory mites.

*Note: Swiss research showed that mulching infested pruned canes does not lead to rust mite re-infesting in the following spring.*

#### Sanitation

Do not allow contaminated equipment, vines, grapes, or winery waste near uninfected vineyards. Use certified planting material or sanitise dormant cuttings with hot water treatment.

#### Chemical control

If summer bronzing was moderate to severe the previous season, spray at woolly bud the next spring, which is the only time when mites are exposed enough and susceptible to spraying. If leaf bronzing was low, there is no need to spray against rust mite the following spring.

'Woolly bud' spray with 0.66% wettable sulphur mixed with 2% canola oil, or wettable sulphur alone, or canola oil alone. The spray volume must be appropriate to saturate the thick bark of vine cordons (→900 L/ha). If wettable sulphur is used, the temperature at the time of spraying needs to be above 15°C.

*Note: Mixtures of wettable sulphur and canola oil - when sprayed too late (i.e. once green tissue appears) - can cause severe damage to newly unfolding leaves and shoots. Lime sulphur pre-bud burst is not compatible with IPM (it is very highly toxic to beneficials), and is not effective against rust mite or bud mite. Spray programs must exclude sprays toxic to predators to achieve a lasting biological control.*

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- (3) **Bernard, M.** PhD Thesis, Latrobe University, 2005.
- (4) **Bernard M., Horne P. A. and Hoffmann A. A.,** Ecological Pest Management: The effect of viticultural fungicides on beneficial predatory mites, *The Australian and New Zealand Grapegrower and Winemaker*, 485a, pp 7-12, 2004.

## EUTYPA (EUTYPA LATA)

Eutypa dieback, caused by the fungus *Eutypa lata*, is a major trunk disease of grapevines. Infected grapevines gradually decline in productivity and eventually die. *Eutypa* is potentially one of the main threats to Barossa vineyards, and surveys have shown that eutypa dieback is widespread in many premium winegrowing regions of Australia. *Eutypa* dieback can also be found worldwide in cool climate wine regions.

### Symptoms

*Eutypa* dieback foliar symptoms are most obvious in spring when shoots are 30-70 cm long (Fig 1). Foliar symptoms include stunted shoots with chlorotic leaves, often cupped and with tattered margins. Attempts to isolate the fungus from affected foliage have been unsuccessful. Expression of foliar symptoms may occur 3-8 years after infection. Bunch size is also often affected with decreased berry number and size resulting in significant yield reduction. After many years, dieback symptoms the fungus produces a trunk canker and internal wedge shaped staining (Fig 2).

Figure 1.



Photo credit Peter Magarey

Figure 2.



Photo credit Peter Magarey

### Disease cycle

*E. lata* ascospores are released from diseased wood after it becomes wet (min. 2 mm rain). *E. lata* infects when spores land on open pruning or grafting wounds. The fungus then grows slowly within the vascular tissue of the cordons and trunk toward the base of the trunk. Foliar symptoms are thought to be caused by toxic metabolites produced by the fungus in the wood and transported to the foliage

### Economic Impact

- Gradual decline in yield once symptoms are first sighted.
- Control is costly as it is labour intensive and Fungicide control is limited.
- Secondary fungal infections spreading to adjoining vines and vineyards
- Vineyards potentially will be become unviable and have to be removed.

### Management

Prune late in the dormant season to promote rapid healing of wounds. Remove and burn infected wood inside the vineyard and dead wood in adjacent vineyards and orchards to reduce the spread of the pathogen. Cut out and

## MAJOR PESTS AND DISEASES IN BAROSSA VINEYARDS (CONT.)

remove dead arms and cordons from the vineyard during dormancy. Completely remove all cankers, pruning below the canker on the vine or trunks until no darkened canker tissue remains. Double pruning cordon-trained vines can help final pruning cuts to be made quickly and late in dormancy, thus reducing the chance for infection. Avoid making large exposed cuts and for additional protection, consider treating pruning wounds.

*UC IPM Pest Management Guidelines: Grape*

*UC ANR Publication 3448*

# PHYLLOXERA

One risk to the booming South Australian wine industry is a tiny pest called phylloxera (fil-ox-era). This insect attacks grapevine roots, slowly causing a decline in vine health and ultimately destroying the vine. South Australia is currently free of phylloxera. However, as the industry expands and there is more movement of machinery, grapevine material and people between the regions, the risk of spreading phylloxera is increasing. A concerted and diligent approach from everyone involved in the wine industry is required to ensure South Australia remains phylloxera-free.

To prevent the spread of phylloxera from infested areas, each state has legislation (laws) and associated regulations, which restrict or prohibit the movement of “phylloxera risk vectors” - ie things that could carry phylloxera. These include grapevine material, grape products and vineyard or winery equipment and machinery. Each state has slightly different legislation. Anyone wishing to move any risk products between states MUST comply with the legislation of the destination state.

However, even when these risk products are being moved between regions in the same state, or within regions, there is still a chance that phylloxera could be spread - if it is present in a vineyard or region but has not yet been detected. Growers are therefore encouraged to follow guidelines called protocols, which are designed to minimise the risk of transferring phylloxera - or other unwanted pests, diseases or weeds - accidentally from one vineyard to another.



## South Australian Vineyard Protection Protocols

The South Australian Vineyard Protection Protocol (2007) has been developed by the Board to help growers protect their vineyards from pests - including phylloxera - as well as diseases and weeds. It is based on two simple strategies: restricted vineyard access (keep unwanted organisms out) and cleaning and disinfestations for any “risk vector” that could

be carrying an unwanted organism. These are the same principles that the National Phylloxera Management Protocol is based on. The protocol is also consistent with state regulations governing the entry of grapevines, vineyard machinery and grape products into South Australia. The

Board recommends that all growers apply the strategies contained in the protocol to safeguard their vineyard from phylloxera and other pests and diseases. Vineyard Protection Protocols can be downloaded from the Phylloxera Board web page [www.phylloxera.com.au/regulation/protocols/](http://www.phylloxera.com.au/regulation/protocols/) which includes individual procedure sheets and other resources.

### Rootstocks:

#### Protection against phylloxera

Grape phylloxera is regarded as the world’s worst grapevine pest. Since the mid to late 19th century it has devastated vineyards across Europe, North America, New Zealand, South Africa and parts of South America and Australia. Productive viticulture cannot normally continue

## PHYLLOXERA (CONT.)

on own-rooted vines following an infestation by phylloxera. The only effective long-term management strategy for controlling phylloxera damage is a replanting program using vines grafted on phylloxera tolerant rootstocks.

Phylloxera tolerant rootstocks are bred from grapevines native to North America known as American vitis species. These particular species evolved in the presence of the phylloxera and so developed tolerance mechanisms that allowed them to continue to flourish in the presence of the insect. The mechanism by which tolerance occurs is mainly by the formation of a layer of cork tissue around the root lesion, which limits the spread of decay, and, to a lesser extent, resistance by repulsion.

### Rootstock use in South Australia

Unlike other grape growing regions in the rest of the world, South Australia and indeed most of Australia are free of phylloxera. This has meant that the use of rootstocks has not been essential. Currently rootstocks account for 12,872 ha (18%) of plantings in South Australia, mainly in the Riverland (7,900 ha or 11%). However, since 2000, 28% of new plantings have been on rootstocks, indicating the industry's increased awareness of the risk of phylloxera and the other benefits associated with planting on rootstocks. In 2008, 57% of new plantings were on rootstocks.

Traditionally rootstocks have also been used in Australia to overcome another soil-borne pest: nematodes. More recently it has been recognised that rootstocks are able to provide a number of other benefits apart from their tolerance/resistance to phylloxera and nematodes.

### Viticultural benefits of Rootstocks

Rootstocks can provide viticultural benefits as well as protection against phylloxera, and should

be seen as an extra 'tool' that growers can use to help them increase their efficiency and profitability. The main benefits that rootstocks can provide in addition to phylloxera tolerance are:

- Nematode resistance
- Soil salinity (salt) tolerance
- Water use efficiency/drought tolerance
- Increased fruit-set
- Increased or decreased scion vigour
- Advanced or delayed fruit maturity
- Lime tolerance
- Soil acidity tolerance

### Considerations

There is no single rootstock that can meet the different challenges of every site. Each rootstock has its own particular set of characteristics, strengths and weaknesses. The selection of the most appropriate rootstock for any given situation requires a thorough understanding of the particular site in which the vines are to be planted, as well as knowing the likely product end-use specifications.

There is an excellent "Rootstock Selector" interactive tool available on the Yalumba Nursery web site <http://www.yalumbanursery.com/>

## USING AGROCHEMICALS

A current list of chemicals is available on the AWRI website and an updated booklet “Agrochemicals registered for use in Australian Viticulture”, is printed each year by the Australian Wine Research Institute (see [www.AWRI.com.au/industry\\_support/viticulture/agrochemicals/agrochemical\\_booklet/](http://www.AWRI.com.au/industry_support/viticulture/agrochemicals/agrochemical_booklet/)). Note: Growers should always contact their grape purchaser/s (or potential purchaser/s) before applying any agrochemicals in their vineyard as their recommendations may vary to those given by the AWRI each year.

### Regulations

Many wineries randomly test grape samples for compliance with Maximum Residue Limits (MRLs) of agrochemicals in grapes.

*Note: Australian tolerances which are on the label of the agrochemical bottle may be different to those of the countries the wine will be exported to.*

Any non-compliance may lead to rejection of fruit by your purchaser or a delay in harvest with negative quality and price implications.

*Note: If you need to spray outside of the recommended use time please contact your grape purchaser before applying the spray. If you have sprayed with their consent, samples may be taken in the field pre-harvest and sent to an accredited laboratory for analysis at the grape purchaser's expense.*

### Withholding period

This is the period of safe application not to cause MRL problems, and the number of days represents the time between the last application and harvest. Most wineries perform an audit of all spray diaries prior to harvest. If the audit identifies that a particular vineyard's fruit had been sprayed later than the recommended withholding period before harvest, and may potentially exceed the MRL's at harvest,

the grapes can be rejected, or analyses will be required to prove that the fruit meets specification.

*Note: These will most of the time be at the growers' expense.*

### Re-entry

Agrochemicals represent a risk to you or to grape purchasing staff if a vineyard is entered before an agrochemical re-entry period has expired.

*Note: You should notify visitors if you have recently applied an agrochemical.*

### Preventing agrochemical violations

- Read the product label
- Ensure that you adhere to the Restriction on Use in the AWRI agrochemicals list
- Make sure that your spray equipment is calibrated
- Plan your spray programs with the possibility of an early harvest in mind
- If in any doubt, speak to your grape purchaser.

### Biological products

Biological products are agricultural products that have been derived from a living organism (plant, animal, micro-organisms etc.). They may be used for pest and disease control provided that growers are able to demonstrate that grape quality, occupational health and safety and the environment is not compromised with their pattern of use. Growers should check with their grape purchasers if they intend to apply these products.

There are four major groups of biological products:

- Biological chemicals - hormones, pheromones, growth regulators, vitamins and enzymes
- Microbial agents – viruses, bacteria and fungi
- Extracts – plant extracts, oils
- Other living organisms – microscopic insects, plants and animals.

## USING AGROCHEMICALS (CONT.)

### Nutritional products

Nutritional products are not regulated in the same way as pesticides. Technical analytical information should always accompany a nutritional product. Use of these products should be guided by this technical analysis along with soil and petiole tests. Only nutritional products that are accompanied by a full technical analysis should be used in the production of wine grapes. Growers should check with their grape purchasers if they intend to apply these products.

### General precautions

Agrochemicals have been proven to be safe when handled and applied as per label instructions. However caution is necessary when using agrochemicals:

- **Time the sprays** to coincide with the most vulnerable/ easy to destroy stage in the life cycle of the pest, disease or weed.
- **Target** the right chemical for the pest to be controlled. Preventive chemicals will not work as eradicants.
- **Trust nobody** – read the label yourself and

follow all instructions for safe handling of the agrochemical - the most dangerous moment is handling the concentrate.

- **Treat wisely** at the right time and with the best possible technology, at the correct rate and avoiding drift or losses to non target areas.
- **Trace** the effectiveness by monitoring success of spraying.

### Avoiding spills

- Locate mixing and washing sites away from streams, drains and bores
- Pour with extreme care
- Quarantine all tail waters on farm, avoiding contamination
- Dispose of chemicals safely

### Avoiding drift

Minimise spray drift by correctly setting the spray pump's pressure, nozzle direction and the tractor speed, before calibration.

The Beaufort wind scale is a simple scale devised to gauge wind speed based on observations.

The Beaufort scale values below (adapted from the Commonwealth Bureau of Meteorology) may be needed in your Spray Diary form.

Beaufort No.	Descriptive term	Km/h	Description
0	Calm	↔1	Smoke rises vertically.
1	Light air	1 – 5	Wind direction shown by smoke-drift, but not by wind vanes.
2	Light breeze	6 -11	Wind felt on face; leaves rustle; ordinary vanes moved by wind.
3	Gentle breeze	12 – 19	Leaves and twigs in constant motion; wind extends light flag.
4	Moderate breeze	20 – 28	Raises dust and loose paper; small branches are moved.
5	Fresh breeze	29 – 38	Small limbs in trees begin to sway; crested wavelets form on inland waters.

## Preparing and calibrating spray equipment

### Why calibrate the spray unit?

The spray unit must be calibrated to apply the correct volume before the first spray is applied to;

- Provide better disease control
- Avoid chemical wastage, thus saves money
- Minimise off-target damage to surrounding crops and the environment
- Avoid the build-up of resistance in pests and diseases by under dosing

### Calibrating Tractor Speed

*Travel speed (km/h) = Distance travelled (m) divided by time taken (seconds) x 3.6.*

#### Example:

*100 metres ffi 46 seconds x 3.6 = 7.8 km/h.*

1. Mark a set length of 100 m - preferably in a vine row or on a similar surface
2. Attach the sprayer and fill with water to maximum capacity
3. Select and record the gear setting and engage the PTO
4. Select and record the engine revs and set the operating pressure
5. Measure and record the time taken to travel the measured distance
6. Repeat "Point 5" three times and calculate the average

### Measuring the nozzle or aperture output

1. Partly fill the sprayer with water.
2. Replace the tank lid assembly and open the suction line valve.
3. Engage the PTO and allow the plant to run for a few minutes to circulate the water in the unit.
4. Operate the control switches to check all jets, pressures and spraying patterns are adjusted to the correct ranges for the work.
5. Visually check there are no leaks from any part of the sprayer.
6. Check that none of the nozzles or filters is

blocked – to unblock, DO NOT use wire or hard objects!

7. While running the sprayer at normal operating pressure, measure output per nozzle over time. It may be necessary to fit a funnel or hose over each nozzle for proper collection of liquid.
8. Discard any nozzle that is +/- 5% the average output of all nozzles.
9. Check the output of the replaced nozzles.

### Calculating nozzle output (L/min)

Combined nozzle output (L) divided by the amount of minutes the sprayer was operational (min).

#### Example:

*7 x 8 litres per nozzle and 5 x 7 litres per nozzle = 91 L + 5 min = 18 L/min.*

### Calculating required nozzle output (L/min) when changing water rates.

*Required output (L/ha) x Row width (m) divided by 100 = Area output (L/100 m).*

*Area output (L/100 m) x Required speed (km/h) divided by 6 = Total nozzle output (L/min).*

*Total nozzle output (L/min) divided by Number of nozzles on sprayer = Required Individual nozzle output.*

#### Example:

*450 L/ha x 3.2 m ffi 100 = 14.4 L/100 m*

*14.4 L/100 m x 7 km/h ffi 6 = 16.8 L/min*

*16.8 L/min ffi 20 nozzles = 0.84 L/min per nozzle.*

# USING AGROCHEMICALS (CONT.)

## Determining the concentration factor (CF)

Below is a guide to theoretical (dilute) spray volumes for grapevine canopies, see (1). Reproduced with permission from (2).

SPRAWL CANOPY	Up to 0.5x0.5 m	Up to 1x1 m	Up to 1.5x1.5 m	Up to 2x2 m and above
	Indicative volume L/100 m	10 to 20	20 to 40	45 to 60
Indicative volume L/ha (for 3 m row spacing*)	300 to 650	650 to 1,300	1,500 to 2,000	2,000 to 3,000
VSP CANOPY	Up to 0.5x0.5 m	Up to 1x1 m	"Wires up" stage, up to 1.5x0.5 m	Up to 2x0.5 m
	Indicative volume L/100 m	10 to 20	20 to 40	30 to 55
Indicative volume L/ha (for 3 m row spacing*)	300 to 650	650 to 1,300	1,000 to 1,800	1,500 to 2,500

### Theoretical (dilute) spray volume

A range of theoretical (dilute) spray volumes are given above for each canopy size, which changes throughout the growing season. For dense canopies choose a volume at the top end of the range.

### Actual spray volume

This is the volume of water the canopy spray unit has been calibrated to supply in either L/100 m or L/ha. This figure will vary when spray equipment setup is changed, i.e. tractor speed, nozzle size, number of nozzles used.

### Concentration factor

Concentration factor (CF) = theoretical (dilute) spray volume divided by actual spray volume.

#### Example 1 - Dilute spraying

Taking into account the young canopy size and density, you decide that the theoretical (dilute)

spray volume is 500 L/ha. After calibrating the spray unit to achieve good coverage, you find that the actual spray volume needed is 500 L/ha.

### Concentration factor (CF)

$$= \text{theoretical} \div \text{actual spray volume}$$

$$= 500 \div 500$$

$$= 1$$

#### Example 2 – Concentrate spraying

Taking into account the canopy size and density, you decide that the theoretical (dilute) spray volume is 1700 L/ha. After calibrating the spray unit to achieve good coverage, you find that the actual spray volume needed is 600 L/ha.

### Concentration factor (CF)

$$= \text{theoretical} \div \text{actual spray volume}$$

$$= 1700 \div 600$$

$$= 2.8$$

*Note: Herbicides always have a CF of 1. Wetters and foliar fertilisers always have a CF of 1 even if the rest of the tank mix has a CF greater than 1. Maximum CF's also apply – always consult the product label when deciding on spray volumes and CF's*

- (1) **Furness, G.** Orchard and Vineyard Spraying Handbook. Winetitles, 2006.
- (2) **Radunz, L.** New label directions for spraying – a review of experiences over the past year. Australian Grapegrower and Winemaker 451, pp 45-46, 2001.

**Calculating the amount of registered product used**

Wineries require information about the amount of registered product (g, kg, ml, L) used per hectare or per 100 m, for each chemical.

**Product/ha:** Chosen label rate of registered product per 100 L x CF x actual amount of water sprayed per ha divided by 100.

**Example for Fungicides and Insecticides:**

*Actual spraying volume is 500 L/ha  
Concentration Factor (CF) is 3  
Chosen 'Kumulus DF' label rate is 350 g /100 L*

$$\begin{aligned} \text{Product/ha} &= \frac{\text{chosen label rate per 100 L} \times \text{CF} \times \text{actual spraying volume (L/ha)}}{100} \\ &= \frac{350 \times 3 \times 500}{100} \\ &= 5.25 \text{ kg/ha} \end{aligned}$$

**Example for herbicides:**

*Actual spraying volume is 500 L/ha  
Concentration Factor (CF) is always 1  
Chosen 'Basta' label rate is 3 L/ha  
Product/ha = 3 L*

**Example for wetters:**

*Actual spraying volume is 500 L/ha  
Concentration Factor (CF) is always 1  
Chosen label rate is 10 mL/100L  
Product/ha = 50mL*

**Product/100m:** Chosen label rate of registered product per 100 L x CF x actual amount of water sprayed per 100 m divided by 100.

**Example for Fungicides and Insecticides:**

*Actual spraying volume = 15 L /100 m  
Concentration Factor (CF) = 3  
Chosen 'Kumulus DF' label rate = 350 g /100L*

$$\begin{aligned} \text{Product/100m} &= \frac{\text{chosen label rate per 100 L} \times \text{CF} \times \text{actual spraying volume (L/100 m)}}{100} \\ &= \frac{350 \times 3 \times 15}{100} \\ &= 157.5 \text{ g / 100 m} \end{aligned}$$

**Amount of chemical to add to tank for Air Assisted Vine Sprayers**

Chemical label rate (/100 L) x Conc. factor x Tank volume (L) divided by 100

**Example:**

*0.4 kg Sulphur (per 100 L) x 2 x 1500 L ÷ 100 = 12 kg Sulphur to be added to tank*

**Amount of chemical to add to tank for Herbicide Boom/CDA Sprayers**

Volume of tank (L) x Chemical rate (L/ha) divided by Volume applied (L/ha)

**Example:**

*400 litre tank x 2 litres of Roundup per ha ÷ 110 litre spray volume per ha  
= 7.3 litres of Roundup to add to tank*

## USING AGROCHEMICALS (CONT.)

### Calculating the number of tank fills required

Area to spray (ha) x Application volume (L/ha)  
divided by Volume of tank (L)

#### Example:

*8 hectares to spray x 485 litres per hectare spray  
volume ÷ 2000 litre tank  
= 1.94 tanks required*

### Calibrating fertiliser spreaders and seed drills

1. Decide on the speed of travel.
2. Attach the fertiliser unit to a tractor.
3. Cover the distributing point(s) with suitable collecting container(s). For fertiliser spreaders engage the PTO and allow the unit to run for a set period of time (e.g. 1 minute). For seed drills rotate the wheels of the seed drill the correct number of times to match the number of wheel rotations the drill would make for one minute of travel at the intended speed.
4. Collect the amount of material the unit distributes. This is the total output quantity.
5. Measure the width of the distribution output (e.g. Seed Drill = 2.4 m, Fertiliser Spreader = 20 m)
6. Calculate the distribution output in kg/ha.

#### Example:

*Total Output Quantity (kg/min) x 600 divided by  
Band Width (m) divided by Speed (km/h)*

*= 5.5 kg of DAP per minute total output x 600  
÷ 2.4 metre wide distribution ÷ 10 km/h  
= 138 kg DAP per hectare.*

**Using a Water Rate Conversion Table**

This table can be used for fast conversion of ;

☞ **Litres per hectare (L/ha) to Litres per 100 metres (L/100 m)**

<b>ROW WIDTH</b>	7'	8'	9'	10'	11'	12'	13'	<b>feet</b>
	2.1	2.4	2.7	3.0	3.3	3.6	3.9	<b>metres</b>
<b>m/ha</b>	4762	4167	3704	3333	3030	2778	2564	<b>m/ha</b>
<b>100 m/ha</b>	47.62	41.67	37.04	33.33	30.30	27.78	25.64	<b>100 m/ha</b>

	L/ha	L/100 m							L/ha
<b>SPRAY VOLUME</b>	300	6.3	7.2	8.1	9.0	9.9	10.8	11.7	300
	400	8.4	9.6	10.8	12.0	13.2	14.4	15.6	400
	500	10.5	12.0	13.5	15.0	16.5	18.0	19.5	500
	600	12.6	14.4	16.2	18.0	19.8	21.6	23.4	600
	700	14.7	16.8	18.9	21.0	23.1	25.2	27.3	700
	800	16.8	19.2	21.6	24.0	26.4	28.8	31.2	800
	900	18.9	21.6	24.3	27.0	29.7	32.4	35.1	900
	1000	21.0	24.0	27.0	30.0	33.0	36.0	39.0	1000
	1100	23.1	26.4	29.7	33.0	36.3	39.6	42.9	1100
	1200	25.2	28.8	32.4	36.0	39.6	43.2	46.8	1200
	1300	27.3	31.2	35.1	39.0	42.9	46.8	50.7	1300
	1400	29.4	33.6	37.8	42.0	46.2	50.4	54.6	1400
	1500	31.5	36.0	40.5	45.0	49.5	54.0	58.5	1500
	1600	33.6	38.4	43.2	48.0	52.8	57.6	62.4	1600
	1700	35.7	40.8	45.9	51.0	56.1	61.2	66.3	1700
	1800	37.8	43.2	48.6	54.0	59.4	64.8	70.2	1800
	1900	39.9	45.6	51.3	57.0	62.7	68.4	74.1	1900
	2000	42.0	48.0	54.0	60.0	66.0	72.0	78.0	2000
	2100	44.1	50.4	56.7	63.0	69.3	75.6	81.9	2100
	2200	46.2	52.8	59.4	66.0	72.6	79.2	85.8	2200
2300	48.3	55.2	62.1	69.0	75.9	82.8	89.7	2300	
2400	50.4	57.6	64.8	72.0	79.2	86.4	93.6	2400	
2500	52.5	60.0	67.5	75.0	82.5	90.0	97.5	2500	

1. Choose the row width matching your vineyard block from the top rows. Where there is not an exact match, choose the nearest.
  2. Select the spray volume to be sprayed (in L/ha) from the side columns. Where there is not an exact match, choose the nearest.
  3. Follow across the appropriate spray volume and down the specified row width to where they intersect - read the specified value.
  4. This value is the spray volume in L/100m that matches your vineyard block.
- Example: On 3.0 m wide rows, a spray volume of 1500 L/ha is equivalent to 45.0 L / 100 m.

## USING AGROCHEMICALS (CONT.)

### After spraying

#### Cleaning the spray tank

Spray tanks must be cleaned after every spray session to avoid problems of a residual chemical mixing with a new chemical and to not have chemical residues dry on sprayer parts.

1. Dilute any remaining chemical in the spray tank with approximately a quarter of a tank of clean water and spray or drain the mixture over an approved area away from water courses and buildings.
2. Clean filters by removing and rinsing them in clean water and a deactivating agent.
3. Clear the machine of all chemical residues by replacing the filter cover and, with the pump running, washing the inside of the tank completely while operating all the sprayer valves and components.
4. Dispose the waste to an approved area away from water courses and buildings.
5. Wash with appropriate detergent or cleaning agent. Partly refill the sprayer with clean water, and then add the detergent or chemical cleaning/deactivating agent.
6. Spread the mix through the sprayer system, starting the sprayer and operating all the controls
7. Drain and rinse. Stop the sprayer and open the tank drain valve to allow the sprayer to empty while continuing to rinse the inside of the tank with clean water.
8. Replace the sprayer filters.
9. Wash the outside of the machine completely with a brush or sponge to loosen all surface residue while taking care to ensure the waste water drains to an approved disposal area.

### Checking spray targeting

Staple at least 10 water sensitive paper strips to leaves in the target zone of application (when humidity is below 80% and leaves are dry). Ensure these are placed inside and outside of the vine canopy to check for full coverage.

Note: Water sensitive paper strips will generally underestimate cover as only droplets >100 µm can be seen. Use as

# IRRIGATION

## CALCULATIONS

### Number of drippers per vine

Number = Vine spacing divided by Dripper Spacing.

E.g.  $2.1\text{ m} \div 2.1\text{ m} = 1$  Drippers per Vine.

E.g.  $1.8\text{ m} \div 0.5\text{ m} = 3.6$  Drippers per Vine  
 $\times 1852$  Vines/ha  
 $= 6667$  Drippers /ha

### Dripper output rate per vine

Time (h) x Output per emitter (L/h) x No. emitters per vine

E.g.  $10\text{ hours} \times 2\text{ L/h} \times 2 = 40\text{ L per vine}$

### Dripper output rate per hectare

Time (h) x Output per emitter (L/h) x No. emitters per vine x No. vines per hectare

E.g.  $10\text{ hrs} \times 2\text{ L/h} \times 2 \times 1852 = 74,080\text{ L per ha}$

### Dripper output rate per block

Time (h) x Output per emitter (L/h) x No. emitters per vine x No. vines per hectare x block size (ha)

E.g.  $10\text{ hrs} \times 2\text{ L/h} \times 2 \times 1852 \times 2.15\text{ ha}$   
 $= 159,272\text{ L on block}$

### Conversions

☞  $1\text{ millimetre (mm)}$   
 $= 1\text{ litre per square metre}$

☞  $100\text{ millimetres}$   
 $= 1\text{ Megalitre per hectare}$

☞  $1\text{ kilolitre} = 1000\text{ litres}$

☞  $1000\text{ kilolitres} = 1\text{ Megalitre}$

### Litres per vine (L/vine)

Flow rate (L/h) multiplied by hours of irrigation multiplied by number of drippers/vine

Eg. Flow rate is  $2\text{ L/h}$ ,  $8\text{ hours of irrigation}$ ,  
 $2\text{ drippers/vine}$   
 $2\text{ L/h} \times 8\text{ h} \times 2 = 32\text{ L/vine}$

### Amount of water applied (mm/irrigation)

Litres/vine divided by vine spacing/row (m) and distance between rows (m)

Eg: Vine received  $32\text{ L/irrigation}$ , vine spacing is  $2\text{ m}$ , Row spacing is  $3\text{ m}$   
 $32\text{ L/vine} \div 2\text{ m} \div 3\text{ m} = 5.3\text{ mm}$

### Percentage of area wetted

Area wetted by one dripper (m<sup>2</sup>) multiplied by number of dripper/vine divided by vine spacing/row (m) and distance between rows (m) multiplied by 100

Eg: Wetted area of one dripper is  $0.6\text{ m}^2$  and there are  $2\text{ drippers/vine}$ , vine spacing is  $2\text{ m}$ , row spacing is  $3\text{ m}$   
 $0.6\text{ m}^2 \times 2\text{ drippers/vine} \div 2\text{ m} \div 3\text{ m} \times 100 = 20\%$

### Application rate (mm/h)

Average flow rate per dripper divided by dripper spacing (m) divided by row spacing (m)

Eg: Average flow rate per dripper is  $2\text{ L/h}$ , dripper spacing is  $1\text{ m}$ , row spacing is  $3\text{ m}$   
 $2\text{ L/h} \div 1\text{ m} \div 3\text{ m} = 0.66\text{ mm/h}$

### Hours required applying irrigation

Depth required (mm) multiplied by % wetter area divided by application rate (mm/h)

Eg: Required irrigation depth is  $50\text{mm}$ , wetted area is  $20\%$  ( $0.2$ ), application rate equals  $0.66\text{ mm/h}$   
 $50\text{mm} \times 0.2 \div 0.66\text{ mm/h} = 15\text{h}$

### Assessing the number of vines per hectare

$= 10,000$  divided by Row Spacing divided by Vine Spacing (Divide answer by  $2.47$  to calculate vines per acre)

Eg.:  $10,000 \div 3\text{ metre rows} \div 0.8\text{ metre vine spacings} = 1852\text{ vines per hectare} \div 2.47 = 750\text{ vines per acre}$

## RECORD KEEPING

### RECORD KEEPING FOR GRAPE PURCHASERS

Precise records are required by grape processing companies to ensure that:

- your operation has safe and best practice standards of agrochemical use and machinery handling
- safe amounts of inputs are guaranteed in order to support Australian wine's environmental status
- sustainable management practices are encouraged and verified
- agrochemical residues are avoided or kept below the MRL set by the countries the wine is exported to
- **Record soil moisture monitoring results** for at least indicator blocks in the vineyard
- **Sign the declaration form** for your grape purchaser that verifies that all information is true and correct.

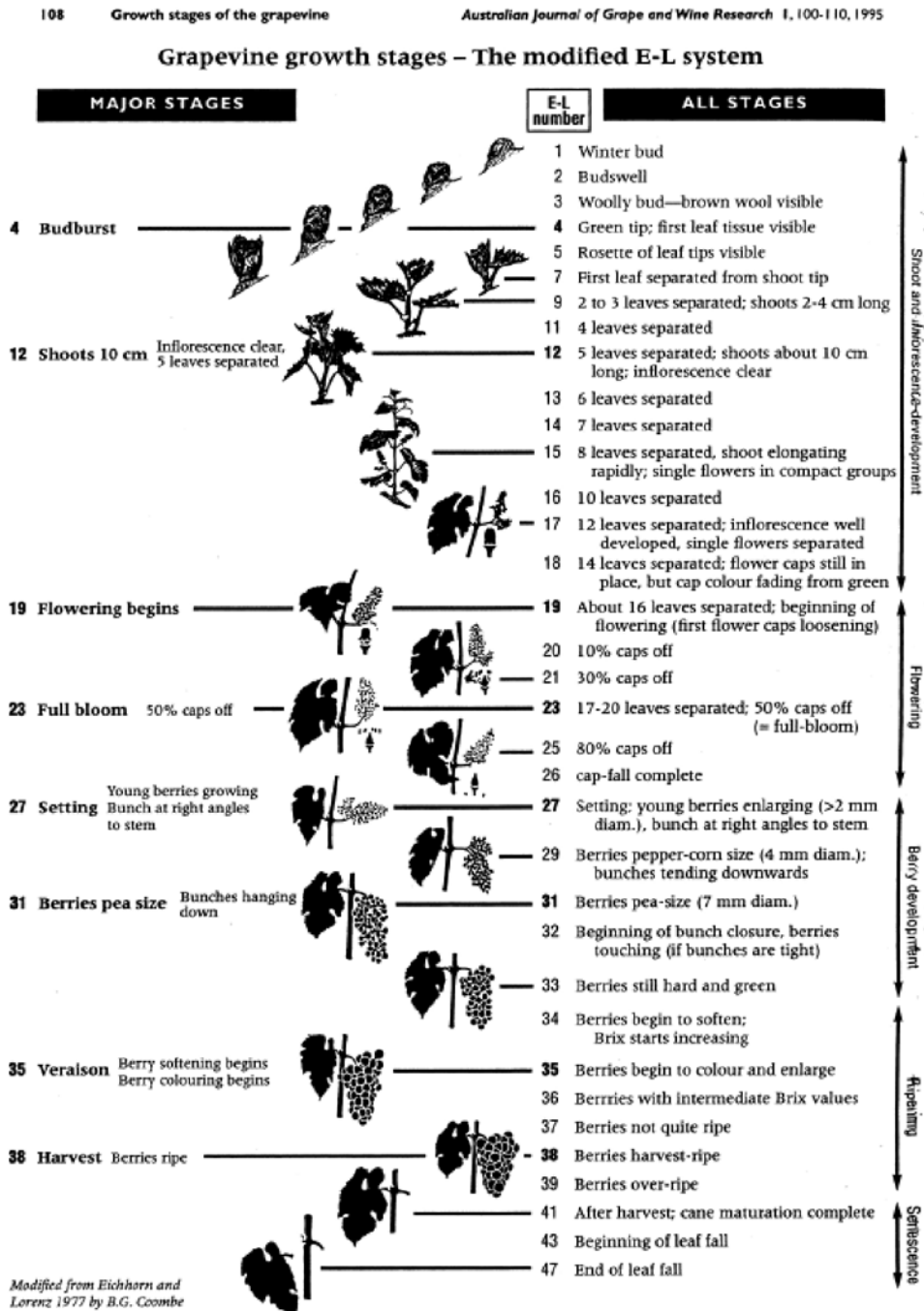
*Note: Whilst records of any agrochemical sprays applied prior to budburst may not be asked for by your grape purchaser, it is good practice to keep these records, as well as those of any other inputs (e.g. fertilisers).*

Wineries will generally reject grapes without the below information and signature. Some wineries will accept electronic records. Please contact your grape purchaser.

- **Record all chemical and fertiliser container details including batch numbers** on a Chemical Shed Inventory record sheet.
- **Record the calibration process** for vine canopy sprayers and for herbicide sprayers at least once during the season.
- **Record any pest, disease and beneficial insect scouting information** on a Pest, Disease & Beneficial Scouting Record Sheet.
- **Record all agrochemical applications** for all blocks during the season on Application Record Sheets.
- **Record nutritional inputs** on record sheets and document with site information nutritional imbalances if observed, and soil or petiole analyses.
- **Record irrigation inputs** for all blocks on irrigation sheets and note any problems of vine vigour.

## GRAPEVINE GROWTH STAGES

It is advisable to record the growth stages not only by calendar date as vine development will be different in each season. Use the E-L numbers as from the table below in your records.



From Coombe, B.G. Adoption of a system for identifying grapevine growth stages. Australian Journal of Grape and Wine Research 1, 104-110, 1995 (with permission from the Australian Society of Viticulture and Oenology).

## CONCLUDING REMARKS

There is a lot of information in this guide; it was put together with the help of some of the best leaders and researchers to help Barossa grapegrowers make informed decisions on how to manage their vineyards. The wine industry is ever evolving, and we as wine grape growers have to evolve with it. We are not grapegrowers any more, we are WINEGROWERS. We have to grow grapes that fit into the market. If you don't adapt to the changes required by your customers, you may find that your grape purchaser will look for another winegrower that will.

I have given various web page references throughout this guide and below, and suggest that on a rainy day you get onto the internet and check them out. There is a wealth of knowledge just a "click" away. For those who require more assistance with technological information, there are various courses run periodically through Grape Barossa, and the Barossa and Light Development Board. Take advantage of these and other courses to better your skills. You should be constantly learning and updating your skills and knowledge.

### **Adrian Hoffmann**

Barossa wine grape grower

### **Some useful industry web pages:**

Grape Barossa – Local information linked to grower and wine organisations  
[www.barossa.com](http://www.barossa.com)

Barossa Viticulture Technical Group – Local viticultural technical group  
[www.bvtg.com.au](http://www.bvtg.com.au)

Phylloxera and Grape Industry Board of South Australia – Information on phylloxera, SA grape crush surveys with district pricing  
[www.phylloxera.com.au](http://www.phylloxera.com.au)

Wine Grape Growers Australia – National Grapegrowers organization  
[www.wgga.com.au](http://www.wgga.com.au)

Winemakers Federation of Australia – National winemaker's organization  
[www.wfa.org.au](http://www.wfa.org.au)

South Australian Research and Development Institute – Current research  
[www.sardi.sa.gov.au/viticulture](http://www.sardi.sa.gov.au/viticulture)

Department of Primary Industry and Resources of SA  
[www.pir.sa.gov.au](http://www.pir.sa.gov.au)

The Grape and Wine Research and Development Corporation – Current research  
[www.gwrdc.com.au](http://www.gwrdc.com.au)

The Australian Wine Research Institute – Agrochemicals booklet and spray book templates  
[www.AWRI.com.au](http://www.AWRI.com.au)

Australian Wine and Brandy Corporation – Information on Markets  
[www.wineaustralia.com/australia/](http://www.wineaustralia.com/australia/)



