# **Post-harvest Vineyard Management** Growers guide for Riverina Vineyards



Edited by Shayne Hackett and Kristy Bartrop March 2011



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## Foreword

In the Riverina, harvest may be over but the last few months of the season until leaffall are not for relaxation. This is particularly so in the Riverina where continuing warm, dry weather can be put to good effect if grapevines are managed carefully.

In this booklet, commissioned by the Riverina Wine Grapes Marketing Board, viticultural research and extension specialists with the National Wine and Grape Industry Centre (NWGIC) describe why the post-harvest period in the Riverina is so important and provide guidelines as to what can be done to lay the foundation for grape quality and yield success next season.

Behind the guidelines are a number of years of research in Riverina vineyards in which NWGIC scientists have worked in collaboration with commercial vineyard operators to understand how water supply, crop load, mineral nutrition, heat and disease management all influence grapevine performance. The common factor behind those influences is their impact on seasonal changes in carbohydrate and mineral nutrient reserves stored within the grapevine. This accounts for the strong emphasis we put on those reserves in preparing these guidelines.

Of course, the post-harvest period is only one part of the grapevine season and the guidelines provided here are only parts of a seasonal management program. What we provide here is consistent with a greater vineyard management program that we trust will prepare the Riverina well to adapt to the challenges of water supply limitations and variable weather events that are expected to accompany increasing temperature and rising  $CO_2$  levels.

The NWGIC congratulates the Riverina Wine Grapes Marketing Board on this initiative. We trust that readers will find these guidelines both informative and inspiring.

Mardie

Jim Hardie Director, National Wine and Grape Industry Centre, Charles Sturt University, Wagga Wagga, NSW The National Wine and Grape Industry Centre is an alliance of Charles Sturt University, Industry and Investment NSW and the NSW Wine Industry Association.

## 1. Caring for unharvested vineyards

Shayne Hackett & Gregory Moulds

With changing industry requirements there can be a situation where a crop is left unharvested. Assuming that the unharvested block will be required for production next season, vineyard managers are left with the predicament of how to manage this block to ensure that next season's crop is healthy. If a block is no longer required, autumn is a convenient time to remove it.

#### 1.1 Disease management

Autumn conditions in the Riverina generally favour development of several diseases that if left uncontrolled can have negative impacts on grapevine growth and yield in the following season. The approach to managing disease in unharvested blocks during autumn largely depends on the amount of crop left on the vines and the level of carbohydrate and nutrient depletion in the vine (see section 3).

#### Powdery mildew

Regardless of nutrient reserve restoration, if left unchecked powdery mildew can quickly develop spore-containing cleistothecia from which infection can spread in the following season (see section 4). A single early-autumn sulphur application will normally prevent this situation.

#### Downy mildew

The incidence of downy mildew results from the weather conditions in spring rather than seasonal carryover. If existing infections are allowed to spread there is potential for a higher carryover into the next season. The risk of late infection by downy mildew reduces once the night time temperatures drop below 12°C. Prevention may be achieved by the application of an early-autumn protectant fungicide.

#### 1.2 Nutritional requirements

Typical amounts of nutrients removed in each tonne of grapes from Riverina vineyards are detailed in section 3. When vines are not harvested these nutrients effectively remain within the vineyard. Of course, until the fruit is decomposed the nutrients will not be available to the vine. In the Riverina this process is quite rapid whether or not the fruit is left on the vine or dropped on the ground. Therefore, it is unlikely that autumn fertilisers will be necessary in un-harvested vineyards.

#### **1.3 Irrigation requirements**

Vines in unharvested blocks should be watered normally during the autumn to ensure adequate leaf function for the remainder of the season so as to ensure normal restoration of carbohydrate and mineral nutrient reserves (see section 2).

#### 1.4 Fruit removal

Leaving unharvested fruit on vines has no impact on plant health provided that the bunch remnants are removed at pruning. Bunches left unharvested become rot infected and leaving these bunch remnants attached after pruning is likely to increase the risk of infection to developing fruit in the next season. Mulching of pruning material containing bunch remnants will assist in microbial decomposition of rot infected material.

# 2. Post-harvest irrigation management in the Riverina

Jason Smith

Grapevines in the Riverina can retain their leaves for between one and three months after harvest depending on the variety and harvest date. Providing these leaves remain healthy and the supply of water and nutrients is adequate continued photosynthesis and nutrient uptake during this period allows vines to store carbohydrate and nutrient reserves for use in the next season.

If restoration is prevented for whatever reason by an early loss of leaf function, then the grape crop may be reduced in the following season. The normal management approach for the post-harvest period has therefore been to promote the restoration of reserves through continued irrigation. However, where reduced water allocations or low rainfall limit irrigation options after harvest, it may not always be possible to maintain soil moisture levels for the entire period after harvest. Growers may also look to the post-harvest period as an opportunity to deliberately save some water.

Post-harvest irrigation is important because of its impact on restoration of carbohydrate and mineral nutrient reserves. There are three particular reasons. Firstly, leaves need to be well hydrated to maximise carbohydrate production from photosynthesis. Secondly, the movement of water through the soil profile helps move fertilisers into the root-zone, and nutrients are more accessible to the roots in moist soils. Thirdly, active leaf transpiration is necessary to carry the major mineral nutrients through the grapevine. Photosynthesis and mineral nutrition are also closely linked, as an adequate nutritional status is needed to maintain photosynthetic rates, while the carbohydrates produced by photosynthesis are in turn needed as a source of energy for mineral uptake.



Figure 1 Post-harvest irrigation is important for restoring carbohydrate and nutrient reserves

#### 2.1 When is post-harvest recovery needed and how long will soil water need to be maintained to sustain it?

Without directly measuring carbohydrate or nutrient reserve concentrations in the wood and roots at harvest, it is difficult to predict exactly how long the post-harvest restoration is likely to take for a particular vineyard. Fruit load at harvest can be used as an approximate guide to measure the vines reserves.

Grapevines with fruit loads of between 5 and 10 tonnes per hectare are normally able to restore carbohydrate reserves by harvest and require minimal post-harvest irrigation for restoration purposes.

For yields between 10 and 20 tonnes per hectare post-harvest restoration becomes more important. Under normal Riverina weather conditions grapevines in that range may require up to a month or so to restore reserves and irrigation may be necessary to sustain leaf function for that time.

Grapevines yielding between 20 and 35 tonnes per hectare will generally require between four and eight weeks to restore carbohydrate and mineral reserves.

If grapevines in any fruit load category have excessively shaded leaf canopies, or experience prolonged periods of high temperature or water-stress during ripening, then the restoration period will take longer. Defoliation caused by disease, insect pests or machine harvesting may also reduce the photosynthetic capacity of the canopy after harvest, but providing at least half of the leaves can be maintained in reasonable health during the post-harvest period the impact on reserve restoration will be minimal.

#### 2.2 Grapevine water use in the post-harvest period

Irrigation requirements after harvest can be estimated from evapotranspiration and rainfall during the post-harvest period. Assuming that soil is fully watered (i.e. to field capacity) at the start of the post-harvest period, and that thereafter the intent is to maximise photosynthesis by matching vineyard water use with irrigation, the total post-harvest irrigation requirement in the Riverina would range from about 1-2ML/Ha depending on the time necessary for restoration (Table 1). It is only around early to mid April that vineyard water requirements normally start to be matched by rainfall. Chardonnay vineyards in the Riverina generally receive post-harvest irrigation ranging between about 1.0 and 2.5 ML/Ha; the higher applications being to blocks harvested early for sparkling wine. For Shiraz, the amounts range between 0.5 and 1.5 ML/Ha; mainly due to the later maturation dates.

	February	March	April
Reference Evaporation ETo (mm)	190	160	90
Crop Coefficient Kc	0.7	0.7	0.45
Vineyard Evapotranspiration (mm)	133	112	40
Rainfall (mm)	25	30	35
Vineyard Water Requirement (mm)	108	82	5
Irrigation Requirement (ML/ ha)	1.1	0.8	0.05

 Table 1 Estimated monthly irrigation requirements for post-harvest restoration of carbohydrate and mineral nutrient reserves in the Riverina.

It is important to note that these estimates are based on maintaining the grapevines in a maximum state of hydration, i.e. the entire root zone is maintained at close to field capacity. However, in the Riverina, research is exploring the effects of allowing a greater grapevine water deficit during the post-harvest period. The general finding of these trials is that yield, at least over a period of two or three years, was not reduced when 50% or more of the normal post-harvest irrigation was withheld. There was no significant effect on carbohydrate or mineral reserve restoration, which suggests there may be some opportunity for some water savings in the postharvest period, however until the limit is known take caution against greater deficits.

# 3. The importance of post-harvest vineyard management and restoration of grapevine carbohydrate and mineral nutrient resources in the Riverina

Bruno Holzapfel and Jason Smith

The early season development of the grapevine from budburst until flowering requires mineral nutrients and carbohydrates from the roots, trunk and arms where they are stored as reserves to re-start the annual growth cycle after winter and to buffer against variable supply from root uptake and photosynthesis at other times in the season. Mineral nutrient and carbohydrate reserves in the roots and woody parts of the grapevine are highest in winter. The greatest proportions of both reserves are stored in the roots. The post-harvest period up to leaf-fall is an important time for restoration of carbohydrate and mineral nutrient reserves.

During spring grapevines depend on carbohydrates and nutrients stored in the roots and wood to support the new season's growth. By flowering there are normally sufficient leaves and new roots to meet the grapevine's requirement for carbohydrates and mineral nutrients, so the reserves used after budburst start to be replaced. Restoration continues from that time provided that supply exceeds the requirements for growth and fruit development.

In the Riverina, the generally high number of buds retained at pruning places a great demand on carbohydrate reserves (and other stored nutrients) during spring. Furthermore reserves may be used during the ripening period to maintain ripening when photosynthetic production of carbohydrates is impaired by excessive temperature and heat or water-stressed leaves or by a high proportion of heavily shaded leaves. These factors account largely for our observation that, in the Riverina, restoration of reserves continues beyond harvest and through to leaf-fall. In contrast, in cooler regions with generally lower bud numbers after pruning and therefore fewer requirements for reserves for seasonal re-establishment, the restoration of those reserves may be completed by harvest.

As many grape growers know, grape ripening time increases if fruit loads are excessive and such cropping not only removes greater amounts of mineral nutrients and carbohydrates but it also limits the time remaining after harvest for their restoration. Research by the National Wine and Grape Industry Centre (NWGIC) has found that such imbalances between fruit load and the number of functional leaves leads to a low crop in the following season and ultimately to alternate bearing.



Figure 2 Post-harvest up to leaf fall is an important time for carbohydrate and nutrient restoration

#### 3.1 Restoration of Carbohydrates

Grapevines, like all plants, obtain their carbohydrates from photosynthesising leaves. Therefore it is important to ensure that the leaves remain healthy and fully functional after harvest. This means that care should be taken to minimise leaf loss during machine harvesting. It also means that water stress, pests and fungal diseases must be avoided until the leaves naturally senesce and fall.

#### 3.2 Restoration of Nutrients

The amounts of mineral nutrients typically removed in each tonne of grapes from Riverina vineyards are substantial (see Table 2). Significant proportions of the seasonal grapevine requirement for each of the major mineral nutrients namely, nitrogen, phosphorous and potassium, are accumulated during the post-harvest period (see Table 3).

Mineral Nutrients	Kilograms Removed Per Tonne
Nitrogen	2.13
Phosphorous	0.33
Potassium	3.34
Magnesium	0.15

**Table 2** Mineral nutrients removed in each tonne of Chardonnay in the Riverina (data is the average of 6 vineyards sampled in 3 seasons)

	Nitrogen	Phosphorous	Potassium	Magnesium	Calcium
Proportion of total seasonal uptake (%)	30	30	15	20	20

**Table 3** Typical proportions of total seasonal mineral nutrient requirements taken up by grapevines

 from the soil in the post-harvest period in the Riverina

Minerals are acquired from the soil but in autumn significant amounts move from the leaves to the roots and woody parts of the grapevine before the leaves fall. A healthy, functional, hydrated, leaf canopy is also important for continuity of transpiration and photosynthesis on which mineral nutrient uptake depends. Greater post-harvest mineral nutrient accumulation is found in vineyards where irrigation water has been applied.

#### 3.3 Phosphorous, potassium and other mineral nutrients

Post-harvest phosphorous uptake from the soil continues until leaf-fall, but potassium uptake during that period is relatively small. Studies of phosphorous applications in the Riverina suggest that applications of 5 - 10 kg/ha are generally required to meet grapevine requirements. Despite removal of large amounts of potassium by the grape crop, routine fertilisation with potassium is rarely required in Riverina vineyards.

Calcium and magnesium also accumulate in the roots and woody parts after harvest but little of either of those nutrients are returned from leaves. Their uptake relies largely on young roots which may appear after harvest, particularly if reserves are high at harvest.

#### 3.4 Nitrogen

In the Riverina, nitrogen uptake from soil after harvest can make a major contribution to winter reserves. Between harvest and leaf-fall the amount of nitrogen in the roots and woody parts of grapevines in nitrogen-enriched soil increases almost threefold. Post-harvest nitrogen enrichment also raised leaf petiole nitrogen levels at flowering in the following spring.

Riverina based studies of Chardonnay also showed that approximately 16% of the nitrogen stored in spurs during winter came from leaves after harvest (see Table 4).

Leaves	Nitrogen %	Phosphorous%	Potassium %	Magnesium%
Retained	0.75	0.091	0.70	0.131
Removed	0.63	0.082	0.67	0.121
Difference	16% less	10% less	4% less	8% less

**Table 4** The influence of removal all leaves from the day of harvest on winter nutrient reserves in spurs

 of Semillon grapevines in the Riverina

Uptake of nitrogen from cold soil is particularly slow and may slow normal leaf greening. Post-harvest storage of nitrogen (and other nutrients) ensures that adequate reserves are already in the plant in spring.



Figure 3 Seasonal nitrogen contents in various parts of a 10-year old Shiraz grapevines in the Riverina. BB; budburst, F; flowering, V; veraison, H; harvest, LF; leaf fall

Whether or not nitrogen needs to be applied after harvest will depend on soil fertility. Figure 3, based on actual measurements of Shiraz grapevines with an average yield of 15 tonnes per hectare in the Riverina suggests that after harvest more than 30kg of nitrogen is restored per hectare. Given that most of 70% comes each season from the soil and about 30% is recycled from the leaves, this data indicates that annual nitrogen input needs to be about 21 kg per hectare to support a 15 tonne per hectare crop. The most common source of nitrogen input is by fertilisation but the use of clover in a winter-active permanent sward is an alternative (see section 8).

This estimate assumes that all applied nitrogen is used by the grapevines and is not removed by other plants or microorganisms nor lost by volatilisation to the atmosphere or leaching.

#### 3.5 Timing of post-harvest fertiliser applications

In the Riverina, fertilisers are usually applied from late March into April. Based on research we have undertaken with Chardonnay on Ramsey rootstock, new fine root growth reaches a peak around this time and may continue until leaf-fall. Since most of mineral nutrient uptake is by such roots there appears to be little advantage, on a physiological basis at least, in applying fertilizers for restoration purposes before mid-March.

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### 4. Post-harvest disease control in the Riverina

Shayne Hackett

The question has often been asked. What is the need for post-harvest application of fungicides? The simple answer is that if diseases have been well controlled during the growing season then there is generally little requirement to apply sprays after harvest. However, if there has been a build-up of some diseases earlier in the season and autumn is wet, post-harvest fungicide sprays may be required.

#### 4.1 Powdery mildew Control

In most seasons there is no need to spray for powdery mildew after harvest provided the disease has been well controlled throughout the growing season. However, in the Riverina there may be up to 3 months between harvest and the onset of leaf fall. In humid seasons, powdery mildew can slowly increase from low to moderate or high levels during this time. Severe infections of powdery mildew can disrupt the production and storage of carbohydrates needed for the following spring. However powdery mildew generally only infects young leaves so for post-harvest carbohydrate and mineral nutrient restoration which generally rely on maintaining the functionality of existing leaves this may be of little consequence.

While this applies to mature grapevines, the carbohydrate and mineral restoration of young growing grapevines may be greatly affected if powdery mildew control is not maintained during the post-harvest period. Apart from impaired reserves, affected vines fail to harden-off and are susceptible to winter chill. It is also very important to prevent the powdery mildew from establishing in the buds of young grapevines and thus creating a recurring problem, associated with self-infecting 'flag' shoots, for seasons to come. Maintaining low levels of the disease in young grapevines will minimise the potential for this disease from establishing in the first place.



**Figure 4** Powdery mildew on young Zinfandel vines. The infection should be controlled to prevent bud infection and damage to the green shoots (Photo S Hackett).

One of the more important consequences of powdery mildew development during the post-harvest period is the increased potential for the formation of cleistothecia; the overwintering spore-forming structures of the powdery mildew fungus, *Erysiphe necator*. If powdery mildew is well controlled during the post-harvest period, the development of these spore bodies can be minimised so that the potential for new infection early in the next season is also minimised.

In most cases, one post-harvest application of a sulphur-based product should protect the foliage from further infection. As the shoots lignify, they become resistant to infections. If the incidence of Powdery mildew is particularly high and fungicides other than sulphur forms are contemplated, the use of single-site mode of action fungicides should be avoided to reduce the potential for the development of fungicide resistance.

#### 4.2 Downy Mildew Control

Maintaining healthy leaves aids the restoration of carbohydrate and mineral nutrient reserves. Post-harvest downy mildew infections of mature leaves are not all that common, nor widely recognised, but when they occur they can seriously impair leaf function and should therefore be avoided. If downy mildew has become established earlier in the season, particular care should be taken to avoid the further spread of the disease in order to protect the existing leaves from infection.

Young grapevines should be managed to protect the leaf tissue and maximise the storage of carbohydrates and mineral reserves leading into dormancy. As with powdery mildew, the risk of downy mildew infection reduces as the shoots lignify to become canes. For both young and mature grapevines protectant sprays such as copper or similar should be used to protect any new and existing foliage. Avoid the use of synthetic eradicant fungicides which can result in fungicide resistance.



#### Further reading

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## 5. Pest and disease monitoring in winter before pruning

Shayne Hackett

Before pruning in winter is a good time to monitor a vineyard for overwintering pests and diseases that may become serious problems. While conditions during the following season will usually determine whether the pests or diseases actually become a threat, in some cases, pruning can be used to minimise the risk of disease later on. In other cases knowing in advance where the threat is likely to come from and where to focus control measures can be far more efficient and effective than applying remedies to the whole vineyard after pests or diseases have spread from a 'hotspot' across the whole vineyard. The following is a description of the major pests and diseases that can be found in Riverina vineyards and how their incidence and severity in winter relates to the risk of an outbreak in following season.

#### 5.1 Powdery mildew

The potential for powdery mildew to become a problem starts with the amount of the fungus surviving from one season to the next in infected buds or as Cleistothecia. Grapevine buds become infected with the fungus as they form during the season and develop into so-called 'flag' shoots in the following spring. Cleistothecia form late in the season when the mildew is allowed to build up to high levels.

At budburst 'flag' shoots emerge heavily infected with powdery mildew which under the right conditions, produces spores that spread to infect green shoots, leaves, flowers and grape bunches. Grapevine buds are susceptible to Powdery mildew infection for about 18 days from the time they appear at the base of each leaf. However because 'flag' shoots emerge at budburst already infected with the mildew it is likely that the buds already formed on those shoots have become infected. As a result, it is most likely that those buds will produce new 'flag' shoots in the following season. The retention of spurs bearing such buds means that powdery mildew tends to first appear season after season on the same vines in the same part of the vineyard. Identifying those 'hotspots' is the most effective way of breaking the reinfection cycle and minimising the need for chemical remedies.

While it is not possible to detect 'flag' shoots in winter, it is possible to identify canes that are heavily scarred by Powdery mildew and that are likely to have 'flag' shoot buds. The position of the scarring along the cane indicates the time of infection in the previous season and where 'flag' shoot buds are most likely to be. Before pruning, look for vines bearing canes with scarring around the lower buds (nodes 1 and 2, see Figure 6). To greatly reduce the risk of powdery mildew becoming a problem, avoid retaining such canes or forming spurs from them. A practical way to deal with this risk in winter is to inform pruners where vines with such canes have been found and to instruct them that canes or spurs that are scarred in that way should be removed, particularly if replacement canes can be used. If some scarred spurs or canes have been retained, consider the use of a systemic fungicide at about 4 weeks after budburst. Spraying earlier than this is not considered as effective as often flags shoots emerge several weeks after normal budburst.



#### 5.2 Australian Grapevine Yellows

Australian Grapevine Yellows (AGY) disease is caused by a bacteria-like microorganism called a phytoplasma. AGY disrupts the normal growth of shoots by blocking the flow of nutrients and sugars within them. It is thought that the disease is transmitted to grapevines by leaf hoppers from other infected plant hosts.

Recognition of AGY generally requires the presence of more than one symptom. One symptom alone is generally not considered a reliable diagnosis. Usually only a few shoots on a vine show symptoms. The most common symptoms that may be observed in winter are shoots with dead tips and abnormally short internodes that have failed to form hardened canes. The shoots feel rubbery and appear slightly purple.

Where AGY infected shoots are detected, the cordon from which they have grown should be removed and replaced with a healthy cane from near the crown. Severely infected vines should be cut off below the cordons and re-formed with new shoots.

#### 5.3 Botryosphaeria rot and Eutypa dieback

Botryosphaeria rot ('Bot' rot) and Eutypa dieback are trunk diseases that can lead to a gradual decline in grapevine growth and productivity over a number of years. Monitoring for trunk diseases should be carried out prior to the pruning season so the appropriate remedial action can be carried out. Symptoms to look for in winter and remedial actions are described in section 7.

#### 5.4 Grapevine Scale

Grapevine scale is a small, oval shaped, sucking insect up to 6 mm long with a dark brown, waxy shield-like coat. The insect feeds mainly on the shoot stems or canes. When its numbers are high grapevine scale reduces vine growth and grape production.

Grapevine scale is most readily detected after leaf-fall. It is quite common for grapevine scale to occur in high numbers in small areas of a vineyard; particularly those that have been minimally pruned or hedge-pruned where a high proportion of the previous seasons' wood is retained. 'Hot spots' of grapevine scale should be identified for appropriate remedial action.

Usually, adequate control can be achieved with careful pruning of infested canes if pruners know what to look for and where.

# 6. Preparing for pruning in the Riverina

Jason Cappello

Pruning is one of the most costly but critical aspects to successful grape growing. Pruning has important impacts for vine function as it influences:

- the form and size of the vine
- the balance between vegetative and fruit growth within the vine
- the quantity and quality of fruit production

Because of the impact of this operation it is important to prepare carefully in the lead-up to leaf-fall, after which, pruning may commence.

The post-harvest period is an ideal time for an appraisal of grapevine 'balance', and planning for winter training and pruning.

#### 6.1 The timing of pruning

In the Riverina leaf-fall normally occurs in May, depending somewhat on seasonal weather. The timing of pruning within the period from leaf-fall to budburst in September is not particularly critical. Varieties such as Chardonnay, Colombard and Verdelho which burst in early spring are often pruned last in order to delay budburst as long as possible and thus minimise the risk of frost damage. Varieties such as Sauvignon Blanc which normally burst later are often pruned first, from late May to early June.

#### 6.2 Managing Botryosphaeria canker and Eutypa dieback

Both Botryosphaeria canker and Eutypa dieback occur in Riverina vineyards and can only be controlled by removal of infected arms and trunks. Prior to pruning, infected vines are best identified in preparation for instructing and equipping pruners for dealing with infected vines and the wood removed from them.

#### 6.3 Assessment of bud fruitfulness

Before pruning, bud fruitfulness may be assessed by collecting and dissecting buds under a microscope and counting the number of inflorescences. This can be performed rapidly and results can be obtained well before decisions on pruning levels are made. The method also allows an assessment of the extent of any primary bud necrosis, a condition that causes less fruitful secondary buds to burst and consequently lower yields. There are a number of commercial bud dissection services, and the cost is approximately \$1.50 per bud.

Bud dissections are most useful when done over multiple seasons, so that long-term trends can help establish the normal level of fruitfulness in the vineyard and more confidently identify seasons of unusually high or low fruitfulness. Long-term trend data also provides a better chance to distinguish seasonal or weather-related effects on fruitfulness that are beyond the control of viticulturists from issues directly associated with the management of a particular block or vineyard.



#### 6.4 Grapevine 'balance'

Leaf-fall is a convenient stage to assess grapevine 'balance'. Unbalanced grapevines may be easily recognised by their great variability in shoot length and/or their incompletely ripened canes. Unbalanced grapevines also have a high number of shoots that bear less than two bunches and many buds that do not burst at all. Unbalanced grapevines require a careful re-appraisal of pruning practices regarding the number of buds to be retained and subsequent canopy management practices.

#### 6.5 How is pruning to be done?

Spur pruning is generally the most economical system of pruning wine grapes and is ideal for the Riverina. Growers can choose from a range of cost-effective spur pruning technology to suit most grapevine training systems but the critical decision is less about the cost of pruning (i.e. the cutting operation itself) and more about the most cost effective way of pruning for achieving grapevine 'balance' and the benefits that flow from it; namely, maximal sustainable grape yield and quality with minimal variation from season to season. From this perspective growers have a broader question to consider before pruning, that is; what is the most economical training system for achieving 'balanced' grapevines?

In the future robotic pruning systems may expand the range of grapevine training system options but at present NWGIC research and experience suggests that the training systems which lend themselves to mechanical pre-pruning and manual adjustment of the number of fruit-bearing spurs are best suited to achieving grapevine 'balance' across a vineyard.

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### 7. Pruning in wet conditions – a major disease risk

Sandra Savocchia, Wayne Pitt and Tony Somers

Infection of grapevines by both *Eutypa lata*, the fungus that causes Eutypa dieback, and Botryosphaeriaceae spp., the group of fungi that cause 'Bot' canker, results in decline and dieback of grapevines. Both diseases have been found in grapevines in the Riverina.

The diseases start when the fungi infect the wood, usually through pruning cuts and other wounds. Infection leads to the formation of cankers, small areas of dead tissue that slowly expand, usually over a number of years, causing a slow decline and dieback of the trunk and cordons. Dieback leads to the loss of shoot-bearing spurs along cordons resulting in fewer shoots and less fruit. Botryosphaeriaceae spp. may also infect grapes resulting in bunch rot.

#### 7.1 Disease symptoms

#### 'Bot' canker

• Death of spurs and buds (Figure 8)



• Cankers around pruning or other wounds (Figure 9)





- Wedge of dead or dying tissue when spurs, cordons and trunks are cut in crosssection (Figure 10)
- Bleached or discoloured canes with fruiting bodies (pycnidia) forming on dormant wood tissue
- Bunch rots with pycnidia appearing on the berry surface

#### Eutypa dieback

- Wedge of dead tissue when spurs, cordons and trunks are cut in cross-section (Figure 10)
- Cankers around pruning or other wounds (Figure 9)
- Fruiting bodies (perithecia) may be seen on blackened dead wood of cankers of old vines by scraping back the surface of the wood (Figure 11)



Figure 11 Dead wood containing the fruiting bodies of *Eutypa lata* (Photos: Mark Sosnowski SARDI)

Stunted shoots with short internodes and cupped leaves with dying edges (Figure 12)



Few bunches, poor berry set and variable berry ripening

Figure 12 Stunted shoots with shortened internodes and cupped leaves with dying edges margins, symptoms characteristic of Eutypa dieback.

#### 7.2 Disease cycles

#### 'Bot' canker

The causal fungi of 'Bot' canker overwinter as pycnidia (Figure 13) on diseased wood and pruning debris and release spores throughout the year, particularly during wet conditions. Spores can germinate and grow over a wide range of temperatures  $(5-40^{\circ}C)$  depending on the fungal species.

Infection occurs when spores are dispersed by wind or rain, subsequently colonising fresh pruning or other wounds. Wounds are most susceptible to infection immediately after pruning and become less susceptible as the wounds heal. There are reports from California that wounds may remain susceptible over the course of the dormant season. The exact period of susceptibility under Australian conditions remains unknown, but it does depend on wound size and age, time of pruning and daily temperature. For example, smaller wounds made towards the end of grapevine dormancy in early spring when temperatures increase, heal more rapidly and are susceptible for a shorter period of time than wounds made in mid-winter.

#### Eutypa dieback

*Eutypa lata* produces fruiting bodies on blackened areas of infected dead wood and following wet periods (overhead irrigation or rainfall) spores are released and splashed or blown onto fresh wounds.

As little as 2mm of rain can release spores which then germinate at a wide range of temperature between 2 - 25°C. Eutypa dieback is most common in high rainfall (500 - 600mm per year) areas but can also occur in low rainfall areas. Overhead irrigation can also contribute to spores being released.

Wounds are most susceptible to infection at the time the pruning cut is made and become less susceptible as the wounds heal. Like 'Bot' canker, susceptibility to Eutypa infection is influenced by wound size and age, time of pruning and daily temperature.



#### 7.3 Preventing 'Bot' canker and Eutypa dieback

- Prune during dry weather and do not prune if rain is predicted as spores will be released and may land on fresh pruning wounds.
- Prune early in winter when spore production is low or late in dormancy after sap flow begins as wounds are less susceptible to infection and heal rapidly.
- Currently there is little or no evidence that contaminated pruning tools contribute to the spread of grapevine trunk diseases. However, the practice of decontaminating pruning tools may be beneficial for minimising the spread of other pests and diseases of grapevines.
- Remove diseased wood from the vineyard, preferably burning the wood. If the vineyard is 'barrel pruned' by machine, the wood is cut into short lengths and falls on the vineyard floor. In this case it is impractical to remove the wood. If it can be incorporated into the soil by slashing or cultivation, the risk will be minimised.
- If trunk diseases are detected in grapevines, remove visibly infected wood and at least 10cm of healthy wood below it.

- Infected cordons or whole grapevines may be replaced by laying down new canes or training up shoots from below the infected area. If machine pre-pruning is to be used, lay down replacement canes before this operation.
- 'Double pruning' has been reported to significantly reduce infection by *E. lata*. During 'double pruning' the grapevines are mechanically pre-pruned early in winter, leaving long canes. Canes are then pruned to two buds in late winter prior to bud burst, when spore production is low and wound healing is accelerated.
- Protect fresh pruning wounds with fungicides, paints, pastes and biological control agents. The following products are currently registered in Australia.

Product	Use
Greenseal (Tebuconazole, 10g/L)	Pruning wound dressing for control of Eutypa dieback
Vinevax	Biological fungicide

 Table 5: Recommended products for protecting pruning wounds from disease

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# 8. Floor management for the Riverina; a sustainable approach Robyn M. Wood

With the increasing pressures on wine-grape growers to conserve water and energy, it is vital that we find ways to improve the efficient use of water and minimise water losses. Vineyard floor management can greatly assist in achieving this. Vineyard floor management aims to preserve optimum soil surface structure to ensure that water infiltration, drainage and aeration are optimal. This can only be achieved in established vineyards if soil tillage is reduced to an absolute minimum and if floor plants are used wisely to preserve high populations of beneficial organisms, including earthworms, bacteria, fungi and nematodes, in surface soil.

The greatest water loss from a vineyard during the growing season is due to the water usage, via transpiration of grapevines and summer-active plants, together with evaporation from the soil. At times, evaporation from wet soil can be the greatest loss from a vineyard. While transpiration and evaporation are generally considered together as evapotranspiration, they are separate processes to be managed.

Water loss through grapevine transpiration can be minimised through proper canopy management that reduces excessive foliage. On the other hand, evaporation from the soil can be reduced significantly with an appropriate floor management which is the topic of this article.

A range of vineyard floor management options have been researched and tried commercially over the years. They have included tillage, annual cover crops and annual or perennial grass swards. Some rely on the regular use of herbicides or application of mulches along the grapevine row.

Several points are worth making in regard to the sustainability of these options on economic and environmental grounds:

- Tillage and annual cover cropping are expensive in terms of the costs of fuel, labour and seed.
- Continuous annual use of tillage or herbicides can result in the breakdown of soil structure which, in turn, can reduce water penetration into the soil and limit access of nutrients and water to the vine.
- Long-term reliance on herbicides often favours the build up of large populations of summer-active broadleaf weeds that are significant users of water and also hosts of some grapevine insect pests (e.g. Light Brown Apple Moth)
- Importing and applying mulch is not an economically or environmentally sustainable practice. Its use in the short term may be justifiable when applied along the grapevine row during vine establishment when weed control is essential.

#### 8.1 Advantages of a permanent vineyard floor cover

# Improved capture and infiltration of moisture from rain, dew and irrigation

Dew as a source of plant moisture is rarely considered in water budgets. However, the presence of living grasses in winter actually creates a large condensation surface that captures significant amounts of dew. The cold winter nights of the Riverina particularly favour dew formation and this dew may provide some moisture for the mid-row sward during drier periods.

#### Improved soil water-holding capacity

The generally deep roots of perennial grasses can also greatly assist in increasing the water- holding capacity of a soil by promoting water infiltration to depth.

Improved nutrient availability for grapevines from capture and recycling of nutrients between the sward and the soil

During winter the perennial grasses take up nutrients from the soil, not only from the top but also at depth. In spring and summer when the grass sward is dormant some rootlets decay naturally to release nutrients back into the soil and hence become available to the grapevine during its growing season. Where the grasses capture nutrients that would otherwise be leached from the root zone, this strategy can also significantly reduce the need for fertilisers.

#### Fibrous roots bind soil and add organic matter (humus)

The presence at all times of actively growing and naturally-decaying roots, of either grapevines or grasses ensures a renewable supply of organic matter and maintains nutrients in the top part of the profile, where they may be accessed by the grapevines when required.

- Chemical-free control of spring/summer broadleaf weeds
   Winter-active grasses cover and shade the ground in late winter and prevent
   germination of common summer-active broadleaf weeds.
- Chemical-free control of insect pests

Pollen of grasses is food for insects such as lacewings, wasps, lady beetles, predatory shield bugs and predatory mites that keep grapevine insect pests such as grapevine moth under control.

Grasses also prevent the establishment of broadleaf weeds that are host to insect pests such as Light Brown Apple Moth and garden weevil.

- Lower grapevine canopy temperatures in summer The presence of a dormant grass cover in summer reduces heat radiation from the ground and thus significantly moderates heating of grapes and leaves.
- Trafficable surfaces that facilitate critical fungicide applications in spring
- One-off cost of establishment and low maintenance

#### 8.2 Species cultivar selection

It is essential to select grass species that are winter growing and summer dormant such as perennial rye and fescue; either a mix or alone. Regionally suited cultivars should be selected in consultation with a local agronomist. The cultivars should be early maturing, that is, they should set seed in early spring and suited to the soil type.

Medics, clovers and/or vetches can be included as a source of nitrogen for the grasses; and the grapevines in spring.

Native grasses are also an option provided they are winter-growing and spring/summer dormant (unfortunately there are very few with these attributes that are commercially available).



**Figure 14** A permanent winter-growing perennial grass and clover sward across the entire vineyard floor. A. Winter, B, Summer in the same vineyard (Note that in winter (A) the grasses were established in the mid-row in the previous winter and then allowed to spread under the vines in the current winter. In the RHS of the photo where the grasses have established broadleaf weeds are absent. An application of a broadleaf-selective herbicide allowed the grasses to fully establish as shown in summer of that season (B)) (Photos R Wood)

#### 8.3 General Guidelines for establishment

Till the soil to remove trash and provide a fine tilth for sowing. Sow as early in autumn as possible to maximise early growth; i.e. warm soils but the start of cold nights that bring dew which can be an effective substitute for autumn rains.

Sowing rate will depend on the species mix and region, however doubling the recommended pasture rate (i.e. to 50 kg per hectare) will help to ensure a dense cover to out-compete the broadleaf weeds.

Either direct drill seeds or broadcast with a single strength superphosphate at a rate of 100 kg per hectare and a soluble nitrogen fertiliser

Medics, clovers and vetches should be inoculated with the appropriate strains of rhizobium and either broadcast or no-till drill either the grasses or into well established grass stands. In some situations rolling the rows after sowing improves soil contact with the seed for better germination.

In the first season, control broadleaf weeds in winter with one or two applications of a selective herbicide when the weeds are at the rosette stage. This is generally only required for one season to allow the grasses to become established.

#### **Further Reading:**

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