

VINEYARD WEED CONTROL

GLYPHOSATE RESISTANCE

Barossa Viticulture Technical Group

FACT SHEET

2010

Controlling weeds in vineyards is a key management practice to ensuring good vineyard performance and the sustainable use of resources. The use of herbicides is a primary weed control tool due to their effectiveness and cost efficiency, however problems with their use such as resistance development may arise if they are used inappropriately.

The broad spectrum herbicide, glyphosate, has for many years provided agriculture with a very effective and cost efficient means of controlling weeds in crops, and notably has provided grape growers with excellent under-vine weed control. Whilst this herbicide continues to meet the needs of grape growers, issues with resistance development to glyphosate among some

weed species - notably annual ryegrass - have arisen. This problem has been observed in broad acre cropping for a number of years, and is becoming increasingly evident in vineyards in several states of Australia.

This fact sheet has been produced to raise awareness around herbicide resistance, and provide practical advice on how to reduce

the risk of development, and how to manage it. Herbicide resistant weed populations can also spread beyond the individual farm or vineyard, so all users of herbicides have a degree of responsibility in managing this risk, whilst also undertaking best management practices and caring for the environment.

Key Points

- Populations of annual ryegrass resistant to glyphosate have been confirmed in Australian vineyards
- The numbers of cases of glyphosate resistant annual ryegrass in vineyards has been growing rapidly in recent years
- Glyphosate is too valuable to lose from vineyard systems, and replacement products may be more expensive or years away from being available
- Over-intensive use of a herbicide is the primary cause of resistance development

Understanding herbicide resistance

Cost to viticulture

The real cost of herbicide resistance to viticulture is difficult to quantify, but it has the potential to become increasingly significant. Issues such as having to increase the number of herbicide applications per season, or having to use more expensive herbicides or control methods can impose additional and unexpected costs for grape growers.

There may also be increased costs with the need for more intensive vineyard hygiene and monitoring practices where herbicide resistant weeds exist. Growers must also consider environmental impacts when addressing herbicide resistance, and carefully consider any negative impacts of changes in practices such as agrochemical inputs or cultivation.

How does it occur?

Herbicide resistance may occur when a weed species is intensively treated with one herbicide (or group), and no alternative herbicide or weed control method is employed over a considerable period of time. In any weed population there can be small numbers of weeds with some natural resistance, brought about by factors such as gene mutation or selection pressure (see Figure 1). When applied correctly, herbicides will kill the vast majority of the target weed

population. However, the continued and sole use of one herbicide (or group) can eventually result in an increasing number of resistant weeds in the population to where resistance ultimately becomes a problem.

Species affected and cases reported

Herbicide resistance in agriculture has been documented in several weed species, and to several herbicides, however so far the only reported cases in vineyards are with glyphosate resistance in annual ryegrass. Glyphosate resistance has also been reported in Barnyard Grass (NSW and QLD) and Liverseed Grass (NSW), although to date this problem has not been reported in any vineyards.

Glyphosate resistance in annual ryegrass was first discovered in 1996 from a farm site in Victoria, and has since been found in SA, NSW and WA. Current scientific research has confirmed around 100 sites with glyphosate resistance across these states, with the number of confirmed cases increasing at a rapid rate (see Figure 2). This however may only be 20% of all cases as this figure does not take into account unreported or non-scientifically tested cases. Furthermore, many of the more recent scientifically tested cases in SA have been found in vineyards.



Modes of resistance

There are two mechanisms by which resistance develops; gene mutation and reduced herbicide translocation. Both mechanisms convey resistance, although some weed populations can accumulate both mechanisms and become highly resistant.

Spread of resistance

The spread of resistance (ie increasing number of cases) is due to two factors. The first factor is the development of new herbicide resistant weed populations due to selection pressure (ie intensive use of the herbicide).

The second factor is through the physical spread of herbicide resistant weed seeds. Resistant genes can potentially spread through seed and pollen movement, although in the case of glyphosate resistance, gene transfer through pollen movement has not been shown to be a major factor. In the case of glyphosate resistant annual ryegrass, seeds can be spread by wind (over relatively short distances), livestock, crop seed, and imported straw mulch or fodder. The other way in which seed can be spread is on machinery, such as vineyard mowers, cultivation equipment and machine harvesting equipment.

How quickly does glyphosate resistance develop?

Field experience and simulation modelling suggests that the likelihood of glyphosate resistance development can increase substantially after a weed population has received approximately fifteen years of glyphosate applications. However, many field populations have received numerous glyphosate applications over longer periods of time and have not developed glyphosate resistance. Some users of glyphosate have suggested that as resistance increases to glyphosate, new replacement products will become available. This is simply not the case. Currently there is no glyphosate equivalent in development, and even if one were found today, it could take ten years before registration would be completed.

Therefore it is essential that users of glyphosate use it responsibly, and take all possible steps to prevent the development of glyphosate resistant weeds.

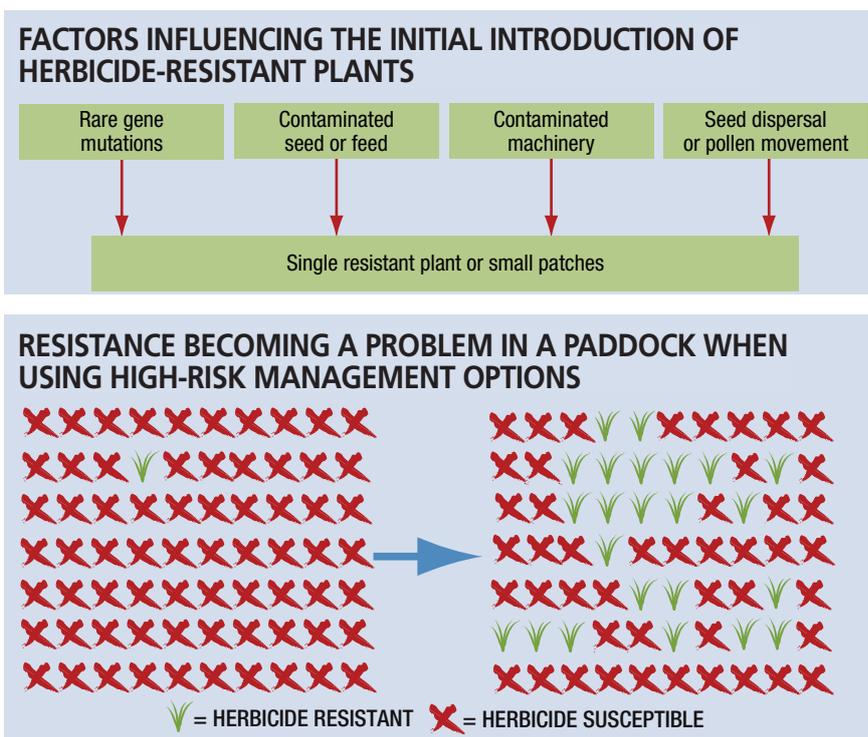
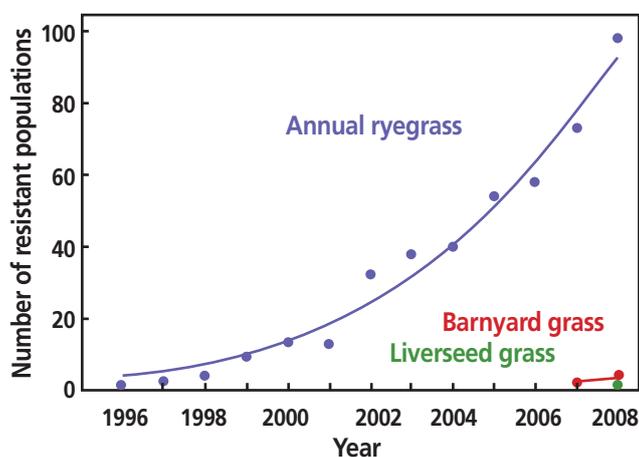


FIGURE 1

Source: Grains Research and Development Corporation, 2009. "Herbicide Resistance Fact Sheet, Glyphosate and Trifluralin – non-selective herbicides losing control".



Glyphosate-resistant annual ryegrass populations by states:

State	Number of populations
NSW	44
SA	33
WA	11
Vic	10

FIGURE 2

Source: Australian Glyphosate Sustainability Working Group, 7/10/2009. "Australian glyphosate resistance register: summary". www.glyphosateresistance.org.au.

Identifying herbicide resistance and assessing your risk

What does glyphosate resistance look like?

In the field, glyphosate resistant populations generally begin to appear as a scattering of single plants or small patches of plants that have survived a glyphosate application (see Figure 3). Resistant plants are likely to show typical glyphosate damage symptoms. Growth is affected for a few weeks before the weeds recover. This may indicate developing resistance, however other factors apart from resistance may be responsible for poor herbicide performance. Annual ryegrass is a winter-spring plant that emerges in late autumn. Germination is greatest at 2 to 4 centimetres seed depth, with optimum germination occurring at soil temperature of around 11 degrees Celsius. The majority of seed germination occurs after the first two rainfalls of greater than 20mm. Annual ryegrass seed remains viable in the soil for at least four years which suggests that resistant weed populations could take several years to eliminate. Photographs of annual ryegrass infestations are included in this fact sheet (figures 5 & 6), however if growers are unsure of a weed species in their vineyard they should seek expert agronomist advice before taking action.



Figure 3. Example of an 'escape' weed in a Pea crop (Source: www.pestresistance.com)

Assessing your risk

Anyone who uses glyphosate intensively is at risk of developing glyphosate resistant weeds in their vineyard. There is also the risk of glyphosate resistant weed populations being introduced to the vineyard as plants or seed. There are several factors to consider when evaluating herbicide resistance risk as described in this fact sheet. Failure to achieve expected weed control levels does not automatically mean that herbicide resistance is the reason. A full analysis of the herbicide application, rate of use, weed type and stage of growth, climatic conditions and agronomic practice should be reviewed.

A quick reference risk assessment chart is provided in this fact sheet (figure 4). Below are some key questions to ask when assessing risk and considering if you have herbicide resistant weeds in your vineyard.

- ◆ Has the same herbicide (or group) been used exclusively in the vineyard for several years?
- ◆ Has the uncontrolled species been successfully controlled in the past by the herbicide in question?
- ◆ Does the pattern of surviving plants suggest a spray miss or other application problems?
- ◆ Has a decline in control been noticed in recent years?
- ◆ Are there known cases of resistant weeds in adjacent vineyards, paddocks, headlands, roadsides, etc?
- ◆ Is the level of weed control generally good on the other susceptible species?
- ◆ Have other control methods been used in recent years to control weeds?
- ◆ What spread factors has the vineyard been exposed to? (eg import of seeds from other properties)

- ◆ How good have herbicide application practices been in recent years? (eg coverage, rates, uptake)
- ◆ Is there a good understanding of the products used (eg do they include glyphosate as their active)?
- ◆ Have high weed populations been allowed to develop in the past before herbicides were applied?
- ◆ Have there been escape weeds from previous sprays, and were these allowed to grow and set seed?

If resistance is strongly suspected after assessing the risk factors, expert agronomist advice should be sought. One option might be to have the suspect weeds scientifically tested for resistance.

Key Points

- Weeds that survive herbicide application should be investigated as they may indicate resistance, and if allowed to set seed, pose the highest risk of herbicide resistance development
- Annual ryegrass is a winter-spring grass, and is most at risk of developing glyphosate resistance
- The application of any herbicides poses some risk of resistance development, but this risk can be significantly reduced through Integrated Weed Management (IWM) practices
- Herbicide resistant weeds can quickly spread over short and long distances depending on management and vineyard hygiene practices
- Monitoring weed populations, control practices and their efficacy are vital tools in assessing risk and preventing resistance development

FIGURE 4. Assessment of resistance risk

Management Option	Risk of Resistance		
	Low	Moderate	High
Herbicide mix or rotation	>2 modes of action	2 modes of action	1 mode of action
Weed control methods	Cultural, mechanical and chemical	Cultural and chemical	Chemical only
Use of same mode of action per season (herbicide group)	Once	More than once	Many times
Poor herbicide application practices (coverage, timing, rate, conditions)	Low coverage or uptake but no weeds survive to seed set	Some escape weeds from spraying but are killed pre seed set via other controls	spray escape weeds that also set seed
Weed infestation	Low	Moderate	High
Control in last 3 years	Good	Declining	Poor

Adapted from Herbicide Resistance Action Committee, David Nevill et al, August 1998. HRAC Management and Weed Resistance - the Role of HRAC in the Management of Weed Resistance (www.pestresistance.com).



Figure 5. An example of a high population of glyphosate resistant annual ryegrass along a Barossa vineyard under-vine bank that has been allowed to set seed

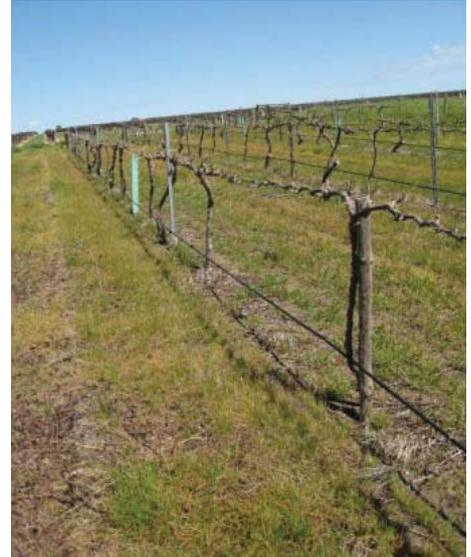


Figure 6. An example of widespread glyphosate resistant annual ryegrass in a Barossa vineyard

Preventing and managing herbicide resistance

Integrated weed management

There are many ways to manage glyphosate resistance and to avoid or slow its onset. Planning is essential. Investigate the various weed management options that are available and create a weed management plan that has a range of strategies that are flexible and reviewed regularly.

In vineyards, the strategic use of alternative knockdown herbicides, residual herbicides and herbicide mixtures, cultivation, mowing and mulching are all weed control strategies that can be used to help reduce the risk of developing glyphosate resistant weeds.

How to reduce the risk of glyphosate resistance development

Even if you don't have glyphosate resistant annual ryegrass in your vineyard, you still need to reduce the risk of resistance development.

Continuous use of glyphosate, and allowing ryegrass numbers to increase, are both situations that amplify the risk of glyphosate resistance occurring and should be avoided. The following strategies will go a long way to reducing the risk of developing glyphosate resistance:

Strategies to improve weed control:

- ◆ Sustainable weed management requires a diverse range of weed control methods - i.e. Integrated Weed Management (IWM)
- ◆ Integrated strategies should embrace the use of herbicides, but not be wholly herbicide dependent for an indefinite period of time
- ◆ The rotation of herbicides with different modes of action is an essential strategy to avoid herbicide resistance development
- ◆ Keep weed numbers as low as possible
- ◆ Practice good farm hygiene to prevent the introduction and movement of resistant seeds or plants (e.g. clean mower between blocks or properties)
- ◆ Consider non-chemical strategies
 - Undervine mulching
 - Undervine mowing
 - Undervine cultivation
- ◆ Maintain good field records to monitor the rotation and effectiveness of control methods, and to ensure that any reduction in herbicide efficacy can be detected and acted upon early
- ◆ Control escape populations - early control of these small patches is critical to prevent resistant plants from setting seed
- ◆ Optimise herbicide efficacy through good spray coverage and ideal spray conditions

Key Points

- Herbicide resistance development can be prevented
- The first step is to assess your risk
- Reliance on a single herbicide or control method over a long period should be avoided
- The adoption of Integrated Weed Management (IWM) will go a long way to preventing resistance development and reducing long term costs
- Ensuring herbicides work effectively through good application practices can also reduce the risk of resistance development
- DO NOT do nothing if you notice poor control after applying glyphosate, and 'escape' weeds should not be allowed to survive and set-seed

Strategies to improve herbicide efficacy:

Herbicide choice

- ◆ When knockdown herbicides are used, rotate the use of glyphosate with herbicides of a different mode of action
- ◆ Consider using residual herbicides (eg pre-emergents)
- ◆ Check products mode of action and herbicide group

Herbicide application

- ◆ Control weeds early (i.e. after first autumn rains)
- ◆ Use herbicides at the right rate and at the right time
- ◆ Calibrate herbicide equipment to ensure optimum coverage
- ◆ Monitor herbicide coverage and assess control

Spraying conditions

- ◆ Good soil moisture (eg avoid spraying when weeds are under moisture stress)
- ◆ Low wind (eg avoid spraying in wind that can reduce coverage)
- ◆ Suitable Delta-T (eg avoid low humidity and high temperatures)

Weed factors

- ◆ Spray when weeds are small and populations are low
- ◆ Time sprays to control all germinations

- ◆ Avoid spraying stressed weeds (eg due to frost or low soil moisture)
- ◆ Control escape weeds throughout the season to prevent seed-set

How to control Glyphosate resistant weeds

If you have identified that your vineyard contains glyphosate resistant ryegrass, where to from here?

Herbicide Choices:

- ◆ Use herbicides with different modes of action, but caution is required using Group A herbicides (eg fluazifop-P) to control resistant ryegrass as resistance can develop with this group also
- ◆ Look at other herbicide options (eg knockdowns such as paraquat/diquat, glufosinate ammonium, amitrole/paraquat, and pre-emergent's such pendimethrin or oryzalin)
- ◆ Use correct rate for weed size
- ◆ Look at additives to increase herbicides efficacy and buffer against low water quality (avoid high pH or water high in minerals)

Timing:

- ◆ Time herbicide applications early when weeds are small and easier to kill with normal label rates (ie don't wait until there are high or dense weed populations)

- ◆ Control ryegrass as soon as possible after Autumn germination and before seed-set
- ◆ Consider a "double-knock" strategy, especially for dense and large stands of annual ryegrass (eg two sprays in succession of different groups at approximately 1-14 days apart)
- ◆ Utilise weather forecasts to optimise spray planning and timing (eg use www.spraywisecisions.com.au)

Cultural Practices:

- ◆ Prevent seed-set and seed spread. This maybe required over several years to reduce resistant seed bank
- ◆ Consider other control methods (eg mowing, cultivation)

Finally, seek expert agronomist advice.

Summary

Weed control is an essential component of vineyard management, and if not successful or cost effective, can negatively impact on profitability and sustainability. Herbicides are widely used to provide weed control, but are posed to the risk of resistance development if used inappropriately. Potentially all herbicides are at risk of resistance development with intensive and continuous use. Some herbicide groups are more at risk than others, and some weed species develop resistance more rapidly than others. Glyphosate resistance in annual ryegrass already exists in parts of Australia, and an increasing number of cases have been reported in vineyards in recent years. Awareness and practical information on resistance prevention and management strategies are provided in this fact sheet. Of greatest importance is the adoption of integrated weed management practices so as to maximise the availability and cost effectiveness of weed control options, and in the case of herbicides will ensure their useful life is as long as possible.

For further reading about herbicide resistance, the following websites are useful information resources:

Glyphosate Sustainability Working Group	http://www.glyphosateresistance.org.au
Herbicide product information – the Australian Pesticides and Veterinary Medicines Authority	http://www.apvma.gov.au/
CropLife Australia	http://www.croplifeaustralia.org.au
Resistance testing (or contact local agronomist)	http://www.glyphosateresistance.org.au

References:

- CropLife Australia, 2009, "Herbicide Resistance Management Strategies"
- National Sustainability Working Group, 2006, "Glyphosate resistance on the increase in Vineyards". Media Release.
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- Herbicide Resistance Action Committee, David Nevill et al, August 1998. HRAC Management and Weed Resistance - the Role of HRAC in the Management of Weed Resistance (www.pestresistance.com).

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DISCLAIMER

The information supplied in this fact sheet is offered in good faith and was the best available at the time of publication. However, the specific application of information to individual circumstances will vary from one situation to another, and the understanding of herbicide resistance is constantly evolving. The reader should always consider all other relevant information, and seek professional advice prior to making their own diligent and informed judgement regarding management strategies and practices for their vineyards. All responsibility for vineyard management rests with the reader.

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