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Pesticide impacts on beneficial species

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Introduction

Chemical applications have negative impacts on the populations of beneficial insects of vineyard pests, but these can be minimised by considered use of the chemicals applied. This factsheet provides information on the relative impacts of chemicals used in the Australian viticulture industry on beneficial insects. This information can help growers make an informed choice when deciding on a spray program. Moving the balance of pest control away from chemicals to the control provided by beneficial organisms has the potential to reduce costs, and supports the wine industry's focus on sustainability.

Beneficial insects and pest control

Chemicals are still the main means of pest and disease control in vineyards, but they may have negative effects on beneficials (predators and parasitoids) that exert control of pests, and on other non-target organisms in the environment. Beneficials can make a major contribution to pest control in vineyards, particularly for pests that are less accessible to chemicals, such as light brown apple moth, mealybugs, grapevine scale, weevils and mites. In this factsheet, we report data on mortality related to chemical applications in vineyards. Chemicals have diverse toxic effects on beneficials, including through residues that affect the survival of a range of life cycle stages, reductions in reproductive capacity, changes in the suitability of hosts for parasitising or predation, and reduced emergence of parasitoids from sprayed host eggs. However, these effects are difficult to assess, and therefore we only focus on mortality in this factsheet.

Figure 1: Ladybird beetles can be diverse and abundant in well-managed vineyards. They not only provide a colourful reminder of the benefits of biodiversity in a healthy vineyard but also a range of species are important predators of scale and mealybugs. Other species eat light brown apple moth eggs and caterpillars. (Photo courtesy MA Nash)

Figure 2: Robber flies make spectacular captures 'on the wing'. (Photo courtesy MA Nash)

Impact of chemicals applied in vineyards on beneficials

Currently, the control of insect and mite pests in vineyards is provided both through applications of chemicals and through the action of the natural enemies of pests, including numerous invertebrate predators and parasitoids. These methods of control are often not compatible, because the application of pesticides can have a negative impact on the beneficial species present in a vineyard. Information on the impact of pesticides on beneficials is therefore essential if viticulture is to move towards less use of chemical applications, which will bring both environmental and economic advantages.

The impact of pesticide applications on non-target species (beneficial organisms) is normally evaluated through standardised sets of laboratory tests involving the application of individual chemical constituents to a few representative species. The mortality of individuals is scored at given concentrations of active constituents to provide information on a lethal dosage, or percentage mortality at field concentrations. Even some 'softer' pesticides may be harmful to particular beneficials, so understanding the potential effects of chemicals that are available is important.

The toxicity ratings for individual chemicals are derived from laboratory and semi-field-based tests in accordance with the guidelines of the International Organization for Biological and Integrated Control (IOBC) Working Group on Pesticides and Beneficial Organisms. Toxicity ratings indicate the reduction in the ability of the beneficial species tested to provide pest control, and range from 1 to 4:

1 The chemical is 'harmless' and kills fewer than 25% of the beneficial species of interest.

2 The chemical is 'slightly harmful' and kills between 25% and 50% of the beneficial species of interest.

3 The chemical is 'moderately harmful' and kills between 50% and 75% of the beneficial species of interest.

4 The chemical is 'harmful' and kills more than 75% of the beneficial species of interest.

Ratings for individual pesticides are assigned according to the highest IOBC toxicity rating assigned when different beneficial species show variation in their ratings for toxicity. As new information becomes available, there will generally be minor changes to these ratings.

The rate of application can be important. For example, sulphur can be used as either a fungicide or a miticide and is compatible with organic systems. The rate at which sulphur is applied has been found to influence its toxicity on important vineyard natural enemies, especially parasitoids (including *Trichogramma*) and predatory mites, so applications are assigned toxicity ratings based on the actual amount applied. The toxicity rating for sulphur is calculated as follows: <3000 g active constituent/ha (g ac/ha) = 1, 3000–4000 g ac/ha = 2, 4000–6000 g ac/ha = 3, and >6000 g ac/ha = 4. The high level of sulphur usage in vineyards leads to this product often having the greatest negative impact on beneficial species.

The impact of pesticides is also complicated by the cumulative effects of multiple applications across a season or of a single application of a mixture of products (tank mixes; see Estimating season ratings below), and by products that contain two or more active constituents. Combined products are given the IOBC toxicity rating for the most harmful active constituent applied: for example, for Ridomol Gold plus® (copper hydroxide and metalaxyl-M), the higher IOBC toxicity rating is for metalaxyl-M, so a rating of 3 is applied to the product.

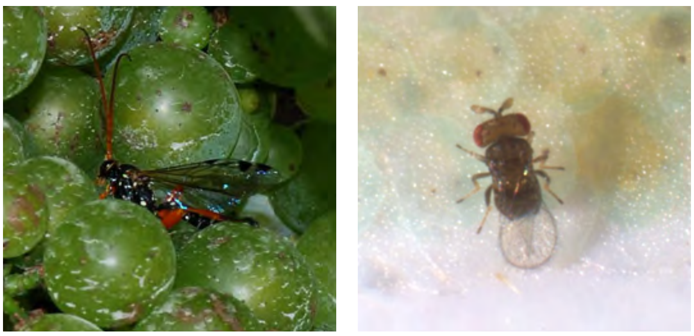

Figure 3: Parasitoids like these are diverse and abundant in vineyards, attacking light brown apple moth, grapevine moth, scale, mealybugs and even mites and weevils. On the right is one of the best-known parasitoids in Australian vineyards, a species of *Trichogramma*, which are important egg parasitoids of light brown apple moth. (Photo courtesy MA Nash)

Sources of information on chemical toxicities

GWRDC has produced information for growers that is available as a user-searchable database (IMPACT for Viticulture) at http://cesar.org.au/index.php?option=com_collateral_manage. The database can be searched by product name or active ingredient, or for impacts on a specific beneficial species. The information is designed to indicate the relative impacts of chemicals used in the Australian viticulture industry on beneficial species, and enables growers to assess the potential impact of different chemicals on beneficials when deciding on a spray program. The database has been devised to make information readily available to growers.

Other sources of information are available. IOBC information is available from Koppert (a biological crop protection company based in the Netherlands) at http://side-effects.koppert.nl/, and from Biobest (a sustainable crop management company based in Belgium) at http://www.biobest.be/neveneffecten/3/3/, for selected beneficals. The University of California also provides information at www.ipm.ucdavis.edu/PMG/r302900111.html. Commercial providers of beneficial insects in Australia also have an interest in raising awareness of chemical impacts, and provide information such as that available at www.goodbugs.org.au/chemicals.html.

Note that products can be toxic to some beneficial organisms, yet still be useful in integrated crop protection. For example, 'hot spots' can be treated without having a significant impact on overall populations of beneficials. In most circumstances, a lower dosage of a product will decrease the negative impact on the population of beneficial insects.

Estimating season ratings

A rating for an entire season can be estimated by summing modified IOBC toxicity values for each application over that season. The modified IOBC toxicity values are obtained by subtracting 1 from each toxicity rating, giving a range of 0–3 (rather than 1–4); the 'harmless' rating of 1 then becomes 0, and so does not contribute to the overall season rating. Where a tank mix of products is applied in one application, the highest individual product score is used. For example, sulphur at 1500 g/ha (0) and indoxacarb (3) applied together would result in a score of 3 being used to calculate the overall season rating. A tool has been provided on the IMPACT for Viticulture webpage (see link given above) to enable growers to calculate season ratings for potential spray programs. Table 1 contains data on the toxicity effects on specific beneficial species of insecticides and miticides registered for use in Australian vineyards.

Table 1: Toxicity effects on specific beneficial insects of insecticides and miticides registered for use in Australian vineyards. Reduction in population (mortality) following application is represented by shading (see legend below). No shading or dash represents no literature found at time of writing (2011). ? indicates that the rating was based on limited data. Data is sourced from scientific literature and databases including IOBC, as compiled on IMPACT for Viticulture (http://cesar.org.au/index.php?option=com_collateral_manage).

Active Ingredient	Grouping	Parasitoids	Predators							Overall rating
			Beetle	Ladybirds	Predatory bugs	Predatory flies	Predatory mites	Lacewings	Spiders	
Bacillus thuringiensis	11C	0	–	0	0	0	0	0	–	0
Sulphur < 3000 g ac/ha	M2	1	–	2	–	–	1	0	1	1
Sulphur 3000–4000g ac/ha	M2	1	–		0	1	1	0	–	2
Sulphur 4000–6000g ac/ha	M2	2	–	–	0	1	2	0	–	3
Buprofezin	16	0	–	1	0	1	0	–	–	1
Chlorantraniliprole	28	0	0	–	–	–	0	–	–	1?
Methoxyfenozide	18	1	–	1	1	–	0	–	–	1
Emamectin	6A	–	–	–	–	–	–	0	–	1?
Petroleum/paraffinic oil	unspecified	–	0	0	–	3	0	2	0	2?
Clothianidin	4A	3	3	–	–	–	3	–	–	3
Carbaryl & methomyl	1A	3	–	3	3	3	3	3	–	3
Fipronil	2C	3	–	–	3	3	3	3	–	3
Dicofol	UN	2	–	0	–	3	3	1	–	3
Indoxacarb	22A	3	–	–	3	0	2	–	–	3
Organophosphates[a]	1B	3	–	2	3	3	3	3	–	3
Pyrethroids[b]	3A	3	–	3	3	3	3	3	–	3
Spinosad	5A	3	–		3	3	3	3	–	3

[a]Organophosphates (1B) include azinphos-methyl, chlorpyrifos, diazinon, dimethoate, fenamiphos, fenthion, fenitrothion, malathion, parathion-methyl, trichlorfon.

[b]Pyrethroids (3A) include alpha-cypermethrin, bifenthrin, esfenvalerate, and permethrins + piperonyl butoxide.

Legend: Values represent reduction in ability to provide pest control, as modified from IOBC toxicity ratings.

Colours represent mortality of beneficial insects

0 ('harmless')	< 25%	green
1	25–50%	yellow
2	50–75%	orange
3	> 75%	red

Figure 4: Spiders are particularly important in vineyards and are known as 'generalist predators'. With their range of hunting styles and their ability to eat diverse prey, they can make an important contribution to pest control (Photo courtesy MA Nash)

High ratings, particularly those above 15, have been linked to a decrease in numbers of beneficial species in southeastern Australian vineyards, whereas low ratings (below 4) have been linked to higher numbers of beneficials. The results of field validation of laboratory-derived IOBC toxicity ratings for beneficials in Australian commercial vineyards have been published (Thomson & Hoffmann 2006, Nash *et al.* 2010).

An example of a planned spray program over a season

A grower has scheduled four fungicide applications for the season and usually applies sulphur at full rates (modified rating 3 if >6000 g/ha). A neighbouring vineyard has had trouble with mealybugs, so an application of Lorsban® (chlorpyrifos, modified rating 3) is planned for in August, just in case. A spring outbreak of light brown apple moth is expected, which will need to be treated with Proclaim® (emamectin, modified rating 3). Predicted moist weather in December, combined with a second flight of light brown apple moth in late December, adds the possibility of an application of copper hydroxide (modified rating 0), with the addition of Avatar® (indoxacarb, modified rating 3) into the tank; the rating for this application is therefore 3, due to the indoxacarb. Another two fungicide applications are planned in response to the predicted wet season conditions, this time using Ridomil Gold plus® (modified rating 2). The overall rating with which the impacts of the season's applications can be assessed is therefore 25, calculated by considering the toxicity of each chemical proposed: 12 (four applications of sulphur at toxicity 3) + 3 (single Lorsban®) + 3 (single Proclaim®) + 3 (single Avatar®) + 4 (two applications of Ridomil Gold plus® at toxicity 2). An overall rating this high would severely impact beneficial species populations, and thus limit any effective biological control. The grower could consider the availability of effective chemicals of lower toxicity to beneficials with flow on effects to pest control.

A couple of happy stories

Predatory mites and pest mites

A specific example is the interaction between pest mites, vine damage, predatory mites and chemical use. Damage to grapevines, including vine leaf and shoot distortions, retarded early spring growth, and leaf bronzing in summer due to eriophyoid mite populations, has been reduced largely by limiting the use of Mancozeb, which is toxic to predatory mites of the family Phytoseiidae (Bernard *et al.* 2004), and thereby encouraging populations of the phytoseiid mites, which, in the absence of the chemical, are able to largely control the pest! (Bernard *et al.* 2005)

Trichogramma and sulphur

While sulphur (particularly wettable sulphur) is an integral component of disease and pest management in vineyards, in particular against powdery mildew, laboratory and field studies indicate that high concentrations of sulphur are harmful to adult *Trichogramma* and even to immature stages contained within hosts (light brown apple moth eggs), in which it increases mortality and reduces the fitness of the emerged wasps. Limiting the impact of sulphur on *Trichogramma* enhances the abundance and effectiveness of these parasitoids in light brown apple moth control in vineyards (Thomson *et al*. 2000).

Figure 5: A vineyard with midrows sown with grass species to provide good habitat for natural enemies. (Photo courtesy MA Nash).

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Further reading

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