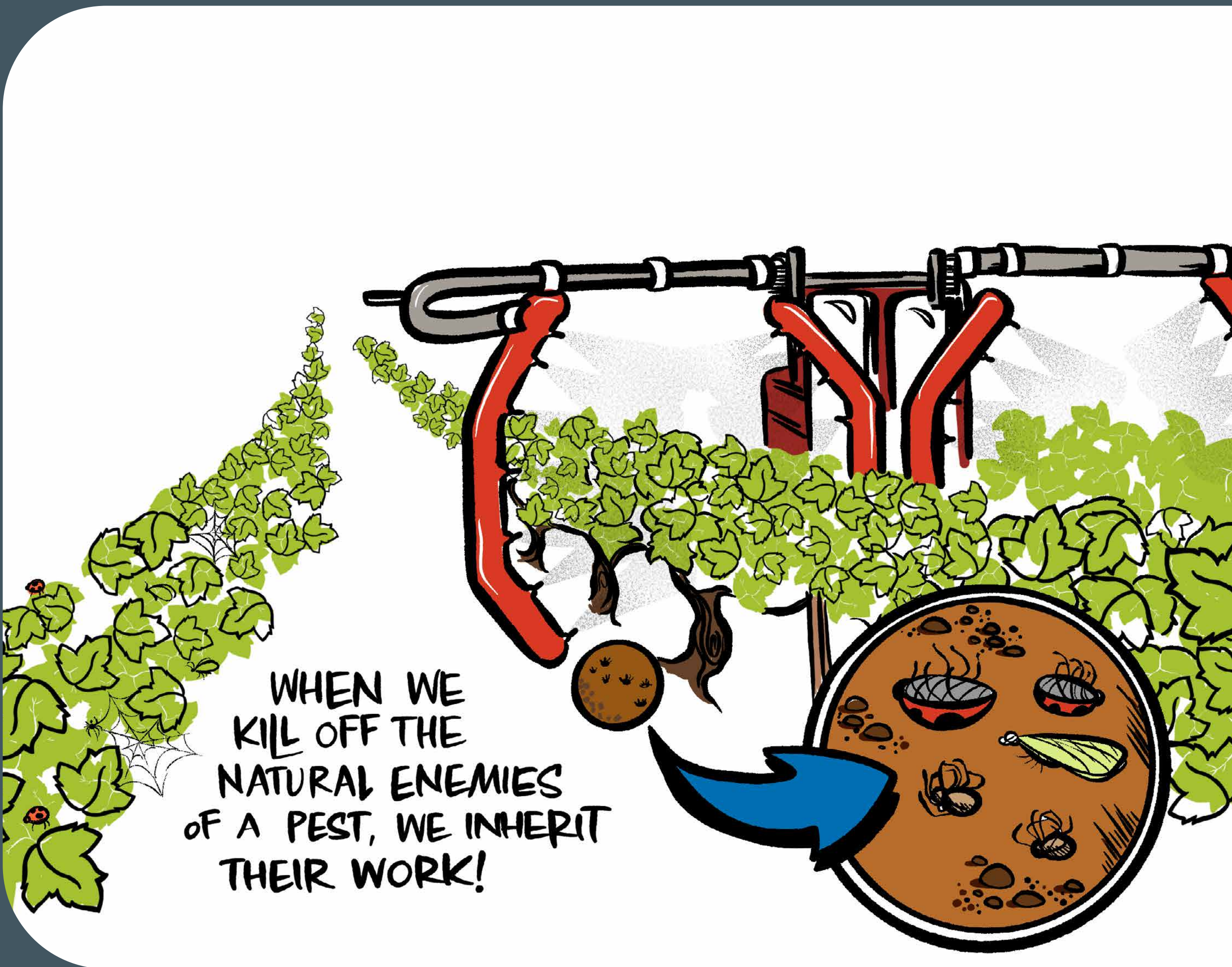
EcoVineyards
GROWING RESILIENCE NATURALLY

FACT SHEET

THE IMPACT OF AGROCHEMICALS ON NATURAL ENEMIES

By Dr Linda Thomson, The University of Melbourne



Wine Australia

retallack viticulture

PEARG
Pest & Environmental Adaptation Research Group

A BALANCED APPROACH TO INSECT PEST MANAGEMENT

This fact sheet provides readily accessible information about chemical impacts on natural enemies, which has been summarised as a ready reference for wine growers.

Long-term prevention of crop pests and diseases through increasing biological control aims to reduce the need for, and impacts of, pesticide use in agriculture for both economic and environmental benefit. While undertaking habitat changes it is important to also consider chemical use on farm and take steps to include low impact chemicals to gain maximum benefit from vegetation.

When chemical controls are deemed necessary, product selection, timing, and application methods are designed to maximise efficacy against the pest or disease while minimising impacts on natural enemies and other non-target organisms.

The use of chemicals to control crop pests can cause a wide range of unintentional effects on beneficial parasitoids and predators (Thomson and Hoffmann 2006a). For example, parasitism can be higher in vineyards with low chemical use and particularly low sulfur inputs (Thomson et al., 2000) as it was shown to be highly toxic to parasitoids at rates of ≥400 g/100 litres.

NB: this rate assumes a concentration factor (CF) of 1 or dilute spraying volumes that have historically been based on 4 kg sulfur per hectare at water application volume of 1,000 L/ha.

Hence, the choice of chemicals with low toxicity to beneficials is a critical point and should be carefully considered to contribute to the preservation and maintenance of natural enemies in the vineyard. It has recently been shown that a pesticide regime can reduce the positive impact of parasitoids and predator numbers from adjacent vegetation (Pandey et al., 2022).

"*By establishing supplementary flora in and around vineyards, we aim to help growers save time and resources by producing healthy grapes with lower pest incidence while, at the same time, enhancing the resilience and biodiversity of their vineyard.*" Dr Mary Retallack, Retallack Viticulture Pty Ltd

Vineyard pests have many natural enemies, including predators and parasitoids, which reduce their impact on grapevine foliage and fruit. The diversity of natural enemies is amazing and includes frequently observed spiders, ladybird beetles, predatory beetles, predatory bugs, lacewings, and the less conspicuous, such as predatory flies and parasitoids.

Parasitoids are heroes of crop protection and help control common grapevine pests

LIGHT BROWN APPLE MOTH: Twenty-eight species of parasitoid wasp contribute to biocontrol of LBAM, ranging from the tiny Trichogramma egg parasitoids, where a single female can parasitise and, thus, destroy an entire raft of eggs, to those that parasitise caterpillars and pupae.

SCALE: Fourteen parasitoids destroy scale insects in our vineyards.

MEALYBUG: Parasitoids can penetrate the external waxy secretions of mealybugs and the protective cover of scale.

A particularly desirable aspect of parasitoids is their ability to reach hiding places where chemical access is problematic, e.g. scale under bark, light brown apple moth in leaf rolls or bunches.

A further advantage of natural enemies is that they are always present. These predators and parasitoids exist in all vineyards, exhibiting varying diversity and abundance. Vineyard management drives both and the practices with the greatest impact involve provision of alternative resources, including supplementary flora (insectary plants used to increase functional biodiversity) and chemical selection.

IPM typically relies on biological, cultural, and chemical control methods and we suggest they are considered in that order, and that chemicals should be used as a last resort in a targeted manner (and only if needed).

Key messages

- Pesticide selections are made with the goal of controlling the target pest and preserving natural enemies where possible. If natural enemies and chemicals can work synergistically then we have a more successful system and less environmental impact.
- Long-term prevention of crop pests and diseases by increasing biological control aims to reduce the need for, and impacts of, pesticide use for both economic and environmental benefit. When chemical controls are deemed necessary, product selection, timing, and application methods are designed to maximise efficacy against the pest or disease, while minimising impacts on natural enemies and other non-target organisms.
- Hence, the choice of chemicals with low toxicity to beneficials is a critical point, and should be carefully considered to contribute to the preservation and maintenance of natural enemies in the vineyard.

"Integrated Pest Management is an ecosystem approach to crop production and protection that combines different management strategies and practices to grow healthy crops and minimise the use of pesticides." (FAO, 2024)

WHY SOME CHEMICALS ARE SO TOXIC TO NATURAL ENEMIES

Broad spectrum

Many natural enemies are insects, just like the pests, so 'insecticides' that aim to kill insects also have the potential to harm natural enemies.

Insecticides that kill a wide range of insects, including natural enemies, are called broad spectrum. A broad-spectrum pesticide does not discriminate between pests and beneficial species.

Examples of broad-spectrum insecticides include:

- organophosphates
- carbamates
- neonicotinoids
- pyrethroids.

Narrow spectrum

Pesticides that are designed to kill or manage a specific pest known to cause damage are termed narrow spectrum. Narrow spectrum insecticides are often designed to interact with a characteristic of the pest.

Examples include:

- ***Bt (Bacillus thuringiensis)***: derived from different strains of a soil-dwelling bacterium (e.g. *B. thuringiensis kurstaki* strain and *B. thuringiensis aizawai* strain); is regarded as a biological method that does not harm most non-target organisms.
- **Insect growth regulators (IGRs)**: such as methoxyfenozide and tebufenozide, which have selective activity against Lepidoptera but low activity against natural enemies (which, with rare exceptions, are not caterpillars).
- **Spirotetramat:** is a systemic insecticide of a relatively new class of pesticides (cyclic keto-enol insecticides and acarides) that act through supressing lipid biosynthesis.

NB: Although spirotetramat is reported as low toxicity in most published studies, extensive field work completed by CSIRO in cotton indicates its use may reduce the abundance of lacewings and ladybird beetles (Dr Simone Heimoana, CSIRO pers. comm. 14/02/2024; CRDC, 2019).

Impact of insecticides on natural enemies in vineyards

A simplified summary of available data on the impact of insecticides on natural enemies is presented below (**Table 1**). It is intended as a guide to provide information when alternative chemicals are recommended and allows selection of an option with less toxic effects on predators and parasitoids.

The range of toxicities recorded for some chemicals occurs because different species of the same group may show different responses. Toxicities are averages of reported effects and should be used only as a general guide. Actual toxicity of a specific chemical depends on the species of predator or parasite, environmental conditions, and application rate.

Table 1. Impact of insecticides on natural enemies in Australian vineyards (high to lower toxicity)

Active ingredient	Activity group	Coccinellid[1] (ladybird beetle)	Green lacewing[2]	Parasitoid wasp[3]	Predatory bug[4]	Predatory beetle[5]	Predatory mite[6]	Spider[7]	Earwig[8]
Chlorpyrifos	1B	Red	Red	Red	Red	Red		Red	Red
Abamectin	6	Red Green	Yellow Green	Red Orange Green	Red Orange Green		Red Orange Green		
Emamectin	6	Green	Red	Red Orange Green	Red Orange Green		Red Orange	Green	
Spinetoram	5	Red Orange	Red Green	Red Green	Orange Yellow		Red Orange Yellow	Green	
Clothianidin	4A	Red Orange	Yellow	Red Orange	Red				
Spinosad	5	Yellow Green	Green	Red Orange	Orange	Orange	Red Orange Green	Red Orange Yellow	Orange
Acetamiprid	4A	Red Orange Yellow	Orange Yellow	Red Orange Green	Orange Yellow		Yellow Green		
Chlorantraniliprole	28	Red Orange Green	Red Yellow Green	Green	Yellow Green	Yellow	Green	Green	
Indoxacarb	22A	Green	Red	Red Orange Green	Orange Yellow Green		Yellow Green	Green	Orange
Mancozeb	M3		Green	Red Yellow Green			Red		
Sulfur	M2	Yellow	Yellow Green	Red Orange Green	Yellow		Red Green	Yellow	
Lime sulfur	M2	Green		Red			Red Green		
Mineral oils		Yellow Green	Green	Red Orange Green	Yellow		Yellow Green		Green
Methoxyfenozide	18	Green	Yellow Green	Green	Green		Green	Green	
Buprofezin	16	Yellow Green	Orange Yellow Green	Yellow Green	Green		Yellow Green		
Potassium bicarbonate	M2	[9]		Green	Green		Green		
Pyriproxyfen	7C	Orange Yellow Green	Yellow Green	Orange Yellow Green	Green Orange		Green	Green	
Spirotetramat	23	Yellow	Yellow	Green	Green		Green	Green	
Tebufenozide	18	Green	Green	Green					
Bacillus thuringiensis (Bt)	11	Green	Green	Green	Green		Green	Green	

- Green: < 25% mortality
- Yellow: 25 to 50% mortality
- Orange: 50 to 75% mortality
- Red: > 75% mortality

Disclaimer: *The information provided in **Table 1** is based on the best information available from research data collated in 2024. The impact of pesticides may vary in the field and between crop types. Users of chemical products should check the label for further details or rates, pest spectrum, safe handling, and application. Further information on the products can be obtained from the manufacturer. Wine Australia, Retallack Viticulture Pty Ltd, and Melbourne University accept no responsibility whatsoever for any loss occasioned by any person acting or refraining from action as a result of reliance on this data.*

Footnotes

Pesticides as listed in the 'Dogbook', Agrochemicals registered for use in Australian viticulture for the control of specific insect pests.

Data has been obtained from published studies based on research in Australia and internationally.

1 Ladybird beetles are major contributors to the control of scale and mealybug. Results reported on more than ten species, including important vineyard residents *Cryptolaemus montrouzieri*, mealybug destroyer, and *Chilocorus* spp.

2 Green and brown lacewings are important generalist predators. Most reported are species of *Chrysoperla* spp., green lacewing.

3 The diversity of parasitoids contributing to pest control in vineyards (destroying eggs, larvae, and pupae) is reflected in the range of species tested. More than 24 different species are included here with ten of them *Trichogramma* spp.

4 Lots of testing indicates the importance of these generalist predators, including the effects reported for 11 species of predatory bug.

5 Predatory beetles are important generalist predators. Information is lacking for many pesticides.

6 Predatory mites are essential for the control of pest mites. Limiting high rates of sulfur application is important.

7 Like predatory beetles the importance of spiders as generalist predators is not reflected in the amount of information available. More testing is needed.

8 The only earwig represented is the commonly occurring *Forficula auricularia*, European earwig. No data was found for our native earwigs (of which there are many).

9 Limited information on the effects of potassium bicarbonate on coccinellids though there is one study that records outcome as H (> 75% mortality).

Table notes

Notes on other commonly used foliar chemicals and products:

SULFUR: The harmful effects of sulfur on phytoseids (predatory mites) are well documented in both laboratory and field experiments (Beers et al., 2009; Costello, 2007; Uddin et al., 2015).

Spraying below 400 g/100 litres of water is recommended to minimise the impact on predatory mites and other natural enemies. Negative effects of sulfur have also been shown to be persistent. 600 g/100L is recommended rate for powdery control according to Wine Australia (sulfur as a fungicide). 200 to 600 g/100L is commonly recommended on industry products (see 'Dogbook' for powdery mildew control e.g. Ecosulfur (Organic Crop Protectants Sulfur 800 WG and Syngenta Thiovet jet). 600 g/100L is the desired maximum for less disruption to populations of parasitoids (Thomson et al., 2000) and predatory mites (Bernard et al., 2010)

Lime sulfur similarly disrupts parasitoids (Newman et al., 2004) and predatory mites (Beers et al., 2009).

POTASSIUM SILICATE (ECOCARB PLUS) AS A FOLIAR SPRAY: Application via foliar spray or soil application results in deposition within the leaves. Its effectiveness in powdery mildew control (Singh et al. 2022) is well known as it coats the leaf cuticle, partly preventing penetration by germinating conidia. Foliar silicon applications have also been shown to reduce pest mite damage due to the increase in leaf silica.

A further advantage of potassium silicate is that its application, with the resulting increase in leaf silicates, is related to an increase in the activity of defence-related enzymes (Reynolds et al., 2016). For example, jasmonic acid and salicylic acid induce the production of various herbivore-induced plant volatiles, resulting in the strengthening of natural biological control by attracting more natural enemies and elevating the resistance of different crops against insect pests.

Herbivore-induced plant volatiles impacted by silica concentration in plant tissues result in a cascade effect on the attraction of the natural enemies of pests, known to locate their prey or hosts based on plant volatile cues.

Further to this there are suggestions that foliar application can directly contribute to pest control. Foliar spray of potassium silicate caused larval mortality of *Spodoptera frugiperda*, fall army worm, i.e., significant negative impact on *S. frugiperda* by increasing the mortality of newly emerged larvae. Not via direct application to larvae but via larvae feeding on treated leaves (Ul Haq et al., 2021).

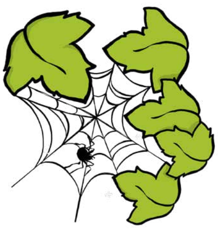
SUNSCREEN (KAOLIN): Although applied as a sunscreen, there are reports of kaolin negatively impacting pest control due to being both repellent and toxic to predatory beetles, bugs, parasitoids, spiders, and even earwigs (Knight et al., 2001; Markó et al., 2010; Sackett et al., 2007), disrupting predation and parasitism. Kaolin is recorded as moderately toxic to predatory mites and generalist predators (UC IPM, 2015),

PYRETHRUM: Natural pyrethrum as an agricultural insecticide is less disruptive to IPM programs that include beneficial insects than conventional insecticides.

There are, however, several references to the negative impacts of pyrethrum on parasitoids (Bradley et al., 1997; Simmonds et al., 2002; Tunca et al., 2012), including acting as a repellent (Tunca et al., 2012). Synthetic pyrethroids, developed to increase the stability of pyrethrum, provide effective pest control for longer though demonstrated increased toxicity to predators and parasitoids. Common examples of synthetic pyrethroids include permethrin, cypermethrin, bifenthrin, deltamethrin, and fenvalerate.

SPIROTETRAMAT: Although spirotetramat is reported as low toxicity in most published studies, extensive field work completed by CSIRO in cotton indicates its use may reduce the abundance of lacewings and ladybird beetles (Dr Simone Heimoana, CSIRO pers. comm. 14/02/2024; (CRDC, 2019).

Reference examples:



Indicative notes for each chemical with examples of references:

- **Chlorpyrifos:** Highly toxic (Attia et al., 2022)
- **Abamectin:** Toxic (Kaspi et al., 2019)
- **Emamectin:** Variation in toxicity with target natural enemy (Ozawa and Uchiyama, 2016; Shan et al., 2020)
- **Spinetoram:** May reduce parasitoids (Cardoso et al., 2021), ladybird beetles (Ozawa and Uchiyama, 2016), lacewings (Amarasekare et al., 2019), and predatory mites (Beers and Schmidt, 2014).
- **Clothianidin:** Take care around ladybird beetles (Moser and Obrycki, 2009) and parasitoids (Sugiyama et al., 2011)
- **Spinosad:** Parasitoids impacted (Cardoso et al., 2021)
- **Acetamiprid:** Parasitoids (Radrigán-Navarro et al., 2021) and ladybird beetles (Cheng et al., 2022) likely to be impacted
- **Chlorantraniliprole:** Ladybird beetles (Depalo et al., 2017) may be impacted.
- **Indoxacarb:** Parasitoids impacted (Ramirez-Ceron et al., 2022).
- **Mancozeb:** Predatory mites impacted (Auger et al., 2004; Bernard et al., 2010).
- **Mineral oils:** Parasitoids impacted (Hall and Nguyen, 2010).
- **Methoxyfenozide, Buprofezin, Potassium bicarbonate, Pyriproxyfen, Spirotetramat, Tebufenozide and Bt:** current research indicates these pesticides are compatible with natural enemy contribution to pest control.

REFERENCES

Amarasekare, K.G., Brown, P.H., Shearer, P.W. (2019) Field-Aged Insecticide Residues on Chrysoperla johnsoni (Neuroptera: Chrysopidae). Journal of Economic Entomology 112:2109-2115. DOI: 10.1093/jee/toz149.

Attia, S., Mansour, R., Abdennour, N., Sahraoui, H., Blel, A., Rahmouni, R., Lebdi, K.G., Mazzeo, G. (2022) Toxicity of Mentha pulegium essential oil and chemical pesticides toward citrus pest scale insects and the coccinellid predator Cryptolaemus montrouzieri. International Journal of Tropical Insect Science 42:3513-3523. DOI: 10.1007/s42690-022-00870-y.

Auger, P., Kreiter, S., Mattioda, H., Duriatti, A. (2004) Side effects of mancozeb on Typhlodromus pyri (Acari: Phytoseiidae) in vineyards:: results of multi-year field trials and a laboratory study. Experimental and Applied Acarology 33:203-213. DOI: 10.1023/B:APPA.0000032957.42594.b3.

Beers, E.H., Martinez-Rocha, L., Talley, R.R., Dunley, J.E. (2009) Lethal, sublethal, and behavioral effects of sulfur-containing products in bioassays of three species of orchard mites. Journal of Economic Entomology 102:324-335. DOI: 10.1603/029.102.0143.

Beers, E.H., Schmidt, R.A. (2014) Impacts of orchard pesticides on Galendromus occidentalis: Lethal and sublethal effects. Crop Protection 56:16-24. DOI: 10.1016/j.cropro.2013.10.010.

Bernard, M.B., Cole, P., Kobelt, A., Horne, P.A., Altmann, J., Wratten, S.D., Yen, A.L. (2010) Reducing the impact of pesticides on biological control in Australian vineyards: Pesticide mortality and fecundity effects on an indicator species, the predatory mite Euseius victoriensis (Acari: Phytoseiidae). Journal of Economic Entomology 103:2061-2071. DOI: 10.1603/ec09357.

Bradley, S.J., Murrell, V.C., Shaw, P.W., Walker, J.T.S., New Zealand Plant Protect Soc I.N.C. (1997) Effect of orchard pesticides on Aphelinus mali, the woolly apple aphid parasitoid, 50th New Zealand Plant Protection Conference, Lincoln Univ, Canterbury, New Zealand. pp. 218-222.

Cardoso, T.D., Stupp, P., Rakes, M., Martins, M.B., Filho, J.G.D., Grutzmacher, A.D., Nava, D.E., Bernardi, D., Botton, M. (2021) Lethal and sublethal toxicity of pesticides used in fruit growing on the parasitoid Diachasmimorpha longicaudata (Hymenoptera: Braconidae): Implications for integrated fruit fly management. Journal of Economic Entomology 114:2412-2420. DOI: 10.1093/jee/toab176.

Cheng, S.H., Yu, C.H., Xue, M.M., Wang, X.J., Chen, L.P., Nie, D.X., Zhang, N., Zhang, J., Hou, Y.H., Lin, R.H. (2022) Toxicity and risk assessment of nine pesticides on nontarget natural predator Harmonia axyridis (Coleoptera: Coccinellidae). Pest Management Science 78:5124-5132. DOI: 10.1002/ps.7130.

Costello, M.J. (2007) Impact of sulfur on density of Tetranychus pacificus (Acari: Tetranychidae) and Galendromus occidentalis (Acari: Phytoseiidae) in a central California vineyard. Experimental and Applied Acarology 42:197-208. DOI: 10.1007/s10493-007-9087-9.

CRDC. (2019) Cotton Pest Management Guide 2018–19 at https://cottoninfo.com.au/sites/default/files/documents/CPMG%202018-19%20update%20Dec%202018.pdf.

Depalo, L., Lanzoni, A., Masetti, A., Pasqualini, E., Burgio, G. (2017) Lethal and sub-lethal effects of four insecticides on the Aphidophagous Coccinellid Adalia bipunctata (Coleoptera: Coccinellidae). Journal of Economic Entomology 110:2662-2671. DOI: 10.1093/jee/tox243.

FAO. (2024) Pest and pesticide management, Food and Agriculture Organisation of the United Nations, Rome. https://www.fao.org/pest-and-pesticide-management/ipm/integrated-pest-management/en/.

Halld D.G., Nguyend R. (2010) Toxicity of pesticides to Tamarixia radiata, a parasitoid of the Asian citrus psyllid. Biocontrol 55:601-611. DOI: 10.1007/s10526-010-9283-0.

Kaspi, R., Madar, R., Domeradzki, S. (2019) Acaricides compatibility with the armored scale predator Rhyzobius lophanthae. Biological Control 132:42-48. DOI: 10.1016/j.biocontrol.2019.01.011.

Knight, A.L., Christianson, B.A., Unruh, T.R. (2001) Impacts of seasonal kaolin particle films on apple pest management. Canadian Entomologist 133:413-428. DOI: 10.4039/Ent133413-3.

Markó, V., Bogya, S., Kondorosy, E., Blommers, L.H.M. (2010) Side effects of kaolin particle films on apple orchard bug, beetle and spider communities. International Journal of Pest Management 56:189-199. DOI: 10.1080/09670870903324206.

Moser, S.E., Obrycki, J.J. (2009) Non-target effects of neonicotinoid seed treatments; mortality of coccinellid larvae related to zoophytophagy. Biological Control 51:487-492. DOI: 10.1016/j.biocontrol.2009.09.001.

Newman, I.C., Walker, J.T.S., Rogers, D.J. (2004) Mortality of the leafroller parasitoid Dolichogenidea tasmanica (Hym: Braconidae) exposed to orchard pesticide residues, 57th Annual Meeting of the New-Zealand-Plant-Protection-Society, Hamilton, NEW ZEALAND. pp. 8-12.

Ozawa, A., Uchiyama, T. (2016) Effects of pesticides on adult ladybird beetle Serangium japonicum (Coleoptera: Coccinellidae), a potential predator of the tea spiny whitefly Aleurocanthus camelliae (Hemiptera: Aleyrodidae). Japanese Journal of Applied Entomology and Zoology 60:45-49. DOI: 10.1303/jjaez.2016.45.

Radrigán-Navarro, C., Beers, E.H., Alvear, A., Fuentes-Contreras, E. (2021) Acute toxicity of lethal and sublethal concentrations of neonicotinoid, insect growth regulator and diamide insecticides on natural enemies of the woolly apple aphid and the obscure mealybug. Chilean Journal of Agricultural Research 81:398-407. DOI: 10.4067/s0718-58392021000300398.

Ramirez-Ceron, D., Rodriguez-Leyva, E., Lomeli-Flores, J.R., Soto-Rojas, L., Ramirez-Alarcon, S., Segura-Miranda, A. (2022) Toxicity and residual activity of insecticides against Diadegma insulare, a parasitoid of the diamondback moth. Insects 13. DOI: 10.3390/insects13060514.

Reynolds, O.L., Padula, M.P., Zeng, R.S., Gurr, G.M. (2016) Silicon: potential to promote direct and indirect effects on plant defense against arthropod pests in agriculture. Frontiers in Plant Science 7. DOI: 10.3389/fpls.2016.00744.

Sackett, T.E., Buddle, C.M., Vincent, C. (2007) Effects of kaolin on the composition of generalist predator assemblages and parasitism of Choristoneura rosaceana (Lep., Tortricidae) in apple orchards. Journal of Applied Entomology 131:478-485. DOI: 10.1111/j.1439-0418.2007.01199.x.

Shan, Y.X., Zhu, Y., Li, J.J., Wang, N.M., Yu, Q.T., Xue, C.B. (2020) Acute lethal and sublethal effects of four insecticides on the lacewing (Chrysoperla sinica Tjeder). Chemosphere 250. DOI: 10.1016/j.chemosphere.2020.126321.

Simmonds, M.S.J., Manlove, J.D., Blaney, W.M., Khambay, B.P.S. (2002) Effects of selected botanical insecticides on the behaviour and mortality of the glasshouse whitefly Trialeurodes vaporariorum and the parasitoid Encarsia formosa. Entomologia Experimentalis Et Applicata 102:39-47. DOI: 10.1046/j.1570-7458.2002.00923.x.

Sugiyama, K., Katayama, H., Saito, T. (2011) Effect of insecticides on the mortalities of three whitefly parasitoid species, Eretmocerus mundus, Eretmocerus eremicus and Encarsia formosa (Hymenoptera: Aphelinidae). Applied Entomology and Zoology 46:311-317. DOI: 10.1007/s13355-011-0044-z.

Thomson, L.J., Glenn, D.C., Hoffmann, A.A. (2000) Effects of sulfur on Trichogramma egg parasitoids in vineyards:: measuring toxic effects and establishing release windows. Australian Journal of Experimental Agriculture 40:1165-1171. DOI: 10.1071/ea00074.

Tunca, H., Kilinçer, N., Özkan, C. (2012) Side-effects of some botanical insecticides and extracts on the parasitoid, Venturia canescens (Grav.) (Hymenoptera: Ichneumonidae). Turkiye Entomoloji Dergisi-Turkish Journal of Entomology 36:205-214.

UC IPM. (2015) Relative Toxicities of Insecticides and Miticides Used in Apples to Natural Enemies and Honey Bee, Agriculture: Apple Pest Management Guidelines, University of California, https://ipm.ucanr.edu/agriculture/apple/relative-toxicities-of-insecticides-and-miticides-used-in-apples-to-natural-enemies-and-honey-bees/.

Uddin, M.N., Alam, M.Z., Miah, M.R.U., Mian, M.I.H., Kishowar, E.M. (2015) Toxicity of pesticides to Tetranychus urticae Koch (Acari: Tetranychidae) and their side effects on Neoseiulus californicus (Acari: Phytoseiidae). International Journal of Acarology 41:688-693. DOI: 10.1080/01647954.2015.1094512.

Ul Haq, I., Khurshid, A., Inayat, R., Zhang, K.X., Liu, C.Z., Ali, S., Zuan, A.T.K., Al-Hashimi, A., Abbasi, A.M. (2021) Silicon-based induced resistance in maize against fall armyworm Spodoptera frugiperda (Lepidoptera: Noctuidae). Plos One 16. DOI: 10.1371/journal.pone.0259749.

Disclaimer

For more information about the National EcoVineyards Program please visit www.ecovineyards.com.au @EcoVineyards

PROGRAM PARTNERS

REGIONAL PARTNERS

The National EcoVineyards Program is funded by Wine Australia with levies from Australia's grape growers and winemakers and matching funds from the Australian Government.

ACKNOWLEDGEMENT OF COUNTRY

EcoVineyards proudly acknowledge the Aboriginal and Torres Strait Islander Peoples, and their ongoing cutural and spirital connection to this ancient land on which we work and live.

As the Traditional custodians we recognise their wealth of ecological knowledge and the importance of caring for Country.

We pay our respect to elders past and present and extend this respect to all Aboriginal and Torres Strait Islander Peoples.

ECO VINEYARDS

GROWING RESILIENCE NATURALLY