THE SCIENCE BEHIND THE RESISTANCE MANAGEMENT STRATEGY FOR THE GREEN PEACH APHID (*MYZUS PERSICAE*) IN AUSTRALIAN GRAINS

Developed by the grains National Insecticide Resistance Management (NIRM) working group of the Grains Pest Advisory Committee

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Science Behind the Resistance Management Strategy for the green peach aphid (*Myzus persicae*) in Australian grains

This document details the scientific and industry information used in the development of the Resistance Management Strategy for the green peach aphid in Australian grains. To download the GPA Resistance Management Strategy visit: http://ipmguidelinesforgrains.com.au/ipm-information/resistance-management-strategies.

GRDC Project Code: UM00048

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Special thanks to Mr Craig Davis (AW Vater & Co), Helen Barclay (**cesar**), Annabel Clouston (**cesar**) and the Grains Research & Development Corporation

ISBN: 978-1-921779-64-0

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Design and production: coretext.com.au

1. BACKGROUND INFORMATION

TABLE 1 Background information on the green peach aphid (GPA)

Attribute	What is known about GPA?	References	Knowledge gaps
Economic importance to grains	• GPA has developed resistance to more insecticides than any other insect species. • Direct feeding and associated virus transmission can potentially reduce canola yield by up to 50%.	Whalon et al. 2008; Valenzuela and Hoffmann 2014	Impact of direct aphid feeding damage on yield loss poorly identified and is probably underestimated
Mode of reproduction	• In Australia the majority of GPA are nearly always asexual (anholocyclic). • Populations are comprised of a mixture of holocyclic (sexual/asexual, host-alternating) and anholocyclic (asexual, non host-alternating) clones.	Blackman 1974; Vorburger et al. 2003; Moran 1992	
Life cycle (incl. # generations)	• Present all year round. GPA populations predominately peak in autumn and spring in southern grain growing areas. They have multiple generations per year. Under ideal conditions generation time is < 2 weeks. • Females give birth to live young (typically 5 instars before reaching adulthood). • In sexual clones, mating takes place on the primary host (*Prunus*), where the eggs are laid and undergo diapause over winter (this is rare in Australia). • The optimum temperature for GPA is about 22°C, with most activity occurring during the warmer, milder months of the year. Threshold minimum and maximum temperatures for their development are approximately 5°C and 33°C respectively.	Van Emden et al. 1969; Moran 1992	
Crop hosts	• Very broad host range. Includes oilseeds, pulses, brassicas, leafy vegetables, citrus, pome/stone fruits, cut flowers. • In grains they are known to attack maize, sorghum, canola, lupins, sunflower, faba beans, field peas, vetch & soybean • Some plant-host preferences among GPA clones/biotypes.	Van Emden et al. 1969; Weber 1985; Nikolakakis et al. 2003; Zitoudi et al. 2001	
Non-crop hosts	• There are many weeds including capeweed, wild radish, wild turnip, fathen, nightshade and other cruciferous weeds.		
Distribution	• Australia wide, very common across all grain growing regions as well as being a cosmopolitan species.	Bailey 2007; Bellati et al. 2010	
Dispersal/ movement	• In winter grain crops, infestations start when winged aphids fly into crops from autumn weeds (e.g. roadside vegetation). Large infestations of GPA on seedling crops can cause leaf distortion, wilting of cotyledons, stunting of growth, premature leaf senescence and seedling death. • Likely to be broad-scale movement across Australia.	Vorburger et al. 2003; Bailey 2007; Berlainder et al. 2010	Uncertainty of gene flow and long-distance dispersal capacity on a national scale (and between different regions)
Feeding behaviour	• Sucking pest, mostly on the underside of older plant leaves. Also found on growing tips in young plants and on developing and mature flowers. • In grains crops, GPA typically cause less direct feeding damage than other aphid species. Young vegetative canola is most susceptible to aphid damage during autumn. Although they may be found in canola at later stages, numbers are usually insufficient to cause significant yield loss through feeding. • GPA also transmit many important plant viruses, including cucumber mosaic virus, bean yellow mosaic virus and beet western yellows virus. • Secretion of honeydew can cause secondary fungal growth (i.e. sooty moulds), which inhibits photosynthesis and can decrease plant growth. When deposited on fruit, honeydew and sooty mould greatly reduces the marketability of horticulture produce.		
Chemical controls	• Chemicals remain key to control within grains and as well as other industries. • There are approximately 200 insecticide products registered in Australia, but these are mostly from 4 chemical groups -organophosphates (e.g. dimethoate), carbamates (e.g. pirimicarb), synthetic pyrethroids (e.g. alpha-cypermethrin) and neonicotinoids (e.g. imidacloprid).		
Biological control options	• There are many effective natural enemies of aphids. Hoverfly larvae, lacewings, ladybird beetles and damsel bugs are known predators that can suppress populations. Aphid parasitic wasps lay eggs inside bodies of aphids and evidence of parasitism is seen as bronze-coloured enlarged aphid 'mummies'. If mummified aphids make up 10% of the total aphid population within a paddock, it is likely that the majority of the remaining aphids have also been parasitised. This is an indication that the population is likely to crash within 2 weeks. • Entomopathogenic fungal diseases are also known to be important in causing rapid colony decline in cropping situations where large aphid populations exist.	Volkl et al. 2007; P. Mangano (Pers. Comm.)	

2. INSECTICIDE PRODUCTS REGISTERED IN AUSTRALIA

TABLE 2 Products with label claims for green peach aphid (and general aphid) control in Australia

IRAC MoA group	Insecticide category	Example trade name	Active ingredient	Registered crops for GPA	Registered crops for aphids (general)
Group 1A	Carbamates	Marlin, Lannate, Electra	methomyl	Peaches, nectarines	–
Group 1A	Carbamates	Pirimicarb, Pirimor, Aphidex	pirimicarb	Stone fruit, beetroot, Brussels sprouts, cabbages, cauliflowers, chinese cabbage, kale, radish, swedes, turnips, canola, cotton, lupins	Asparagus, blueberries, broadbean, capsicum, citrus, cucurbits, duboisia, endive, garden cress, globe artichoke, honeydew melon, horned melon, leek, lettuce, lima bean, okra, ornamental, pea, pepino, potkin, pumpkin, rockmelon, shallot, spinach, silverbeet, squash, strawberries, tomatoes, watercress, watermelon, winter cereals
Group 1B	Organophosphates	Strike-out, Chlorpyrifos	chlorpyrifos	Tomatoes, fruiting and cucurbit vegetables	Brussels sprouts
Group 1B	Organophosphates	Diazol, Diazinon	diazinon	Cabbage, cauliflower, broccoli, Brussels sprouts, kale, kohlrabi, stonefruit	Nursery plants
Group 1B	Organophosphates	Danadim, Dimethoate	dimethoate	Adzuki beans, cowpeas, mungbeans, navy beans, pigeon peas, chickpeas, lupins, borlotti beans, cabbage, cauliflower, Brussels sprouts, broccoli	Sorghum, field peas and beans, sesame, blackberries, raspberries, blueberries, bilberries and other vaccinium berries, citrus fruit (oranges, lemons, limes, mandarins), grapes, passionfruit, stonefruit (peaches, plums, nectarines, cherries), tomatoes, melons, zucchini, capsicum, chilli, peppers, asparagus, onions, rhubarb, sweetcorn, beans, peas, globe artichoke, beetroot, carrots, parsnips, potatoes, sweet potatoes, radish, turnips, broccoli, cabbage, cauliflower, celery, ornamentals, ornamentals shrubs, ornamental farm and forest trees, wild flowers, proteas
Group 1B	Organophosphates	Fyfanon, Maldison	maldison	Stonefruit	Bean, carrot, cabbage, cauliflower, celery, cucurbit, lettuce, tomatoes, flowers, ornamentals, wildflowers, proteas, flowers, ornamentals, wildflowers, proteas
Group 1B	Organophosphates	Folimat	omethoate	Lupins	Citrus, cotton, potatoes, carnations, chrysanthemums, pelargoniums, roses, callistemons, eucalyptus spp., Grevillea spp., paperbarks, wattles, callistemon, carnation, geranium, myrtle
Group 1B	Organophosphates	Thimet	phorate		Cotton, ornamentals (chrysanthemums, carnations, dahlias, lily bulbs, azaleas, roses and other woody ornamentals), cabbage, cauliflower, broccoli, Brussels sprouts, tomatoes, carrots, potatoes

TABLE 2 continued

IRAC MoA group	Insecticide category	Example trade name	Active ingredient	Registered crops for GPA	Registered crops for aphids (general)
Group 23	Tetronic and Tetramic acid derivatives	Movento	spirotetramat (iso)	Beans, green peas, snow peas, sugarsnap peas, broccoli, broccolini, Brussels sprout, cabbage, cauliflower, kohlrabi, bok choy, Chinese broccoli, Chinese cabbage, choy sum, kale, mibuna, mustard, pak choy, celery, cucurbits, eggplant, peppers, tomatoes, chard, cress, rocket, silverbeet, spinach, lettuce, chicory, endive, radicchio	–
Group 28/4A	Diamides / Neonicotinoids	Durivo, Voliam Flexi	chlorantraniliprole / thiamethoxam	Cotton, broccoli, Brussels sprouts, cabbage, cauliflower, brassica leafy vegetables, tomatoes, capsicum, eggplant, lettuce, endive, silverbeet, spinach	–
Group 3A	Pyrethroids	Ambush, Axe, Pounce	permethrin	Cabbage, cauliflower, Brussels sprouts, broccoli	
Group 3A	Pyrethroids	Richgro beat-a-bug naturally based insect spray concentrate	piperonyl butoxide / chilli / garlic extract / pyrethrins	Fruit trees, vegetables (except capsicum and lettuce) cut flowers, grapevines, nursery plants, ornamentals, roses, trees, greenhouse and glasshouse crops	–
Group 3A	Pyrethroids	Amgrow pyrethrum insect spray	piperonyl butoxide / pyrethrins	Peaches, apricots, strawberries, cucumbers, lettuce, tomatoes, cabbages, cherries, roses and other flowers	–
Group 3A	Pyrethroids	Klartan, Mavrik aquaflow	tau-fluvalinate	Tomatoes	Roses, ornamental plants
Group 3A/4A	Pyrethroids / Neonicotinoids	Cruiser opti insecticide seed treatment	lambda-cyhalothrin / thiamethoxam	Canola	–
Group 4A	Neonicotinoids	Intruder, Supreme	acetamiprid	Potatoes	–
Group 4A	Neonicotinoids	Samurai	clothianidin	Peaches, nectarines	–
Group 4A	Neonicotinoids	Confidor, Nuprid	imidacloprid	Peach, apricot, nectarine, plum, Zucchini, capsicum, melons, cucurbits, eggplant, potatoes, tomatoes, duboisia, cotton, rose, ornamental plants, zucchini, melons	Cotton, ornamental plant, roses, shrubs, Plants and ornamental plants, non-bearing citrus tree, ornamental citrus
Group 4A	Neonicotinoids	Actara	thiamethoxam	Tomatoes	–
Group 4C	Sulfoxaflor	Transform	sulfoxaflor	Canola, cereals, cotton, cucurbits (pumpkin, squash, melons and cucumber), chilli, capsicum, eggplant, okra, tomatoes, lettuce, asian greens, silverbeet, spinach, potatoes, turnips, carrot, broccoli, Brussels sprouts, cabbage, cauliflower, apricots, cherry, nectarines, peaches, plums	–

TABLE 2 continued

IRAC MoA group	Insecticide category	Example trade name	Active ingredient	Registered crops for GPA	Registered crops for aphids (general)
Group 9B	Pymetrozine	Chess, Endgame	pymetrozine	Broccoli, Brussels sprouts, cabbage, cauliflower, potatoes, stonefruit	–
Not member of a Group		Eco-oil	emulsifiable botanical oils	–	Tomatoes, cucumbers, strawberries, capsicum in covered crop situations such as glasshouses, shadehouses, and polyhouses
Not member of a Group		Canopy	paraffinic oil	Pulse and oilseed crops (adzuki beans, canola, chickpeas, faba beans, field peas, lentils, linola, linseed, lucerne, lupins, mungbeans, navy beans, pigeon peas, safflower, soybeans, sunflower, vetch)	–
Not member of a Group		Richgro lime sulfur fungicide and insecticide	sulfur	Fruit trees	–
Not member of a Group		Natrasoap	fatty acid - K salts	–	Cotton, vegetable, fruit tress, pots, indoor plants

Note: crops in red are grain crops.

SOURCE: APVMA-PUBLIC CHEMICAL REGISTRATION INFORMATION SYSTEM SEARCH (PUBCRIS), AUSTRALIAN PESTICIDES & VETERINARY MEDICINES AUTHORITY; ACCESSED MARCH 2014

Industry chemical use and secondary chemical exposure:

The use (and motivations for use) of insecticides to control GPA varies from region-to-region. A phone-survey of 15 broad-acre advisers (agronomists and consultants) from Queensland, New South Wales, Victoria, South Australia and Western Australia was completed in late March 2014. In addition, spray records were obtained for >40 paddocks.

GPA is regarded as a common pest, typically occurring every year, or in some locations, every 2-3 years. Canola was identified as being more vulnerable to GPA attack than pulse crops. The majority of canola crops are reportedly sown with imidacloprid-treated seed, while only a small proportion of pulse crops were sown with imidacloprid-treated seed. Foliar insecticides are sprayed in about 80% (on average) of canola paddocks annually, although many of these applications do not specifically target GPA. When insecticides are being applied for GPA, approximately one-third of sprays are used prophylactically. With the exception of seed treatments, Group 3A, 1A and 1B products are almost exclusively used to combat GPA in grains crops nationally, with Group 4C expected to have greater usage following the registration of sulfloxaflor in 2013.

In horticultural crops the prevalence and recognized pest importance of GPA is far greater. Application rates of insecticides are much higher, particularly in capsicums, eggplants, lettuce, cabbage, cauliflowers, broccoli, tomatoes and potatoes. It is not uncommon for some crops to be sprayed with 8-10 separate applications of insecticides from the vegetable seedling stage through to harvest (often with 2-4 plantings in a single paddock per year). There is a more extensive range of chemical groups registered for use in vegetable crops. The choice of products used to combat GPA varies considerably between regions and with crop type. Group 1A, 1B, 23, 3A and 4A products appear to be commonly used in vegetable crops to combat GPA nationally.

3. CURRENT STATUS OF INSECTICIDE RESISTANCE

TABLE 3 Current status of insecticide resistance in the green peach aphid within Australia

Attribute	What is known about GPA?	References	Knowledge gaps
Resistance status	• Confirmed widespread resistance to pyrethroids, organophosphates and carbamates. • Evidence that resistance to neonicotinoids is emerging. • Recently reported (unconfirmed) chemical control failures involving spirotetramat in northern Qld vegetables.	Umina et al. 2014a, Edwards et al. 2008,	Unsure of neonicotinoid resistance in Australian populations, as well as to other chemical groups such as spirotetramat and pymetrozine Limited understanding of the distribution of resistance to pyrethroids, organophopshates and carbamates nationally
Mode of Action of resistance & cross-resistance	• Synthetic pyrethroids: parasodium channel (mutations at kdr, superkdr loci), some cross-resistance from E4/ FE4 • Organophosphates: amplified esterases (E4, FE4) • Carbamates: modified acetylcholinesterase (MACE), some cross-resistance from E4, FE4 • Neonicotinoids: Amplified P450, modified AChR receptor	Martinez-Torres et al. 1999; Field & Devonshire 1998; Moores et al. 1994; Puinean et al. 2010; Bass et al. 2011	Mechanisms underlying any neonicotinoid resistance in Australia unknown FE4 not known in Australia (associated with sexuality)
Known fitness costs	• Synthetic pyrethroids: reduced motility/responsiveness to alarm pheromone, parasitoid avoidance at low temperatures (initially attributed to E4/FE4) • Carbamates: reduced response to alarm pheromone, parasitoid avoidance.	Foster et al. 1996, 1997, 2003, 2010	Fitness costs never evaluated in Australia
Genetic basis for resistance	• Synthetic pyrethroids: kdr and Super-kdr are co-dominant • Organophosphates: E4 and FE4 co-dominant and induced • Carbamates: MACE thought to be co-dominant • Neonicotinoids: P450 co-dominant, modified AChR thought to be recessive (only found homozygous)	Criniti et al. 2008; Field 2000; Field et al. 1999; Puinean et al. 2010	Super-kdr and MACE only present as heterozygotes in field populations

4. RESISTANCE MANAGEMENT AND MINIMISATION STRATEGY

The aim of this strategy is to minimise the selection pressure for resistance to the same chemical group across consecutive generations of *Myzus persicae*.

Due to regional differences in resistance levels across Australia, there is a need to implement strategies that are regionally relevant. We have relied upon the latest (2012-2013) resistance surveillance activities published by Umina et al. 2014a, 2014b. It is assumed that carbamate resistance is now commonplace in WA, SA and Qld, but remains relatively rare in Vic and NSW grain growing areas. There is also an assumption that the probability of resistance to imidacloprid will increase significantly with proximity to horticultural crops. It is assumed that the resistance status of GPA in grain growing areas is likely to be variable between seasons and between regional areas.

There is strong evidence that proximity to horticulture is a major factor influencing the likelihood of resistance appearing in grains crops, and a distance of 50km from horticultural regions has been selected to designate areas of grain crops most likely to be affected. This figure is based on a maximum seasonal movement based on estimates of maximum dispersal distance (5km) and generations per season (10), and by necessity ignores the small number of aphids that use wind-aided dispersal to travel longer distances (10s to 100s of kms) and then successfully establish on suitable host plants (Loxdale et al. 1993).

In the future, resistance management strategies for GPA should ideally establish resistance levels on early-season aphid populations (especially in years where they are anticipated to reach damaging levels) covering regionally diverse areas. This would provide a scientifically valid approach for the selection of chemicals to be used against these pest populations (i.e. confidence in the selection of chemical groups based on known resistance levels, allowing for a wider selection and rotation of chemicals in some seasons).

FIGURE 1 Carbamate resistance in green peach aphid populations.

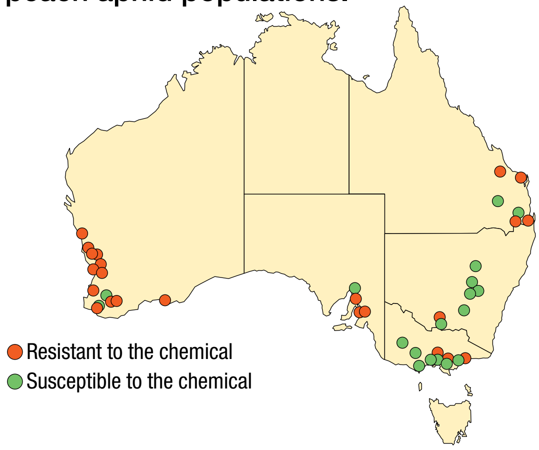

FIGURE 2 Organophosphate resistance in green peach aphid populations.

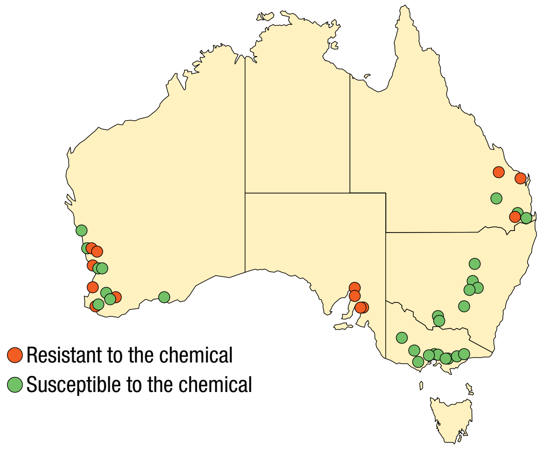

FIGURE 3 Synthetic pyrethroid resistance in green peach aphid populations.

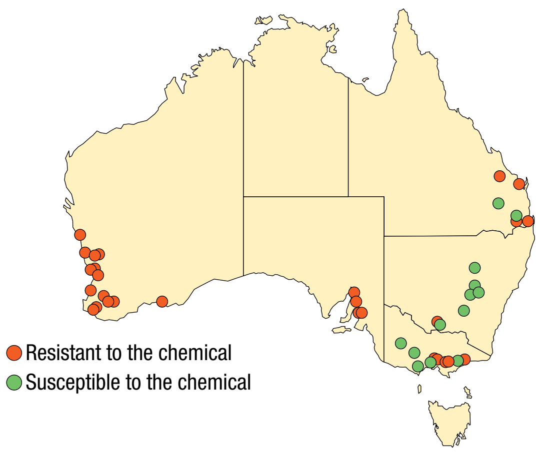

TABLE 4 Resistance management and minimisation strategy for the green peach aphid

State	Crop type and location	Pre-emergence and establishment	Post establishment/pre-flowering	Rationale
WA/Qld/SA	Canola >50 km from commercial horticultural regions	Imidacloprid (4A)	Sulfloxaflor (4C) or Paraffinic oil	Carbamate resistance is commonplace in WA, SA and Qld. Its use is not recommended.
WA/Qld/SA	Canola < 50 km from commercial horticultural regions	Sulfloxaflor (4C)	Paraffinic oil **	Carbamate resistance is commonplace in WA, SA and Qld. Its use is not recommended. Imidacloprid resistance is emerging in horticultural crops, thus its use is not recommended.
NSW/Vic	Canola >50 km from commercial horticultural regions	Imidacloprid (4A) or Lambda-cyhalothrin + thiamethoxam (3A + 4A)	Pirimicarb (1A) or Paraffinic oil If further applications required, choose Sulfloxaflor (4C)	Carbamate resistance remains relatively rare in Vic and NSW.
NSW/Vic	Canola < 50 km from commercial horticultural regions	Sulfloxaflor (4C)	Pirimicarb (1A) or Paraffinic oil	Carbamate resistance remains relatively rare in Vic and NSW. Imidacloprid resistance is emerging in horticultural crops. Its use is not recommended.
WA/Qld/SA	Pulses > 50 km from commercial horticultural regions	Imidacloprid (4A)	Dimethoate/Omethoate (1B) or Paraffinic oil (Note: apply a single treatment of 1B only, do not use repeated applications. Efficacy of 1B may be reduced if previous applications of 1B have been applied)	Carbamate resistance is commonplace in WA, SA and Qld, thus its use is not recommended. Organophosphate resistance is due to amplified E4 esterase, which is induced in populations by the prior exposure to organophosphates.
WA/Qld/SA	Pulses < 50 km from commercial horticultural regions	**	Dimethoate/Omethoate (1B) or Paraffinic oil (Note: apply a single treatment of 1B only, do not use repeated applications. Efficacy of 1B may be reduced if previous applications of 1B have been applied)	Carbamate resistance is commonplace in WA, SA and Qld. Its use is not recommended. Organophosphate resistance is due to amplified E4 esterase, which is induced in populations by the prior exposure to organophosphates. Imidacloprid resistance is emerging in horticultural crops. Its use is not recommended.
NSW/Vic	Pulses > 50 km from commercial horticultural regions	Imidacloprid (4A)	Pirimicarb (1A) or Paraffinic oil	Carbamate resistance remains relatively rare in Vic and NSW.
NSW/Vic	Pulses < 50 km from commercial horticultural regions	**	Pirimicarb (1A) or Paraffinic oil	Carbamate resistance remains relatively rare in Vic and NSW. Imidacloprid resistance is emerging in horticultural crops. Its use is not recommended.
All States	All crops and areas	Cultural/Biological control - improved prediction of aphid outbreak years to inform spray decisions		Using local knowledge and availability of climatic data, we are now in a stronger position to predict the likely pest severity of a green peach aphid outbreak. In low risk years, we can eliminate the need for prophylactic insecticide use, such as seed treatments (High risk = summer rainfall creating green bridge, warm conditions in autumn that favour early aphid build-up and timing of flights).
All States	All crops and areas	-	Cultural/Biological control - do not spray for *Myzus persicae* at or post inflorescence stage	GPA rarely causes economic yield loss in southern grain crops (or significant quality loss) once the crops have reached the stem elongation growth stage in high or medium rainfall areas. In lower rainfall areas or under drought conditions, yield losses can result from the combination of drought stress and aphid damage.
All States	All crops > 50 km from commercial horticultural regions	Cultural/Biological control - Control summer and autumn weeds, particularly wild radish, wild turnip, capeweed and volunteer canola & lupins. Eliminate weeds (ideally area wide) at least 3-4 weeks before sowing		This practice will reduce the availability of alternate hosts between growing seasons and will reduce aphid population sizes at the beginning of the cropping season.
All States	All crops in commercial horticultural regions & summer irrigation	Cultural/Biological control - Little that can be done about weeds		There is likely to be a suitable 'green bridge' for green peach aphids all year round in the vast majority of horticultural & summer irrigation regions.

** There is an urgent need for alternative chemical control options.
Note: paraffinic oils are registered for suppression of GPA only.

Other general recommendations:

- Monitor pest and beneficial populations before using insecticides (Note: In many cases we lack basic threshold data on beneficial to pest ratio that would provide confidence to growers of when not to spray. However the current sampling strategies adopted because chemical use is the primary tool being deployed, precludes the use of key information on relative pest population growth and abundance of natural enemies that would make this possible).
- Use economic spray thresholds where available.
- Consider paddock border sprays with insecticides to prevent/delay the build-up of aphids and retain beneficial insects.
- Avoid repeated applications of products from the same insecticide group on GPA or related pests.
- Do not re-spray a paddock in the same season where a known spray failure has occurred using the same product or another product from the same insecticide group, or if a spray failure has occurred where the cause has not been identified.
- To encourage beneficial insects, avoid broad-spectrum sprays, particularly early in the crop cycle.
- Comply with all 'directions for use' on product labels.
- Ensure spray rigs are properly calibrated and sprays achieve good coverage, particularly in canola crops with a bulky canopy.

5. INTERACTIONS WITH INSECTICIDE RESISTANCE IN OTHER PEST SPECIES

Insecticides used to control other pests will increase section pressure on GPA if they are also present in the crop at the time of application. Similarly, insecticide applications aimed at GPA will expose other insect pests to selection pressure for resistance. Repeated chemical exposure to the same chemical group(s) should be avoided wherever possible, regardless of the pest being targeted.

Group 1A (e.g. pirimicarb) insecticides are aphid-specific in their effects, and as such are not used against non-aphid pests. The risk of resistance developing to Group 4C (e.g. sulfoxaflor) and 4A (e.g. imidacloprid) chemicals in other pests as a result of the recommendations of this Strategy is likely to be relatively low. The recommendation of a single application of Group 1B (e.g. dimethoate, omethoate) in some regions (where Group 1A resistance is common) is unlikely to result in significant additional risk of resistance development in other pest species.

There is industry concern that widespread and continual seed application of neonicotinoids on canola will lead to unnecessary exposure of plant feeding pests to low doses of chemicals and likely increase resistance selection. In many grain-growing areas of southern Australia, GPA is not considered an annual pest, but rather a one in 3-5 year pest. It would be prudent to reserve the use of neonicotinoid-treated seed to those regions and seasons considered "at risk" of virus transmission and/or aphid feeding damage.

It was noted that the use of insecticides (in particular Group 1B and 3A chemicals) in pulses and canola to combat other invertebrate pests (such as weevils, mites, caterpillars) will impose additional selection pressure on GPA. However, this cannot be addressed through this Resistance Management Strategy.

6. INDUSTRY NEXT STEPS

TABLE 6 Industry next steps

Policy/ initiatives	GRDC	Promotion of alternate chemistry, promotion of ongoing resistance monitoring across States, access to data for estimating selection pressures, biosecurity issues around movement of genes, engage with quarantine
	HAL	Development of an Insecticide Resistance Management (IRM) strategy for GPA on horticultural crops that complements the GRDC strategy, screening populations for imidacloprid resistance, ensure engagement with the quarantine/biosecurity sectors
	Cotton	Communication across agencies

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