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INTRODUCTION:

The CropLife Australia Expert Committee on Insecticide Resistance (ECHR) has drafted insect resistance management strategies in conjunction with growers, researchers and agronomists to minimise the development of insect resistance to insecticides. These strategies provide growers with guidelines for insecticide use (and other methods) for sustainable insect control.

PRINCIPLES OF RESISTANCE MANAGEMENT:

Insecticide or acaricide resistance management strategies seek to minimise the selection for resistance to any one type of insecticide or acaricide. This requires an understanding of insecticides as they are grouped according to similarity of Mode of Action (MoA) in controlling insects and mites.

In practice, sequences or rotations of compounds from different MoA groups provide an effective approach to resistance management. These MoA groups are shown in the **Mode of Action Classification for Insecticides Table**.

EFFECTIVE RESISTANCE MANAGEMENT STRATEGIES USE ALTERNATIONS OR SEQUENCES OF DIFFERENT MODES OF ACTION

The objective of Insecticide Resistance Management is to prevent or delay resistance developing to insecticides, or to help regain susceptibility in insect pest populations in which resistance has already arisen. IRM is important in maintaining the efficacy of valuable insecticides. It is usually easier to prevent resistance occurring than it is to reactively regain susceptibility.

Insecticide applications are often arranged into MoA spray windows or blocks that are defined by the stage of crop development and the biology of the pest(s) of concern. Local expert advice should always be followed with regard to spray windows and timings. Several sprays of a compound may be possible within each spray window but it is generally essential to ensure that successive generations of the pest are not treated with compounds from the same MoA group.

WHAT IS RESISTANCE?

Resistance to insecticides and acaricides may be defined as '*a heritable change in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species.*'

Resistance arises through the over use or misuse of an insecticide or acaricide against a pest species and results in the selection of resistant forms of the pest and the consequent evolution of populations that are resistant to that insecticide or acaricide.

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RESISTANCE MECHANISMS

There are a number of ways insects can become resistant to insecticidal crop protection products.

Metabolic resistance

Resistant insects may detoxify or destroy the toxin faster than susceptible insects, or quickly rid their bodies of the toxic molecules. Metabolic resistance is the most common mechanism and often presents the greatest challenge. Insects use their internal enzyme systems to break down insecticides. Resistant strains may possess higher levels or more efficient forms of these enzymes. In addition to being more efficient, these enzyme systems also may have a broad spectrum of activity (i.e., they can degrade many different insecticides).

Target-site resistance

The target site where the insecticide acts in the insect may be genetically modified to prevent the insecticide binding or interacting at its site of action thereby reducing or eliminating the pesticidal effect of the insecticide.

Penetration resistance

Resistant insects may absorb the toxin more slowly than susceptible insects. Penetration resistance occurs when the insect's outer cuticle develops barriers which can slow absorption of the chemicals into their bodies. This can protect insects from a wide range of insecticides. Penetration resistance is frequently present along with other forms of resistance, and reduced penetration intensifies the effects of those other mechanisms.

Behavioural resistance

Resistant insects may detect or recognize a danger and avoid the toxin. This mechanism of resistance has been reported for several classes of insecticides, including organochlorines, organophosphates, carbamates and pyrethroids. Insects may simply stop feeding if they come across certain insecticides, or leave the area where spraying occurred (for instance, they may move to the underside of a sprayed leaf, move deeper in the crop canopy or fly away from the target area).

MODE OF ACTION, TARGET-SITE RESISTANCE AND CROSS-RESISTANCE

In the majority of cases, not only does resistance render the selecting insecticide ineffective but it often confers cross-resistance to other chemically related compounds. Compounds within a specific chemical group usually share a common target site within the pest, and thus share a common Mode of Action (MoA). It is common for resistance to develop that is based on a genetic modification of this target site. When this happens, the compound loses its pesticidal efficacy.

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Because all compounds within the chemical sub-group share a common MoA, there is a high risk that the resistance will automatically confer cross-resistance to all the compounds in the same sub-group. It is this concept of cross-resistance within chemically related insecticides or acaricides that is the basis of the Mode of Action classification.

ALTERNATION OF CHEMISTRY

Constant use of insecticides from one chemical grouping (MoA) will increase the risk of rapid build-up of resistance to that chemical group. Alternate use of chemical groups with different MoAs will slow down the process of selection for resistance.

USE OF CULTURAL PRACTICES

Incorporation of cultural techniques for controlling an insect pest will reduce selection pressure from the insecticides. Any resistance management strategies should incorporate all available methods of control for the insect pest concerned.

UNDERSTANDING OF THE INSECT/MITE LIFE CYCLE

A good understanding of the life cycle of the pest is essential so that control methods can be effectively targeted. An insecticide or acaricide should always be targeted at the pest growth stage that is most susceptible for that insecticide or acaricide.

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APPLICATION

Label Recommendations

Insecticide labels have been carefully developed to ensure the most effective control of the pest. The label should at all times be carefully read and adhered to.

Rates

Full recommended rates of registered insecticides should always be used to ensure the most effective control of the pest.

Coverage

The majority of insecticides require good coverage of the target area to ensure the best possible chance of contact and subsequent control of the pest.

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RESISTANCE MANAGEMENT STRATEGY DESIGN

Crop/Pest or Regional Strategies

The strategies below are provided on a CROP by PEST basis (e.g. Tomato - Heliothis). However, in horticultural and agricultural areas often a range of crops are grown that are attacked by a range of pests.

In many cases, a specific MoA insecticide can be used across this range of crops to control multiple pests that have the ability to move from crop to crop. There is interaction between intensive horticulture and broadacre farming, as with Diamondback Moth (DBM) in Brassica vegetables and resistance strategies that could be compromised by widespread use of insecticides for DBM control in canola.

Also, the pest complex for a specific crop will vary within production regions, especially between Northern and Southern Australia.

For this reason, CROP by PEST strategies can be flawed and further Insecticide Resistance Management (IRM) advice for specific pests should always be sought on a local basis.

An alternative to the CROP by PEST strategy is that of "Regional strategies" such as those for Cotton, Brassicas and the Southern NSW and Northern Victorian IRM strategy for grain and annual horticultural crops".

These regional or specific crop strategies are available on the CropLife Australia website.

The overall Resistance Management Strategy of avoiding overuse of individual Modes of Action insecticides should be followed, not just on a specific crop and pest but on a broad perspective of crops and pest complex.

ADDITIONAL INFORMATION

Further information on Insecticide Resistance, Management Strategies and Insecticide Mode of Action can be found on the International IRAC (Insecticide Resistance Action Committee) website: <https://www.irac-online.org/>.

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Crop(s): Banana

Insect(s): Banana weevil borer (*Cosmopolites sordidus*) and Rust Thrips (*Chaetanaphothrips signipennis*)

Comments on the Strategy:

1. Use only clean planting material.
2. If re-planting into an old banana block, allow at least 6 months fallow after old banana material has rotted down.
3. Remove weeds and trash around banana stools to allow maximum effectiveness of insecticides and to reduce sheltering sites for weevils. Application of insecticide to trash may lead to reduced control of banana weevil borer.
4. Cut up fallen and harvested pseudostems to reduce weevil breeding sites.
5. Monitor regularly for banana weevil borer activity by trapping (when adult weevils are active) or conduct corm damage ratings.
6. Only use insecticides when populations reach or exceed accepted threshold levels. Refer to local Department of Agriculture guidelines.
7. Only use insecticides at the registered rate of application and apply at times when the particular product will have the maximum impact, i.e. use contact insecticides only when weevil borer adults are active.
8. Use insecticides only in the years indicated in the following diagrams.
9. Consider the impact of the use of other pesticides for other insects or nematodes on banana weevil borers.
10. For rust thrips control, a combination of control methods such as butt/band sprays, stem injection or spray and bunch sprays may be required.

The following two diagrams are alternative Resistance Management Strategies depending on which product(s) are chosen for banana weevil borer and rust thrips control.

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Strategy A: Where products other than controlled release formulations of imidacloprid are being used to control insects in bananas

Group*	Chemical sub-group	Example chemical	Year 1 Use	Year 2 Use	Year 3 Use	Year 4 Use	Year 5 Use	Year 6 Use
1A or 1B	Carbamates Organophosphates	oxamyl ¹ or acephate ² cadusafos ¹ chlorpyrifos ³ diazinon ³ prothiofos ¹ terbufos ¹	YES	NO	YES	NO	YES	NO
2B	Phenylpyrazoles (Fiproles)	fipronil ³	YES	NO	YES	NO	YES	NO
3A	Synthetic pyrethroids	bifenthrin ³	NO	YES	NO	YES	NO	YES
4A	Neonicotinoids	clothianidin ³ imidacloprid ³	NO	YES	NO	YES	NO	YES
5	Spinosyns	spinetoram ²	NO	YES	NO	YES	NO	YES

*Refer: CropLife Australia Expert Committee on Insecticide Resistance Mode of Action Classification for Insecticides

¹Products registered for banana weevil borer control

²Product registered for rust thrips control as bunch sprays only

³Products registered for banana weevil borer and rust thrips control

Guidelines:

1. The resistance management strategy may start at any point in the product group rotation and planting may occur in any year of the strategy.
2. The product(s) used in any one year **should not be** followed by product(s) from the same insecticide group in the following year.
3. Only products from the **YES** insecticide groups shown in the diagram above **should be** applied for banana weevil borer control and/or rust thrips control in the same year.
4. If products from **Group 1A** or **1B** (oxamyl, cadusafos or terbufos) are being used for nematode control in a block of bananas, then products from these groups **should not be** used for banana weevil borer control in the following year.

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- Where there is evidence of banana weevil borer or rust thrips resistance to a product or group of products, these should not be used again for banana weevil borer or rust thrips control until there has been use of products from other Insecticide Mode of Action groups for a period of at least 2 years.

Strategy B: Where products including controlled release formulations of imidacloprid are being used to control insects in bananas

Group*	Chemical sub-group	Example chemical	Year 1 Use	Year 2 Use	Year 3 Use	Year 4 Use	Year 5 Use	Year 6 Use
1A or 1B	Carbamates Organophosphates	oxamyl ¹ or acephate ² cadusafos ¹ chlorpyrifos ³ diazinon ³ prothiofos ¹ terbufos ¹	NO	YES	NO	YES	NO	YES
2B	Phenylpyrazoles (Fiproles)	fipronil ³	YES	NO	YES	NO	YES	NO
3A	Synthetic pyrethroids	bifenthrin ³	NO	YES	NO	YES	NO	YES
4A	Neonicotinoids	CR imidacloprid ³	YES	YES	YES	NO	NO	NO
5	Spinosyns	spinetoram ²	YES	NO	YES	NO	YES	NO

*Refer: CropLife Australia Expert Committee on Insecticide Resistance Mode of Action Classification for Insecticides

¹Products registered for banana weevil borer control

²Product registered for rust thrips control as bunch sprays only

³Products registered for banana weevil borer and rust thrips control

Guidelines:

- The resistance management strategy may start at year 1 or year 4 in the product group rotation.
- Controlled release imidacloprid provides 3 years control of banana weevil borer with one application at planting, so after the 3rd year, insecticide products from other Groups are to be used in rotation for at least 3 years for banana weevil borer and rust thrips control in a given

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block of bananas.

3. Alternative product groups are provided in these 3 years for control of rust thrips as soil or stem treatments or bunch sprays.
4. Only products from the **YES** insecticide groups shown in the diagram above **should be** applied for banana weevil borer control and/or rust thrips control in the same year.
5. If products from Group 1A or 1B (oxamyl, cadusafos or terbufos) are being used for nematode control in a block of bananas, then products from these groups **should not be** used for banana weevil borer control in the following year.
6. Where there is evidence of banana weevil borer or rust thrips resistance to a product or group of products, these should not be used again for banana weevil borer control until there has been use of products from other Insecticide Mode of Action groups for a period of at least 2 years.

Notes regarding the application of insecticides:

1. To ensure the most effective control of the pest:
 - a. Product labels should at all times be carefully read and adhered to;
 - b. Full recommended rates of registered insecticides should always be used; and
 - c. Ensure good coverage of the target area to maximise contact.

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Crop(s): Brassica

Insect(s): Diamondback moth, Cabbage moth (*Plutella xylostella*).

Guidelines:

1. To help prevent the development of resistance to any one specific active ingredient (see table below), observe the following instructions:
 - a. Use in accordance with the current IRMS for your region. For growers in the Lockyer Valley region, please refer to the [Lockyer Valley Diamondback Moth Insecticide Resistance Management Strategy](#). For growers in Western Australia, please refer to the Western Australian Department of Primary Industries and Regional Development [two-window strategy](#).
 - b. Apply a specific active ingredient using a "window" approach to avoid exposure of consecutive insect pest generations to the same mode of action. Multiple successive applications of a specific active ingredient are acceptable if they are used to treat a single pest generation.
 - c. Following a "window" of a specific mode of action product, rotate to a "window" of applications of effective insecticides with a different mode of action.
 - d. The total exposure period of any one mode of action "active window" applied throughout the crop cycle (from seedling to harvest) should not exceed 50% of the crop cycle.
 - e. Incorporate IPM techniques into the overall pest management program and
 - f. Monitor insect populations for loss of field efficacy.
2. Always read and follow product labels and use the full recommended label rates of application. Some products place a limit on the number of times they can be applied per crop (see table below) and when they can be applied.
3. Monitor crops regularly and only apply insecticide when the pest threshold is reached.
4. When an insecticide with foliar activity on diamondback moth has been used as seed treatment or drench application in nursery production (as determined by label claims), rotate to alternative mode of action insecticide for a period covering at least one generation of diamond back moth. This may require a minimum of 2 applications of alternate mode of action insecticides. Ensure spray rig is properly calibrated and achieving good coverage with appropriate sized spray droplets.
5. Time the application to the most susceptible life stage of the target pest.
6. To encourage beneficial insects, use *Bacillus thuringiensis* (Bt) sprays and avoid broad spectrum

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insecticides where possible, particularly early to mid-crop cycle.

7. Be cautious of using insecticide tank-mixes where both active ingredients control DBM as this strategy is generally not considered best practice for resistance management. Refer to the [IRAC International Insecticide Mixture Statement](#) for more information on this subject.
8. **DO NOT** re-treat a spray failure with a product from the same chemical group.
9. Practice good crop hygiene to reduce DBM pressure - plant clean seedlings and incorporate crop residue as soon as practical after harvest.

Group*	Active ingredient	Number applications permitted per crop per season from product label
1A	methomyl, thiodicarb	Not specified
2B	fipronil	4 per year within 8-week period
3A	synthetic pyrethroids (various)	Not specified
5	spinetoram	4
6	emamectin benzoate	4 per any one crop
11A	<i>Bacillus thuringiensis</i>	not specified
13	chlorfenapyr	2 but 4 in brussels sprouts
22A	indoxacarb	4
23	spirotetramat	2 but 3 in brassica leafy vegetables
28	chlorantraniliprole, flubendiamide	3 but 1 for mixtures of chlorantraniliprole and thiamethoxam

*Refer: CropLife Australia Expert Committee on Insecticide Resistance Mode of Action Classification for Insecticides

Notes regarding the application of insecticides:

1. To ensure the most effective control of the pest:
 - a. Product labels should at all times be carefully read and adhered to;
 - b. Full recommended rates of registered insecticides should always be used; and
 - c. Ensure good coverage of the target area to maximise contact.

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Crop(s): Canola, Forage brassica

Insect(s): Diamondback moth, Cabbage moth (*Plutella xylostella*)

Guidelines:

1. For information refer to the IPM guidelines: <https://ipmguidelinesforgrains.com.au/ipm-information/resistance-management-strategies/>

Notes regarding the application of insecticides:

1. To ensure the most effective control of the pest:
 - a. Product labels should at all times be carefully read and adhered to;
 - b. Full recommended rates of registered insecticides should always be used; and
 - c. Ensure good coverage of the target area to maximise contact.

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Crop(s): Cotton

Insect(s): All pests

Guidelines:

1. For information refer to the current Cotton Pest Management Guide:
<https://www.cottoninfo.com.au/publications/cotton-pest-management-guide>

Notes regarding the application of insecticides:

1. To ensure the most effective control of the pest:
 - a. Product labels should at all times be carefully read and adhered to;
 - b. Full recommended rates of registered insecticides should always be used; and
 - c. Ensure good coverage of the target area to maximise contact.

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Crop(s): Pasture/Winter crops

Insect(s): Redlegged Earth Mite; RLEM (*Halotydeus destructor*)

Guidelines:

1. **Rotate** insecticide Groups.
2. **Do not** apply consecutive sprays of products from any one insecticide Group.

Crop stage	Group*	Chemical sub-group	Example chemical
Seed treatment (or in-furrow)	4A	neonicotinoids or	imidacloprid
	1B	organophosphates or	dimethoate
	2B	phenylpyrazoles	fipronil
Bare Earth (Pre-emergent)	1B	organophosphates or	omethoate
	3A	synthetic pyrethroids	bifenthrin
Early Season (Autumn when limited green growth)	1B	organophosphates or	chlorpyrifos
	3A	synthetic pyrethroids	alpha-cypermethrin
Spring	1B	organophosphates or	omethoate
	3A	synthetic pyrethroids	gamma-cyhalothrin

*Refer: CropLife Australia Expert Committee on Insecticide Resistance Mode of Action Classification for Insecticides

3. If both autumn and spring applications are needed, alternate between synthetic pyrethroids and organophosphates.
4. Timing of Sprays
 - a. Monitor Redlegged Earth Mite (RLEM) activity carefully and only treat if damage has reached threshold levels.
 - b. One well timed spray in Autumn or Spring will maximise effectiveness of treatment.
5. Placement of Sprays
 - a. Apply perimeter sprays where infestations are concentrated on the edge of fields.
 - b. Use blanket sprays where appropriate.
6. Cultural Practices

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- a. Heavy grazing or cutting for hay or cultivation will reduce mite numbers.
 - b. Develop damage thresholds.
 - c. Rotate crops and pastures that are more tolerant to the pest.
 - d. Encourage predator survival by judicious use of insecticides.
 - e. Control alternative hosts such as Capeweed and Paterson's curse. For more detail on resistance management for RLEM in grain crops and pastures, refer to:
<http://ipmguidelinesforgrains.com.au/ipm-information/resistance-management-strategies/>

Notes regarding the application of insecticides:

1. To ensure the most effective control of the pest:
 - a. Product labels should at all times be carefully read and adhered to;
 - b. Full recommended rates of registered insecticides should always be used; and
 - c. Ensure good coverage of the target area to maximise contact.

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Crop(s): Pome fruit

Insect(s): Two-spotted mite (*Tetranychus urticae*), European red mite (*Panonychus ulmi*)

Guidelines:

1. Make **no more than one application** from each registered miticide group per season. Rotate registered miticides that have different mode of action (i.e. **Group 6, Group 10A, Group 10B, Group 12B, Group 12C, Group 13, Group 20D** and **Group 21A**).
2. For miticides that have the same mode of action (e.g. **Group 21A**) do not use consecutive applications within and between seasons.

Group*	Chemical sub-group	Example chemical
6	Avermectins, milbemycins	abamectin, milbemectin
10A	Clofentezine, hexythiazox	clofentezine, hexythiazox
10B	Etoxazole	etoxazole
12B	Organotin miticides	fenbutatin oxide
12C	Propargite	propargite
13	Chlorfenapyr	chlorfenapyr
20D	Bifenazate	bifenazate
21A	METI acaricides	fenpyroximate, tebufenpyrad

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*Refer: CropLife Australia Expert Committee on Insecticide Resistance Mode of Action Classification for Insecticides

Notes:

1. Miticides should be used as part of an Integrated Mite Control (IMC) program.
2. Mite levels should be monitored and thresholds utilised before deciding to make miticide applications.
3. Where practicable, predatory mites should be incorporated into an IMC program.
4. When using insecticides/miticides to control other pests of pome fruit such as codling moth, lightbrown apple moth and woolly aphid, consider the chemical group and the potential impact

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it may have on resistance development of mite pests

5. When using insecticides/miticides to control other pests of pome fruit consider the effect on beneficial insects and the potential to flare mite populations
6. For more information refer to the current [NSW Orchard Plant Protection Guide](#).

Notes regarding the application of insecticides:

1. To ensure the most effective control of the pest:
 - a. Product labels should at all times be carefully read and adhered to;
 - b. Full recommended rates of registered insecticides should always be used; and
 - c. Ensure good coverage of the target area to maximise contact.

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Crop(s): Potato

Insect(s): Potato tuber moth / Tomato leafminer (*Phthorimaea operculella*)

1. Monitor pest levels and **do not** spray unless pest thresholds are exceeded.
2. **Rotate** insecticide groups and **do not** use two consecutive applications of products with the same Mode of Action.
3. Integrate both chemical and non-chemical means of control as part of the overall control strategy. Examples are the use of predators/parasites and relevant cultural practices (crop hygiene, rotation of planted areas, and strategic time of planting).

Group*	Chemical sub-group	Example chemical
1B	Organophosphates	acephate, azinphos-methyl, methamidophos, diazinon, dichlorvos
1A	Carbamates	carbaryl, methomyl
3A	Pyrethroids	permethrin
5	Spinosyns	spinosad, spinetoram
28	Diamides	chlorantraniliprole, flubendiamide

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*Refer: CropLife Australia Expert Committee on Insecticide Resistance Mode of Action Classification for Insecticides

Notes regarding the application of insecticides:

1. To ensure the most effective control of the pest:
 - a. Product labels should at all times be carefully read and adhered to;
 - b. Full recommended rates of registered insecticides should always be used; and
 - c. Ensure good coverage of the target area to maximise contact.

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Crop(s): Sorghum, Maize, Summer & Winter Grain Legumes

Insect(s): Heliothis/Cotton bollworm/Native budworm (*Helicoverpa* spp.)

Guidelines:

6. To help prevent the development of resistance to any one specific active ingredient (see table below), observe the following instructions:
 - a. Use in accordance with the current IRMS for your region.
 - b. Apply a specific active ingredient using a "window" approach to avoid exposure of consecutive insect pest generations to the same mode of action. Multiple successive applications of a specific active ingredient are acceptable if they are used to treat a single pest generation.
 - c. Following a "window" of a specific mode of action product, rotate to a "window" of applications of effective insecticides with a different mode of action.
 - d. The total exposure period of any one mode of action "active window" applied throughout the crop cycle (from seedling to harvest) should not exceed 50% of the crop cycle.
 - e. Incorporate IPM techniques into the overall pest management program and
 - f. Monitor insect populations for loss of field efficacy.
7. Always read and follow product labels. Some products place a limit on the number of times they can be applied per crop (see table below) and when they can be applied.
8. Monitor crops regularly and only apply insecticide when the pest threshold is reached.
9. Ensure spray rig is properly calibrated and achieving good coverage with appropriately sized spray droplets.
10. Time the application to the most susceptible life stage of the target pest.
11. To encourage beneficial insects, use *Bacillus thuringiensis* (Bt) or NPV sprays and avoid broad spectrum insecticides where possible, particularly early to mid-crop cycle.
12. Be cautious of using insecticide tank-mixes where both active ingredients control *Helicoverpa* spp. as this strategy is generally not considered best practice for resistance management. Refer to document [IRAC International Insecticide Mixture Statement](#) for more information on this subject.
13. **Do not** re-treat a spray failure with a product from the same chemical group.
14. Practice effective pupae busting as soon as practicable after harvest.

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Group*	Active ingredient	Number applications per crop per season [‡]	Crops [‡]
1A	Methomyl (eg. Lannate® L), thiodicarb (eg. Larvin®)	not specified	All cereal grains, oilseed, pulses
3A	synthetic pyrethroids (various – eg. Bulldock®, Dominex® Duo, Karate® Zeon, Sumi-alpha® Flex, Trojan®)	not specified	All cereal grains, oilseed, pulses
5	Spinetoram (Success® Neo)	TBC	All pulses
6	emamectin benzoate (eg. Affirm®)	2	All pulses
11A	<i>Bacillus thuringiensis</i> (eg. Dipel®, Xentari®)	not specified	All cereal grains, oilseed, pulses
22A	Indoxacarb (eg. Steward® EC)	1	chickpea, faba bean, mung bean, soybean, azuki bean
28	Chlorantraniliprole (Altacor®)	Refer to label	All pulses
Not categorised	Nucleopolyhedrovirus (NPV) – (eg. Gemstar®, Vivus® Max)	no limit but avoid season long use of low rates	All cereal grains, oilseed, pulses

*Refer: CropLife Australia Expert Committee on Insecticide Resistance Mode of Action Classification for Insecticides

[‡]Refer: Registered product label

Notes:

1. For more information refer to the IPM Guidelines *H. armigera* RMS for Australian grains:

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<https://ipmguidelinesforgrains.com.au/ipm-information/resistance-management-strategies/#heli>

Notes regarding the application of insecticides:

2. To ensure the most effective control of the pest:
 - d. Product labels should at all times be carefully read and adhered to;
 - e. Full recommended rates of registered insecticides should always be used; and
 - f. Ensure good coverage of the target area to maximise contact.

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Crop(s): Strawberries/Ornamentals

Insect(s): Two-spotted mite (*Tetranychus urticae*)

Guidelines:

1. Monitor mite activity and treat infestations before thresholds are reached, i.e. spray earlier rather than later. Seek advice on local threshold levels.
2. **Do not** apply sequential applications of products from any one chemical group.
3. Preferably products with the same Mode of Action should not be used more than twice in a growing season
4. Incorporate the use of predatory mites for the control of this pest wherever possible.

Notes regarding the application of insecticides:

1. To ensure the most effective control of the pest:
 - a. Product labels should at all times be carefully read and adhered to;
 - b. Full recommended rates of registered insecticides should always be used; and
 - c. Ensure good coverage of the target area to maximise contact.

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Crop(s): Sweet Corn

Insect(s): Corn earworm (*Helicoverpa armigera*) aka Heliothis

Guidelines:

1. The critical stage of infestation is during silking. Even low levels of heliothis infestation are unacceptable at the silking stage. Because sweet corn is less attractive to heliothis before flowering and it is picked soon after silking is completed, there is a relatively short period of protection required.
2. Control of heliothis at the tasselling stage (occurs prior to silking stage) can be important in some regions as the tassel can act as a nursery for heliothis, which can then move onto the young developing cobs. Control of heliothis at this stage is not as difficult as at the silking stage.
3. Use of biological insecticides, Bt and Nuclear Polyhedrosis Virus (NPV), in the early stages of crop development is encouraged.
4. Monitor crops regularly, at least weekly during silking and **do not** spray unless pest thresholds are exceeded.
5. Labels of new products place a limit on the number of applications. If further control is required on one planting, chemicals from different mode of action groups within the same window should be used.
6. **Do not** retreat a spray failure with a product from the same chemical group.
7. **Do not** use mixtures of insecticides for controlling heliothis.
8. Cultivation after harvest to destroy pupae will greatly assist in managing heliothis.
9. Seek local advice on pest incidence and on the risk of resistance developing from insecticide programs used to control heliothis in crops other than sweet corn.
10. To help prevent the development of resistance to any one specific active ingredient (see table below), observe the following instructions:
 - a. Use in accordance with the current IRMS for your region;
 - b. Apply a specific active ingredient using a "window" approach to avoid exposure of consecutive insect pest generations to the same mode of action. Multiple successive applications of a specific active ingredient are acceptable if they are used to treat a single insect generation;
 - c. Following a "window" of a specific mode of action product, rotate to a "window" of applications of effective insecticides with a different mode of action.

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- d. The total exposure period of any one mode of action “active window” applied throughout the crop cycle (from seedling to harvest) should not exceed 50% of the crop cycle;
- e. Incorporate IPM techniques into the overall pest management program; and
- f. Monitor insect populations for loss of field efficacy.

Group*	Active ingredient
1A	Methomyl, thiodicarb
3A	Synthetic pyrethroids (several)
5	Spinetoram
6	Emamectin benzoate
28	Chlorantraniliprole

*Refer: CropLife Australia Expert Committee on Insecticide Resistance Mode of Action Classification for Insecticides

Notes regarding the application of insecticides:

1. To ensure the most effective control of the pest:
 - a. Product labels should at all times be carefully read and adhered to;
 - b. Full recommended rates of registered insecticides should always be used; and
 - c. Ensure good coverage of the target area to maximise contact.

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Region	January	February	March	April	May	June	July	August	September	October	November	December												
North Queensland	No Crop		Vegetative phase	Emamectin Benzoate		Methomyl, Thiodicarb, SP's		Chlorantraniliprole		Spinetoram		No Crop												
Heliothis pressure	L	L	L	L	M	H	H	H	H	M	L	L												
South East Queensland	Spinetoram	Chlorantraniliprole			Methomyl, Thiodicarb, SP's		No Crop				Vegetative phase	Emamectin Benzoate	Spinetoram											
Heliothis pressure	H	H	H	H	H	H	M	M	L	L	L	L	L	L	L	L	M	M	H	H	H	H	H	H
Central NSW / Northern Victoria	Spinetoram			Chlorantraniliprole		Methomyl, Thiodicarb, SP's		No crop					Vegetative phase	Emamectin Benzoate										
Heliothis pressure	H	H	H	H	H	M	M	L	L	L	L	L	L	L	L	L	L	L	M	M	M	M	H	H
Tasmania	Chlorantraniliprole		Spinetoram		No crop							Emamectin Benzoate												
Heliothis pressure	M	M	M	M	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
In all regions	Nuclear Polyhedrosis Viruses (NPV's), <i>Bacillus thuringiensis</i> (Bt) and Methomyl at the ovicidal rate can be used season long with no resistance management implications																							

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H: High pressure period; M: medium pressure period; L: Low pressure period

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Crop(s): Tomato

Insect(s): Heliothis/Tomato budworm (*Helicoverpa* spp.)

Guidelines:

1. Monitor pest levels and **do not** spray unless pest thresholds are reached.
2. **Do not** apply products outside their window of application for that chemical group.
3. Use an integrated pest control approach where both chemical and non-chemical measures are adopted as part of the overall strategy. Examples are the use of predators/parasites and relevant cultural practices (crop hygiene, rotation of planted areas, and strategic time of planting).
4. Seek local advice on pest incidence and the risk of resistance development from insecticide programs used to control heliothis in other crops or to control other pests
5. When using insecticides/miticides to control other pests on tomato, consider the chemical group in relation to contributing to resistance development of heliothis.
6. Avoid using insecticides from the same chemical group against *Helicoverpa* spp. or other pests, as this will increase the selection pressure
7. Do not re-spray a crop in the same season where a failure (which is known or unknown) has occurred using the same insecticide or other active ingredients from the same chemical group.

Notes regarding the application of insecticides:

1. To ensure the most effective control of the pest:
 - a. Product labels should at all times be carefully read and adhered to;
 - b. Full recommended rates of registered insecticides should always be used; and
 - c. Ensure good coverage of the target area to maximise contact.

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Crop(s): Various

Insect(s): Fall armyworm (*Spodoptera frugiperda*)

List of active constituents approved for use under permits by the Australian Pesticides and Veterinary Medicines Authority (APVMA) as of May 2020:**

Group*	Chemical subgroup	Active ingredient
1A	carbamates	Methomyl (eg. Lannate® L)
3A	pyrethroids	Gamma-cyhalothrin (Trojan®), alpha-cypermethrin (eg. Dominex® Duo)
5	spinosyns	Spinetoram (Success® Neo)
6	Avermectins	Emamectin benzoate (eg. Affirm®, Proclaim®)
22A	oxadiazines	Indoxacarb (eg. Steward® EC, Avatar® eVo)
28	Diamides	Chlorantraniliprole (Altacor®, Coragen®), flubendiamide (Belt®).

*Refer: CropLife Australia Expert Committee on Insecticide Resistance Mode of Action Classification for Insecticides

**Refer to the APVMA's PubCris website (<https://portal.apvma.gov.au/permits>) to ensure permit is still active

Guidelines:

- An Integrated Pest Management (IPM) approach should be adopted in the production system to help manage this pest, with focus on cultural methods and the preservation of beneficial arthropods (insects and spiders).
 - This includes regular crop monitoring (at least 2 times per week) to determine incidence x crop damage and the impact of beneficial arthropods.
 - Consideration should also be given to the impact of prevailing weather conditions on the rate of pest development in the field.
- Avoid** sequential plantings of preferred crops, e.g. corn, sorghum, sugarcane, as this will increase local populations of fall armyworm.
- Management of crop residues/volunteer plants before planting and after harvest also helps reduce local populations of fall armyworm.

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4. Where possible, **avoid** the use of broad spectrum foliar applied insecticides in the production system for both larvae and moth control. If broad-spectrum insecticides are to be used, apply at timings when preservation of beneficial species is less likely to be important – i.e. at end of growing season
5. Consider controlling moths using light or attractant traps and encourage micro-bat habitat (natural or artificial roosting sites) adjacent to production areas.
6. In situations where insecticides are required, consider beneficial arthropods when making spray decisions.
7. When applying insecticides to this pest, key considerations should be given to:
 - Apply insecticides only when needed based on economic thresholds;
 - **Target early instar stages** (hatching larvae) of the pest before they become entrenched in the crop e.g. lower whorl of maize, sweet corn or grain sorghum;
 - Use a **medium spray quality** to ensure sufficient droplets cover the spray target to ensure the larvae ingest a lethal dose of insecticide;
 - Use a well calibrated, functioning boom spray with appropriate water rate for the target crop to ensure optimum spray coverage;
 - Use the recommended insecticide rates as stipulated on the relevant APVMA Emergency Use Permit;
 - Use a recommended adjuvant if stipulated on the relevant APVMA Emergency Use Permit; and
 - Inspect the performance of the insecticide 3-4 days after application. Always document the effectiveness of each insecticide application and never re-spray a failure with an insecticide with the same mode of action. Inform your local reseller or agronomist of any spray failures. Internationally, known resistance has occurred to the following MoA groups: Carbamates (Group 1A); Organophosphates (Group 1B); Pyrethroids (Group 3); Bacillus thuringiensis and Cry1F protein (Group 11A).
8. When using selected insecticides in-crop targeting fall armyworm, the following resistance management strategy guidelines should be implemented:
 - If the label allows and it is required for sustained pest management, use two sequential applications of any one Mode of Action (MOA) insecticide to span a **single generation of fall armyworm** (~20 - 30 days) and then **rotate to a different MOA insecticide**;
 - Do not treat successive generations with products of the same MOA
 - The total exposure period of any one MOA insecticide applied throughout the crop

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cycle (from seedling to harvest) **should not exceed 50% of the crop cycle;**

- Abide by the individual label recommendation for maximum **number of allowable applications per crop per season;**
- Abide by individual label recommendation for the **minimum reapplication interval** and always use the **full recommended label rates;**
- Where possible, an Area Wide Management strategy should be adopted where the same MOA insecticides are used **by all growers** in the **same time period;** and
- As the industry learns more about how to manage this pest, this Strategy may be updated and regional-specific strategies may be developed. Check the CropLife Resistance Management [website](#) to ensure you are following the most up to date fall armyworm strategy.

9. Useful fall armyworm reference documents are available at:

- <https://portal.apvma.gov.au/permits>: search for APVMA insecticide permits to use on FAW).
- <https://www.cottoninfo.com.au/insect-and-mite-management>
- <https://thebeatsheet.com.au/fall-armyworm-should-you-be-concerned/>
- <https://irac-online.org/pests/spodoptera-frugiperda/>
- <https://irac-online.org/new-guidelines-on-ipm-irm-for-fall-armyworm-in-s-african-maize/>
- <https://grdc.com.au/resources-and-publications/resources/fall-armyworm>

Notes regarding the application of insecticides:

2. To ensure the most effective control of the pest:
 - d. Product labels should at all times be carefully read and adhered to;
 - e. Full recommended rates of registered insecticides should always be used; and
 - f. Ensure good coverage of the target area to maximise contact.

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Crop(s): Various

Insect(s): Cotton/Melon Aphid (*Aphis gossypii*) and Green Peach Aphid (*Myzus persicae*).

Guidelines:

1. **Rotate** between registered insecticides that have different modes of action (e.g. **Groups 1, 4, 9, 12A** (cotton crop only), **23, 28** and **29**).
2. **Do not** apply consecutive applications of insecticides that have the same mode of action within and between seasons or exceed the recommended maximum number of applications in a crop.
3. **Do not** follow a seed/seedling/soil treatment with a foliar application from the same Group.
4. The Modes of Action (Groups) and registered insecticides for control of cotton/melon aphid and/or green peach aphid are listed below.

Group*	Chemical sub-group	Example chemical
1A	Carbamates	pirimicarb
1B	Organophosphates	methamidophos
4A	Neonicotinoid	imidacloprid
4C	Sulfoximines	sulfoxaflor
9B	Pymetrozine	pymetrozine
9D	Pyropenes	afidopyropen
12A	Diafenthiuron	diafenthiuron
23	Spirotetramat	spirotetramat
28	Diamide	cyantranilprole
29	Flonicamid	flonicamid

*Refer: CropLife Australia Expert Committee on Insecticide Resistance Mode of Action Classification for Insecticides

Notes:

Please note:

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1. There is known cross-resistance between **Groups 1A** and **1B**. Rotate between **Group 1** and **Group 4, 9B, 9D, 12A, 23, 28** and **29**.
2. Consecutive applications of a **Group 4A** and **Group 4C** product may be made only if no other effective option is available – either because:
 - no other group is registered in the crop; or
 - the target pest is resistant to the other Groups.
3. Seek advice from the manufacturers and/or government advisory services to determine local resistance levels for particular mode of action Groups.
4. **Do not** exceed the maximum number of applications permitted on the insecticide label.
5. When using insecticides/miticides to control other pests, consider the chemical group in relation to contributing to resistance development of Cotton/Melon Aphid and Green Peach Aphid.
6. When using insecticides/aphicides to control other pests consider the effect on beneficial insects and the potential to flare aphid populations.
7. For more information about insecticide resistance in the green peach aphid refer to <http://cesaraustralia.com/latest-news/all/insecticide-resistance-in-the-green-peach-aphid>.
8. For more detail on resistance management of aphids in cotton refer to the current [Cotton Pest Management Guide](#) or for more detail on resistance management for Green Peach Aphid in grain refer to <https://ipmguidelinesforgrains.com.au/ipm-information/resistance-management-strategies/> or <https://grdc.com.au/resources-and-publications/all-publications/factsheets/2015/07/grdc-fs-greenpeachaphid>.

Notes regarding the application of insecticides:

1. To ensure the most effective control of the pest:
 - a. Product labels should at all times be carefully read and adhered to;
 - b. Full recommended rates of registered insecticides should always be used; and
 - c. Ensure good coverage of the target area to maximise contact.

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Crop(s): Various

Insect(s): Silverleaf Whitefly (*Bemisia tabaci*)

Guidelines:

1. Monitor pest numbers and apply control measures before adult populations reach high levels.
2. Select registered insecticide control measures according to the primary growth stage of the pest, the infestation level and the age and type of crop.
3. In cotton, spray decisions should be based on the Silverleaf Whitefly threshold matrix. Refer to the current [Cotton Pest Management Guide](#) for further details
4. Where possible, utilise selective insecticides during the early stages of crop development to minimise the impact on beneficial insects.
5. Rotate between registered insecticides that have different modes of action (e.g. **Groups 1, 3, 4, 7, 12, 23, 28** and **29**).
6. **Do not** apply more than two consecutive applications of insecticides that have the same Mode of Action within and between seasons.
7. The Modes of Action (groups) and registered insecticides for control of Silverleaf Whitefly are listed below:

Group*	Chemical sub-group	Example chemical
1B	Organophosphate	acephate
3A	Synthetic pyrethroids	bifenthrin
4A	Neonicotinoids	acetamiprid, dinotefuran, imidacloprid, thiamethoxam
7C	Pyriproxyfen	pyriproxyfen
12A	Diafenthiuron	diafenthiuron
16	Buprofezin	buprofezin
23	Spirotetramat	spirotetramat
-	Petroleum oil	petroleum oil
28	Diamides	cyantraniliprole
29	Flonicamid	flonicamid

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**Refer: CropLife Australia Expert Committee on Insecticide Resistance Mode of Action Classification for Insecticides*

8. Seek advice from the manufacturers and/or government advisory services to determine local resistance levels for particular mode of action Groups.
9. **Do not** exceed the maximum number of applications permitted on the insecticide label.
10. When using insecticides to control other pests, consider the chemical group in relation to contributing to resistance development of Silverleaf Whitefly.
11. When using insecticides to control other pests consider the effect on beneficial insects and the potential to flare Silverleaf Whitefly populations.

Notes:

1. Not all chemical groups listed have registered products available in all crops affected by Silverleaf Whitefly. Only use products registered for use in crop to be treated.

Cultural practices:

1. In vegetable crops, ensure seedlings are free of pests prior to transplanting. Inspect transplants carefully upon arrival for whitefly eggs, nymphs and adults.
2. Control alternate weed hosts of Silverleaf Whitefly two-three weeks before planting to reduce early population levels.
3. Clean-up crop residues:
 - a. Where moderate population levels remain after harvest, apply a registered insecticide or oil treatment effective against adults.
 - b. Plough in crops within two-three days of application to kill all remaining nymphs on crop foliage to reduce pest migration into new plantings.

Notes regarding the application of insecticides:

1. To ensure the most effective control of the pest:
 - a. Product labels should at all times be carefully read and adhered to;
 - b. Full recommended rates of registered insecticides should always be used; and
 - c. Ensure good coverage of the target area to maximise contact.

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Crop(s): Various

Insect(s): Western Flower Thrips (*Frankliniella occidentalis*)

Guidelines:

1. For information refer to the NSW Department of Primary Industries website:
<http://archive.dpi.nsw.gov.au/content/agriculture/horticulture/pests,-diseases-and-disorders-in-horticultural-crops/wft-resistance>

Notes regarding the application of insecticides:

1. To ensure the most effective control of the pest:
 - a. Product labels should at all times be carefully read and adhered to;
 - b. Full recommended rates of registered insecticides should always be used; and
 - c. Ensure good coverage of the target area to maximise contact.

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