

Crucifer Vegetable Insecticide Resistance Management Strategies and Issues in Australia



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The Australian Crucifer Vegetable Industry

- ~15-20,000 ha crucifer vegetables nationally
- Individual farms produce 20-200 ha crucifers per annum
- Insecticide spraying is the primary pest control tactic



The Key Pests of Australian Crucifer Vegetables

- In the temperate southern States DBM is the key pest (6-9 generations pa).



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- In the temperate southern States DBM is the key pest (6-9 generations pa).
- In subtropical Queensland a complex of pests occurs:
 - *Crocidolomia pavonana*
 - *Helicoverpa* spp.
 - *Hellula hydralis*
 - *Spodoptera litura*
 - *Bemisia tabaci* biotype B
 - *Thrips tabaci*
 - and DBM (12+ generations pa)



History of DBM Resistance in Australia

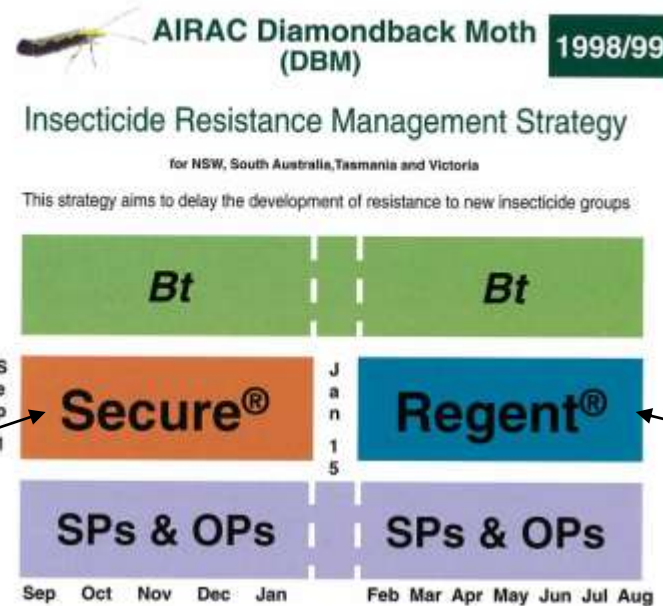
- SP/OP resistance
 - 1st documented in mid 1980's in Queensland
 - By mid 1990's widespread throughout southern States
- An IRM strategy was implemented in QLD in the late 1980's
 - Monthly rotation of SP-OP-Carbamate-Cyclodeine products
 - Summer crop break
 - Crop monitoring and *Bacillus thuringiensis* (*Bt*) use promoted
- No corresponding IRM response in southern States
 - Greater use of *Bt* in 1990's as SP/OP efficacy declined
- No new insecticide classes were registered in Australia from 1980-1998

The Late 1990's 'Renaissance'

- 1996-97: likely registration of 4 new DBM insecticides, each with a unique mode of action.
 - fipronil, chlorfenapyr, spinosad & emamectin benzoate
- Both a great opportunity and a great challenge.
- Researchers, CropLife Australia and the 4 chemical Co.'s devised an IRM strategy.
 - Agreed to a 'two-window' rotation strategy.
 - Based on modelling and limited experimental evidence likely to increase the effective life of the rotated chemistries.

The '2-window' Rotation Strategy

Version I - 1998/99 (Windowed the first two registered products)



chlorfenapyr

fipronil

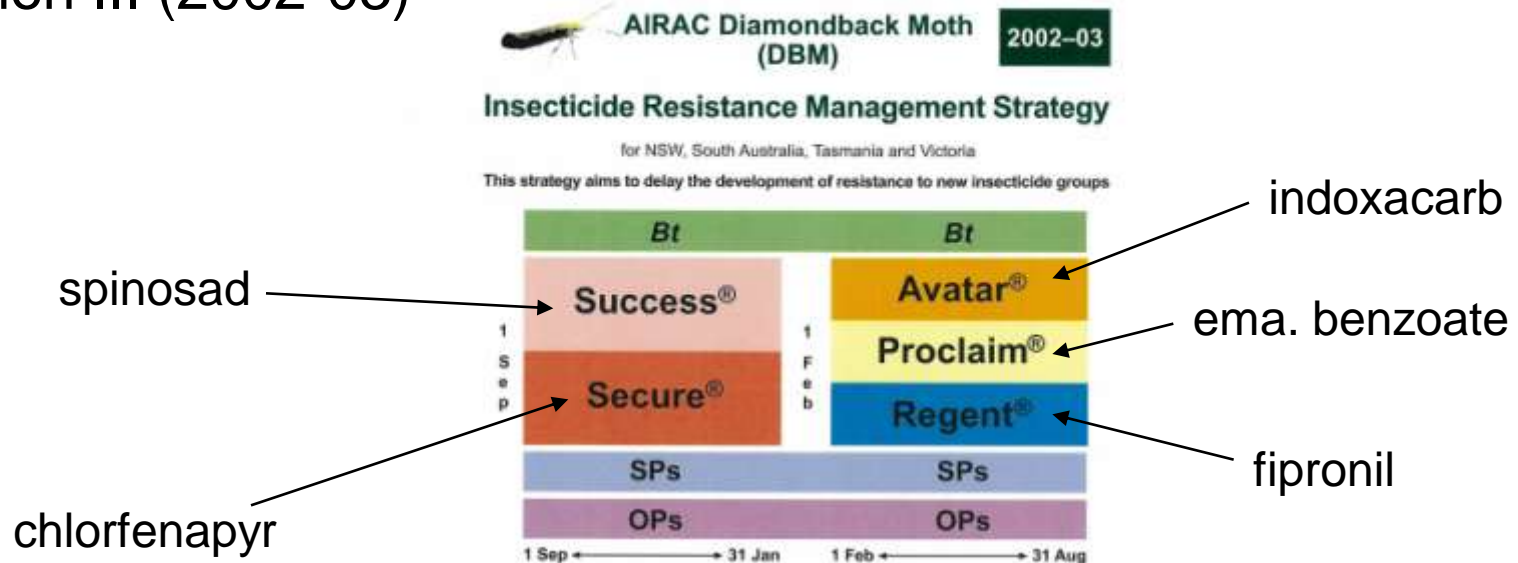
- Secure® may be used from 1 September until 15 January.
- Regent® may be used from 16 January until 31 August.
- Labels of new products will limit use within the windows.
- It is important to monitor crops regularly for DBM.
- Do not use mixtures of insecticides for controlling DBM.
- Use of the biological insecticide, Bt, in the early stages of crop development is encouraged at all times of the year.
- Good crop hygiene such as use of clean seedlings will reduce your DBM problems.



The '2-window' Rotation Strategy

Progressively updated as new products registered:

Version III (2002-03)



- Use of the biological insecticide *Bt* in the early stages of crop development is encouraged.
- Secure® or Success® may be used from 1 Sep until 31 Jan.
- Regent®, Proclaim® or Avatar® may be used from 1 Feb until 31 Aug.
- Labels of new products place a limit on the number of applications to be used. If further control is required on one planting, different groups from within the same window should be rotated.
- It is important to monitor crops regularly for DBM.
- Do not use mixtures of insecticides for controlling DBM.
- Good crop hygiene, such as the use of clean seedlings and the prompt working in of harvested crops, will reduce your DBM problems.



AIRAC is Avcare's Insecticide Resistance Action Committee

The '2-window' Rotation Strategy

Progressively updated as new products registered:

Version IV (2009) – incorporates the Group 28 diamides



Insecticide Resistance Management Strategy

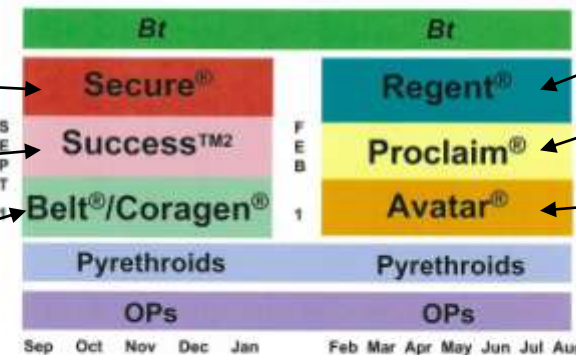
for NSW, Victoria, Tasmania, South Australia and Stanthorpe district, QLD

This strategy aims to delay the development of resistance to new insecticide groups

chlorfenapyr

spinosad

flubendiamide/
chlorantraniliprole



fipronil

ema. benzoate

indoxacarb

The industry aims to promote co-ordinated use of insecticides to control DBM. Using chemicals in a random manner will cause DBM to rapidly develop resistance. Help to avoid this by adopting this IRM strategy.

Secure[®], Success[™] or Belt[®]/Coragen[®] may be used from 1 Sep until 31 Jan.

Regent[®], Proclaim[®] or Avatar[®] may be used from 1 Feb until 31 Aug.

Labels of some products place a limit on the number of times they can be used. If further control is required on one planting, different groups from within the same window should be rotated.

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Do not use mixtures of insecticides for controlling DBM (eg Bt's and pyrethroids).

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Good crop hygiene - planting clean seedlings and the prompt working in of post harvest crop residues - will help to reduce DBM pressure.



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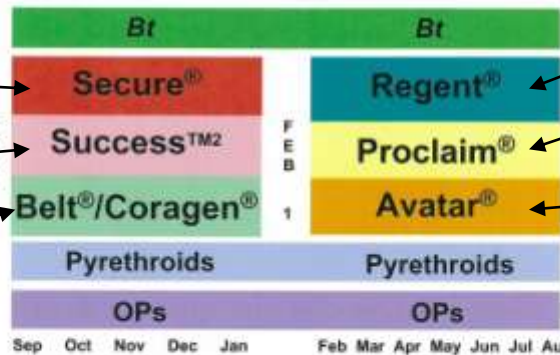
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Chemical groups & products for DBM 2009

1B	Organophosphates (OPs)
2C	pyrethroids
3A	spinosyns
4A	diatomaceous earth
5A	insect growth regulators
7C	biologicals
13A	chlorfenapyr
22A	indoxacarb
28A	diamide receptor activators
9X	Insecticide Mode of Action Groups

IRAC
chemical
groups &
product
names
information.

The information provided by CropLife Australia is for information only and does not constitute a recommendation of any product. It is the responsibility of the user to ensure that the product is used in accordance with the label and that the user is aware of any restrictions on its use. The user is responsible for the application of the product.

The '2-window' Rotation Strategy

Three regionally-specific versions:

- take account of (i) seasonal differences in DBM pressure and spraying across the production regions, and (ii) the lepidopteran pest complex in Queensland.



IRMRG Diamondback Moth (DBM) 2009
Insecticide Resistance Management Strategy
 for the Lockyer Valley, Queensland

This strategy aims to delay the development of resistance to new insecticide groups.

Br	Br
Proclaim [®]	Success TM
Belt [®] /Coragen [®]	Secure TM
Regent [®]	Avatar [®]
Pyrethroids OPs	Pyrethroids OPs

Feb Mar April May June July Aug Sept Oct

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IRMRG Diamondback Moth (DBM) 2009-10
Insecticide Resistance Management Strategy
 for WINE, VITICULTURE, TURFGRASS, SOUTH AUSTRALIA and SOUTHWEST AUSTRALIA

This strategy aims to delay the development of resistance to new insecticide groups.

Br	Br
Secure TM	Regent [®]
Success TM	Proclaim [®]
Belt [®] /Coragen [®]	Avatar [®]
Pyrethroids	Pyrethroids
OPs	OPs

Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug

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DIAMONDBACK MOTH (DBM) INSECTICIDE RESISTANCE MANAGEMENT (IRM) STRATEGY WESTERN AUSTRALIA Update 15 Sept. 2010

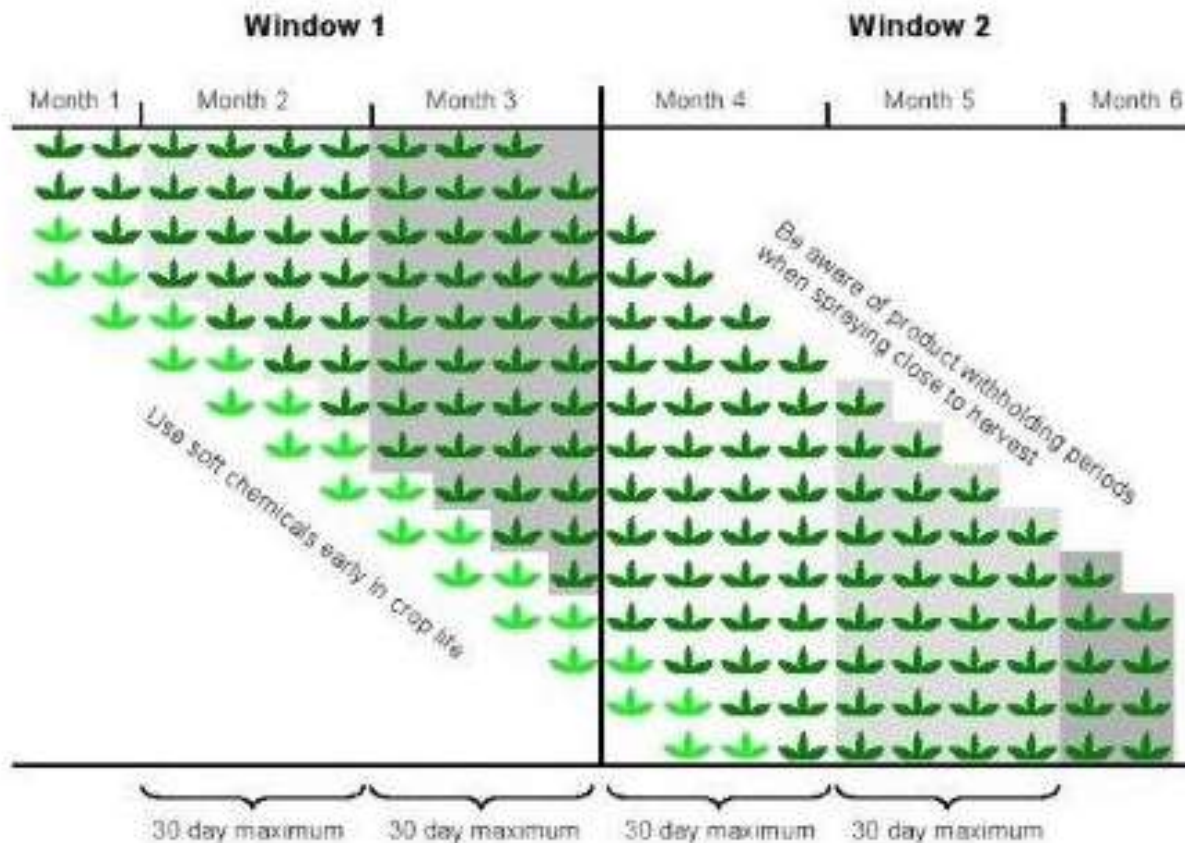
Consult product labels with regards to registration on specific vegetable/corn crops and application information.

Group	Window 1: 1 June - 30 Nov	Window 2: 1 Dec - 31 May
Group 2E	Dyfed	WHP 2A ¹
Group 11C	BRs (Excelsior Group/Genus) e.g. Batches, Delfin, Opal, Full-Bac, Xenata	WHP 2B ¹
Group 5A	Entrest, Success	Group 22A: Avatar
Group 2B	Belt/Coragen	Group 2C: Regal, Regent, Viala
Group 2A	Secure	Group 5A: Proclaim
Group 1A	Synthetic Pyrethroids e.g. Bullock, Cypermethrin, Deltamethrin, Fastac, Bifenthrin, Fenprophethrin, Fenprophos, Spiromethrin, Trigon	WHP 2 ¹
Group 1B	Chromophenols e.g. Py-Me [®] , Lannex, Delmas 85a, Lannex, Talstar [®]	WHP 2 ¹
Group 1E	Organophosphates Phosalone, pyrethroids if not used, insecticides applied after 15 Nov	WHP 2 ¹

WHP 2 - sub-window period in West.
¹ Rotate, rotate two active ingredients from Group 2B and Group 4. ² WHP for Dyfed in 2B days for both broadcast and 4L drops for other vegetable/soilless crops. ³ WHP for Bullock on broadcast in 3 days. ⁴ Rotated in only registered for cauliflower. ⁵ WHP for Delmas 85a registered for cabbage and cauliflower only. ⁶ WHP for Fenprophos and Lannex on broadcast in 14 days. ⁷ Talstar is not registered for cauliflower.

The '2-window' Rotation Strategy

Now considering the introduction of generation/calendar time windows within the 2 main Windows:



Grower Compliance with the Window Strategy

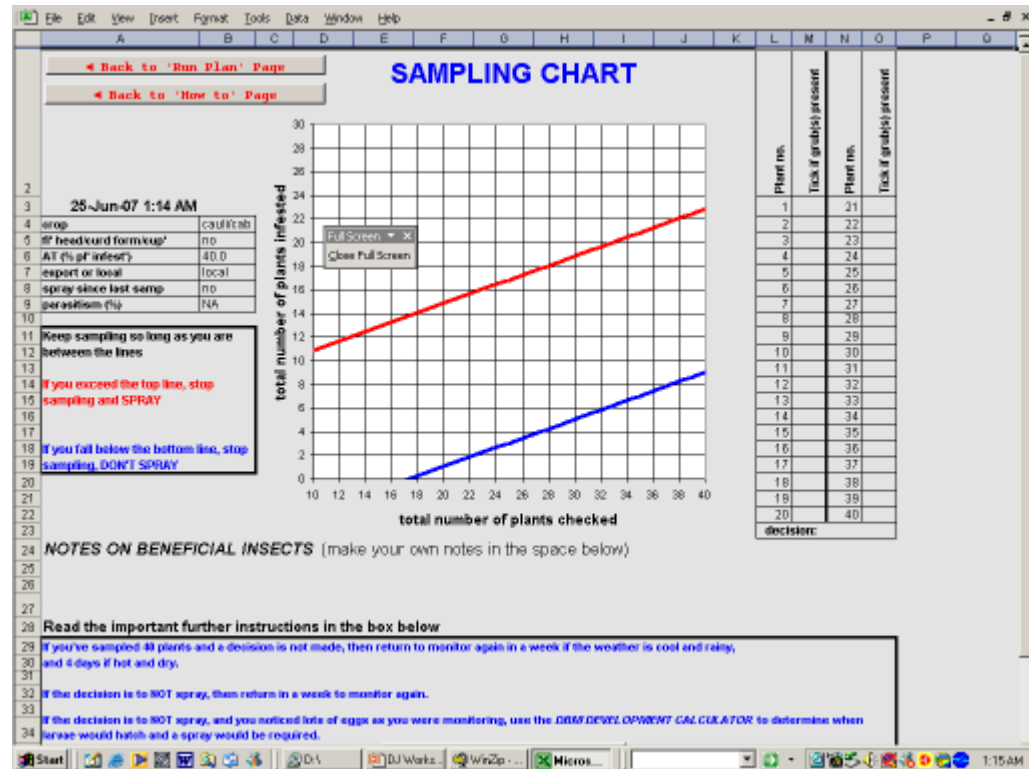
- The level of grower compliance is moderate.
 - 2006 survey: ~40% of growers claimed to follow the strategy.
- However growers that do adhere to the strategy are still likely to benefit, because of DBM's limited property-to-property movement (Mo *et al.* (2003) *Environmental Entomology* 32, 71-79).

Other Key IRM Strategies

These aim to preserve susceptible individuals by reducing spray frequency:

1. Spray decision making based on crop monitoring and ETs

Electronic sampling plan:



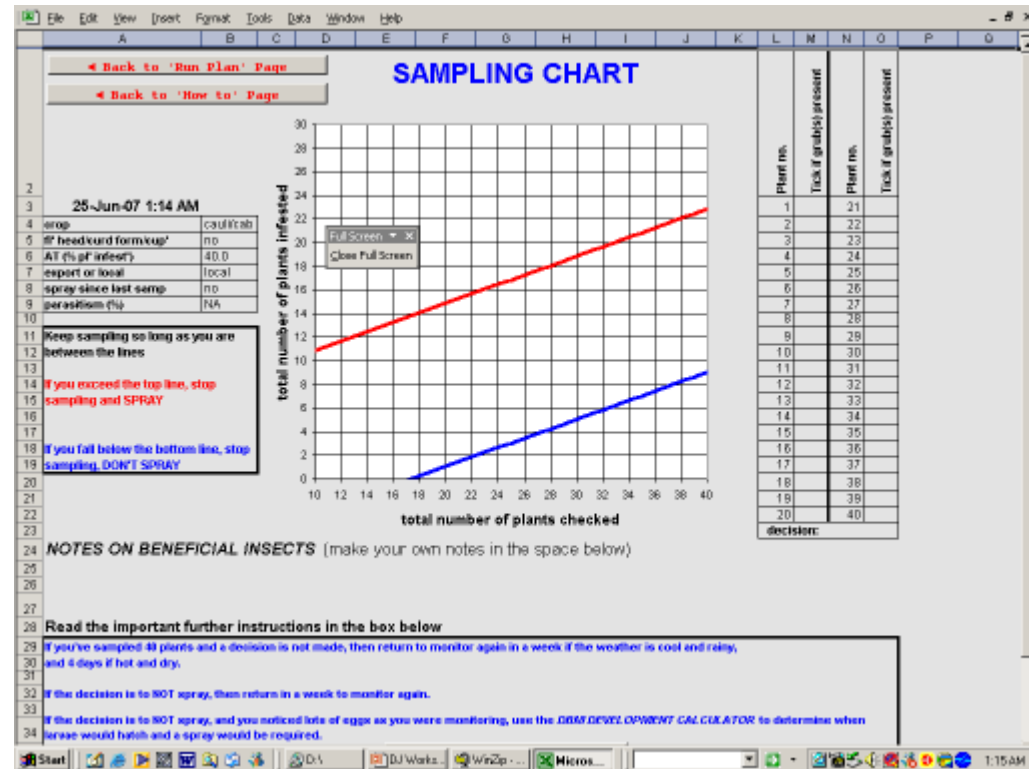
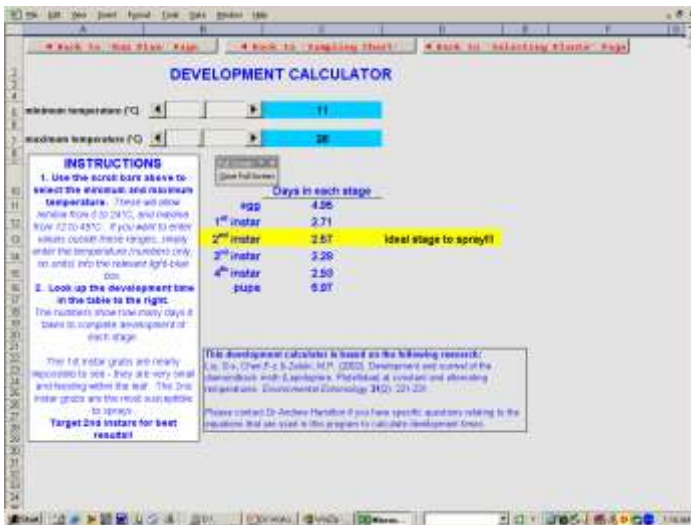
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1. Spray decision making based on crop monitoring and ETs

Electronic sampling plan:

DBM development calculator:



Hamilton *et al.* (2004) J. Econ. Entomology,

Other Key IRM Strategies

2. Natural enemy conservation

Encourage choice of soft chemistries:

IMPACT OF INSECTICIDES ON NATURAL ENEMIES FOUND IN BRASSICA VEGETABLES							
Information provided is based on the current best information available from research data. Users of insecticides should check the label for registration in their particular Crop & State, and for rates, pest spectrum, safe handling and application details.							
INSECTICIDES	TOXIC EFFECT ON SPECIFIC NATURAL ENEMIES*						RATING OF INSECTICIDE IMPACT ON NATURAL ENEMIES OVERALL*
	Parasitic wasps		Predators				
Active Ingredient	Egg Parasitoid Trichogramma	Larval and Pupal Parasitoids	Predatory Beetles	Predatory Bugs	Lacewings	Spiders	The Natural Enemies Assessed: Larval, Egg and Pupal Parasitoids Predatory Beetles Predatory Bugs Lacewings Spiders
Bacillus thuringiensis (Bt)	VL	VL	VL	VL	VL	VL	★ ★ ★ ★ ★ SOFTEST
pirimicarb (Pirior®)	H	VL	VL	L	VL	VL	★ ★ ★ ★ ★
pymetrozine (Chess®)	L	L	L	L	L	L	★ ★ ★ ★
spinosad (Success®, Entrust®)	VH	M	VL	M	VL	VL	★ ★ ★ ★
emamectin benzoate (Proclaim®)	M	M	L	H	L	M	★ ★ ★ ↓
imidacloprid (Confidor®) soil	L	L	L	M	L	L	★ ★ ★ ↓
indosacarb (Avatar®)	L	M	H	L	VL	VL	★ ★ ★ ↓
chlorfenapyr (Secure®)	VH	M	M	M	L	L	★ ★ ★
endosulfan	VH	M	M	M	L	M	★ ★ ★
flupyrifur (Regent®)	VH	H	L	M	VL	M	★ ★ ↓
imidacloprid (Confidor®) foliar	VH	M	H	H	L	L	★ ★ ↓
organophosphates	H	H	H	H	L	M	★ ★ ↓
methomyl (Lannate®, Marlin®, Nadrin®, Electra®)	H	H	VH	H	H	M	★ ★
synthetic pyrethroids	H	VH	VH	VH	H	VH	★ HARDEST

LEGEND VL = Very Low L = Low M = Medium H = High VH = Very High
Toxic Effect: rating derived from reduction in the natural enemy numbers due to toxic effect after spraying
★ Rating: derived from an average toxic effect on all the natural enemies by the product group after spraying

Prepared by Bronwyn Wabsh with other members of the Horticulture Australia Ltd. National Diamondback moth project team. For enquiries phone Bronwyn of DM&F: (07) 5466 2222
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Other Key IRM Strategies

- Crop break
 - promoted in Queensland



IRMRG Diamondback Moth (DBM)

2009

Insecticide Resistance Management Strategy

for the Lockyer Valley, Queensland

This strategy aims to delay the development of resistance to new insecticide groups



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Other Key IRM Strategies

3. Crop break

- promoted in Queensland

4. Crop hygiene

- clean seedlings
- prompt post-harvest crop destruction



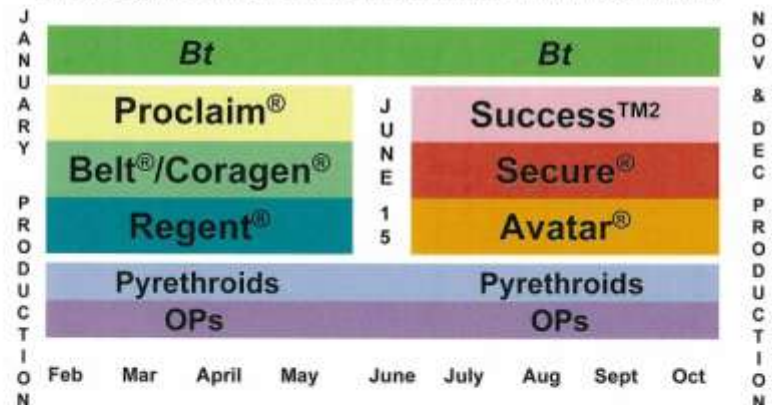
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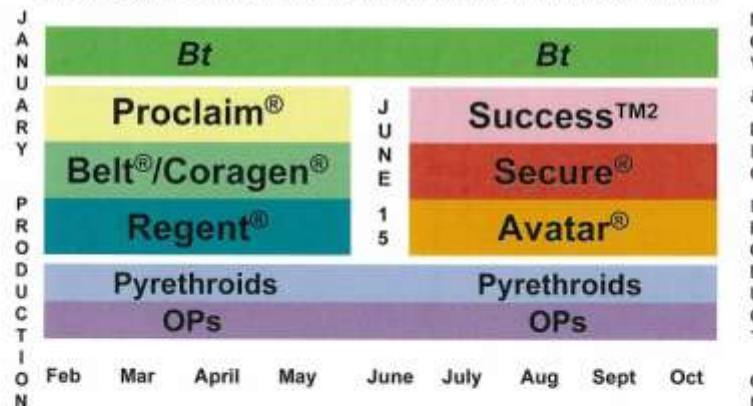
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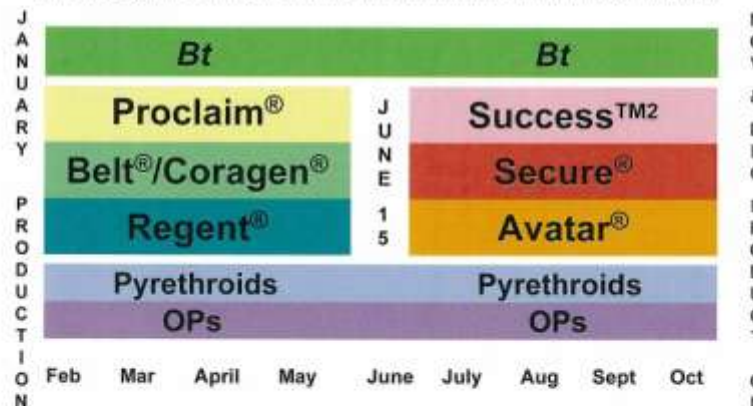
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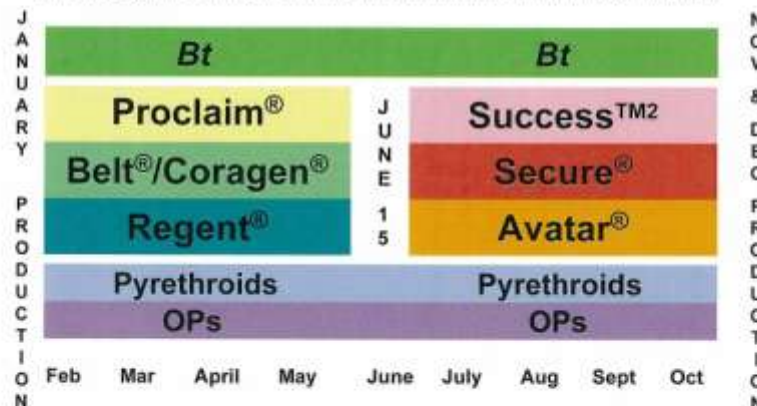
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Resistance Screening

A national resistance screening program helps inform the IRM program.

- Potter tower application to 3rd instars on cabbage leaf discs.
- Four insecticides are being tested:
 - emamectin benzoate
 - indoxacarb
 - spinosad
 - Bt kurstaki
- Results:
 1. Low-moderate resistance to the 3 synthetics, particularly in Queensland populations (highest RR's at LC₅₀ ranging from 5.0–13.3).
 2. No detectable shifts in Bt susceptibility.



Group 28 Diamide IRM

- The Group 28 Diamides - high lepidopteran larval activity
 - minimal impact on beneficials
 - low mammalian toxicity
- An Australian Diamide Working Group has formed to help preserve the Group 28 products against the resistance risk
- The national resistance screening program will be expanded to include the Group 28 products

Group 28 Diamide IRM Challenges

1. Immediate Challenge: Durivo™

This new diamide (chlorantraniliprole)–neonicotinoid (thiamethoxam) seedling drench mixture formulation presents a particular IRM challenge, due to:

1. formulation persistence
2. potential for successive crop treatment

To conserve the Diamides as effective DBM insecticides we advise:

1. restrict Durivo™ transplant use to the Window allocated for Diamides
2. work in Durivo™-treated crops immediately after harvest

2. Longer-term Challenge: registration of more Group 28 products

Future registrants may not wish to ‘window’ their products

Acknowledgments

- **Dupont**
- **Syngenta**
- **Dow Agrosiences**
- **Bayer CropSciences**
- **HAL / AUSVEG**
- **CropLife Australia**
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