2018

2018 Update Mtg: Pesticide Resistance Management in Cranberry

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Pesticide Resistance Management in CRANBERRY

by Katie Ghantous and Marty Sylvia

with input from
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With special thanks to:

- Dr. Margaret McGrath, Cornell University
- Dr. Andrei Alyokhin, University of Maine
- Dr. Richard Bonanno, University of Massachusetts

NORTHEAST SARE Sustainable Agriculture Research & Education

NE-SARE Professional Development Program ENE15-140-29994

What is Pesticide Resistance?

- Genes naturally occur in pest population
  - Not mutations caused by chemical

- Pesticide use “selects” for resistance
  - Kills susceptible individuals - those *without* the gene to protect them die
  - Those with the gene don’t die, and are “Selected” for by killing off other types

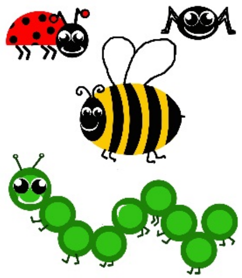
What is Pesticide Resistance?

- Pests *with* gene live, reproduce, and pass on the genes for resistance to their offspring
- The pest population has increasing numbers of resistant individuals
- Over time, population as a whole is more resistant to the pesticide

What is Pesticide Resistance?

Inheritable (genetic) characteristic of a pest that makes it less sensitive to a pesticide

- Can occur in **all** types of pests
  - weeds, insects, fungi, etc.



- Pest is able to survive pesticide exposure that would kill those without the genes

All types of pesticides are at risk for resistance!

Herbicides
Herbicide Resistance Action Committee (HRAC)
http://www.hracglobal.com

Fungicides
Fungicide Resistance Action Committee (FRAC)
http://www.frac.info

Insecticides
Insecticide Resistance Action Committee (IRAC)
http://www.irac-online.org

International groups founded by the agrochemical industry for a cooperative approach to resistance management. Sources for info and education materials.

Why is Managing Resistance Important?

- Pesticide resistance is increasing
- Currently:
  - 520 insect and mite species
    - At least 17 insect species are resistant to **all** major classes of insecticides
  - 273 weed species
  - 150 plant diseases
  - 10 rodent species

Mode of action (MoA)

The chemical structure of a pesticide defines:

- **Target site** - the “where” - physical location within an organism where the pesticide acts
- **Mode of action** - the “how” - action of a pesticide at its target site.

Pesticide Groups

- Each pesticide has been assigned a **Group Number** to help growers make resistance management decisions
- Group number based on target site and MoA
- Pesticides in a group share similar characteristics and risk cross-resitance
- Group number is clearly marked on most labels

Herbicides - HRAC and WSSA groups

HRAC (letters) and WSSA (Weed Science Society of America, #'s) codes, differ slightly but very similar

Herbicides - HRAC and WSSA groups

HRAC (letters) and WSSA (Weed Science Society of America, #'s) codes, differ slightly but very similar

HRAC Group	Site of Action	Chemical Family	Active Ingredient	WSSA Group
A	Inhibition of acetyl CoA carboxylase (ACCase)	Aryloxyphenoxy-propionate 'FOPs'	clodinafop-propargyl cyhalofop-butyl diclofop-methyl fenoxaprop-P-ethyl fluazifop-P-butyl haloxyfop-R-methyl propaquizafop quizalofop-P-ethyl	1
		Cyclohexanedione 'DIMs'	alloxydim butroxydim clethodim cycloxydim *profoxydim* sethoxydim *tepraloxydim* tralkoxydim	
		Phenylpyrazoline 'DEN'	pinoxaden	
B	Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS)	Sulfonylurea	amidosulfuron azimsulfuron bensulfuron-methyl chlorimuron-ethyl	2

Consult the label for RM info

RESISTANCE MANAGEMENT

GROUP 11 FUNGICIDE

Abound (azoxystrobin) is a Group 11 fungicide. The mode of action for Abound is the inhibition of the QoI (quinone outside) site within the electron transport system [Group 11]. Fungal pathogens can develop resistance to products with the same mode of action when used repeatedly. Because resistance development cannot be predicted, use of this product should conform to resistance management strategies established for the crop and use area. Consult your local or State agricultural authorities for resistance management strategies that are complementary to those in this label. Resistance management strategies may include alternating and/or tank-mixing with products having different modes of action or limiting the total number of applications per season. Syngenta encourages responsible resistance management to ensure effective long-term control of the fungal diseases on this label.

Follow the crop specific resistance management recommendations in the directions for use.

If no resistance recommendation on number of applications is specified in the directions for use, follow the recommendations in the table below.

If planned total number of fungicide applications per crop is:	1	2	3	4	5	6	7	8	9	10	11	12
Recommended Solo QoI fungicide sprays	1	1	2	2	2	2	2	3	3	3	3	4
Recommended QoI fungicide sprays in												

Consult the Cranberry Chart book!

6 RESISTANCE MANAGEMENT

Fungicide Resistance Action Committee (FRAC) Grouping for cranberry fungicides

FRAC GROUP	TRADE NAME	COMMON NAME	MODE OF ACTION	GROUP NAME	CHEMICAL GROUP	Resistance Development Risk
4	**Metastar** **Ridomil** **Ultra Flourish**	mefenoxam metalaxyl	**A1**: RNA polymerase I	PA – fungicides (PhenylAmides)	acylalanines	**High Risk**
11	**Abound**	azoxystrobin	**C3**: cytochrome bc1 at Qo site	QoI-fungicides	methoxy-acrylates	**High Risk**
	Aftershock **Evito**	fluoxastrobin		Strobilurins	dihydro-dioxazines	
3	**Indar** **Proline**	fenbuconazole prothioconazole	**G1**: c14-demethylase in sterol biosynthesis	DMI-fungicides (DeMethylation Inhibitors)	triazoles	**Medium Risk**
19	**OSO** **Ph-D**	polyoxin	**H4**: chitin synthase	polyoxins	peptidyl pyrimidine nucleoside	**Medium Risk**
	Aliette	fosetyl-Al			ethyl	

Key Points About Managing Resistance

- Goal is **delaying** development of resistance, **<u>not</u>** managing resistant pest biotypes once detected
- Use Integrated Pest Management (IPM) program
- Minimize use of at-risk products

Applications must be timed correctly

- Target the most vulnerable life stage of the pest
- Use spray rates and application intervals recommended by the manufacturer and in compliance with local agricultural extension regulations.
  - A high rate can take out pests that might be somewhat resistant, but using a rate too low may allow them to survive

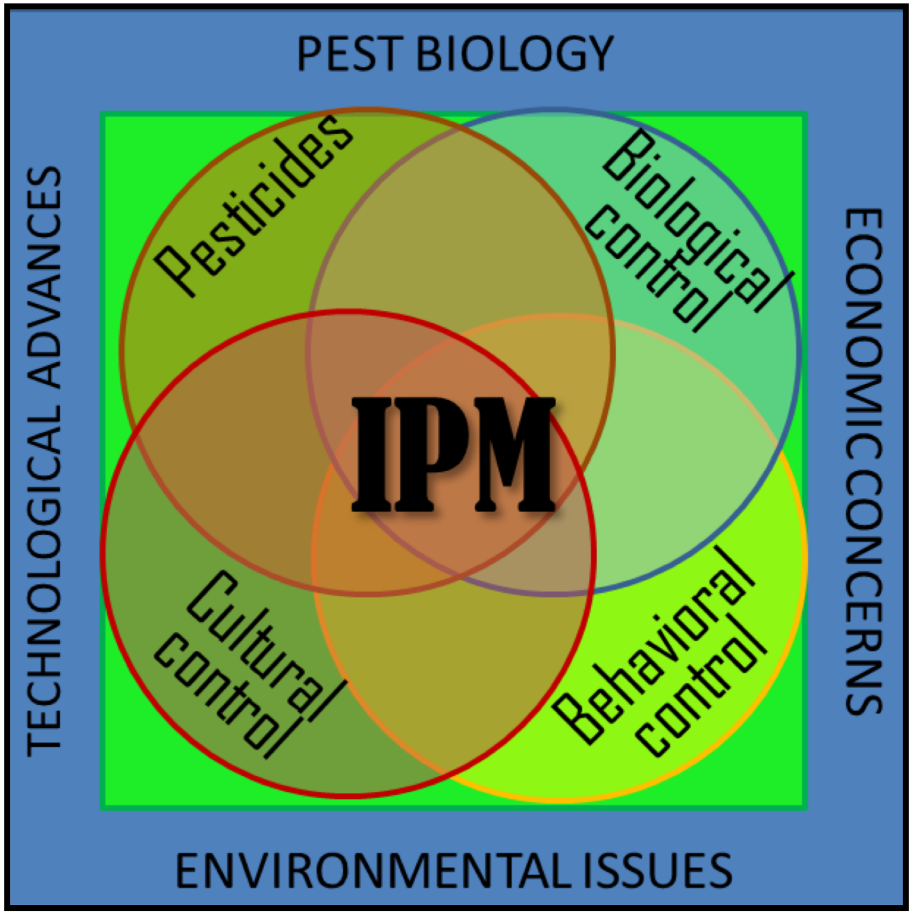
Challenges to Managing Resistance

- Not always something to rotate to, even if you try!

- Not many cranberry herbicides
  - e.g. clethodim and sethoydim for grasses

✓ Do not rely on pesticides alone

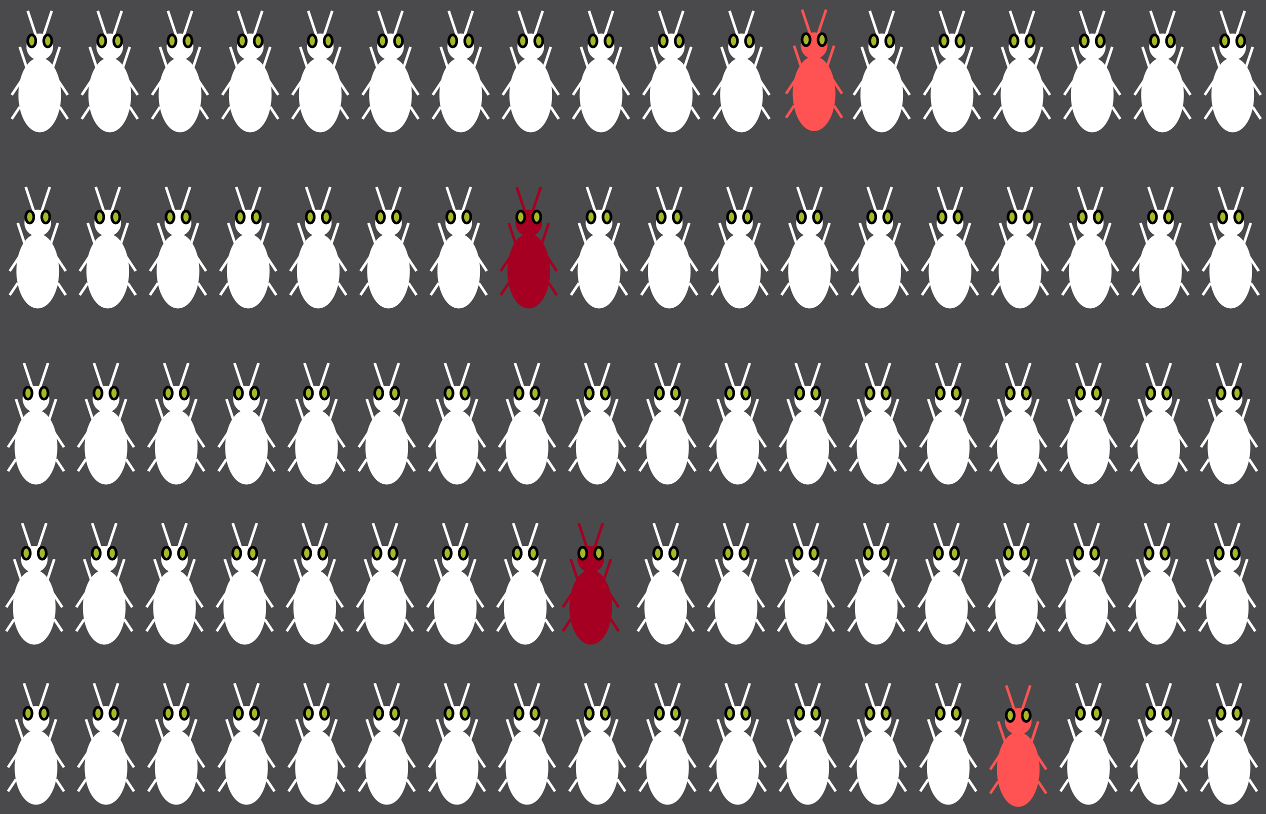
Integrate different controls!



- synthetic pesticides
- biological pesticides
- beneficial insects (predators/parasites)
- cultural practices
- chemical attractants/deterrents

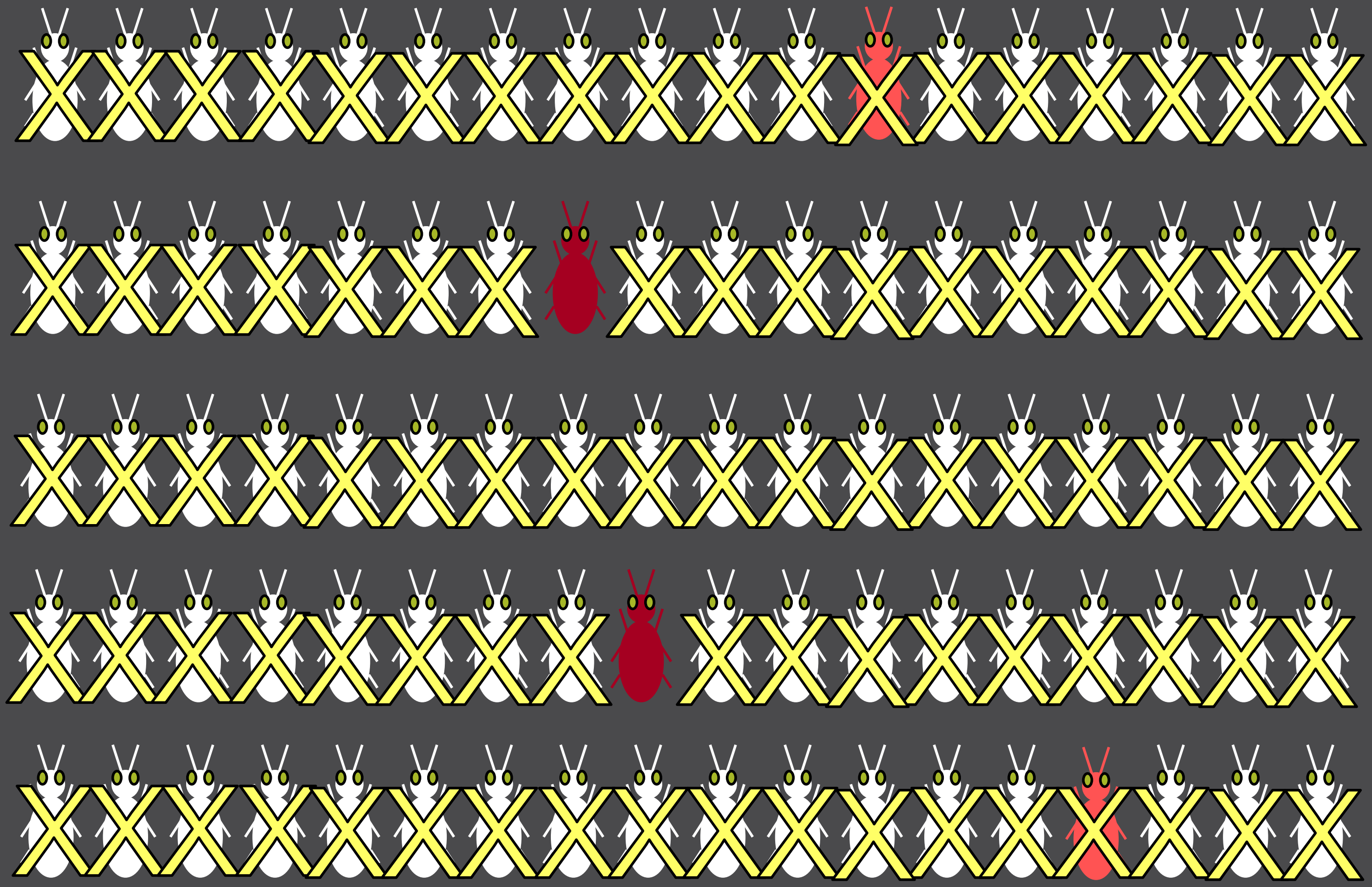
Natural pest population

- Some bugs have genes that make them less sensitive to a pesticide



Pesticide application

- The bugs that are susceptible die



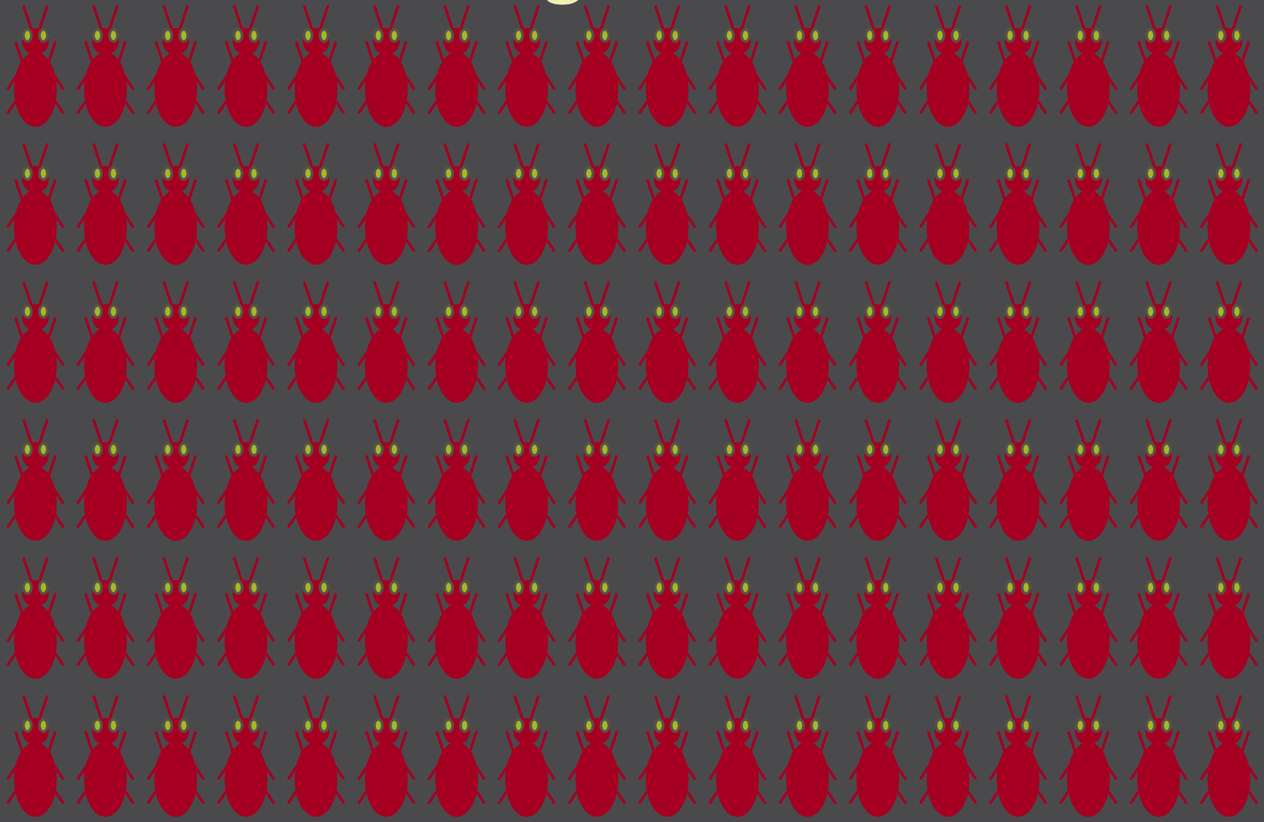
Pesticide application

- The bugs that have naturally occurring genes that make them less sensitive to a pesticide survive…

After pesticide application

- We have applied selection pressure.
- The bugs with genes that make them less sensitive to a pesticide reproduce.
- The offspring have the genes that make them less sensitive to the pesticide.
- The new population is more resistant than a natural population.

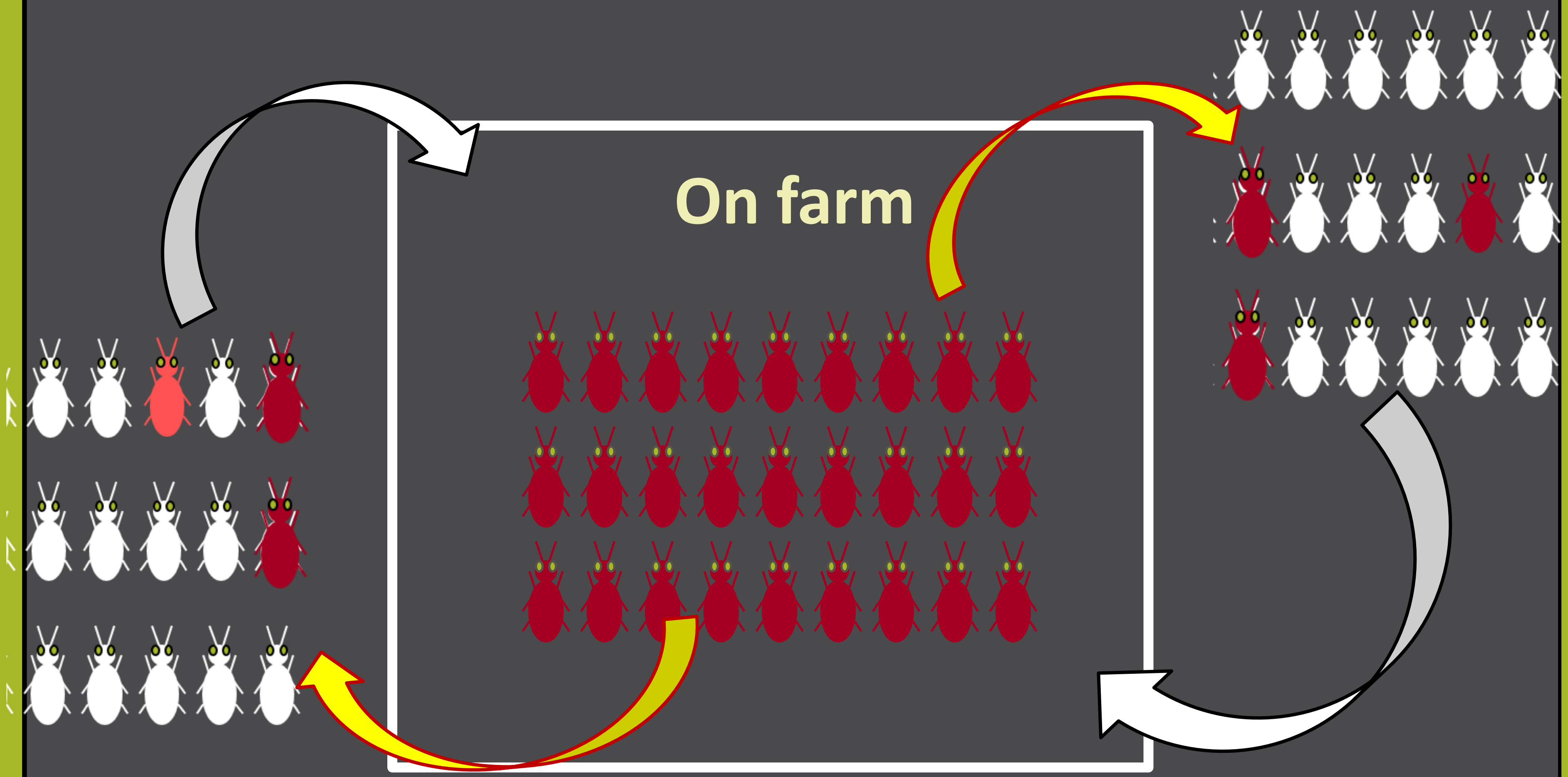
- Eventually, the population is mostly made up of resistant individuals.
- Under permanent selection pressure, resistant insects outnumber susceptible ones and the insecticide is no longer effective.



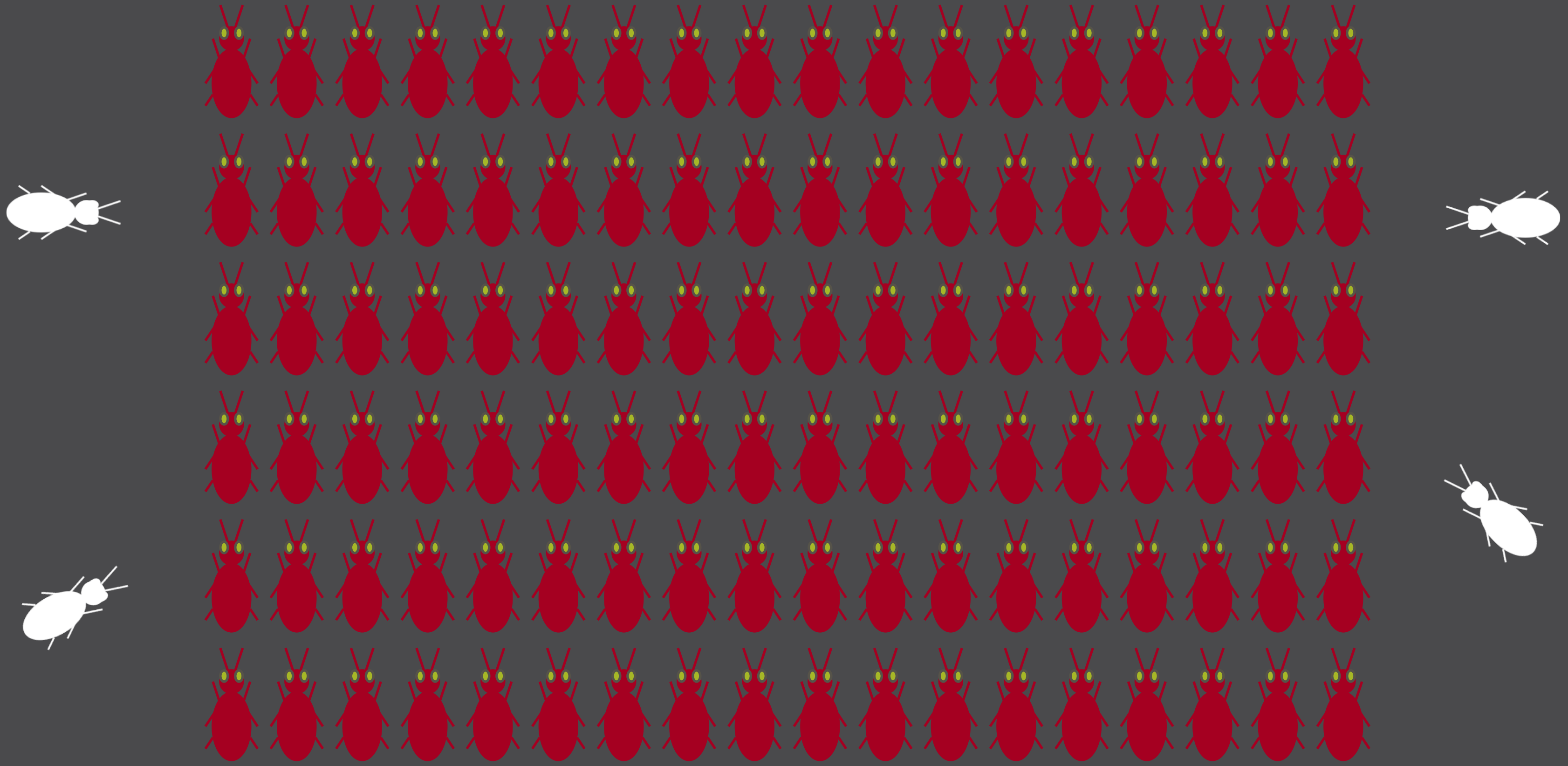
Cranberry Weevil

- Resistant to organophosphates in 2000
- Lorsban
- Guthion
- Parathion
- Imidan
- Orthene
- Sevin

Resistance takes time to develop!



- Outside population brings in susceptible gene.
- But it takes a long time to change.



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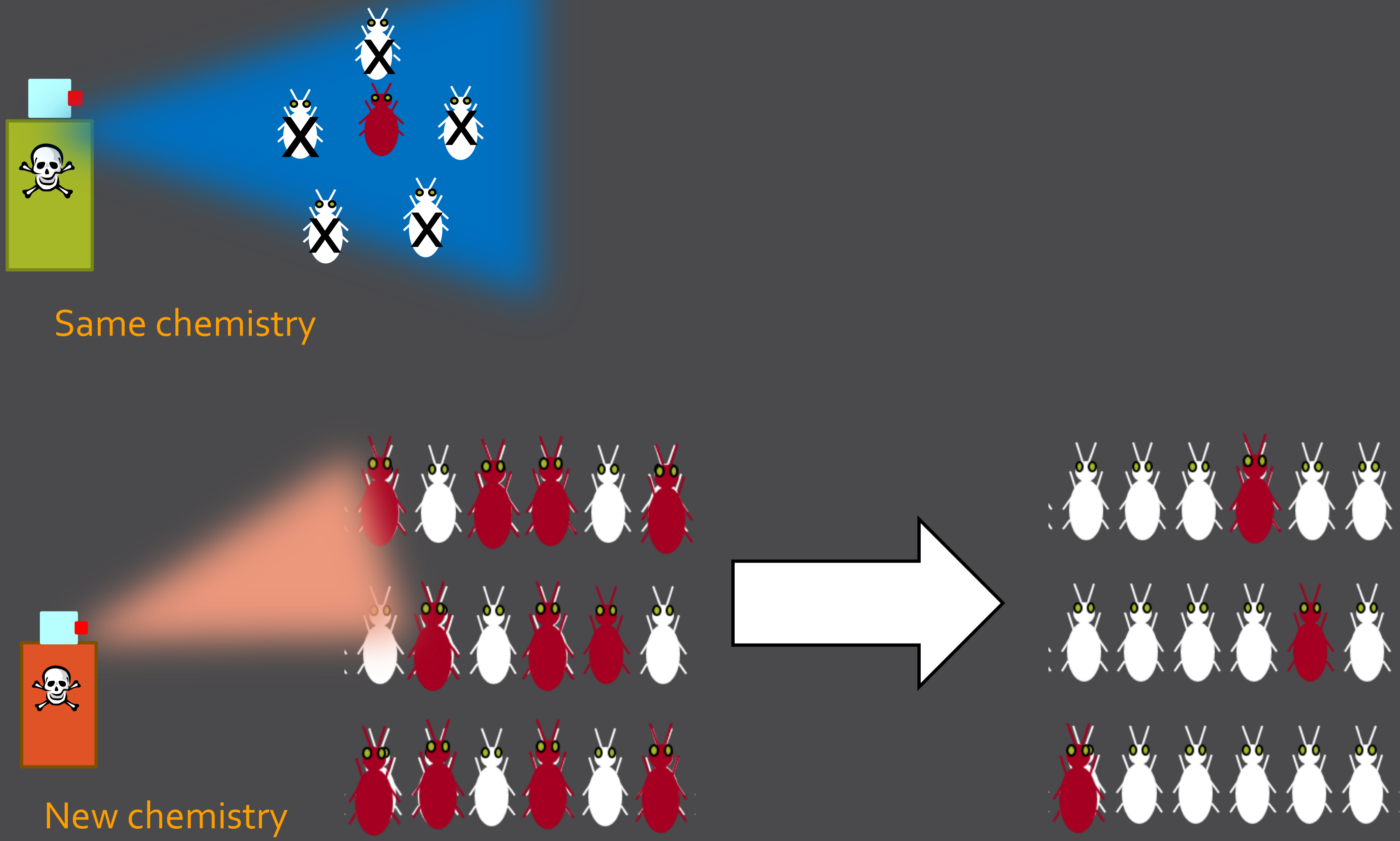


I R A C

INSECTICIDE RESISTANCE ACTION COMMITTEE

Insecticide Mode of Action Classification:

Diversity is a key to successful resistance management

CropLife INTERNATIONAL

IRAC promotes the use of a mode of action classification of insecticides as the basis for effective and sustainable insecticide resistance management. Insecticides are allocated to specific groups based on their target site. The use of sequences or alternations of insecticides with different modes of action reduces selection pressure on individual target sites. This prevents, delays or reverses resistance and helps maintain product diversity and efficacy.

Midgut

Group 11 Microbial disruptors of insect midgut membranes

The midgut is the target for the toxins produced by the bacterium *Bacillus thuringiensis* (Bt). Bt toxins cause fatal lesions in the midgut wall. Transgenic crops such as Bt-cotton express high levels of specific Bt toxins. Sprayable Bt also contains such toxins.

BT- Dipel

Stimulatory Nervous System

The nervous system is the target for most current insecticides, but within this system are many target sites. Insecticides with specific modes of action act at these targets:

Group 1 Acetylcholinesterase (AChE) inhibitors

Carbamates and Organophosphates act as inhibitors of AChE at nerve synapses. This results in hyperactivity in the nervous system.

DIAZ, LORSBAN, SEVIN…

Group 4 Acetylcholine receptor agonists / antagonists

The Chloronicotinyls act as agonists of acetylcholine at the post-synaptic nicotinic ACh receptor (nAChR). This leads to neuronal overstimulation and hyperactivity.

ACTARA, ADMIRE, ASSAIL…

Group 5 Acetylcholine receptor modulators

Spinosyns act at the nAChR, interfering with normal functioning.

DELEGATE, SPINTOR, ENTRUST…

Group 3 Sodium channel modulators

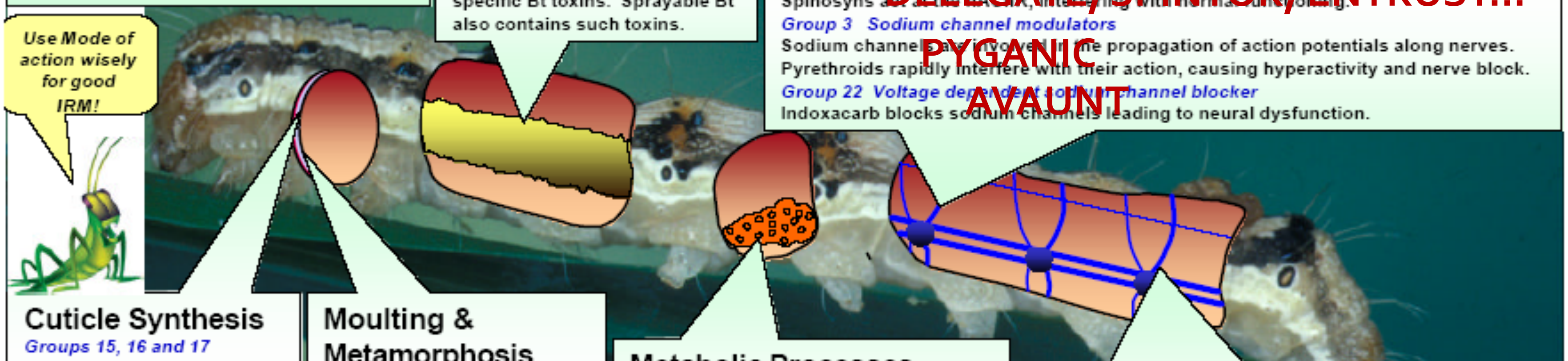
Sodium channels are involved in the propagation of action potentials along nerves. Pyrethroids rapidly interfere with their action, causing hyperactivity and nerve block.

PYGANIC

Group 22 Voltage dependent sodium channel blocker

Indoxacarb blocks sodium channels leading to neural dysfunction.

AVAUNT



Cuticle Synthesis

Groups 15, 16 and 17 Inhibitors of chitin biosynthesis

New cuticle is synthesised during the moult cycle. The Benzoylureas in Group 15 are broadly active and inhibit a key part of this process, leading to insect death. Similar *Inhibitors of Homopteran and Dipteran chitin biosynthesis are in Groups 16* (Buprofezin) and *17* (Cyromazine).

RIMON

Moulting & Metamorphosis

Controlled by two hormones, juvenile hormone (JH) and ecdysone.

Group 18 Ecdysone agonist / disruptor

Tebufenozide acts as an ecdysone agonist.

CONFIRM

Group 7 Juvenile hormone mimics

INTREPID

Applied in the pre-metamorphic instar, disrupt and prevent metamorphosis

Metabolic Processes

Acting on a wide range of metabolic processes:

Group 12 Inhibitors of oxidative phosphorylation, disruptors of ATP - Diafenthiuron & Organotin miticides

Group 12 Uncoupler of oxidative phosphorylation via disruption of H proton gradient – Chlorfenapyr

Group 20 Site I electron transport inhibitors – Hydramethylon and Dicofol

Group 21 Site II electron transport inhibitors – Rotenone, METI acaricides

Inhibitory Nervous System

In the insect nervous system system GABA is an inhibitory neurotransmitter. The GABA receptor is a target for a number of insecticide groups.

Group 2 GABA-gated chloride channel antagonists

The Cyclodienes and Fiproles bind to the GABA receptor complex and inhibit the action of GABA causing neuronal hyperactivity.

Group 6 Chloride channel activators

Avermectin, Emamectin Benzoate and Milbemycin. The mectins bind to the GABA receptor complex, mimicking GABA and causing paralysis.

Alan McCaffery, Nov 2003

IRAC

Insecticide Mode of Action Classification

Insecticide Resistance Action Committee **www.irac-online.org**

CropLife

Introduction

Insecticide Resistance Action Committee [IRAC] promotes the use of a Mode of Action (MoA) classification of insecticides as the basis for effective and sustainable insecticide resistance management (IRM). Insecticides are allocated to specific groups based on their target site. Reviewed and re-issued periodically, the IRAC MoA classification list provides farmers, growers, advisors, extension staff, consultants and crop protection professionals with a guide to the selection of insecticides or acaricides in IRM programs. Effective IRM of this type preserves the utility and diversity of available insecticides and acaricides.

Nerve & Muscle Targets

Group 1 Acetylcholinesterase (AChE) inhibitors
1A: Carbamates (e.g. Thiodicarb)
1B: Organophosphates (e.g. Chlorpyrifos)

DIAZ, LORSBAN, SEVIN...

Group 2 GABA-gated chloride channel blockers
2A: Cyclodiene Organochlorines (e.g. Endosulfan)
2B: Phenylpyrazoles (e.g. Fipronil)

Group 3 Sodium channel modulators
3A: Pyrethrins, Pyrethroids (e.g. Cypermethrin)
3B: DDT, Methoxychlor

PYGANIC

Group 4 Nicotinic acetylcholine receptor (nAChR) competitive modulators
4A: Neonicotinoids (e.g. Imidacloprid, Thiamethoxam)
4B: Nicotine
4C: Sulfoximines (e.g. Sulfoxaflor)
4D: Butenolides (e.g. Flupyradifurone)

ACTARA, ADMIRE, ASSAIL...

Group 5 Nicotinic acetylcholine receptor (nAChR) allosteric modulators
5: Spinosyns (e.g. Spinosad, Spinetoram)

DELEGATE, SPINTOR, ENTRUST...

Group 6 Glutamate-gated chloride channel (GluCl) allosteric modulators
6: Avermectins, Milbemycins (e.g. Abamectin, Emamectin benzoate)

Group 9 Chordotonal organ TRPV channel modulators
9B: Pyridine azomethine derivatives (e.g. Pymetrozine, Pyrfluquinazon)

Group 14 Nicotinic acetylcholine receptor (nAChR) channel blockers
14: Nereistoxin analogs (e.g. Cartap hydrochloride)

Group 19 Octopamine receptor agonists
19: Amitraz

Group 22 Voltage-dependent sodium channel blockers
22A: Oxadiazines (e.g. Indoxacarb)
22B: Semicarbazones (e.g. Metaflumizone)

AVAUNT

Group 28 Ryanodine receptor modulators
28: Diamides (e.g. Chlorantraniliprole, Cyantraniliprole, Flubendiamide)

ALTACOR

Group 29 Chordotonal organ modulators – undefined target site
29: Flonicamid

Midgut Targets

Group 11 Microbial disruptors of insect midgut membranes
11A: *Bacillus thuringiensis*
11B: *Bacillus sphaericus*

BT-Dipel

Miscellaneous non-specific (multi-site) inhibitors

Group 8 8A: Alkyl halides, 8B: Chloropicrin, 8C: Fluorides, 8D: Borates, 8E: Tartar emetic, 8F: Methyl isothiocyanate generators

Effective IRM strategies: MoA Sequences & alternations

All effective insecticide resistance management (IRM) strategies seek to minimise the selection of resistance to any one type of insecticide. In practice, alternations, sequences or rotations of compounds from different MoA groups provide sustainable and effective IRM for pest insects. This ensures that selection from compounds in the same MoA group is minimised, and resistance is less likely to evolve.

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 species of concern. Local expert advice should always be followed with regard to spray windows and timings. Several sprays 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. Metabolic resistance mechanisms may give cross-resistance between MoA groups, and where this is known to occur, the above advice must be modified accordingly. IRAC also provides general recommendations for resistance management tactics regarding specific MoA groups, e.g. neonicotinoids (Group 4A).

MoA w	MoA x	MoA y	MoA z	MoA w	MoA x

Sequence of insecticides through season

MoA Sequences & alternations – Exceptions

IRAC recommends alternations, sequences or rotations of compounds from different MoA groups to provide a sustainable and effective approach to IRM. Three groups (8, 13 and UN) are exempt from the recommendations as they do not contain compounds acting at a common target site

Color Scheme Notes:

The color scheme used here associates modes of action into broad categories based on the physiological functions affected, as an aid to understanding symptomology, speed of action and other properties of the insecticides, and not for any resistance management purpose. **Rotations for resistance management should be based only on the numbered mode of action groups.** The cross-resistance potential between sub-groups is higher than that between different groups, so rotation between sub-groups should only be used where effective registered insecticides from other MoA groups are unavailable.

Respiration targets

Group 12 Inhibitors of mitochondrial ATP synthesis
12A: Diafenthiuron
12B: Organotin miticides (e.g. Cyhexatin)
12C: Propargite
12D: Tetradifon

Group 13 Uncouplers of oxidative phosphorylation via disruption of the proton gradient
13: Pyrroles (e.g. Chlorfenapyr), Dinitrophenols, (e.g.DNOC), Sulfuramid

Group 20 Mitochondrial complex III electron transport inhibitors
20A: Hydramethylnon
20B: Acequinocyl
20C: Fluacrypyrim
20D: Bifenazate

Group 21 Mitochondrial complex I electron transport inhibitors
21A: METI acaricides & insecticides (e.g. Pyridaben)
21B: Rotenone (Derris)

Group 24 Mitochondrial complex IV electron transport inhibitors
24A: Phosphides (e.g. Phosphine)
24B: Cyanides (e.g. Sodium cyanide)

Group 25 Mitochondrial complex II electron transport inhibitors
25A: *Beta*-ketonitrile derivatives (e.g. Cyenopyrafen, Cyflumetofen)
25B: Carboxanilides, (e.g. Pyflubumide)

Growth & Development targets

Group 7 Juvenile hormone mimics
7A: Juvenile hormone analogues (e.g. Methoprene)
7B: Fenoxycarb
7C: Pyriproxyfen

KNACK or ESTEEM

Group 10 Mite growth inhibitors
10A: Clofentezine, Diflovidazin, Hexythiazox
10B: Etoxazole

Group 15 Inhibitors of chitin biosynthesis, Type 0
15: Benzoylureas (e.g. Flufenoxuron, Novaluron)

RIMON

Group 16 Inhibitors of chitin biosynthesis, type 1
16: Buprofezin

Group 17 Moulting disruptors, Dipteran
17: Cyromazine

CONFIRM, INTREPID

Group 18 Ecdysone receptor agonists
18: Diacylhydrazines (e.g. Methoxyfenozide, Tebufenozide)

Group 23 Inhibitors of acetyl CoA carboxylase
23: Tetronic & Tetramic acid derivatives (e.g. Spirodiclofen)

MOVENTO

Unknown

Group UN Compounds of unknown or uncertain mode of action (e.g. Azadiractin, Benzoximate, Bromopropylate, Chinomethionat, Dicofol, Lime sulfur, Pyridalyl, Sulfur)

Designed & produced by the IRAC MoA Team, Dec. 2015, Ver. 4, Based on MoA Classification Ver. 8.0, Photograph courtesy of N. Armes
For further information visit the IRAC website: www.irac-online.org, IRAC document protected by © Copyright

INSECTICIDE RESISTANCE

Insecticide Resistance Action Committee (IRAC) Grouping for cranberry insecticides

IRAC GROUP	TRADE NAME	ACTIVE INGREDIENT	MODE OF ACTION	CHEMICAL FAMILY
1	**Diazinon**	diazinon	Acetylcholine esterase inhibitor	Organophosphates and carbamates
	Imidan	phosmet		
	Lorsban	chlorpyrifos		
	Orthene	acephate		
	Sevin	carbaryl		
3	**Pyganic**	pyrethrin	Sodium channel modulators	Pyrethrins
4, 4A	**Actara**	thiamethoxam	Nicotinic Acetylcholine receptor agonists	Neonicotinoids
	Admire	imidacloprid		
	Assail	acetamiprid		
	Belay	clothianidin		
	Scorpion	dinotefuran		
5	**Delegate**	spinetoram	Nicotinic Acetylcholine receptor allosteric activators	Spinosyns
	Entrust	spinosad		

Nufos
Hatchet
Warhawk

Widow, Malice
Wrangler, Alias
Nuprid

Anarchy

Safari, Venom

SpinTor

INSECTICIDE RESISTANCE

11	**Dipel** **Xentari** **Biobit**	*Bacillus thuringiensis*	Microbial disruptors of insect midgut membranes	Bacillus thuringiensis
15	**Rimon**	novaluron	Inhibitors of chitin biosynthesis	Benzoylureas
18	**Confirm** **Intrepid**	tebufenozide methoxyfenozide	Ecdysone agonists / molting disruptors	Diacylhydrazines
21	**Nexter**	pyridaben	Mitochondrial complex / electron transport inhibitor	Meti acaracides
22	**Avaunt**	indoxacarb	Voltage-dependent sodium channel blockers	Oxadiazines
23	**Oberon**	spiromesifen	Inhibitors of acetyl CoA carboxylase	Tetramic acid derivatives
28	**Altacor**	chlorantraniliprole	Ryanodine receptor modulators	Diamides
	Exirel	cyantraniliprole		

Troubadour Helena
Turnstyle UF

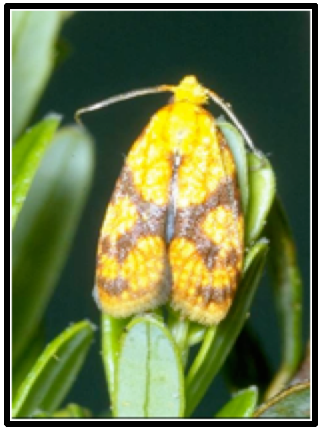
We have seen this in cranberry already….

Weevil

- Resistant to organophosphates
- Worried developing resistance to Avaunt

Spag

- Resistant to organophosphates
- May be developing to Delegate



Good news….

photos by C. Armstrong

BHF – Blackheaded fireworm

- Not likely to develop resistance

CFW – Cranberry Fruitworm

- Not likely to develop resistance

Cranberry Weevil Compounds

- Avaunt 2007 SPRING
  Indoxacarb

Dupont X FMC

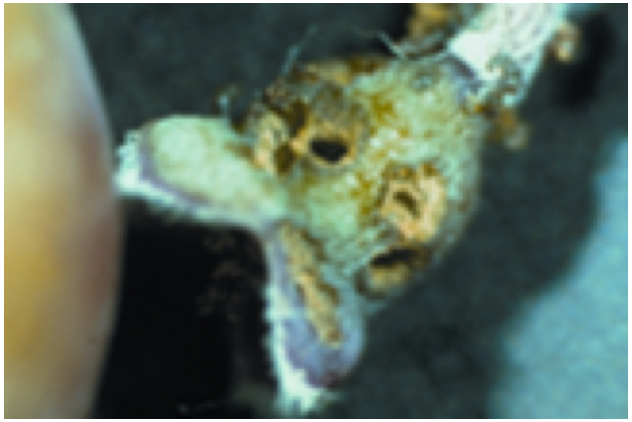
- Actara 2005 SPRING OR SUMMER
  Thiamethoxam (also known as Helix, Cruiser, Vigor)
  neonicotinoid, high bee toxicity
  Zone II Restricted

Syngenta

- Belay 2010 SUMMER
  Clothianidin (also known as Clutch, Arena)
  neonicotinoid, high bee toxicity

Valent

Avaunt (indoxacarb)



Spring population	Summer population
Superb! weevil control! May have to retreat as more weevil come in from woods	**NOT EFFECTIVE** **Do not use Avaunt**

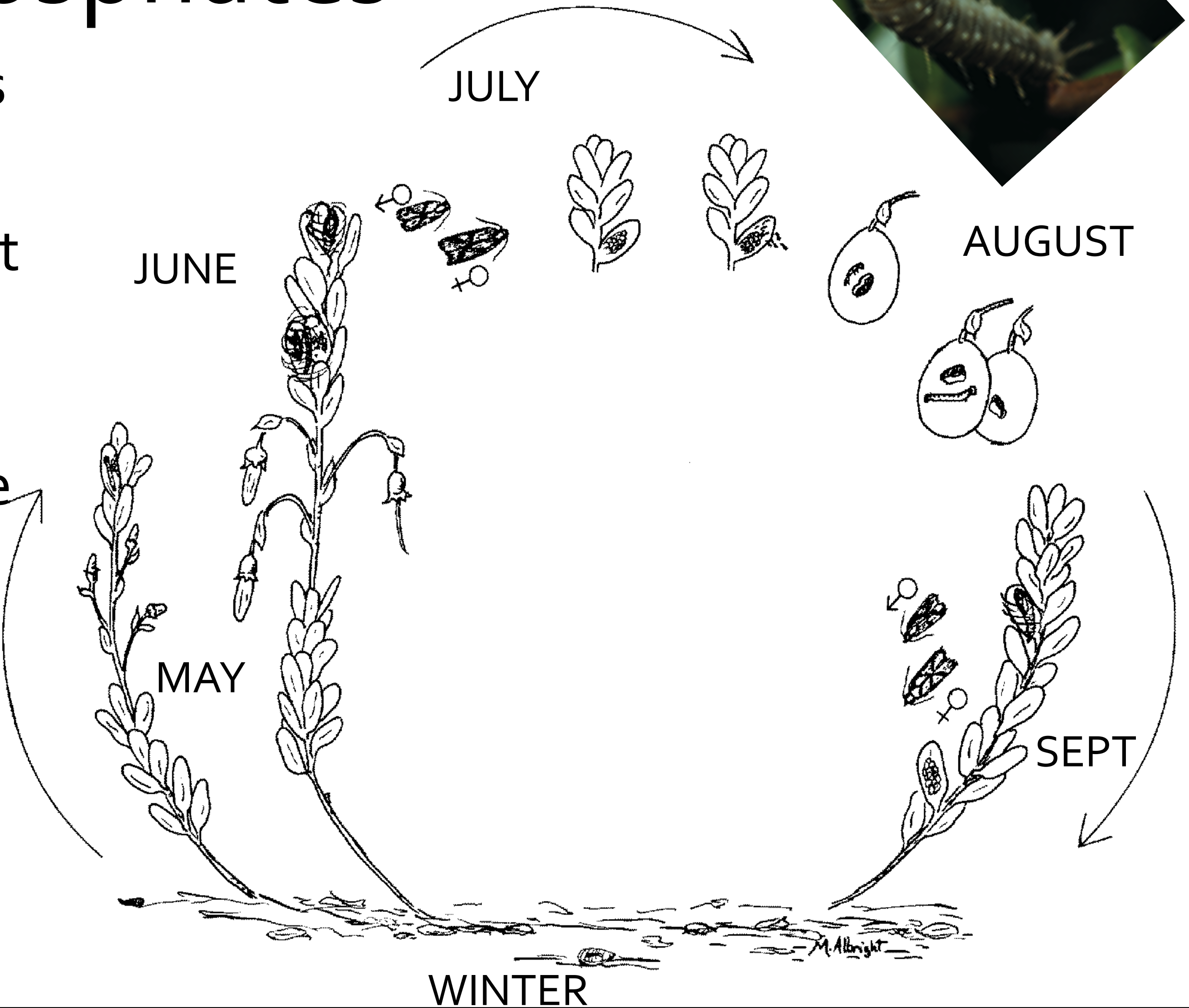
Sparganothis fruitworm




Comes in different styles— the wriggler

Sparganothis resistance to organophosphates

- Began ca. 20 years ago in Carver area
- Spread throughout industry
- Lorsban, Orthene no longer effective on most populations



80 bog sites monitored (10 years ago)

- ALL SITES had some Sparganothis flight!

- 32 (40%) had a peak flight of 50-100 moths
- 40 (50%) had a peak flight of 100-200 moths
- 8 (10%) had a peak flight over 200 moths (per week monitored).

- Peak flight was 1st or 2nd week of JULY

SPAG Spring Spray Options

- Altacor
- Assail
- Avaunt
- **Intrepid**, Confirm
  - **Troubadour** Helena
  - **Turnstyle** UPI
- **Delegate**
- ~~Diazinon~~
- ~~Imidan~~
- ~~Lorsban~~
- ~~Orthene~~
- ~~Sevin~~

Resistance

- Best management approach is to focus on the spring
- Summer populations much harder to monitor and manage
- Delegate and Intrepid best (only) choices for spring management
- Med-large larvae – Delegate?
- Some growers have better luck with Intrepid even on larger larvae!

FUNGICIDES - Alternate, rotate, or sequence different pesticide MoA classes

Use FRAC, IRAC, and HRAC when choosing chemicals!

- Do not rely on product names
- Do not rely on active ingredients
  - Many different products and active ingredients can be in the same group!

11	**Abound**	azoxystrobin	**C3**: cytochrome bc1 at Qo site	QoI-fungicides	methoxy-acrylates	**High Risk**
	Aftershock **Evito**	fluoxastrobin		Strobilurins	dihydro-dioxazines	
3	**Indar** **Proline**	fenbuconazole difenconazole prothioconazole	**G1**: c14-demethylase in sterol biosynthesis	DMI-fungicides (DeMethylation Inhibitors)	triazoles	**Medium Risk**
19	**OSO** **Ph-D**	polyoxin	**H4**: chitin synthase	polyoxins	peptidyl pyrimidine nucleoside	**Medium Risk**

FUNGICIDE RESISTANCE

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	Aftershock **Evito**	fluoxastrobin		Strobilurins	dihydro-dioxazines	
3	**Indar** **Proline**	fenbuconazole prothioconazole	**G1**: c14-demethylase in sterol biosynthesis	DMI-fungicides (DeMethylation Inhibitors)	triazoles	**Medium Risk**
19	**OSO** **Ph-D**	Polyoxin D zinc salt	**H4**: chitin synthase	polyoxins	peptidyl pyrimidine nucleoside	**Medium Risk**

Satori

Quadris Top
azoxy+difenconazole

FUNGICIDE RESISTANCE

Badge
Copper Count
Cuprofix
Kentan
Kocide
MasterCop
Nordox
Nu-Cop
Top Cop

33	**Aliette** **Legion**	fosetyl-Al aluminum-tris	Unknown	phosphonates	ethyl phosphonates	Low Risk
	Fosphite **Fungi-Phite** **K-Phite** **Phostrol** **ProPhyt** **Rampart**	phosphorous acids and salts				
M1	**Champ** **Kocide**	copper (salts)	**M1**: Multi-site contact activity	inorganic	inorganic	Low Risk
M3	**Ferbam**	ferbam	**M3**: Multi-site contact activity	dithiocarbamates	dithiocarbamates	Low Risk
	Manzate **Dithane** **Penncozeb**	mancozebs		EBDC's (Ethylene bis dithio carbamate)		
M5	**Bravo** **Chloronil** **Echo** **Equus** **Initiate**	chlorothalonil	**M5**: Multi-site contact activity	chloronitriles	chloronitriles	Low Risk

FUNGICIDE RESISTANCE

33	**Aliette** **Legion**	fosetyl-Al aluminum-tris	Unknown	phosphonates	ethyl phosphonates	Low Risk
	Fosphite **Fungi-Phite** **K-Phite** **Phostrol** **ProPhyt** **Rampart**	phosphorous acids and salts				
M1	**Champ** **Kocide**	copper (salts)	**M1**: Multi-site contact activity	inorganic	inorganic	Low Risk
M3	**Ferbam**	ferbam	**M3**: Multi-site contact activity	dithiocarbamates	dithiocarbamates	Low Risk
	Manzate **Dithane** **Penncozeb**	mancozebs		EBDC's (Ethylene bis dithio carbamate)		
M5	**Bravo** **Chloronil** **Echo** **Equus** **Initiate**	chlorothalonil	**M5**: Multi-site contact activity	chloronitriles	chloronitriles	Low Risk

Roper

FRUIT ROT MANAGEMENT

11	**Abound**	azoxystrobin	**C3**: cytochrome bc1 at Qo site	QoI-fungicides	methoxy-acrylates	**High Risk**
	Aftershock **Evito**	fluoxastrobin		Strobilurins	dihydro-dioxazines	
3	**Indar** **Proline**	fenbuconazole difenconazole prothioconazole	**G1**: c14-demethylase in sterol biosynthesis	DMI-fungicides (DeMethylation Inhibitors)	triazoles	**Medium Risk**
19	**OSO** **Ph-D**	Polyoxin D zinc salt	**H4**: chitin synthase	polyoxins	peptidyl pyrimidine nucleoside	**Medium Risk**
M1	**Champ** **Kocide**	copper (salts)	**M1**: Multi-site contact activity	inorganic	inorganic	Low Risk
M3	**Ferbam**	ferbam	**M3**: Multi-site contact activity	dithiocarbamates	dithiocarbamates	Low Risk
	Manzate **Dithane** **Penncozeb**	mancozebs		EBDC's (Ethylene bis dithio carbamate)		
M5	**Bravo** **Chloronil** **Echo** **Equus** **Initiate**	chlorothalonil	**M5**: Multi-site contact activity	chloronitriles	chloronitriles	Low Risk

Mix together

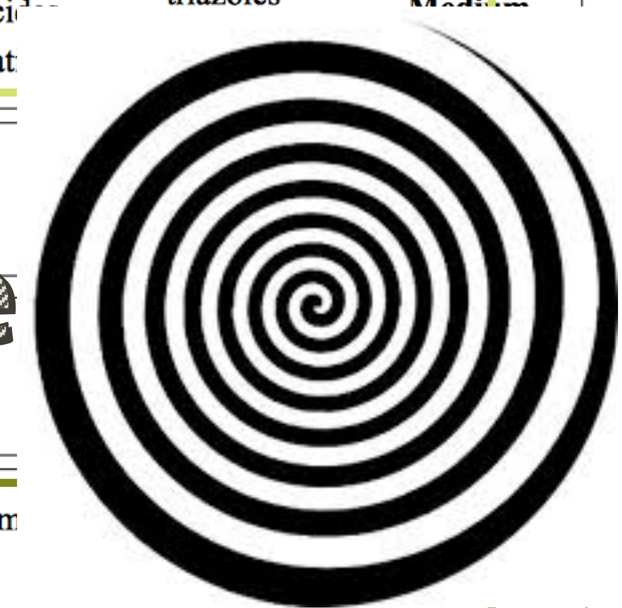
Broad Spectrum

FRUIT ROT MANAGEMENT

11	Abound	azoxystrobin	C3: cytochrome bc1 at Qo site	QoI-fungicides	methoxy-acrylates	High Risk
	Aftershock Evito	fluoxastrobin		Strobilurins	dihydro-dioxazines	
3	Indar Proline	fenbuconazole difenconazole prothioconazole	G1: c14-demethylase in sterol biosynthesis	DMI-fungici (DeMethylat	triazoles	Medium
19	OSO Ph-D	Polyoxin D zinc salt	H4: chitin synthase	polyoxins		
M1	Champ Kocide	copper (salts)	M1: Multi-site contact activity	inorganic		
M3	Ferbam	ferbam	M3: Multi-site contact activity	dithiocarbam		
	Manzate Dithane Penncozeb	mancozebs		EBDC's (Ethylene bis dithio carbamate)		
M5	Bravo Chloronil Echo Equus Initiate	chlorothalonil	M5: Multi-site contact activity	chloronitriles	chloronitriles	Low Risk

Mix together

and Rotate



Broad Spectrum

Questions?