Insecticide Resistance Action Committee

Activities of the Insecticide Resistance Action Committee (IRAC): a brief introduction

Ralf Nauen, PhD



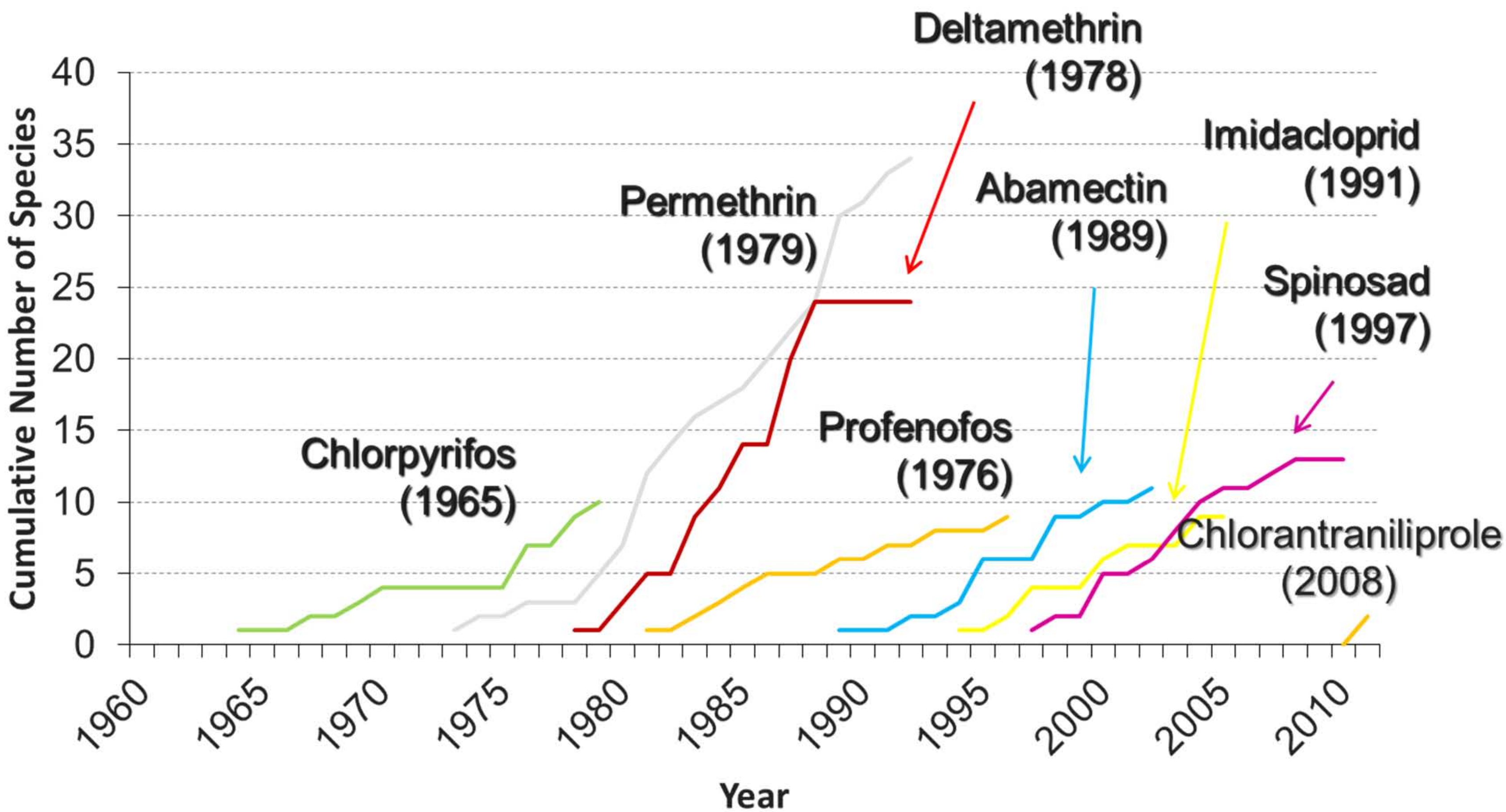


Introduction

- **Insecticide Resistance Action Committee (IRAC)**
  - Formed in 1984 – now in its 28th year and still growing
  - Specialist technical expert group of the agrochemical industry
  - Association with CropLife International (Formal part of CLI´s Stewardship Committee since June 2010)
  - Provides a coordinated industry response to the development of resistance in insect and mite pests
  - Around 75 industry representatives and specialist members in different working groups
  - 7 Country/Regional Groups with a further 70-80 representatives

IRAC

Cases of resistance during the first 14 years following launch (number of species - lab and field)



Resistance can and will develop to any insecticide!

IRAC

Top 10 resistant species (MSU database)

Based on number of actives)

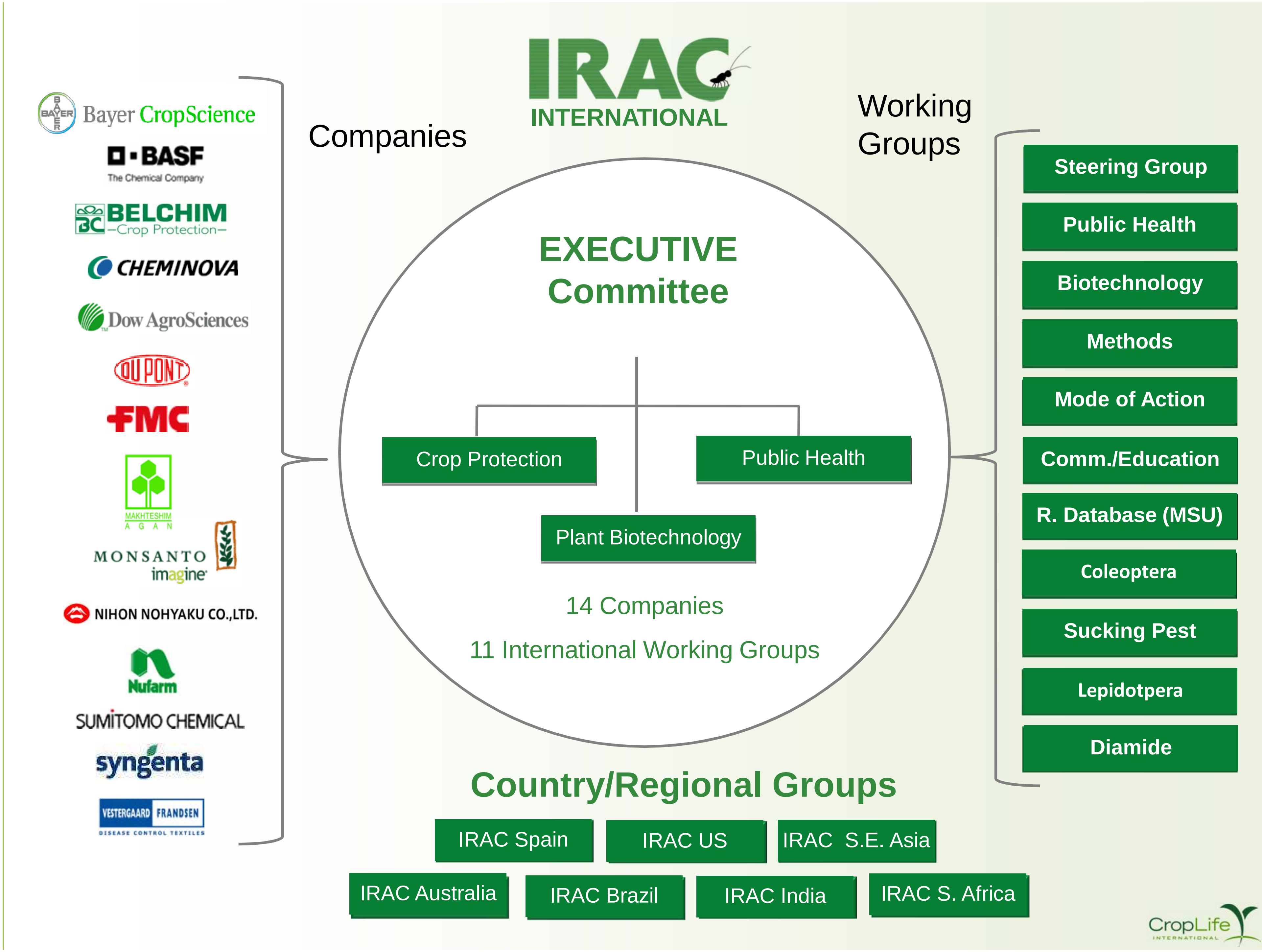
Species	Order	No. of compounds
Tetranychus urticae	Acari	91
Plutella xylostella	Lepidoptera	81
Myzus persicae	Homoptera	72
Leptinotarsa decemlinetata	Coleoptera	51
Musca domestica	Diptera	47
Blattella germanica	Blattodea	43
Boophilus microplus*	Ixodida	43
Panonychus ulmi	Acari	41
Bemisia tabaci	Homoptera	39
Aphis gossypii	Homoptera	37

*Rhiphicephalus

Why effective resistance management is essential?

- Sustaining effective commercial life of current insecticides requires intelligent use of presently available compounds
  - Insecticide Resistance Management (IRM)
- For any crop / pest situation, effective IRM requires the availability of a broad range of modes of action
- IRM is made much more difficult by loss of modes of action through resistance development caused by misuse or overuse of insecticides
- We cannot always rely on having a steady stream of new modes of action to circumvent resistance problems…….

IRAC


IRAC
INTERNATIONAL
Companies
Bayer CropScience
BASF
The Chemical Company
BELCHIM
Crop Protection
CHEMINOVA
Dow AgroSciences
DUPONT
FMC
MAKHTESHIM AGAN
MONSANTO
imagine
NIHON NOHYAKU CO.,LTD.
Nufarm
SUMITOMO CHEMICAL
syngenta
VESTERGAARD FRANDSEN
DISEASE CONTROL TEXTILES
EXECUTIVE
Committee
Crop Protection
Public Health
Plant Biotechnology
14 Companies
11 International Working Groups
Working
Groups
Steering Group
Public Health
Biotechnology
Methods
Mode of Action
Comm./Education
R. Database (MSU)
Coleoptera
Sucking Pest
Lepidotpera
Diamide
Country/Regional Groups
IRAC Spain
IRAC US
IRAC S.E. Asia
IRAC Australia
IRAC Brazil
IRAC India
IRAC S. Africa
CropLife
INTERNATIONAL

IRAC Annual Meeting with up to 50 participants

IRAC

The IRAC website – www.irac-online.org

- IRAC's key communication vehicle
- IRAC Country group information
- Information on IRAC, Mode of Action, advice on IRM
- eTools
- Education modules
- Resources - key papers, posters, etc.
- Home, diary and other general pages
- Team and group areas

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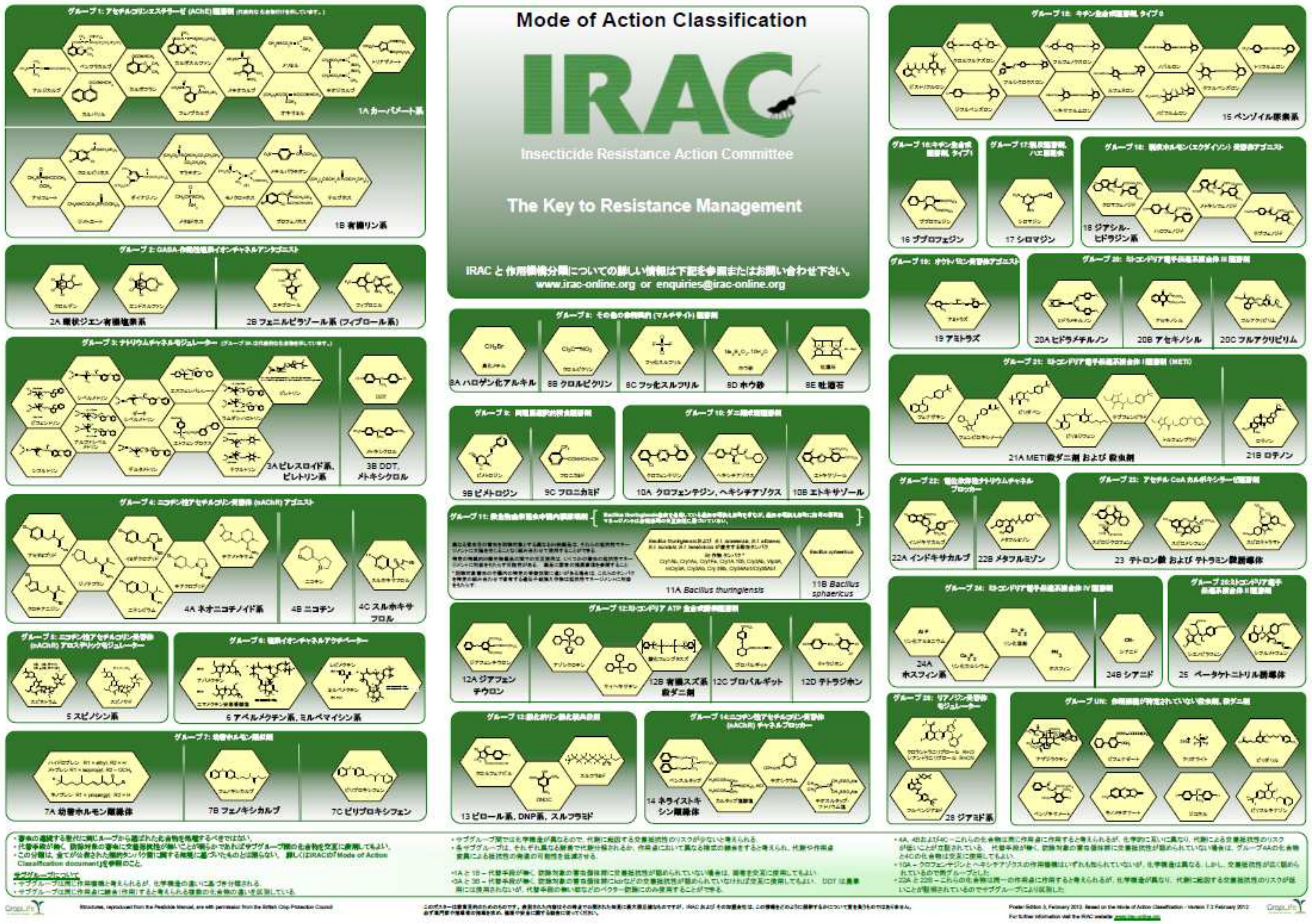
IRAC mode of action classification (Japanese version)



eMethods tool

Insecticide Resistance Action Committee
www.irac-online.org

IRAC Susceptibility Test Methods Series
Version: 3 (June 2009)

Method No: 005

Details:

Method:	No 005 (Formally Method No.5)	
Status:	Approved	
Species:	*Nilaparvata lugens* *Nephotettix cincticeps*	
Species Stage	Adult	
Product Class:	Suitable for all insecticides	*Nilaparvata lugens*
Comments:		

Description:

Materials:
Transparent plastic or glass tubes, or suitable glass jars. Cut plastic stoppers (see figure), fine, soft spring tweezers, containers for solution preparation. 30-50 ml plastic syringes, 100-1000-µl micro-pipettes for liquids or microbalance for solids, Extravon (Invadin) or a similar non-ionic wetting agent, untreated rice seedlings 10-12 days old (BPH susceptible cultivar grown in seedling box), paper towel, maximum/minimum thermometer.

Method:

(a) Make test solutions in water containing 0.03 % w/v Extravon (or similar wetter) using formulated insecticides. At least five to six concentrations are required. The highest concentration should be based on the use recommendation in g ai ha^{-1} converted into p.p.m. (e.g. 500 g ai ha^{-1}–500 p.p.m.; 200 g ai ha^{-1}–200 p.p.m.). Use a 0.4-fold dilution or if necessary, other dilution factors (0.5- or 0.8-fold) to obtain two different mortalities above and below 50 %, respectively. Use water-Extravon alone for untreated control.
(b) Prepare treatment tubes as shown in Fig.
(c) Dip seedlings completely for 5 s in the test solutions and leave them to dry in air for 10-15 min depending on the ambient relative humidity.
(d) Field populations of hoppers may be collected by hand or by suction and kept in holding cages containing potted rice plants. Insects should be collected at random from several points in a field and from a few fields in an area then pooled together as parent stock.

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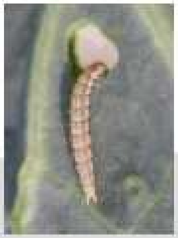
IRAC Susceptibility Test Methods Series
Version: 3.4

Method No: 018

Details:

Method:	IRAC No. 018	
Status:	Approved	
Species:	Diamondback Moth *(Plutella xylostella)*	
Species Stage	Larvae (L2/L3)	
Product Class:	This method is specifically recommended by the IRAC Diamide Working Group for evaluating the susceptibility status of **diamide insecticides (IRAC MoA 28)**** This method is also suitable for the following insecticide classes (IRAC MoA class): Carbamate (1A)* Organophosphate (1B)* Organochlorine (2A)* Fiprole (2B)* Pyrethroid (3A)* Spinosyn (5)* Avermectin (6)* Benzyl urea (15)** Diacylhydrazine (18)*** Indoxacarb (22A)* Metaflumizone (22B)* Pyridalyl (un)*	*Plutella xylostella larvae* *Courtesy of BASF*

Comments:

Mortality assessment period may vary depending on insecticide mode of action

The following guidelines may be used:

*72 hours assessment period
**96 hour assessment period
***120 hour assessment period (addition of fresh plant material may be necessary to avoid starvation). Larvae should go through full molt before mortality assessment.

Description:

Materials:
Insect-proof containers, scissors, forceps, fine pointed brush, beakers for test liquids, syringes/pipettes for liquids or weighing balance for solids, syringes/pipettes for making dilutions, binocular microscope or hand lens (optional), untreated leaves of a host plant, paper towels, maximum/minimum thermometer, filter papers, seeking pin or fine forceps.

New posters coming soon

IRAC

Insecticide Resistance Action Committee

The Asian citrus psyllid, *Diaphorina citri:* ‘Insect Resistance Management’ the Base for a Successful IPM Program

www.irac-online.org

Introduction and Biology

The Asian citrus psyllid (ACP), *Diaphorina citri* Kuwayama (Fig. 1a.), is the insect vector associated with the bacteria *Candidatus* Liberobacter asiaticus and *C.* L. americanus. These bacteria are suspected to be the causal agents of Huanglongbing (HLB) in Asia, and America. Infected citrus trees start showing symptoms such as early fruit drop and mottled leaves anywhere from 5 months to 3 years after they become infected. During this initial asymptomatic period of time, the plants can also be source of inoculum, hence the need to manage the vector even if the trees are not showing symptoms (Fig. 1b.). Once the trees are infected, the production rapidly declines rendering the infected trees unproductive in a few years.

Fig. 1: (a.) Adult of *D. citri* feeding on a young orange leave. (b.) HLB infected trees: asymptomatic (left) and symptomatic (right). Notice fruits on the ground, leaf coloration, and dieback more prominent on the symptomatic plant

Citrus psyllids lay their eggs on the inner-side of unfolding leaves which protects the eggs and early nymphs from adequate insecticide contact, rendering applications of non-systemic insecticides inefficient to manage nymphs. The psyllid nymphal stage has 5 instars taking between 15 and 47 days in total to become an adult depending on environmental conditions. Nymphs acquire the bacteria and the adults vector the disease to uninfected plants and to plants that are already infected, increasing the bacterial titer in already diseased plants. Adults are considered to be the preferred targets for foliar insecticide applications, since they vector the bacteria and the nymphs are protected from contact insecticides by the developing leaves. Systemic soil insecticide target nymphs and adults in young trees

Resistance to Insecticides

Various levels of insecticide susceptibility have been reported in Florida, USA (Table 1). Although the resistance ratios are not very high in comparison to those of other pests, it is a concern that the efficacy of some of the most popular insecticides is already declining. These results were attributed to elevated levels of general esterase, glutathione S-transferase and 14 monooxygenase enzymes in both adults and nymphs.
However, ACP carrying HLB were shown to be more senstivie to insecticides than non-infected psyllids.

Table 1: Highest Resistance Fractor $_{50}$ values observed on various wild population of *D. citri* in Florida in 2010. (Tiwari et al. 2011)

	imidacloprid	chlorpyrifos	thiamethoxam	malathion	carbaryl	spinetoram
RR_{50} adults	35X	18X	15X	5X	3X	2X
RR_{50} nymphs	4X	3X	No tested	No tested	3X	6X

Integrated ACP Management Guidelines

✓ Protect nurseries from ACP under netting and use only plant nursery stock certified free of Greening Disease. Do not transport infected nursery stock around the country according to local regulations

✓Protect young and non-bearing trees from ACP with soil applied systemic insecticides. In older trees, soil applied systemic insecticides (i.e Group 4) may not work satisfactorily on the pest

✓Rotate soil-applied insecticides with foliar sprays of other modes of action. Rotation of different modes of action is key to resistance management.

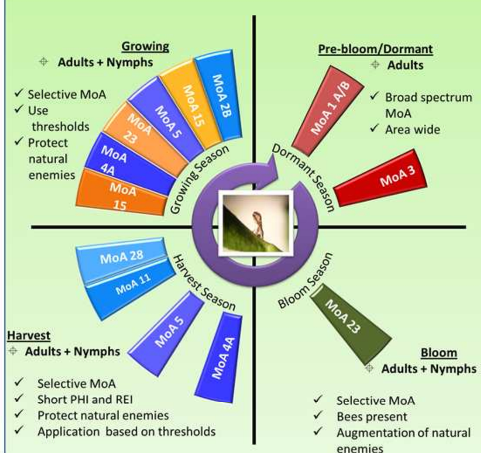
✓Management of adults during the pre-bloom through thje dormant season is key to maintain low populations for the rest of the cycle

✓Use locally defined monitoring methods and intervention thresholds to make spray decisions. Notify any product performance failures immediately.

✓Protect beneficial by timing and selecting the appropriate MoA for the season (Figure 2)

Management Plan cont.

Figure 2: Management plan and opportunities for MoA rotation used for citrus psyllid management based on plant phenology. The rotation uses 10 different MoA which are registered and labeled for control of citrus psyllids. The rotations and number of MoA might vary according to the number of products registered in each country.



Relevant Literature

Arevalo. H.A., A.B. Fraulo, G. Snyder, and P. A. Stansly. 2011. Citrus Greening Bibliographical Database. University of Florida. http://swfrec.ifas.ufl.edu/entomology/extension/hlb/

IRAC . 2009. IRAC Susceptibility Test Methods Series, Method 002. Psylla spp. Version 3 http://www.irac-online.org/wp-content/uploads/2009/09/Method_002_v3_june09.pdf

Rogers, M.E., P.A. Stansly, L.L. Stelinski. 2012. 2012 Florida Citrus Pest Management Guide: Asian Citrus Psyllid and Citrus Leaf Miner . IFAS –University of Florida . ENY-734 . http://edis.ifas.ufl.edu/in686

Tiwari, S., R.S. Mann, M.E. Rogers, L.L. Stelinski. 2011. Insecticide Resistance in Field Populations of Asian Citrus Psillid in Florida. Pest Management Science 67: 1258-1268

IRAC

Insecticide Resistance Action Committee

Under developement

Rice Hoppers

www.irac-online.org

Introduction

There are five key species of plant and leaf hoppe… known to be important pests of rice in Asia and Aus…

They belong to two families, the Delphacidae and Cicadellidae. Delphacidae includes the brown planthopper (*Nilaparvata lugens*), small brown planthopper (*Laodelphax striatellus*) and whitebacked planthopper (*Sogatella furcifera*) which tend to inhabit the base of the plant, whilst the green paddy leafhopper (*Nephotettix virescens*) and rice green leafhopper (*Nephotettix cincticeps*) from the Cicadellidae family tend to inhabit the upper parts of the rice plant.

Both famillies are economically important pests of rice, when favourable conditions allow them to reach high infestation levels. All the species feed by the insertion of stylet mouth parts into the plant phloem tissue and damage is caused by either direct sap loss or through the injection of toxic saliva. The distinctive browning and wilting of rice plants, which is caused by hopper infestation is commonly known as `hopper burn`. Plant and leafhoppers are also know to transmit various plant viruses such as grassy stunt and rice-stripe cereal mosiac

Treatment with insecticides has been the primary control option for growers, with systemic insecticides more favoured in recent years. However the selection of resistant plant varieties and use of biological control agents are also important contro

Insecticide Resistance

Insecticide Resistance has been recorded in rice hopper species since the early 1960's, when organophospahte, carbamate and cyclodiene organochlorine insecticides were the main methods of chemical control. Although further insecticide chemistry has been introduced to control hoppers, the importance of rice as a staple food crop and the reliance on insecticides for the control of insect pests has seen the continued evolution of insecticide resistance. The most recent developments has seen populations of *Nilaparvata lugens, Laodelphax striatellus* and *Sogatella furcifera* independantly develop resistance to neonicotinoid and phenylpyrazole insecticides. At the time of writing there is no evidence of a common cross-resistance resistance between chemical classes of insecticide across these species, however there is evidence that individual hoppers may exhibit multiple mechanisms of resistance to one or more insecticide modes of action. Currently pymetrozine is the only insecticide which is registered for rice hopper control, with no recorded cases of resistance reported.

Table 1: Countries where field collected rice hoppers have been reported in literature as being resistant to the insecticides registered for their control (1960-2010).

Insecticide Chemistry	Mode of Action	*Nilaparvata lugens*	*Laodelphax striatellus*	*Sogatella furcifera*	*Nephotettix virescens*	*Nephotettix cincticeps*
Carbamates	1A	CHN, IDA, JPN, MLY, PHI, TWN	JPN, KOA,	CHN, JPN, SRL	MLY, PHI	JPN, TWN, KOA
Organophosphates	1B	CHN, JAP,PHI, TWN, VNM	CHN, JPN, KOA	CHN, JPN	PHI, IDA	JPN, CHN, KOA, TWN
Cyclodiene organochlorines	2A	FIJ, JPN, TWN	JPN			
Phenylpyrazoles (Fiproles)	2B	CHN	CHN, JPN, TWN, VNM	CHN, JPN, PHI, TWN, VNM		
Pyrethroids	3A	THD	CHN	CHN		
Neonicotinoids	4A	CHN, IND, IDA, JPN, MLY, TWN, THD, VNM	CHN, JPN, TWN, VNM	JPN		
Pymetrozine	9B					
Buprofezin	16	CHN	CHN	CHN		

Distribution & Migration

Table 2: Recorded regional range of different rice hoppers.

	N.Lugens	*L.striatellus*	*S.furcifera*	*N.virescens*	*N.cincticeps*
Japan	X	X	X	X	X
Korea	X	X	X		X
Taiwan	X	X	X	X	X
China	X	X	X	X	X
Philippines	X	X	X	X	
Vietnam	X	X	X	X	
Laos	X	X	X	X	
Cambodia	X	X	X	X	
Thailand	X	X	X	X	
Myanmar	X	X	X	X	
Malaysia	X	X	X	X	
Indonesia	X	X	X	X	
Australia	X		X		
India	X	X	X	X	
Pakistan	X		X		
Pacific Islands	X		X		

The regional range of each of the five key species of rice hoppers varies and in many cases over-lap. Many of the species are migratory in nature and therefore each species may not reach pests status in all of its range every year.

The brown planthopper (*Nilaparvata lugens*) for example is recorded as being an immigrant pest in China, Japan and Korea after migrations from tropical and sub-tropical regions of S.E. Asia. Infestation levels in these countries are often dependant on environmental conditions throughout the region.

Resistance Management

As there is no evidence of cross-resistance amongst the groups insecticides used for rice hopper control, it is recommended that the rotation of effective insecticides with different modes of action are used to provide insect control, whilst at the same time reducing the risk of insecticide resistance from developing. The following should be considered when designing an insect control program for rice hoppers:

- Plan ahead. Determine when in a typical season insecticides applications are likely to be needed and plan for the rotation of insecticides with different modes of action, avoiding the consecutive use of products belonging to the same mode of action group. Plan for contingencies in case extra applications are needed due untypical pest infestations. Consider the presence of other insect pests of rice (e.g. Stemborers or leaffolders) and required treatments .
- Determine which insecticides are most effective for controlling each rice pest during each application timing. If the presence of other rice pests over-lap with rice hoppers, consider using pest specific insecticides rather than broad spectrum insecticides, which may increase unnecessary resistance selection pressure for either or both pests.
- Evaluate the current insecticide resistance situation in the area (consult local crop advisors and experts). Avoid using insecticides already affected by resistance where possible.
- Consider the impact of the insecticides on non-target insects and natural predators, especially during early season applications, where maintaining natural predators can reduce the need for later sprays.
- Consider the use of insect-resistant rice varieties and the use of biological control agents.
- Always follow insecticide label instructions for application timings, volumes and concentrations.

Monitoring

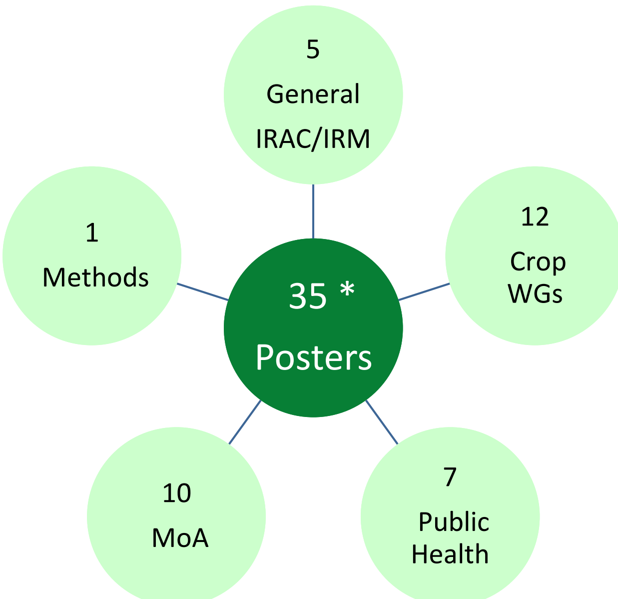
The topical application of insecticides using a syringe, as described by multiple researchers has proved to be a useful bioassay in determining the susceptibility of insecticides, which have strong contact activity against rice hoppers. Extensive monitoring programs have been conducted across the host range of these pests with neonicotinoid, carbamate, phenylpyrazole and buprofezin insecticides.

Alternativly leaf dip assays, as described in the IRAC approved method No. 0005, provide a method of assessing the activity of all Insecticides wihch are utilised for the control of planthoppers, including pymetrozine, which primarily acts by reducing feeding and egg lay.

Further details may be found at www.irac-online.org. Designed and produced by IRAC Sucking Pest WG, July 2011 Photograph courtesy of xxxxxxxx.

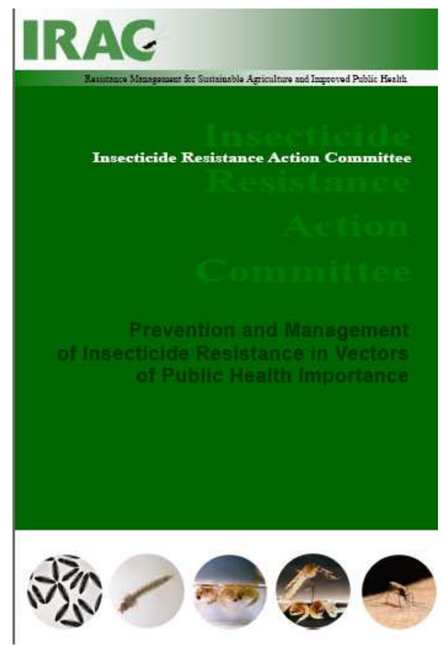
CropLife INTERNATIONAL

Posters and publications overview



* Several others drafted or under development

In 2012 two method videos (YouTube)



IRAC eConnection Newsletter

- Issued 3-4 times per year
- Self-subscribed via website
- Email notification of new issue
- Users download from the web
- Topical issues
- Short scientific notes
- New posters
- Conferences
- Spotlight on recent resistance papers


IRAC NEWSLETTER ISSUE 28 JANUARY 2012

IRAC
Insecticide Resistance Action Committee
eConnection

ISSUE 28 SUMMARY

Photograph: Tom Sparks, Dow AgroSciences and IRAC Mode of Action Team Leader. Winner of the 2012 award for research into Agrochemicals from the American Chemical Society.

IN THIS ISSUE:

IRAC US SYMPOSIUM

First report from this highly popular US Symposium on the topic of insecticide mixtures.

FOCUS ON P450 RESEARCH

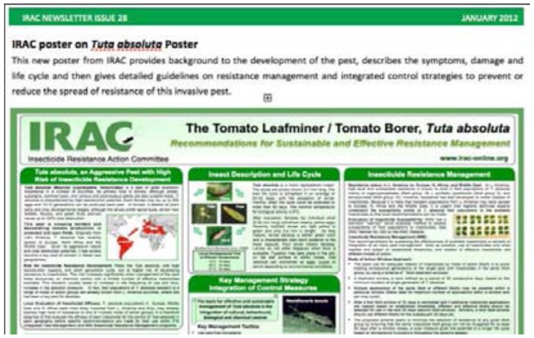
About This Issue

Welcome to another IRAC eConnection newsletter. As always, we try to bring you interesting and informative articles about the work of IRAC and keep you updated on developing insecticide resistance issues around the world.

In this issue we report on the IRAC-US sponsored symposium on the use of insecticide mixtures, particularly in relation to resistance management; we include an overview on research on the cytochrome P450 mechanism; there is an update on activities and resources being developed to combat resistance to the tomato leafminer, *Tuta absoluta* and a review of articles and reports on insecticide resistance appearing in publications over the last few months

Remember, if you have any news or resistance topics of interest, please let us know so that we can inform others in the IRAC Network. We hope you enjoy the issue.

Report on the IRAC-US Symposium Series: No: 7 at the 2012 Entomological Society of America Meeting.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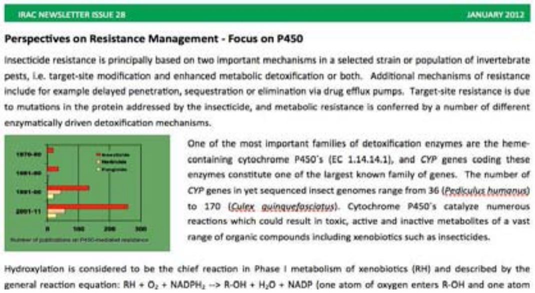
IRAC poster on *Tuta absoluta* Poster

This new poster from IRAC provides background to the development of the pest, describes the symptoms, damage and life cycle and then gives detailed guidelines on resistance management and integrated control strategies to prevent or reduce the spread of resistance of this invasive pest.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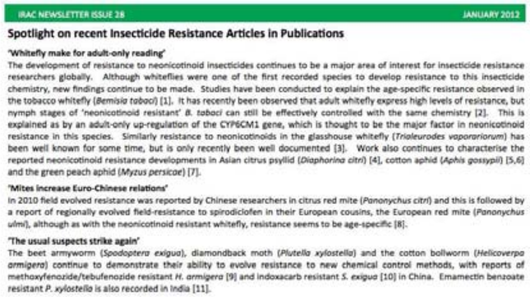
Perspectives on Resistance Management - Focus on P450

Insecticide resistance is principally based on two important mechanisms in a selected strain or population of invertebrate pests, i.e. target-site modification and enhanced metabolic detoxification or both. Additional mechanisms of resistance include for example delayed penetration, sequestration or elimination via drug efflux pumps. Target-site resistance is due to mutations in the protein addressed by the insecticide, and metabolic resistance is conferred by a number of different enzymatically driven detoxification mechanisms.

One of the most important families of detoxification enzymes are the heme-containing cytochrome P450's (EC 1.14.14.1), and *CYP* genes coding these enzymes constitute one of the largest known family of genes. The number of *CYP* genes in yet sequenced insect genomes range from 36 (*Pediculus humanus*) to 170 (*Culex quinquefasciatus*). Cytochrome P450's catalyze numerous reactions which could result in toxic, active and inactive metabolites of a vast range of organic compounds including xenobiotics such as insecticides.

Hydroxylation is considered to be the chief reaction in Phase I metabolism of xenobiotics (RH) and described by the general reaction equation: RH + O_2 + $NADPH_2$ --> R-OH + H_2O + NADP (one atom of oxygen enters R-OH and one atom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Spotlight on recent Insecticide Resistance Articles in Publications

'Whitefly make for adult-only reading'

The development of resistance to neonicotinoid insecticides continues to be a major area of interest for insecticide resistance researchers globally. Although whiteflies were one of the first recorded species to develop resistance to this insecticide chemistry, new findings continue to be made. Studies have been conducted to explain the age-specific resistance observed in the tobacco whitefly (*Bemisia tabaci*) [1]. It has recently been observed that adult whitefly express high levels of resistance, but nymph stages of 'neonicotinoid resistant' *B. tabaci* can still be effectively controlled with the same chemistry [2]. This is explained as by an adult-only up-regulation of the CYP6CM1 gene, which is thought to be the major factor in neonicotinoid resistance in this species. Similarly resistance to neonicotinoids in the glasshouse whitefly (*Trialeurodes vaporariorum*) has been well known for some time, but is only recently been well documented [3]. Work also continues to characterise the reported neonicotinoid resistance developments in Asian citrus psyllid (*Diaphorina citri*) [4], cotton aphid (*Aphis gossypii*) [5,6] and the green peach aphid (*Myzus persicae*) [7].

'Mites increase Euro-Chinese relations'

In 2010 field evolved resistance was reported by Chinese researchers in citrus red mite (*Panonychus citri*) and this is followed by a report of regionally evolved field-resistance to spirodiclofen in their European cousins, the European red mite (*Panonychus ulmi*), although as with the neonicotinoid resistant whitefly, resistance seems to be age-specific [8].

'The usual suspects strike again'

The beet armyworm (*Spodoptera exigua*), diamondback moth (*Plutella xylostella*) and the cotton bollworm (*Helicoverpa armigera*) continue to demonstrate their ability to evolve resistance to new chemical control methods, with reports of methoxyfenozide/tebufenozide resistant *H. armigera* [9] and indoxacarb resistant *S. exigua* [10] in China. Emamectin benzoate resistant *P. xylostella* is also recorded in India [11].


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Tuta absoluta

The IRAC Lepidotera Working Group along with other IRAC Teams have been developing resources and educational material to help prevent or delay developmemt of resistance to this rapidly spreading invasive pest. Resources include a poster, a small booklet and a video explaining IRAC Susceptibility Test Method No: 022 for *Tuta absoluta*. All the materials were displayed at the recent Agadir meeting. Further information on the meeting and the available resources are given below and on the following page.

Report on the *Tuta absoluta* Meeting in Agadir

From 16-18 November 2011, Agadir, Morocco was the site of the joint EPPO/IOBC/FAO/NEPPO symposium on management of *Tuta absoluta*. Two hundred participants from more than 30 European and Mediterranean Countries as well

IRAC Stand at Agadir

New IRAC booklet on *Tuta absoluta* link


IRAC NEWSLETTER ISSUE 28 JANUARY 2012

IRAC News Snippets

★ IRAC International has now set up a new working group focussed on resistance management in Coleoptera which includes the team working on pollen beetles and other pests of oilseed rape. Conference calls with the new group were held in August and December 2011 to set objectives for the team in the 2012. IRAC Members interested in joining the team should contact Alan Porter via the website or at the address below.

★ A monitoring programme investigating reports of resistance in the green

FURTHER INFORMATION

SOURCE:

The eConnection is the newsletter of IRAC International

SUBSCRIPTION:

Free via the IRAC website

IRAC Intl. Diamide Working Group

- Formed in January 2008
  - Development of a global IRM strategy for Group 28 insecticides (ryanodine receptor modulators) *from the scratch*, thus proactively preventing (delaying) the evolution of resistance
  - Since 2009 several regional and sub-teams established; very active group!

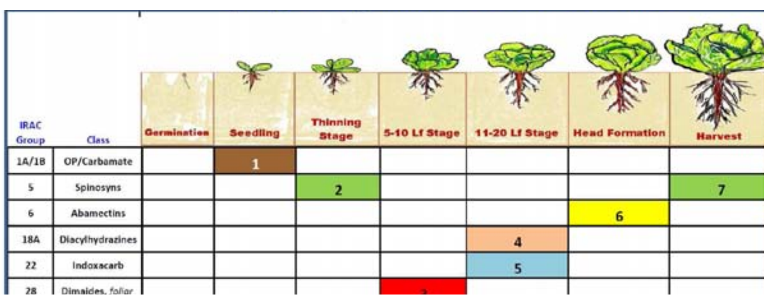
Spain
Philippines
Italy
Japan
Argentina
China
Morocco
Mexico
India
Indonesia
Brazil
Thailand
Vietnam
USA
Malaysia
Korea

IRAC

IRAC funded IRM training program - Philippines

Date	Venue	Number of participants
17-May	Benguet	109
19-May	Pangasinan	91
07-Jun	Cebu	113
19-Jul	Davao	118
12-Aug	Quezon	121
16-Aug	Laguna	228
Total		780

Train the trainer´s



IRAC Group	Class	Germination	Seedling	Thinning Stage	5-10 Lf Stage	11-20 Lf Stage	Head Formation	Harvest
1A/1B	OP/Carbamate		1					
5	Spinosyns			2				7
6	Abamectins						6	
18A	Diacylhydrazines					4		
22	Indoxacarb					5		
28	Diamides, foliar				[illegible]			

IRAC Diamide WG poster: PS4TH071 – Thu-Fri

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Insecticide Resistance Action Committee

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Global Effort to Maintain Susceptibility of the Ryanodine Receptor Modulators and Other Insecticide Modes of Action: Efforts of the IRAC International Diamide (Group 28) Working Group

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Diamide insecticides are IRAC mode of action Group 28 ryanodine receptor modulators, currently including products containing chlorantraniliprole, cyantraniliprole, and flubendiamide.

The IRAC International Diamide Working Group

WHO ARE WE?

The IRAC International Diamide Working Group was created in 2007 to prevent or delay the development of insect resistance to the diamides, a new mode of action chemical class, by founding member companies Nihon Nohyaku/Nichino, DuPont Crop Protection, Bayer Crop Science, and Syngenta and supported by IRAC International and Crop Life membership companies.

WHAT WE DO AND WHY?

The IRAC Diamide Working Group promotes sustainable use of all insecticides through industry education and implementation of IRM disciplines and strategies. The main objective of the Diamide team is to maintain the longevity of all crop protection products available to growers by preventing or delaying the development of resistance to insect pests.

Activities of the IRAC Diamide Working Group

Resistant Management Guidelines

1) Incorporate IPM practices into insect control program.
2) Follow the label. Do not reduce rates. Follow recommended timing of applications and spray volume.
3) Know the MoA of insecticides for rotation programs

GROUP **28** INSECTICIDE

4) Rotate insecticide MoA groups
   - Avoid exclusive use of Group 28 insecticides throughout a crop cycle for a pest species with more than one generation.
   - Apply insecticides using a "window" approach to avoid exposure of consecutive insect pest generations to the same mode of action.
   - A "Treatment Window" is defined as the period of residual activity provided by a single, multiple, or sequence of product applications with the same mode of action within an approximate 30 day period (15 - 45

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Conclusions

- The major insecticide manufacturers undertake extensive research to understand factors influencing the effectiveness of their compounds
- There is a large body of ongoing work to maintain awareness of susceptibility in key at-risk pests
- Key companies are collaborating both internationally and at a local level to harmonise their guidelines for IRM for different classes of insecticides
- IRAC works for the industry to promote awareness of and solutions to resistance
  - Communication and education on IRM are vital
  - IRAC provides key resources such as the MoA scheme, methodologies, IRM advice to help manage resistance
  - IRAC country groups work to tackle local problems

Resistance is everyone's problem - managing it is vital!

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