Insecticide Resistance Action Committee

Insect Resistance Management: Science, Scope, and *Solutions*

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For

IRAC U.S.

Facilitating IRM Communication & Education

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Insecticide Resistance Action Committee

IRAC History & Mission

- IRAC formed in 1984 to provide a coordinated industry response to the development of resistance in insect and mite pests
- A technical working group (task-force) of CropLife, the trade association of crop protection manufactures, formulators and distributors.
- Promote the development and implementation of resistance management strategies in crop protection and vector control to maintain efficacy and support sustainable agriculture and improved public health
  - Facilitate communication and education on insect and mite IRM


IRAC
INTERNATIONAL
Bayer CropScience
BASF
Cheminova
Chemtura
Dow AgroSciences
DuPont
FMC
Nihon Nohyaku
Nufarm
Makhteshim Agan
Monsanto
Sumitomo
Syngenta
EXECUTIVE
Committee
Crop Protection
Public Health
Plant Biotechnology
13 Companies &
13 International Working Groups
Steering Group
Public Health
Biotechnology
Methods
Mode of Action
Comm./Education
EU Liaison
R. Database (MSU)
Pollen Beetle
Sucking Pest
Codling Moth
Neonic
Diamide
Country/Regional Groups
IRAC Spain
IRAC US
IRAC S.E. Asia
IRAC Australia
IRAC Brazil
IRAC India
IRAC S. Africa
CropLife

Roles of IRAC International

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- Actively promote and support work of IRAC Country groups
- Interact effectively with and support IRAG groups
- Cooperate with CropLife International
- Interact with regulatory authorities responsible for insecticide registration

Liaison and coordination activities

IRAC International

A comprehensive approach to tackling resistance

Technical outputs

- Help to identify the scope and nature of resistance problems
- Provide methods for detecting and monitoring resistance
- Provide key resources to aid in developing effective IRM e.g. Mode of action scheme

Communication and education

- Develop IRAC website to provide communication and education on resistance to all stakeholders
- Develop educational resources to improve understanding of IRM
- Act as key global communicator on topical resistance issues

IRAC

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Role of Country Groups

- Deal with key resistance issues at local level – supported by IRAC Intl. (liaison officer affiliated to each country group)
- Develop projects to support local problems –
  e.g. IRAC-India developing project to tackle resistance in BPH
  e.g. IRAC-Brazil developed local Mode of Action based IRM schemes
- Often include additional companies not involved in IRAC International
- May involve others from academia, research institutes & regulatory bodies
- Country groups can help with translation of IRAC materials & resources

Current IRAC Country groups:

- IRAC Australia (AIRMG)
- IRAC Brazil
- IRAC India
- IRAC South Africa
- IRAC Spain
- IRAC US

Mode of Action Classification

IRAC

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The Key to Resistance Management

More information on IRAC and the Mode of Action Classification is available from:
www.irac-online.org or enquiries@irac-online.org

Group 1: Acetylcholinesterase inhibitors

1A Carbamates

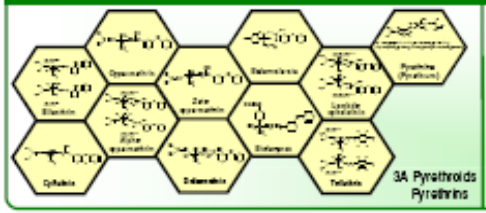
1B Organophosphates

Group 2: GABA-gated chloride channel antagonists

2A Cyclodiene Organochlorines

2B Phenylpyrazoles (Fiproles)

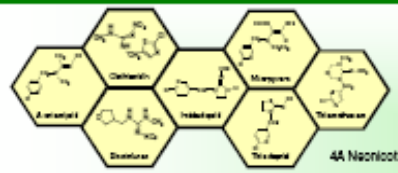
Group 3: Sodium channel modulators



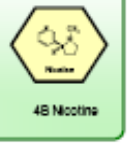
3A Pyrethroids Pyrethrins

3B DDT, Methoxychlor

Group 4: Nicotinic acetylcholine receptor agonists/antagonists



4A Neonicotinoids



4B Nicotine

Group 5: Nicotinic acetylcholine receptor allosteric activators

5 Spinosyns

Group 6: Chloride channel activators

6 Avermectins, Milbemycins

Group7: Juvenile hormone mimics

7A Juvenile hormone analogues

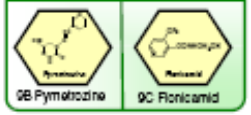
7B Fenoxycarb

7C Pyriproxyfen

Group 8: Miscellaneous non-specific (multi-site) inhibitors

8A Alkyl halides | 8B Chloropicrin | 8C Sulfuryl fluoride | 8D Borax | 8E Tartar emetic

Group 9: Selective homopteran feeding blockers



9B Pymetrozine | 9C Flonicamid

Group 10: Mite Growth Inhibitors

10A Clofentezine | 10A Hexythiazox | 10B Etoxazole

Group 11: Microbial disruptors of insect midgut membranes and derived toxins

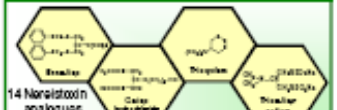
Group 12: Inhibitors of mitochondrial ATP synthase

12A Diafenthiuron | 12B Organotin miticides | 12C Propargite | 12D Tetradifon

Group 13: Uncouplers of oxidative phosphorylation via disruption of proton gradient

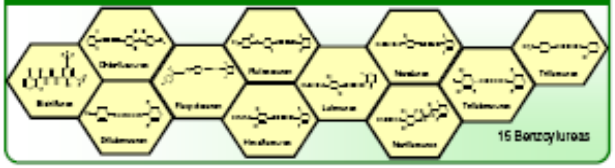
Chlorfenapyr | DNOC

Group 14: Nicotinic acetylcholine receptor channel blockers



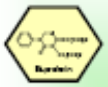
14 Nereistoxin analogues

Group 15: Inhibitors of chitin biosynthesis, type 0, Lepidopteran



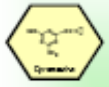
15 Benzoylureas

Group 16: Chitin biosynthesis inhibitors type 1, Homopteran



Buprofezin

Group 17: Moulting disruptor, Dipteran



Cyromazine

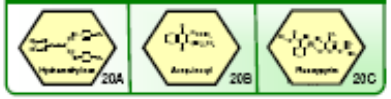
Group 18: Ecdysone agonists/ moulting disruptors 4

18 Diacylhydrazines

Group 19: Octopamine receptor agonists

Amitraz

Group 20: Mitochondrial complex III electron transport inhibitors (Coupling site II)

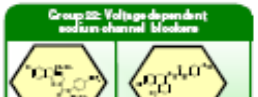


20A | 20B | 20C

Group 21: Mitochondrial complex I electron transport inhibitors

21A METI acaricides | 21B Rotenone

Group 22: Voltage-dependent sodium channel blockers



22A Indoxacarb | 22B Metaflumizone

Group 23: Inhibitors of acetyl CoA carboxylase

23 Tetronic & Tetramic acid derivatives

Group 24: Mitochondrial complex IV electron transport inhibitors

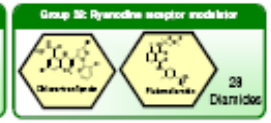
24A Phosphine | 24B Cyanide

Group 25: Vacant

Group 26: Vacant

Group 27: Vacant

Group 28: Ryanodine receptor modulator



28 Diamides

Group UN: Compounds of unknown or uncertain mode of action

Guidance on the use of Sub-Groups:

- Represent distinct structural classes believed to have the same mode of action
- Provides differentiation between compounds that may bind at the same target site
- Are structurally different such that risk of metabolic cross-resistance is lower than for close chemical analogs
- Are likely to be metabolized by different enzymes – may bind differently enough within the target site that the chance of selection for metabolic/target-site resistance is reduced compared to close analogs.

- In the absence of other alternatives, it may be possible to rotate compounds between sub-groups if it is clear that cross resistance mechanisms do not exist in the target populations.
- Not all of the current groupings are based on knowledge of a shared target protein. For further information please refer to the IRAC Mode of Action Classification document.
- 1A & 1B - If there are no other alternatives, compounds may be rotated in situations where cross-resistance mechanisms are known to be absent in the insect populations to be treated.

- 3A & 3B - If there are no other alternatives, compounds may be rotated in situations where cross-resistance mechanisms (e.g. kdr) are known to be absent in the insect populations to be treated. DDT is no longer used in agriculture and therefore this is only applicable for the control of human disease vectors such as mosquitoes, because of a lack of alternatives.
- 10A - Clofentezine & Hexythiazox are grouped because they commonly exhibit cross-resistance even though they are structurally distinct, and the target site for neither compound is known.
- 22A & 22B - Although these compounds are believed to have the same target site, they have been sub-grouped because they are chemically distinct, and current evidence indicates that the risk of metabolic cross-resistance is low.

Poster Version: 2 August 2015, Based on the Mode of Action Classification Version 8.1

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MSU Database & New IRAC Survey

- One of the original roles of IRAC was to track the status of resistance situations and provide recommendations
- In the late 80's and early 90's this done with an internal survey of experts but was phased out when we began supporting the MSU Database
- The MSU Database played a valuable role by collecting all of the published reports of resistance cases.
- However, as resistance is dynamic it is not a good indicator of the current situations
- To augment the MSU Database, IRAC has reestablished an expert survey of the recent status of resistance situations and is making it available on the MSU website

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IRAC Survey Guidelines

- The IRAC survey represents the current working knowledge of a wide range of experts from academia, government and industry, with IRAC making the final decision on status. IRAC makes no claims as to completeness or accuracy as situations can change quickly.
- Insect resistance is a local phenomenon therefore the data should not be used to project what is happening in other areas or in the future.
- IRAC makes no suggestions as to which products should or should not be used where resistance is present. Furthermore the report of resistance to a product should not be taken as an indicator of that products performance on that pest and resistance to one pest does not predict resistance to another pest.
- The data reported represents the working knowledge of that year but may represent resistance that was developed earlier and continues to persist.

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IRAC Survey Guidelines

- **Resistance Status**
  - None = none known, default no need to list
  - Low = a few (<10) isolated areas
  - Medium = consistent issues in more than 10 areas/counties but product still useful
  - High = most areas with some issues and product only used occasionally
  - Severe = widespread and little remaining usefulness
- **Resistance Impact**
  - None
  - Low = occasional reduction in use, increase in rate, or rotation to similar priced chemistry or control tactic
  - Medium = common reduction in performance with crop loss or significant increase in rate or rotation to alternates that are 2X more expensive
  - High = Significant economic consequence to growers
  - Severe = crop goes or is going out of production due to loss

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Value of the Survey

- Should give us better near real time data which will be highly useful in setting research and management priorities
- Overtime it should illustrate the history of resistance development which will be highly useful in evaluation the loss of products and hopefully the successful impact of IRM programs

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Invitation to Improve the Quality

- You can email IRAC or the MSU database if you know of additional situations or disagree with the current ranking
- You can agree to becoming one of the annual experts for your geography
- www.irac-online.org
- www.pesticideresistance.org