Insecticide Mode of Action Classification:
A key to effective insecticide resistance management

Insecticide Resistance Action Committee

IRAC website: www.irac-online.org

Introduction

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. A selection of MoA groups is shown below.

Use Mode of Action wisely for good IRM!

Effective IRM strategies: Alternations or sequences of MoA

All effective insecticide (and acaricide) resistance management (IRM) strategies seek to minimise the selection for resistance from any one type of insecticide or acaricide. In practice, alternations, sequences or rotations of compounds from different MoA groups provide sustainable and effective IRM. This ensures that selection from compounds in the same MoA group is minimised. 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. Metabolic resistance mechanisms may give cross-resistance between MoA groups, and where this is known to occur, the above advice must be modified accordingly.

Moulting & Metamorphosis

Group 18 Ecdysone agonist / disruptor
Diacylhydrazines (e.g. Tebufenozide)
Group 7 Juvenile hormone mimics
JH analogues, Fenoxycarb, Pyriproxyfen, etc

Midgut

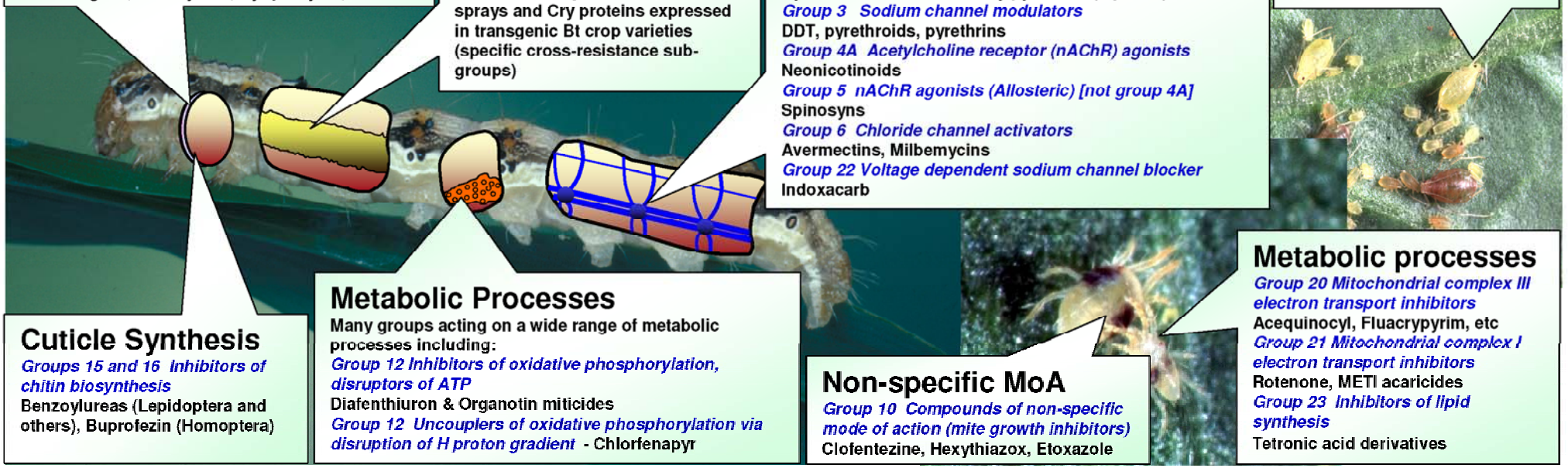
Group 11 Microbial disruptors of insect midgut membranes
Toxins produced by the bacterium *Bacillus thuringiensis* (Bt): Bt sprays and Cry proteins expressed in transgenic Bt crop varieties (specific cross-resistance sub-groups)

Nervous System

Groups 1A & B Acetylcholinesterase (AChE) inhibitors
Carbamates and Organophosphates
Group 2 GABA-gated chloride channel antagonists
Cyclodienes OCs and Phenylpyrazoles (Fiproles)
Group 3 Sodium channel modulators
DDT, pyrethroids, pyrethrins
Group 4A Acetylcholine receptor (nAChR) agonists
Neonicotinoids
Group 5 nAChR agonists (Allosteric) [not group 4A]
Spinosyns
Group 6 Chloride channel activators
Avermectins, Milbemycins
Group 22 Voltage dependent sodium channel blocker
Indoxacarb

Non-specific MoA

Group 9 Compounds of non-specific mode of action (selective feeding blockers)
Pymetrozine, Flonicamid, etc.



Cuticle Synthesis

Groups 15 and 16 Inhibitors of chitin biosynthesis
Benzoylureas (Lepidoptera and others), Buprofezin (Homoptera)

Metabolic Processes

Many groups acting on a wide range of metabolic processes including:
Group 12 Inhibitors of oxidative phosphorylation, disruptors of ATP
Diafenthiuron & Organotin miticides
Group 12 Uncouplers of oxidative phosphorylation via disruption of H proton gradient - Chlorfenapyr

Non-specific MoA

Group 10 Compounds of non-specific mode of action (mite growth inhibitors)
Clofentezine, Hexythiazox, Etoxazole

Metabolic processes

Group 20 Mitochondrial complex III electron transport inhibitors
Acequinocyl, Fluacrypyrim, etc
Group 21 Mitochondrial complex I electron transport inhibitors
Rotenone, METI acaricides
Group 23 Inhibitors of lipid synthesis
Tetronic acid derivatives

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