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

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.

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 subgroups)

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 (Alloselic) [not group 4A]
- Spinosyns
- Group 6: Chloride channel activators
- Avermectins, Milbemycins
- Group 22: Voltage dependent sodium channel blocker
- Indoxacarb

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
  - Diazinon & Organotin miticides

Non-specific MoA
- Group 6: Compounds of non-specific mode of action (mite growth inhibitors)
- Clofentezine, Hexythiazox, Etoxazole

Effective IRM strategies: Alternations or sequences of MoA
All effective insecticide (and acaricide) resistance management (IRM) strategies seek to minimize 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 minimized. 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.

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

Metabolic processes
- Group 20: Mitochondrial complex III electron transport inhibitors
- Acel로nic, 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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