Insecticide Mode of Action Classification:

A Key to Effective Insecticide Resistance Management in Whiteflies

IRAC
Insecticide Resistance Action Committee

Introduction

IRAC has developed a Mode of Action (MoA) classification for insecticides. It promotes the use of this as the basis for effective and sustainable insecticide resistance management (IRM). Thus, 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.

When resistance to an insecticide arises, not only does this resistance render the selecting compound ineffective but it also confers cross-resistance to other chemically related compounds. This is because compounds within a specific chemical group usually share a common MoA. It is common for resistance to develop that is based on a genetic modification of this target site. When this happens the interaction of the selecting compound with the target site is impaired and the compound loses its pesticidal efficacy. Because all compounds within the same chemical sub-group share a common MoA, there is a high risk that the resistance that has developed will automatically confer cross-resistance to all the compounds in the same sub-group.

By selecting sequences of insecticides from different MoA groups a sustainable IRM program can be developed. Effective IRM of this type can help to preserve the utility and diversity of insecticides for pest insect control. This poster details the mode of action of insecticides available for the control of whiteflies.

Insecticides acting on the nervous system

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

Group 1 Acetylcholinesterase (AChE) inhibitors
Carbamates (1A) and Organophosphates (1B) act as inhibitors of AChE at nerve synapses. This results in hyperactivity in the nervous system

Group 2 GABA-gated chloride channel antagonists
Cyclodiene organochlorines (2A) bind to the GABA-gated chloride channel receptor complex and inhibit the action of GABA causing neuronal hyperactivity

Group 3 Sodium channel modulators
Sodium channels are involved in the propagation of action potential along nerves. Pyrethroids rapidly interfere with their action, causing hyperactivity and nerve block

Group 4 Acetylcholine receptor agonists
The neonicotinoids (4A) act as agonists of acetylcholine at the post-synaptic nicotinic Acetylcholine receptor (nAChR). This leads to overstimulation and hyperactivity

Insecticides interfering with metamorphosis

Metamorphosis is controlled by hormones including juvenile hormone and disruption of this system is insecticidal

Group 7 Juvenile hormone mimics
Pyriproxyfen (7C) acts as a mimic of JH and when applied to juvenile stages disrupts and prevents metamorphosis

Insecticides inhibiting cuticle synthesis (Type 1)

New cuticle is synthesised during the moult cycle and insecticides which interfere with this process disrupt the molt cycle leading to death of the insect

Group 16 Inhibitors of chitin biosynthesis (Homoptera): Buprofezin
This compound inhibits chitin synthesis in a number of insects including whiteflies

Insecticides inhibiting metabolic processes

A number of metabolic processes are the target of whitefly insecticides:

Group 12A Inhibitors of oxidative phosphorylation, disruptors of ATP formation: Diafenthiuron

Diafenthiuron is a mitochondrial respiration inhibitor for whitefly control in some countries

Group 23 Inhibitors of lipid synthesis: Spiromesifen

In this new MoA group, the tetronic acid derivative Spiromesifen inhibits lipid synthesis, leading to insect death.

Insecticides acting as feeding blockers

Group 9 Compounds of unknown action: Pymetrozine
Pymetrozine (9B) has a non-specific mode of action which appears to involve a selective inhibition of whitefly feeding. Insects die as a result of starvation

Effective IRM strategies: Alternations or sequences of MoA

All effective insecticide resistance management (IRM) strategies seek to minimise the selection for resistance from any one type of insecticide.

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.

Cross-resistance between MoA groups can arise through metabolic mechanisms and users should be aware of local issues in this regard. In the absence of such information alternations or sequences of MoA will always minimise selection pressures.

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 are not treated with compounds from the same MoA group.

Insecticide classes for whitefly control

IRAC lists 26 mode of action groups (42 including sub-groups); 10 of these are commonly used for whitefly control

Group	Mode of Action	Chemical sub-group or exemplifying active ingredient
1A	Acetylcholinesterase inhibitors	Carbamates
1B		Organophosphates
2A	GABA-gated chloride channel antagonists	Cyclodiene organochlorines
3	Sodium channel modulators	Pyrethroids
4A	Nicotinic Acetylcholine receptor agonists	Neonicotinoids
7C	Juvenile hormone mimics	Pyriproxyfen
9B	Compounds of unknown or non-specific action (selective feeding blockers)	Pymetrozine
12A	Inhibitors of oxidative phosphorylation, disruptors of ATP formation	Diafenthiuron
16	Inhibitors of chitin biosynthesis, type 1, Homopteran	Buprofezin
23	Inhibitors of lipid synthesis	Tetronic acid derivative: Spiromesifen

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