PI-83

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IRAC's Insecticide Mode of Action Classification[1]

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This guide explains the rationale behind the Insecticide Resistance Action Committee's (IRAC) insecticide and acaricide mode of action classification and provides a listing of those insecticide common names with their groupings, and primary modes of action for insecticides currently registered in Florida.

What is IRAC?

IRAC has groups formed in several countries, including the United States, Brazil, South Africa, Spain, India, and Australia. The group's purpose is to communicate and educate agricultural producers and crop protection professionals by providing resistance management information. Members of an IRAC group are generally professionals who are actively engaged in the insecticide and acaricide manufacturing industry. Some university researchers also participate.

Resistance to Pesticides

Resistance refers to an inheritable change in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species. Resistance does not always occur, but has been documented with insecticides as early as 1914, and there are many known instances today where resistance is a problem. Not only has resistance occurred with insecticides, but other pesticides, such as fungicides, herbicides, and rodenticides. Complicating the understanding and management of resistance is the problem of knowing which type of resistance is present in a given pest population. For example, some pest populations are known to have cross-resistance. That is, they are not effectively controlled with pesticides having the same mode of action which generally target the same site within the pest. For example, both the carbamate and organophosphate insecticides target acetylcholine esterase, although each group of insecticides is chemically different from one another. The greatest resistance concern arises when multiple-resistance is confirmed. Multiple-resistance is the situation of a pest population that is resistant to pesticides having different modes of action. It is the most difficult type of resistance to manage, because the number of management options is reduced. For more information on resistance, see UF/IFAS EDIS Document ENY-624, 2005 Florida Citrus Pest Management Guide: Pesticide Resistance and Resistance Management.

1. This document is PI-83, one of a series of the Pesticide Information Office, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date October 2005. Visit the EDIS Web Site at http://edis.ifas.ufl.edu.

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IRAC's Classification Scheme

IRAC's insecticide classification scheme is based on mode of action. The goal of the scheme is to provide information to applicators of acaricides and insecticides so that they can make sound decisions on selecting insecticides to prevent or manage resistance. Besides selecting products that have different modes of action, growers are also encouraged to integrate other methods into insect and mite control programs. Table 1 contains those acaricides and insecticides registered for use in Florida, though it changes constantly. They are listed according to IRAC's classification scheme by their group and subgroup codes, primary target site of action, chemical sub-group or exemplifying active ingredient, and active ingredient, based on that appearing in The Pesticide Manual, 13th edition, 2003, edited by C.D.S. Tomlin, published by The British Crop Protection Council.

Using the IRAC Classification Scheme with Product Labels

IRAC is currently encouraging manufacturers of pesticides to indicate the IRAC mode of action group number and description on their product labels; some registrants are now doing so, especially with newer products. Such information would be helpful in assisting pesticide applicators in the selection of acaricides and insecticides for use in resistance management strategies. An example of the manner that IRAC is encouraging registrants to list this information:

Insecticide® 50 SC

IRAC Mode of Action Group 15
Inhibitors of chitin biosynthesis, type 0, Lepidopteran Benzoylureas

Active Ingredient: [Diflubenzuron]
Formulation details

Additional Information

IRAC: http://www.irac-online.org/groups/guide.

McCoy, C.W., M.E. Rogers, and L.W. Timmer. 2004. 2005 Florida citrus pest management guide: pesticide resistance and resistance management. UF/IFAS EDIS Document ENY-624. http://edis.ifas.ufl.edu/CG026.

Tomlin, C.D.S., ed. 2003. The pesticide manual: a world compendium, 13th edition. The British Crop Protection Council. 1250 pp., ISBN 1 901396 13 4.

Table 1. IRAC's classification scheme for acaricides and insecticides registered for use in Florida.

Group	Subgroup	Primary target site of action	Chemical subgroup or exemplifying active ingredient	Active ingredients
1*	1A	Acetylcholine esterase inhibitors	Carbamates	Aldicarb
				Bendiocarb
				Carbaryl
				Carbofuran
				Methiocarb
				Methomyl
				Oxamyl
				Propoxur
				Thiodicarb
	1B		Organophosphates	Acephate
				Azinphos-methyl
				Chlorpyrifos
				Chlorpyrifos-methyl
				Coumaphos
				Diazinon
				Dichlorvos
				Dicrotophos
				Dimethoate
				Disulfoton
				Ethoprop
				Fenamiphos
				Fenthion
				Isofenphos
				Malathion
				Methamidophos
				Methidathion
				Methyl parathion
				Naled
				Oxydemeton-methyl
				Phorate
				Profenofos
				Propetamphos
				Temephos
				Terbufos
				Tetrachlorvinphos
				Trichlorfon
2*	2A	GABA-gated chloride channel antagonists	Cyclodiene organochlorines	Endosulfan
				Lindane
	2B		Fipronil (phenylpyrazoles)	Fipronil

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Group	Subgroup	Primary target site of action	Chemical subgroup or exemplifying active ingredient	Active ingredients
3		Sodium channel modulators	Pyrethroids	Allethrin
				d-cis-trans Allethrin
				d-trans Allethrin
				Bifenthrin
				Bioallethrin S-cyclopentenyl
				Cyfluthrin
				Beta-Cyfluthrin
				Cypermethrin
				zeta-Cypermethrin
				Cyphenothrin [(1R)-trans-isomers]
				Deltamethrin
				Esfenvalerate
				Fenpropathrin
				Fenvalerate
				Imiprothrin
				Permethrin
				Phenothrin [(1R)-trans-isomer]
				Prallethrin
				Resmethrin
				Tefluthrin
				Tetramethrin
				Tralomethrin
			Pyrethrins	Pyrethrins (pyrethrum)
			Methoxychlor	Methoxychlor
4*	4A	Nicotinic acetylcholine receptor agonists/antagonists	Neonicotinoids	Acetamiprid
				Imidacloprid
				Thiamethoxam
	4B		Nicotine	Nicotine
6		Chloride channel activators	Avermectins, Milbemycins	Abamectin
7*	7A	Juvenile hormone mimics	Juvenile hormone analogues	Hydroprene
				Kinoprene
				Methoprene
	7B		Fenoxycarb	Fenoxycarb
8*	8A	Compounds of unknown or non-specific mode of action (fumigants)	Methyl bromide	Methyl bromide and other alkyl halides
	8B		Chloropicrin	Chloropicrin
	8C		Sulfuryl fluoride	Sulfuryl fluoride
9*	9A	Compounds of unknown or non-specific mode of action (selective feeding blockers)	Cryolite	Cryolite

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Group	Subgroup	Primary target site of action	Chemical subgroup or exemplifying active ingredient	Active ingredients
10*	10A	Compounds of unknown or non-specific mode of action (mite growth inhibitors)	Clofentezine	Clofentezine
			Hexythiazox	Hexythiazox
	10B		Etoxazole	Etoxazole
11*	11A1	Microbial disruptors of insect midgut membranes (includes transgenic crops expressing *B.t.* toxins)	*B.t.* var. israelensis	B.t. var. israelinsis
	11B1		*B.t.* var. aizawai	*B.t.* var. aizawai
	11B2		*B.t.* var. kurstaki	*B.t.* var. kurstaki
12*	12B	Inhibitors of oxidative phosphorylation, disruptors of ATP formation (inhibitors of ATP synthase)	Organotin miticides	Fentutatin oxide
	12C		Propargite	Propargite
15		Inhibitors of chitin biosynthesis, type 0, Leptdopteran	Benzoylureas	Diflubenzuron
				Hexaflumuron
				Novaluron
17		Moulting disruptor, Dipteran	Cyromazine	Cyromazine
18*	18A	Ecdysone agonists/moulting disruptors	Diacylhydrazines	Halofenozide
				Methoxyfenozide
				Tebufenozide
	18B		Azadirachtin	Azadirachtin
19		Octopaminergic agonists	Amitraz	Amitraz
20*	20A	Mitochondrial complex III electron transport inhibitors (Coupling site II)	Hydramethylnon	Hydramethylnon
21		Mitochondrial complex I electron transport inhibitors	METI acaricides, Rotenone	Rotenone
22		Voltage-dependent sodium channel blockers	Indoxacarb	Indoxacarb
24*	24A	Mitochondrial complex IV electron transport inhibitors	Aluminum phosphide	Aluminum phosphide
	24C		Phosphine	Phosphine
25		Neuronal inhibitors (unknown mode of action)	Bifenazate	Bifenazate
27*	27A	Synergists	P450 monooxygenase inhibitors	Piperonyl butoxide
UN	UNC	Compounds with unknown mode of action**	Dicofol	Dicofol
	UND		Pyridalyl	Pyridalyl
NS	NSA	Miscellaneous non-specific (multi-site) inhibitors†	Borax	Borax

*Groups and Sub-groups: although sharing the same primary target site, it is possible that not all members of a single mode of action class have been shown to be cross-resistant. Different resistance mechanisms that are not linked to the target site, such as enhanced metabolism, may be common for such a group of chemicals. In such cases, the mode of action grouping is further divided into sub-groups.

**A compound with an unknown mode of action or an unknown mode of toxicity will be held in category UN until evidence becomes available to enable that compound to be assigned to a more appropriate mode of action class.

†Category NS is used for compounds or preparations with a non-specific, multisite action.