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. There are many known instances today where resistance is a problem. Not only has resistance occurred with insecticides but also with 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 that generally targets 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

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. Revised April 2011. Visit the EDIS website at http://edis.ifas.ufl.edu.

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Document ENY-624, *2011 Florida Citrus Pest Management Guide: Pesticide Resistance and Resistance Management*, http://edis.ifas.ufl.edu/cg026.

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, 15th edition*, 2009, 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 is as follows:

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/

Rogers, M.E., and M. M. Dewdney. 2010. 2011 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. 2009. The pesticide manual. 15th 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 Ethion Ethoprop Fenamiphos Fenthion Fosthiazate 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

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	2B		Phenylpyrazoles (Fiproles)	Fipronil
3*	3A	Sodium channel modulators	Pyrethroids Pyrethrins	Allethrin and isomers Bifenthrin and isomers Cyfluthrin and isomers Cyhalothrin and isomers Cypermethrin and isomers Cyphenothrin Deltamethrin Esfenvalerate Fenpropathrin Fenvalerate Imiprothrin Permethrin Phenothrin Prallethrin Pyrethrins (pyrethrum) Resmethrin Tefluthrin Tetramethrin Tralomethrin
	3B		Methoxychlor	Methoxychlor
4	4A	Nicotinic acetylcholine receptor agonists	Neonicotinoids	Acetamiprid Clothianidin Dinotefuran Imidacloprid Thiamethoxam
	4B		Nicotine	Nicotine
5		Nicotinic acetylcholine receptor allosteric activators	Spinosyns	Spinetoram Spinosad

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6		Chloride channel activators	Avermectins, Milbemycins	Abamectin Emamectin benzoate Milbemectin
7	7A	Juvenile hormone mimics	Juvenile hormone analogues	Hydroprene
				Kinoprene
	7B		Fenoxycarb	Fenoxycarb
	7C		Pyriproxyfen	Pyriproxyfen
8	8A	Miscellaneous non-specific (multi-site) inhibitors	Alkyl halides	Methyl bromide and other alkyl halides
	8B		Chloropicrin	Chloropicrin
	8C		Sulfuryl fluoride	Sulfuryl fluoride
	8D		Borax	Borax
10	10A	Mite growth inhibitors	Clofentezine Hexythiazox	Clofentezine Hexythiazox
	10B		Etoxazole	Etoxazole
11		Microbial disruptors of insect midgut membranes (includes transgenic crops expressing *B.t.* toxins)	*Bacillus thuringiensis* or *Bacillus sphaericus* and the insecticidal proteins they produce	*Bacillus thuringiensis subsp. israelensis* *Bacillus sphaericus* *Bacillus thuringiensis subsp. Kurstaki* Bt crop proteins
12	12B	Inhibitors of mitochondrial ATP synthase	Organotin miticides	Fentutatin oxide
	12C		Propargite	Propargite
13		Uncouplers of oxidative phosphorylation via disruption of the proton gradient	Chlorfenapyr	Chlorfenapyr
15		Inhibitors of chitin biosynthesis, type 0, Leptdopteran	Benzoylureas	Diflubenzuron Hexaflumuron Lufenuron Novaluron Noviflumuron
16		Inhibitors of chitin biosynthesis, type 1	Buprofezin	Buprofezin
17		Moulting disruptor, Dipteran	Cyromazine	Cyromazine
18		Ecdysone receptor agonists	Diacylhydrazines	Halofenozide Methoxyfenozide Tebufenozide
19		Octopamine receptor agonists	Amitraz	Amitraz

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20*	20A	Mitochondrial complex III electron transport inhibitors	Hydramethylnon	Hydramethylnon
	20B		Acequinocyl	Acequinocyl
21*	21A	METI acaricides and insecticides	Fenazaquin	Fenazaquin Fenpyroximate Pyridaben Tolfenpyrad
	21B	Mitochondrial complex I electron transport inhibitors	Rotenone	Rotenone
22*	22A	Voltage-dependent sodium channel blockers	Indoxacarb	Indoxacarb
	22B		Metaflumizone	Metaflumizone
23		Inhibitors of acetyl CoA carboxylase	Tetronic and tetramic acid derivatives	Spirodiclofen Spiromesifen Spirotetramat
24	24A	Mitochondrial complex IV electron transport inhibitors	Phosphine	Aluminum phosphide Phosphine Zinc phosphide
28		Ryanodine receptor modulators	Diamides	Chlorantraniliprole Flubendiamide
UN		Compounds of unknown or uncertain mode of action[@]	Azadirachtin	Azadirachtin
			Bifenazate	Bifenazate
			Cryolite	Cryolite
			Dicofol	Dicofol
			Pyridalyl	Pyridalyl

*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 or controversial 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.