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 in several countries, including the United States, Brazil, South Africa, Spain, India, and Australia. An IRAC group's purpose is to provide agricultural producers and crop-protection professionals with information on resistance management. 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.

Resistance has not only 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 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. Multiple-resistance is the most difficult type of resistance to manage because the number of management options is reduced. For more information on resistance, see EDIS Publication ENY-624,*2005 Florida Citrus Pest Management Guide: Pesticide Resistance and Resistance Management*, http://edis.ifas.ufl.edu/cg026.

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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 programs for insect and mite control. Table 1 contains those acaricides and insecticides registered for use in Florida in 2008. Keep in mind, however, these registrations change constantly. The registered acaricides and insecticides 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, 14th edition, 2006, edited by C.D.S. Tomlin, published by The British Crop Protection Council.

Using the IRAC Classification Scheme with Product Labels

IRAC is encouraging manufacturers of pesticides to indicate the IRAC mode-of-action group number and description on their product labels, and some registrants are 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. One example the manner which IRAC suggests registrants list this information follows below.

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, EDIS Publication ENY-624, http://edis.ifas.ufl.edu/CG026. Entomology and Nematology Department, University of Florida, Gainesville, FL.

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
				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
				Lindane
	2B		Phenylpryazoles (Fiproles)	Fipronil

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Group	Subgroup	Primary target site of action	Chemical subgroup or exemplifying active ingredient	Active ingredients
3	3A	Sodium channel modulators	Pyrethrins	Allethrin and isomers
				Bifenthrin and isomers
				Cyfluthrin and isomers
				Cyhalothrin and isomers
				Cypermethrin and isomers
				Cyphenothrin isomers
				Deltamethrin
				Esfenvalerate
				Fenpropathrin
				Fenvalerate
				Imiprothrin
				Permethrin
				Phenothrin isomers
				Prallethrin
				Pyrethrins
				Resmethrin
				Tefluthrin
				Tetramethrin
				Tralomethrin
	3B		Methoxychlor	Methoxychlor
4*	4A	Nicotinic acetylcholine receptor agonists	Neonicotinoids	Acetamiprid
				Clothianidin
				Imidacloprid
				Thiamethoxam
	4B		Nicotine	Nicotine
5		Nicotinic acetylcholine receptor allosteric activators	Spinosyns	Spinetoram
				Spinosad
6		Chloride channel activators	Avermectins	Abamectin
			Milbemycins	Milbebectin
7*	7A	Juvenile hormone mimics	Juvenile hormone analogues	Hydroprene
				Kinoprene
	7B		Fenoxycarb	Fenoxycarb
8*	8A	Miscellaneous non-specific (multi-site) inhibitors	Methyl bromide	Methyl bromide and other alkyl halides
	8B		Chloropicrin	Chloropicrin
	8C		Sulfuryl fluoride	Sulfuryl fluoride
	8D		Borax	Borax
10*	10A	Mite growth inhibitors	Clofentezine	Clofentezine
			Hexythiazox	Hexythiazox
	10B		Etoxazole	Etoxazole
11		Microbial disruptors of insect midgut membranes (includes transgenic crops expressing *B.t.* toxins)	*Bacillus thuringiensis or Bacillus sphaericus*	*Bacillus thuringiensis*
				Bacillus sphaericus

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Group	Subgroup	Primary target site of action	Chemical subgroup or exemplifying active ingredient	Active ingredients
12	12B	Inhibitors of mitochondrial ATP synthase	Organotin miticides	Fentutatin oxide
	12C		Propargite	Propargite
15		Inhibitors of chitin biosynthesis, type 0, Leptdopteran	Benzoylureas	Diflubenzuron
				Hexaflumuron
				Novaluron
				Noviflumuron
17		Moulting disruptor, Dipteran	Cyromazine	Cyromazine
18		Ecdysone receptor agonists	Diacylhydrazines	Halofenozide
				Methoxyfenozide
				Tebufenozide
19		Octopamine agonists	Amitraz	Amitraz
20*	20A	Mitochondrial complex III electron transport inhibitors (Coupling site II)	Hydramethylnon	Hydramethylnon
21*	21B	Mitochondrial complex I electron transport inhibitors	Rotenone	Rotenone
22*	22A	Voltage-dependent sodium channel blockers	Indoxacarb	Indoxacarb
23		Inhibitors of acetyl CoA carboxylase	Tetronic and tetramic acid derivatives	Spirotetramat
24*	24A	Mitochondrial complex IV electron transport inhibitors	Phosphine	Aluminum phosphide
				Phosphine
				Zinc phosphide
UN		Compounds of unknown or uncertain mode of action[@]	Azadirachtin	Azadirachtin
			Bifenazate	Bifenazate
			Cryolite	Cryolite
			Dicofol	Dicofol

* 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.