

CLASSIFICATION OF INSECTICIDES AND ACARICIDES FOR RESISTANCE MANAGEMENT

*A. M. SHELTON, W. T. WILSEY, AND D. M.
SODERLUND*

*Department of Entomology
New York State Agricultural Experiment Station
Geneva, NY 14456
315-787-2352*

September 2001

IMPORTANT INFORMATION

Please Read

.....

Not all products listed in this booklet are registered in New York. To verify a product is registered in New York, check Cornell's Pesticide Management Education Program at
<http://pmep.cce.cornell.edu/regulation/index.html>

Important Information

Classification of Insecticides and Acaricides by Their Target Sites and Modes of Action: A Resource for Resistance Management Strategies

This book provides information on the common and trade names of the most frequently used insecticides and acaricides, including their mode of action, chemical group, pattern of cross-resistance, and mammalian toxicity. This information is gleaned from several sources, but the primary format was obtained from an EPA document on a strategy to develop a pesticide resistance management program under NAFTA (North American Free Trade Agreement). We recommend this book be supplemented with the following publication: Agricultural Chemicals: Book I-Insecticides, 2001 Edition. Thompson Publications, Fresno, CA 270PP

The information contained in these tables does not include information on whether the product can be legally applied in your state on a particular crop. Applicators are advised to check registrations before applying any insecticide and to follow the label. The information contained in these tables is not a substitute for the pesticide label.

Why have this book? Even experienced entomologists and farmers often have difficulty in finding concise information on the mode of action of insecticides and acaracides used in agriculture, but this information is important in resistance management. This is especially relevant now that several new types of insecticides that have unique modes of action are entering the market. It is important to know the mode of action of an insecticide to implement a resistance management program.

Besides knowing the chemical class of an insecticide and its mode of action, other factors are at least as important for developing sound resistance management strategies. The proportion of a population that is exposed to a selection agent is among the most important factors influencing the evolution of resistance, and resistance evolves more quickly where a high proportion of the population is exposed each generation. Resistance will evolve faster with dominant alleles (i.e., where the heterozygous carriers of one resistance allele and one susceptible allele survive). The 'fitness costs' to resistance do not seem to have a significant effect on slowing resistance unless the costs are large and affect heterozygotes, which seems generally not to be the case.

The following guidelines are recommended to delay the onset of resistance.

1. Integrate chemical control with effective cultural and biological control practices.
2. Treat only when needed as determined by sampling the field and using a threshold.

3. Time the application against the most susceptible life stage of the insect.
4. Use an insecticide at its recommended rate and with good application practices.
5. Do not rely on a single insecticide class.
6. When there is more than one generation of an insect, it is better to use one insecticide class against a generation (this is called the a 'rotation' strategy) than to use two or more insecticide classes against the same generation. This means avoid mixtures of insecticides which are targeted against the same pest because this will lead to more rapid resistance development to each insecticide, compared to using the insecticides in a rotation.
7. Rotate the use of an insecticide over an entire area rather than use a 'mosaic' in which one insecticide is applied to one part of the field and another is applied to a different part of the field.
8. Apply the insecticide only to areas of the field that need it. This will help create refuges for susceptible insects and delay the overall development of resistance.
9. Avoid persistent formulations. Users want enough persistence to control the pest, but excessive persistence can continue to select for resistance long after the pest has been suppressed below damaging numbers.
10. In the event of a control failure, first check the method of applying the insecticide. If good application practices were performed and resistance appears to be present, do not re-treat with the same class of insecticide. Contact your Cooperative Extension Service or consulting service to help determine whether you have a resistant population.

Listed below are explanations of the terms used in this booklet.

Group. Groups with different numbers mean that they have different sites of action and are not likely to be cross resistant. In some cases the number may be followed by different letters, meaning they have the same target site but may not have developed significant cross resistance. When only this group of products is available, alternation of compounds from subgroup A and subgroup B are recommended.

If an insect has become resistant to an insecticide it is common that such resistance is due to a change at the target site inside the insect. Once such a change at the target site has occurred, it is unlikely that even higher doses of the insecticide will kill the insect. What is needed is an insecticide that attacks a different target site altogether. For example, an insect could be resistant to malathion because the target site is no longer sensitive to an acetylcholinesterase inhibitor but it should still be sensitive to endosulfan which blocks GABA receptors.

Apply the following strategy to use this column properly. If you have used an insecticide which is labeled for a particular insect **and have applied it properly with good coverage and under favorable environmental conditions**, but find that it fails to control the insect, you may have a resistant strain of the insect. First, alert your local extension personnel and the person who sold the material. Next, locate the insecticide within the table and see what is listed.

ed in the column entitled, "Group". Check other registered insecticides against the target pest on the particular crop to determine what other insecticides you might be able to use legally. **If the insecticide that failed to control the pest has a different "group number" than one of the other insecticides that are registered for that pest on the crop, then you can use the second insecticide with some assurance that the insect will be susceptible to it.** If the second insecticide has a different "group number" and still fails to control the insect, then your problems may be more severe and you should again contact your local extension personnel and the person who sold the material.

Mode of action. There are many ways in which an insecticide can kill an insect (e.g. nerve poison). However, within these broad categories there may be several methods. For example, one insecticide may be a nerve poison because it is an acetylcholinesterase inhibitor while another insecticide may be a nerve poison because it blocks GABA receptors. Thus, even though these insecticides are both nerve poisons, they have different modes of action. The mode of action will largely determine whether there is cross resistance between chemicals.

Chemical Group. Insecticides which share a common chemical heritage will also have the same target site in an insect and these are placed in a chemical group to show their similarities. Organophosphate, carbamate and pyrethroid are common chemical groups of insecticides with many members in each group. Some of the newer insecticides may only have a single insecticide in a group. For example, spinosad (common name) is the only common insecticide in its class.

Active Ingredient/Common name. This is the name of the active ingredient of the insecticide. Different companies may have different products with the same active ingredient.

Toxicity. This rating is taken from EPA which rates chemicals based on their acute oral values (LD50) to mammals. Classification of I= highly toxic with a LD50 value of 0-50 and a required label of DANGER with a skull and crossbones label; II= moderately toxic with a LD50 value of 50-500 and a required label of WARNING; III= slightly toxic with a LD50 value of 500-5000 and a required label of CAUTION; IV= relatively non-toxic with a LD50 value >5000 and a required label of CAUTION. The effects of these products on other non-target organisms such as parasites and predators generally follows the same classification.

Trade Name. This is the name that a company will list as its product. For example, one company markets a product called Ambush and another company markets a product called Pounce, but both have the same active ingredient, permethrin.

N.B. This guide is not a complete list of all active ingredients/common names or trade names, and the authors are not responsible for the information contained herein. If there are errors, please contact the authors.

Acknowledgements: The authors thank and the members of the Department of Entomology at Cornell's NYSAES and the CCE educators for their helpful input. We also thank Donna Boyce, Beth Ditzell and the staff at Communication Services at NYSAES for their help in publishing this book.

Insecticides/Acaricides Common Names and Groups

*Common Names and
Groups*

Insecticides/Acaricides Common Names and Groups

abamectin-6	<i>Beauveria bassiana</i> -22	Cry1C from <i>Bacillus</i>	endosulfan-2A
acephate-1B	bendiocarb-1A	<i>thuringiensis</i> var. <i>aizawai</i> -11	esfenvalerate-3A
aldicarb-1A	bensultap-4	Cry1F-11	ethion-1B
alpha-cypermethrin-3A	bifenazate-28	cryolite-9B	ethoprop-1B
aluminum phosphide-8B	bifenthrin-3A	cyfluthrin-3A	ethylene dibromide-8C
amitraz-19	buprofezin-16	cyhexatin-12	fenamiphos-1B
<i>Anagrypha falcifera</i> NPV-24	cadusafos-1B	cypermethrin-3A	fenbutatin oxide-12
azadirachtin-18	carbaryl-1A	cyromazine-17	fenitrothion-1B
azamethiphos-1B	carbofuran-1A	deltamethrin-3A	fenoxy carb-7
azinphosmethyl-1B	cartap-4	demeton-1B	fenpropathrin-3A
<i>Bacillus popilliae</i> -11	chlordane-4	diafenthuron-20	fensulfothion-1B
<i>Bacillus sphaericus</i> -11	chlorethoxyfos-1B	diazinon-1B	fenthion-1B
<i>Bacillus thuringiensis</i> var. <i>aizawai</i> -11	chlorfenapyr-13	dichlorvos-1B	fenvalerate-3A
<i>Bacillus thuringiensis</i> var. <i>israelensis</i> -11	chlorfenvinphos-1B	dicofol-27	fipronil-2B
<i>Bacillus thuringiensis</i> var. <i>kurstaki</i> -11	chlorpyrifos-1B	dicrotophos-1B	flucythrinate-3A
<i>Bacillus thuringiensis</i> var. <i>tenebrionis</i> -11	clofentezine-10	diflubenzuron-15	fluvalinate-3A
	coumaphos-1B	dimethoate-1B	fonofos-1B
	Cry1Ac from <i>Bacillus</i>	dioxathion-1B	formetanate
	<i>thuringiensis</i> var. <i>kurstaki</i> -11	disulfoton-1B	hydrochloride-1A
	Cry1Ac + Cry1C-11	emamectin benzoate-6	<i>Helicoverpa zea</i> NPV-24

hexakis-12	methyl bromide-8A	pymetrozine-9A	<i>Steinernema riobravis</i> -23
hydramethylnon-20	methyl parathion-1B	pyrazophos-1B	sulfotepp-1B
hydroprene-7	naled-1B	pyrethrins-3A	tebufenozide-18
imidacloprid-4	nicotine-4	pyridaben-21	tebupirimphos- 1B
indoxacarb-26	oil-25	pyriproxyfen-7	tefluthrin-3A
lambda-cyhalothrin-3A	oxamyl-1A	resmethrin-3A	temephos-1B
kinoprene-7	oxydemetonmethyl-1B	rotenone-21	tepp-1B
lindane-2	<i>Paecilomyces fumosoroscus</i> -22	ryania-29	terbufos-1B
malathion-1B	parathion-1B	soap-25	tetrachlorvinphos-1B
Metarhizium anisopliae-22	permethrin-3A	sodium aluminum fluoride-9B	tetramethrin-3A
methamidophos-1B	phorate-1B	spinosad-5	thiamethoxam-4
methidathion-1B	phosalone-1B	spinosyns A-5	thiocloprid-4
methiocarb-1A	phosmet-1B	spinosyns D-5	thiodicarb-1A
methomyl-1A	pirimicarb-1A	<i>Spodoptera exigua</i> NPV-24	tralomethrin-3A
methoprene-7	profenofos-1B	<i>Steinernema carpocapsae</i> -23	trichlorfon-1B
methoxychlor-3B	propargite-14	<i>Steinernema feltiae</i> -23	trimethacarb-1A
methoxyfenozide-18	propoxur-1A	<i>Steinernema glaseri</i> -23	zeta-cypermethrin-3A

Insecticides/Acaricides Trade Names

Trade Names

Insecticides/Acaricides-Trade Names and Groups

Abate-1B	Amdro-20	Bactimos-11	BioBlast-22	Chimigor 40-1B
Accothion-1B	Ammo-3A	Bactospeine-11	BioVector 25-23	Chrevron RE 12420-1B
Accolade-16	<i>Anagrapha falcifera</i>	Basudin-1B	BioVector 355-23	Citation-17
ACJ217,300-20	NPV-24	Bay 17147-1B	Birlane-1B	Chlordane-2A
Actara-4	Apache-1B	Bay 21-1B	Black Leaf 40-4	Clinch-6
Adage-4	Apavap-1B	Bay 29493-1B	Bladaform-1B	Co-Ral-1B
Address-1B	Apex-7	Bay 41831-1B	Blattanex-1A	Comite-14
Adept-15	Applaud-16	Bay 70143-1A	Bolfo-1A	Concord-3A
Admire-4	Apollo-10	Bay 9010-1A	Botanigard-22	Condor-11
Affirm-6	Aquit-3A	Bay 9010-1A	Brigade-3A	Confirm-18
Agree-11	Armor-17	Bay S276-1B	Brodan-1B	Conserve-5
Agri-Mek-6	Arprocarb-1A	Baycid-1B	Butamin-3A	CoStar-11
Agridip-1B	Asana-3A	Bayer 39007-1A	Caladan-4	Cotnion-methyl-1B
Agrothion-1B	Asataf-1B	Baygon-1A	Calypso-4	Counter-1B
Aimthane-1B	Astro-3A	Baymix-1B	Capture-3A	Crymax-11
Alert-13	Asunthol-1B	Baytex-1B	Carbamine-1A	Cryolite-9B
Align-18	Attain-3A	Baythroid-3A	Carbicron-1B	Curacron -1B
Alfacron-1B	Avid-6	Benfos-1B	Carfene-1B	Curaterr-1A
Altosid-7	Avaunt-26	Bidrin-1B	Carzol-1A	Cutlass-11
Aluminum phosphide- 8B	Aza-direct-18	Bifex-1A	Cekusan-1B	Cybolt-3A
Ambush-3A	Azatin-18	Biflex-3A	Cekuthoate-1B	Cyfen-1B
	Aztec-1B	Biobit-11	Celthion-1B	Cygon-1B

Cymbush-3A	Diacon-7	Dithiosystox-1B	Ethylene dibromide-8C	Garvox-1A
Cypona-1B	Diapadrin-1B	DMTP-1B	Exathion-1B	Gaucho-4
Cytel-1B	Dibrom-1B	Doom-11	Farimos-11	Gemstar-24
Cythion-1B	Dicarbam-1A	Dowco 179-1B	Fensta-1B	Gentrol-7
D1221-1A	Dicofen-1B	DPX 1410-1A	Ferkethion-1B	Gnatrol-11
Dalf-1B	Dicofol-27	Duo-Kill-1B	Ficam-1A	Gusathion-1B
Danitol-3A	Dicron-1B	DuraPlex-1b/3A	Filitox-1B	Gusathion-M-1B
Daphene-1B	Didivane-1B	Duravos-1B	Fighter- 1B	Guthion-1B
Dasanit-1B	Dielathion-1B	Dursban-1B	Floramite-28	Helix-4
DDVP-1B	Difonate-1B	Dy-fonate-1B	Fly-Die-1B	Herkol-1B
De-Fend-1B	Dilice-1B	Dycarb-1A	Folithion-1B	Hexavin-1A
Decis-3A	Dimate 267-1B	Dylox-1B	Foray-11	Imidan-1B
Decathlon-3A	Dimet-1B	Dyphonate-1B	Force-3A	Intrepid-18
Declare-1B	Dimethoat Tech 95%-1B	Ecothrin-3A	Fortress-1B	Invisigard-1A
Delfin-11	Dimethopgen-1B	Ektafos-1B	Fostion MM-1B	Isotox-2A
Delnav-1B	Dimilin-15	EI 4049-1B	Frontline-2B	Javelin-11
Deliver-11	DiPel-11	Elastrel-1B	Frumin AL-1B	K-Obiol-3A
Demos NF-1B	Dipterex-1B	Emmaton-1B	Fulfill-9A	Kabat-7
Denapon-1A	Distance-7	Enstar-7	Furacarb-1A	Kaleit-1B
Derriban-1B	Disyston-1B	ENT 27164-1A	Furadan-1A	Karate-3A
Derribante Devikol-1B	Disystox-1B	Entex-1B	Fury-3A	Karbaspray-1A
Detmol UA-1B	Dithiodemeton-1B	Eradex-1B	Fyfanon-1B	Karbofos-1B
Devigon-1B	Dithione-1B	Esteem-7	Gamba-20	Kelthane-27
Devour-23		Ethion-1B	Gardona-1B	Ketch-11

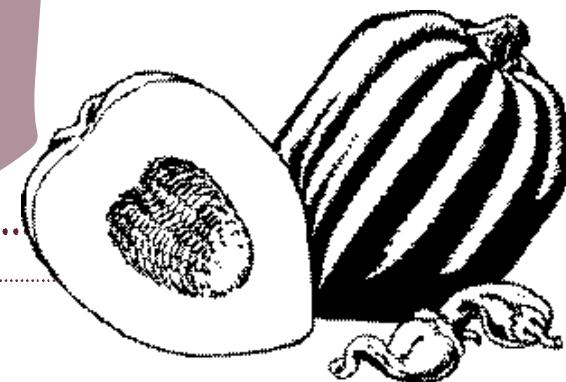
Kilmite-1B	Mavrik-3A	Mustang-3A	Orthene-1B	Plantfume-1B
Kitron-1B	Maxforce-20	MVP-11	Ortho-1B	Platinum-4
Knox Out-1B	Meldane-1B	Mycotrol-22	Ortran-1B	Plictran-12
Kryocide-9B	Mep-1B	Nac-1A	Ortril-1B	Polo-20
Lannate-1A	Mercaptophos-1B	Naturalis-22	Ovasyn-19	Pounce-3A
Lanox-1A	Mesurol-1A	Neemactin-18	Oxamimidic Acid-1A	Precision-7
Larvadex-17	Metasystox-R-1B	Neemix-18	Oxamyl-1A	Preclude-7
Larvin-1A	Metathion-1B	Negashunt-1B	Padan-4	Precor-7
Lebaycid-1B	Methavin-1A	Nemacur-1B	Par F 70-25	Prentox Fenthion-1B
Lepinox-11	Methyl bromide-8A	Nemasys-23	Parathion-1B	Prentox-1B
Logic-7	Methyl-guthion-1B	Nexter-21	Patap-4	Prince-2B
Lorsban-1B	Micromite-15	Nicotine-4	Patrole-1B	Proclaim-6
M-C-11	Micromite-1B	Niomil-1A	PayOff-3A	Prodigy-18
M-Pede-25	Millenium-23	Nitofol-1B	Pegasus-20	Prokil-9B
M-Press-11	Mimic-18	No-Pest-1B	Penncap-M-1B	Prolate-1B
Magnet-23	Minex-7	Novathion-1B	Perfekthion-1B	Propogon-1A
Malathion-1B	Missle-1B	Novodor-11	Pestroy-1B	Propyon-1A
Malice-4	Mitac-19	Nudrin-1A	Pfr-97-22	Provado-4
Margosan-18	Mocap-1B	Nuratron-1B	Pharorid-7	Pydrin-3A
Marathon-4	Monitor-1B	Nuvanol-1B	Phaser-2A	Pyramite-21
Marlate-3B	Multamat-1A	Omite-14	Phorate-1B	Pyrellin-3A
Marvex-1B	Multimet-1A	Ornatin-18	Pillarthene-1B	Pyrenone-3A
Matador-3A	Mundial-2B	Orchex 796-25	Piridane-1B	Pyretherm-3A
Mattch-11	Muscatox-1B	Organigard-22	Pirimor-1A	Queletox, S 1752-1B

Rabon-1B	Seedox-1A	Stryker-3A	Tendex-1A	Union Carbide 7744-1A
Ravyon-1A	Sendra-1A	Success-5	Tercyl-1A	Vaponna-1B
Regent-2B	Sendran-1A	Sumanone-1B	Thiamethoxam-4	Vaponite-1B
Resistox-1B	Septene-1A	Sumithion-1B	Thimet-1B	Vectolex-11
Rhoden-1A	Sevigor-1B	Suncide-1A	Thiocloprid-4	Vendex-12
Rogodan-1A	Sevin-1A	SunSpray Ultra Fine	Thiodan-2A	Verdican-1B
Rogodial-1B	Snip-1B	Spray Oil-25	Thiotep-1B	Verdipor-1B
Rogor-1B	Solvirex-1B	Suntol-1B	Thioxamyl-1A	Vetaron-1B
Rotacide-21	Somonic-1B	Supone-1B	Tiguvon-1B	Verdisol-1B
Rotanox-21	Somonil-1B	Supracide-1B	Topicide-3A	Verthion-1B
Rotate-1A	Spectracide-1B	Suprathion-1B	Tracer-5	Volck Supreme-25
Roxion-1B	SpinTor-5	Swipe-1B	Triact-18	Vydate-1A
Ruban-4	Spod-XLC-24	Synthrin-3A	Tricarnam-1A	Warrior-3A
Rugby 1B	Spotton-1B	Systox-1B	Trigard-17	X-Gnat-23
Ryanex-29	Spur-3A	Talodex-1B	Trilogy-18	XenTari-11
Ryanicide-29	SRA 5172-1B	Talstar-3A	Trimetion-1B	Yaltox-1A
Safer-25	Stauffer N 2790-1B	Tam-1B	Turcam-1A	Zephyr-6
Safer BioNeem-18	Steinernema glaseri-23	Tamanox-1B	Turex-11	Zolone-1B
Sanmite-21	Steinernema feltiae-23	Tamaron-1B	Ultracide-1B	ZR-515-7
Savey-10	Steward-26	Tame-3A	Umbethion-1B	
Scanmask-23	Stipend-1B	Teknar-11	UNDEN-1A	
Scout-3A	Stop-3A	Temik-1A	Undene-1A	

Notes in Tables

- 1 Group is based on site of action according to the following document but with some modifications by the authors: EPA 2000. Draft guidance for pesticide registrants on voluntary pesticide resistance management labelling based on mode/target site of action on the pest. Fed. Reg. 65: 30115- 30117 (EPA pp-00646, FRL-6496-8).
The classification scheme is based on target site mode of action. It is recognized that resistance of insects and mites to insecticides and acaricides can also result from enhanced metabolism, or reduced penetration. If a group number is followed by a different letter (e.g. 1A and 1B) then there is some difference in the target site mode of action, but not enough to warrant a separate number.
- 2 Toxicity ratings for mammals
I - Highly toxic with oral LD50 values 0-50 mg/kg
II - Moderately toxic with oral LD50 values 50-500 mg/kg
III - Slightly toxic with oral LD50 values 500-5000 mg/kg
IV - Relatively non-toxic with oral LD50 values more than 5000 mg/kg
Source: Agricultural Chemicals: Book I Insecticides, 2001 Edition. Thompson Publications, Fresno, CA. 270pp
- 3 Sources: <http://pmep.cce.cornell.edu/profiles/>
<http://www.agrobiologicals.com/glossary/G2402.htm>
Agricultural Chemicals: Book I Insecticides, 2001 Edition. Thompson Publications, Fresno, CA. 270pp
Other sources of useful information are Insecticide Resistance Action Committee, <http://Plantprotection.org/irac/>
Compendium of Pesticide Common Names, <http://www.hclrss.demon.co.uk/>

1A

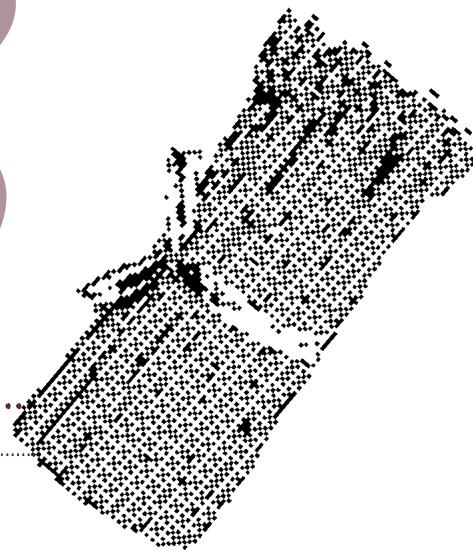


Carbamates

1A

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
1A	Acetylcholinesterase inhibitors Inhibition of the enzyme Acetylcholinesterase, interrupting the transmission of nerve impulses.	Carbamates	aldicarb bendiocarb carbaryl carbofuran formetanate hydrochloride methiocarb methomyl oxamyl pirimicarb propoxur thiodicarb trimethacarb	I I III I I I I II II —	Temik Closure, Ficam, Dycarb, Garvox, Multamat, Multimet, Niomil, Rotate, Seedox, Turcam Carbamine, Denapon, Dicarbam, Hexavin, Karbaspray, Nac, Rayvon, Septene, Sevin, Tercyl, Tricarnam, Union Carbide 7744 Bay 70143, Curaterr, D 1221, ENT 27164, Furacarb, Furadan, Yaltox Carzol Mesurol Lannate, Lanox, Methavin, Nudrin DPX 1410, Oxamimidic Acid, Oxamyl, Thioxamyl, Vydate Pirimor Arprocarb, Bayer 39007, Bay 9010, Baygon, Bifex, Blattanex, Bolfo, Invisigard, Propogon, Propyon, Rhoden, Sendra, Sendran, Suncide, Tendex, UNDEN, Undene. Larvin Broot

18



Organophosphates

1B

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
1B	Acetylcholinesterase inhibitors Inhibition of the enzyme Acetylcholinesterase, interrupting the transmission of nerve impulses.	Organophosphates	acephate azamethiphos azinphosmethyl cadusafos chlorethoxyfos chlorfenvinphos chlorpyrifos coumaphos demeton	III III I I I I II I I	Address, Aimthane, Asataf, Chrevon RE 12420, Kitron, Ortran, Orthene, Ortho, Ortril, Pillathene Alfacron, Snip Bay 17147, Carfene, Cotnion-methyl, Guthion, Gusathion, Gusathion-M, Methyl-Guthion Apache, Rugby Fortress Birlane, Supone Brodan, Detmol UA, Dowco 179, DuraGuard, DuraPlex (includes cyfluthrin), Dursban, Eradex, Lorsban, Piridane, Stipend Agridip, Asunthol, Bay 21, Baymix, Co-Ral, Dilice, Meldane, Muscatox, Negashunt, Resistox, Suntol, Umbethion Systox

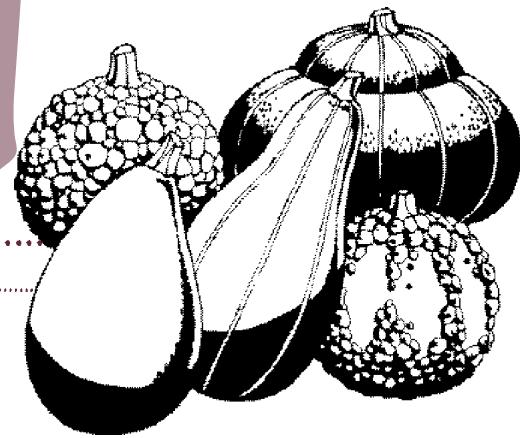
GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
1B			diazinon dichlorvos dicrotophos demethoate dioxathion	III I I II —	Basudin, Knox-Out and Spectracide. Diazinon may be found in formulations with a variety of other pesticides such as pyrethrins, lindane, disulfoton. Apavap, Benfos, Cekusan, Cypona, DDVP, Derriban, Derribante Devikol, Didivane, Duo-Kill, Duravos, Elastrel, Fly-Die, Fly-Fighter, Herkol, Marvex, No-Pest, Prentox, Vaponna, Vaponite, Verdican, Verdiport, Verdisol Bidrin, Carbicron, Diapadrin, Dicron, Ektafos Cekuthoate, Chrimigor 40, Cygon 400, Daphene, De-Fend, Demos NF, Devigon, Dimate 267, Dimet, Dimethoat Tech 95%, Dimethopgen, Ferkethion, Fostion MM, Perfekthion, Rogodan, Rogodial, Rogor, Roxion, Sevigor, Trimeton. Delnav

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
1B			disulfoton ethion ethoprop fenamiphos fenitrothion fensulfothion fenthion fonofos	I I II I II — II I	Bay S276, Disyston, Disystox, Dithiodemeton, Dithiosystox, Frumin AL, Solvirex Ethion Mocap Nemacur Accothion, Agrothion, Bay 41831, Cyfen, Cytel, Dicofen, Fenstan, Folithion, Kaleit, Mep, Metathion, Micromite, Novathion, Nuvanol, Pestroy, Sumanone, Sumithion, Verthion Dasanit Bay 29493, Baycid, Baytex, Dalf, DMTP, Entex, Lebaycid, Mercaptophos, Prentox Fenthion, Prentox Fenthion, Queletox, S 1752, Spotton, Talodex, Tiguon. Difonate, Dy-fonate, Dyphonate, Stauffer N 2790

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
1B			malathion methamidophos methidathion methyl parathion naled oxydemetonmethyl parathion phorate phosalone phosmet profenofos pyrazophos	III I I I II II I I II II —	Celthion, Cythion, Dielathion El 4049, Emmaton, Exathion, Fyfanon, Karbofos, Malathion Filitox, Monitor, Nitofol, Nuratron, Patrole, SRA 5172, Swipe, 7Tam, Tamanox, Tamaron, Vетарон Semonic, Somonil, Supracide, Supratheion, Ultracide Declare, Penncap-M Dibrom Metasystox-R Parathion Phorate, Thimet Zolone Imidan, Prolate Curacron Missle, Pyrazofos

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
1B			sulfotepp tebupirimphos temephos TEPP terbufos tetrachloryinphos trichlorfon	— I III — I III II	Bladaform, Dithione, Thiotep, Plantfume Aztec Abate Kilmite Counter Rabon, Gardona Dipterex, Dylox

2A

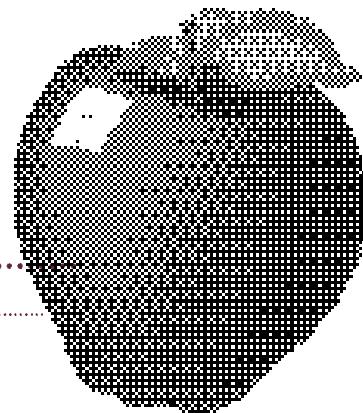


**Chlorinated Cyclodienes and
Polychlorocycloalkanes**

2A

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
2A	GABA-gated chloride channel antagonists Interferes with GABA neurons, leading to receptors of insect repetitive nervous discharges	Chlorinated Cyclodienes and Polychloro-cycloalkanes	chlordanne endosulfan lindane	— II II	Chlordane Phaser, Thiodan Isotox

28

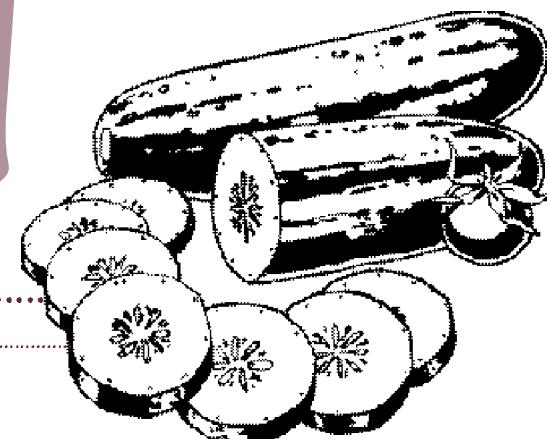


Phenylpyrazoles

2B

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
2B	GABA-gated chloride channel antagonists Interferes with GABA receptors of insect neurons, leading to repetitive nervous discharges - fiprole site	phenylpyrazoles	fipronil	II	Frontline, Mundial, Prince, Regent

3A

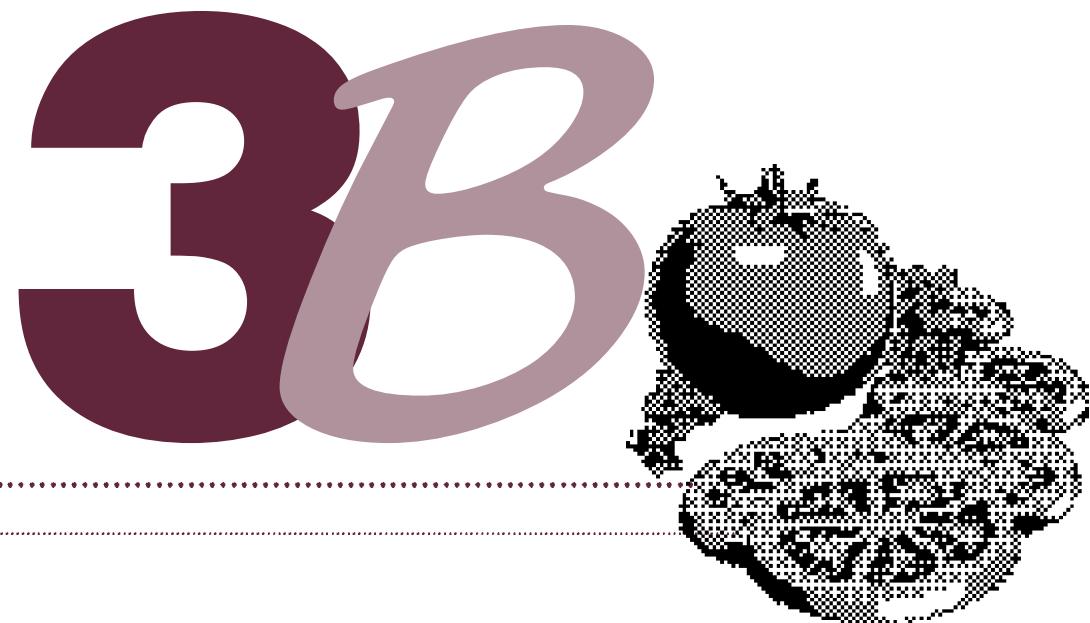


Pyrethroids
and
Pyrethrum

3A

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
3A	Sodium channel modulators Acts as an axonic poison by interfering with the sodium channels of both the peripheral and central nervous system stimulating repetitive nervous discharges, leading to paralysis.	Pyrethroids and Pyrethrum	bifenthrin cyfluthrin cypermethrin alpha-cypermethrin zeta-cypermethrin deltamethrin esfenvalerate fenpropathrin fenvalerate flucythrinate fluvalinate lambda-cyhalothrin	II III II II II II II II II II II	Attain, Biflex, Brigade, Capture, Talstar Baythroid, Decathlon, Dura Plex (includes Chlorpyrifos) Ammo, Cymbush Aquit, Concord Fury, Mustang Decis, K-Obiol Asana Danitol, Tame Pydrin Cybolt, PayOff Mavrik, Spur Karate, Matador, Topicide, Warrior

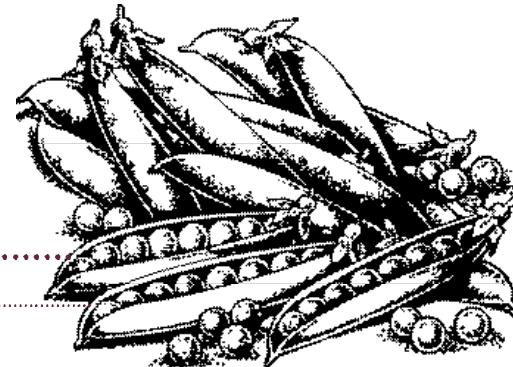
GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
3A			permethrin pyrethrins resmethrin tefluthrin tetramethrin tralomethrin	II III III I III II	Ambush, Astro, Pounce Pyrenone, Pyrethrum (also combined with Rotenone and called Pyrellin). Pyretherm, Synthrin Force Butamin, Ecothrin Scout, Stryker



3B

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
3B	Sodium channel modulators Acts as an axonic poison by interfering with the sodium channels of both the peripheral and central nervous system stimulating repetitive nervous discharges, leading to paralysis.	DDT analogues	methoxychlor	IV	Marlate

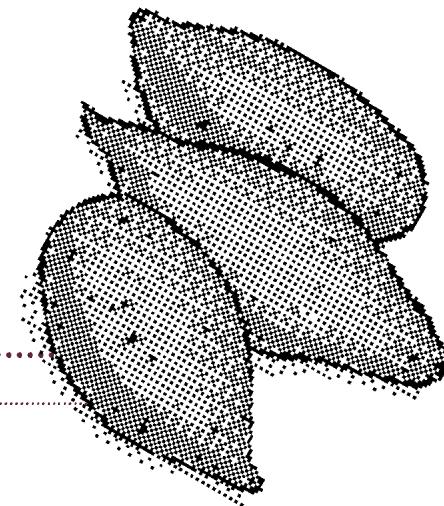
4



**Neonicotinoids
and Nicotine**

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
4	Acetylcholine receptor agonists Binds to nicotinic acetylcholine receptor, disrupting nerve transmission	Neonicotinoid Nicotine	imidacloprid thiocloprid thiamethoxam nicotine cartap bensultap	II III II II II	Admire, Gaucho, Provado, Marathon Calypso Actara, Adage, Helix, Platinum Black Leaf 40, Nicotine Caladan, Padan, Patap Malice, Ruban

5

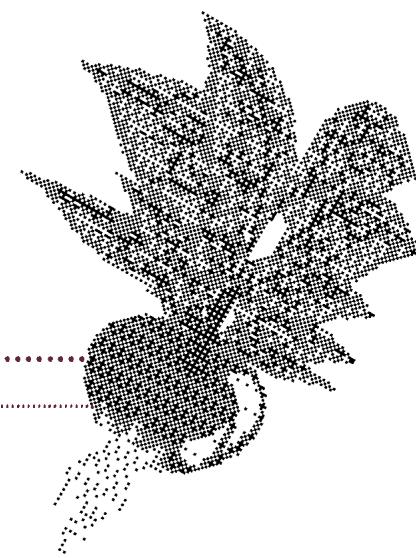


Spinosyns

5

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
5	Acetylcholine receptor modulators Alters acetylcholine receptor site and disrupts binding	Spinosyns	spinosyns A + spinosyns D spinosad	III	Conserve, SpinTor, Success, Tracer

6



Avermrctin

6

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
6	Glutamate-gated chloride channel agonist Causes paralysis by increasing chloride permeability of nerve and muscle cells.	Avermectin	abamectin emamectin benzoate	I II	Affirm, Agri-Mek, Avid, Clinch, Zephyr Proclaim

7



Juvenile hormones

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
7	Juvenile hormone analogues (Insect growth regulators) Mimics juvenile hormones which prevent moulting from the larval to the adult stage.	Juvenile hormone	eyprixyfen fenoxy carb hydro prene methoprene kinoprene	IV IV III IV	Distance, Esteem, Knack Logic, Precision Gentrol Altosid, Apex, Diacon, Dianex, Kabat, Minex, Pharorid, Precor, ZR-515 Enstar

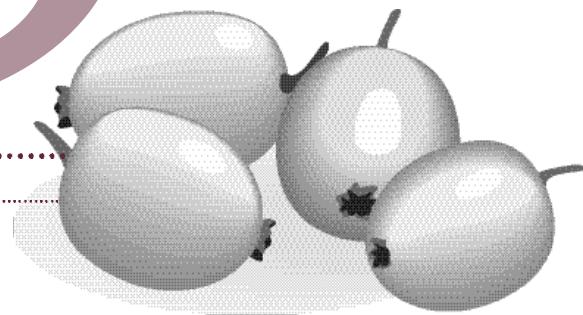


Fumigant

8A

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
8A	Unknown or non-specific mode of action	Fumigant	methyl bromide	IV	Methyl bromide

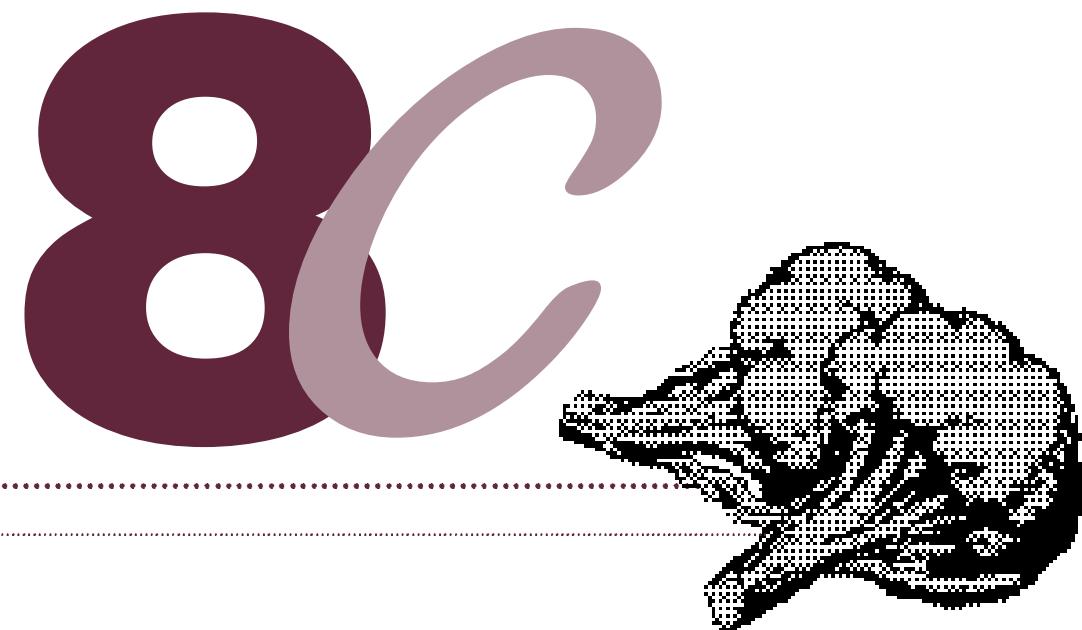
88



Fumigant

8B

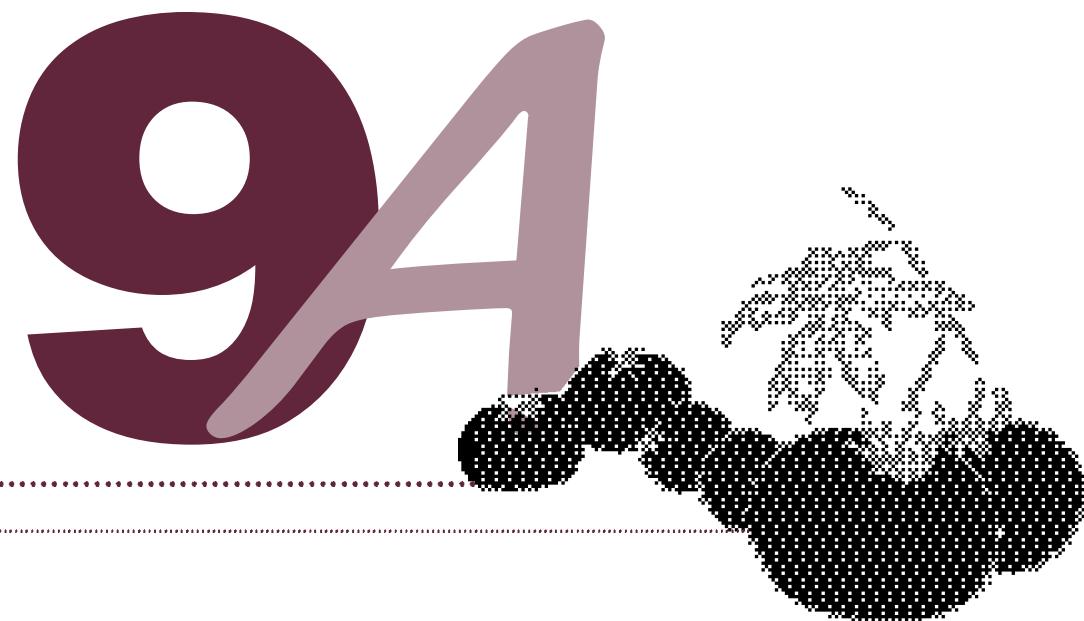
GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
8B	Unknown or non-specific mode of action	Fumigant	aluminum phosphide	—	Aluminum phosphide



Fumigant

8C

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
8C	Unknown or non-specific mode of action	Fumigant	ethylene dibromide	—	Ethylene Dibromide

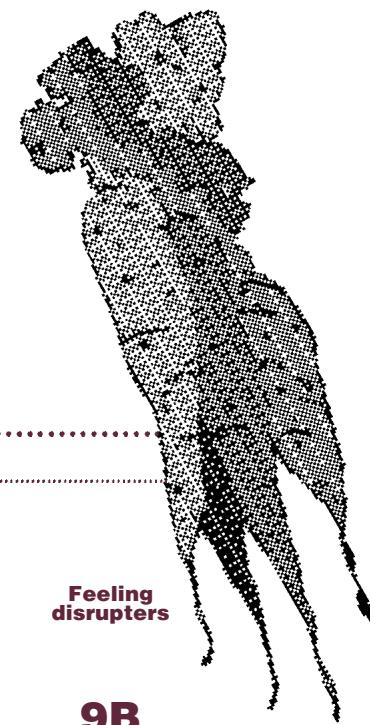


Feeling
disrupters

9A

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
9A	Compounds of unknown or non specific mode of action (feeding disrupters)	Feeding disrupters	pymetrozine	IV	Fulfill

98



Feeling
disrupters

9B

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
9B	Compounds of unknown or non specific mode of action (feeding disrupters)	Feeding disrupters	cryolite, sodium aluminum fluoride	IV	Cryolite, Kryocide, Prokil

10

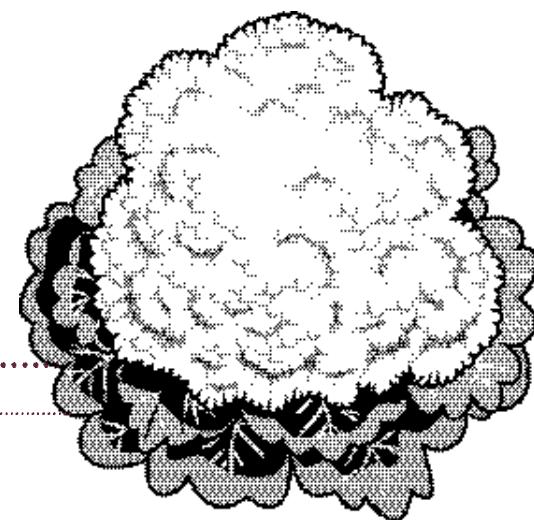


Mite growth
inhibitors

10

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
10	Compounds of unknown or non-specific mode of action	Mite growth inhibitors (Ovicide)	clofentezine	IV	Apollo
			hexythiazox	IV	Savey

11



Bt Microbials

11

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
11	<p>Microbial disruptors of insect midgut membranes Organism has protein inclusions that are released in the gut of the target pest resulting in gut paralysis and cessation of feeding.</p> <p>N.B. Different Bts may contain different cry proteins which may have different target sites. Thus, if an insect is resistant to one of there Bts it may or may not be resistant to another Bt, although they are in the same "Group". However, all the Bts have a different mode of action compared to other "Groups"</p>	Bt Microbials	<i>Bacillus popilliae</i> <i>Bacillus thuringiensis</i> var. <i>aizawai</i> Cry1C from <i>Bacillus thuringiensis</i> var. <i>aizawai</i> <i>Bacillus thuringiensis</i> var. <i>tenebrionis</i> <i>Bacillus sphaericus</i> <i>Bacillus thuringiensis</i> var. <i>israelensis</i> <i>Bacillus thuringiensis</i> var. <i>kurstaki</i> Cry1Ac from <i>Bacillus thuringiensis</i> var. <i>kurstaki</i> Cry1Ac + Cry1C Cry1F	IV IV IV IV IV IV IV IV I IV IV	Doom Agree, Ketch, Turex, XenTari M-C Novodor Farimos, Vectolex Bactimos, Gnatriol, Teknar Bactospeine, Biobit, Condor, CoStar, Crymax, Cutlass, Delfin, DiPel, Foray, Javelin, Lepinox, Thuricide Deliver, MVP Mattch M-Press

12

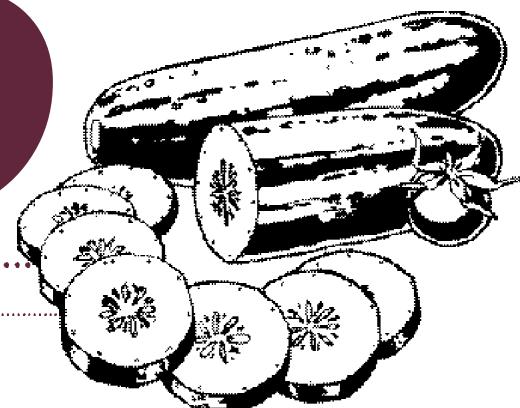


Organotin
miticides

12

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
12	Inhibition of oxidative phosphorylation (disrupts ATP formation) Inhibition of oxidative phosphorylation at the site of dinitrophenol uncoupling, disrupts formation of ATP	Organotin miticides	fenbutatin oxide/hexakis cyhexatin	III III	Vendex Plictran

13



Pyrrole
compounds

13

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
13	Uncoupler of oxidative phosphorylation (disrupts proton gradient formation)	Pyrrole compound (broad spectrum contact poison)	chlorfenapyr	II	Alert

14

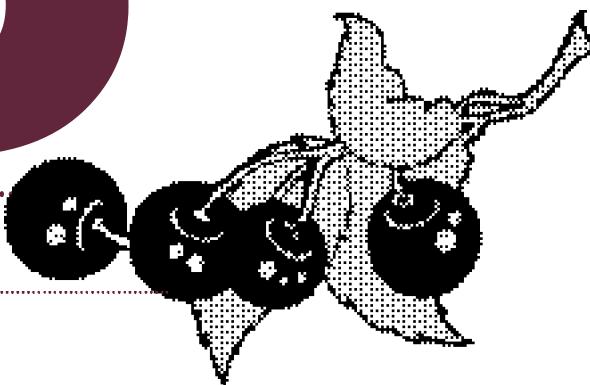


Sulfite ester
miticides

14

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
14	Unknown mode of action	Sulfite ester miticides	propargite	III	Comite, Omite

15

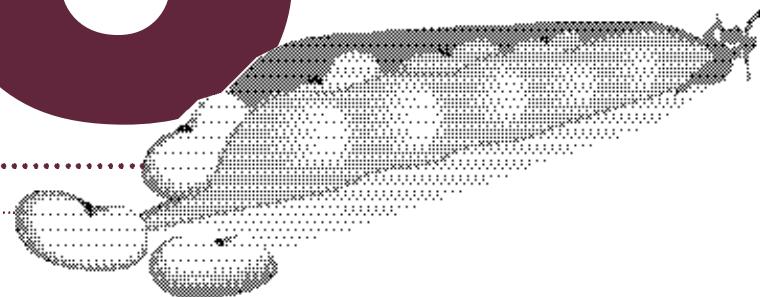


Substituted
benzoylurea

15

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
15	Inhibits chitin biosynthesis	Substituted benzoylurea	diflubenzuron	III	Adept, Dimilin, Micromite

16



Thiadizine

16

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
16	Inhibits chitin biosynthesis type 1 - Homopteran	Thiadizine	buprofezin	III	Accolade, Applaud

17



Triazine

17

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
17	Inhibits chitin biosynthesis type 2 -Dipteran	Triazine	cyromazine	III	Armor, Citation, Trigard, Larvadex

18



Diacylhydrazine and
Botanicals

18

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
18	Ecdysone agonist/disruptor. Disrupts insect molting by antagonizing the insect	Diacylhydrazine Botanical (Neem oil or azadirachtin)	tebufenozide methoxyfenozide azadirachtin	I IV IV	Confirm, Mimic Intrepid, Prodigy Align, Aza-Direct, Azatin, BioNeem, Margosan, Neemactin, Neemix, Ornatin, Safer, Triact, Trilogy

19



Triazapentasiene

19

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
19	Octopaminergic agonist	Triazapentadiene	amitraz	III	Mitac, Ovasyn

20



Hydrazones
and
Thioureas

20

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
20	Site II electron transport inhibitors	Hydrazones Thioureas	hydramethylnon diafenthiuron	III III	ACJ217,300, Amdro, Maxforce Gamba, Pegasus, Polo

21

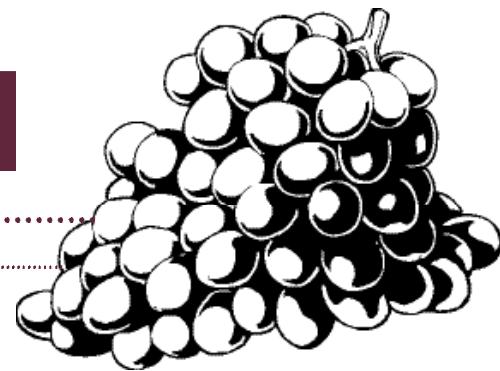


**Botanical and
Pyridazinone**

21

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
21	Site I electron transport inhibitors	Botanical Pyridazinone	rotenone pyridaben	II III	Rotacide, Rotanox Nexter, Pyramite, Sanmite

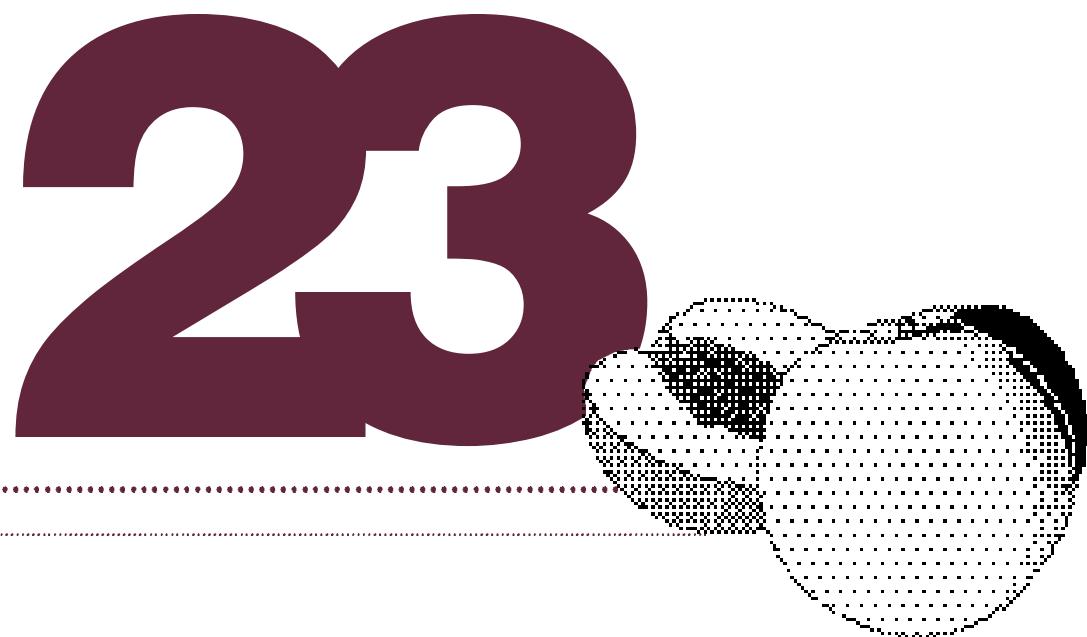
22



Fungi

22

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
22	Penetrates cuticle and multiplies within insect	Fungi	<i>Beauveria bassiana</i> <i>Paecilomyces fumosoroscus</i> <i>Metarhizium anisopliae</i>	IV IV IV	BotaniGard, Mycotrol, Naturalis, Organigard Pfr-97 BioBlast

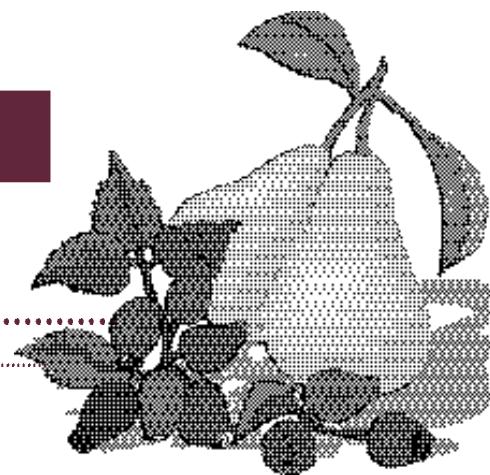


Nematodes

23

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
23	Multiple effects leading to death	Nematodes	<i>Steinernema carpocapsae</i> <i>Steinernema feltiae</i> <i>Steinernema glaseri</i> <i>Steinernema riobravis</i>	IV IV IV IV	BioVector 25, Millenium, Scanmask Magnet, Nemasys, <i>Steinernema feltiae</i> , X-Gnat <i>Steinernema glaseri</i> BioVector 355, Devour

24



Virus

24

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
24	Multi-effects through ingestion and debilitation of larva	Virus	Anagrapha falcifera NPV Helicoverpa zea NPV Spodoptera exigua NPV	IV IV IV	Anagrapha falcifera NPV Gemstar Spod-XLC

25

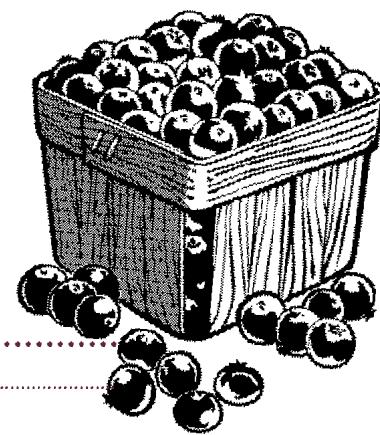


Oil and Soap

25

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
25	Physical poisons	Oil Soap	oil soap	IV IV	Orchex 796, Par F 70, SunSpray Ultra Fine Spray Oil, Volck Supreme, M-Pede, Safer

26

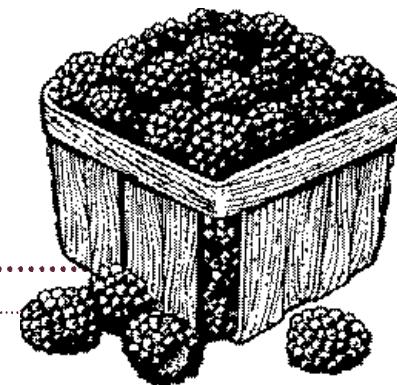


Pyrazolines

26

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
26	Blocks sodium channel and disrupts nerve transmission	Pyrazolines	indoxacarb	II	Avaunt, Steward

27

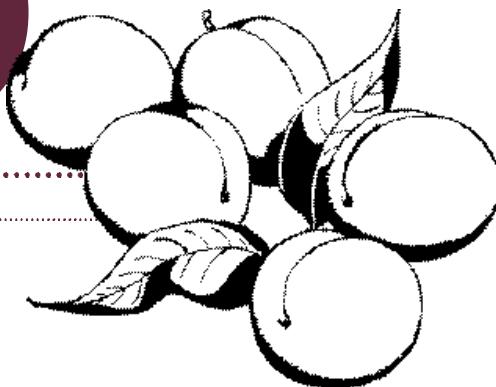


Metabolite
of DDT

27

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
27	Unknown	Metabolite of DDT	dicofol	III	Dicofol, Kelthane

28

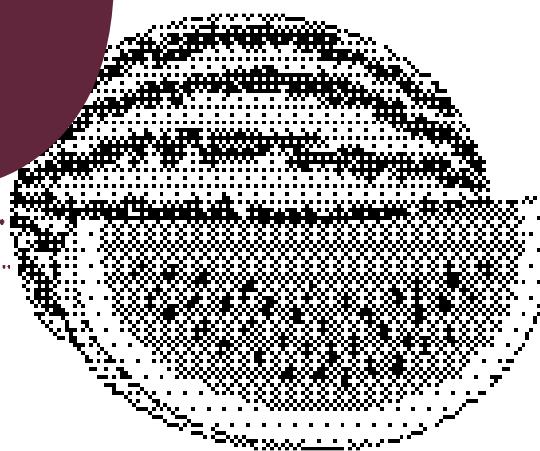


Carbazate

28

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
28	GABA(gamma-aminobutyric acid) antagonist in the peripheral nervous system	Carbazate	bifenazate	IV	Floramite

29

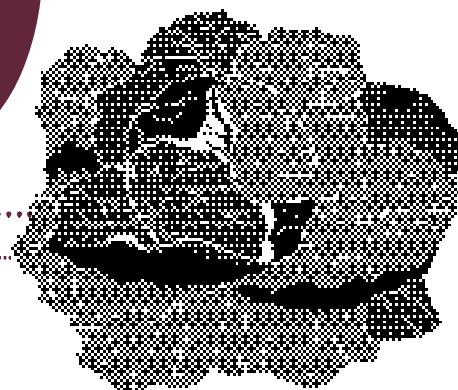


Botanical

29

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
29	Blocks Ca ²⁺⁺ channels of sarcoplasmic reticulum	Botanical (from <i>Ryania speciosa</i>)	ryania	III	Ryanex, Ryanicide

30



Pheromones

30

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³
30	Attracts and/or disrupts mating of some moths, beetles and flies	Pheromones	various	—	various names depending on insect species and distributor. One source for a list of pheromones is www.gemplers.com

NOTES

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³

NOTES

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³

NOTES

GROUP ¹	MODE OF ACTION	CHEMICAL GROUP	ACTIVE INGREDIENT /COMMON NAME	TOXICITY ²	TRADE NAME ³

NOTES

NOTES

NOTES
