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MICHIGAN STATE UNIVERSITY
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**PEST MANAGEMENT
GUIDE
for
FIELD CROPS
INSECTS**

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College of Agriculture
and Natural Resources
MICHIGAN STATE UNIVERSITY



COLLEGE OF FOOD, AGRICULTURAL,
AND ENVIRONMENTAL SCIENCES

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- Michigan: https://www.canr.msu.edu/field_crops/insect-guides
- Ohio: <https://aginsects.osu.edu/extension-publications/msuosu-ipm-guide>

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How to Use this Guide

This publication is set up as a series of chapters with information on biology, damage, management recommendations, and insecticides related to insect pests in field crops in Michigan and Ohio. Chapters cover field corn, soybean, wheat and other small grains, alfalfa and grass forage, and (for Michigan growers) dry beans and sugar beet. Each chapter stands alone, focusing on a particular crop. This was done so that we can update information frequently without changing the entire publication and you can download or print only the sections you need.

In the preparation of this guide, we checked state databases and consulted labels for each of the pesticides listed in the crop chapters; we made every effort to include correct information and to list most of the commonly-used products for Michigan and Ohio. However, labels do change over time. Always read the labels of the products you use to reconfirm application rate, precautions, PPE, pre-harvest intervals, and other key pieces of information prior to spraying.

Users are the best source of feedback on this guide. If you see information that is not correct or complete, or products which are not listed, please contact us so that we can update the guide accordingly.

The rest of this introduction has the following information:

- Figure 1: How to read the insecticide tables in this bulletin
- Table 1: Active ingredient (s), registrants, and EPA registration numbers
- Table 2: RUP status, signal words, REIs, and modes of action numbers
- Table 3: Sites and modes of action for insecticides & related pesticides in field crops

Introduction Figure 1: How to read the insecticide tables in this bulletin – a made-up example!

Active ingredients (AI) are listed alphabetically, then insecticides are listed by Trade Name under each AI. Allows for comparison or substitution of products.

See Table 1 to cross reference active ingredients x insecticide.

A letter under an insect indicates it is on the label

- The specific letter corresponds to use rates in column 2.

Compare PHIs between products

A few of the important statements on the label

Active ingredient Trade names	Labeled rate per acre	caterpillars	cutworm	grasshopper	spider mite	stink bugs	Pre - harvest Interval (PHI) in days	Precautions and Remarks
abamectin Big-Ten SC	(a) 1.7 - 3.5 oz				a		28	<ul style="list-style-type: none"> Apply when spider mites are first observed
An AI with one trade name and a single rate (a) for one pest (spider mite)								
bifenthrin Brutus Buckeye	(a) 3.5 - 5.0 oz (a) 7.0 - 10 oz	a	a	a		a	18	<ul style="list-style-type: none"> Do not make applications less than 30 days apart
An AI with two trade names, each with its own single rate (a) for multiple insects								
chlorantraniliprole O-Hi Advanced	(a) 14 oz (b) 20 oz	a		b			1	<ul style="list-style-type: none"> Must be applied before insects reach damaging levels
An AI with one trade name but different rates, (a) and (b), for different pests								
cyhalothrin (lambda) Izzo AG Green-UP WDG Lansing LV Scarlet 4F Spartan Izzo Extra Spartan Maxx	(a) 3 oz (b) 6 oz (a) 1 oz (b) 2 oz	a	a	b		b	30	<ul style="list-style-type: none"> Do not graze or harvest vines as forage or hay
An AI with many trade names, grouped by use rates; products in a group are similar and interchangeable								

Table 1:
Active ingredient(s), registrants, and EPA registration numbers for insecticides in the MSU / OSU Field Crops Insect Pest Management Guide

TABLE 1	Active Ingredient (s)	Registrant/ Company	EPA Registration #
Abba Ultra	abamectin	AMVAC	5481-621
Acephate 90 Prill	acephate	ADAMA	66222-123
Acephate 90 WDG	acephate	Loveland	34704-1051
Acephate 90 WSP	acephate	Loveland	34704-862
Acephate 97 UP	acephate	UPL NA	70506-8
Acephate 97 WDG	acephate	ADAMA	66222-266
Acramite 4SC	bifenazate	UPL NA	400-514
Admire Pro	imidacloprid	Bayer CropScience	264-827
Advise Four	imidacloprid	WinField United	228-528-1381
Agree WG	Bt aizawai	Certis USA	70051-47
Agri-Mek SC	abamectin	Syngenta	100-1351
Alias 4F	imidacloprid	ADAMA	66222-156
Annex LFR	bifenthrin	TENKOZ Inc	279-3302-55467
Annihilate LV	methomyl	MacDermid Ag Solutions	400-597
Annihilate SP	methomyl	MacDermid Ag Solutions	400-598
Arctic 3.2EC	permethrin	WinField United	1381-187
Argyle OD	bifenthrin acetamiprid	UPL NA	70506-346
Asana XL	esfenvalerate	Valent	59639-209
Avaunt eVo	indoxacarb	FMC	279-9629
Aztec 4.67G	tebupirimphos cyfluthrin	AMVAC	5481-9028
Aztec HC	tebupirimphos cyfluthrin	AMVAC	5481-577
Baythroid XL	cyfluthrin (beta)	Bayer CropScience	264-840
Belay	clothianidin	Valent	59639-150
BeLeaf	flonicamid	FMC	71512-10-279
Besiege	chlorantraniliprole cyhalothrin (lambda)	Syngenta	100-1402
Bifen 2 Ag Gold	bifenthrin	WinField United	83222-1
Bifender FC	bifenthrin	Vive Crop Protection	89118-2
Bifenthrin 2EC	bifenthrin	Aceto Ag Chem Corp	2749-556
Bifenture 10DF	bifenthrin	UPL NA	70506-227
Bifenture EC	bifenthrin	UPL NA	70506-57
Bifenture LFC	bifenthrin	UPL NA	70506-305
Blackhawk	spinosad	Corteva Agriscience	62719-523
Brigade 2EC	bifenthrin	FMC Corporation	279-3313

TABLE 1	Active Ingredient (s)	Registrant/ Company	EPA Registration #
Trade name			
Brigadier	bifenthrin imidacloprid	FMC Corporation	279-3332
Capture 3RIVE 3D	bifenthrin	FMC Corporation	279-3467
Capture LFR	bifenthrin	FMC Corporation	279-3302
Carbaryl 4L	carbaryl	Drexel	19713-49
Carbaryl 4L	carbaryl	Loveland	34704-447
Coragen	chlorantraniliprole	FMC Corporation	279-9606
Corrida 90 WSP	methomyl	Sinon USA	82557-2
Counter 20G (Smartbox, Lock'N Load, or Smart Cartridge)	terbufos	AMVAC	5481-562
Deadline Bullets	metaldehyde	AMVAC	5481-507
Deadline GT	metaldehyde	AMVAC	6836-350-5481
Deadline MPs	metaldehyde	AMVAC	5481-507
Declare	cyhalothrin (gamma)	FMC Corporation	279-3571
Defcon 4.67G	tebupirimphos cyfluthrin	Helena	5481-9028-5905
Delta Gold	deltamethrin	WinField United	264-1011-1381
Denim	emamectin benzoate	Syngenta	100-903
Diamond	novaluron	ADAMA	66222-35
Dibrom 8E	naled	AMVAC	5481-479
Dimate 4E	dimethoate	WinField United	9779-273
Dimethoate 400	dimethoate	Loveland & FMC Corp	34704-207
Dimethoate 4EC	dimethoate	Drexel	19713-231
Dipel 10G	Bt kurstaki	Valent Biosciences	73049-14
Dipel DF	Bt kurstaki	Valent Biosciences	73049-39
Dipel ES	Bt kurstaki	Valent Biosciences	73049-17
Discipline 2EC	bifenthrin	AMVAC	5481-517
Durham 7.5	metaldehyde	AMVAC	5481-103
Elevest Insect Control	bifenthrin chlorantraniliprole	FMC Corporation	279-9652
Empower 2	bifenthrin	Helena	5905-548
Endigo ZC	cyhalothrin (lambda) thiamethoxam	Syngenta	100-1276
Endigo ZCX	cyhalothrin (lambda) thiamethoxam	Syngenta	100-1458
Entrust	spinosad	Corteva Agriscience	62719-282
Entrust SC	spinosad	Corteva Agriscience	62719-621
Ethos Elite LFR	bifenthrin	FMC Corporation	279-9651
Ethos XB	bifenthrin	FMC Corporation	279-3473
Evergreen EC 60-6	pyrethrins	MGK	1021-1770

TABLE 1	Active Ingredient (s)	Registrant/ Company	EPA Registration #
Exirel Insect Control	cyantraniliprole	FMC Corporation	279-9615
Fanfare 2EC	bifenthrin	ADAMA	66222-99
Fanfare EC	bifenthrin	ADAMA	66222-261
Fanfare ES	bifenthrin	ADAMA	66222-236
Fastac CS	cypermethrin (alpha)	BASF Ag Products	7969-364
Fastac EC	cypermethrin (alpha)	BASF Ag Products	7969-298
Ferroxx Slug & Snail Bait	sodium ferric EDTA	Neudorff	67702-33
Ferroxx AQ	iron phosphate	Neudorff	67702-49
Force 6.5G	tefluthrin	Syngenta	100-1625
Force 10G HL Smartbox, SmartCartridge	tefluthrin	AMVAC	100-1615-5481
Force EVO	tefluthrin	Syngenta	100-1610
Fyfanon ULV Ag	malathion	FMC Corporation	279-3540
Grizzly Too	cyhalothrin (lambda)	WinField United	100-1295-1381
Hero	bifenthrin cypermethrin (zeta)	FMC Corporation	279-3315
Hero EW	bifenthrin cypermethrin (zeta)	FMC Corporation	279-3329
Index Liquid At-Plant	chlorethoxyfos bifenthrin	AMVAC	5481-587
Intrepid 2F	methoxyfenozide	Corteva Agriscience	62719-442
Intrepid Edge	methoxyfenozide spinetoram	Corteva Agriscience	62719-666
Invertid 2F	methoxyfenozide	Loveland	34704-1107
Javelin WG	Bt kurstaki	Certis USA	70051-66
Kendo 22.8CS	cyhalothrin (lambda)	Helm Agro	74530-54
Kendo Insecticide	cyhalothrin (lambda)	Helm Agro	74530-38
Kilter	Imidacloprid cyhalothrin (lambda)	NuFarm	228-717
Lambda-Cy	cyhalothrin (lambda)	UPL NA INC. Inc	70506-121
Lambda-Cy Ag	cyhalothrin (lambda)	WinField United	83222-42
Lambda-Cy. 1EC	cyhalothrin (lambda)	Nufarm	228-708
LambdaStar	cyhalothrin (lambda)	LG Life Sciences	71532-20-91026
Lambda-T	cyhalothrin (lambda)	Helena	100-1112-5905
Lamcap II	cyhalothrin (lambda)	Syngenta	100-1295
Lannate LV	methomyl	Corteva Agriscience	352-384
Lannate SP	methomyl	Corteva Agriscience	352-342
Lanveer LV	methomyl	Innvictis	89167-91-89391
Leverage 360	imidacloprid cyfluthrin	Bayer CropScience	264-1104
Malathion 5	malathion	WinField United	9779-5

TABLE 1	Active Ingredient (s)	Registrant/ Company	EPA Registration #
Trade name			
Malathion 5EC	malathion	Drexel	19713-217
Minecto Pro	cyantraniliprole abamectin	Syngenta	100-1592
Montana 4F	imidacloprid	Rotam North America	83100-21-83979
Movento	spirotetramat	Bayer CropScience	264-1050
Movento HL	spirotetramat	Bayer CropScience	264-1188
Mustang	cypermethrin (zeta)	FMC Corporation	279-3126
Mustang Maxx	cypermethrin (zeta)	FMC Corporation	279-3426
Nirvana Complete	bifenthrin	Innvictis	89168-129-89391
Nirvana RTU	bifenthrin	Innvictis	91234-177-89391
Nudrin LV	methomyl	Rotam North America	83100-27-83979
Nudrin SP	methomyl	Rotam North America	83100-28-83979
Nuprid 2SC	imidacloprid	Nufarm	228-572
Nuprid 4F Max	imidacloprid	Nufarm	228-528
Nurizma	broflanilide	BASF Ag Products	7969-423
Oberon 2SC	spiromesifen	Bayer CropScience	264-719
Onager	hexythiazox	Gowan	10163-277
Orthene 97	acephate	AMVAC	5481-8978
Paradigm VC	cyhalothrin (lambda)	WinField United	33270-41
Permastar AG	permethrin	LG Life Sciences	71532-15-91026
Perm-UP 25DF	permethrin	UPL NA	70506-66
Perm-UP 3.2EC	permethrin	UPL NA	70506-9
Pounce 1.5G	permethrin	FMC Corporation	279-3059
Pounce 25WP	permethrin	FMC Corporation	279-3051
Prevathon	chlorantraniliprole	FMC Corporation	279-9612
Prey 1.6	imidacloprid	Loveland	34704-894
Proaxis	cyhalothrin (gamma)	FMC Corporation	279-3583
Province II	cyhalothrin (lambda)	TENKOZ Inc	100-1295-55467
Provoke	imidacloprid	Innvictis	89168-23-89391
PyGanic EC 1.4 II	pyrethrins	MGK	1021-1771
Pyganic 5.0 II	pyrethrins	Valent / MGK	1021-1772
Radiant SC	spinetoram	Corteva Agriscience	62719-545
Ravage	cyhalothrin (lambda)	Innvictis	89168-16-89391
Ravage II	cyhalothrin (lambda)	Innvictis	89167-119-89391
Reaper 0.15EC	abamectin	Loveland	34704-923
Reaper Clearform	abamectin	Loveland	34704-1078
Renestra	cypermethrin afidopyropen	BASF Ag Products	7969-436
Reveal			89168-19-89391
Reveal EndurX	bifenthrin	Innvictis	

TABLE 1	Active Ingredient (s)	Registrant/ Company	EPA Registration #
Ridgeback	sulfoxaflor bifenthrin	Corteva Agriscience	62719-749
Savoy	acetamiprid bifenthrin	Innvectis	89168-74-89391
Sefina	afidopyropen	BASF Ag Products	7969-391
Sevin 4F	carbaryl	Tessenderlo Kerley	61842-38
Sevin XLR Plus	carbaryl	Tessenderlo Kerley	61842-37
S-fenvalostar	esfenvalerate	LG Life Sciences	71532-21-73006
Shenzi 400SC	chlorantraniliprole	UPL NA	70506-607
Sherpa	imidacloprid	Loveland	34704-983
Silencer	cyhalothrin (lambda)	ADAMA	66222-104
Sivanto 200SL	flupyradifurone	Bayer CropScience	264-1141
Sivanto HL	flupyradifurone	Bayer CropScience	264-1198
Sivanto Prime	flupyradifurone	Bayer CropScience	264-1141
Skyraider	bifenthrin imidacloprid	ADAMA	66222-247
Sluggo	iron phosphate	Certis USA	67702-3-70051
SmartChoice 5G	chlorethoxyfos bifenthrin	AMVAC	5481-561
Smartchoice HC	chlorethoxyfos bifenthrin	AMVAC	5481-579
Sniper	bifenthrin	Loveland	34704-858
Sniper Helios	bifenthrin	Loveland	34704-858
Sniper LFR	bifenthrin	Loveland	34704-1089
Spear-Lep	GS-omega/kappa- Hxtx-Hv1a	Vestaron	88847-6
Spintor 2SC	spinosad	Corteva Agriscience	62719-294
Steed	bifenthrin cypermethrin (zeta)	FMC Corporation	279-3380
Steward EC	indoxacarb	FMC Corporation	279-9596
Stifle SC	etoxazole	AMVAC	5481-651
Swagger	bifenthrin imidacloprid	Loveland	34704-1045
Tombstone	cyfluthrin	Loveland	34704-912
Tombstone Helios	cyfluthrin	Loveland	34704-978
Tracer	spinosad	Corteva Agriscience	62719-267
Transform WG	sulfoxaflor	Corteva Agriscience	62719-625
Tundra EC	bifenthrin	WinField United	1381-196
Vantacor	chlorantraniliprole	FMC Corporation	279-9656
Warrior II w/ Zeon Tech.	cyhalothrin (lambda)	Syngenta	100-1295
Willowood Lambda-Cy1EC	cyhalothrin (lambda)	Willowood LLC	87290-24

TABLE 1	Active	Registrant/ Company	EPA Registration #
Trade name	Ingredient (s)		
Wrangler	imidacloprid	Loveland	34704-931
Xentari Biological	Bt aizawai	Valent Biosciences	73049-40
Xpedient Plus V	bifenthrin	AMVAC	5481-609
Zeal	etoxazole	Valent	59639-123
Zeal Pro	etoxazole	Valent	59639-241
Zeal SC	etoxazole	Valent	59639-202
Zyrate	esfenvalerate	Rotam North America	71532-21-83979

Table 2: RUP status, signal words, reentry intervals for workers, and modes of action numbers to aid in choosing among insecticides in the Insect Pest Management Guide

- **Restricted Use Pesticides (RUPs)** can be applied only by certified applicators
- **Signal words** rate acute (short term) toxicity. Rarely, there is no signal word on a label. From low to high, the signal words are caution, warning, and danger
- A **Reentry interval (REI)** is the minimum time in hours between a pesticide application and workers entering a field without additional protective clothing. This time frame is usually in the Ag Use Requirements box on each label. REIs are particularly important in field crops like sugar beets and seed corn which may need detasseling, thinning, or weeding
- **Mode of action classification numbers** are set by the Insecticide Resistance Action Committee (IRAC). Insecticides with the same number have the same mode of action and may need to be rotated with insecticides in different groups to delay resistance

TABLE 2 Pesticide trade name	Restricted use (RUP)	Signal Word	REI (hours)	Mode of action classification
Abba Ultra	yes	warning	12	6
Acephate 90 Prill, WDG & WSP	no	caution	24	1B
Acephate 97 UP & WDG	no	caution	24	1B
Acramite 4SC	no	caution	12	20D
Admire Pro	no	caution	12	4A
Advise Four	no	caution	12	4A
Agree WG	no	caution	4	11A
Agri-Mek SC	yes	warning	12	6
Alias 4F	no	caution	12	4A
Annex LFR	yes	warning	12	3A
Annihilate LV & SP	yes	danger	48	1A
Arctic 3.2EC	yes	caution	12	3A
Argyle OD	yes	warning	12	3A, 4A
Asana XL	yes	warning	12	3A
Avaunt eVo	no	caution	12	22A
Aztec 4.67G & HC	yes	warning	48	1B, 3A
Baythroid XL	yes	warning	12	3A
Belay	no	caution	12	4A
BeLeaf	no	caution	12	29
Besiege	yes	warning	24	3A, 28
Bifen 2 Ag Gold	yes	warning	12	3A
Bifender FC	yes	warning	12	3A
Bifenthrin 2EC	yes	warning	12	3A
Bifenture 10DF	yes	caution	12	3A, 4A
Bifenture EC	yes	warning	12	3A
Bifenture LFC	yes	caution	12	3A
Blackhawk	no	caution	4	5
Brigade 2EC	yes	warning	12	3A

TABLE 2 Pesticide trade name	Restricted use (RUP)	Signal Word	REI (hours)	Mode of action classification
Brigadier	yes	warning	12	3A, 4A
Capture 3RIVE 3D	yes	caution	12	3A
Capture LFR	yes	warning	12	3A
Carbaryl 4L	no	caution	by crop	1A
Coragen	no	none	4	28
Corrida 90 WSP	yes	danger	48	1A
Counter 20G (various)	yes	danger	48	1B
Deadline (various)	no	caution	12	none
Declare	yes	caution	24	3A
Defcon 4.67G	yes	warning	48	1B, 3A
Delta Gold	yes	danger	12	3A
Denim	yes	danger	48	6
Diamond	no	warning	12	15
Dibrom 8E	yes	danger	48	1B
Dimate 4E	no	warning	by crop	1B
Dimethoate 400 & 4EC	no	warning	by crop	1B
Dipel 10G, DF, & ES	no	caution	4	11A
Discipline 2EC	yes	warning	12	3A
Durham 7.5 Granules	no	caution	12	none
Elevest Insect Control	yes	caution	12	3A, 28
Empower 2	yes	caution	24	3A
Endigo ZC & ZCX	yes	warning	24	3A, 4A
Entrust	no	caution	4	5
Entrust SC	no	none	4	5
Ethos Elite LFR	yes	warning	12	3A
Ethos XB	yes	caution	12	3A
Evergreen EC 60-6	no	caution	12	3A
Exirel Insect Control	no	caution	12	28
Fanfare 2EC, EC, & ES	yes	warning	12	3A
Fastac CS	yes	caution	12	3A
Fastac EC	yes	danger	12	3A
Ferroxx Slug & Snail Bait	no	caution	0	none
Ferroxx AQ	no	caution	4	none
Force 6.5G	yes	caution	48	3A
Force 10G HL	yes	warning	48	3A
Force EVO	yes	danger	48	3A
Fyfanon ULV Ag	no	caution	by crop	1B
Grizzly Too	yes	warning	24	3A
Hero & Hero EW	yes	caution	12	3A
Index Liquid At-Plant	yes	danger	48	1B, 3A

TABLE 2 Pesticide trade name	Restricted use (RUP)	Signal Word	REI (hours)	Mode of action classification
Intrepid 2F	no	caution	4	18
Intrepid Edge	no	caution	4	5, 18
Invertid 2F	no	caution	4	18
Javelin WG	no	caution	4	11A
Kendo / Kendo 22.8 CS	yes	warning	24	3A
Kilter	yes	danger	24	3A, 4A
Lambda-Cy & Lambda-Cy Ag	yes	warning	24	3A
Lambda-Cyhalothrin 1EC	yes	warning	24	3A
LambdaStar	yes	danger	24	3A
Lambda-T	yes	warning	24	3A
Lamcap II	yes	warning	24	3A
Lannate LV & SP	yes	danger	48	1A
Lanveer LV	yes	danger	48	1A
Leverage 360	yes	caution	12	3A, 4A
Malathion 5 & 5EC	no	warning	by crop	1B
Minecto Pro	yes	warning	12	6, 28
Montana 4F	no	caution	12	4A
Movento / Movento HL	no	caution	24	23
Mustang Maxx	yes	warning	12	3A
Nirvana Complete & RTU	yes	warning	12	3A
Nudrin LV & SP	yes	danger	48	1A
Nuprid 2SC & 4F Max	no	caution	12	4A
Nurizma	no	caution	12	30
Oberon 2SC	no	caution	12	23
Onager	no	caution	12	10A
Orthene 97	no	caution	24	1B
Paradigm VC	no	caution	24	3A
Permastar AG	yes	caution	12	3A
Perm-UP 25DF	yes	warning	12	3A
Perm-UP 3.2EC	yes	caution	12	3A
Pounce 1.5G & 25WP	yes	caution	12	3A
Prevathon	no	none	4	28
Prey 1.6	no	caution	12	4A
Proaxis	yes	caution	24	3A
Province II	yes	warning	24	3A
Provoke	no	caution	12	4A
PyGanic EC 1.4 II & 5.0 II	no	caution	12	3A
Radiant SC	yes	caution	4	5
Ravage	yes	warning	24	3A
Ravage II	yes	warning	24/48	3A

TABLE 2 Pesticide trade name	Restricted use (RUP)	Signal Word	REI (hours)	Mode of action classification
Reaper 0.15EC & Clearform	yes	warning	12	6
Renestra	yes	warning	12	3A, 9D
Reveal/ Reveal EndurX	yes	warning	12	3A
Ridgeback	no	warning	24	3A, 4C
Savoy	yes	warning	12	3A, 4A
Sefina	no	caution	12	9D
Sevin 4F or XLR Plus	no	caution	by crop	1A
S-fenvalostar	yes	warning	12	3A
Shenzi 400SC	no	caution	4	28
Sherpa	no	caution	12	4A
Silencer	yes	warning	24	3A
Sivanto 200SL, HL, & Prime	no	caution	4	4D
Skyraider	yes	warning	12	3A, 4A
Sluggo	no	caution	0	n/a
SmartChoice 5G	yes	danger	48	1B, 3A
SmartChoice HC	yes	warning	48	1B, 3A
Spear-Lep	no	caution	4	32
Sniper / Sniper Helios & LFR	yes	warning	12	3A
Spintor 2SC	no	none	4	5
Steed	yes	warning	12	3A
Steward EC	no	caution	12	22
Stifle SC	no	caution	12	10B
Swagger	yes	danger	12	3A, 4A
Tombstone	yes	danger	12	3A
Tombstone Helios	yes	warning	12	3A
Tracer	no	none	4	5
Transform WG	no	danger	24	4C
Tundra EC	yes	warning	12	3A
Vantacor	no	none	4	28
Warrior II w/ Zeon	yes	warning	24	3A
Willowood Lambda-Cy 1EC	yes	warning	24	3A
Wrangler	no	caution	12	4A
Xentari Biological	no	caution	4	11A
Xpedient Plus V	yes	warning	12	3A
Zeal (various)	no	caution	12	10B
Zyrate	yes	warning	12	3A

Table 3: Target sites and modes of action for insecticides in field crops.

Modes of action are based on the classification scheme developed by the Insecticide Resistance Action Committee (IRAC) at irac-online.org. If an insecticide is followed by the word “part”, that indicates it is a mixture of active ingredients with different modes of action.

IRAC number and group	Target site • Mode of action	Example active ingredient(s)	Example trade name(s)
1A carbamates	<i>Nervous system</i> • Bind to the acetylcholinesterase enzyme, preventing it from ‘cleaning’ the gap between nerves. Death from overstimulation of nerves. The effect is brief, compared to OPs (below).	carbaryl methomyl	Carbaryl Corrida Lannate Lanveer Nudrin Sevin
1B organophosphates (OPs)	<i>Nervous system</i> • Bind to the acetylcholinesterase enzyme similar to carbamates, but the effect is longer-lasting. This usually makes OPs more hazardous than carbamates.	acephate chloroxyfos dimethoate malathion tebupirimphos terbufos	Aztec (part) Counter Dibrom Dimethoate Index (part) Malathion Smartchoice (part)
3A pyrethrins & pyrethroids	<i>Nervous system</i> • Disrupt sodium channels along the nerve axon, resulting in continuous firing of nerves. • Pyrethrins are botanical insecticides extracted from chrysanthemum. Some products may carry an organic registration. • Pyrethroids are chemically based on these molecules but are NOT used in organic crops. • Performance of pyrethrins & some pyrethroids is increased by adding a synergist to the formulation.	<u>botanical:</u> pyrethrin <u>conventional:</u> bifenthrin cyfluthrin α -cyhalothrin λ -cyhalothrin cypermethrin esfenvalerate permethrin tefluthrin	<u>botanical:</u> Pyganic <u>conventional:</u> Arctic Asana Aztec (part) Baythroid Besiege (part) Bifenture Brigade Capture Elevest (part) Empower Force Hero Lambda-Cy Mustang Perm-Up Pounce Proaxis Silencer Tombstone Warrior

IRAC number and group	Target site • Mode of action	Example active ingredient(s)	Example trade name(s)
4A neonicotinoids	<i>Nervous system</i> • Hyper-stimulate nerves by binding to their nicotinic acetylcholine receptors in the synapse. The binding is better to insect receptors than to mammalian receptors.	clothianidin imidacloprid thiamethoxam	Admire Belay Brigadier (part) Cruiser Leverage (part) Nuprid Poncho
4C sulfoximines 4D butenolides	<i>Nervous system</i> • Bind to nicotinic acetylcholine receptors in the synapse, but have a different structure than 4A, neonicotinoids.	sulfoxaflor flupyradifurone	Transform Sivanto
5 spinosyns	<i>Nervous system</i> • Bind to nicotinic acetylcholine receptors in the synapse, but in a different way than neonicotinoids.	spinosad spinetoram	Entrust IntrepidEdge (part) Radiant Spintor Tracer
6 avermectins	<i>Nervous system</i> • Block the transmission of signals in nerve and muscle cells, causing paralysis, by increasing the effect of glutamate at insect glutamate-gated chloride channels (mammals don't have glutamate-gated channels).	abamectin	Abba Ultra Agri-Mec Denim Reaper Minecto Pro (part)
9D pyropenes	<i>Chordotonal stretch receptors</i> • Disrupt proteins in the neurons of insect chordotonal stretch receptors under the cuticle which are important in hearing, movement, balance, and flight. Ultimately insects stop feeding and other behaviors for survival.	afidopyropen	Renestra Sefina
10A 10B mite growth inhibitors	<i>Growth inhibitor</i> • Not well understood. Disrupts synthesis of chitin (a key component of the mite exoskeleton) during development. Impacts eggs and nymphs, but not adults.	hexythiazox etoxazole	Onager Stifle Zeal

IRAC number and group	Target site • Mode of action	Example active ingredient(s)	Example trade name(s)
11A Bacillus thuringiensis (Bt)	<i>Midgut membrane</i> • Cry proteins bind to specific receptors in the gut. Gut contents leak into body cavity & insect dies slowly of septicemia.	Bt kurstaki Bt aizawai	Agree Dipel Javelin Xentari (also Bt crops)
15 benzoylureas	<i>Chitin biosynthesis</i> • Inhibits an enzyme involved in the synthesis of chitin, the major component of the insect exoskeleton. Immatures cannot molt properly.	novaluron	Diamond
18 diacylhydrazines	<i>Ecdysone (hormone) receptor</i> • Causes lepidopteran larvae (caterpillars) to molt prematurely, which is lethal to them.	methoxyfenozide	Intrepid Intrepid Edge (part) Invertid
20D bifenazate	<i>Mitochondria</i> • Inhibits the process of respiration, so that cells can't utilize energy. Paralysis and eventual death.	bifenazate	Acramite
22A oxadiazines	<i>Nervous system</i> • Block sodium channels and thus disrupt signals along nerve axon. Insects cannot feed or move.	indoxacarb	Avaunt Steward
23 tetronic & tetramic acid derivatives	<i>Growth inhibitor</i> • Inhibits the enzyme acetyl coenzyme A carboxylase, which is important in lipid biosynthesis. Results include slow development, reduced egg production, and death.	spiromesifen	Movento Oberon
28 diamides	<i>Nervous system</i> • Activate ryanodine receptors on muscles, causing them to contract. Leads to paralysis then death.	chlorantraniliprole	Besiege (part) Coragen Elevest (part) Exirel Minecto Pro (part) Prevathon Shenzi Vantacor

IRAC number and group	Target site • Mode of action	Example active ingredient(s)	Example trade name(s)
29 flonicamid	<i>Chordotonal stretch receptors</i> • Disrupt proteins in the neurons of insect chordotonal stretch receptors under the cuticle which are important in hearing, movement, balance, and flight. Ultimately insects stop feeding and other behaviors for survival.	flonicamid	Beleaf
30 GABA-gated chloride channel modulators	<i>Nervous system & muscles</i> • Interferes with the receptor for GABA, a neurotransmitter which normally blocks or calms nerve signals. This causes overexcitation of the nervous system, convulsions, and death.	broflanilide	Nurizma
32 Nicotinic acetylcholine receptor allosteric modulators	<i>Nervous system</i> • Peptides bind to and overexcite nicotinic acetylcholine receptors, leading to paralysis & death. Products must be combined w/ a Bt insecticide so the peptides can leave the gut and move to the target site.	GS-omega/kappa HTX-Hv1a	Spear-Lep bioinsecticide
Not classified Aldehydes	<i>Mucus cells</i> • Irreversibly destroys mucus producing cells, leading to death.	metaldehyde	Deadline Durham
Not classified Iron phosphate	<i>Digestive tract</i> • Interferes with calcium metabolism in the gut. Snails & slugs stop eating and die.	iron phosphate	Ferroxx AQ Sluggo
Not classified sodium ferric EDTA	<i>Oxygen transport</i> • Interacts with hemocyanin, the oxygen transport protein in slugs. Slugs suffocate and die.	sodium ferric EDTA	Ferroxx