

CHEMICAL CLASS CHART



GREENHOUSE &
NURSERY PRODUCTION

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Insecticides/Miticides
Fungicides
Herbicides
Plant Growth Regulators

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REFERENCE GUIDE for GREENHOUSE and NURSERY PRODUCTION INSECTICIDES / MITICIDES

RESISTANCE MANAGEMENT

Pest populations that are over exposed to a single pesticide may develop resistance to that pesticide. Resistance is due to the innate ability of some individuals in the pest population to survive even after being treated with a pesticide. When using pesticides repeatedly for crop protection, it is important to manage pesticide resistance by rotating chemicals with different modes of action (MOA) on the target pest or combining chemicals with different modes of action in the tank/spray mix.

When labels permit, make two (2) applications of a product or tank mix in sequence, then rotate to products with different modes of action to improve coverage on target life stages of the pest. Try to avoid applying pesticides with the same mode of action to more than one generation of the pest per cycle.

Good resistance management starts with accurate identification of the pest problem and good record-keeping of all pesticide applications.

Time pesticide applications to coincide with the susceptible life stage of the pest based on their life cycle.

The appropriate and labeled (legal) method of application is also a very important factor to consider.

Low volume (L.V.) applications (smoke generator, thermal fog, cold fog, aerosol, and electrostatic) are commonly used in greenhouses. Low volume sprays generally are more effective against adults than immature stages. Use high volume sprays, directed under the leaves for best results against insect and mite eggs and nymphs.

Always read the label and check with your state or county extension specialists for further information regarding resistance management.

****Use Site(s) Key:** GH = Greenhouse N = Nursery

(by Mode of Action Group and Class)

MOA Group*	Class	Common Name	Trade Name	REI	Use Site(s)**	Company
1A	Carbamates	Carbaryl	Sevin®	12	N	ENVU
1B	Organophosphates	Acephate	Orthene® TT&O	24	GH/N	Amvac Chemical Corp.
		Chlorpyrifos	1300 Orthene® TR	24	GH	BASF
			DuraGuard® ME	24	GH/N	BASF
			Dursban® 50 WP	24	N	Corteva Agriscience
		Malathion	Gowan Malathion 8F	12	N	Gowan Company
Phosmet	Imidan® 70W	24	N	Gowan Company		
2B	Phenylpyrazoles	Fipronil	TopChoice®	24	N	ENVU
3	Pyrethroids	Bifenthrin	Talstar®	12	GH/N**	FMC Corp.
			OnyxPro®	12	N	FMC Corp.
			Attain® TR	12	GH	BASF
		Fenpropathrin	Tame®	24	GH/N	Nufarm
		Fluvalinate	Mavrik® Aquaflow	12	GH/N	Wellmark International
		Lambda-Cyhalothrin	Scimitar® GC	24	GH/N	Syngenta
		Permethrin	Astro®	12	GH	FMC Corp.
			Permethrin 3.2 EC	12	GH/N***	Helena Agri-Enterprises, LLC
			Ambush®	12	GH/N***	Amvac Chemical Corp.
			*** Greenhouse roses only			
Botanicals	Pyrethrins	Pyrethrum® TR	12	GH	BASF	
		PyGanic®	12	GH/N	Mycorrhizal Applications, LLC	

* Depends on Greenhouse ventilation

** Greenhouse and/or nursery uses depend on the formulation. Check labels for uses.

Insecticides / Miticides

continued

(by Mode of Action Group and Class)

MOA Group*	Class	Common Name	Trade Name	REI	Use Site(s)**	Company
7A	Neonicotinoids	Acetamiprid	Imstar®	12	GH/N	Nufarm
		Dinotefuran	Safari®	12	GH/N	Nufarm
		Imidacloprid	Marathon®	0-12	GH/N	OHP, Inc.
			CoreTect Tree and Shrub Tablets™	12	GH/N	ENVU
		Thiamethoxam	Flagship®	12	GH/N	Syngenta
4D	Butenolides	Flupyradifurone	Altus™	4	GH/N	ENVU
5	Spinosyns	Spinosad	Conserve®	4	GH/N	Corteva Agriscience
			Entrust®	4	GH/N	Corteva Agriscience
6	Glycosides	Abamectin	Avid®	12	GH/N	Syngenta
		Milbemectin	Ultiflora®	12	N	Gowan Company
7A	Juvenile hormone mimics	s-Kinoprene	Enstar® AQ	12	GH	Wellmark International
7B	Juvenile hormone mimics	Fenoxycarb	Award®	12	N	Syngenta
7C	Juvenile hormone mimics	Pyriproxyfen	Distance®	12	GH/N	Nufarm
			Fulcrum®	12	GH/N	OHP, Inc.
9A	Pyridine azomethines	Pymetrozine	Endeavor®	12	GH/N	Syngenta
9B	Pyridine azomethine derivatives	Pyrifluquinazon	Rycar®	12	GH	SePRO Corp.
9D	Pyropenes	Afidopyropen	Ventigra™	12	GH/N	BASF
10A	Mite growth inhibitors	Clofentezine	Notavo®	12	GH/N	OHP, Inc.
	Thiazolidinones	Hexythiazox	Hexygon® IQ	12	GH/N	Gowan Company
10B	Mite growth inhibitors	Etoxazole	TetraSan®	12	GH/N	Nufarm
			Beethoven™ TR	4-24*	GH	BASF
11	Microbial disruptors of insect midgut	<i>Bacillus thuringiensis</i> Kurstaki	DiPel® Pro DF	4	GH/N	Nufarm
		<i>Bacillus thuringiensis</i> Israelensis	Gnatrol®	4	GH/N	Nufarm
13	Pyrroles	Chlorfenapyr	Pylon®	12	GH	BASF
15	Inhibitors of chitin biosynthesis	Diflubenzuron	Adept®	12	GH	OHP, Inc.
			Dimilin® WP	12	GH/N**	OHP, Inc.
		Novaluron	Pedestal®	12	GH/N	OHP, Inc.
16	Buprofezin	Buprofezin	Talus®	12	GH/N	SePRO Corp.
17	Molting disruptors, Diptera	Cyromazine	Citation®	12	GH/N	Syngenta

* Depends on Greenhouse ventilation

** Greenhouse and/or nursery uses depend on the formulation. Check labels for uses.

Insecticides / Miticides

continued

(by Mode of Action Group and Class)

MOA Group*	Class	Common Name	Trade Name	REI	Use Site(s)**	Company
	Diacetyl dehydrogenases	Methoxyfenozide	Intrepid®	4	GH/N	Corteva Agriscience
20A	Mitochondrial c. III electron transport inhibitors	Hydramethylnon	Amdro® Pro	12	N	BASF
20B	Mitochondrial c. III electron transport inhibitors	Acequinocyl	Shuttle® O	12	GH/N	OHP, Inc.
20D	Mitochondrial c. III electron transport inhibitors	Bifenazate	Floramite®	12	GH/N	OHP, Inc.
21A	METI Acaricides and Insecticides	Pyridaben	Sanmite®	12	GH/N	Gowan Company
		Fenpyroximate	Akari®	12	GH	SePRO Corp.
		Tolfenpyrad	Hachi-Hachi® SC	12	GH	SePRO Corp.
		Fenazaquin	Magus™	12	GH/N	Gowan Company
23	Tetronic acids	Spiromesifen	Savate™	12	GH/N	ENVU
	Tetramic acids	Spirotetramat	Kontos®	0-24	GH/N	ENVU
25A	Beta-ketonitrile	Cyflumetofen	Sultan™	12	GH/N	BASF
28	Diamides for all active ingredients	Cyantraniliprole	Mainspring®	4	GH/N	Syngenta
		Chlorantraniliprole	Acelepyrn®	4	GH/N	Syngenta
	Diamide	Cyclaniliprole	Sarisa®	4	GH/N	OHP, Inc.
29	Chordotonal organ modulators	Fonicamid	Aria®	12	GH/N	FMC Corp.
UN	Biopesticide:	Azadirachtin	Azatin® O	4	GH/N	OHP, Inc.
	Pyridalyl	Pyridalyl	Overture®	12	GH	Nufarm
UNB	Biopesticide: Bacterial Agents	Chromobacterium Subtsugae	Grandevo® WDG	4	GH/N	Profarm Group
		Burkholderia spp. strain A39	Venerate® XC	4	GH/N	Profarm Group
UNF	Biopesticide: Fungal Agents	<i>Beauveria bassiana</i>	BotaniGard®	4	GH/N	OHP, Inc.
			BioCeres® WP	4	GH/N	Biosafe Systems
			Mycotrol® O	4	GH/N	OHP, Inc.
		Strain PPRI 5339	Velifer®	12	GH	BASF
		<i>Isaria fumosorosea</i> Apopka Strain 97(ATCC20874)	Ancora®	4	GH/N	OHP, Inc.
UNE	Botanical essence	Botanical oil	Captiva®	4	GH/N	Gowan Company
		Clarified hydrophobic extract of neem oil	Triact® 70	4	GH/N	OHP, Inc.

* Depends on Greenhouse ventilation

** Greenhouse and/or nursery uses depend on the formulation. Check labels for uses.

MOA Combination Products

MOA Group*	Class	Common Name	Trade Name	REI	Use Site(s)**	Company
UNM	Mechanical and physical disruptors	Potassium salts of fatty acids	AllPro® Insecticidal Soap	12	GH/N	Value Garden Supply
			Kopa™ Insecticidal Soap	12	GH/N	OHP, Inc.
		Mineral oil	M-Pede®	12	GH/N	Gowan Company
			Ultra-Pure™ Oil	4	GH/N	BASF
			Suffoil-X™	4	GH/N	BioWorks, Inc.
3+UNF	Botanicals + Biopesticide	pyrethrins + Beauveria bassiana	BotaniGard® MAXX	12	GH/N	OHP, Inc.
3+Synergist	Pyrethrins	Pyrethrins + Piperonyl butoxide	Evergreen® Pro 60-6	12	GH/N	Mycorrhizal Applications, LLC
1+3	Organophosphate + Pyrethroid	Chlorpyrifos + Cyfluthrin	DuraPlex® TR	24	GH	BASF
4C+5	Sulfoximines + Spinosyns	Sulfoxaflor + Spinetoram	XXpire®	12	GH/N	Corteva Agriscience
6+20D	Glycoside+Carbazate	Abamectin + Bifenazate	Sirocco®	12	GH/N	OHP, Inc.
28+29	Diamide + Pyridine carboxamides	Cyclanilprole + Flonicamid	Pradia®	12	GH/N	OHP, Inc.

*Insecticides / Miticides Modes of Action

1. Acetylcholinesterase inhibitors.
2. GABA-gated chloride channel blockers.
3. Sodium channel modulators.
4. Nicotinic acetylcholine receptor (nAChR) agonists.
5. Nicotine acetylcholine receptor allosteric modulators- Site I
6. Glutamate-gated chloride channel allosteric modulators
7. Juvenile hormone mimics.
9. Chordotonal organ TRPV channel modulators.
10. Mite growth inhibitors affecting CHS1
11. Microbial disruptors of insect midgut membranes.
12. Inhibitors of mitochondrial ATP synthase.
13. Uncouplers of oxidative phosphorylation via disruption of the proton gradient
15. Inhibitors of chitin biosynthesis affecting CHS1
16. Inhibit chitin biosynthesis – type 1
17. Molting disruptor, Dipteran
18. Ecdysone receptor agonists.
20. Mitochondrial complex III electron transport inhibitors.
21. Mitochondrial complex I electron transport inhibitors
22. Voltage-dependent sodium channel blockers.
23. Inhibitors of acetyl CoA carboxylase
25. Mitochondrial complex II electron transport inhibitors
28. Ryanodine receptor modulators
29. Chordotonal organ nicotinamidase inhibitors
- UN Products with unknown or uncertain MoA
- UNE Botanical essence including synthetic, extracts and unrefined oils with unknown or uncertain MoA
- UNF Fungal agents of unknown or uncertain MoA
- UNM Non-specific mechanical disruptors

This list is from the U.S Environmental Protection Agency, in cooperation with the Insecticide Resistance Action Committee (IRAC). IRAC is a technical working group within the Global Crop Protection Federation (GCPF). More information on the Insecticide Resistance Action Committee and the Mode of Action Classification is available from: www.irac-online.org.

REFERENCE GUIDE for GREENHOUSE and NURSERY PRODUCTION FUNGICIDES

RESISTANCE MANAGEMENT

As with other pesticides, fungicides must be used in a program to avoid or delay resistance. Do not rely on products with the same mode of action. Rotation of products with different modes of action, and using product combinations with different modes of action are parts of a resistance management strategy. Be especially careful when using products considered to be high risk for resistance development. This category includes many of our newer products. See the explanation of resistance risk at the end of the fungicide section.

Most fungicides work more effectively to prevent disease from becoming established, rather than eradicating disease that is already present. Constant monitoring – and modification where possible – of environmental conditions and scouting crops for signs of disease symptoms are vital parts of effective fungicide use and resistance management.

Always read the label and check with local authorities for further information regarding resistance management.

****Use Site(s) Key:** GH = Greenhouse N = Nursery

Fungicides

(by Mode of Action Group and Class)

MOA Code* & Group	Class	Common Name	Trade Name	REI	Use Site(s)**	Company
1	Thiophanates	Thiophanate-methyl	OHP 6672®	12	GH/N	OHP, Inc.
			3336™	12	GH/N	Nufarm
MBC-fungicides (Methyl Benzimidazole Carbamates) Resistance risk High (See explanation of resistance risk following the mode of action listing)						
2	Dicarboximides	Iprodione	OHP Chipco® 26019	12	GH/N	OHP, Inc.
			Chipco® 26019 FLO	12	GH/N	ENVU
3	Imidazoles	Triflumizole	Terraguard®	12	GH/N	OHP, Inc.
	Pyrimidines	Fenarimol	Banner® MAXX® II	12	N	Gowan Company
	Triazoles	Propiconazole	Eagle® 20 EW	12	N	Syngenta
		Myclobutanil	Avelyo®	24	GH/N	BASF
DMI-fungicides (DeMethylation Inhibitors) Resistance risk Medium						
4	Acylalanines	Metalaxyl-M (=Mefenoxam)	Subdue® MAXX®	0-48	GH/N	Syngenta
PA-fungicides (PhenyAmides) Resistance risk High						
5	Piperadines	Piperalin	Pipron®	12	GH	SePRO Corp.
Amines ("Morpholines") Resistance risk Low to Medium						
7	Thiophene amides	Isofetamid	Astun®	12	GH/N	OHP, Inc.
	Phenyl-Benzamides	Flutolanil	ProStar®	12	GH/N	ENVU
SDHI (Succinate dehydrogenase inhibitors) Resistance risk Medium to High						

* Depends on Greenhouse ventilation

** Greenhouse and/or nursery uses depend on the formulation. Check labels for uses.

Fungicides

continued

(by Mode of Action Group and Class)

MOA Code* & Group	Class	Common Name	Trade Name	REI	Use Site(s)**	Company
11	Oximino-acetates	Trifloxystrobin	Compass®	12	GH/N	ENVU
	Methoxy-acrylates	Azoxystrobin	Heritage®	4	GH/N	Syngenta
	Methoxy-carbamates	Pyraclostrobin	Empress™ Intrinsic	12	GH/N	BASF
	Imidazolinones	Fenamidone	Fenstop®	12	GH	Gowan Company
	Dihydro-dioxazines	Fluoxastrobin	Fame SC	12	GH/N	FMC
QoI-fungicides (Quinone outside inhibitors) Resistance risk High						
12	Phenylpyrroles	Fludioxonil	Medallion®	12	GH/N	Syngenta
			Spirato	12	GH/N	Nufarm
PP-fungicides (PhenylPyrroles) Resistance risk Low to Medium						
14	Aromatic Hydrocarbons	PCNB	Terraclor®	12	GH/N	OHP, Inc.
	Thiadiazole	Etridiazole	Terrazole®	12	GH/N	OHP, Inc.
			Truban®	12	GH/N	ICL/Everiss
AH fungicides (Aromatic Hydrocarbons) Resistance risk Low to Medium						
17	Hydroxyanilides	Fenhexamid	Decree®	12	GH/N	SePRO Corp.
(SBI: Class III) Resistance risk Low to Medium						
19	Polyoxins	Polyoxin-D	Affirm™	4	GH/N	Nufarm
Polyoxins Resistance risk Medium						
21	Cyano-imidazole	Cyazofamid	Segway® O	12	GH/N	OHP, Inc.
Qil-fungicide (Quinone inside inhibitor) Resistance risk Medium to High						
28	Carbamates	Propamocarb	Banol®	24	GH/N	ENVU
Carbamates Resistance risk Low to Medium						
40	Cinnamic Acid Amides	Dimethomorph	Stature® SC	12	GH/N	BASF
	Mandelic Acid Amides	Mandipropamid	Micora™	4	GH/N	Syngenta
CAA-fungicides (Carboxylic Acid Amides) Resistance risk Low to Medium						
43	Pyridinylmethyl-benzamides	Fluopicolide	Adorn®	12	GH/N	Nufarm
Benzamides Resistance risk Medium						
49	Piperidinyl-thiazole-isoxazolines	Oxathiapiprolin	Segovis®	4	GH/N	Syngenta
Piperidinyl-thiazole-isoxazolines Resistance risk Medium to High						
50	Benzoylpyridine	Pyriofenone	Seido™	4	GH/N	OHP, Inc.
Benzoylpyridine Resistance risk Medium						
BM 01	Fungal	Extract from the cotyledons of lupine plantlets ("BLAD") C108	Regime™	4	GH/N	FMC Corp.
Resistance risk Unknown						

* Depends on Greenhouse ventilation

** Greenhouse and/or nursery uses depend on the formulation. Check labels for uses.

Fungicides

continued

(by Mode of Action Group and Class)

MOA Code* & Group	Class	Common Name	Trade Name	REI	Use Site(s)**	Company
BM 01 Resistance risk Unknown	Biopesticide	<i>Swinglea glutinosa</i>	EcoSwing™	4	GH/N	Gowan Company
BM 02	<i>Bacillus</i> sp. and the fungicidal lipopeptides produced	<i>Bacillus amyloliquefaciens</i> strain D747	Triathlon® BA	4	GH/N	OHP, Inc.
		<i>Bacillus subtilis</i> GB03	Companion®	4	GH/N	Growth Products
		<i>Bacillus subtilis</i> MBI600	Subtilex® NG	4	GH	BASF
		<i>Bacillus subtilis</i> QST713	Cease®	4	GH/N	BioWorks, Inc.
		<i>Bacillus amyloliquefaciens</i> F727	Stargus™	4	GH/N	Profarm Group
	Biopesticide	<i>Streptomyces lydicus</i> WYEC108	Actinovate® SP	4	GH/N	Mycorrhizal Applications, LLC
	Polypeptide (lectin)	<i>Trichoderma asperellum</i> (ICC 012) <i>Trichoderma gamsii</i> (ICC 080)	Obtego™	4	GH/N	SePRO Corp.
	Biopesticide	<i>Trichoderma harzianum</i> T22	PlantShield® HC	0	GH/N	BioWorks, Inc.
			RootShield®	0	GH/N	BioWorks, Inc.
		<i>Trichoderma harzianum</i> T22 + <i>Trichoderma virens</i> G41	RootShield® Plus	0	GH/N	BioWorks, Inc.
Resistance risk Unknown						
M 01	Inorganic	Copper octanoate	Grotto®	4	GH/N	OHP, Inc.
		Copper sulfate	Cuproxat®	24	GH/N	Nufarm
			Phyton® 27	24	GH/N	Phyton Corp.
			Phyton® 35	24	GH/N	Phyton Corp.
		Copper hydroxide	CuPro™ 5000	48	GH/N	SePRO Corp.
Inorganic Resistance risk Low			Kalmor®	24	GH/N	OHP, Inc.
		Cuprous Oxide	Nordox 75WG	12	GH/N	Brandt Chemical
M 03	Dithiocarbamates and relatives	Mancozeb	Dithane®	24	GH/N	Corteva Agriscience
			Fore®	24	GH/N	Corteva Agriscience
		Mancozeb + CuOH	Junction™	24	GH/N	SePRO Corp.
Resistance risk Low		Manganese + zinc	Protect™ DF	24	GH/N	Nufarm
M 05	Chloronitriles (phthalonitriles)	Chlorothalonil	Daconil® Ultrex®	12	GH/N	Syngenta
Chloronitriles (phthalonitriles) Resistance risk Low			AllPro® Exotherm Termil	*	GH	Value Garden Supply * Depends on greenhouse ventilation
P 05	Plant extract	<i>Reynoutria sachalinensis</i>	Regalia®	4	GH/N	Profarm Group
Resistance risk Unknown						
P 07	Ethyl Phosphonates	Fosetyl-Al	Aliette®	12	GH/N	ENVU
		[Also classified by EPA with plant host defense inducers]				
			Areca®	12	GH/N	OHP, Inc.
	Phosphite	Phosphorous acid	Alude™	4	GH/N	Nufarm
Phosphonates Resistance risk Low						

* Depends on Greenhouse ventilation

** Greenhouse and/or nursery uses depend on the formulation. Check labels for uses.

Fungicides

continued

MOA Combination Products

MOA Code* & Group	Classes	Common Name	Trade Name	REI	Use Site(s)**	Company
NC	Biopesticide	<i>Ulocladium oudemansii</i> (U3 Strain)	BotryStop™	4	GH/N	BioWorks, Inc.
			Actino Iron	4	GH/N	Mycorrhizal Applications, LLC
	Bicarbonate	Potassium bicarbonate	Carb-O-Nator™	4	GH/N	Certis Biologicals
			MilStop®	1	GH/N	BioWorks, Inc.
	Hydrogen Dioxide/Peroxide	Hydrogen dioxide + peroxyacetic acid	ZeroTol®	0-1	GH/N	Biosafe Systems
			Hydrogen dioxide + peroxyacetic acid + octanoic acid	X3™	0-2	GH/N
	Oils	Clarified hydrophobic extract of neem oil (also classified by EPA as a biopesticide)	Triact® 70	4	GH/N	OHP, Inc.
			Petroleum oil	Suffoil-X™	4	GH/N
	Quaternary Ammonium	Quaternary Amines	Greenshield®	0	GH	BASF
			Didecyl dimethyl ammonium chloride	KleenGrow™	0	GH
Soaps	Potassium salts of fatty acids	Kopa™ Insecticidal Soap	12	GH/N	OHP, Inc.	
		potassium salts of fatty acids	M-Pede®	12	GH/N	Gowan Company
Resistance risk Unknown						
1+2	Thiophanate + Dicarboxamide	Thiophanate-methyl + Iprodione	26/36™	12	GH/N	Nufarm
1+14	Thiophanate + Thiadiazole	Thiophanate-methyl + Etridiazole	Banrot®	12	GH/N	ICL/Everiss
1+M 05	Thiophanate + Chloronitrile	Thiophanate-methyl + Chlorothalonil	Spectro® 90	12	GH/N	Nufarm
3+M 05	Demethylation inhibitor + Chloronitrile	Propiconazole + Chlorothalonil	Concert® II	12	N	Syngenta
7+3	SDHI + DMI	Pydiflumetofen + Difenconazole	Postiva™	12	GH/N	Syngenta
7+11	SDHI + Strobilurin	Boscalid + Pyraclostrobin	Pageant® Intrinsic™	12	GH/N	BASF
		Fluopyram + Trifloxystrobin	Broadform™	12	GH/N	ENVU
		Benzovindiflupyr + Azoxystrobin	Mural™	12	GH/N	Syngenta
		Fluxapyroxad + Pyraclostrobin	Orkestra™ Intrinsic®	12	GH/N	BASF
45+40	Triazolo-pyrimidylamines + Cinnamic Acid Amides	Ametoctradin + Dimethomorph	Orvego™	12	GH/N	BASF
9+12	Anilo-pyrimidine+ Phenylpyrrole	Cyprodinil + Fludioxinil	Palladium™	12	GH/N	Syngenta

* Depends on Greenhouse ventilation

** Greenhouse and/or nursery uses depend on the formulation.
Check labels for uses.

*Fungicides Modes of Action

- | | | |
|--|---|--|
| 1. Inhibition of tubulin formation in mitosis | 14. Cell peroxidation (proposed) | 49. Lipid homeostasis and transfer/storage |
| 2. MAP histidine-kinase in osmotic signal transduction, E3 | 17. 3-keto reductase during C4 demethylation | BM. Biologicals with multiple modes of action. |
| 3. DMI (DeMethylation Inhibitors) Demethylase in sterol biosynthesis | 19. Chitin synthase inhibition in cell wall development | BM 02. Microbial disrupters of pathogen cell membranes (Biologicals) |
| 4. Phenylamides-Affect RNA synthesis | 21. Quinone inside inhibitors (Qil) | M. Multi-site activity. Chemicals that act at several sites, which may differ among the group members. |
| 5. Inhibition of reductase and isomerase in sterol biosynthesis | 28. Affect cell membrane permeability, fatty acids (proposed) | NC. Unknown: <i>The mode of action cannot be placed within any other defense</i> |
| 7. Inhibitors of succinate-dehydrogenase (SDHs) and respiration | 40. Cell wall biosynthesis: cellulose synthase | P. Host plant defense induction. |
| 11. Quinone outside inhibitors (Qol) | 43. Delocalization of spectrin-like proteins | |
| 12. MAP histidine-kinase in osmotic signal transduction E2 | 45. Respiration Complex III: cytochrome bc1 (ubiquinone reductase) at Qo site | |

Explanation of Resistance Risk

This list is from the U.S. Environmental Protection Agency, in cooperation with the Fungicide Resistance Action Committee (FRAC). FRAC is a technical working group within the Global Crop Protection Federation (GCPF). More information on the Fungicide Resistance Action Committee and the Mode of Action Classification is available from: www.frac.info. Resistance risk categories were developed by FRAC. There are ways to estimate the potential for resistance development. The resistance risk is generally based on whether the fungicide mode of action (MOA) is single or multi-site. Single site MOA products have a higher resistance risk than multi site MOA products. The pathogen types targeted by the fungicides also are factors.

Fungicides should always be used by rotating MOA types. Users need to be especially careful not to rotate or alternate among fungicides in any one high resistance risk category. Follow resistance management instructions on product labels.

REFERENCE GUIDE for GREENHOUSE and NURSERY PRODUCTION PLANT GROWTH REGULATORS

***Use Site(s) Key: GH = Greenhouse N = Nursery

Plant Growth Regulators (PGRs)

(by Mode of Action Group and Class)

MOA Group*	Class	Activity Level**	Common Name	Trade Name	REI	Use Site(s)***	Company
1	Pyrimidine	Medium	Ancymidol	A-Rest®	12	GH/N	SePRO Corp.
	Quaternary Ammonium	Medium	Flurprimidol	Topflor®	12	GH/N	SePRO Corp.
			Chlormequat chloride	Altercel® <i>*formerly Cycocel</i>	12	GH	OHP, Inc.
	Hydrazide	Low	Daminozide	B-Nine®	12	GH/N	OHP, Inc.
	Triazole	High	Paclobutrazol	PAC O™* <i>*formerly Paczol®</i>	12	GH/N	OHP, Inc.
Bonzi®				12	GH/N	Syngenta	
			Uniconazole-p	Sumagic®	12	GH	Nufarm
2	Cyclohexaketone	Medium	Dikegulac-sodium	Atrimmec	4	GH/N	PBI Gordon Corp.
3	Fatty acid	Medium	Methyl esters of fatty acids	Off-Shoot-O	0	GH/N	Cochran Corp.
4	Gibberellin (GA)	High	Gibberellic acid (A3)	ProGibb® T&O	12	GH/N	Mycorrhizal Applications, LLC
	Synthetic Cytokinin/ Gibberellin	High	Cytokinin/ Gibberellic acid	Fascination®	4	GH	Nufarm
	Synthetic Cytokinin	High	N-(phenylmethyl)- IH-purine-6-amine	Configure®	12	GH	Fine Agrochemicals, LTD.
5	Organophosphorus	Medium	Ethephon	Flore brand Pistill	48 to 72	GH/N	Monterey Chemical
				Flore brand Ethephon	48 to 72	GH/N	Southern Agricultural Insecticides, Inc.
6	Rooting Hormones Synthetic Auxin		IBA	Hormodin®	0	GH/N	OHP, Inc.
			IBA + NAA	Dip'N Grow	0 to 24	GH/N	Dip'N Grow, Inc.

** PGR activity varies greatly depending on product class; e.g. the triazole class is very active. The low, medium and high ratings are guides to product activity. The higher the level of activity the more care must be taken when using.

Thank you to Dr. Joyce Latimer, Virginia Tech, for help in preparing the PGR chart.

*Plant Growth Regulators Modes of Action

1. Gibberellic Acid synthesis inhibitors
2. DNA synthesis inhibitor
3. Chemical pincher
4. Growth promoter
5. Ethylene generator
6. Rooting hormones
7. ABA abscisic acid
- UN. Unknown mode of action

REFERENCE GUIDE for GREENHOUSE and NURSERY PRODUCTION HERBICIDES

RESISTANCE MANAGEMENT

Herbicide rotation is just as important as the rotation of other pest control products. Herbicide mode of action (MOA) groups are listed by the Herbicide Resistance Action Committee (HRAC). Rotating MOAs on a regular basis is key to controlling weeds and maintaining the effectiveness of herbicides.

Please read and follow all label directions and precautions.

**Use Site(s) Key:

PO = post emergence

PR = pre emergence

SF = Soil fumigant

GH = registered for use in greenhouses

A = Annual Grasses

BW = Broadleaf Weeds

P = Perennials

MA = Most annuals

S = Sedges

WO = Certain Woody

Ornamentals

Herbicides

continued

(by Mode of Action Group and Class)

MOA Group*	Class	Common Name	Trade Name	REI	Use Site(s)**	Company
1	Aryloxyphenoxy propionate 'FOPs'	Fenoxaprop-p-ethyl	Acclaim® Extra	24	PO; A, P	ENVU
		Fluazifop-P-butyl	Fusilade® II	12	PO; A, P	Syngenta
	Cyclohexanedione 'DIMs'	Clethodim	Envoy Plus®	24	PO; A, P	Nufarm
		Sethoxydim	Segment™	12	PO; A, P	BASF
3	Pyridine	Dithiopyr	Dimension®	12	PR; A, BW	Corteva Agriscience
	Benzamide	Pronamide	Kerb®	24	PR/PO; A, BW	Corteva Agriscience
	Dinitroaniline	Pendimethalin	Pendulum® 2G, Pendulum AquaCap	24	PR; A, BW	BASF
			Corral®	24	PR; A, BW	ICL/Everiss
		Prodiamine	Barricade®	12	PR; A, BW	Syngenta
Benzoic acid	DCPA	Dacthal®	12	PR; A, BW	Amvac Chemical Corp.	
4	Pyridine carboxylic acid	Clopyralid	Lontrel®	12	PO; WO	Corteva Agriscience
5	Triazine	Simazine	Princep®	48*	PR; A, BW	Syngenta
6	Benzothiadiazinone	Bentazon	Basagran® T/O	48	PO; BW, S	BASF

*48 hrs listed as REI for Xmas trees

Herbicides

continued

(by Mode of Action Group and Class)

MOA Group*	Class	Common Name	Trade Name	REI	Use Site(s)**	Company
9	Glycine	Glyphosate	Roundup Pro®, QuikPro & PROMAX	4	PO; A, P, BW, GH	ENVU
10	Phosphinic acid	Glufosinate	Finale®, XL T&O	12	PO; MA, P, GH	BASF
14	Diphenylether	Oxyfluorfen	Goal®	24	PR; PO, A, BW	Dow Agriscience
	Oxadiazole	Oxadiazon	Ronstar®, FLO & G	12	PR; A, BW	ENVU
	N-phenylphthalimides	Flumioxazin	BroadStar®	12	PR; A, BW	Nufarm
SureGuard®, SC			12	PR; PO, A, BW	Nufarm	
15	Acetamide	Napropamide	Devrinol®	12-24	PR; A, BW	United Phosphorous
	Chloroacetamide	S-metolachlor	Pennant® Magnum	24	PR; A, BW	Syngenta
		Dimethenamid-P	Tower®	12	PR; A BW, S	BASF
20	Nitrile	Dichlobenil	Casoron®	12	PR; A, P	OHP, Inc.
21	Benzamide	Isoxaben	Gallery®	12	PR A, BW	Corteva Agriscience
22	Bipyridylum	Diquat	Reward®	24	PO; MA, P, GH	Syngenta
26	Unknown	Dazomet	Basamid®, G	24	SF; MA, P	Certis Biologicals
		Metam sodium	Vapam®, HL	48	SF; MA, P	Amvac Chemical Corp.
		Pelargonic and fatty acids	Scythe®	12	PO; MA, P, GH	Gowan Company
29	Alkylazines	Indaziflam	Marengo®	12	PR; A, GH, BW	ENVU
			Marengo®, G	12	PR; A, BW	ENVU
3+21	Dinitroaniline + Benzamide	Prodiamine + Isoxaben	Gemini®, G, SC	12	PR; A, BW	ICL/Everiss
14+3	Diphenylether + Dinitroaniline	Oxyfluorfen + Pendimethalin	OH2®	24	PR; A, BW	ICL/Everiss
14+3	Diphenylether + Dinitroaniline	Oxyfluorfen + Prodiamine	Biathlon®	24	PR; A, BW	OHP, Inc.

(by Mode of Action Group and Class)

MOA Group*	Class	Common Name	Trade Name	REI	Use Site(s)**	Company
14+3	N-phenylphthalimides + Dinitroaniline	Flumioxazin + Prodiamine	Fuerte®	12	PR; A, BW	OHP, Inc.
		Oxyfluorfen + Orzalin	Rout	24	PR; A, BW	ICL/ Everris
14+3	Oxadiazole + Dinitroaniline	Oxadiazon + Prodiamine	RegalStar® II	12	PR; A, BW	Regal Chemical Co.
		Oxyfluorfen + Pendimethalin	OH2	24	PR; A, BW	ICL/ Everris
14+14	Diphenylether + Oxadiazole	Oxyfluorfen + Oxadiazon	Regal O-O®	24	PR; A, BW	Regal Chemical Co.
15+3	Chloroacetamide + Dinitroaniline	Dimethenamid-P + Pendimethalin	Freehand®	12	PR; A, BW, S	BASF
21+3	Benzamide + Pyridine	Isoxaben + Dithiopyr	Fortress®	12	PR; A, BW	OHP, Inc.
21+3	Benzamide + Dinitroaniline	Isoxaben + Trifluralin	Snapshot® TG	12	PR; A, BW	Corteva Agriscience
22+9	Glycine + Bipyridylum	Glyphosate + Diquat	Razor Burn®	4	PR, A BW	Nufarm
M	Soaps	Ammonium Nonanoate	Axxe®	4	PO; GH	BioSafe Systems
		Caprylic + Capric Acid	FireWorxx™	24	PO; GH	OHP, Inc.

*Herbicides Modes of Action

1. Inhibition of acetyl CoA carboxylase (ACCase)
2. Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS)
3. Microtubule assembly inhibition
4. Action like indole acetic acid (synthetic auxins)
5. Inhibition of photosynthesis at photosystem II (C1)**
6. Inhibition of photosynthesis at photosystem II (C3)**
7. Inhibition of photosynthesis at photosystem II (C2)**
9. Inhibition of EPSP synthase
10. Inhibition of glutamine synthetase
12. Bleaching: inhibition of carotenoid biosynthesis at the phytoene desaturase step (PDS)
14. Inhibition of protoporphyrinogen oxidase (PPO)
15. Inhibition of VLCFAs (Inhibition of cell division)
20. Inhibition of cell wall (cellulose) synthesis
21. Inhibition of cell wall (cellulose) synthesis
22. Photosystem -I- electron diversion
26. Unknown
29. Inhibit cellulose biosynthesis
- M. Miscellaneous

**Subclasses with different binding behavior at the binding protein D1, or different classes

*This mode of action listing is based on the Herbicide Resistance Action Committee (HRAC) and the Weed Science Society of America (WSSA). More information on the Herbicide Resistance Action Committee and the Mode of Action Classification is available from: www.hracglobal.com.

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