CHEMICAL CLASS CHART

GREENHOUSE & NURSERY PRODUCTION

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Volume XXIV

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	Bayer Environmental Science
		Methiocarb	Mesurol®	24	GH/N	Gowan Company
1B	Organophosphates	Acephate	Orthene® TT&O	24	GH/N	Amvac Chemical Corp.
			Orthene® TR	24	GH	BASF
		Chlorpyrifos	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	Bayer Environmental Science
3	Pyrethroids	Bifenthrin	Talstar®	12	GH/N**	FMC Corp.
			OnyxPro®	12	N	FMC Corp.
			Attain® TR	12	GH	BASF
		Cyfluthrin	**Decathlon®**	12	GH/N	**OHP, Inc.**
		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
4A	Neonicotinoids	Acetamiprid	TriStar®	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	Bayer Environmental Science
		Thiamethoxam	Flagship®	12	GH/N	Syngenta
4D	Butenolides	Flupyradifurone	Altus™	4	GH/N	Bayer Environmental Science
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	Pyridine - Insect Growth Regulators	Pyriproxyfen	Distance®	12	GH/N	Nufarm
			Fulcrum®	12	GH/N	**OHP, Inc.**
9A	Pyridine azomethines	Pymetrozine	Endeavor®	12	GH/N	Syngenta
9B	Pyridine azomethines	Pyrifluquinazon	Rycar®	12	GH	SePRO Corp.
9D	TRPV channel modulators	Afidopyropen	Ventigra™	12	GH/N	BASF
10A	Tetrazines	Clofentezine	**Notavo®**	12	GH/N	**OHP, Inc.**
	Thiazolidinones	Hexythiazox	Hexygon® IQ	12	GH/N	Gowan Company
10B	2, 4 - Diphenyloxzoline Derivatives	Etoxazole	TetraSan®	12	GH/N	Nufarm
			Beethoven™ TR	4-24*	GH	BASF
11	Biopesticides	*Bacillus thuringiensis* Kurstaki	DiPel® Pro DF	4	GH/N	Nufarm
		Bacillus thuringiensis Israelensis	Gnatrol®	4	GH/N	Nufarm
13	Pyrroles	Chlorfenapyr	Pylon®	12	GH	BASF
15	Benzoylureas - Insect Growth Regulators	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	Cyromazine - Insect Growth Regulators	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
18	Diacylhydrazines	Tebufenozide	Confirm®	4	N	Gowan Company
		Methoxyfenozide	Intrepid®	4	GH/N	Corteva Agriscience
20A	Trifluoromethyl Aminohydrazone	Hydramethylnon	Amdro® Pro	12	N	BASF
20B	Napthoquinone Derivatives	Acequinocyl	**Shuttle® O**	12	GH/N	**OHP, Inc.**
20D	Carbazates	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
22B	Semicarbazone	Metaflumizone	Siesta™	12	GH/N	BASF
23	Tetronic acids	Spiromesifen	Savate™	12	GH/N	Bayer Environmental Science
	Tetramic acids	Spirotetramat	Kontos®	0-24	GH/N	Bayer Environmental Science
25A	Beta-ketonitrile	Cyflumetofen	Sultan™	12	GH/N	BASF
28	Anthranillic diamide	Cyantraniliprole	Mainspring®	4	GH/N	Syngenta
		Chlorantraniliprole	Acelepyrn®	4	GH/N	Syngenta
	Diamide	Cyclaniliprole	**Sarisa®**	4	GH/N	**OHP, Inc.**
29	Pyridine carboxamides	Flonicamid	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	Marrone Bio Innovations
		Burkholderia spp. strain A39	Venerate® XC	4	GH/N	Marrone Bio Innovations
UNF	Biopesticide: Fungal Agents	*Beauveria bassiana*	BotaniGard®	4	GH/N	BioWorks, Inc.
			BioCeres® WP	4	GH/N	Biosafe Systems
			Mycotrol® O	4	GH/N	BioWorks, Inc.
		Strain PPRI 5339	Velifer®	12	GH	BASF
		Isaria fumosorosea Apopka Strain 97(ATCC20874)	**Ancora®**	4	GH/N	**OHP, Inc.**
UNE	Oils	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.

Insecticides / Miticides

continued

MOA Combination Products

MOA Group*	Class	Common Name	Trade Name	REI	Use Site(s)**	Company
UNM	Soaps	Potassium salts of fatty acids	AllPro® Insecticidal Soap	12	GH/N	Value Garden Supply
			Kopa™ Insecticidal Soap	12	GH/N	**OHP, Inc.**
			M-Pede®	12	GH/N	Gowan Company
		Mineral oil	Ultra-Pure™ Oil	4	GH/N	BASF
			Suffoil-X™	4	GH/N	BioWorks, Inc.
3+UNE	Pyrethrins + Oils	Pyrethrins + Canola Oil	**Pycana®**	12	GH/N	**OHP, Inc.**
	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
3+4A	Pyrethroid + Neonicotinoid	Cyfluthrin + Imidacloprid	**Discus® L**	12	GH/N	**OHP, Inc.**
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	Cyclaniliprole + Flonicamid	**Pradia®**	12	GH/N	**OHP, Inc.**

*Insecticides / Miticides Modes of Action

1. Acetylcholinesterase inhibitors. Inhibition of the enzyme acetylcholinesterase, interrupting the transmission of nerve impulses
2. GABA-gated chloride channel blockers: Interferes with GABA receptors of insect neurons, leading to repetitive nervous discharges
3. 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.
4. Nicotinic acetylcholine receptor (nAChR) agonists. Binds to nicotinic acetylcholine receptor disrupting nerve transmission.
5. Nicotine acetylcholine receptor allosteric modulators- Site I
6. Glutamate-gated chloride channel allosteric modulators
7. Juvenile hormone mimics (Insect growth regulator): Mimic juvenile hormones, which prevent molting from the larval to the adult stage.
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. Energy metabolism
21. Mitochondrial complex I electron transport inhibitors
22. Voltage-dependent sodium channel blockers: Nerve action
23. Inhibitors of acetyl CoA carboxylase
25. Mitochondrial complex II electron transport inhibitors
28. Ryanodine receptor modulators
29. Chordotonal organ Modulators – undefined target site: Nerve

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	Bayer Environmental Science
Resistance risk **Medium** to **High**						
3	Imidazoles	Triflumizole	**Terraguard®**	12	GH/N	**OHP, Inc.**
	Pyrimidines	Fenarimol	Banner® MAXX® II	12	N	Gowan Company
	Triazoles (includes conazole)	Propiconazole	Eagle® 20 EW	12	N	Syngenta
		Myclobutanil	Avelyo™	24	GH/N	Corteva Agriscience
		Mefentrifluconazole	Trinity®	12	GH/N	BASF
		Triticonazole	Trinity® TR	12	GH/N	BASF
				4-12	GH	BASF
DMI-fungicides (DeMethylation Inhibitors) Resistance risk **Medium**						
4	Acylamines	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	Bayer Environmental Science
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	Bayer Environmental Science
	Methoxy-acrylates	Azoxystrobin	Heritage®	4	GH/N	Syngenta
	Methoxy-carbamates	Pyraclostrobin	Empress™ Intrinsic	12	GH/N	BASF
	Imidazolinones	Fenamidone	Fenstop®	12	GH	Gowan Company
		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.**
AH fungicides (Aromatic Hydrocarbons) Resistance risk **Low** to **Medium**			Truban®	12	GH/N	ICL Specialty Fertilizers
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.**
QiI-fungicide (Quinone inside inhibitor) Resistance risk **Medium** to **High**						
28	Carbamates	Propamocarb	Banol®	24	GH/N	Bayer Environmental Science
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 Corporation
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	Biopesticide	*Swinglea glutinosa*	EcoSwing™	4	GH/N	Gowan Company
Resistance risk **Unknown**						
BM 02	*Bacillus* sp. and the fungicidal lipopeptides produced	*Bacillus amyloliquefaciens* strain D747	**Triathlon® BA**	4	GH/N	**OHP, Inc.**
		Bacillus subtilis GB03	Companion®	4	GH/N	Growth Products
		Bacillus subtilis MBI600	Subtilex® NG	4	GH	BASF
		Bacillus subtilis QST713	Cease®	4	GH/N	BioWorks, Inc.
		Bacillus amyloliquefaciens F727	Stargus™	4	GH/N	Marrone Bio Innovations
	Biopesticide	*Streptomyces lydicus* WYEC108	Actinovate® SP	4	GH/N	Mycorrhizal Applications, LLC
	Polypeptide (lectin)	*Trichoderma asperellum* (ICC 012) *Trichoderma gamsii* (ICC 080)	Obtego™	4	GH/N	SePRO Corp.
	Biopesticide	*Trichoderma harzianum* T22	PlantShield® HC	0	GH/N	BioWorks, Inc.
			RootShield®	0	GH/N	BioWorks, Inc.
		Trichoderma harzianum T22 + *Trichoderma virens* 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			**Kalmor®**	24	GH/N	**OHP, Inc.**
Resistance risk **Low**		Cuprous Oxide	Nordox 75WG	12	GH/N	Nordox AS
M 03	Dithiocarbamates and relatives	Mancozeb	Dithane®	24	GH/N	Corteva Agriscience
			Fore®	24	GH/N	Corteva Agriscience
		Mancozeb + Copper Hydroxide	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)			AllPro® Exotherm Termil	*	GH	Value Garden Supply
Resistance risk **Low**					* Depends on greenhouse ventilation	
P 05	Ethanol extract	*Reynoutria sachalinensis*	Regalia®	4	GH/N	Marrone Bio Innovations
Resistance risk **Unknown**						
P 07	Ethyl Phosphonates	Fosetyl-Al	Aliette®	12	GH/N	Bayer Environmental Science
			[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	*Ulocladium oudemansii* (U3 Strain)	BotryStop™	4	GH/N	BioWorks
			Actino Iron	4	GH/N	Mycorrhizal Applications, LLC
	Bicarbonate	Potassium bicarbonate	Carb-O-Nator™	4	GH/N	Certis USA, LLC
			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	Phyton Corp.
	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	BioWorks, Inc.
	Quaternary Ammonium	Quaternary Amines	Greenshield®	0	GH	BASF
		Didecyl dimethyl ammonium chloride	KleenGrow™	0	GH	Pace 49
	Soaps	Potassium salts of fatty acids	**Kopa™ Insecticidal Soap**	12	GH/N	**OHP, Inc.**
Resistance risk **Unknown**		potassium salts of fatty acids	M-Pede®	12	GH/N	Gowan Company
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 Specialty Fertilizers
1+M 05	Thiophanate + Chloronitrile	Thiophanate-methyl + Chlorothalonil	Spectro® 90	12	GH/N	Nufarm
3+11	Demethylation Inhibitors (DMI fungicides) + Strobilurins	Triadimefon + Trifloxystrobin		12	GH/N	Bayer Environmental Science
3+M 05	Demethylation inhibitor + Chloronitrile	Propiconazole + Chlorothalonil	Concert® II	12	N	Syngenta
7+11	SDHI + Strobilurin	Boscalid + Pyraclostrobin	Pageant® Intrinsic™	12	GH/N	BASF
		Fluopyram + Trifloxystrobin	Broadform™	12	GH/N	Bayer Environmental Science
		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
2. MAP histidine-kinase in osmotic signal transduction, E3
3. DMI (DeMethylation Inhibitors) Demethylase in sterol biosynthesis
4. Phenylamides-Affect RNA synthesis
5. Inhibition of reductase and isomerase in sterol biosynthesis
7. Inhibitors of succinate-dehydrogenas (SDHIs) and respiration
11. Quinone outside inhibitors (Qol)
12. MAP histidine-kinase in osmotic signal transduction E2
14. Cell peroxidation (proposed)
17. 3-keto reductase during C4 demethylation
19. Chitin synthase inhibition in cell wall development
21. Quinone inside inhibitors (Qil)
28. Affect cell membrane permeability, fatty acids (proposed)
40. Cell wall biosynthesis: cellulose synthase
43. Delocalization of spectrin-like proteins
45. Respiration Complex III: cytochrome bc1 (ubiquinone reductase) at Qo site
49. Lipid homeostatis and transfer/storage

BM. Biologicals with multiple modes of action.

BM 02. Microbial disrupters of pathogen cell membranes (Biologicals)

M. Multi-site activity. Chemicals that act at several sites, which may differ among the group members.

NC. Unknown: *The mode of action cannot be placed within any other defense*

P. Host plant defense induction.

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.
			Flurprimidol	Topflor®	12	GH/N	SePRO Corp.
	Quaternary Ammonium	Medium	Chlormequat chloride	**Altercel®**	12	GH/N	**OHP, Inc.**
	Hydrazide	Low	Daminozide	**B-Nine®**	24	GH/N	**OHP, Inc.**
	Triazole	High	Paclobutrazol	**PAC O™*** **formerly* Paczol®	12	GH/N	**OHP, Inc.**
				Bonzi®	12	GH/N	Syngenta
			Uniconazole-p	Sumagic®	12	GH	Nufarm
2	Cyclohexaketone	Medium	Dikegulac-sodium	Atrimmec	12	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-(phenylmethly)-IH-purine-6-amine	Configure®	12	GH	Fine Agrochemicals, LTD.
5	Organophosphorus	Medium	Ethephon	Florel brand Pistill	48 to 72	GH/N	Monterey Chemical
				Florel 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
A = Annual Grasses
S = Sedges

PR = pre emergence
BW = Broadleaf Weeds
WO = Certain Woody Ornamentals

SF = Soil fumigant
P = Perennials

GH = registered for use in greenhouses
MA = Most annuals

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	Bayer Environmental Science
		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
2	Imidazolinone	Imazaquin	Image®	12	PR/PO; A, P, BW, S	BASF
3	Pyridine	Dithiopyr	Dimension®	12	PR; A, BW	Corteva Agriscience
	Benzamide	Pronamide	Kerb®	24	PR/PO; A, BW	Corteva Agriscience
	Dinitroaniline	Pendimethalin	Pendulum®	24	PR; A, BW	BASF
			Corral®	24	PR; A,BW	ICL Specialty Fertilizers
		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®	12	PR; A, BW	Syngenta
6	Benzothiadiazinone	Bentazon	Basagran® T/O	48	PO; BW, S	BASF

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®	4	PO; A, P, BW, GH	Bayer Environmental Science
			Refuge™	12	PO; A, P, BW, GH	Syngenta
10	Phosphinic acid	Glufosinate	Finale®	12	PO; MA, P, GH	Bayer Environmental Science
12	Pyridazinone	Norflurazon	Predict®	12	PR; A, BW	Syngenta
14	Diphenylether	Oxyfluorfen	Goal®	24	PR; PO, A, BW	Nufarm
	Oxadiazole	Oxadiazon	Ronstar®	12	PR; A, BW	Bayer Environmental Science
	N-phenylphthalimides	Flumioxazin	BroadStar®	12	PR; A, BW	Nufarm
			SureGuard®	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	Bipyridylium	Paraquat	Gramoxone® Inteon	12 to 24	PO; MA, P, BW	Syngenta
		Diquat	Reward®	24	PO; MA, P, GH	Syngenta
26	Unknown	Dazomet	Basamid®	24	SF; MA, P	Certis USA, LLC
		Metam	Vapam®	48	SF; MA, P	Amvac Chemical Corp.
		Pelargonic acid	Scythe®	12	PO; MA, P, GH	Gowan Company
29	Alkylazines	Indaziflam	Marengo®	12	PR; A, GH, BW	Bayer Environmental Science
			Marengo® G	12	PR; A, BW	Bayer Environmental Science
3+21	Dinitroaniline + Benzamide	Prodiamine + Isoxaben	Gemini® G	12	PR; A, BW	ICL Speciality Fertilizers
14+3	Diphenylether + Dinitroaniline	Oxyfluorfen + Pendimethalin	OH2®	24	PR; A, BW	ICL Speciality Fertilizers
14+3	Diphenylether + Dinitroaniline	Oxyfluorfen + Prodiamine	**Biathlon®**	24	PR; A, BW	**OHP, Inc.**

Herbicides

continued

(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.**
14+3	Oxadiazole + Dinitroaniline	Oxadiazon + Prodiamine	RegalStar® II	12	PR; A, BW	Regal Chemical Co.
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
M	Soaps	Ammonium Nonanoate	Axxe®	24	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.

Notes

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