

CHEMICAL CLASS CHART



GREENHOUSE &
NURSERY PRODUCTION

June 2022

Volume XXIV

Insecticides/Miticides
Fungicides
Herbicides
Plant Growth Regulators



An American Vanguard Company

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 | Mesuro® | 24 | GH/N | Gowan Company |
| 1B | Organophosphates | Acephate | Orthene® TT&O | 24 | GH/N | Amvac Chemical Corp. |
| | | Chlorpyrifos | 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 | 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® Aquaflo | 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 |
| | | Botanicals | Pyrethrins | Pyrethrum® TR | 12 | GH |
| | PyGanic® | | | 12 | GH/N | Mycorrhizal Applications, LLC |

* Depends on Greenhouse ventilation

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

*** Greenhouse roses only

Insecticides / Miticides

continued

(by Mode of Action Group and Class)

| MOA Group* | Class | Common Name | Trade Name | REI | Use Site(s)** | Company |
|------------|---|---|----------------------------------|-------|---------------|-----------------------------|
| | Neonicotinoids | Acetamiprid | TriStar® | 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 | <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 | 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 | Acelepym® | 4 | GH/N | Syngenta |
| | Diamide | Cyclaniliprole | Sarisa® | 4 | GH/N | OHP, Inc. |
| 29 | Pyridine carboxamides | 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 | Marrone Bio Innovations |
| | | Burkholderia spp. strain A39 | Venerate® XC | 4 | GH/N | Marrone Bio Innovations |
| UNF | Biopesticide: Fungal Agents | <i>Beauveria bassiana</i> | 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 |
| | | <i>Isaria fumosorosea</i> 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.

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. |
| | | Mineral oil | M-Pede® | 12 | GH/N | Gowan Company |
| | | | 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. |
| | | | Truban® | 12 | GH/N | ICL Specialty Fertilizers |
| AH fungicides (Aromatic Hydrocarbons) Resistance risk Low to Medium | | | | | | |
| 17 | Hydroxylanilides | 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 | 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 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 | Marrone Bio Innovations |
| | 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 | 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) Resistance risk Low | | | AllPro® Exotherm Termil | * | GH | Value Garden Supply |
| | | | | | | * Depends on greenhouse ventilation |
| P 05 Resistance risk Unknown | Ethanol extract | <i>Reynoutria sachalinensis</i> | Regalia® | 4 | GH/N | Marrone Bio Innovations |
| 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 | <i>Ulocladium oudemansii</i> (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 |
| | | | 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 |
| | 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 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 |
| | | | Broadform™ | 12 | GH/N | Bayer Environmental Science |
| | | | Mural™ | 12 | GH/N | Syngenta |
| | | | Fluxapyroxad + Pyraclostrobin | 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. |
| | | | Flurprimidol | Topflor® | 12 | GH/N | SePRO Corp. |
| | Quaternary Ammonium | Medium | Chlormequat chloride | Altercel ® | 12 | GH/N | OHP, Inc. |
| | | | Daminozide | B-Nine ® | 24 | GH/N | OHP, Inc. |
| | | | Paclobutrazol | PAC O ™* *formerly Paczol® | 12 | GH/N | OHP, Inc. |
| | | 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-(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 | 4. Growth promoter | 7. ABA abscisic acid |
| 2. DNA synthesis inhibitor | 5. Ethylene generator | UN. Unknown mode of action |
| 3. Chemical pincher | 6. Rooting hormones | |

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 | Bipyridylum | 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. |

(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.

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CCC. 06/2022



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