# Pesticide Families and Mode of Action and Resistance Management

# Why Resistance Management?

- Less Reliance on Broad Spectrum Pesticides
- Modes of Action are very specific which helps beneficial species but might allow for resistance to occur faster.
- Loss of older chemistry and less options to rotate to or use.
- Less R&D by companies fewer new chemistries available to combat new resistant species.
- To much reliance on specific MOA.

# Pesticide Resistance Management Labeling

- Mandatory in Canada
- First published in a PR-Notice in 2001 suggesting Registrants include resistance management wording and adding Mode of Action Numbers to labeling.
- Standardizes format for MOA numbering on labels.
- Originally included chart of all pesticide types of MOA but now references web sites.

# Where to Find MOA Charts

- HRAC http://www.hracglobal.com/
- IRAC http://www.irac-online.org/
- FRAC http://www.frac.info/frac/menu.htm

Register Login

HRAC

# Herbicide Resistance Action Committee

Home | Overview | Publications | Regional | Books | Links | Contacts | Glossary

Search ○ Web ◉ Site

Partnership in the Management of Resistance
La prevensión y el control de las resistencias
Confirming Resistance

December 8, 2009

The Herbicide Resistance Action Committee (HRAC) is an international body founded by the agrochemical industry as part of the GCPF organization.

**The aims of HRAC have the general purpose of supporting a cooperative approach to the management of herbicide resistance.**

HRAC is keen to support the establishment of a worldwide herbicide resistance database. With this aim in mind, HRAC is supporting the worldwide survey of resistant weeds initiated by the Weed Science Society of America. The International Survey of Herbicide-Resistant Weeds is being conducted by Ian Heap and is located at http://www.weedscience.com/



Home | Links | Contacts | Glossary

| HRAC Group | Mode of Action | Chemical Family | Active Ingredient | WSSA Group |
|---|---|---|---|---|
| A | Inhibition of acetyl CoA carboxylase (ACCase) | Aryloxyphenoxy-propionate 'FOPs' | clodinafop-propargyl<br>cyhalofop-butyl<br>diclofop-methyl<br>fenoxaprop-P-ethyl<br>fluazifop-P-butyl<br>haloxyfop-R-methyl<br>propaquizafop<br>quizalofop-P-ethyl | 1 |
| | | Cyclohexanedione 'DIMs' | alloxydim<br>butroxydim<br>clethodim<br>cycloxydim<br>*profoxydim*<br>sethoxydim<br>*tepraloxydin*<br>tralkoxydim | |
| | | Phenylpyrazoline 'DEN' | pinoxaden | |
| B | Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS) | Sulfonylurea | amidosulfuron<br>azimsulfuron<br>bensulfuron-methyl<br>chlorimuron-ethyl<br>chlorsulfuron<br>cinosulfuron<br>cyclosulfamuron<br>ethametsulfuron-methyl<br>ethoxysulfuron<br>flazasulfuron<br>flupyrsulfuron-methyl-Na<br>foramsulfuron<br>halosulfuron-methyl<br>*imazosulfuron*<br>iodosulfuron<br>mesosulfuron<br>metsulfuron-methyl<br>nicosulfuron<br>*oxasulfuron* | 2 |

# IRAC

Insecticide Resistance Action Committee

*Resistance Management for Sustainable Agriculture and Improved Public Health*

username password Go

## Country Groups





Next Event:

>> Indianapolis, USA, December 13-17, 2009
Entomological Society of America

Full Diary

Help us help you:

Which new eTool would you like to see next?

- ○ eForum (Discussion)
- ○ eLibrary (Bookmarks)
- ○ eNetwork (Contacts)

Sponsors

FMC syngenta DUPONT Chemtura Bayer CropScience

### Latest News

**IRAC holds 44th IRAC International Conference**

The 44th meeting of IRAC International was held at the end of March/beginning of April and consisted of a mixture of concurrent IRAC working group meetings and reviews, a meeting of the Executive Committee, IRAC España and an international session which included presentations from local Spanish experts. The meeting also was an opportunity to celebrate the 25th anniversary of the formation of IRAC and was arguably the most successful ever with an attendance of 45 international delegates....read more

**New country groups for France and Argentina on the horizon**

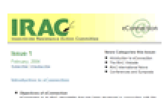
Strong interest has been shown in forming new IRAC Country Groups in France and Argentina. Discussions are under way and potential members have been contacted to determine interest

**Try the new eTool: IRAC eMethods**

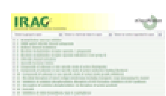
A new online tool called eMethods is now available on the IRAC website. This makes it easier to select the appropriate susceptibility test method taking account of pest, life stage and MOA. The plan is to extend this to include other non-IRAC methods for reference where IRAC methods are not yet available

### eTools

IRAC are in the process of developing a suite of eTools to help in the communication and education of good IRM practices. Availble so far is eConnection, the quarterly IRAC Newsletter and eClassfication which provides quick access into the IRAC MoA Classifcation scheme through a series of drop down menus. Links to both eTools are given below.



eConnection



eClassification

>>Latest issue of eConnection<<

### MoA Resources

A full listing of all the Mode of Action documents can be found via the link at the bottom of the panel.

- Acaricide MOA Poster Aug 09
- General MOA Poster (2007)
- Lepidoptera MOA Poster Oct 09
- MoA Structures Poster (v2.7) Oct 2009
- Sucking Pest MoA Poster v5.9 Sept 09
- Whitefly MOA Poster (2007)

Full Listing of IRAC MoA Documents

# IRAC Mode of Action Classification v 6.3, July 2009 [1]

| *Main Group and Primary Site of Action* | Chemical Sub-group or exemplifying Active Ingredient | Active Ingredients |
|---|---|---|
| **1*** **Acetylcholinesterase (AChE) inhibitors** Nerve action {Strong evidence that action at this protein is responsible for insecticidal effects} * *Please see footnotes for further information on the use of compounds between sub-groups* | **1A** Carbamates | Alanycarb, Aldicarb, Bendiocarb, Benfuracarb, Butocarboxim, Butoxycarboxim, Carbaryl, Carbofuran, Carbosulfan, Ethiofencarb, Fenobucarb, Formetanate, Furathiocarb, Isoprocarb, Methiocarb, Methomyl, Metolcarb, Oxamyl, Pirimicarb, Propoxur, Thiodicarb, Thiofanox, Triazamate,Trimethacarb, XMC, Xylylcarb |
| | **1B** Organophosphates | Acephate, Azamethiphos, Azinphos-ethyl, Azinphos-methyl, Cadusafos, Chlorethoxyfos, Chlorfenvinphos, Chlormephos, Chlorpyrifos, Chlorpyrifos-methyl, Coumaphos, Cyanophos, Demeton-S-methyl, Diazinon, Dichlorvos/ DDVP, Dicrotophos, Dimethoate, Dimethylvinphos, Disulfoton, EPN, Ethion, Ethoprophos, Famphur, Fenamiphos, Fenitrothion, Fenthion, Fosthiazate, Heptenophos, Imicyfos, Isofenphos, Isopropyl *O*-(methoxyaminothio-phosphoryl) salicylate, Isoxathion, Malathion, Mecarbam, Methamidophos, Methidathion, Mevinphos, Monocrotophos, Naled, Omethoate, Oxydemeton-methyl, Parathion, Parathion-methyl, Phenthoate, Phorate, Phosalone, Phosmet, Phosphamidon, Phoxim, Pirimiphos-methyl, Profenofos, Propetamphos, Prothiofos, Pyraclofos, Pyridaphenthion, Quinalphos, Sulfotep, Tebupirimfos, Temephos, Terbufos, Tetrachlorvinphos, Thiometon, Triazophos, Trichlorfon, Vamidothion |
| **2** **GABA-gated chloride channel antagonists** Nerve action {Strong evidence that action at this protein is responsible for insecticidal effects} | **2A** Cyclodiene organochlorines | Chlordane, Endosulfan |
| | **2B** Phenylpyrazoles (Fiproles) | Ethiprole, Fipronil |
| **3*** | **3A** | |

# Lepidoptera Insecticide Mode of Action Classification:

## A key to effective insecticide resistance management

IRAC

Insecticide Resistance Action Committee

www.irac-online.org

### Introduction and background

The agrochemical industry has developed a broad range of very effective insecticides for the control of lepidopteran pests. Unfortunately, as a consequence of the misuse or overuse of these insecticides, many species have developed resistance. Populations of *Plutella xylostella*, for example, have developed resistance to virtually every insecticide used against them. Additionally, there are numerous other species prone to resistance development. In recent years the industry has worked especially hard to develop new types of insecticides with novel modes of action, but this process is becoming ever harder and more costly. It is therefore vital that effective insecticide resistance management (IRM) strategies are implemented, to ensure that resistance does not develop to these new compounds, or to older chemistries that are still effective.

In order to help prevent or delay the incidence of resistance, IRAC promotes the use of a Mode of Action (MoA) classification of insecticides in effective and sustainable IRM strategies. Available insecticides are allocated to specific groups, based on their target site, as described below. By using sequences or alternations of insecticides from different MoA classes, resistance is less likely to occur. Available at the IRAC website www.irac-online.org, this IRAC MoA classification list provides farmers, growers, advisors, extension staff, consultants and crop protection professionals with a guide to the selection of insecticides in IRM programs.

### Effective IRM strategies: Sequences or alternations of MoA

Effective insecticide resistance management (IRM) strategies seek to minimise the selection of resistance to any one type of insecticide. In practice, alternations, sequences or rotations of compounds from different MoA groups provide sustainable and effective IRM.

Example:

MoA w → MoA x → MoA y → MoA z → MoA w → MoA x

Sequence of insecticides through season

Applications are often arranged into MoA spray windows or blocks that are defined by the stage of crop development and the biology of the Lepidopteran species of concern. Local expert advice should always be followed with regard to spray windows and timing. Several sprays may be possible within each spray window, but it is generally essential that successive generations of the pest are not treated with compounds from the same MoA group. Metabolic resistance mechanisms may give cross-resistance between MoA groups; where this is known to occur, the above advice should be modified accordingly.

### Nerve and Muscle Targets

Most current insecticides act on nerve and muscle targets. Insecticides that act on these targets are generally fast acting.

**Group 1 Acetylcholinesterase (AChE) inhibitors**
Inhibit AChE, causing hyperexcitation. AChE is the enzyme that terminates the action of the excitatory neurotransmitter acetylcholine at nerve synapses.
*1A* Carbamates (e.g. Methomyl, Thiodicarb) *1B* Organophosphates (e.g. Chlorpyrifos)

**Group 2 GABA-gated chloride channel antagonists**
Block the GABA-activated chloride channel, causing hyperexcitation and convulsions. GABA is the major inhibitory neurotransmitter in insects.
2A Cyclodiene Organochlorines (e.g. Endosulfan) *2B* Phenylpyrazoles (e.g. Fipronil)

**Group 3 Sodium channel modulators**
Keep sodium channels open, causing hyperexcitation and, in some cases, nerve block. Sodium channels are involved in the propagation of action potentials along nerve axons.
*3A* Pyrethrins, Pyrethroids (e.g. Cypermethrin, λ-Cyhalothrin)

**Group 4 Nicotinic acetylcholine receptor (nAChR) agonists**
Mimic the agonist action of acetylcholine at nAChRs, causing hyperexcitation. Acetylcholine is the major excitatory neurotransmitter in the insect central nervous system.
*4A* Neonicotinoids (e.g. Acetamiprid, Thiacloprid, Thiamethoxam)

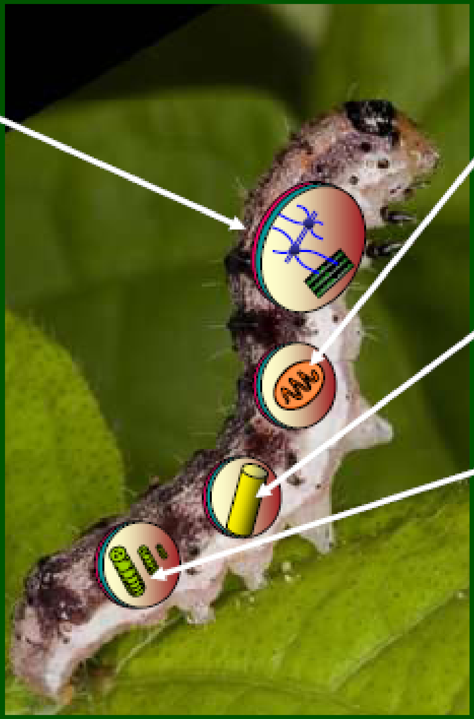
**Group 5 Nicotinic acetylcholine receptor (nAChR) allosteric modulators**
Allosterically activate nAChRs, causing hyperexcitation of the nervous system. Acetylcholine is the major excitatory neurotransmitter in the insect central nervous system.
Spinosyns (e.g. Spinosad, Spinetoram)

**Group 6 Chloride channel activators**
Allosterically activate glutamate-gated chloride channels (GluCls), causing paralysis. Glutamate is an important inhibitory neurotransmitter in insects.
Avermectins, Milbemycins (e.g. Abamectin, Emamectin Benzoate)

**Group 14 Nicotinic acetylcholine receptor (nAChR) blockers**
Block the nAChR ion channel, resulting in nervous system block and paralysis. Acetylcholine is the major excitatory neurotransmitter in the insect central nervous system.
Bensultap, Cartap

**Group 22 Voltage dependent sodium channel blockers**
Block sodium channels, causing nervous system shutdown and paralysis. Sodium channels are involved in the propagation of action potentials along nerve axons.
22A Indoxacarb 22B Metaflumizone

**Group 28 Ryanodine receptor modulators**
Activate muscle ryanodine receptors, leading to contraction and paralysis. Ryanodine receptors mediate calcium release into the cytoplasm from intracellular stores.
Diamides (e.g. Chlorantraniliprole, Flubendiamide)



### Respiration Targets

Mitochondrial respiration produces ATP, the molecule that energizes all vital cellular processes. In mitochondria, an electron transport chain uses the energy released by oxidation to charge a proton gradient battery that drives ATP synthesis. Several insecticides are known to interfere with mitochondrial respiration by the inhibition of electron transport and/or oxidative phosphorylation. Insecticides that act on individual targets in this system are generally fast to moderately fast acting.

**Group 13 Uncouplers of oxidative phosphorylation via disruption of the proton gradient**
Protonophores that short-circuit the mitochondrial proton gradient so that ATP can not be synthesized.
Chlorfenapyr

**Group 21 Mitochondrial complex I electron transport inhibitors**
Inhibit electron transport complex I, preventing the utilization of energy by cells.
21A Tolfenpyrad

### Midgut Targets

Lepidopteran-specific microbial toxins that are sprayed or expressed in transgenic crops.

**Group 11 Microbial disruptors of insect midgut membranes**
Protein toxins that bind to receptors on the midgut membrane and induce pore formation, resulting in ionic imbalance and septicemia.
Bacillus thuringiensis, Bacillus sphaericus

### Growth and Development Targets

Insect development is controlled by the balance of two principal hormones: juvenile hormone and ecdysone. Insect growth regulators act by mimicking one of these hormones or by directly affecting cuticle formation/deposition or lipid biosynthesis. Insecticides that act on individual targets in this system are generally slowly to moderately slowly acting.

**Group 7 Juvenile hormone mimics**
Applied in the pre-metamorphic instar, these compounds disrupt and prevent metamorphosis.
*7B* Juvenile hormone analogues (e.g. Fenoxycarb)

**Group 15 Inhibitors of chitin biosynthesis, Type 0**
Incompletely defined mode of action leading to inhibition of chitin biosynthesis.
Benzoylureas (eg. Flufenoxuron, Lufenuron, Novaluron)

**Group 18 Ecdysone receptor agonists**
Mimic the moulting hormone, ecdysone, inducing a precocious molt.
Diacylhydrazines (e.g. Methoxyfenozide, Tebufenozide)

### Unknown

Several insecticides are known to affect less well-described target-sites or functions, or to act non-specifically on multiple targets.
Azadirachtin, Pyridalyl



Designed & produced by IRAC MOA Working Group, September 2009, Poster Ver. 3.3 Based on MoA Classification Ver. 6.3
For further information visit the IRAC website: www.irac-online.org Photograph courtesy of Nigel Armes

# IRAC

Insecticide Resistance Action Committee

# Aphids, Whiteflies and Hoppers - Insecticide Mode of Action Classification:

## A key to effective insecticide resistance management

www.irac-online.org

## Introduction and Background

The agrochemical industry has developed a broad range of very effective insecticides for the control of sucking insect pests such as aphids, whiteflies and hoppers. Unfortunately, as a consequence of the misuse or overuse of these insecticides, many species have developed resistance. The green peach aphid (*Myzus persicae*), and the sweet potato whitefly (*Bemisia tabaci*) are important examples of sucking pests that have developed resistance to a wide range of chemical classes.

In recent years the industry has worked especially hard to develop new types of insecticides with novel modes of action, but this process is becoming ever harder and more costly. It is therefore vital that effective insecticide resistance management (IRM) strategies are implemented, to ensure that resistance does not develop to these new compounds, or to older chemistries that are still effective.

In order to help prevent or delay the incidence of resistance, IRAC promotes the use of a Mode of Action (MoA) classification of insecticides in effective and sustainable IRM strategies. Available insecticides are allocated to specific groups, based on their target site, as described below. By using sequences or alternations of insecticides from different MoA classes, resistance is less likely to occur. Available at the IRAC website www.irac-online.org, this IRAC MoA classification list provides farmers, growers, advisors, extension staff, consultants and crop protection professionals with a guide to the selection of insecticides in IRM programs.

## Effective IRM strategies: Sequences or alternations of MoA

Effective insecticide resistance management (IRM) strategies seek to minimise the selection of resistance to any one type of insecticide. In practice, alternations, sequences or rotations of compounds from different MoA groups provide sustainable and effective IRM.

Example:

MoA w → MoA x → MoA y → MoA z → MoA w → MoA x

Sequence of insecticides through season

Applications are often arranged into MoA spray windows or blocks that are defined by the stage of crop development and the biology of the sucking pest species of concern. Local expert advice should always be followed with regard to spray windows and timing. Several sprays may be possible within each spray window, but it is generally essential that successive generations of the pest are not treated with compounds from the same MoA group. Metabolic resistance mechanisms may give cross-resistance between MoA groups; where this is known to occur, the above advice should be modified accordingly.

## Nerve and Muscle Targets

Most current insecticides act on nerve and muscle targets. Insecticides that act on these targets are generally fast acting.

***Group 1 Acetylcholinesterase (AChE) inhibitors***

Inhibit AChE, causing hyperexcitation. AChE is the enzyme that terminates the action of the excitatory neurotransmitter acetylcholine at nerve synapses.

- 1A Carbamates (e.g. Methomyl)
- 1B Organophosphates (e.g. Chlorpyrifos)

***Group 2 GABA-gated chloride channel antagonists***

Block the GABA-activated chloride channel, causing hyperexcitation and convulsions. GABA is the major inhibitory neurotransmitter in insects.

- 2A Cyclodiene Organochlorines (e.g. Endosulfan)
- 2B Phenylpyrazoles (eg. fipronil)

***Group 3 Sodium channel modulators***

Keep sodium channels open, causing hyperexcitation and, in some cases, nerve block. Sodium channels are involved in the propagation of action potentials along nerve axons.

- 3A Pyrethrins, Pyrethroids (e.g. Cypermethrin, λ-Cyhalothrin)

***Group 4 Nicotinic acetylcholine receptor (nAChR) agonists***

Mimic the agonist action of acetylcholine at nAChRs, causing hyperexcitation. Acetylcholine is the major excitatory neurotransmitter in the insect central nervous system.

- 4A Neonicotinoids (e.g. Acetamiprid, Imidacloprid, Thiamethoxam)

***Group 9 Selective homopteran feeding blockers***

Incompletely defined mode of action causing selective inhibition of aphid and whitefly feeding.

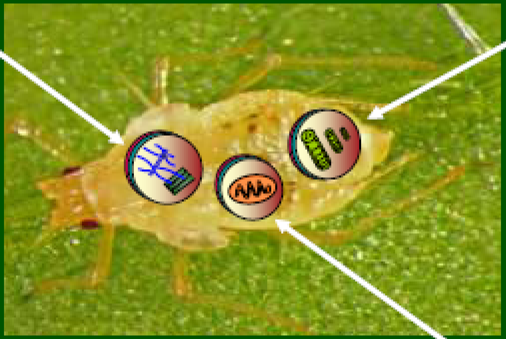
- 9B Pymetrozine
- 9C Flonicamid

***Group 22 Voltage-dependent sodium channel blockers***

Block sodium channels, causing nervous system shutdown and paralysis. Sodium channels are involved in the propagation of action potentials along nerve axons.

- 22A Indoxacarb [1]

Footnotes:
[1] active only on certain species of leafhoppers



## Growth and Development Targets

Insect development is controlled by the balance of two principal hormones: juvenile hormone and ecdysone. Insect growth regulators act by mimicking one of these hormones or by directly affecting cuticle formation/deposition or lipid biosynthesis. Insecticides that act on individual targets in this system are generally slowly to moderately slowly acting.

***Group 7 Juvenile hormone mimics***

Applied in the pre-metamorphic instar, these compounds disrupt and prevent metamorphosis

- 7C Pyriproxyfen

***Group 15 Inhibitors of chitin biosynthesis, Type 0***

Incompletely defined mode of action leading to inhibition of chitin biosynthesis.

- Benzoylureas (e.g. Novaluron, Bistrifluron)

***Group 16 Inhibitors of chitin biosynthesis, Type 1***

Incompletely defined mode of action leading to inhibition of chitin biosynthesis in a number of insects, including whiteflies (e.g. Buprofezin)

***Group 23 Inhibitors of lipid synthesis***

Inhibition of acetyl Coenzyme A carboxylase, part of the first step in lipid synthesis, leading to insect death. (e.g. Spiromesifen, Spirotetramat)

## Respiration Targets

Mitochondrial respiration produces ATP, the molecule that energizes all vital cellular processes. In mitochondria, an electron transport chain uses the energy released by oxidation to charge a proton gradient battery that drives ATP synthesis. Several insecticides are known to interfere with mitochondrial respiration by the inhibition of electron transport and/or oxidative phosphorylation. Insecticides that act on individual targets in this system are generally fast to moderately fast acting.

***Group 12 Inhibitors of mitochondrial ATP synthase***

Inhibit the enzyme that synthesizes ATP.

- 12A Diafenthiuron

***Group 21 Mitochondrial complex I electron transport inhibitors***

Inhibit electron transport complex I preventing the utilization of energy by cells.

- 21A Tolfenpyrad, Pyridaben



Designed & produced by the IRAC MoA Team, Sept 2009, Poster Ver 5.9 Based on MoA Classification Ver. 6.3

For further information visit the IRAC website: www.irac-online.org Photographs courtesy of Dr. Fikru Haile

IRAC

| IRAC Mode of Action Classification v5.1, September 2005 - Ag Uses | | |
|---|---|---|
| Main Group - Primary Site of Action | | |
| Chemical Subgroup or exemplifying Active Ingredient | | |
| Active Ingredient | Product Name | Registrant |
| Group 1 - Acetylcholine esterase inhibitors | | |
| 1A - Carbamates | | |
| Aldicarb | Temik®, Bolster™ | Bayer CropScience, Amvac |
| Carbaryl | Sevin® | Bayer CropScience, Drexel, Gowan, UAP-Loveland, Wilbur-Ellis |
| Carbofuran | Furadan® | FMC |
| Formetanate | Carzol® SP | Gowan |
| Methiocarb | Mesurol® | Gowan |
| Methomyl | Lannate® | DuPont |
| Oxamyl | Vydate® | DuPont |
| Pirimicarb | Pirimor® | Syngenta |
| Thiodicarb | Larvin® | Bayer CropScience |
| 1B - Organophosphates | | |
| Acephate | Orthene® | Cheminova, Micro Flo, TENKOZ, United Phosphorus, Valent |
| Azinphos-methyl | Guthion® | Bayer CropScience, Micro Flo |
| Chlorpyrifos | Govern™, Lock-On®, Lorsban®, Nufos®, Warhawk™, Whirlwind™, Yuma™ | Dow AgroSciences, Makhteshim Agan NA, Agriliance, Drexel, Gowan, Helena, TENKOZ, UAP-Loveland |
| Diazinon | Diazinon | Drexel, Gowan, Helena, Makhteshim Agan NA, Micro Flo, UAP-Loveland, Wilber-Ellis |
| Dimethoate | Dimethoate | Agriliance, Britz, Drexel, Gowan, Helena, Micro Flo, UAP-Loveland |
| Disulfoton | Di-syston | Bayer CropScience |
| Ethoprophos | Mocap® | Bayer CropScience |
| Fenamiphos | Nemacur® | Bayer CropScience |
| Fosthiazate | Nemathorin® | ISK |
| Malathion | Fyfanon®, Malathion | Agriliance, Cheminova, Gowan, Helena, Micro Flo, UAP-Loveland |
| Methamidophos | Monitor® | Bayer CropScience |
| Methidathion | Supracide® | Gowan |
| Methyl parathion | Penncap-M® | Cerexagri |
| Naled | Dibrom® | Amvac |
| Oxydemeton-methyl | MSR® Spray Concentrate | Gowan |
| Phorate | Phorate, Thimet® | Agriliance, Micro Flo, UAP-Loveland, Amvac |
| Phosmet | Imidan® | Gowan |
| Pirimiphos-methyl | Actellic® | Agriliance |
| Profenofos | Curacron® | Syngenta |
| Tebupirimfos | Aztec®, Defcon™ | Bayer CropScience, Amvac |
| Terbufos | Counter® | BASF |
| Group 2 - GABA-gated chloride channel antagonists | | |
| 2A - Cyclodiene organochlorines | | |
| Endosulfan | Thionex® | Drexel, Makhteshim Agan NA |
| 2B - Phenylpyrazoles (Fiproles) | | |
| Fipronil | Regent® | BASF |

FRAC
FUNGICIDE RESISTANCE ACTION COMMITTEE

- Home
- What's New
- About FRAC
- Organisation
- Working Groups
- Expert Fora
- Monitoring Methods
- Publications
- FRAC Regional
- Links

FRAC is a specialist technical group of CropLife INTERNATIONAL

Transferring data from www.frac.info...

## Publications

### Monographs

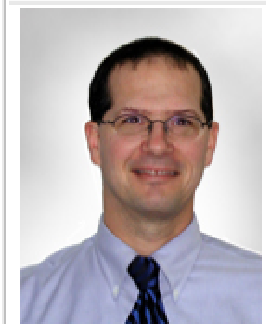
| File | Title |
|---|---|
| | Monograph 1:<br><br>Fungicide Resistance in Crop Pathogens:<br>How can it be managed?<br>by Keith J. Brent, 2007 (second, revised edition) |
| | Monograph 2:<br><br>Fungicide Resistance, the Assessment of Risk<br>by Keith J. Brent and Derek W. Hollomon, 2007 (second, revised edition) |
| | Monograph 3:<br><br>Sensitivity Baselines in Fungicide<br>Resistance Research and Management<br>by Phil E. Russell, July 2004 |

### FRAC Code List©

| File | Title |
|---|---|
| | FRAC Code List 2009©<br><br>Fungicides sorted by mode of action (including FRAC Code numbering) |

### FRAC Mode of Action Poster©

### Contact




**Dr. R. Gold**
FRAC Website Manager

BASF SE
Agricultural Research Station
Limburgerhof
D-67114 Limburgerhof, Germany
Tel: +49 62 16 02 79 06
Fax: +49 62 16 02 83 10
Email: Dr. R. Gold


### Site

- Disclaimer
- Impressum



Done

| MOA | TARGET SITE AND CODE | GROUP NAME | CHEMICAL GROUP | COMMON NAME | COMMENTS | FRAC CODE |
|---|---|---|---|---|---|---|
| A: nucleic acids synthesis | **A1:** RNA polymerase I | **PA** – fungicides (**P**henyl**A**mides) | acylalanines | benalaxyl<br>furalaxyl<br>metalaxyl<br>metalaxyl-M<br>(=mefenoxam) | Resistance and cross resistance well known in various Oomycetes but mechanism unknown.<br><br>**High risk.**<br>**See FRAC Phenylamide Guidelines for resistance management** | **4** |
| | | | oxazolidinones | oxadixyl | | |
| | | | butyrolactones | ofurace | | |
| | **A2:** adenosin-deaminase | hydroxy-(2-amino-) pyrimidines | hydroxy-(2-amino-) pyrimidines | bupirimate<br>dimethirimol<br>ethirimol | Medium risk Resistance and cross resistance known in powdery mildews. Resistance management required. | **8** |
| | **A3:** DNA/RNA synthesis (proposed) | heteroaromatics | isoxazoles | hymexazole | Resistance not known | **32** |
| | | | isothiazolones | octhilinone | | |
| | **A4:** DNA topoisomerase type II (gyrase) | carboxylic acids | carboxylic acids | oxolinic acid | Bactericide. Resistance known. Risk unknown. Resistance management required. | **31** |
| | **B1:** ß-tubuline assembly in mitosis | **MBC** - fungicides (**M**ethyl **B**enzimidazole **C**arbamates) | benzimidazoles | benomyl<br>carbendazim<br>fuberidazole<br>thiabendazole | Resistance common in many fungal species. Several target site mutations, mostly E198A/G/K, F200Y in β-tubulin gene<br><br>Positive cross resistance between the group members. Negative cross resistance to N-Phenylcarbamates | **1** |
| | | | thiophanates | thiophanate | | |

# MOA vs Chemical Family

- Families are different class of pesticides
- Different families may still have the same MOA
- Label numbering system is for strictly MOA

- Pesticide Family
- Grouped by source, chemical structure physical properties, or origin
- By modes of action

Important for preventing resistance and assessing non-target effects

# Herbicide Families

- Aryloxyphenoxy propionate (Phenyl-pyridazine)
- Ureas (linuron)
- Amide (propanil)
- Thiocarbamates (EPTC)
- Triazole (amitrole)
- Pyridazinone (norflurazon)
- Isoxazolidinone (clomazone
- Diphenylethers (aclonifen
- N-phenylphthalamides (flumioxazin
- Triazolinone (*carfentrazone-ethyl*
- Chloroacetamides (acetochlor
- Oxyacetamides (flufenacet
- Benzofuran (ethofumesate
- Organoarsenicals (MSMA
- Cyclohexanediones(sethoxydim

# Herbicide Families

- Sulfonylurea (metsulfuron-methyl)
- Imidazolinone (imazapyr)
- Dinitroanilines (pendimethalin)
- Pyridazines (norflurazon)
- Phenoxys (2,4-D)
- Benzoic Acids (dicamba)
- Carboxylic acids (triclopyr)
- Quinoline carboxylic acid (quinclorac)
- Triazines (atrazine)
- Triazinones (metribuzin)
- Uracils (bromacil)
- Nitriles (bromoxynil)
- Benzothidiazole (bentazon)

# Herbicide Families

- Carbamate (asulam)
- Phthalamate (naptalam)
- Nitrile (dichlobenil)
- Benzamide (isoxaben)
- Bipyridyliums (diquat)
- Carbamates (carbetamide)
- Dinitrophenol(dinoseb)
- Arylaminopropionic acid (Flamprop-M-methyl )
- Triketone (mesotrione)
- Isoxazole (isoxaflutole)
- Pyrazole (pyrazoxyfen)

# Herbicide MOA

- 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
- 6 Inhibition of photosynthesis at photosystem II
- 7 Inhibition of photosynthesis at photosystem II
- 8 Inhibition of lipid synthesis – not ACCase inhibition
- 9 Inhibition of EPSP synthase
- 10 Inhibition of glutamine synthetase
- 11 Bleaching: Inhibition of carotenoid biosynthesis (unknown target)
- 12 Bleaching: Inhibition of carotenoid biosynthesis at the phytoene desaturase step (PDS)
- 13 Bleaching: Inhibition of carotenoid biosynthesis (unknown target)

# Herbicide MOA

- 14 Inhibition of protoporphyrinogen oxidese (PPO)
- 15 Inhibition of VLCFAs (Inhibition of cell division)
- 17 *
- 18 Inhibition of DHP (dihydropteroate) synthase
- 19 Inhibition of auxin transport
- 20 Inhibition of cell wall (cellulose) synthesis
- 21 Inhibition of cell wall (cellulose) synthesis
- 22 Photosystem-I-electron diversion
- 23 Inhibition of mitosis / mircrotubule organization
- 24 Uncoupling (Membrane disruption)
- 25 *
- 26 Inhibition of lipid synthesis – not ACCase inhibition
- 27 *
- 28 Bleaching: Inhibition of 4-hydroxyphenyl-pyruvate-dioxygenase (4-HPPD)

# Insecticide Families

- Inorganics
- □ Boric acid
- □ Diatomaceous earth
- □ Sulfur
- □ Calcium and Lead Arsenates

# Insecticide Families

- Oils
- □ Dormant season grade
- □ Summer season grade
- □ Citrus oil
- □ Salts of Fatty Acids (soaps)
- □ Insecticidal soaps

# Insecticide Families

- Botanicals
- Neem (Azadiractin)
- Pyrethrum
- Rotenone
- Nicotine
- Ryania

# Insecticide Families

- Microbial toxins
- □ Bacillus thuringiensis
- □ Avermectin B
- □ Spinosyns

# Insecticide Families

- Synthetic Organic Pesticides
- □ Organochlorines - (DDT, Lindane,)
- □ Organophosphates (Malathion,
- acephate, diazinon)
- □ Carbamates (carbaryl, methiocarb)
- □ Pyrethroids (permethrin, bifenthrin)
- □ Chloronicotynils and Neonicotynils
- (imidacloprid)
- □ Insect Growth Regulators

# Insecticide Families

- Fiproles -(fipronil)
- Pyrroles -Chlorfenapyr (Pylon))
- Pyrazoles (Fenpyroximate)
- Pyradizones -Pyradiben(Sanmite)
- Quinazolines (Fenazaquin,Hydramethalnon)

# Insecticide MOA

- Physical toxicants
- □ Antifeedants
- □ Axonic poisons (nerve poison)
- □ Synaptic poisons (nerve poison)
- □ Metabolic inhibitors
- □ Cytolitic toxins
- □ Muscle poisons
- □ Alkylating agents
- □ Disruptors of molting, metamorphosis and
- cuticle formation (Insect Growth Regulators)

# Insecticide Resistance

- Arthropod Pesticide Resistance Database
- http://www.pesticideresistance.org/


| Active Ingredient | Category |
|---|---|
| abamectin | ABM |
| acephate | OP |
| acetamiprid | NICO |
| acetamiprid | NICO |
| acrinathrin | PYR |
| alanycarb | CAR |
| aldicarb | CAR |
| aldrin | CYCLO |
| allethrin | PYR |
| allethrin-bio | PYR |
| allethrin-bio-S-cyclopentenyl | PYR |
| amidithion | OP |
| aminocarb | CAR |
| amitraz | FORM |
| azadirachtin | MISC |
| azamethiphos | OP |
| azinphos-ethyl | OP |
| azinphos-methyl | OP |
| azinphos-methyl + PBO | OP |

# Fungicide Families

- **Dithiocarbamates**
- **Dicarboximides**
- **Benzimidazoles**
- **Sterol Inhibitors or Demethylase Inhibitors**

- **Strobilurins**
- Plus others.

# Weed Resistance Managment

- ALS Type herbicides resistance shows up quickly. Pigweeds in Oklahoma.
- Increased use of glyphosate has progressed glyphosate resistance weeds around the US.
- Glyphosate resistant horseweed, ragweed and johnsongrass has been found in Arkansas.

# HERBICIDE RESISTANT WEEDS SUMMARY TABLE

Monday, December 07, 2009

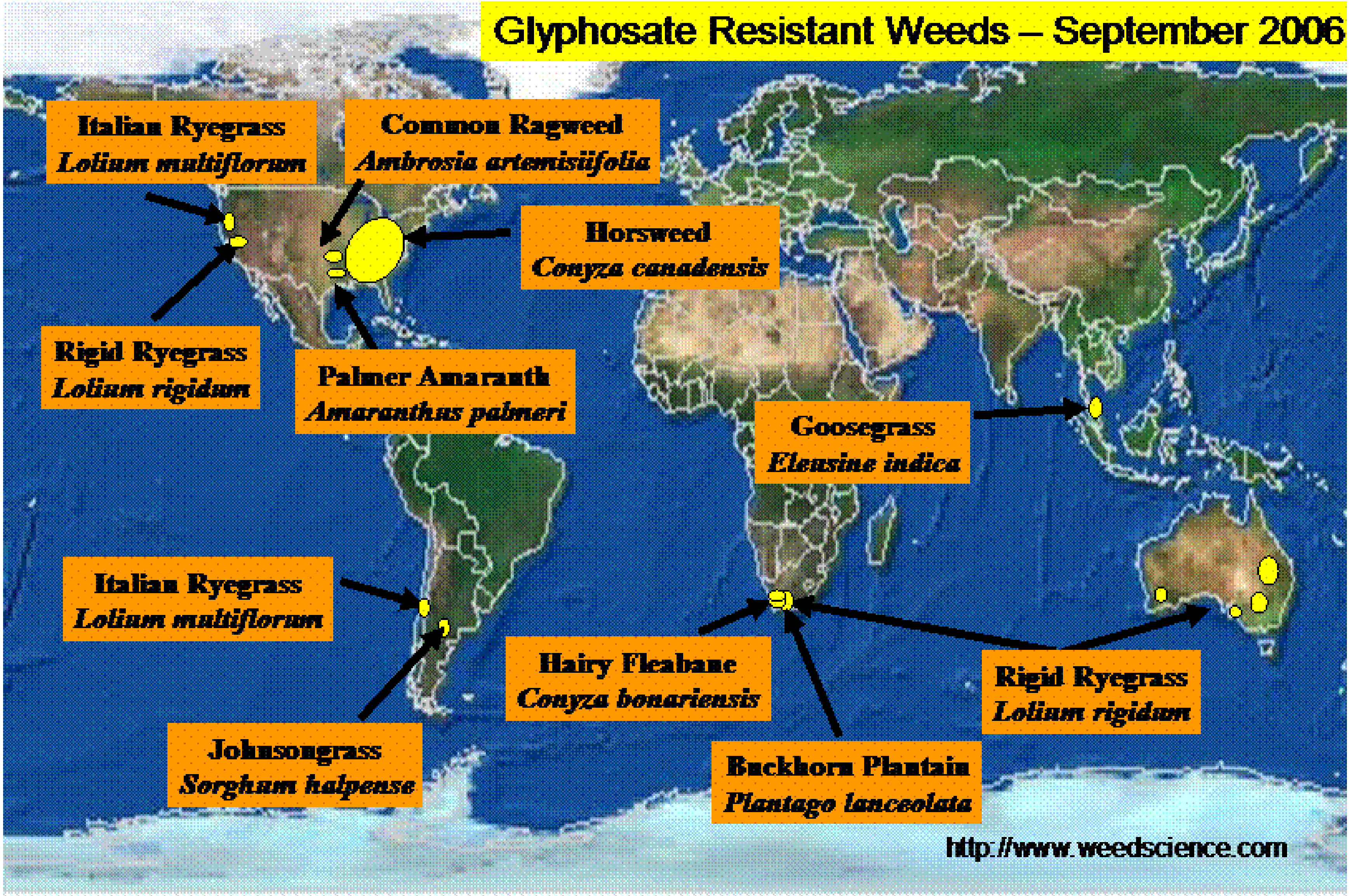
| Herbicide Group<br>Click for details | Mode of Action | HRAC Group | Example Herbicide | Total |
|---|---|---|---|---|
| ALS inhibitors | Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS) | B | Chlorsulfuron | 107 |
| Photosystem II inhibitors | Inhibition of photosynthesis at photosystem II | C1 | Atrazine | 68 |
| ACCase inhibitors | Inhibition of acetyl CoA carboxylase (ACCase) | A | Diclofop-methyl | 38 |
| Synthetic Auxins | Synthetic auxins (action like indoleacetic acid) | O | 2,4-D | 28 |
| Bipyridiliums | Photosystem-I-electron diversion | D | Paraquat | 24 |
| Ureas and amides | Inhibition of photosynthesis at photosystem II | C2 | Chlorotoluron | 21 |
| Glycines | Inhibition of EPSP synthase | G | Glyphosate | 16 |
| Dinitroanilines and others | Microtubule assembly inhibition | K1 | Trifluralin | 10 |
| Thiocarbamates and others | Inhibition of lipid synthesis - not ACCase inhibition | N | Triallate | 8 |
| PPO inhibitors | Inhibition of protoporphyrinogen oxidase (PPO) | E | Oxyfluorfen | 4 |
| Triazoles, ureas, isoxazolidiones | Bleaching: Inhibition of carotenoid biosynthesis (unknown target) | F3 | Amitrole | 4 |
| Chloroacetamides and others | Inhibition of cell division (Inhibition of very long chain fatty acids) | K3 | Butachlor | 3 |
| Carotenoid biosynthesis inhibitors | Bleaching: Inhibition of carotenoid biosynthesis at the phytoene desaturase step (PDS) | F1 | Flurtamone | 2 |
| Arylaminopropionic acids | Unknown | Z | Flamprop-methyl | 2 |
| Nitriles and others | Inhibition of photosynthesis at photosystem II | C3 | Bromoxynil | 1 |
| Mitosis inhibitors | Inhibition of mitosis / microtubule polymerization inhibitor | K2 | Propham | 1 |
| Cellulose inhibitors | Inhibition of cell wall (cellulose) synthesis | L | Dichlobenil | 1 |
| Unknown | Unknown | Z | (chloro) - flurenol | 1 |
| Organoarsenicals | Unknown | Z | MSMA | 1 |
| **Total Number of Unique Herbicide Resistant Biotypes** | | | | **340** |

weedscience.com

# Most Important Herbicide-Resistant Species

| | | |
|---|---|---|
| 1. | Rigid Ryegrass | *Lolium rigidum* |
| 2. | Wild Oat | *Avena fatua* |
| 3. | Redroot Pigweed | *Amaranthus retroflexus* |
| 4. | Common Lambsquarters | *Chenopodium album* |
| 5. | Green Foxtail | *Setaria viridis* |
| 6. | Barnyardgrass | *Echinochloa crus-galli* |
| 7. | Goosegrass | *Eleusine indica* |
| 8. | Kochia | *Kochia scoparia* |
| 9. | Horseweed | *Conyza canadensis* |
| 10. | Smooth Pigweed | *Amaranthus hybridus* |

- weedscience.com


Glyphosate Resistant Weeds – September 2006
Italian Ryegrass
Lolium multiflorum
Common Ragweed
Ambrosia artemisiifolia
Horsweed
Conyza canadensis
Rigid Ryegrass
Lolium rigidum
Palmer Amaranth
Amaranthus palmeri
Goosegrass
Eleusine indica
Italian Ryegrass
Lolium multiflorum
Hairy Fleabane
Conyza bonariensis
Rigid Ryegrass
Lolium rigidum
Johnsongrass
Sorghum halpense
Buckhorn Plantain
Plantago lanceolata
http://www.weedscience.com

# Labels and MOA Group Numbers

- Quick MOA Group number listed on front of label.
- Is to give a quick reference and help insure a switch to a different mode of action.
- Resistant management statements will also be included in body of label.

PULL HERE TO OPEN

GROUP 9 HERBICIDE

# Touchdown Total®

iQ® TECHNOLOGY

## Herbicide

*Nonselective Foliar Systemic Herbicide for Weed Control*

| | |
|---|---|
| *Active Ingredient:* | |
| *Glyphosate: N-(phosphonomethyl) glycine | 36.5% |
| *Other Ingredients:* | 63.5% |
| *Total:* | 100.0% |

LOW FOAM TECHNOLOGY

**Contains 500 grams per liter or 4.17 pounds per U.S. gallon of glyphosate acid.*

***KEEP OUT OF REACH OF CHILDREN.***

## *CAUTION*

*See additional precautionary statements and directions for use inside booklet.*

*EPA Reg. No. 100-1169*
*EPA Est. 100-LA-001*

***SCP 1169A-L1F 0209***
***296132***

**2.5 gallons**
**Net Contents**

syngenta®

OSU PSEP

## GLYPHOSATE RESISTANT WEED MANAGEMENT

Some naturally occurring weed biotypes resistant to glyphosate may exist through normal genetic variability in any weed population. The repeated use of herbicides with the same mode of action is known to lead under certain conditions to a selection of resistant weeds. Certain agronomic practices reduce the likelihood that resistant weed populations will develop and integrated strategies are known to manage such problem weeds.

Glyphosate is the active ingredient in the herbicide Touchdown Total. The primary mode of action of glyphosate involves inactivation of the target enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS). This enzyme is involved in the synthesis of several essential amino acids that are the building blocks for proteins needed for plant growth and development. In susceptible weeds glyphosate binds tightly to EPSPS rendering the enzyme inactive. With the inactivation of EPSPS, the plant is unable to produce certain essential amino acids resulting in plant death. Initial studies on the mechanistic basis of resistance to glyphosate in various weed species have to date, revealed EPSPS target site resistance, and involvement of differences in translocation as important. Other mechanisms by which plants can become resistant to herbicides include differences in uptake, metabolism and sequestration. Within the USA specific biotypes of a number of species, including horseweed/marestail (*Conyza canadensis*), hairy fleabane (*Conyza bonariensis*), rigid ryegrass (*Lolium rigidum*), Palmer amaranth (*Amaranthus palmeri*), common waterhemp (*Amaranthus rudis*), common ragweed (*Ambrosia artemisiifolia*), giant ragweed (*Ambrosia trifida*), and johnsongrass (*Sorghum halepense*), have become resistant to glyphosate. The first incident reported to the Herbicide Resistance Action Committee (HRAC) of glyphosate resistance was in 1998 on rigid ryegrass.

Following is a list of Best Weed Management practices to be considered in glyphosate-based programs.

Diversify glyphosate-dependent weed control programs with alternative herbicides or cultural practices.

a. In glyphosate-tolerant corn and soybean systems, do not use more than two applications of a glyphosate based herbicide over a two year period. Diversify with alternative herbicides/cultural practices.

b. In glyphosate-tolerant cotton, up to three glyphosate applications may be used in crop per year if employing in-crop cultivation/residual herbicide.

c. Use alternative burndown and/or residual herbicides for glyphosate-tolerant crops likely to require more than one application of glyphosate.

d. To manage glyphosate-tolerant volunteers, rotate RR crops with conventional crops.

e. Use full label rates of glyphosate and tank mix partners. Minimize weed escapes.

f. Monitor treated weed populations for any loss of field efficacy.

g. Contact your local extension specialist, certified crop advisor, and/or manufacturer for herbicide resistance management and/or integrated weed management recommendations for specific crops and resistant weed biotypes.

Since the occurrence of resistant weeds is difficult to detect prior to use, Syngenta Crop Protection accepts no liability for any losses that may result from the failure of Touchdown Total to control resistant weeds.

BASF

The Chemical Company

GROUP **11** FUNGICIDE

SPECIMEN

# Cygnus® Fungicide

**For use on ornamentals in greenhouses, lath- and shade-houses, outdoor nurseries, retail nurseries and other nonresidential landscape areas.**

**ACTIVE INGREDIENT:**
Kresoxim-methyl (methyl (E)-2-methoxyimino-2-[2-(o-tolyloxymethyl)phenyl] acetate) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .50.0%
**INERT INGREDIENTS:** . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 50.0%
**TOTAL:** . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .100.0%

and is effective against pathogens resistant to fungicides with modes of action different from those of QoI fungicides (Target site **Group 11**), such as, dicarboximides, sterol inhibitors, benzimidazoles, or phenylamides. Fungal isolates resistant to **Group 11** fungicides such as, kresoxim-methyl, azoxystrobin, trifloxystrobin, and pyraclostrobin, may eventually dominate the fungal population if **Group 11** fungicides are used predominantly and repeatedly in the same field in successive years as the primary method of control for the targeted pathogen species. This may result in reduction of disease control by **Cygnus® fungicide** or other **Group 11** fungicides.

To limit the potential for development of resistance to **Cygnus** and other **Group 11** fungicides:

- For outdoor use, **DO NOT** make more than six applications of **Cygnus** or other strobilurin fungicides per season.
- For use in greenhouses, **DO NOT** make more than eight applications of **Cygnus** or other strobilurin fungicides per year.
- For powdery mildew control, alternate each application of **Cygnus** with two sequential applications of labeled non-strobilurin fungicides with a different mode of action.
- For control of scab, leaf spots and rusts, **DO NOT** make more than two sequential applications of **Cygnus**. Then alternate to at least an equal number of sequential applications of labeled non-strobilurin fungicides with a different mode of action before applying **Cygnus** again.

The following recommendations may be considered to delay the development of fungicide resistance:

1. **Tank mixtures:** Use tank mixtures with fungicides from different target site of action groups that are registered/permitted for the same use and that are effective against the pathogens of concern. BASF recommends using at least the minimum labeled rates of each fungicide in the tank mix.
2. **IPM: Cygnus** should be integrated into an over all disease and pest management program. Cultural practices known to reduce disease development should be followed. Consult your local extension specialist, certified crop advisor and/or BASF representative for additional IPM strategies established for your area. Cygnus may

The following recommendations may be considered to delay the development of fungicide resistance:

1. **Tank mixtures:** Use tank mixtures with fungicides from different target site of action groups that are registered/permitted for the same use and that are effective against the pathogens of concern. BASF recommends using at least the minimum labeled rates of each fungicide in the tank mix.
2. **IPM: Cygnus** should be integrated into an over all disease and pest management program. Cultural practices known to reduce disease development should be followed. Consult your local extension specialist, certified crop advisor and/or BASF representative for additional IPM strategies established for your area. **Cygnus** may be used in Agricultural Extension advisory (disease forecasting) programs, which recommend application timing based on environmental factors favorable for disease development.
3. **Monitoring:** Monitor efficacy of all fungicides used in the disease management program against the targeted pathogen and record other factors that may influence fungicide performance and/or disease development. If a **Group 11** target site fungicide, such as **Cygnus**, appears to be less effective against a pathogen that it previously controlled or suppressed, contact a BASF representative, local extension specialist, or certified crop advisor for further investigation.

# Specimen Label

Dow AgroSciences

**Blackhawk™**

**Naturalyte® Insect Control**

™Trademark of Dow AgroSciences LLC

**For control of lepidopterous larvae (worms or caterpillars), leafminers, and thrips.**

| Group | 5 | INSECTICIDE |
|---|---|---|

| | |
|---|---|
| Active Ingredient: | |
| spinosad | |
| (a mixture of spinosyn A | |
| and spinosyn D) | 36% |
| Other Ingredients | 64% |
| Total | 100% |

Contains 36% active ingredient on a weight basis.

## Environmental Hazards

This product is toxic to bees exposed to treatment for 3 hours following treatment. Do not apply this pesticide to blooming, pollen-shedding or nectar-producing parts of plants if bees may forage on the plants during this time period. This product is toxic to aquatic invertebrates. Do not apply directly to water, to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwaters.

**Notice:** Read the entire label. Use only according to label directions. **Before using this product, read Warranty Disclaimer, Inherent Risks of Use, and Limitation of Remedies elsewhere on this label. If terms are unacceptable, return at once unopened.**

In case of emergency endangering health or the environment involving this product, call 1-800-992-5994.

## Directions for Use

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.
Read all Directions for Use carefully before applying.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your state or tribe, consult the agency responsible for pesticide regulation.

## Agricultural Use Requirements

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR Part 170. This Standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides.

**Insecticide Resistance Management (IRM)**

Blackhawk contains spinosad, a Group 5 insecticide. Insect/mite biotypes with acquired resistance to Group 5 insecticides may eventually dominate the insect/mite population if Group 5 insecticides are used repeatedly in the same field or area, or in successive years as the primary method of control for targeted species. This may result in partial or total loss of control of those species by Blackhawk or other Group 5 insecticides. Currently, only spinetoram and spinosad active ingredients are classified as Group 5 insecticides. These two insecticide active ingredients share a common mode of action and must not be rotated with each other for control of pests listed on this label. Spinetoram and spinosad may be rotated with all other labeled insecticide active ingredients.

To delay development of insecticide resistance, the following practices are recommended:

- Carefully follow the specific label guidelines within the use directions sections of this label, especially in regard to IRM recommendations.
- Avoid use of the same active ingredient or mode of actoin (same insecticide group) on consecutive generations of insects. However, multiple applications to reduce a single generation are acceptable. Treat the next generation with a different active ingredient that has a different mode of action or use no treatment for the next generation.
- Avoid using less than labeled rates of any insecticide when applied alone or in tank mixtures.
- Applications should be targeted against early insect developmental stages whenever possible.
- Base insecticide use on comprehensive IPM programs including crop rotations.
- Monitor treated insect populations in the field for loss of effectiveness.
- Contact your local extension specialist, certified crop advisor, and or manufacturer for insecticide resistance management and/or IPM recommendations for the specific site and resistant pest problems.
- For further information or to report suspected resistance, contact your local Dow AgroSciences representative or by calling 800-258-3033.

SPECIMEN

GROUP 7 11 FUNGICIDE

# Pageant™ Fungicide

**For disease control on ornamentals and flower bulbs grown in outdoor nurseries, retail nurseries, golf courses, residential and commercial landscapes, interiorscapes, greenhouses, lathhouses and shadehouses, containers, and on forest and conifer nurseries and plantations.**

| | |
|---|---|
| **Active Ingredients:** | |
| **pyraclostrobin**, (carbamic acid, [2-[[[1-(4-chlorophenyl)-1*H*-pyrazol-3-yl]oxy]methyl]phenyl]methoxy-, methyl ester) | 12.8% |
| **boscalid**, 3-pyridinecarboxamide,2-chloro-N-(4'-chloro(1,1'-biphenyl)-2-yl) | 25.2% |
| **Other Ingredients:** | 62.0% |
| **Total:** | 100.0% |

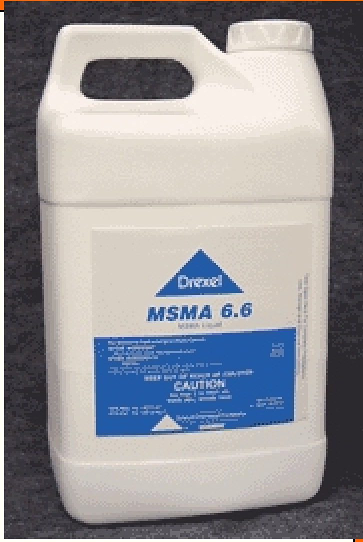
0.128 oz (0.008 lb) of pyraclostrobin in 1 oz of **Pageant**
0.252 oz (0.0158 lb) of boscalid in 1 oz of **Pageant**

**EPA Reg No. 7969-251** **EPA Est. No.**

## Resistance Management

The active ingredients in **Pageant** are pyraclostrobin (**Group 11**) and boscalid (**Group 7**).

Fungal isolates resistant to **Group 11** (strobilurin or QoI) fungicides, such as pyraclostrobin, azoxystrobin, trifloxystrobin, and kresoxim-methyl, and **Group 7** (carboximide) fungicides may eventually dominate the fungal population if **Group 7** or **11** fungicides are used predominantly and repeatedly in the same area in successive years as the primary method of control for the targeted pathogen species. This may result in reduction of disease control by **Pageant** or other **Group 7** or **11** fungicides. Apply **Pageant** in an alternation or tank mix program with other registered fungicides that have a different mode of action and to which pathogen resistance has not developed. **DO NOT** make more than 2 sequential applications of **Pageant**. Alternate with a fungicide of a different mode of action before reapplying **Pageant**. **DO NOT** alternate **Pageant** with other **Group 11** fungicides.




# MSMA STATUS

- MSMA Final timeline has been set. Final comment on cancelations due 8/7/09.
- December 31, 2009 will be the last date manufacturers will be able to sell MSMA with all current uses especially residential turf.
- December 31, 2010 will be last date for distributors (Estes, Helena, etc.) and retail sellers Atwoods, Tractor Supply, Lowes, Wal Mart, etc.) will be able to sell MSMA with all current uses (residential turf).

# MSMA Continued


- **December 31, 2010 no more use of MSMA can occur on residential turf after this date!** DSMA, CAMA, cacodylic acid and its sodium salt would be prohibited after this date also.

  Golf course, sod farms, and right-of-way use will remain until December 31, 2013.
- Do not stockpile any more MSMA than you can use by the dates above on those use sites. Use will not be allowed on those sites after the dates listed!

# Companies Involved

Table 3 of this unit includes the names and addresses of record for the registrants of the products listed in Table 1 and Table 2 of this unit.

TABLE 3.—REGISTRANTS REQUESTING VOLUNTARY CANCELLATION AND/OR AMENDMENTS

| EPA Company No. | Company Name and Address |
|---|---|
| 239 | The Scotts Co., d/b/a/ The Ortho Group, PO Box 190, Marysville, OH 43040 |
| 538 | The Scotts Co., 14111 Scottslawn Rd, Marysville, OH 43041 |
| 769 | Value Gardens Supply, LLC d/b/a/ Value Garden Supply, PO Box 585, Saint Joseph, MO 64502 |
| 869 | Valent GI Corp., c/o Valent USA Corp., Agent For: Green Light Co., 1600 Riviera Ave. Suite 200, Walnut Creek, CA 94596 |
| 2217 | PBI/Gordon Corp., PO Box 014090, Kansas City, MO 64101-0090 |
| 5481 | Amvac Chemical Corp., d/b/a/ Amvac, 4695 Macarthur Ct., Suite 1250, Newport Beach, CA 92660-1706 |
| 5887 | Value Gardens Supply, LLC d/b/a/ Value Garden Supply, PO Box 585, Saint Joseph, MO 64502] |
| 5905 | Helena Chenical Co., 7664 Moore Rd., Memphis, TN 38120 |
| 7401 | Mandava Associates, LLC, Agent for: Voluntary Purchasing Groups, Inc., N. Dallas Pkwy., Suite 200, Plano, TX 75024 |

TABLE 3.—REGISTRANTS REQUESTING VOLUNTARY CANCELLATION AND/OR AMENDMENTS—Continued

| EPA Company No. | Company Name and Address |
|---|---|
| 8660 | United Industries Corp., d/b/a Sylorr Plant Corp., PO Box 142642, St. Louis, MO 63114-0642 |
| 9779 | Winfield Solutions, LLC, PO Box 64589, St. Paul, MN 55164-0589 |
| 10088 | Athea Laboratories Inc., PO Box 240014, Milwaukee, WI 53224 |
| 19713 | Drexel Chemical Co., PO Box 13327, Memphis, TN 38113-0327 |
| 28293 | Phaeton Corp., d/b/a/ Unicorn Laboratories, PO Box 290, Madison, GA 30650 |
| 33955 | PBI/Gordon Corp., PO Box 014090, Kansas City, MO 64101-0090 |
| 42519 | Luxemborg-Pamol, Inc., 5100 Poplar Ave. Suite 2700, Memphis, TN 38137 |
| 42750 | Albaugh Inc., 1525 NE 36th Street, Ankeny, IA 50021 |
| 46515 | Celex, Division of United Industries Corp., PO Box 142642, St. Louis, MO 63114-0642 |
| 59144 | RegWest Company, LLC, Agent for: Gro Tec, Inc., 30856 Rocky Rd. Greely, CO 80631-9375 |
| 61483 | KMG-Bernuth, Inc., 9555 W. Sam Houston Pkwy South, Suite 600, Houston, TX 77099 |
| 62719 | Dow Agrosciences LLC, 9330 Zionsville Rd 308/2e, Indianapolis, IN 46268-1054 |

TABLE 3.—REGISTRANTS REQUESTING VOLUNTARY CANCELLATION AND/OR AMENDMENTS—Continued

| EPA Company No. | Company Name and Address |
|---|---|
| 72155 | Bayer Advanced, PO Box 12014, 2 TW Alexander Dr., Research Triangle Park, NC 27709 |

**IV. What is the Agency's Authority for Taking this Action?**

Section 6(f)(1) of FIFRA provides that a registrant of a pesticide product may at any time request that any of its pesticide registrations be canceled or amended to terminate one or more uses. FIFRA further provides that, before acting on the request, EPA must publish a notice of receipt of any such request in the **Federal Register**. Thereafter, following the public comment period, the Administrator may approve such a request.

**V. Procedures for Withdrawal of Request and Considerations for Reregistration of Organic Arsenicals**

Registrants who choose to withdraw a request for cancellation must submit such withdrawal in writing to the person listed under **FOR FURTHER INFORMATION CONTACT**, postmarked before August 7, 2009. This written withdrawal of the request for cancellation will apply only to the applicable FIFRA section 6(f)(1) request listed in this notice. If the products(s) have been subject to a previous cancellation action, the effective date of cancellation and all other provisions of any earlier cancellation action are controlling.

**VI. Provisions for Disposition of Existing Stocks**

Existing stocks are those stocks of registered pesticide products which are currently in the United States and which were packaged, labeled, and released for shipment prior to the effective date of the cancellation action. In any order issued in response to these requests for cancellation of product registrations, EPA proposes to include the following provisions for the treatment of any existing stocks of the