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Nebraska Extension Master Gardener Program

Pesticide Modes of Action

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Mode of Action (MOA)

The organisms' process or pathway inhibited by the pesticide at the cellular or tissue level

OR

The part or parts of the organism affected by the pesticide to cause injury or death

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Different Modes of Action

- **Herbicides**
- **Insecticides**
- **Fungicides**

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Why Different Modes of Action?

Utilize multiple / different MOAs to help prevent, slow-down, or offset **RESISTANT** organism populations in the environment; so that the pesticides can be continued to be utilized

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What is a RESISTANT Organism?

A RESISTANT organism is one that develops / evolves / survives in a population from the continued use of a single MOA

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What is a RESISTANT Organism?

When a single MOA pesticide is applied to a susceptible organism population continuously, some of the organisms are not affected. Continued use of the single MOA controls susceptible individuals, but some are not affected, and continue to reproduce. The unaffected organisms survive and the organism is considered RESISTANT, and the MOA is no longer effective

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MOAs

Pesticides have been assigned different code numbers based on their MOA for:

- Herbicides
- Insecticides
- Fungicides

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MOAs

Pesticides MOAs are based on:

- MOA Group
- Mode of Action
- Chemical Family (Group)
- Active Ingredients

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Herbicide Weed Science Society (WSSA) MOAs

- Group 1 – Lipid synthesis inhibitors
- Group 2 – Amino acid synthesis inhibitors
- Group 3 – Seedling root growth inhibitors
- Group 4, 19 – Growth regulators – **2,4-D, dicamba**
- Group 5, 6, 7 – Photosynthesis inhibitors
- Group 8, 15 – Seedling shoot growth inhibitors
- Group 9 – Amino acid synthesis inhibitors –
Glyphosate
- Group 10 – Nitrogen metabolism
- Group 13, 27 – Pigment inhibitors
- Group 14, 22 – Cell membrane disruptors

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Insecticide Resistance Action Committee (IRAC) MOAs

- Group 1A, 1B – Acetylcholine esterase inhibitors
- Group 2A, 2B – GABA-gated chloride channel antagonists
- Group 3 – Sodium channel modulators
- Group 4A, 4B, 4C – Nicotinic acetylcholine receptor agonists / antagonists
- Group 5 – Nicotinic acetylcholine receptor agonists, not Group 4
- Group 6 – Chloride channel activators

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Insecticide Resistance Action Committee (IRAC) MOAs

- **Group 7A, 7B, 7C – Juvenile hormone mimics**
- **Group 8A, 8B, 8C – Compounds of unknown or non-specific Mode of Action (fumigants)**
- **Group 9A, 9B, 9C – Compounds of unknown or non-specific Mode of Action (selective feeding blockers)**
- **Group 10A, 10B – Compounds of unknown or non-specific Mode of Action (mite growth inhibitors)**

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Insecticide Resistance Action Committee (IRAC) MOAs

- **Group 11A1, 11A2, 11B1, 11B2, 11C – Microbial disruptors of insect midgut membranes (includes transgenic crops expressing *Bacillus thuringiensis* toxins)**
- **Group 12A, 12B, 12C – Inhibitors of oxidative phosphorylation, disruptors of ATP formation (inhibitors of ATP synthase)**
- **Group 13 – Uncouplers of oxidative phosphorylation via disruption of proton gradient**

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Insecticide Resistance Action Committee (IRAC) MOAs

- **Group 15 – Inhibitors of chitin biosynthesis, type 0, Lepidopteran**
- **Group 16 – Inhibitors of chitin biosynthesis, type 1, Homopteran**
- **Group 17 – Molting disruptor, Dipteran**
- **Group 18A, 18B – Ecdysone agonists / molting disruptors**
- **Group 19 – Octopaminergic agonists**

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Insecticide Resistance Action Committee (IRAC) MOAs

- **Group 20A, 20B, 20C – Mitochondrial complex III electron transport inhibitors (Coupling site II)**
- **Group 21 – Mitochondrial complex I electron transport inhibitors**
- **Group 22 – Voltage-dependent sodium channel blockers**
- **Group 23 – Inhibitors of lipid synthesis**

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Insecticide Resistance Action Committee (IRAC) MOAs

- **Group 24A, 24B, 24C – Mitochondrial complex IV electron transport inhibitors**
- **Group 25 – Neuronal inhibitors (unknown mode of action)**
- **Group 26 – Aconitase inhibitors**
- **Group 27A, 27B – Synergists**
- **Group 28 – Ryanodine receptor modulators**

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Fungicide Resistance Action Committee (FRAC) MOAs

- **Group 1 – Mitosis & cell division**
- **Group 2 – Respiration**
- **Group 3 – Sterol synthesis**
- **Group 4 – Nucleic acid synthesis**
- **Group 7 – Respiration**
- **Group 9 – Protein synthesis**
- **Group 11 – Respiration**
- **Group 12 – Signaling**
- **Group 13 – Signaling**

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Fungicide Resistance Action Committee (FRAC) MOAs

- Group 14 – Lipids & membranes
- Group 17 – Sterol synthesis
- Group 19 – Cell wall synthesis
- Group 21 – Respiration
- Group 22 – Cell division
- Group 24 – Protein synthesis
- Group 25 – Protein synthesis
- Group 27 – Unknown
- Group 28 – Cell membrane permeability

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Fungicide Resistance Action Committee (FRAC) MOAs

- Group 29 – Respiration
- Group 30 – Respiration
- Group 33 – Phosphorus acid & salts
- Group 40 – Cell wall synthesis
- Group 41 – Protein synthesis
- P – Host plant defense induction
- M – Multi-site contact activity
- NC – Not classified – Oils – mineral, organic

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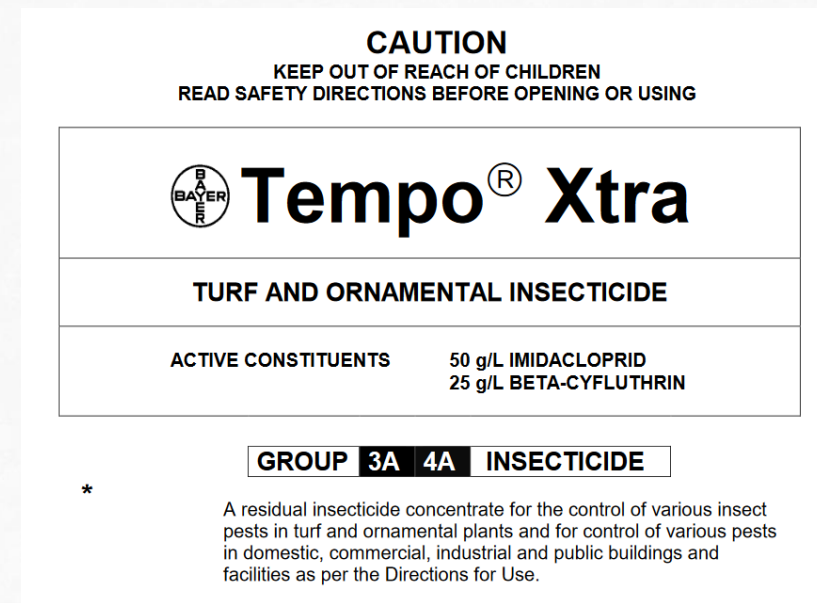
Where & What to Look For: the LABEL



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Where & What to Look For: the LABEL



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Where & What to Look For: the LABEL

Specimen Label

AMINOPYRALID	GROUP	4	HERBICIDE
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CORTEVA
agriscience

Milestone[®]

HERBICIDE

®™ Trademarks of Dow AgroSciences, DuPont or Pioneer and their affiliated companies or respective owners

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Where & What to Look For: the LABEL

3336[®] **EG**

Turf and Ornamental Systemic Fungicide **Group 1 Fungicide**

Commercial Product, General Use: For Turf and Ornamental Applications

For the prevention and control of turf diseases and the diseases of annual and perennial flowers, bedding plants, foliage plants, ground covers, deciduous and evergreen trees and shrubs, and conifer nurseries.

ACTIVE INGREDIENT:
Thiophanate-methyl (dimethyl 4,4'-o-phenylenebis[3-thioallophanate]) 50.00%

OTHER INGREDIENTS 50.00%

TOTAL 100.00%

KEEP OUT OF REACH OF CHILDREN
CAUTION

See label booklet for additional PRECAUTIONARY STATEMENTS and DIRECTIONS FOR USE

For Chemical Spill, Leak, Fire, or Exposure, Call CHEMTREC (800) 424-9300
For Medical Emergencies Only, Call (877) 325-1840

EPA Reg. No. 1001-89

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Where & What to Look For: the LABEL



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Where & What to Look For: the LABEL



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So where are the MOAs on some of these labels???

- Might be due to where the products are used / sites the product is labeled for
- There are more agricultural sites - more product used than (homeowner) horticultural sites - less product used
- That is to say there isn't the possibility of resistance occurring in the horticultural arena
- Takes time to change labels - \$\$\$\$

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More commonly used turf and ornamental pesticides

Herbicides

27 Different WSSA MOA Codes

Group 1

“FOPs”

fenoxaprop-P-ethyl

fluazifop-P-butyl - Fusilade

“DIMs”

clethodim - Select

sethoxydim - Poast

Lipid Synthesis Inhibitors

Interferes with plant growth in roots and shoots,
new plant growth stops

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N**More commonly used turf and ornamental pesticides****Herbicides****27 Different MOA Codes**

Group 2	Sulfonylurea	halosulfuron-methyl idosulfuron thifensulfuron-methyl trifloxysulfuron
	Imidoazolinone	indaziflam

Amino Acid Synthesis Inhibitors

Prevent specific enzymes from producing certain amino acids in younger, actively growing plant tissue

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N**More commonly used turf and ornamental pesticides****Herbicides**

Group 3	Dinitroaniline	benefin - Balan pendimethalin - Pendulum trifluralin - Preen
	Pyridine Benzamide	dithiopyr - Dimension propyzamide

Seedling Root Growth Inhibitors

Inhibits cell division at growing points of developing seedlings & do not develop correctly

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N**More commonly used turf and ornamental pesticides****Herbicides**

Group 4	Phenoxy-carboxylic acid	2,4-D dichlorprop MCPA mecoprop / MCPP
	Benzoic acid Pyridine carboxylic acid	dicamba clopyralid fluroxypyr triclopyr

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N**More commonly used turf and ornamental pesticides****Herbicides****Group 4** **Quinoline carboxylic acid** **quinclorac - Drive****Growth Regulators****Act on multiple sites to disrupt hormone balance and protein synthesis causing plant growth abnormalities**

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More commonly used turf and ornamental pesticides

Herbicides

Group 9 Glycine glyphosate - Roundup

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EPSP Synthase Inhibitor

EPSP inhibition depletes aromatic amino acids needed for protein synthesis

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More commonly used turf and ornamental pesticides

Herbicides

Group 14 Triazolione carfentrazone-ethyl
sulfentrazone

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PPO Inhibitors / Cell Membrane Disrupters

Group 22 Bipyridylium diquat

Photosystem I Electron Diverter / Cell Membrane Disrupters

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More commonly used turf and ornamental pesticides

Insecticides

34 Different IRAC MOA Codes

Group 1A

Carbamates

carbaryl - Sevin

Group 1B

Organophosphates

acephate - Orthene
dimethoate
malathion

Acetylcholine Esterase Inhibitor – nerve action

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More commonly used turf and ornamental pesticides

Insecticides

34 Different MOA Codes

Group 2B

Phenylpyrazoles

fipronil

GABA-gated chloride channel antagonist – nerve action

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More commonly used turf and ornamental pesticides

Insecticides

Group 3	Pyrethroids	bifenthrin beta-Cyfluthrin zeta-Cypermethrin deltamethrin
Group 3	Pyrethrins	pyrethrins

Sodium Channel Modulators – nerve action

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More commonly used turf and ornamental pesticides

Insecticides

Group 4A	Neonicotinoids	clothianidin imidacloprid - Merit
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Nicotinic Acetylcholine Receptor agonists – nerve action

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More commonly used turf and ornamental pesticides

Insecticides

Group 5 Spinosyns spinosad

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Nicotinic acetylcholine receptor allosteric activators
nerve action

Group 6 Avermectins abamectin

Chloride channel activators – nerve action

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More commonly used turf and ornamental pesticides

Insecticides

Group 15 Benzoylureas hexaflumuron

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Inhibitors of chitin biosynthesis – growth regulation

Group 20A Hydramethylnon hydramethylnon

Mitochondrial complex III electron transport inhibitors,
coupling site II

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More commonly used turf and ornamental pesticides

Insecticides

Group 11A1	B.t.s	Bacillus thuringiensis, <i>Israelensis</i>
Group 11A2	B.t.s	Bacillus thuringiensis, <i>Sphaericus</i> Certain mosquito larvae
Group 11B1	B.t.s	Bacillus thuringiensis, <i>Aizawai</i>
Group 11B2	B.t.s	Bacillus thuringiensis, <i>Kurstaki</i> Lepidopteran larvae
Group 11C	B.t.s	Bacillus thuringiensis, <i>Tenebrionis</i> Certain coleoptera
Microbial disruptors of insect midgut membranes		

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More commonly used turf and ornamental pesticides

Fungicides

58 Different FRAC MOA Codes

Group 1	thiophanates benzimidazoles	thiophanate methyl benomyl
Mitosis & cell division		
Group 2	dicaroximides	iprodione
Signal transduction (across or through a cell)		

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More commonly used turf and ornamental pesticides

Fungicides **58 Different FRAC MOA Codes**

Group 3 DeMethylation Inhibitors / DMI fenarimol
 myclobutanil
 triadimefon
 propicoazole

Sterol biosynthesis in membranes

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More commonly used turf and ornamental pesticides

Fungicides

Group 4 phenylamides / PA metalaxyl

Nucleic acid synthesis

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More commonly used turf and ornamental pesticides

Fungicides

Group 11 Quinone outside inhibitors / QoI - strobilurins

azoxystrobin
trifloxystrobin
pyraclostrobin
fluoxastrobin
mandestrobin

Cell respiration (convert sugars into energy)

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More commonly used turf and ornamental pesticides

Fungicides

Group 12 phenylpyrroles / PP fludioxonil

Signal transduction (across or through a cell)

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More commonly used turf and ornamental pesticides

Fungicides

Code 14 aromatic hydrocarbons / AH
 PCNB / quintozone
 chloroneb
 ethazole

Lipids & membrane synthesis

N

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More commonly used turf and ornamental pesticides

Fungicides

Code M1 inorganic copper

Code M2 inorganic sulfur

Code M3 dithiocarbamates mancozeb
 maneb
 thiram
 zineb

Multi-site contact activity

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More commonly used turf and ornamental pesticides

Fungicides

Code M4	phthalimides	captan
Code M5	chloronitriles	chlorothalonil
Multi-site contact activity		
Code NC	not classified	mineral oils

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How to avoid / prevent / minimize resistance?

Practice Integrated Pest Management – IPM

- Plant pest resistant cultivars – extension, seed catalogs
- Use biological control when possible
- Use cultural practices – rotate crops, use different planting dates, mulches, plant spacing
- Hoe, hoe, hoe! - mechanical
- Use different / multiple pesticide MOAs
- **SANITATION!**

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Thank You! Questions?

