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How to Reduce the Risk of Pesticide Resistance

in Apple Pests in Oregon

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Pesticides—including insecticides, acaricides, fungicides, and bactericides—are essential for maintaining healthy crops with reliable yields and quality. In many instances, pesticides have become less effective as target organisms have developed resistance. The first record of resistance dates to 1897, when orchardists began having problems controlling San Jose scale *(Quadraspidiotus perniciosus* [Comstock]) and codling moth *(Cydia pomonella* [L.]). Since then, pesticide resistance has become a worldwide threat to commercial agriculture. By the end of 2006, there were 645 specific cases of agricultural insecticide resistance, with 542 species of arthropods resistant to at least one compound. In total, 316 compounds are affected.

There has also been a gradual increase in fungicide resistance since 1960. Fungicide resistance usually develops rapidly compared to insecticide resistance. However, poor disease control can also result from other factors such as incorrect disease identification, adverse weather conditions, and poor application technique or timing. Always consider these possible causes before concluding that poor control is the result of resistance.

Timely action to prevent resistance development will ensure that horticultural industries gain maximum benefit from effective pesticides for as long as possible. This publication suggests strategies to prevent resistance development. It also provides detailed information on insecticides and fungicides currently registered for use on apples in Oregon, including information regarding the pests for which each product is registered, mode of action, chemical groupings, and classification. Extension personnel, field consultants, and growers should use this information to reduce the risk of resistance to insecticides and fungicides.

Insecticide and acaricide resistance

According to the Insecticide Resistance Action Committee (IRAC), resistance to insecticides is "*a heritable change in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species*."

When a chemical is used continuously, insecticide resistance may lead to reduced insect control in the field. One likely response is to reapply the insecticide; when that fails, the dosage is raised, and the interval between applications may be shortened. These strategies work only for as long as it takes for resistance to be expressed across the entire insect population. The product is then abandoned, and another class of products with increased efficacy is used. The cycle repeats, and crop losses may amount to millions of dollars internationally.

Not only does resistance lead to increased costs of production, but in some cases secondary or minor pests have become major pests as predator populations are reduced by pesticide use.

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Furthermore, resistance to a specific compound also confers cross resistance to other chemically related compounds that share a common target site and mode of action within the pest.

Insecticide and acaricide resistance has occurred across the entire spectrum of arthropods, including Diptera, Lepidoptera, Hymenoptera, Heteroptera, Coleoptera, and Acarina. Insect pests of apples with documented resistance to insecticides in the United States, and in particular in the Pacific Northwest, include codling moth, European red mite, Pandemis leafroller, obliquebanded leafroller, aphids, western flower thrips, and many others.

Some pesticides are more prone to resistance problems than others. Chemistries implicated include carbamates, organophosphates, and pyrethroids. However, other products such as indoxacarb and *Bacillus thuringiensis* (*Bt*), widely used in Oregon for insect control in apple orchards, are not immune from resistance buildup. Two recent studies found that insects can develop resistance to crystalline toxins produced by the *Bt* bacterium. This is cause for concern due to the increased worldwide reliance on this product.

The coordinated use of two insecticides is better than using a single pesticide. However, improper application of two insecticides in one study resulted in resistance to both pesticides when a single resistance would have arisen if only one pesticide had been used.

To avoid pesticide resistance, growers need to understand insecticide and acaricide modes of action and how different chemical groups target pests. They also need a clear understanding of how to use an effective multiple-pesticide strategy.

Apple insecticide and acaracide charts

Chemicals currently registered for use on apples in Oregon appear in Charts 1 and 2. Chart 1 lists pests of major concern to apple growers in Oregon, along with all active ingredients (and some common trade names) registered for use on those pests. Restricted-entry intervals (REI) and preharvest intervals (PHI) are included. Use requirements change frequently, and similar products may not have the same restrictions. Check the latest information concerning label requirements and restrictions before selecting and applying a product. For up-to-date information, see Washington State University's Pesticide Notification Network (http://ext.wsu.edu/pnn/).

Chart 2 lists active ingredients alphabetically, together with all currently registered trade names. In addition, Chart 2 details the chemical class, mode of action, IRAC main group and primary site of action, and chemical subgroup or exemplifying active ingredient for each compound.

Product trade names currently registered by Organic Materials Review Institute (OMRI) are shown in bold in Chart 2 (http://www.omri.org/). Products listed by OMRI change frequently, and organic growers are advised to check the latest information concerning label registrations before selecting and applying a product (http://www.omri.org/).

Classifications used by IRAC (http://www.irac-online.org/) are used in this publication, and IRAC's cooperation is gratefully acknowledged.

Strategies for preventing insecticide and acaricide resistance

- When planting new blocks, consider planting cultivars with early-maturing fruit or those with pest tolerance. For example, the Geneva rootstock series from Cornell has resistance to woolly apple aphid (*Eriosoma lanigerum*). Rootstocks bred in Quebec have woolly apple aphid resistance in addition to dwarfing attributes.
- Integrate chemical applications with other control methods; e.g., cultural and biological control programs. For example, consider inoculating with beneficial nematodes, which control a wide range of insect pests.
- Before you spray, make sure that insect or mite populations are high enough to justify control. Use appropriate local economic thresholds. Contact your local OSU Extension agent to obtain threshold levels.
- Understand the specific pest's life cycle and phenological model (http://ippc2.orst.edu/cgi-bin/ddmodel.pl). When controlling larval stages, target younger larval instars, if possible, because these stages usually are more effectively controlled by insecticides than older stages.
- Where possible, select insecticides and other pest management tools that preserve beneficial insects. When you kill natural enemies, you inherit their job.

- Use only well-maintained and well-calibrated equipment to apply insecticides. Follow recommendations for water volumes, spray pressures, and optimal temperatures.
- Observe spray intervals on label recommendations.
- Alternate products from different IRAC mode of action groups to which there is no locally known cross resistance. When making multiple applications per year or growing season, alternate products from different mode of action classes, preferably in rotations of at least three. Utilize the IPM Decision Aid website from WSU (http://entomology.tfrec.wsu.edu/das/).
- In the event of a control failure, do not reapply the same pesticide. Choose a pesticide with a different mode of action and to which there is no locally known cross resistance.
- Insecticide mixtures (cocktails) may offer a short-term solution to resistance problems. However, each component must have a different insecticidal mode of action and must be used at its full rate.
- Consider monitoring resistance in the most commercially important situations, and gauge levels of control. Contact university researchers for input.
- If in doubt, consult a local agricultural adviser or Extension agent for up-to-date spray recommendations and advice on Integrated Pest Management (IPM) and Insecticide Resistance Management (IRM) programs.

Fungicide and bactericide resistance

Fungicide and bactericide resistance in apples is not as common internationally as insecticide resistance. It is important to note that fungicide resistance occurs in relatively few pathogens; most fungicides are still very effective against the target organisms for which they were developed.

Resistance has been found in the following:

- Apple scab *(Venturia inequalis)* to quinone outside inhibitors, or QoI fungicides (e.g., kresoxim-methyl and trifloxystrobin); guanidines (e.g., dodine); and triazoles (e.g., myclobutanil)
- Fireblight *(Erwinia amylovora)* to antibiotics (e.g., streptomycin)

Resistance has also resulted from improper use of systemic fungicides such as methyl benzimidazole carbamates, or MBC fungicides (e.g., carbendazim); phenylamides, or PA fungicides (e.g., metalaxyl); QoI fungicides (e.g., azoxystrobin); demethylation inhibitor, or DMI fungicides (e.g., tebuconazole); and dicarboximides (e.g., iprodione).

Fungicide resistance can arise rapidly and may result in partial or complete loss of disease control. Resistance is first noticed when expected levels of disease control are no longer achieved with label-recommended dosages.

Fungicides generally have very specific modes of action, making them more susceptible than insecticides to resistance. Some fungal pathogens seem more likely than others to become resistant. Factors that affect the development of fungicide resistance include the type of fungicide, its frequency of use, whether it is used alone or in a rotation program, the target pathogen, and the ability of resistant forms to survive.

To prevent resistance development, growers need a thorough understanding of fungicide and bactericide modes of action and how these chemical groups target pests. They also need to know how to implement an effective multiple-pesticide spray program.

Apple fungicide and bactericide charts

Fungicides and bactericides currently registered for use on apples in Oregon appear in Charts 3 and 4. Chart 3 lists diseases of major concern to apple growers in Oregon, along with all fungicidal and bactericidal active ingredients (and some common trade names) registered for use on those diseases. Restricted-entry intervals (REI) and preharvest intervals (PHI) for most products are included. These restrictions change frequently, and similar products may have different restrictions. Check the latest information concerning label requirements and restrictions before selecting and applying a product. Refer to the label every time you purchase or apply products. For up-to-date information, see WSU's Pesticide Notification Network (http://ext.wsu.edu/pnn/).

Chart 4 lists active ingredients alphabetically, together with all currently registered trade names. In addition, Chart 4 details the mode of action, Fungicide Resistance Action Committee (FRAC) group name, chemical activity, and FRAC code for each compound.

Note that "chemical activity" is given in the broadest possible terms and may not always apply to every compound within that group.

Product trade names currently registered by OMRI are shown in bold in Chart 4. Products listed by OMRI change frequently, so check the latest information concerning label registrations before selecting and applying a product (http://www.omri.org/).

Classifications used by FRAC (http://www.frac.info/frac/) are used in this publication, and FRAC's cooperation is gratefully acknowledged.

Strategies for preventing fungicide resistance

- Make full use of disease-resistant cultivars, including rootstocks and scions.
- Sterilize soil before replanting to reduce the incidence or spread of diseases.
- Consider mulching and inoculating soils with beneficial organisms (e.g., *Trichoderma)* that actively compete with detrimental fungi such as *Phytophthora*.
- Understand the disease cycle and apply fungicides accordingly.
- Maximize spray penetration through proper canopy management; i.e., pruning and training the trees to allow air movement and light penetration.
- Minimize the use of fungicides by setting thresholds and avoiding unnecessary prophylactic treatments.
- Use only well-maintained and well-calibrated equipment. Follow recommendations for water volumes, spray pressures, and temperatures.
- When possible, use fungicides with a multisite mode of action; these products are less prone to fungicide resistance problems.
- Use recommended formulated mixtures or tank-mixes designed to combat resistance. Fungicide mixtures (cocktails) may offer a short-term solution to resistance problems. However, each component must have a different fungicidal mode of action and must be used at its full rate.
- Use fungicides at effective doses and observe recommended spray intervals. Reduced (sublethal) doses quickly select populations with average levels of tolerance, while doses that are too high may impose excessive selection pressures.
- In the event of a control failure, do not reapply the same fungicide. Change the class of fungicide to one having a different mode of action and to which there is no locally known cross resistance.
- Practice good crop hygiene by disinfecting orchard tools, disposing of plant debris, and eliminating other sources of inoculum such as unpicked fruit, pruning piles, and garbage heaps.
- Avoid repeated applications of fungicides of the same group and/or mode of action. Use fungicides from different FRAC groups in rotation cycles of three or more. Refer to Charts 3 and 4 for easier decision making.
- Consider monitoring the incidence of resistance in the most commercially important situations, and gauge levels of control obtained. Contact university researchers for input.
- If in doubt, consult a local Extension agent or agricultural adviser for up-to-date spray recommendations and advice on IPM and Fungicide Resistance Management (FRM programs.

Conclusions

Insect pest and disease resistance to pesticides remains a problem globally and in the Pacific Northwest. Every effort must be made to reduce the risk that resistance will develop in Oregon. Growers and pesticide applicators are advised to utilize the strategies in this publication. A thorough understanding of the modes of action, chemical groups/classes, chemical activities, and codes will enable informed decisions about which chemicals to use in sound rotations. Chemicals listed as high risk by IRAC and FRAC should be used as preventive measures rather than as curative responses when pests or diseases are out of control.

Because of the high cost of bringing new pesticides to market, and closer scrutiny and retesting of existing products, pressure is mounting on currently registered products. Organic agriculture may be at even greater risk, since these producers have a smaller arsenal of products.

The limited number of pesticide products available to homeowners is another problem. Commercial fruit industries in close proximity to cities risk being infested with resistant pests and diseases as a result of repeated use of certain chemicals by homeowners.

Although international efforts by IRAC and FRAC have made advances in classifying chemicals, the list does not cover all the products, both synthetic and of natural origin, registered in the United States. Consequently, an effort should be made to coordinate efforts to produce a classification system that applies to the entire country.

IRAC Mode of Action Classification
Fully revised & reissued, July 2007

Version: 5.3

The IRAC Mode of Action (MoA) classification provides farmers, growers, advisors, extension staff, consultants and crop protection professionals with a guide to the selection of insecticides or acaricides for use in an effective and sustainable insecticide or acaricide resistance management (IRM) strategy. In addition to presenting the MoA classification, this document outlines the background to, and purposes of, the classification list and provides guidance on how it is used for IRM purposes. The list is reviewed and reissued at intervals as required.

What is resistance

Resistance to insecticides may be defined as "a heritable change in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species" (IRAC). This definition differs slightly from others in the literature, but IRAC believes it represents the most accurate, practical definition of relevance to farmers and growers. Resistance arises through the overuse or misuse of an insecticide or acaricide against a pest species and results in the selection of resistant forms of the pest and the consequent evolution of populations that are resistant to that insecticide or acaricide.

MoA, target-site resistance and cross resistance

In the majority of cases, not only does resistance render the selecting compound ineffective but it often also confers cross resistance to other chemically related compounds. This is because compounds within a specific chemical group usually share a common target site within the pest and thus share a common mode of action (MoA). It is common for resistance to develop that is based on a genetic modification of this target site. When this happens, the interaction of the selecting compound with its target site is impaired, and the compound loses its pesticidal efficacy. Because all compounds within the chemical subgroup share a common MoA, there is a high risk that the resistance that has developed will automatically confer cross resistance to all the compounds in the same subgroup. It is this concept of cross resistance within chemically related insecticides or acaricides that is the basis of the IRAC mode of action classification.

Effective IRM strategies use alternations or sequences of different modes of action (MoA)

The objective of successful Insecticide Resistance Management (IRM) is to prevent or delay the evolution of resistance to insecticides, or to help regain susceptibility in insect pest populations in which resistance has already arisen. Effective IRM is thus an important element in maintaining the efficacy of valuable insecticides. It is important to recognize that it is usually easier to proactively prevent resistance occurring than it is to reactively regain susceptibility. Nevertheless, the IRAC MoA classification will always provide valuable guidance to the design of effective IRM strategies.

Experience has shown that all effective insecticide or acaricide resistance management strategies seek to minimise the selection for resistance from any one type of insecticide or acaricide. In practice, alternations, sequences or rotations of compounds from different MoA groups provide a sustainable and effective approach to IRM. This ensures that selection from compounds in any one MoA group is minimised. The IRAC classification in this document is provided as an aid to insecticide selection for these types of IRM strategies.

Applications are often arranged into MoA spray windows or blocks that are defined by the stage of crop development and the biology of the pest(s) of concern. Local expert advice should always be followed with regard to spray windows and timings. Several sprays of a compound may be possible within each spray window, but it is generally essential to ensure that successive generations of the pest are not treated with compounds from the same MoA group.

Nontarget site resistance mechanisms

It is fully recognized that resistance of insects and mites to insecticides and acaricides can, and frequently does, result from enhanced metabolism by enzymes within the pest. Such metabolic resistance mechanisms are not linked to any specific site of action classification, and therefore they may confer resistance to insecticides in more than one IRAC MoA group. Where such metabolic resistance has been characterized and the cross resistance spectrum is known, it is possible that certain alternations, sequences or rotations of MoA groups cannot be used. Similarly, mechanisms of reduced penetration of the pesticide into the pest, or behavioural changes of the pest may also confer resistance to multiple MoA groups. Where such mechanisms are known to give cross resistance between MoA groups, the use of insecticides should be modified appropriately.

Where the resistance mechanism(s) is unknown, the intelligent use of alternations, sequences or rotations of compounds from different MoA classes remains an entirely viable resistance management technique, since such a practice will always minimise selection pressures.

The Mode of Action (MoA) classification

The following classification scheme developed and endorsed by IRAC is based on the best available evidence of the mode of action of available insecticides. Details of the listing have been agreed by IRAC companies and approved by internationally recognized industrial and academic insect toxicologists and biochemists.

It is our aim to ensure that insecticide and acaricide users are aware of mode of action groups and that they have a sound basis on which to implement season-long, sustainable resistance management through the effective use of alternations, sequences or rotations of insecticides with different modes of action. To help delay resistance it is strongly recommended that growers also integrate other control methods into insect or mite control programmes. Further advice is given in Appendix 2.

Note: Inclusion of a compound in the MoA list does not necessarily signify regulatory approval.

Rules for inclusion of a compound in the MoA list

- Chemical nomenclature is based on that appearing in *The Pesticide Manual*, 13th edition, 2003, Ed. C.D.S. Tomlin, published by The British Crop Protection Council. 1250 pp., ISBN 1 901396 13 4.
- To be included in the active list, compounds must have, or be very close to having, a minimum of one registered use in at least one country. Superseded, obsolete or withdrawn compounds with no current registration are listed separately.
- In any one MoA classification subgroup, where more than one active ingredient in that chemical subgroup is registered for use, the chemical subgroup name is used.
- In any one MoA classification subgroup, where only one active ingredient is registered for use, the name of that exemplifying active ingredient is used.
- Where more than one chemical subgroup or exemplifying active ingredient appears in a single mode of action group, each is named according to the above rules; chemical subgroups having precedence over single active ingredients.

General notes

This document has been prepared using the most up-to-date information available to IRAC. It is provided to user groups, grower organisations, extension personnel, regulatory authorities such as the US EPA and all those involved in resistance management, as an agreed definitive statement by the agrochemical industry on the mode of action of insecticides currently in use. Given the broad nature of this user community and the many uses that are demanded of this document, readers should be aware that IRAC has sought to provide a workable listing that serves the needs of as many of these users as possible.

In a continued effort to refine the list, readers are kindly asked to inform IRAC of factual errors or omissions, citing definitive evidence wherever possible. Such submissions should be directed to IRAC via the website at: http://ww.irac-online.org. Suggestions for improvements are likewise welcome.

Updates

The IRAC MoA classification is reviewed and reissued at intervals as required. The latest version is always available for reference via IRAC's website (http://www.irac-online.org).

Submissions for new active ingredients together with recommendations for their inclusion in specific new or existing MoA classes, together with citations or evidence for classification should be made to IRAC through the website. IRAC member companies review draft versions before an agreed final version of any update is published. In addition, a number of internationally well-known insect toxicologists and biochemists are also consulted regarding additions, deletions or other changes to the list.

Changes to the listing may have serious consequences. In those countries where insecticide labels display the IRAC MoA number or class name as an aid to good IRM (see Appendix 1), changes may be especially costly to implement. In general, changes are therefore only endorsed when the scientific evidence supporting the change is compelling.

Appendix 1. Product labels: Indication of MoA of active ingredient and accompanying IRM advice

To assist users in the selection of insecticides for use in IRM strategies employing sequences, rotations or alternations of MoA groups, IRAC is encouraging producers to clearly indicate the IRAC MoA group number and description on the product label, and to accompany this with appropriate advice of the type indicated below. Thus, in addition to the detailed product information, handling, and safety information required by local regulations, a typical title label should clearly indicate the IRAC MoA Group number and description, and minimal, brief advice on IRM as in the example below.

example

Insecticide® 50 SC

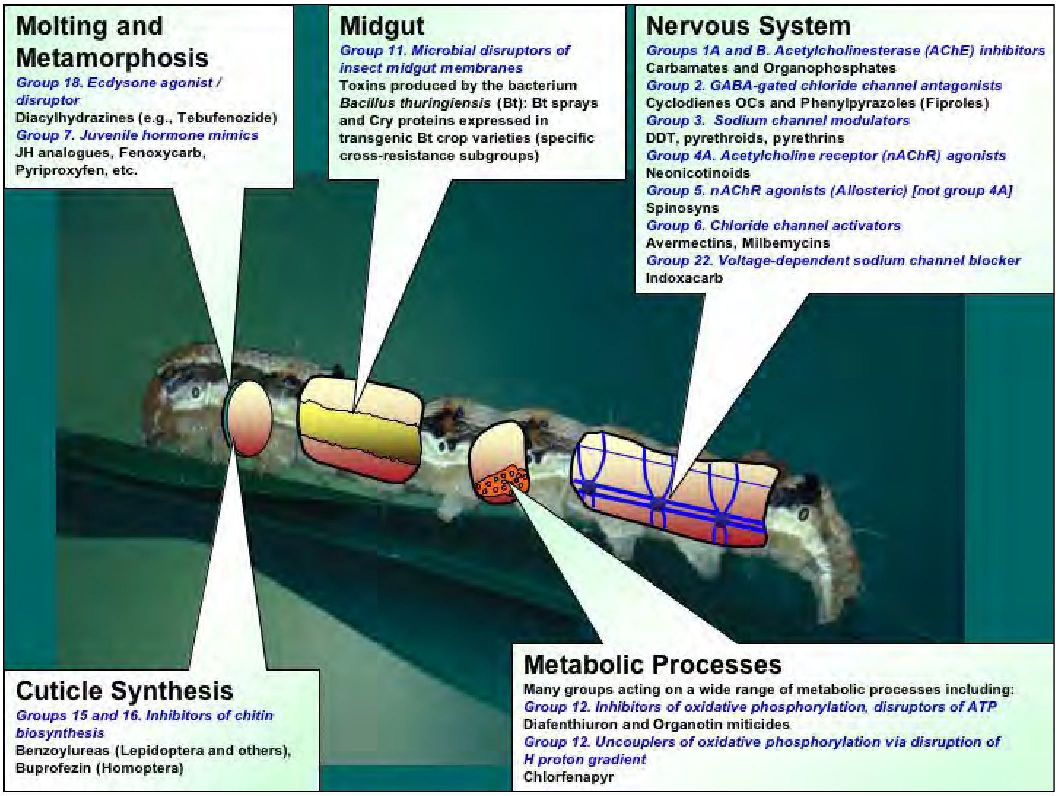
IRAC MoA Group 15
Inhibitors of chitin biosynthesis, type 0,
Lepidopteran
Benzoylureas

Active Ingredient: [Compound name]
Formulation details

"For resistance management purposes, Insecticide 50 SC is an IRAC Mode of Action Group 15 insecticide. Any insect population may contain individuals naturally resistant to Insecticide 50 SC and other Group 15 insecticides. If these insecticides are used repeatedly, the resistant individuals may eventually dominate the pest insect population. These resistant insects may not be controlled by Insecticide 50 SC or by other Group 15 insecticides. To delay the development of resistance:

- Avoid exclusive repeated use of insecticides from the same chemical subgroup (indicated by the IRAC Mode of Action Group number).
- Alternate with products from other IRAC Mode of Action Groups.
- Integrate other control methods (chemical, cultural, biological) into insect control programs.

For further information on resistance management and advice on IRM programmes, contact your local distributor."


Molting and Metamorphosis
Group 18. Ecdysone agonist / disruptor
Diacylhydrazines (e.g., Tebufenozide)
Group 7. Juvenile hormone mimics
JH analogues, Fenoxycarb, Pyriproxyfen, etc.
Midgut
Group 11. Microbial disruptors of insect midgut membranes
Toxins produced by the bacterium Bacillus thuringiensis (Bt): Bt sprays and Cry proteins expressed in transgenic Bt crop varieties (specific cross-resistance subgroups)
Nervous System
Groups 1A and B. Acetylcholinesterase (AChE) inhibitors
Carbamates and Organophosphates
Group 2. GABA-gated chloride channel antagonists
Cyclodienes OCs and Phenylpyrazoles (Fiproles)
Group 3. Sodium channel modulators
DDT, pyrethroids, pyrethrins
Group 4A. Acetylcholine receptor (nAChR) agonists
Neonicotinoids
Group 5. nAChR agonists (Allosteric) [not group 4A]
Spinosyns
Group 6. Chloride channel activators
Avermectins, Milbemycins
Group 22. Voltage-dependent sodium channel blocker
Indoxacarb
Cuticle Synthesis
Groups 15 and 16. Inhibitors of chitin biosynthesis
Benzoylureas (Lepidoptera and others), Buprofezin (Homoptera)
Metabolic Processes
Many groups acting on a wide range of metabolic processes including:
Group 12. Inhibitors of oxidative phosphorylation, disruptors of ATP
Diafenthiuron and Organotin miticides
Group 12. Uncouplers of oxidative phosphorylation via disruption of H proton gradient
Chlorfenapyr

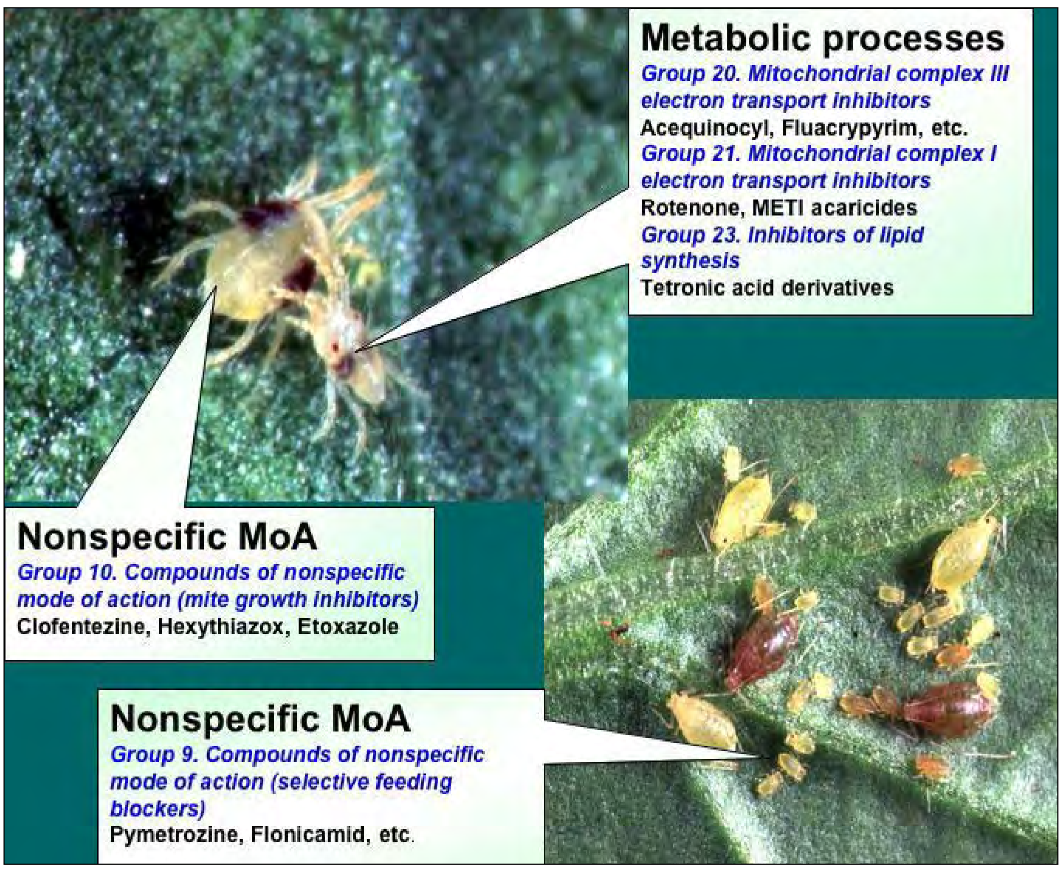

Metabolic processes
Group 20. Mitochondrial complex III electron transport inhibitors
Acequinocyl, Fluacrypyrim, etc.
Group 21. Mitochondrial complex I electron transport inhibitors
Rotenone, METI acaricides
Group 23. Inhibitors of lipid synthesis
Tetronic acid derivatives
Nonspecific MoA
Group 10. Compounds of nonspecific mode of action (mite growth inhibitors)
Clofentezine, Hexythiazox, Etoxazole
Nonspecific MoA
Group 9. Compounds of nonspecific mode of action (selective feeding blockers)
Pymetrozine, Flonicamid, etc.

Table 1. Insect Resistance Action Committee (IRAC) Mode of Action Classification v5.3, September 2007[1] (www.irac-online.org)

Main group and primary site of action	Chemical subgroup or exemplifying active ingredient	Active ingredients
1 Acetylcholine esterase inhibitors	**1A** carbamates	carbaryl, formetanate, methomyl, oxamyl
	1B organophosphates	azinphos-methyl, chlorpyrifos, diazinon, dimethoate, malathion, methidathion, phosmet
2 GABA-gated chloride channel antagonists	**2A** cyclodiene organochlorines	endosulfan
3 Sodium channel modulators	pyrethroids pyrethrins	cyfluthrin, beta-cyfluthrin, lambda-cyhalothrin, gamma-cyhalothrin, deltamethrin, esfenvalerate, fenpropathrin, permethrin pyrethrins (pyrethrum)
4 Nicotinic acetylcholine receptor agonists / antagonists	**4A** neonicotinoids	acetamiprid, clothianidin, imidacloprid, thiacloprid, thiamethoxam
5 Nicotinic acetylcholine receptor agonists (allosteric) (not Group 4)	spinosyns	spinosad
6 Chloride channel activators	avermectins, milbemycins	abamectin
7 Juvenile hormone mimics	**7C** pyriproxyfen	pyriproxyfen
9 Compounds of unknown or nonspecific mode of action (selective feeding blockers)	**9C** flonicamid	flonicamid
10 Compounds of unknown or nonspecific mode of action (mite growth inhibitors)	**10A** clofentezine hexythiazox	clofentezine hexythiazox
	10B etoxazole	etoxazole
11 Microbial disruptors of insect midgut membranes (includes transgenic crops expressing *Bacillus thuringiensis* toxins)	**11A1** *B.t.* subsp. *israelensis*	*Bacillus thuringiensis* subsp. *israelensis*
	11A2 *B. sphaericus*	*Bacillus sphaericus*
	11B1 *B.t.* subsp. *aizawai*	*Bacillus thuringiensis* subsp. *aizawai*
	11B2 *B.t.* subsp. *kurstaki*	*Bacillus thuringiensis* subsp. *kurstaki*
	11C *B.t.* subsp. *tenebrionis*	*Bacillus thuringiensis* subsp. *tenebrionis*

Table 1—continued

Main group and primary site of action	Chemical subgroup or exemplifying active ingredient	Active ingredients
12 Inhibitors of oxidative phosphorylation, disruptors of ATP formation (inhibitors of ATP synthase)	**12B** organotin miticide	fenbutatin oxide
15 Inhibitors of chitin biosynthesis, type 0, Lepidopteran	benzoylureas	novaluron
18 Ecdysone agonists / moulting disruptors	**18A** diacylhydrazines	methoxyfenozide, tebufenozide
	18B azadirachtin	azadirachtin
20 Mitochondrial complex III electron transport inhibitors (Coupling site II)	**20B** acequinocyl	acequinocyl
21 Mitochondrial complex I electron transport inhibitors	METI acaricides rotenone	fenpyroximate, pyridaben rotenone
22 Voltage-dependent sodium channel blockers	indoxacarb	indoxacarb
23 Inhibitors of lipid synthesis	tetronic acid derivatives	spirodiclofen, spirotetramat
25 Neuronal inhibitors (unknown mode of action)	**25** bifenazate	bifenazate
28 Ryanodine receptor modulators	diamides	chlorantraniliprole
un Compounds with unknown mode of action[2]	**unb** chinomethionat	chinomethionat
	unc dicofol	dicofol

Notes to be read in association with Table 1

[1] Inclusion of a compound in the list above does not necessarily signify regulatory approval.

[2] Category 'ns' is used for compounds or preparations with a nonspecific, multisite action.

Groups and Subgroups

Although sharing the same primary target site, it is possible that not all members of a single major MoA class have been shown to be cross resistant. Different resistance mechanisms that are not linked to the target site of action, such as enhanced metabolism, may be common for such a group of chemicals. In such cases, the MoA grouping is further divided into subgroups. For the purposes of this classification it should be assumed that cross resistance exists between compounds in any one MoA subclass. Alternation of compounds from different subgroups within a class *may* be an acceptable part of an IRM strategy. Consult a local resistance expert for further advice.

Products containing multiple or stacked toxins will be differentiated from those containing single toxins only. This will be done by adding a suffix of "m" for multiple-toxin products and "s" for single-toxin products. Products containing spores will be differentiated from those without spores by adding "+" for spore-containing products and "-" for those which do not contain spores. For example, *Bacillus thuringiensis* subsp. *kurstaki* products containing multiple toxins and spores may be designated as 11Dm+, while the same product without spores and expressing only one toxin would be designated as Group 11Ds-.

Superseded, obsolete, or withdrawn compounds for which no current registration exists, and that are no longer in common usage, are not listed.

Table 2. Fungicide Resistance Action Committee (FRAC) CODE List 2007 Fungicides sorted by Mode of Action (MOA) (http://www.frac.info/frac/)

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	metalaxyl-M (=mefenoxam)	Resistance and cross resistance well known in various Oomycetes but mechanism unknown. **High risk.**	4
B: mitosis and cell division	B1: ß-tubuline assembly in mitosis	MBC-fungicides (**M**ethyl **B**enzimidazole **C**arbamates)	benzimidazoles	thiabendazole	Resistance common in many fungal species. Several target site mutations, mostly E198A/G/K, F200Y. Positive cross resistance among the group members. Negative cross resistance to N-Phenylcarbamates. **High risk.**	1
			thiophanates	thiophanate-methyl		
C: respiration	C2: Complex II: succinate dehydrogenase	carboxamides	pridine carboxamides	boscalid	Resistance known for specific fungi. Target site mutation H257L. **Medium risk**. Resistance management required if used for risky pathogens.	7
	C3: Complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (*cyt b gene*)	QoI-fungicides (**Q**uinone **o**utside **I**nhibitors)	methoxy-carbamates	pyraclostrobin	Resistance known in various fungal species. Target site mutations G143A, F129L and additional mechanisms. Cross resistance shown among all members of the QoI group. **High risk.**	11
			oximinoacetates	kresoxim-methyl, trifloxystrobin		
D: amino acids and protein synthesis	D1: methionine biosynthesis (proposed) (*cgs gene*)	AP-fungicides (**A**nilino-**P**yrimidine)	anilino-pyrimidine	cyprodinil, pyrimethanil	Resistance known in *Botrytis* and sporadically in *Venturia*; mechanism speculative (CGS). **Medium risk.**	9
	D4: protein synthesis	glucopyranosyl antibiotic	glucopyranosyl antibiotic	streptomycin	Bactericide. Resistance known. **High risk.** Resistance management required.	25

Table 2—continued

MOA	Target site and code	Group name	Chemical group	Common name	Comments	FRAC code
F: lipids and membrane synthesis	F5: phospholipid biosynthesis and cell wall deposition (proposed)	CAA-fungicides (**C**arboxylic **A**cid **A**mides)	cinnamic acid amides	dimethomorph, flumorph	Low to **medium risk**. Resistance management required.	40
G: sterol biosynthesis in membranes	G1: C14- demethylase in sterol biosynthesis (*erg11/cyp51*)	DMI-fungicides (**De**Methylation **I**nhibitors) (**S**terol **B**iosynthesis **I**nhibitors SBI: Class I)	pyrimidines	fenarimol	There are great differences in the activity spectra of the different DMI fungicides. Resistance is known in various fungal species. Several resistance mechanisms are known, including target site mutation, Y136F in cyp 51 gene, ABC transporters, and others. Generally wise to accept that cross resistance is present among DMI fungicides active against the same fungus. DMI fungicides are Sterol Biosynthesis Inhibitors but show no cross resistance to other SBI classes. **Medium risk.**	3
			imidazoles	triflumizole		
			triazoles	myclobutanil, triadimefon		
U: unknown mode of action	unknown	phosphonates	ethyl phosphonates	fosetyl-Al	Few resistance cases reported in few pathogens. **Low risk**.	33
				phophorous acid and salts		
NC: not classified	unknown	diverse	diverse	mineral oils, organic oils, potassium bicarbonate; material of biological origin	Resistance not known.	NC

Table 2—continued

MOA	Target site and code	Group name	Chemical group	Common name	Comments	FRAC code
M: multisite contact activity	multisite contact activity	inorganic	inorganic	copper (different salts)	Generally considered as a low-risk group without any signs of resistance developing to the fungicides. *For dodine, resistance was reported in *Venturia inequalis,* suggesting that dodine may not be a multisite inhibitor. Resistance management recommended. No cross resistance among group members M1 to M9	M1
		inorganic	inorganic	sulfur		M2
		dithiocarbamates and relatives	dithiocarbamates and relatives	ferbam, mancozeb, maneb, metiram, ziram		M3
		phthalimides	phthalimides	captan, captafol, folpet		M4
		guanidines	guanidines	dodine*, guazatine, iminoctadine		M7

Notes to be read in association with Table 2

When a fungicide is classified as **high** or **medium risk** by FRAC, additional guidelines have been written for resistance management. For additional information concerning the risks and management practices associated with these products, see the FRAC Guidelines for Anilinopyrimidine, Benzimidizole, Carboxylic Acid Amides (CAA), Dicarboximide, Phenylamide, Quinone outside Inhibitors (QoI), and Sterol Biosynthesis Inhibitors (SBI) (http://www.frac.info/frac/index.htm).

Although the current FRAC list is extremely useful in classifying synthetic fungicides and bactericides, it does not cover the following naturally occurring and synthetic products presently registered in Oregon: -2,4-xylenol, gaba (gamma aminobutyric acid), hydrogen peroxide (dioxide), m-cresol, monopotassium phosphate, potassium laurate. These products are covered in Charts 3 and 4.

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Chart 1. Apple Insecticides and Miticides Registered in Oregon, 2008

Apple insect or mite pest	Common name	abamectin (Agri-Mek 0.15 EC)	acequinocyl (Kanemite 15 SC)	acetamiprid (Assail 70 WP)	azadirachtin (Agroneem EC)	azinphos-methyl (Guthion)	*Bacillus thuringiensis* (Dipel, Javelin)	*Beauveria bassiana* ATCC 74040 (Mycotrol)	beta-cyfluthrin (Baythroid XL)	bifenazate (Acramite 50 WS)	canola oil (Pyola, Vegol Insecticidal Oil–OMRI)	carbaryl (Sevin)	chlorpyrifos (Lorsban)	cinnamaldehyde (Cinnacure A3005)	clarified hydrophobic extract of neem oil (Green light fruit tree spray)	clofentezine (Apollo SC)	clothianidin (Clutch 50 WDG)	cyfluthrin (Baythroid 2 EC, Pyrethroid)	deltamethrin (Battalion 0.2 EC, Decis 1.5 EC)	diazinon (Diazinon)	dicofol (Kelthane 50 WSP)	dimethoate (Dimethoate)	dodecadien-1-ol (Isomate C+, Isomate CTT, No Mate, Checkmate)	endosulfan (Thionex 50 WSB, Endosulfan 50 WP)	esfenvalerate (Asana XL)	etoxazole (Zeal 72 WDG)	fenbutatin-oxide (Vendex 50 WP)	fenpropathrin (Danitol 2.4 EC)	fenpyroximate (Fujimite 5 EC)	flonicamid (Beleaf 50 SG)	formetanate (Carzol SP)
REI hours (h) or days (d)		12 h	12 h	12 h	12(4) h	14 d	4 h	4 h	12 h	12 h	12 h	12 h	4 d	4 h	12(4) h	12 h	12 h	12 h	12 h	24 h	48 h	48 h	–	24 h	12 h	12 h	48 h	24 h	12 h	12 h	16 d
PHI hours (h) or days (d)		28 d	14 d	7 d	24 h	14/21 d	0 d	0 d	7 d	7 d	0 d	3 d	DD	48 h	24 h	45 d	7 d	7 d	21 d	21 d	7 d	28 d	–	21 d	21 d	28 d	14 d	14 d	14 d	21 d	PF
Aphids	Apple grain aphid											♦	♦							♦				♦	♦					♦	
	Green apple aphid														♦					♦										♦	
	Rosy apple aphid				♦							♦	♦		♦					♦				♦	♦			♦		♦	
	Woolly apple aphid											♦	♦							♦				♦						♦	
Borers	Pacific flat-headed borer												♦																		
	Ambrosia beetle																							♦							
	Shothole borer												♦																		
Bugs (True)	Lygus bug				♦			♦	♦			♦	♦		♦			♦	♦			♦				♦		♦			♦
	Stink bug				♦	♦		♦	♦			♦	♦		♦			♦	♦					♦				♦			♦
	Campylomma bug			♦																											♦
Caterpillars	Tent caterpillar				♦		♦	♦			♦	♦	♦	♦	♦																
Codling moth	Codling moth			♦	♦	♦	♦		♦			♦	♦	♦	♦		♦	♦	♦				♦		♦			♦			
Eyespotted moths	Eyespotted bud moth				♦		♦						♦		♦					♦		♦									
Grasshopper	Grasshopper				♦	♦		♦	♦			♦	♦		♦			♦	♦	♦		♦			♦						
Leafhoppers	Apple leafhopper								♦			♦						♦	♦					♦	♦			♦	♦		♦
	Rose leafhopper																														
	White apple leafhopper	♦							♦			♦						♦	♦					♦	♦			♦			♦
Leafminers	Western tentiform leafminer	♦		♦								♦								♦				♦	♦						♦
Leafrollers	European leafroller						♦					♦	♦											♦							
	Fruittree leafroller				♦	♦	♦				♦	♦	♦		♦					♦				♦							
	Obliquebanded leafroller				♦		♦		♦				♦				♦	♦	♦	♦					♦						
	Pandemis leafroller						♦		♦			♦	♦					♦						♦				♦			
Maggots	Apple maggot			♦		♦			♦			♦	♦	♦			♦	♦	♦	♦		♦			♦			♦			
Mealybugs	Grape mealybug			♦				♦	♦									♦											♦		
Mites	Apple rust mite											♦									♦			♦			♦				
	Brown mite	♦						♦		♦			♦							♦	♦	♦									
	European red mite	♦	♦			♦				♦	♦	♦	♦			♦				♦	♦					♦	♦		♦		♦
	McDaniel spider mite	♦	♦							♦						♦					♦					♦	♦		♦		♦
	Twospotted spider mite	♦	♦		♦					♦		♦	♦	♦	♦	♦				♦	♦	♦				♦	♦		♦		♦
	Yellow spider mite	♦														♦															
Scales	European fruit lecanium																														
	Oystershell scale											♦																			
	San Jose scale				♦										♦																
Skeletonizers	Apple-and-thorn skeletonizer																			♦											
Thrips	Pear thrips							♦																							
	Western flower thrips				♦			♦										♦													
Worms	Cutworm				♦		♦	♦	♦			♦	♦		♦			♦	♦	♦				♦	♦						
	Lacanobia cutworm				♦	♦	♦					♦	♦	♦	♦													♦			
	Lesser appleworm			♦					♦			♦	♦					♦	♦						♦			♦			
	Green fruitworm				♦	♦	♦		♦			♦	♦					♦	♦					♦	♦			♦			

Apple insect or mite pest	Common name	gamma-cyhalothrin (Tenkoz, Proaxis Insecticide)	garlic oil (Allityn Insect repellent)	granulovirus (Carpovirusine, Cyd-X, Virosoft CP4)	hexythiazox (Onager, Savey 50 DF)	imidacloprid (Provado 1.6 F)	indoxacarb (Avaunt 30 DG)	kaolin (Surround WP)	lambda-cyhalothrin (Warrior)	malathion (Malathion)	methidathion (Supracide)	methomyl (Lannate LV, SP)	methoxyfenozide (Intrepid 2 F)	mineral oil (JMS Stylet-Oil)	novaluron (Rimon 0.83 EC)	oxamyl (Vydate L)	permethrin (Ambush 25 W)	phosmet (Imidan)	potassium laurate (M-Pede, Concern Multi-purpose Insect Killer II–OMRI)	potassium silicate (Sil-MATRIX)	pyrethrin (Pyrenone)	pyridaben (Nexter 75 WP, Pyramite)	pyriproxyfen (Esteem)	rotenone (Pyrellin EC)	rynaxypyr (Altacor)	spinetoram (Delegate WG)	spinosad (Entrust, Success 2 L)	spirodiclofen (Envidor 2 SC)	spirotetramat (Movento)	sulfur (Drexel Suffa, Microthiol DisperssS, Micro Sulf (N), Sulfur 6 L, Sulfur DF)	lime sulfur	tebufenozide (Confirm 2 F)	tetradecanol (Isomate-C)	thiacloprid (Calypso 4 F)	thiamethoxam (Flagship 25 WG)
REI hours (h) or days (d)		24 h	4 h	4 h	12 h	12 h	12 h	4 h	24 h	12 h	14(2) d	3 d	4 h	4 hr	12 h	48 h	12 h	24 h	12 h	4 h	12 h	12 h	12 h	12 h	4 h	4 h	4 h	12 h	24 h	48(24) h	48 h	4 h	–	12 h	NRB
PHI hours (h) or days (d)		21 d	12 h	0 d	28 d	7 d	14 d	0 d	21 d	NRB	DD	14 d	14 d	0 d	14 d	14 d	PF	7 d	0 d	0 d	0 d	25 d	45 d	12 h	14 d	7 d	7 d	7 d	7 d	PF	DD	14 d	–	30 d	NRB
Aphids	Apple grain aphid								♦			♦		♦		♦	♦		♦			♦							♦						♦
	Green apple aphid										♦			♦				♦	♦				♦						♦		♦				♦
	Rosy apple aphid	♦				♦			♦		♦			♦		♦	♦	♦	♦				♦						♦	♦				♦	♦
	Woolly apple aphid					♦																							♦						♦
Borers	Pacific flat-headed borer					♦																													
	Ambrosia beetle																♦																		
	Shothole borer																																		
Bugs (True)	Lygus bug	♦						♦	♦	♦		♦			♦		♦	♦	♦		♦									♦					
	Stink bug	♦				♦		♦	♦			♦			♦		♦		♦		♦			♦											
	Campylomma bug																		♦																
Caterpillars	Tent caterpillar	♦	♦						♦	♦		♦		♦			♦		♦		♦			♦			♦			♦					
Codling moth	Codling moth	♦		♦			♦	♦	♦	♦	♦	♦	♦	♦	♦		♦	♦	♦		♦		♦		♦	♦	♦					♦	♦	♦	
Eyespotted moths	Eyespotted bud moth											♦					♦		♦		♦						♦								
Grasshopper	Grasshopper	♦	♦					♦	♦								♦	♦	♦		♦									♦					
Leafhoppers	Apple leafhopper					♦	♦	♦				♦			♦	♦	♦		♦																♦
	Rose leafhopper									♦									♦																♦
	White apple leafhopper					♦	♦	♦							♦	♦	♦		♦		♦		♦	♦	♦		♦					♦			♦
Leafminers	Western tentiform leafminer	♦							♦			♦	♦		♦		♦						♦			♦	♦								
Leafrollers	European leafroller																																		
	Fruittree leafroller									♦		♦	♦		♦			♦			♦					♦	♦					♦			
	Obliquebanded leafroller							♦				♦	♦		♦		♦				♦		♦	♦	♦	♦	♦					♦			
	Pandemis leafroller							♦					♦		♦								♦			♦	♦								
Maggots	Apple maggot	♦					♦	♦	♦	♦								♦			♦				♦	♦								♦	
Mealybugs	Grape mealybug													♦				♦				♦							♦						♦
Mites	Apple rust mite							♦											♦	♦		♦						♦							
	Brown mite													♦						♦	♦	♦						♦		♦	♦				
	European red mite				♦			♦		♦				♦		♦			♦	♦		♦						♦		♦	♦				
	McDaniel spider mite				♦									♦		♦				♦		♦						♦							
	Twospotted spider mite				♦			♦		♦				♦		♦			♦	♦		♦					♦	♦		♦	♦				
	Yellow spider mite				♦															♦															
Scales	European fruit lecanium																																		
	Oystershell scale									♦				♦													C				♦				
	San Jose scale													♦				♦					♦				C	♦	♦						
Skeletonizers	Apple-and-thorn skeletonizer																																		
Thrips	Pear thrips																																		
	Western flower thrips	♦							♦							♦										♦	♦								
Worms	Cutworm	♦				♦		♦	♦			♦					♦	♦	♦		♦						♦					♦			
	Lacanobia cutworm		♦					♦					♦								♦					♦	♦								
	Lesser appleworm	♦	♦				♦		♦			♦	♦													♦						♦			
	Green fruitworm	♦						♦	♦			♦	♦				♦	♦			♦				♦		♦					♦			

PF = Up to petal fall
NRB = No registration on bearing crops
– = Check label
DD = Delayed dormant
C = Crawler stage only

(red) = Organophosphate
(orange) = Toxic to bees
(lavender) = Use only when temperature is above 35°F and below 90°F

Disclaimers

1) Active ingredients listed above were registered for use on apple trees in Oregon at the time of printing in 2008. It is the applicator's responsibility to ensure that products applied have current registration.

2) Trade names of active ingredients are mentioned as illustrations only. The Oregon State University Extension Service neither discriminates against registered products not listed nor endorses any of these products for efficacy or otherwise. For a more comprehensive list of registered trade names in alphabetical order, see Chart 2, Apple Insecticides and Acaricides Registered in Oregon.

3) Restricted-entry Intervals (REI) and Preharvest Intervals (PHI) are provided as a guide only. These restrictions change frequently, and similar products produced by different manufacturers may have different restrictions. Growers are advised to keep abreast of the latest information concerning individual label requirements and restrictions before selecting and applying a product. Remember, **THE LABEL IS THE LAW.**

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Chart 2. Apple Insecticides and Miticides Registered in Oregon, 2008

Active ingredient	Trade name (bold = OMRI registered)	Chemical class	IRAC main group and mode of action	IRAC chemical subgroup or exemplifying active ingredient
abamectin	Agrimek 0.15 EC, ABBA 0.15 EC, Epi-Mek 0.15 ED	avermectin	6. chloride channel activator	6. avermectins, milbemycins
acequinocyl	Kanemite 15 SC	naphthoquinone	20. mitochondrial complex III electron transport inhibitors (Coupling site II)	20B. acequinocyl
acetamiprid	Assail 70 WP Insect, Assail 70 WP Insecticide, Assail 30 SG	chloro-nicotinyl	4. nicotinic acetylcholine receptor agonists/antagonists	4A. neonicotinoids
azadirachtin	Agroneem EC, **Aza-Direct Biological Insecticide, Green Light Neem Conc., Neemix 4.5 IGR-Organic Production**	botanical	18. ecdysone agonists/molting disruptors	18B. azadirachtin
azinphos-methyl	Guthion, Azinphosmethyl 50W Soluble	organophosphate	1. acetylcholine esterase inhibitors	1B. organophosphates
Bacillus thuringiensis	**Agree WG Biological Insecticide; Biobit HP Bio Insecticide Wettable Powder/Organic Production**; Condor WP Wettable Powder Bioinsecticide; Crymax Bioinsecticide; **Deliver Biological Insecticide/Fruit, Nuts, Vegs & Soybean; Dipel DF Dry Flowable**; Dipel ES; **Javelin WG Biological Insecticide**; Lepinox WDG Insecticide; **Xentari Dry Flowable**	microbial	11. microbial disruptors of insect midgut membranes (includes transgenic crops expressing *Bacillus thuringiensis* toxins)	11A1. *B.t.* subsp. *israelensis*; 11A2. *B. sphaericus*; 11B1. *B.t.* subsp. *tenebrionis*; 11B2. *B.t.* subsp. *kurstaki*; 11C. *B.t.* subsp. *tenebrionis*
Beauveria bassiana ATCC 74040	**Mycotrol O, Naturalis L**, BotaniGard 22 WP, BotaniGard ES	microbial	entomopathogenic fungus	NC (not considered)
beta-cyfluthrin	Baythroid XL	pyrethroid	3. sodium channel modulator	3. pyrethroids
bifenazate	Acramite 50 WS	hydrazine carboxylate	25. neuronal inhibitors (unknown mode of action)	25. bifenazate
canola oil	Pyola	botanical	(a) alters the cuticle structure of the leaf surface, thus repelling the insects, or (b) act as irritants to insects	NC (not considered)
carbaryl	Drexel Carbaryl 4 L Insecticide, Eliminator Bug Killer Conc. Sevin Brand Carbaryl Insecticide, Prokoz Sevin SL, Sevin 4 F Brand Carbaryl Insecticide B, Sevin 80 WSP Carbaryl Insecticide ES, Sevin Brand 80 S Carbaryl Insecticide B, Sevin Brand 80 WSP Carbaryl Insecticide B, Sevin Brand RP4 Carbaryl Inseciticide B, Sevin Brand XLR Plus Carbaryl Insecticide B, Sevin SL Carbaryl Insecticide ES	carbamate	1. acetylcholine esterase inhibitors	1A. carbamates
chlorpyrifos	Lorsban 50W WSP, Agrisolutions Yuma 4 E, Chlorpyrifos 4 E AG, Chlorpyrifos G-PRO 4, Eraser, Govern 4 E, Lorsban 75 WG, Lorsban 4 E, Micro-Flo Chlorpyrifos 4 E AG, Nufos 4 E, Pilot 4 E Chlorpyrifos Agri, Pilot 4 E Chlorpyrifos Agri, Whirlwind	organophosphate	1. acetylcholine esterase inhibitors	1B. organophosphates
cinnamaldehyde	Cinnacure	botanical	exact mode of action unclear; possible interference with glucose uptake or utilization	NC (not considered)
clofentezine	Apollo SC Ovicide/Miticide	tetrazine	10. compounds of unknown or nonspecific mode of action (mite growth inhibitors)	10A. clofentezine
clothianidin	Clutch 50 WDG	chloro-nicotinyl	4. nicotinic acetylcholine receptor agonists/antagonists	4A. neonicotinoids
Cydia pomonella granulosis virus	Carpovirusine, **Cyd-X, Virosoft CP4**	virus	ingestion of virus particles by insect larvae resulting in interference of food adsorption in the larval gut, ultimately causing death of the insect	NC (not considered)
cyfluthrin	Baythroid 2 EC Pyrethroid, Renounce 20 WP	pyrethroid	3. sodium channel modulator	3. pyrethroids
deltamethrin	Battalion 0.2 EC, Decis 1.5 EC	pyrethroid	3. sodium channel modulator	3. pyrethroids
diazinon	Diazinon 50 W, Gowan Diazinon 50 WSB	organophosphate	1. acetylcholine esterase inhibitors	1B. organophosphates
dicofol	Kelthane 50 WSP, Kelthane 50 WSP Miticide	organochlorine	unknown MOA	unc
dimethoate	Cheminova Diomethoate, Drexel Dimethoate	organophosphate	1. acetylcholine esterase inhibitors	1B. organophosphates
disodium octaborate tetrahydrate	Term-a-rid 613 Borate Treated Wood Chips	inorganic	stomach poison	NC (not considered)
dodecadien-1-ol	**Checkmate CM Puffer Dispenser**, Checkmate CM-Codling Moth/Hickory Shuckworm, Check-Mate CM-F, **Checkmate CM-WS, Checkmate CM-XL 1000, Exosex-CM**, Hercon Disrupt CM-Xtra, Nomate CM Fiber, **Nomate CM Spiral**, Puffer CM	pheromone	pheromone	NC (not considered)
dodecanol	**Isomate C Plus, Isomate-C TT**	pheromone	pheromone	NC (not considered)
endosulfan	Drexel Endosulfan 3 EC, Thionex 3 EC, Thionex 50 W, Endosulfan 3 EC, Endosulfan 50 WP	organochlorine	2. GABA-gated chloride channel antagonists	2A. cyclodiene organochlorines
esfenvalerate	Asana XL, DuPont Asana XL	pyrethroid	3. sodium channel modulator	3. pyrethroids
etoxazole	Valent Zeal 72 WDG, Zeal Miticide 1	oxazoline	10. compounds of unknown or nonspecific mode of action (mite growth inhibitors)	10B. etoxazole
fenbutatin-oxide	DuPont Vendex 50 WP, Vendex 50 WP	organotin	12. inhibitors of oxidative phosphorylation, disruptors of ATP formation (inhibitors of ATP synthase)	12B. organotin miticides
fenpropathrin	Danitol 2.4 EC	pyrethroid	3. sodium channel modulator	3. pyrethroids
fenpyroximate	Fujimite 5 EC	pyrazole	21. mitochondrial complex I electron transport inhibitors	21. METI acaricides
flonicamid	Beleaf 50 SG	selective feeding blocker	9. unknown or nonspecific	9C. flonicamid
formetanate	Carzol SP	carbamate	1. acetylcholine esterase inhibitors	1A. carbamates
gamma-cyhalothrin	Tenkoz Proaxis Insecticide	pyrethroid	3. sodium channel modulator	3. pyrethroids
garlic oil	Allityn Insect repellent	botanical	NC (not considered)	NC (not considered)
hexythiazox	Savey 50 DF, Hexagon DF, Onager Miticide	carboxamide mite growth inhibitor	10. compounds of unknown or nonspecific mode of action (mite growth inhibitors)	10A. hexythiazox
imidacloprid	Agristar Impulse 1.6 FL, Couraze 1.6 F, Pasada 1.6 F, Provado 1.6 FL	chloro-nicotinyl	4. nicotinic acetylcholine receptor agonists/antagonists	4A. neonicotinoids
indoxacarb	Avaunt 30 DG, DuPont Avaunt 30 DG	unclassified	22. voltage-dependent sodium channel blockers	22. indoxacarb
kaolin	**Surround WP**	clay	unknown MoA	NC (not considered)
lambda-cyhalothrin	Agrisolutions Taiga Z, Silencer, Warrior	pyrethroid	3. sodium channel modulator	3. pyrethroids
malathion	Eliminator Malathion 50% Maxide Conc Malathion 50 Insect Spray, Prentox Malathion 50% ES	organophosphate	1. acetylcholine esterase inhibitors	1B. organophosphates
methidathion	Supracide 25 W, Supracide 2 E	organophosphate	1. acetylcholine esterase inhibitors	1B. organophosphates
methomyl	DuPont Lannate LV, Dupont Lannate SP, Lannate LV, Lannate SP	carbamate	1. acetylcholine esterase inhibitors	1A. carbamates
methoxyfenozide	Intrepid 2 F	diacylhydrazine	18. ecdysone agonists/molting disruptors	18A. diacylhydrazines
mineral oil	JMS Stylet-Oil, First Choice Gavicide Super 90, Mite-E-Oil Insecticide-Miticide/Spray, **Organic JMS Stylet-Oil**, Pht 435 Oil, PHT V470 Oil, PHT Volck Clear, Pres Trmt Ultra-Fine Oil All Season Hort Insect/Fung, Sunspray Ultra-Fine Year-Round Pesticidal Oil, Superior Spray Oil N.W., Supreme Oil Miticide-Insecticide, Valent Volck Supreme Spray/Western AG, Wil-Gro Hort Oil 98-2	mineral oil	mechanical suffocation by clogging spiracles or disruption of cellular membranes	NC (not considered)
novaluron	Rimon 0.83 EC, Rimon 7.5 WG	benzoylurea	15. inhibitors of chitin biosynthesis, type 0, Lepidopteran	15. benzoylureas
oxamyl	Dupont Vydate L, Vydate L	carbamate	1. acetylcholine esterase inhibitors	1A. carbamates
permethrin	Ambush 25 W, Arctic 3.2 EC, Astro Insecticide, Permethrin 3.2, Perm-Up 24 WP, Perm-Up 3.2 EC, Pounce 25 WP, Pounce 3.2 EC, Tenkoz Permethrin 3.2 EC, Waylay 3.2 AG Permethrin Insecticide	pyrethroid	3. sodium channel modulator	3. pyrethroids
phosmet	Imidan 70 W, Imidan 70 WP, Imidan 70 WSB	organophosphate	1. acetylcholine esterase inhibitors	1B. organophosphates
potassium laurate	**M-Pede, Concern Multi-Purpose Insect Killer II-Omri [Spanish]**	fatty acid	membrane disruption	NC (not considered)
potassium silicate	Sil-MATRIX Fungicide/Miticide/Insecticide	unclassified	unknown MoA	NC (not considered)
pyrethrin	**Concern Multi-Purpose Insect Killer II-Omri [Spanish]**, Evergreen Crop Protection EC 60-6, Prentox Pyronyl Crop Spray, Pres Treatment Pyreth-IT Form2, **Pyganic Crop Protection EC 5.0 II-OMRI**, Pyrenone Crop Spray ES	pyrethroid	3. sodium channel modulator	3. pyrethrin
pyridaben	Nexter 75 WP, Pyramite	pyridazine	21. mitochondrial complex I electron transport inhibitors	21. METI acaricides
pyriproxyfen	Valent Esteem 0.86 EC, Valent Esteem 35 WP, Seize 35 WP	insect growth regulator (IGR)	7. juvenile hormone mimics	7C. pyriproxyfen
rotenone	Pyrellin E.C.	botanical	21. mitochondrial complex I electron transport inhibitors	21. rotenones
rynaxypyr	Altacor	chlorantraniliprole	28. ryanodine receptor modulators	28. diamides
spinetoram	Delegate WG insecticide	microbial	5. nicotinic acetylcholine receptor agonists (allosteric) (not group 4)	5. spinosyn
spinosad	**Entrust-OMRI, GF-120 NF Naturalyte Fruit Fly Bait-OMRI**, Success Naturalyte Insect Control, Success 2 L	microbial	5. nicotinic acetylcholine receptor agonists (allosteric) (not group 4)	5. spinosyns
spirodiclofen	Envidor 2 SC	tetronic acid derivative	23. inhibitors of lipid synthesis	23. tetronic acid derivatives
spirotetramat	Movento	tetronic acid derivative	23. inhibitors of lipid synthesis	23. tetronic acid derivatives
sulfur	**Ben-Sul 85, Cosavet-DF Fungicide-Miticide-OMRI, CSC 80% Thiosperse**, Copper Sulfur Dust, Drexel Suffa, Dusting Sulfur, **Kumulus DF, Micro Sulf (N), Micro-Sul**, Microthiol DispersS, Dusting Sulfur O, Sulfur 6 L, Sulfur DF, Supersix Liquid Sulfur, Sul-Preme 52 Flowable Sulfur, **Thiolux Dry Flowable Micronized Sulfur**, Thiolux Jet Dry Flowable Micronized Sulfur, Wilbur Ellis Spray Sulfur	inorganic	multisite contact activity (proposed)	NC (not considered)
sulfur (lime)	**BSP Lime-Sulfur Solution**, BSP Sulforix, **Green Cypress Lime Sulfur Solution-OMRI**	inorganic	multisite contact activity (proposed)	NC (not considered)
tebufenozide	Confirm 2 F; Confirm 2 F Agricultural Insecticide	diacylhydrazine	18. ecdysone agonists/molting disruptors	18A. diacylhydrazines
tetradecanol	**Isomate-C Plus; Isomate-C TT**	pheromone	pheromone	NC (not considered)
thiacloprid	Calypso 4 F Insecticide	chloro-nicotinyl	4. nicotinic acetylcholine receptor agonists/antagonists	4A. neonicotinoids
thiamethoxam	Flagship 25 WG	chloro-nicotinyl	4. nicotinic acetylcholine receptor agonists/antagonists	4A. neonicotinoids

Disclaimers

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2) The above list of trade names of active ingredients registered for use in commercial apple farming in Oregon may be incomplete. Where registered products have been omitted inadvertently, Oregon State University Extension Service neither intends to discriminate against these products nor endorses any of the products for efficacy or otherwise.

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Chart 3. Apple Fungicides and Bactericides Registered in Oregon, 2008

Apple disease	2,4-xylenol (Gallex)	*Bacillus pumilus* strain qst 2808 (Sonata)	*Bacillus subtilis* strain qst713 (Serenade)	boscalid (Pristine)	captan (Captan)	chitosan (Elexa 4 Plant Defense Booster)	cinnamaldehyde (Cinnacure)	clarified hydrophobic extract of neem oil (Green Light Neem Conc)	copper hydroxide (Kocide DF)	copper metallic (Copper Count-N, L/M Kop-R-Spray Conc)	copper octanoate (Neudorff Cueva Fungicide Conc-OMRI, Soap-Shield Flowable Liquid Copper Fungicide)	copper oxide (cuprous oxide) (Nordox 75 WP)	copper oxychloride ($Cu_2Cl(OH)_3$) (C-O-C-S WDG)	copper salts of fatty and rosin acids (PRES Treatment Camelot Fungicide)	copper sulfate (-pentahydrate) (Quimag Quimicos Aguila Copper Sulfate Crystal)	copper sulfate basic (Basic Copper 53, Basicop Fungicide/Bactericide, Cuprofix Ultra 40 Disperss)	cyprodinil (Vanguard WG Fungicide)	dodine (Syllit FL Fungicide)
REI hours (h) or days (d)	DD	4 h	4 h	12 h	4 d	4 h	24 h	4 h	24 h	24 h	4 h	24 h	24 h	12 h	24 h	24 h	12 h	48 h
PHI hours (h) or days (d)	–	0 d	0 d	0 d	0 d	–	48 h	24 h	AH	AH	PF	AH	AH	PF	77 d	AH	72 d	7 d
Anthracnose			♦		♦			♦	♦	♦	♦	♦	♦	♦		♦		♦
Bacterial canker			♦						♦	♦	♦	♦			♦	♦		
Blue mold			♦	♦					♦			♦			♦			
Bull's eye rot					♦													
Apple burrknot	♦																	
Crown and collar rot			♦						♦	♦		♦				♦		
Crown gall	♦				♦													
Fireblight		♦	♦						♦	♦	♦	♦	♦	♦	♦	♦		
Gray mold		♦	♦	♦	♦			♦	♦	♦	♦			♦	♦			
Nectria canker									♦	♦								
Nectria twig blight					♦			♦	♦	♦		♦	♦	♦		♦		
Powdery mildew		♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	
Apple scab		♦	♦	♦	♦			♦	♦	♦	♦	♦	♦	♦		♦	♦	♦

Apple disease	fenarimol (Rubigan EC)	ferbam (Ferbam Granulo Fungicide)	fosetyl-Al (aluminum tris (o-ethylphosphonate)) (Aliette)	gaba (gamma aminobutyric acid) (AuxiGro WP Plant Metabolic Primer)	glutamic acid (AuxiGro WP Plant Metabolic Primer)	hydrogen peroxide (dioxide) (Oxidate)	jojoba oil (Eco E-Rase)	kresoxim-methyl (Sovran Fungicide)	lime sulfur (BSP Lime-Sulfur Solution, BSP Sulforix, Green Cypress Lime-Sulfur Solution-OMRI)	mancozeb (Dithane M-45, Dupont Manzate Pro-Stick, Mankocide, Manzate Flowable Fungicide, Penncozeb 4 FL)	maneb (Dupont Manex Fungicide, Maneb 75 DF Dry Flowable Fungicide, Manex Fungicide Flowable W/Zinc)	m-cresol (Gallex)	mefenoxam (r-enantiomer of metalaxyl) (Ridomil Gold EC)	metiram (Polyram 80 DF)	mineral oil, petroleum distillates, solvent refined light (JMS Stylet-Oil, Sunspray Ultra-Fine Year-Round Pesticidal Oil)	monopotassium phosphate (Nutrol o-50-32)	myclobutanil (Prokoz Hoist Specialty Fungicide, Rally 40 W, Spectracide Immunox)	oxytetracycline (Flameout, Mycoshield)
REI hours (h) or days (d)	12 h	24 h	12 h	4 h	4 h	0 h	4 h	12 h	48 h	24 h	24 h	DD	48 h	24 h	4 h	4 h	24 h	12 h
PHI hours (h) or days (d)	30 d	7 d	14 d	–	–	0 h	0 d	30 d	DD	77 d	77 d	–	AH	0 d	60 d	10 d	14 d	60 d
Anthracnose			♦			♦			♦	♦	♦						♦	
Bacterial canker																		
Blue mold																		
Bull's eye rot																		
Apple burrknot												♦						
Crown and collar rot			♦			♦				♦			♦			♦	♦	
Crown gall												♦						
Fireblight			♦							♦								♦
Gray mold										♦						♦		
Nectria canker										♦								
Nectria twig blight									♦	♦							♦	
Powdery mildew	♦			♦	♦	♦	♦	♦	♦	♦					♦	♦	♦	
Apple scab	♦	♦				♦		♦	♦	♦	♦			♦			♦	

Apple disease	petroleum base oil (Biocover MLT)	phosphorous acid (Fosphite Fungicide-Master Label, Helena Prophyt, Rampart Potassium Phosphite)	phosphorous acid, mono- and di-potassium salts of (Agri-fos, Arborfos, Crop-Phite, Leaf-Guard Systemic Fungicide)	potassium bicarbonate (Armicarb "O," Green Cure/Organic Production, Kaligreen, Milstop Broad Spectrum F)	potassium laurate (M-Pede)	potassium silicate (Sil-Matrix)	*Pseudomonas fluorescens* a506 (Blightban A506, Nufarm Blightban A506)	pyraclostrobin (Pristine)	pyrimethanil (Scala Brand SC Fungicide (B))	streptomycin sulfate (AG Streptomycin, Agri-Mycin 17 Agricultural Streptomycin (Nu), Bac-Master)	sulfur (Ben-Sul 85, Drexel, Kumulus DF, L/M Sulfur Dust, Micro Sulf (N), Micro-Sul Dusting Sulfur O, Microthiol Disperss)	thiabendazole (Mertect 340-F Fungicide)	thiophanate-methyl (T-Methyl 70 W WSB, Topsin 4.5 FL, Topsin M 70 WDG, Topsin M WSB)	triadimefon (Amvac Bayleton 50% Dry Flowable Fungicide, Bayleton 50% Dry Flowable Fungicide (B))	trifloxystrobin (Flint Fungicide (B))	triflumizole (Procure 480 SC AG Fungicide, Terraguard Ls 50% Wettable Powder Fungicide (CM))	ziram (Ziram 76 DF Fungicide)
REI hours (h) or days (d)	4 h	4 h	4 h	4 h	12 h	4 h	4 h	12 h	12 h	12 h	24 h	12 h	12 h	12 h	12 h	12 h	48 h
PHI hours (h) or days (d)	60 d	0 d	0 d	0 d	12 h	0 d	–	0 d	72 d	50 d	–	0 d	NRB	45 d	14 d	14 d	14 d
Anthracnose			♦	♦									♦		♦		♦
Bacterial canker																	
Blue mold		♦	♦	♦				♦				♦	♦				
Bull's eye rot												♦	♦				♦
Apple burrknot																	
Crown and collar rot		♦	♦										♦				
Crown gall																	
Fireblight		♦	♦				♦			♦							
Gray mold				♦				♦	♦			♦	♦				
Nectria canker													♦				
Nectria twig blight				♦						♦			♦				♦
Powdery mildew	♦	♦		♦	♦	♦		♦			♦		♦	♦	♦	♦	♦
Apple scab		♦	♦	♦				♦	♦		♦		♦		♦	♦	♦

AH = After harvest up to green tip
DD = Delayed dormancy only
PF = Up to petal fall
– = Not specified; follow label
NRB = No registration on bearing crops

Disclaimers

1) All active ingredients listed above were registered for use on apple trees in Oregon at the time of printing in 2008. This situation may change in the future. Consequently it is the applicator's responsibility to ensure that the products selected and applied on apples in Oregon have current registration.

2) Trade names of active ingredients are mentioned as illustrations only. The Oregon State University Extension Service neither intends to discriminate against registered products not listed here, nor to endorse any of these products for efficacy or otherwise. For a more comprehensive list of registered trade names in alphabetical order, see Chart 4, Apple Fungicides and Bactericides in Oregon.

3) Restricted-entry Intervals (REI) and Preharvest Intervals (PHI) are provided as a guide only. These restrictions change frequently, and similar products produced by different manufacturers may not have the same restrictions. Consequently, growers are advised to keep abreast of the latest information concerning individual label requirements and restrictions before selecting and applying a product. Remember, **THE LABEL IS THE LAW.**

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Chart 4. Apple Fungicides and Bactericides Registered in Oregon, 2008

Active ingredient	Trade name (bold = OMRI registered)	Chemical group	Mode of action	Chemical activity	FRAC code
2,4-xylenol	Gallex	phenol	unknown (U)	contact/locally systemic	NC
Bacillus pumilus strain qst 2808	**Sonata Biofungicide/Organic Production**	microbial	not classified (NC)	microbial	NC
Bacillus subtilis strain qst713	Serenade, **Serenade Max/Organic Production, Serenade ASO-OMRI, Serenade Max/Organic Production**, Serenade Solutions	microbial	not classified (NC)	microbial	NC
boscalid	Pristine	pridine carboximide	respiration (C2)	systemic	7
captan	Arvesta Captan 80 WG, Captan 50 WP, Captan 80 WDG, Captan 80-WP, Captan Pro 50 WP Fungicide, Captan Pro 80 WDG, Drexel Captan 4L Fungicide, Drexel Captan 80 WDG	phthalimides	multisite contact activity (M)	contact	M4
chitosan	Elexa 4 Plant Defense Booster	animal derived	not classified (NC)	elicitor	NC
cinnamaldehyde	Cinnacure	cinnamic acid amides	lipid and membrane synthesis (F5)	energy related (glucose uptake)	40
clarified hydrophobic extract of neem oil	**Green Light Neem Conc.**, Trilogy Fungicide/Miticide/Insecticide	botanical	not classified (NC)	contact	NC
copper hydroxide	Champ DP AG Fungicide/Bactericide Dry Prill (NU), Champ Formula 2 F (NU), **Champion Wettable Powder AG Fungicide (NU)**, Dupont Kocide 2000 Fungicide, Junction Fungicide/Bactericide Dry Flowable, Kocide 101 Fungicide/Bactericide, Kocide 101 Protech, Kocide 2000 Protech, Kocide 2000 T/N/O Fungicide/ Bactericide, Kocide 4.5 LF Fungicide/Bactericide, Kocide DF Fungicide/Bactericide, Kocide DF Protech, Kocide LF Fungicide/Bactericide, Mankocide Fungicide/Bactericide, **NU Cop 50 WP Agricultural Fungicide/Bactericide**, NU-Cop 3L, NU-Cop 50 DF Fungicide/Bactericide, Stretch Fungicide	inorganic	multisite contact activity (M1)	contact	M1
copper metallic	Cooke Kop-R-Spray Conc, Copper-Count-N, Hi-Yield Bordeaux Mix Fungicide, L/M Kop-R-Spray Conc	inorganic	multisite contact activity (M1)	contact	M1
copper octanoate	E.B. Stone Copper Soap Conc., **Neudorff Cueva Fungicide Conc-OMRI**, Soap-Shield Flowable Liquid Copper Fungicide	inorganic	multisite contact activity (M1)	contact	M1
copper oxide (cuprous oxide)	**Nordox 75 WG Wettable Granule Fungicide**	inorganic	multisite contact activity (M1)	contact	M1
copper oxychloride ($Cu_2Cl(OH)_3$)	C-O-C-S WDG	inorganic	multisite contact activity (M1)	contact	M1
copper salts of fatty and rosin acids	Prescription Treatment Camelot Fungicide	inorganic	multisite contact activity (M1)	contact	M1
copper sulfate (-pentahydrate)	Quimag Quimicos Aguila Copper Sulfate Crystal, Triangle Brand Copper Sulfate Instant Powder	inorganic	multisite contact activity (M1)	contact	M1
copper sulfate basic	Basic Copper 53, Basicop Fungicide/Bactericide, C-O-C-S WDG, Cuprofix DispersS, Cuprofix MZ DispersS, Cuprofix Ultra 40 DispersS, Dexol Bordeaux Powder, L/M Microcop Fungicide	inorganic	multisite contact activity (M1)	contact	M1
cyprodinil	Vanguard WG Fungicide	anilino-pyrimidine (AP)	amino acids and protein synthesis (D1)	systemic	9
dodine	Syllit FL Fungicide	guanidine	multisite contact activity (M7)	contact	M7
fenarimol	Rubigan EC	pyrimidine	sterol biosynthesis in membranes (G1)	systemic	3
ferbam	Ferbam Granulo Fungicide	dithiocarbamates and relatives	multisite contact activity (M3)	contact	M3
fosetyl-Al (aluminum tris (o-ethylphosphonate))	Aliette WDG Fungicide (B)	phosphonates	unknown (U)	systemic	33
gaba (gamma aminobutyric acid)	Auxigro WP Plant Metabolic Primer	not classified (NC)	not classified (NC)	not classified (NC)	NC
glutamic acid	Auxigro WP Plant Metabolic Primer	not classified (NC)	not classified (NC)	not classified (NC)	NC
hydrogen peroxide (dioxide)	**Oxidate Broad Spectrum Bactericide/Fungicide, Oxyfresh**	inorganic	unknown (U)	contact	NC
jojoba oil	**Eco-Erase OMRI**	botanical	not classified (NC)	contact	NC
kresoxim-methyl	Sovran Fungicide	quinone outside inhibitor (QoI)	respiration (C3)	translaminar	11
lime sulfur	**BSP Lime-Sulfur Solution**, BSP Sulforix, **Green Cypress Lime-Sulfur Solution-OMRI**, L/M Polysul Summer & Dormant Spray Conc	inorganic	multisite contact activity (M2)	contact	M2
mancozeb	Clevis Contains Eagle and Dithane, Cuprofix MZ DispersS, Dithane DF Rainshield Agricultural Fungicide (R), Dithane F-45 Rainshield, Dithane F-45 Rainshield Agricultural Fungicide (R), Dithane M-45, Dithane M-45 Agricultural Fungicide (R), Dupont Manzate Pro-Stick Fungicide, Junction Fungicide/Bactericide Dry Flowable, Mankocide Fungicide/Bactericide, Manzate 75 DF Fungicide, Manzate 80 WP Fungicide, Manzate Flowable Fungicide, Penncozeb 4 FL Flowable Fungicide, Penncozeb 4 FL Flowable Fungicide, Penncozeb 75 DF Dry Flowable Fungicide, Penncozeb 75 DF Dry Flowable Fungicide, Penncozeb 80 WP Fungicide	dithiocarbamates and relatives	multisite contact activity (M3)	contact	M3
maneb	Dupont Manex Fungicide, Maneb 75 DF Dry Flowable Fungicide, Maneb 80 WP Fungicide, Manex Fungicide Flowable W/Zinc	dithiocarbamates and relatives	multisite contact activity (M3)	contact	M3
m-cresol	Gallex	phenol	unknown (U)	contact/locally systemic	NC
mefenoxam (r-enantiomer of metalaxyl)	Axle 2E Fungicide, Ridomil Gold EC Fungicide, Ridomil Gold SL Fungicide	phenylamine	nucleic acids synthesis (A1)	systemic	4
metiram	Polyram 80 DF	dithiocarbamates and relatives	multisite contact activity (M3)	contact	M3
mineral oil, petroleum distillates, solvent refined light	Biocover SS; Biocover UL; Glacial Spray Fluid; IAP 415 Summer Spray Oil; IAP 440 All Purpose Spray Oil; IAP Organic Spray Oil; JMS Stylet-Oil; **Organic JMS Stylet-Oil**; PHT V470 Oil; PHT Volck Clear; Pres Trmt Ultra-Fine Oil All Season Hort Insect/Fungicide; Saf-T-Side; Saf-T-Side Spray Oil Emulsion Fung, Insect, & Miticide; Sunspray Ultra-Fine Year-Round Pesticidal Oil	mineral oil	not classified (NC)	contact	NC
monopotassium phosphate	Nutrol 0-50-32	inorganic	unknown (U)	systemic/contact	NC
myclobutanil	Clevis Contains Eagle and Dithane, Eagle 20 EW, Eagle 40 WP Specialty Fungicide, Eagle WSP T&O Fungicide in WSP, Laredo EC Agricultural Fungicide, Prokoz Hoist Specialty Fungicide, Rally 40W, Rally 40W Agricultural Fungicide in WSP (R), Spectracide Immunox Multi-Purpose Fungicide Spray Conc	triazole	sterol biosynthesis in membranes (G1)	systemic	3
oxytetracycline	Flameout, Mycoshield	microbial	not classified (NC)	microbial	NC
petroleum base oil	Biocover MLT	diverse	not classified (NC)	contact	NC
phosphorous acid	Agrisolutions Topaz Fungicide, Alude Systemic Fungicide, Fosphite Fungicide-Master Label, Helena Prophyt, Phostrol Agricultural Fungicide (NU), Rampart Potassium Phosphite, Rampart T&O Potassium Phosphite	phosphonates	unknown (U)	systemic	33
phosphorous acid, mono- and di-potassium salts of	Agri-fos, Agri-fos Sytemic Fungicide, Arborfos, Crop-Phite Agricultural Fungicide, Leaf-Guard Systemic Fungicide, Prophyt	phosphonates	unknown (U)	systemic	33
potassium bicarbonate	Armicarb "O," Green Cure/Organic Production, **Kaligreen, Milstop Broad Spectrum Foliar Fungicide**	not classified (NC)	not classified (NC)	contact	NC
potassium laurate	M-Pede Insecticide/Fungicide, **M-Pede Insecticide/Fungicide-OMRI**	unknown (U)	fatty acid	contact	NC
potassium silicate	Sil-Matrix Fungicide/Miticide/Insecticide	not classified (NC)	not classified (NC)	contact	NC
Pseudomonas fluorescens a506	Blightban A506, N**ufarm Blightban A506**	microbial	not classified (NC)	microbial	NC
pyraclostrobin	Pristine	methoxy carbamate	respiration (C3)	translaminar/systemic	11
pyrimethanil	Scala Brand SC Fungicide (B)	anilino-pyrimidine (AP)	amino acids and protein synthesis (D1)	systemic	9
streptomycin sulfate	AG Streptomycin, Agricultural Streptomycin, Agri-Mycin 17, **Agri-Mycin 17 Agricultural Streptomycin (Nu)**, Bac-Master, Farmsaver.Com Agricultural Steptomycin, Firewall, Repar Steptomycin 17 AG Streptomycin, Streptrol Agricultural Streptomycin (Nu)	glucopyranosyl antibiotic	amino acids and protein synthesis (D4)	microbial	25
sulfur	**Ben-Sul 85, CSC 80% Thiosperse**, Drexel Suffa, Dusting Sulfur, Golden-Dew, Grant's Sulfur Dust Fung/ Insecticide, **Kumulus DF**, L/M RTU Multi-Purpose Fungicide, L/M Sulfur Dust, Liquid Sulfur Six, **Micro Sulf (N)**, Micro-Sul Dusting Sulfur O, Microthiol Disperss, Sulfur 6L, **Sulfur DF**, Sul-Preme 52 Flowable Sulfur, Supersix Liquid Sulfur, Thiolux Dry Flowable Micronized Sulfur, **Thiolux Jet Dry Flowable Micronized Sulfur**, Wilbur-Ellis Spray Sulfur	inorganic	multisite contact activity (M2)	contact	M2
thiabendazole	Mertect 340-F Fungicide	benzimidazole	mitosis and cell division (B1)	systemic	1
thiophanate-methyl	3336 WP Turf and Ornamental Systemic Fungicide, Farmsaver.Com Thiophanate Methyl 85 WDG, Quali-Pro TM 4.5, Quali-Pro TM 85 WDG, Thiophanate Methyl 85 WDG Fungicide, T-Methyl 4.5 F Ag Fungicide, T-Methyl 70 W WSB, Topsin 4.5 FL, Topsin M 70 WDG, Topsin M 70 WP, Topsin M WSB	thiophanate	mitosis and cell division (B1)	systemic	1
triadimefon	Amvac Bayleton 50% Dry Flowable Fungicide, Bayleton 50% Dry Flowable Fungicide (B)	triazole	sterol biosynthesis in membranes (G1)	systemic	3
trifloxystrobin	Flint Fungicide (B)	quinone outside inhibitor (QoI)	respiration (C3)	translaminar	11
triflumizole	Procure 480 SC AG Fungicide, Procure 480 SC AG Fungicide (CM), Procure 50 WS Agricultural Fungicide (CM), Terraguard Ls 50% Wettable Powder Fungicide (CM)	imidazole	sterol biosynthesis in membranes (G1)	systemic	3
ziram	Ziram 76DF Fungicide	dithiocarbamates and relatives	multisite contact activity (M3)	contact	M3

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