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How to Reduce the Risk of Pesticide Resistance in Winegrape Pests in Oregon

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Pesticides, including insecticides, acaricides, fungicides, bactericides, and herbicides are essential for maintaining healthy grape 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. Several miticides have failed due to resistance by insect and mite species in agricultural ecosystems. 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 because fungal life cycles are short and multiple generations are produced in a single growing season. However, poor disease control can also result from other factors such as incorrect disease identification, adverse weather conditions, and inadequate spray coverage or timing. Always consider these possible causes before concluding that poor control is the result of resistance.

This publication provides detailed information on insecticides and fungicides currently registered for use on winegrapes 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 as they formulate spray programs to reduce the risk of resistance to insecticides and fungicides.

Insecticide and acaricide resistance

Insecticide and acaricide resistance has occurred across the entire spectrum of arthropods, including Diptera, Lepidoptera, Hymenoptera, Heteroptera, Coleoptera, and Acarina. 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*."

Chemistries implicated include carbamates, organophosphates, and pyrethroids. Organic products such as *Bacillus thuringiensis* (*Bt*) 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. Insect pests of winegrapes with documented resistance to insecticides in the United States, and in particular in the Pacific Northwest, include aphids and western flower thrips.

Oregon State University Extension Service

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When a chemical is used continuously, insecticide resistance may lead to the loss of insect control in the field. Crop losses and crop failures may follow. 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, another class of products with increased efficacy is used, and the cycle repeats.

Often, beneficial or nontarget insects are more susceptible to the chemical than the pest species. Not only does resistance lead to increased costs of production, but consecutive spraying can lead to secondary or minor pests becoming major pests due to increased pesticide exposure toward beneficial nontarget species.

Resistance buildup through genetic modification of the pest species to a specific pesticide often confers cross resistance to other chemically related compounds that share a common target site and mode of action within the pest.

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

To avoid pesticide resistance, growers, consultants, Extension agents, and applicators need a thorough understanding of insecticide and acaricide modes of action and how different chemical groups target pests. Combined with a clear understanding of an effective multiple-pesticide attack, this knowledge will help avoid resistance buildup in Oregon vineyards.

Winegrape insecticide and acaracide charts

Active ingredients registered for use on winegrapes in Oregon appear in Charts 1 and 2. Chart 1 lists pests of major concern to winegrape 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. Pesticide information profiles are also available from Oregon State University's Extoxnet (http://extoxnet.orst.edu/pips/ghindex.html).

Chart 2 lists active ingredients alphabetically, together with all currently registered trade names. In addition, Chart 2 details the chemical class, mode of action (MOA), IRAC information, 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. Please be aware that products listed by OMRI change frequently, so organic growers are advised to consult their certifying agency. Chemical labels are also available online through a searchable database at Crop Data Management Systems (http://www.cdms.net/LabelsMsds/LMDefault.aspx).

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 pest tolerance. For example, several American (*Vitis* spp.) rootstocks are tolerant of phylloxera.
- Integrate chemical applications with cultural and biological methods into an insect control program. Consider inoculating with beneficial nematodes (for example, *Steinernema* and *Heterorhabditis*), which control a wide range of insect pests. Or, plant cover crops that support beneficial insect populations.
- Before you spray, make sure that insect or mite populations are high enough to justify control. Use appropriate local economic thresholds for insect populations. Contact your local OSU Extension agent to obtain threshold levels.
- Understand the target insect's life cycle and phenological model (http://ippc2.orst.edu/cgi-bin/ddmodel.pl) for each pest. When controlling immature stages, target younger larval instars if possible because these stages usually are more susceptible and thus much more effectively controlled by insecticides than older stages.
- Where possible, select insecticides and other pest management tools that preserve beneficial insects. These pesticides usually are more pest-specific and

have a shorter residual life, but generally have a higher resistance risk! Remember, 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. Calibrate sprayers annually and before any significant change in spray volume. When calibrating sprayers, be sure to take into account the row spacing, training system, time of year, and desired coverage.
- Observe spray intervals on label recommendations. Do not lengthen intervals.
- 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.
- 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 winegrapes is not as common as insecticide resistance. It is important to note that fungicide resistance occurs in relatively few pathogens, and most fungicides are still very effective against the target organisms for which they were developed. Resistance has, however, been found in the following:

- Powdery mildew *(Uncinula necator)* to Demethylation Inhibitors (DMI) (triadimefon, myclobutanil, and fenarimol) and to Quinoline (quinoxyfen)
- Gray mold *(Botrytis cinerea)* to DMI (triadimefon, myclobutanil, and fenarimol), Benzimidazoles (thiophanate-methyl), and Aniline-pyrimidine (cyprodinil)

Fungicide resistance can arise rapidly and may be either complete or more gradual, resulting in partial 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.

Winegrape fungicide and bactericide charts

Fungicides and bactericides registered for use on winegrapes in Oregon appear in Charts 3 and 4. Chart 3 lists diseases of major concern to winegrape 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 a product. For up-to-date information, see WSU's Pesticide Notification Network (http://ext.wsu.edu/pnn/). Pesticide information profiles are also available from Oregon State University's Extoxnet (http://extoxnet.orst.edu/pips/ghindex.html). Chemical labels are also available online through a searchable database at Crop Data Management Systems (http://www.cdms.net/LabelsMsds/LMDefault.aspx).

Chart 4 lists active ingredients alphabetically, together with all currently registered trade names. In addition, Chart 4 details the mode of action (MOA), chemical activity, and Fungicide Resistance Action Committee (FRAC) group name and 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 virus-indexed or crown-gall-free planting material.
- Choose virgin vineyard land for establishing new blocks when possible. Assess the site before planting, and avoid areas with disease. Good site preparation is necessary to avoid problems with diseases such as Armillaria root rot that are associated with oak groves and forested areas.
- When planting into areas with known disease, rid the area of inoculum by removing and destroying root and shoot debris, and use other cultural methods to control disease. In some cases, soil fumigation may be necessary before replanting to reduce the incidence or spread of diseases or viruses, particularly on old vineyard or orchard sites.
- Consider mulching and inoculating soils with beneficial organisms (e.g., *Trichoderma)* that actively compete with detrimental fungi. These organisms help create a soil buffer to disease organisms by building microbial biodiversity.
- Understand the disease life cycle and disease phenology to effectively target fungicide applications in a timely manner.
- Spray every row.
- Maximize spray penetration of the canopy through proper canopy management; i.e., pruning and training vines to allow air movement and light penetration.
- Use only well-maintained and well-calibrated equipment. Follow recommendations for water volumes, spray pressures, and temperatures to obtain optimal coverage and maximum effect of the fungicide. Calibrate sprayers annually and whenever there is a significant change in spray volume.
- 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 to help 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 recommended rate.
- Use fungicides at effective doses and observe spray intervals on label recommendations. Reduced (sublethal) doses quickly select populations with average levels of tolerance.
- In the event of a control failure with a specific fungicide, do not reapply the same compound. Change the class of fungicide to one having a different mode of action and to which there is no locally known cross resistance.
- Maximize crop hygiene by disinfecting vineyard tools, disposing of old cordons and trunks, and eliminating other sources of inoculum such as unpicked fruit, pruned brush, and garbage heaps.
- Avoid repeated applications of fungicides of the same group and/or mode of action. Use fungicides from at least three different FRAC groups in rotation. Refer to Charts 3 and 4 for easier decision making.
- 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. Also consult the current *PNW Plant Disease Management Handbook*.

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 use the strategies in this publication. A thorough understanding of pesticide modes of action, chemical groups, chemical activities, and IRAC/FRAC codes will enable informed decisions about which chemicals to use in 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 multimillion dollar cost and time associated with bringing new pesticides to market, and closer scrutiny and retesting of existing products, pressure is mounting to maintain the integrity of currently registered products. This situation affects not only conventional agriculture but also organic agriculture. In fact, organic agriculture may be even more at risk, since fewer registered products with different modes of action are available to control pests and diseases.

The limited number of pesticide products available to homeowners is another problem. Commercial fruit industries in close proximity to cities may have a higher risk of 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 of the products, both synthetic and of natural origin, registered in the United States. Consequently, every effort should be made to follow the guidelines in this publication in order to help achieve acceptable control and extend the use of highly effective materials currently registered for use on winegrapes.

Insecticide Resistance Action Committee
www.irac-online.org

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 over-use or mis-use 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 indicated 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 50SC is an IRAC Mode of Action Group 15 insecticide. Any insect population may contain individuals naturally resistant to Insecticide 50SC 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 50SC 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."

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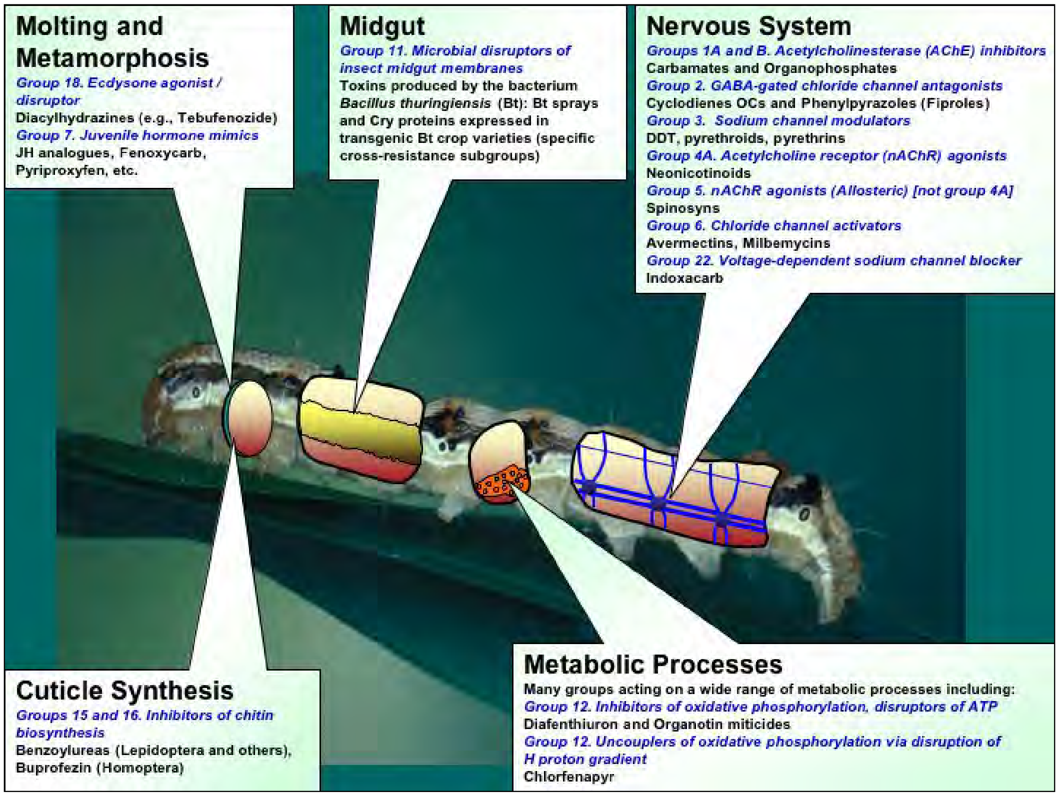
Molting and Metamorphosis
Group 18. Ecdysone agonist / disruptor
Diacylhydrazines (e.g., Tebufenozide)
Group 7. Juvenile hormone mimics
JH analogues, Fenoxycarb, Pyriproxyfen, etc.
Midgut
Group 11. Microbial disruptors of insect midgut membranes
Toxins produced by the bacterium Bacillus thuringiensis (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

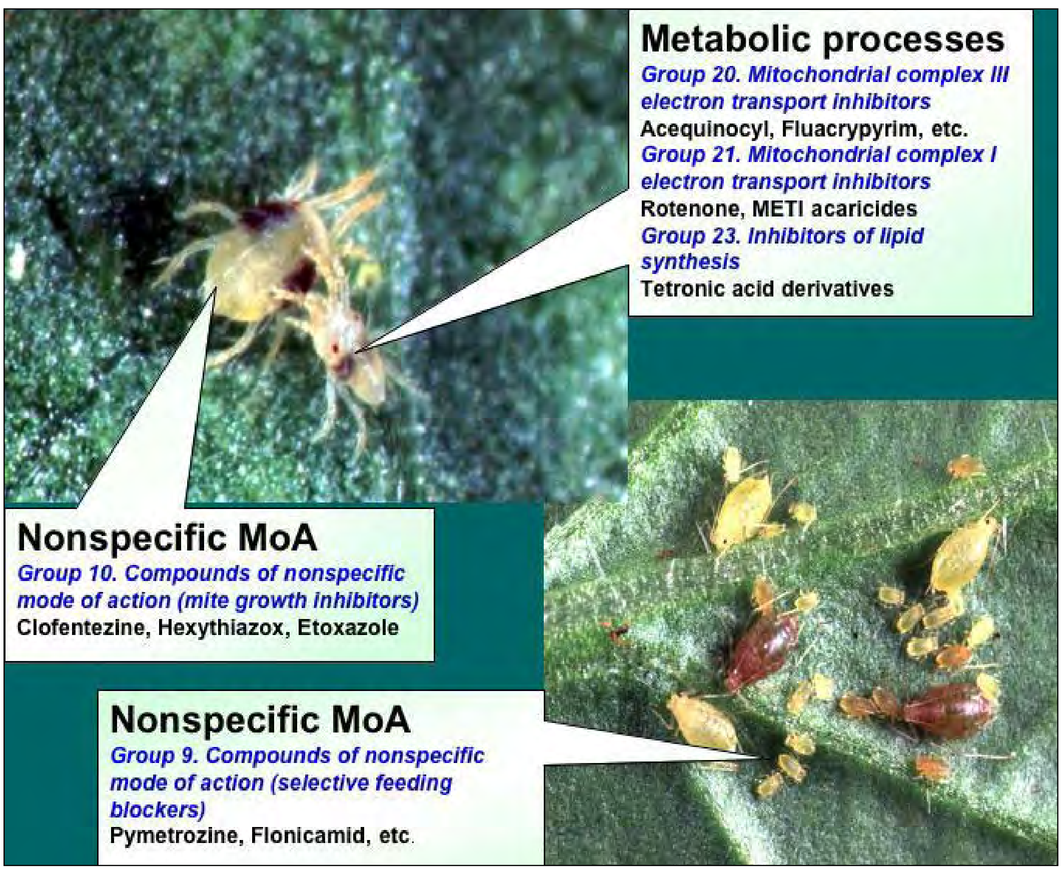
Metabolic processes
Group 20. Mitochondrial complex III electron transport inhibitors
Acequinocyl, Fluacrypyrim, etc.
Group 21. Mitochondrial complex I electron transport inhibitors
Rotenone, METI acaricides
Group 23. Inhibitors of lipid synthesis
Tetronic acid derivatives
Nonspecific MoA
Group 10. Compounds 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, methomyl
	1B organophosphates	chlorpyrifos, fenamiphos, malathion, naled, phosmet
3 Sodium channel modulators	pyrethroids pyrethrins	fifenthrin, cyfluthrin, beta-cyfluthrin, zeta-cypermethrin, fenpropathrin, permethrin pyrethrins (pyrethrum)
4 Nicotinic acetylcholine receptor agonists/ antagonists	**4A** neonicotinoids	acetamiprid, clothianidin, dinotefuran, imidacloprid, 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)	**9A** cryolite	cryolite
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)	**11B1** *B.t.* subsp. *aizawai*	*Bacillus thuringiensis* subsp. *aizawai*
	11B2 *B.t.* subsp. *kurstaki*	*Bacillus thuringiensis* subsp. *kurstaki*
12 Inhibitors of oxidative phosphorylation, disruptors of ATP formation (inhibitors of ATP synthase)	**12B** organotin miticide	fenbutatin oxide
	12C propargite	propargite
16 Inhibitors of chitin biosynthesis, type 1, Homopteran	buprofezin	buprofezin

Table 1—continued

Main group and primary site of action	Chemical subgroup or exemplifying active ingredient	Active ingredients
18 Ecdysone agonists/moulting disruptors	**18A** diacylhydrazines	methoxyfenozide
	18B azadirachtin	azadirachtin
21 Mitochondrial complex I electron transport inhibitors	METI acaricides	fenpyroximate, pyridaben
	rotenone	rotenone
22 Voltage-dependent sodium channel blockers	indoxacarb	indoxacarb
23 Inhibitors of lipid synthesis	tetronic acid derivatives	spirodiclofen
25 Neuronal inhibitors (unknown mode of action)	bifenazate	bifenazate
28 Ryanodine receptor modulators	diamides	chlorantraniliprole
un Compounds with unknown mode of action[2]	**unc** dicofol	dicofol

Notes to be read in association with Table 1

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

[2] A compound with an unknown mode of action or an unknown mode of toxicity will be held in category 'un' until evidence becomes available to enable that compound to be assigned to a more appropriate Mode of Action class.

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.

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)	thiophanates	thiophanate-methyl	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
	B3: ß-tubuline assembly in mitosis	benzamides	toluamides	zoxamide	Low to medium risk. Resistance management required.	22
	B5: delocalisation of spectrin-like proteins	benzamides	pyridinylmethyl-benzamides	fluopicolide	Resistance not known.	43
C: respiration	C2: Complex II: succinate dehydrogenase	carboxamides	pyridine 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 acrylates	azoxystrobin	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
			methoxy-carbamates	pyraclostrobin		
			oximino acetates	kresoxim-methyl, trifloxystrobin		

Table 2—continued

MOA	Target site and code	Group name	Chemical group	Common name	Comments	FRAC code
D: amino acids and protein synthesis	D1: methionine biosynthesis (proposed) (*cgs* gene)	AP-fungicides (**A**nilino-**P**yrimidines)	anilino-pyrimidines	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
E: signal transduction	E1: G-proteins in early cell signaling (proposed)	quinolines	quinolines	quinoxyfen	Resistance known. **Medium risk.** Resistance management required. Cross resistance to proquinazid in *Erysiphe (Uncinula) necator* but not in *Blumeria graminis*. As precaution, proquinazin and quinoxyfen should be managed together for resistance management	13
	E3: MAP/Histidine-Kinase in osmotic signal transduction (*os-1, Daf1*)	dicarboximides	dicarboximides	iprodione	Resistance common in *Botrytis* and some other pathogens. Several mutations in OS-1, mostly I365S. Cross resistance common between the group members. **Medium to high risk. See FRAC Dicarboximide Guidelines for resistance management.**	2
F: lipids and membrane synthesis	F3: lipid peroxidation (proposed)	AH-fungicides (**A**romatic **H**ydrocarbons) (chlorophenyls, nitroanilines)	aromatic hydrocarbons	dicloran	Resistance known to some fungi. Low to medium risk. Cross resistance patterns complex due to different activity spectra.	14

Table 2—continued

MOA	Target site and code	Group name	Chemical group	Common name	Comments	FRAC code
G: sterol biosynthesis in membranes	G1: C14-demethylase in sterol biosynthesis (*erg11/cyp51*)	DMI-fungicides (**De**M**ethylation **I**nhibitors) (**S**terol **B**iosynthesis **I**nhibitor 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 between 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, tebuconazole		
	G3: 3-keto reductase, C4-demethylation (*erg27*)	hydroxyanilides (SBI: Class III)	hydroxyanilides	fenhexamid	Low to medium risk. Resistance management required.	17
U: unknown mode of action	unknown	phosphonates	ethyl phosphonates	fosetyl-Al	Few resistance cases reported in few pathogens. Low risk.	33
				phosphorous 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, ziram		M3
		phthalimides	phthalimides	captan		M4

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, hydrogen peroxide (dioxide), m-cresol, monopotassium phosphate, potassium laurate. These products are covered in Charts 3 and 4.

How to order this publication

To order printed copies of this publication, which includes four full-color charts that are 14 by 20 inches, visit our online catalog at http://extension.oregonstate.edu/catalog and search on EM 8968.

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

Grape insect or mite pest	Common name	abamectin (Abacus Agricultural Miticide/Insecticide, Abamectin E-AG 0.15 EC)	acetamiprid (Assail 30 SG Insecticide)	azadirachtin (Agroneem Emulsifiable Conc–OMRI, Aza-Direct Biological Insecticide–OMRI)	*Bacillus thuringiensis* (Dipel Biological Insecticide/Fruit, Nuts, Veg & Soybean–OMRI, Javelin WG Biological Insecticide–OMRI)	*Beauveria bassiana* ATCC 74040 (Naturalis L)	beta-cyfluthrin (Baythroid XL)	bifenazate (Acramite 50 WS)	bifenthrin (Bifenthrin 2 EC Insecticide/Miticide, Brigadier Insecticide)	buprofezin (Applaud 70 DF Insect Growth Regulator)	carbaryl (Carbaryl 4 L Insecticide, Drexel Carbaryl 4 L Insecticide, Sevin 80 Solupak)	chlorpyrifos (Chlorpyrifos 4 E Ag Insecticide, Nufos 4 E Insecticide, Pilot 4 E Chlorpyrifos)	cinnamaldehyde (Cinnacure)	clofentezine (Apollo SC Ovicide/ Miticide)	clothianidin (Clutch 50 WDG)	cryolite (Kryocide Insecticide, Prokil Cryolite)	cyfluthrin (Baythroid 2 Emulsifiable Pyrethroid Insecticide)	dicofol (Dicofol 4 E Miticide, Kelthane 50 WSP)	dinotefuran (Venom 20 SG Insecticide)	etoxazole (Zeal Miticide 1)	fenamiphos (Nemacur 3 EC Insecticide-Nematicide B)	fenbutatin oxide (Vendex 50 WP)	fenpropathrin (Valent Danitol 2.4 EC Spray)	fenpyroximate (Fujimite 5 EC Miticide/Insecticide)	garlic oil (Allityn Insect Repellant)	hexythiazox (Onager Miticide)	imidacloprid (Admire 2 Flowable Insecticide B, Provado 1.6 Flowable Insecticide B)	indoxacarb (DuPont Avaunt 30 DG)	kaolin (Surround at Home Crop Protectant)	malathion (Fyfanon 8 LB Emulsion, Malathion 5 EC)	methomyl (DuPont Lannate SP Insecticide)	methoxyfenozide (Intrepid 2 F Agricultural Insecticide)	mineral oil (Biocover SS, Organic JMS Stylet-Oil–OMRI)	*Myrothecium verrucaria* (Ditera DF Biological Nematicide)	naled (Dibrom 8 Emulsive Naled Insecticide)	phosmet (Imidan 70 W Ag)	potassium laurate (Concern Multi-Purpose Insect Killer II–OMRI, M-Pede Insecticide/Fungicide–OMRI)	potassium silicate (Sil-Matrix Fungicide/Miticide/Insecticide)	propargite (Omite-30 WS Agricultural Miticide (CM))	pyrethrin (Concern Multi-Purpose Insect Killer II–OMRI, Pyganic Crop Protection EC 1.4 II–OMRI)	pyridaben (Nexter Miticide/Insecticide)	pyriproxyfen (Valent Knack IGR)	*Quillaja saponins* (Nema Q)	rotenone (Pyrellin E.C.)	rynaxypyr (Altacor)	sodium tetrathiocarbamate (Enzone Fungicide-Insecticide-Nematicide Fumigant)	spinetoram (Delegate WG Insecticide)	spinosad (Entrust–OMRI, Success Naturalyte Insect Control)	spirodiclofen (Envidor 2 SC)	spirotetramat (Movento)	sulfur (Ben-Sul 85, Cosavet DF Fungicide-Miticide–OMRI, Kumulus DF, Thiolux Jet Dry Flowable Micronized Sulfur–OMRI, Wilbur-Ellis Spray Sulfur)	sulfur (lime) (BSP Lime-Sulfur Solution, BSP Sulforix, Green Cypress Lime-Sulfur Solution–OMRI)	thiamethoxam (Actara Insecticide, Platinum 75 SG Insecticide, Platinum Insecticide)	zeta-cypermethrin (Mustang Insecticide)
REI hours (h) or days (d)		12 h	12 h	4 h	4 h	4 h	12 h	12 h	12 h	12 h	12 h	24 h	4 h	12 h	12 h	12 h	12 h	48 h	12 h	12 h	48 h	48 h	24 h	12 h	4 h	12 h	12 h	12 h	4 h	12 h	7 d	4 h	4 h	4 h	48 h	24 h	12 h	4 h	14 d	12 h	12 h	12 h	48 h	12 h	4 h	4 d	4 h	4 h	12 h	24 h	24 h	48 h	12 h	12 h
PHI hours (h) or days (d)		28 d	7 d	0 d	0 d	0 d	3 d	14 d	30 d	7 d	7 d	35 d	0 d	21 d	0 d	30 d	3 d	7 d	1 d	14 d	2 d	28 d	21 d	14 d	12 h	28 d	0 d	7 d	0 d	3 d	14 d	30 d	0 d	–	3 d	14 (7) d	V	0 d	21 d	0 d	7 d	21 d	–	12 h	14 d	–	7 d	7 d	14 d	7 d	0 d	–	5 d	1 d
Borers	Borers (general)			♦					♦		♦	♦	♦												♦		♦																					♦						
	Grape twig borer				♦																																															♦		
	Polycaon borer			♦					♦		♦	♦	♦												♦		♦																					♦						
Bugs	Stink bug		♦	♦			♦		♦		♦	♦	♦				♦						♦				♦		♦	♦	♦				♦		♦			♦				♦									♦	♦
Grasshoppers	Grasshoppers			♦		♦	♦		♦		♦	♦					♦								♦		♦		♦	♦						♦	♦			♦											♦		♦	♦
Leafhoppers	Leafhoppers (general)	♦	♦	♦		♦	♦		♦	♦	♦	♦	♦		♦		♦		♦					♦	♦		♦	♦	♦	♦	♦		♦		♦	♦	♦			♦	♦			♦							♦		♦	♦
	Potato leafhopper			♦			♦			♦	♦						♦		♦				♦				♦	♦		♦										♦									♦				♦	♦
	Western grape leafhopper	♦					♦		♦	♦	♦						♦						♦	♦						♦			♦				♦												♦					♦
Mealybugs	Grape mealybug		♦	♦		♦	♦		♦	♦	♦	♦	♦		♦		♦		♦					♦	♦		♦			♦			♦		♦	♦	♦			♦				♦						♦	♦	♦	♦	♦
Mites	Mites (general)	♦		♦		♦			♦		♦	♦	♦					♦						♦	♦	♦			♦	♦			♦				♦	♦	♦	♦				♦					♦		♦	♦		
	Eriophyid mite										♦																						♦																					
	Grape bud mite																							♦			♦																								♦	♦		
	McDaniel spider mite	♦						♦						♦				♦		♦		♦		♦		♦													♦		♦								♦					
	Pacific spider mite	♦		♦				♦	♦				♦	♦				♦		♦		♦		♦		♦							♦				♦		♦		♦								♦		♦			
	Twospotted spider mite	♦		♦				♦	♦		♦	♦	♦	♦				♦		♦		♦	♦	♦		♦			♦	♦			♦		♦		♦		♦		♦								♦		♦	♦		
	Willamette spider mite	♦						♦			♦		♦					♦						♦		♦				♦							♦		♦		♦								♦					
	Yellow spider mite	♦							♦					♦				♦																																				
Moths	Eyespotted bud moth										♦	♦																		♦		♦																						
Nematodes	Nematodes			♦																	♦						♦							♦									♦			♦								
Phylloxera	Grape phylloxera			♦																	♦		♦				♦			♦										♦						♦				♦				
Scales	Scales (general)			♦							♦	♦	♦												♦		♦			♦			♦				♦			♦											♦	♦		
	European fruit lecanium scale										♦																♦			♦			♦									♦												
Thrips	Thrips (general)	♦	♦	♦		♦	♦		♦		♦		♦				♦		♦				♦	♦	♦		♦		♦	♦	♦		♦		♦		♦			♦				♦			♦	♦			♦		♦	♦
Weevils	Black vine weevil			♦					♦			♦															♦		♦											♦														
Worms	Cutworms (general)			♦	♦	♦	♦		♦		♦	♦				♦	♦										♦		♦	♦	♦	♦				♦	♦			♦							♦	♦						♦
	Climbing cutworm						♦					♦				♦	♦						♦				♦				♦														♦			♦						

V = Not past Veraison
NRB = No registration on bearing crops
– = Check label

= Organophosphate
= Toxic to bees
= Use only when temperature is above 35°F and below 90°F

Disclaimers

1) Active ingredients listed above were registered for use on grapes 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, Winegrape Insecticides and Miticides 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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Oregon State University Extension Service

Chart 2. Winegrape 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	Abacus Agricultural Miticide/Insecticide, Abamectic E-AG 0.15 EC Insecticide, Abba 0.15 EC Miticide/Insecticide, Agri-Mek 0.15 EC Miticide/Insecticide, Epi-Mek 0.15 EC Miticide/Insecticide, Reaper 0.15 EC Miticide/Insecticide, Temprano, Timectin 0.15 EC AG Insecticide/Miticide, Zoro Miticide/Insecticide	avermectin	6. chloride channel activator	6. avermectins, milbemycins
acetamiprid	Assail 30 SG Insecticide, Assail 70 WP Insecticide	neonicotinyl	4. nicotinic acetylcholine receptor agonists/antagonists	4A. neonicotinoids
azadirachtin	**Agroneem Emulsifiable Conc-OMRI, Agroneem Plus Emulsifiable Conc./AG., Hort. & G-H Use-OMRI, Aza-Direct Biological Insecticide-OMRI**, Ecozin 3% EC Botanical Insecticide, **Gordon's PRO T&O Azatrol EC Insecticide-OMRI, Neemix 4.5 IGR-OMRI, Trilogy Fungicide/Miticide/ Insecticide-OMRI**	botanical	18. ecdysone agonists/moulting disruptors	18B. azadirachtin
Bacillus thuringiensis	**Agree WG Biological Insecticide-OMRI**, Baritone Bio-insecticide, Biobit HP Bio Insecticide WP/Organic Production, Bonide Thuricide *Bacillus Thuringiensis* (BT) Conc., Condor WP Wettable Powder Bioinsecticide, Crymax Bioinsecticide, **Dipel Biological Insecticide/Fruit, Nuts, Veg & Soybean-OMRI**, Dipel DF Dry Flowable/Organic Production, Dipel ES, **Javelin WG Biological Insecticide-OMRI**, Xentari Dry Flowable/Organic Production	microbial	11. microbial disruptors of insect midgut membranes (includes transgenic crops expressing *Bacillus thuringiensis* toxins)	11B1. *B.t.* subsp. *aizawai*; 11B1. *B.t. aizawai* 91; 11B2. *B.t.* subsp. *kurstaki* 1; 11B2. *B.t.* subsp. *kurstaki* 12; 11B2. *B.t.* subsp. *kurstaki* 123; 11B2. *B.t.* subsp. *kurstaki* 2348; 11B2. *B.t.* subsp. *kurstaki* 7841
Beauveria bassiana ATCC 74040	**Naturalis L**	microbial	entomopathogenic fungus	NC (not considered)
beta-cyfluthrin	Baythroid XL	pyrethroid	3. sodium channel modulator	3. pyrethroids
bifenazate	Acramite-50 WS, Acramite-50 WS (CM), Acramite-50 WS (US)	hydrazine carboxylate	25. neuronal inhibitors (unknown mode of action)	25. bifenazate
bifenthrin	Agrisolutions Tundra EC, Bifenthrin 2 EC AG, Bifenthrin 2 EC Insecticide/Miticide, Bifenture EC AG Insecticide, Brigade 2 EC Insecticide/Miticide, Brigade WSB Insecticide/Miticide, Brigadier Insecticide, Capture 2 EC Insecticide/Miticide, Discipline 2 EC, Fanfare 2 EC Insecticide/Miticide, Sniper Insecticide/Miticide	pyrethroid	3. sodium channel modulator	3. pyrethroids
buprofezin	Applaud 70 DF Insect Growth Regulator, Applaud 70 WP IGR	buprofezin	16. inhibitors of chitin biosynthesis, type 0, Homopteran	16. buprofezin
carbaryl	Carbaryl 4 L Insecticide, Drexel Carbaryl 4 L Insecticide, Eliminator Sevin 5% Dust, Eliminator Sevin 10% Dust, Sevin 4 F Brand Carbaryl Insecticide (B), Sevin 80 Solupak, Sevin Brand 80 S Carbaryl Insecticide (B), Sevin Brand 80 WSP Carbaryl Insecticide (B), Sevin Brand RP 4 Carbaryl Insecticide (B), Sevin Brand XLR Plus Carbaryl Insecticide (B)	carbamate	1. acetylcholine esterase inhibitors	1A. carbamates
chlorpyrifos	Chlorpyrifos 4 E Ag Insecticide, Nufos 4 E Insecticide, Pilot 4 E Chlorpyrifos Agri Insecticide, Quali-Pro Chlorpyrifos 4 E	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	neonicotinyl	4. nicotinic acetylcholine receptor agonists/antagonists	4A. neonicotinoids
cryolite	Kryocide Insecticide, Prokil Cryolite	cryolite	9. Selective feeding blocker	9A. cryolite
cyfluthrin	Baythroid 2 Emulsifiable Pyrethroid Insecticide (B), Leverage 2.7 Suspension Emulsion Insecticide (B), Renounce 20 WP Insecticide (B), Tombstone Helios Insecticide, Tombstone Insecticide	pyrethroid	3. sodium channel modulator	3. pyrethroids
dicofol	Dicofol 4 E Miticide, Kelthane 50 WSP	organochlorine	unknown MOA	unc
dinotefuran	Venom 20 SG Insecticide, Venom Insecticide	neonicotinyl	4. nicotinic acetylcholine receptor agonists/antagonists	4A. neonicotinoids
etoxazole	Zeal Miticide 1	oxazoline	10. compounds of unknown or nonspecific mode of action (mite growth inhibitors)	10B. etoxazole
fenamiphos	Nemacur 3 EC Insecticide-Nematicide (B)	organophosphate	1. acetylcholine esterase inhibitors	1B. organophosphates
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	Valent Danitol 2.4 EC Spray	pyrethroid	3. sodium channel modulator	3. pyrethroids
fenpyroximate	Fujimite 5 EC Miticide/Insecticide	pyrazole	21. mitochondrial complex I electron transport inhibitors	21. METI acaricides
garlic oil	Allityn Insect repellant	botanical	NC (not considered)	NC (not considered)
hexythiazox	Onager Miticide	carboxamide mite growth inhibitor	10. compounds of unknown or nonspecific mode of action (mite growth inhibitors)	10A. hexythiazox
imidacloprid	Admire 2 Flowable Insecticide (B), Admire Pro Systemic Protectant, Agrisolutions Advise 2 FL, Agristar Impulse 1.6 FL, Agristar Macho 2.0 FL, Alias 2 F Flowable Insecticide, Armor-Tech IMD 75, Brigadier Insecticide, Couraze 2 F Insecticide, Couraze Solupak Insecticide, Criterion 2 F Insecticide (ES), Criterion 75 WSP Insecticide (ES), Enforce 75 WSP, Grubex Pro, Hawk-I 2 L Insecticide, Hawk-I 75 WSP, Hunter 2 F Insecticide (ES), Hunter 75 WSP Insecticide (ES), Imida E-AG 1.6 F Insecticide, Imida E-Ag 2 F Insecticide, Lada 2 F Insecticide, Lesco Bandit 2 F Insecticide (ES), Lesco Bandit 75 WSP Insecticide (ES), Leverage 2.7 Suspension Emulsion Insecticide (B), Malice 75 WSP, Mallet 2 F Insecticide, Mallet 7.1% PF Insecticide, Mana Alias 4 F Flowable Insecticide, Merit 2 F Insecticide (ES), Merit 75 WP Insecticide (ES), Midash 2 SC T&O, Montana 2 F Insecticide, Nuprid 1.6 F Insecticide, Nuprid 2 F Insecticide, Nuprid 4.6 F Pro Insecticide, Nuprid-S WG Insecticide/Fungicide, Pasada 75 WSB Wettable Powder Insecticide, Prey 1.6 Insecticide, Prokoz Zenith 2 F Insecticide (ES), Prokoz Zenith 75 WSP Insecticide (ES), Provado 1.6 Flowable Insecticide (B), Provado Solupak 75% WP Insecticide (B), Quali-Pro Imidacloprid 2 F Insecticide, Quali-Pro Imidacloprid 75 WSB Insecticide, Sherpa Insecticide, Submerge 2 F Insecticide (ES), Submerge 75 WSP Insecticide (Es), Torrent 1.6 F, Torrent 2 F, Touchstone 2 F Insecticide (ES), Touchstone 75 WSP Insecticide (Es), Widow Insecticide, Xytect 2 F Insecticide, Xytect 75 WSP Insecticide	neonicotinyl	4. nicotinic acetylcholine receptor agonists/antagonists	4A. neonicotinoids
indoxacarb	DuPont Avaunt 30 DG	unclassified	22. voltage-dependent sodium channel blockers	22. indoxacarb
kaolin	**Surround at Home Crop Protectant**	clay	unknown MoA	NC (not considered)
malathion	Drexel Malathion 5 EC Insecticide/Miticide, Fyfanon 8 LB Emulsion, Gowan Malathion 8 Flowable, Malathion 8 Aquamul, Malathion 5, Malathion 5 EC, Malathion 57 EC, Malathion 8 EC, Prentox 5 LB Malathion Spray	organophosphate	1. acetylcholine esterase inhibitors	1B. organophosphates
methomyl	DuPont Lannate LV Insecticide, DuPont Lannate SP Insecticide	carbamate	1. acetylcholine esterase inhibitors	1A. carbamates
methoxyfenozide	Intrepid 2 F Agricultural Insecticide	diacylhydrazine	18. ecdysone agonists/moulting disruptors	18A. diacylhydrazines
mineral oil	Biocover SS, Biocover UL, IAP 415 Summer Spray Oil, IAP 440 All Purpose Spray Oil, JMS Stylet-Oil, Mite-E-Oil Insecticide-Miticide/Spray, Omni Supreme Spray, **Organic JMS Stylet-Oil-OMRI**, PHT V-415 Spray Oil, PHT V-440 Spray Oil, PHT V-470 Spray Oil, Purespray 10E, Purespray Foliar 15E, Purespray Foliar 22E, Spray Oil 415, Sunspray 6E, Superior Spray Oil N.W., Supreme Oil Miticide-Insecticide, Wil-Gro Hort Oil 98-2	mineral oil	mechanical suffocation by clogging spiracles or disruption of cellular membranes	NC (not considered)
Mycrothecium verrucaria	Ditera DF Biological Nematicide, Ditera ES Emulsifiable Suspension	microbial	entomopathogenic fungus	NC (not considered)
naled	Dibrom 8 Emulsive Naled Insecticide	organophosphate	1. acetylcholine esterase inhibitors	1B. organophosphates
phosmet	Imidan 70 W Ag	organophosphate	1. acetylcholine esterase inhibitors	1B. organophosphates
potassium laurate	Bonide Bon-Neem Insecticidal Soap, Concern Insect Killing Soap Conc., **Concern Multi-Purpose Insect Killer II-OMRI [Spanish]**, E.B. Stone Insect Soap Conc., Earth-Tone Insecticidal Soap Conc./ Organic Production, **M-Pede Insecticide/Fungicide-OMRI**	fatty acid	membrane disruption	NC (not considered)
potassium silicate	Sil-Matrix Fungicide/Miticide/Insecticide	unclassified	NC (not considered)	NC (not considered)
propargite	Omite-30 WS Agricultural Miticide (CM), Omite-30 WS Agricultural Miticide (US)	unclassified	12C. propargite	12C. propargite
pyrethrin	**Concern Multi-Purpose Insect Killer II-OMRI [Spanish]**, Prentox Pyronyl 303 Emulsifiable Conc., Prentox Pyronyl Crop Spray, Pres Trmt Pyreth-IT, Pres Trmt Pyreth-IT Form2, **Pyganic Crop Protection EC 1.4 II-OMRI, Pyganic Crop Protection EC 5.0 II-OMRI**, Pyola, Pyrellin E.C., Pyrenone Crop Spray (ES)	pyrethroid	3. sodium channel modulator	3. pyrethrin
pyridaben	Nexter Miticide/Insecticide	pyridazine	21. mitochondrial complex I electron transport inhibitors	21. METI acaricides
pyriproxyfen	Valent Knack IGR	insect growth regulator (IGR)	7. juvenile hormone mimics	7C. pyriproxyfen
Quillaja saponins	Nema Q	botanical	NC (not considered)	NC (not considered)
rotenone	Pyrellin E.C.	botanical	21. mitochondrial complex I electron transport inhibitors	21. rotenones
rynaxypyr	Altacor	chlorantraniliprole	diamides	28. ryanodine receptor modulators
sodium tetrathiocarbamate	Enzone Fungicide-Insecticide-Nematicide Fumigant	inorganic	NC (not considered)	NC (not considered)
spinetoram	Delegate WG Insecticide	microbial	5. nicotinic acetylcholine receptor agonists (allosteric) (not group 4)	5. spinosyns
spinosad	Bull's-Eye Bioinsecticide, **Entrust-OMRI, Spinosad 0.5% SC Insect Control Product-OMRI**, Success Naturalyte Insect Control	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	tetramic acid derivative (ketoenole)	NC (inhibition of lipogenesis)	NC (not considered)
sulfur	Ben-Sul 85, **Cosavet DF Fungicide-Miticide-OMRI**, Drexel Suffa, Dusting Sulfur, Kumulus DF, Micro Sulf (N), Microthiol DispersS Micronized Wettable Sulfur, Nuprid-S WG Insecticide/Fungicide, Pronatural Micronized Sulfur/Organic Production, Sulfur 6 L, Sulfur DF, Sulfur WG, **Thiolux Jet Dry Flowable Micronized Sulfur-OMRI**, Wilbur Ellis Spray Sulfur	inorganic	multisite contact activity (proposed)	NC (not considered)
sulfur (lime)	Bonide Lime Sulfur Spray/Organic Gardening, BSP Lime-Sulfur Solution, BSP Sulforix, **Green Cypress Lime-Sulfur Solution-OMRI**, Rex Lime Sulfur Solution	inorganic	multisite contact activity (proposed)	NC (not considered)
thiamethoxam	Actara Insecticide, Platinum 75 SG Insecticide, Platinum Insecticide	neonicotinyl	4. nicotinic acetylcholine receptor agonists/antagonists	4A. neonicotinoids
zeta-cypermethrin	Mustang Insecticide, Mustang Max EC Insecticide, Mustang Max EW Insecticide, Mustang Max Insecticide	pyrethroid	3. sodium channel modulator	3. pyrethroids

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

Grape disease	2,4-xylenol (Gallex)	azoxystrobin (Abound Flowable Fungicide)	*Bacillus pumilus* strain qst 2808 (Sonata Biofungicide)	*Bacillus subtilis* qst713 strain (Serenade Max)	boscalid (Endura, Pristine)	captan (Captan 50 WP, Drexel Captan 4 L Fungicide)	chitosan (Elexa 4 Plant Defense Booster)	chloropicrin (67-33 Preplant Soil Fumigant)	cinnamaldehyde (Cinnacure)	clarified hydrophobic extract of neem oil (Trilogy Fungicide/ Miticide/Insecticide)	copper hydroxide (Kocide DF)	copper metallic (Copper-Count-N)	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) (Triangle Brand Copper Sulfate Instant Powder)	copper sulfate basic (Basic Copper 53, Cuprofix Ultra 40 DispersS)	cyprodinil (Vanguard WG Fungicide)
REI hours (h) or days (d)	S	4 h	4 h	4 h	24 h	48 h	4 h	48 h	4 h	4 h	24 h	12 h	4 h	24 h	24 h	12 h	24 h	24 h	12 h
PHI hours (h) or days (d)	–	14 d	0 d	0 d	14 d	0 d	–	P	0 d	B	–	–	0 d	–	–	0 d	–	66 d	7 d
Armillaria root rot								♦											
Black rot (*Guignardia bidwellii*)		♦			♦	♦				♦	♦	♦	♦	♦	♦	♦		♦	
Botrytis bunch rot		♦																	♦
Crown gall	♦					♦													
Downy mildew		♦	♦	♦	♦	♦	♦		♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	
Esca (grape measles)																			
Eutypa dieback											♦	♦		♦	♦	♦	♦		
Phomopsis (cane and leaf spot)		♦			♦	♦					♦	♦	♦	♦	♦	♦	♦	♦	
Powdery mildew		♦	♦	♦	♦	♦	♦		♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦

Grape disease	DCNA-dichloran (Botran 6% Dust)	fenarimol (Rubigan EC)	fenhexamid (Elevate 50 WDG)	ferbam (Ferbam Granulo Fungicide)	fluopicolide (Presidio Fungicide)	hydrogen peroxide (dioxide) (Oxidate)	imidacloprid (Nuprid-S WG Insecticide/Fungicide)	iprodione (Rovral Brand 4 Flowable Fungicide)	jojoba oil (Eco E-Rase)	kresoxim-methyl (Sovran Fungicide)	mancozeb (Dupont Mankocide Fungicide/Bactericide)	maneb (Maneb 75 DF Fungicide)	m-cresol (Gallex)	mefenoxam (r-enantiomer of metalaxyl) (Ridomil Gold EC)	methyl bromide (67-33 Preplant Soil Fumigant, Methyl Bromide 99.5% Fumigant)	mineral oil, petroleum distillates, solvent refined light (JMS Stylet-Oil, Sunspray Ultra-Fine Year-Round Pesticidal Oil)	monopotassium phosphate (Nutrol 0-50-32)	myclobutanil (Prokoz Hoist Specialty Fungicide, Rally 40 W, Spectracide Immunox)	petroleum base oil (Biocover MLT)
REI hours (h) or days (d)	12 h	12 h	12 h	24 h	12 h	1 h	24 h	48 h	4 h	12 h	24 h	24 h	S	48 h	48 h	4 h	4 h	24 h	4 h
PHI hours (h) or days (d)	1 d	21 d	0 d	7 d	21 d	0 d	–	7 d	0 d (T)	14 d	66 d	66 d	–	–	P	0 d	V	14 d	60 d
Armillaria root rot															♦				
Black rot (*Guignardia bidwellii*)				♦		♦		♦		♦	♦	♦						♦	
Botrytis bunch rot	♦		♦					♦			♦								
Crown gall													♦						
Downy mildew					♦	♦				♦	♦	♦		♦				♦	
Esca (grape measles)																			
Eutypa dieback																			
Phomopsis (cane and leaf spot)																			
Powdery mildew		♦	♦			♦	♦		♦	♦	♦					♦	♦	♦	♦

Grape disease	phosphorous acid (Helena Prophyt, Rampart Potassium Phosphite)	phosphorous acid, mono- and di-potassium salts of (Fungi-phite)	potassium bicarbonate (Armicarb "O", Kaligreen, Milstop Broad Spectrum F)	potassium laurate (M-Pede Insecticide/Fungicide)	potassium silicate (Sil-Matrix Fungicide/Miticide/Insecticide)	pyraclostrobin (Pristine Fungicide)	pyrimethanil (Scala)	quinoxyfen (Quintec)	sodium tetraborohydrate decahydrate (Prev Am)	*Streptomyces lydicus* WYEC 108 (Actinovate AG)	sulfur (Ben-Sul 85, Kumulus DF, Micro Sulf (N), Microthiol DisperS, Top Cop W/Sulfur)	sulfur, lime (BSP Lime-Sulfur Solution, BSP Sulforix, Green Cypress Lime-Sulfur Solution–OMRI)	tebuconazole (Adament 50 WG, Elite 45 WP Foliar Fungicide)	thiophanate-methyl (Thiophanate-Methyl 85 WDG, Topsin M 70 WP)	*Trichoderma harzianum* (Plantshield HC Biological Foliar & Root Fungicide)	trifloxystrobin (Flint Fungicide (B))	triflumizole (Procure 480 SC AG Fungicide)	ziram (Ziram 76 DF Fungicide)	zoxamide (Zoxium 80 WSP AG Fungicide)
REI hours (h) or days (d)	4 h	4 h	4 h	12 h	4 h	24 h	12 h	12 h	12 h	1 h	24 h	48 h	12 h	7 d	1 h	12 h	12 h	48 h	48 h
PHI hours (h) or days (d)	0 d	0 d	0 d	0 d	0 d	14 d	7 d	14 d	–	0 d	–	H	14 d	14 d	–	14 d	7 d	B	14 d
Armillaria root rot																			
Black rot (*Guignardia bidwellii*)			♦			♦					♦		♦	♦		♦		♦	
Botrytis bunch rot							♦						♦	♦		♦		♦	
Crown gall																			
Downy mildew	♦	♦	♦			♦			♦	♦	♦		♦			♦		♦	♦
Esca (grape measles)															♦				
Eutypa dieback																			
Phomopsis (cane and leaf spot)						♦							♦			♦		♦	
Powdery mildew	♦	♦	♦	♦	♦	♦		♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	

B = Do not use after bloom
H = Do NOT spray when temperatures are above 85°F
P = Preplant only
S = Spring/Summer
T = Do NOT spray when temperatures are below 50°F
V = Up to Veraison
– = Not specified; follow label

Disclaimers

1) All active ingredients listed above were registered for use on grapes 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 grapes 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, Winegrape Fungicides and Bactericides 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 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. Winegrape 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
azoxystrobin	Abound Flowable Fungicide, Heritage Fungicide, Quadris S Fungicide	methoxyacrylate	respiration (C3)	contact/systemic	11
Bacillus pumilus strain qst 2808	**Sonata Biofungicide-OMRI**	microbial	not classified (NC)	microbial	NC
Bacillus subtilis qst713 strain	**Serenade Aso-OMRI, Serenade Garden Disease Control Conc.-OMRI, Serenade Max-OMRI**	microbial	not classified (NC)	microbial	NC
boscalid	Endura Fungicide, Pristine Fungicide	pridine carboximide	respiration (C2)	systemic	7
captan	Captan 50 Wettable Powder, Captan 80 WDG, Captec 4 L, Drexel Captan 4 L Fungicide, Drexel Captan 80 WDG, Hi-Yield Captan 50 W Fungicide, Hi-Yield Captan Fungicide 50% WP, Hi-Yield Captan 50 W Fungicide	phthalimides	multisite contact activity (M)	contact	M4
chitosan	Elexa 4 Plant Defense Booster	animal derived	not classified (NC)	elicitor	NC
chloropicrin	67-33 Preplant Soil Fumigant	not classified (NC)	not classified (NC)	contact	NC
cinnamaldehyde	Cinnacure	not classified (NC)	lipid and membrane synthesis	contact	NC
clarified hydrophobic extract of neem oil	**Trilogy Fungicide/Miticide/Insecticide-OMRI**	botanical	not classified (NC)	contact	NC
copper hydroxide	Agristar Nu-Cop HB, Champ DP Ag Fungicide/Bactericide Dry Prill (NU), Champ Formula 2 Flowable (NU), Champ WG Agricultural Fungicide (NU), Champion Wettable Powder AG Fungicide (NU), Dupont Kocide 101 Fungicide/Bactericide, Dupont Kocide 2000 Fungicide, Dupont Kocide 3000 Fungicide/Bactericide, Dupont Kocide 4 LF Fungicide/Bactericide, Dupont Kocide, DF Fungicide/Bactericide, Dupont Mankocide Fungicide/Bactericide, Kocide 101 Fungicide/Bactericide, Kocide 101 Protech, Kocide 2000 Fungicide/ Bactericide, 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, Ridomil Gold Copper 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., Natural Guard Copper Soap Liquid Fungicide, **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	Copper Oxychloride ($CU_2CL(OH)_3$)	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)	**Copper Sulfate Crystals-OMRI**, Triangle Brand Copper Sulfate Instant Powder	inorganic	multisite contact activity (M1)	contact	M1
copper sulfate basic	Basic Copper 53, C-O-C-S WDG, Cuprofix DispersS, Cuprofix Mz DispersS, Cuprofix Ultra 40 DispersS, Top Cop W/Sulfur	inorganic	multisite contact activity (M1)	contact	M1
cyprodinil	Vanguard WG Fungicide	anilino-pyrimidine (AP)	amino acids and protein synthesis (D1)	systemic	9
DCNA-dichloran	Botran 6% Dust Fungicide	aromatic hydrocarbon	lipid peroxidation (F3)	locally systemic	14
fenarimol	Rubigan E.C., Vintage SC Fungicide	pyrimidine	sterol biosynthesis in membranes (G1)	systemic	3
fenhexamid	Elevate 50 WDG Fungicide	hydroxyanalides	sterol biosynthesis in membranes (G3)	contact	17
ferbam	Ferbam Granulo Fungicide	dithiocarbamates and relatives	multisite contact activity (M3)	contact	M3
fluopicolide	Presidio Fungicide	benzamides	delocalization of spectrin-like proteins (B5)	contact	43
hydrogen peroxide (dioxide)	HDH Peroxy, **Oxidate Broad Spectrum Bactericide/Fungicide**, Perox-Cide	inorganic	unknown (U)	contact	NC
imidacloprid	Nuprid-S WG Insecticide/Fungicide	not classified (NC)	not classified (NC)	systemic/translaminar	NC
iprodione	Rovral Brand 4 Flowable Fungicide	dicarboximides	MAP/histidine-kinase in osmotic signal transduction (os-1, Daf1) (E3)	contact/locally systemic	2
jojoba oil	**Eco-Erase OMRI**	botanical	not classified (NC)	contact	NC
kresoxim-methyl	Sovran Fungicide	quinone outside inhibitor (QoI)	respiration (C3)	translaminar	11
mancozeb	Clevis Contains Eagle and Dithane, Cuprofix MZ Disperss, Dithane DF Rainshield Fungicide, Dithane F-45 Rainshield, Dithane M45, Dupont Mankocide Fungicide/Bactericide, Dupont Manzate Flowable Fungicide, Dupont Manzate Pro-Stick Fungicide, Mankocide Fungicide/Bactericide, Manzate 75 DF Fungicide, Manzate 80 WP Fungicide, Manzate Flowable Fungicide, Penncozeb 4 FL Flowable Fungicide, Penncozeb 75 DF Dry Flowable Fungicide, Penncozeb 75 DF Fungicide, Penncozeb 80 WP Fungicide	dithiocarbamates and relatives	multisite contact activity (M3)	contact	M3
maneb	Maneb 75 DF Fungicide, Maneb 80 WP	dithiocarbamates and relatives	multisite contact activity (M3)	contact	M3
m-cresol	Gallex	phenol	unknown (U)	contact/locally systemic	NC
mefenoxam (r-enantiomer of metalaxyl)	Ridomil Gold Copper Fungicide, Ridomil Gold MZ Fungicide, Ridomil Gold MZ WG Fungicide	phenylamine	nucleic acids synthesis (A1)	systemic	4
methyl bromide	67-33 Preplant Soil Fumigant, 98-2 Preplant Soil Fumigant, Brom-O-Gas 2%, MBC Concentrate Soil Fumigant, Methyl Bromide 99.5% Fumigant		not classified (NC)	contact	NC
mineral oil, petroleum distillates, solvent refined light	Prescription Treatment Ultra-Pure Oil, Purespray 10 E, Purespray Foliar 15 E, Purespray Foliar 22 E, Biocover SS, Biocover UL, First Choice Narrow Range 415 Spray Oil, Glacial Spray Fluid/Organic Production, IAP 415 Summer Spray Oil, IAP 440 All Purpose Spray Oil, IAP Organic Spray Oil, JMS Stylet-Oil, Leaf Life Gavicide Green 415/Organic Production, **Organic JMS Stylet-Oil-OMRI**, PHT V-415 Spray Oil, PHT V-440 Spray Oil, PHT V-470 Spray Oil, Prescription Treatment Ultra-Fine Oil All Season Hort Insect/ Fung, Purespray Green, Saf-T-Side, 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	Agristar Sonoma 40 WSP Fungicide, Clevis Contains Eagle and Dithane, Eagle 20 EW Specialty Fungicide, Eagle 40 WP Specialty Fungicide, Eagle WSP T&O Fungicide In WSP, Prokoz Hoist Specialty Fungicide, Rally 40 W, Rally 40 WSP Fungicide, Spectracide Immunox Multi-Purpose Fungicide Spray Conc.	triazole	sterol biosynthesis in membranes (G1)	systemic	3
petroleum base oil	Biocover MLT	diverse	not classified (NC)	contact	NC
phosphorous acid	Agrisolutions Topaz Fungicide, Calirus 150, Fosphite Fungicide-Master Label, Helena Prophyt, Kphite 7 LP Systemic Fungicide-Purple-Ornamental, Phostrol Agricultural Fungicide (NU), Rampart Potassium Phosphite, Resist 57, Reveille	phosphonates	unknown (U)	systemic	33
phosphorous acid, mono-and di-potassium salts of	Agri-Fos Systemic Fungicide, Crop-Phite Agricultural Fungicide, Exel LG Systemic Fungicide, Fosphite, Fungi-Phite	phosphonates	unknown (U)	systemic	33
potassium bicarbonate	Armicarb "O", **Bi-Carb Old Fashioned Fungicide-OMRI,** Green Cure/Organic Production, Kaligreen, **Milstop Broad Spectrum Foliar Fungicide-OMRI**	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
pyraclostrobin	Pristine Fungicide	methoxy carbamate	respiration (C3)	translaminar/systemic	11
pyrimethanil	Scala	anilino-pyrimidine (AP)	amino acids and protein synthesis (D1)	systemic	9
quinoxyfen	Quintec	quinolines	G-proteins in early cell signalling (E1)	contact	13
sodium tetraborohydrate decahydrate	Prev Am	not classified (NC)	not classified (NC)	contact	NC
Streptomyces lydicus WYEC 108	Actinovate AG	glucopyranosyl antibiotic	amino acids and protein synthesis (D4)	microbial	25
sulfur	**Ben-Sul 85, Cosavet-DF Fungicide-Miticide-OMRI**, Drexel Suffa, Dusting Sulfur, **Kumulus DF**, Kumulus DF Fungicide/Acaracide, L/M Sulfur Dust Fung/Insect Dust Or Spray, Liquid Sulfur Six, **Micro Sulf (N)**, Microthiol DispersS Micronized Wettable Sulfur, Nuprid-S WG Insecticide/Fungicide, Pronatural Micronized Sulfur/Organic Production, Sulfur 6 L, **Sulfur DF**, Sulphur W.G., **Thiolux Jet Dry Flowable Micronized Sulfur-OMRI**, Top Cop W/Sulfur, Wilbur Ellis Spray Sulfur	inorganic	multisite contact activity (M2)	contact	M2
sulfur, lime	**BSP Lime-Sulfur Solution**, BSP Sulforix, **Green Cypress Lime-Sulfur Solution-OMRI**, Hi-Yield Improved Lime Sulfur Spray	inorganic	multisite contact activity (M2)	contact	M2
tebuconazole	Adament 50 WG Fungicide, Elite 45 DF Foliar Fungicide (B), Elite 45 WP Foliar Fungicide In WSP (B), Orius 45 DF Foliar Fungicide, Orius 45 WP Foliar Fungicide In WSP, Tebuzol 45 DF Fungicide, Trisum 45 WDG	triazole	sterol biosynthesis in membranes (G1)	systemic	3
thiophanate-methyl	Thiophanate Methyl 85 WDG Fungicide, T-Methyl 70 W WSB, T-Methyl E-AG 70 WSB Fungicide, Topsin M 70 WDG, Topsin M 70 WP, Topsin M WSB	thiophanate	mitosis and cell division (B1)	systemic	1
Trichoderma harzianum	Plantshield HC Biological Foliar & Root Fungicide	microbial	not classified (NC)	microbial	NC
trifloxystrobin	Adament 50 WG Fungicide, Flint Fungicide (B)	quinone outside inhibitor (QoI)	respiration (C3)	translaminar	11
triflumizole	Procure 480 SC AG Fungicide (CM), Procure 480 SC AG Fungicide (US), Procure 50 WS Agricultural Fungicide (CM), Procure 50 WS Agricultural Fungicide (US)	imidazole	sterol biosynthesis in membranes (G1)	systemic	3
ziram	Ziram 76 DF Fungicide, Ziram Granuflo Fungicide	dithiocarbamates and relatives	multisite contact activity (M3)	contact	M3
zoxamide	Zoxium 80 WSP AG Fungicide	toluamides	ß-tubulin assembly in mitosis (B3)	contact	22

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