

**EFFICACY AND TIMING OF FUNGICIDES,
BACTERICIDES, AND BIOLOGICALS**
for
**DECIDUOUS TREE FRUIT, NUT,
STRAWBERRY, AND VINE CROPS**
2011



ALMOND
APPLE/PEAR
APRICOT
CHERRY
GRAPE
KIWIFRUIT

PEACH/NECTARINE
PISTACHIO
PLUM
PRUNE
STRAWBERRY
WALNUT

Jim Adaskaveg, Professor

University of California, Riverside

Doug Gubler, Extension Plant Pathologist

University of California Davis

Themis Michailides, Plant Pathologist

University of California, Davis/Kearney Agricultural Center

Brent Holtz, Farm Advisor

University of California Cooperative Extension, San Joaquin County

UC Davis, Dept. of Plant Pathology
www.plpnem.ucdavis.edu

UC Kearney Agricultural Center
www.uckac.edu/plantpath

Statewide IPM Program
www.ipm.ucdavis.edu

TABLE OF CONTENTS

Properties of Registered and Experimental Fungicides	2-3
Properties of Registered and Experimental Antibiotics, Biologicals, Oils, etc	4
Maximum Residue Limits (Tolerances) of Pesticides on Agricultural Food Commodities	5
Fungicides and Their Effects on Non-Target Organisms, Especially Honey Bees.....	6-7
Disease and Pathogen Names	8-9
Fungicides Listed by Chemical Class: Miscellaneous Fungicides/Bactericides	10-11
Fungicides Listed by Chemical Class: Synthetic Fungicides (Single Active Ingredient)	12-16
Fungicides Listed by Chemical Class: Synthetic Fungicides (Multiple Active Ingredients)	17-18
Almond:	
Fungicide Efficacy	19-20
Treatment Timing	20
Suggested Disease Management Programs by Fungicide FRAC Groups.....	21-22
Apple and Pear:	
Fungicide and Bactericide Efficacy	23-24
Treatment Timing	24
Apricot:	
Fungicide Efficacy	25
Treatment Timing	26
Cherry:	
Fungicide Efficacy	27
Treatment Timing	28
Suggested Disease Management Programs by Fungicide FRAC Groups.....	29
Grapevine:	
Fungicide Efficacy	30-31
Treatment Timing	32
Suggested Disease Management Programs by Fungicide FRAC Groups.....	33
Kiwifruit	
Fungicide Efficacy	34
Treatment Timing	34
Peach and Nectarine	
Fungicide Efficacy	35
Treatment Timing	36
Suggested Disease Management Programs by Fungicide FRAC Groups.....	37-38
Pistachio	
Fungicide Efficacy	39
Treatment Timing	40
Plum	
Fungicide efficacy.....	41
Treatment timing.....	42
Prune (Dried Plum)	
Fungicide Efficacy	43
Treatment Timing	44
Strawberry	
Fungicide Efficacy	45
Treatment Timing	46
Walnut	
Bactericide Efficacy.....	47
Treatment Timing	47

General Properties of Registered and Experimental Fungicides Used on Deciduous Tree Fruit, Nut, Strawberry, and Vine Crops in California

Single active ingredient	Trade name	Class (FRAC number) ¹	Systemic action	Mode of action	Resistance potential
copper	various	Inorganic (M1)	No	Multi-site	Low
sulfur	various	Inorganic (M2)	No	Multi-site	Low
mancozeb	Dithane/Manzate/ Penncozeb	Carbamate (EBDC) ² (M3)	No	Multi-site	Low
maneb	Maneb/Manex**	Carbamate (EBDC) ² (M3)	No	Multi-site	Low
thiram	Thiram	Carbamate (DMDC) ³ (M3)	No	Multi-site	Low
ziram	Ziram	Carbamate (DMDC) ³ (M3)	No	Multi-site	Low
captan	Captan	Phthalamide (M4)	No	Multi-site	Low
chlorothalonil	Bravo/Chorothalonil/ Echo/Equus	Chloronitrile (M5)	No	Multi-site	Low
dodine	Syllit	Guanidine (M7)	Yes	Few (Multi-site)	Medium
thiabendazole	Mertect	MBC (1)	Yes	Single-site	Very high ⁴
thiophanate-methyl	Topsin-M/T-Methyl /Incognito	MBC (1)	Yes	Single-site	Very high ⁴
iprodione	Rovral/Iprodione/ Nevado	Dicarboximide (2)	Yes	Single-site?	Medium
difenoconazole	Inspire*	DMI ⁵ -triazole (3)	Yes?	Single-site	High
fenarimol	Rubigan	DMI-pyrimidine (3)	Yes?	Single-site	High
fenbuconazole	Indar (Enable)	DMI-triazole (3)	Yes?	Single-site	High
flutriafol	Topguard*	DMI-triazole (3)	Yes?	Single-site	High
metconazole	Quash	DMI-triazole (3)	Yes?	Single-site	High
myclobutanil	Rally/Laredo	DMI-triazole (3)	Yes?	Single-site	High
propiconazole	Bumper/Mentor/Tilt	DMI-triazole (3)	Yes?	Single-site	High
tebuconazole	Elite/Orius/Tebuzol	DMI-triazole (3)	Yes?	Single-site	High
tetraconazole	Mettle	DMI-triazole (3)	Yes?	Single-site	High
triadimefon	Bayleton	DMI-triazole (3)	Yes?	Single-site	High
triforine	Funginex**	DMI-piperazine (3)	Yes?	Single-site	High
triflumizole	Procure	DMI-imidazole (3)	Yes?	Single-site	High
mefenoxam	Ridomil Gold	Phenylamide (4)	Yes	Single-site	High ⁴
boscalid	Endura	SDHI ⁶ (7)	No	Single-site	High ⁴
fluopyram	Luna Privilege*	SDHI (7)	No	Single-site	High ⁴
fluxapyroxad	Xemium	SDHI (7)	No	Single-site	High ⁴
penthiopyrad	Fontelis	SDHI (7)	No	Single-site	High ⁴
cyprodinil	Vangard	AP ⁷ (9)	Slight	Single-site	High ⁴
pyrimethanil	Scala/Penbotec	AP (9)	Slight	Single-site	High ⁴
azoxystrobin	Abound	QoI ⁸ (11)	Yes?	Single-site	High ⁴
kresoxim-methyl	Sovran	QoI (11)	Yes?	Single-site	High ⁴
pyraclostrobin	Cabrio	QoI (11)	Yes?	Single-site	High ⁴
trifloxystrobin	Flint/Gem	QoI (11)	Yes?	Single-site	High ⁴
fludioxonil	Scholar	Phenylpyrrole (12)	No	Few (Multi-site)	Medium
quinoxifen	Quintec	Quinoline (13)	No	Single-site	Medium
dichloran	Botran/Allisan	Aromatic hydrocarbon (14)	Slight	Single-site	Medium
fenhexamid	Elevate/Judge	Hydroxyanilide (17)	No	Single-site	High ⁴
polyoxin-D	Ph-D/Endorse	chitin synthesis inhibitor (19)	No?	Single-site	Medium
mandipropamid	Revus	cell wall synthesis inhibitor (40)	Yes?	Single-site	High
fluopicolide	Presidio	Benzamide (43)	Yes?	Single-site	High
metrafenone	Vivando	actin disrupter (U8)	No	Unknown (Single-site?)	High?

Multiple active ingredients (Premixtures)	Trade name	Class (FRAC number)¹	Systemic action	Mode of action	Resistance potential
captan/ fenhexamid	CaptEvate	Phthalamide (M4)/ hydroxylanilide (17)	No	Multi- site/Single-site	Low
tebuconazole/ trifloxystrobin	Adament	DMI-triazole (3)/QoI (11)	Yes?	Single-site Single-site	Medium
pyrimethanil/ trifloxystrobin	Distinguish**	AP (9)/QoI (11)	Yes?	Single-site/ Single-site	High
difenoconazole/ cyprodinil	Inspire Super	DMI-triazole (3)/ AP (9)	Yes?	Single-site/ Single-site	Medium
difenoconazole/ propiconazole	Inspire XT*	DMI-triazole (3)/ DMI-triazole (3)	Yes?	Single-site/ Single-site	Medium
tebuconazole/ fluopyram	Luna Experience*	DMI-triazole (3)/ SDHI (7)	Yes?	Single-site/ Single-site	Medium
fluopyram/ trifloxystrobin	Luna Sensation*	SDHI (7)/QoI (11)	Yes?	Single-site/ Single-site	High
pyraclostrobin / boscalid	Pristine	SDHI (7)/QoI (11)	Yes?	Single-site / Single-site	High
difenoconazole/ azoxystrobin/	Quadris Top	DMI-triazole (3)/QoI (11)	Yes?	Single-site / Single-site	Medium
propiconazole/ azoxystrobin/	Quilt Xcel	DMI-triazole (3)/QoI (11)	Yes?	Single-site / Single-site	Medium
fludioxonil / cyprodinil	Switch	Phenylpyrrole (12)/ AP (9)	No/ Slight	Single-site/ Single-site	Medium

* Registration pending in California

** Not registered, label withdrawn or inactive

? = Fungicide is generally considered to have systemic action based on performance data but this characteristic has not been necessarily proven experimentally using more rigorous assays (e.g., radioactively labeled compounds)

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to a fungicide with a different mode of action Group number.

² EBDC = ethylene bisdithiocarbamate.

³ DMDC = dimethyl dithiocarbamate

⁴ Resistance has been found in California for certain fungicides with a single-site mode of action. To reduce the risk of resistance development, take the mode of action into account when choosing a fungicide. At the beginning of a treatment program, use a fungicide with a multi-site mode of action; for subsequent applications rotate or mix fungicides with different mode of action FRAC numbers. Use labeled rates (preferably the upper range) of the single-site fungicides, and limit the total number of applications/season.

⁵ DMI = demethylation (sterol) inhibitor

⁶ SDHI = Succinate dehydrogenase inhibitor

⁷ AP = Anilinopyrimidine

⁸ QoI = quinone outside inhibitor (strobilurin).

General Properties of Registered and Experimental Antibiotics, Biologicals, Oils, and Natural Products Used on Deciduous Tree Fruit, Nut, Strawberry, and Vine Crops in California

Trade name	Active Ingredient	Class	Systemic action	Mode of action (FRAC number) ¹	Resistance potential
Actinovate	<i>Streptomyces lydicus</i> WYEC 108	biological	No	Various	Low
AgriMycin/FireWall/ Ag Streptomycin	streptomycin	antibiotic	Yes	Protein Synthesis(25)	High
Kasumin*	kasugamycin	antibiotic	Yes	Protein Synthesis(24)	High
Mycoshield/FireLine/ (FlameOut**)	oxytetracycline	antibiotic	Yes	Protein Synthesis(41)	High
AQ-10**	<i>Ampelomyces quisqualis</i>	biological	No	Various	Low
Arabesque*	<i>Muscodor albus</i>	biological	No	Various	Low
Auxigro**	GABA/L-glutamic acid	SAR ² -protein	Yes	Host resistance	Unknown
B-lock**	boric acid and latex paint	inorganic salt	No	Various	Low
BlightBan	<i>Pseudomonas fluorescens</i> A506	biological	No	Various	Low
BloomtimeBiological	<i>Pantoea agglomerans</i> E/325	biological	No	Various	Low
Elexa**	glucosamine protein	SAR ² -protein	Yes	Host resistance	Unknown
KeyPlex 350 DP*	yeast extract	SAR ² -protein	Yes	Host resistance	Unknown
Plant Shield	<i>Trichoderma harzianum</i>	biological	No	Various	Low
Serenade	<i>Bacillus subtilis</i>	microbial	No	Various	Low
Sonata	<i>Bacillus pumilis</i>	microbial	No	Various	Low
Messenger	harpin	SAR ² -protein	Yes	Host resistance	Unknown
OxiDate/StorOx/ Perasan	hydrogen dioxide in acetic acid (peroxyacetic acid)	oxidizer	No	Oxidation	Very low
JMS Stylet oil	mineral oil	oil	No	Various	Low
Omni Supreme	low range oil	oil	No	Various	Low
Purespray	low range oil	oil	No	Various	Low
Saf-T-Side	petroleum oil	oil	No	Various	Low
Timorex*	natural oil	oil	No	Various	Low
Trilogy	neem oil	oil	No	Various	Low
Armicarb	potassium bicarbonate	inorganic salt	No	Various	Low
Kaligreen	potassium bicarbonate	inorganic salt	No	Various	Low
M-Pede	potassium salts	inorganic salt	No	Various	Low
Prev-am	sodium tetraborohydrate	inorganic salt	No	Various	Low
VigorCal*	calcium metalosate	inorganic salt	No	Various	Low
VigorK*	potassium metalosate	inorganic salt	No	Various	Low
Cinnacure	cinnamaldehyde	natural product	No	Various	Low
Quiponin*	<i>Quillaja saponaria</i>	natural product	No	Various	Low
Regalia	<i>Reynoutria sachalinensis</i>	natural product	No	Various	Low
Sporan	plant oils (clove, rosemary, thyme)	natural product	No	Various	Low
Valero**	cinnamaldehyde	natural product	No	Various	Low

* Registration pending in California

** Not registered, label withdrawn or inactive

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action Group number.

² SAR = Systemic acquired resistance induced in host

MAXIMUM RESIDUE LIMITS (TOLERANCES) OF PESTICIDES ON AGRICULTURAL FOOD COMMODITIES

Residue tolerances are established for all pesticides registered on agricultural commodities. For synthetic pesticides, as well as materials that are produced by fermentation and are concentrated and/or reformulated, maximum residue limits (i.e., tolerances) have been established by national (country-based) and international regulatory agencies. In the United States, the Environmental Protection Agency (EPA), along with the Food and Drug Administration (FDA) are involved in establishing limits on agricultural food commodities for all registered products including those designated as “exempt” or “generally regarded as safe” or GRAS. Use limits are set for the latter materials, whereas all other materials must have analytical procedures available to measure chemical residues on the commodity. Internationally, the United Nations World Health Organization (WHO) and Food and Agricultural Organization (FAO) created the CODEX Alimentarius Commission to develop food standards, guidelines, and practice codes.

The main goal of national and international agencies is to protect the health of consumers, ensure fair trade practices in food trade, and promote coordination of food standards. The process of registering a pesticide on a food commodity is rigorous and requires numerous evaluations ranging from toxicity to environmental persistence and chemical fate studies. The limits of a pesticide residue are established as a maximum residue limit (MRL) that can occur on each commodity that is still considered an absolute minimal risk to the consumer. Generally, the MRL level is two times higher than what is expected for a residue under labeled pesticide usage. In the United States, the Foreign Agricultural Service or FAS has a website for viewing MRLs of registered pesticides for many markets around the world. The *International Maximum Residue Limit Database* provides users with a list of MRL tolerances by active ingredient to desired export destinations. Users may query by crop, pesticide active ingredient, and pesticide type. The web address is <http://www.mrldatabase.com/>.

Three rules of the International MRL Database should be noted:

1. Only those chemicals that have a permanently established EPA tolerance are included.
2. Foreign market MRLs are included only when an EPA tolerance is in place for the same commodity.
3. Sometimes the EPA sets tolerances for crop groups rather than for individual commodities (e.g. for stone fruit but not for peaches). These crop group MRLs will be shown for the individual commodities that are members of the crop group. A pop-up note will indicate that the commodity is part of a crop group and that the MRL is set for the group and not the individual commodity.

The MRL Database exclusively reflects maximum residue levels that have been established on a permanent basis under domestic US legislation according to the US Code of Federal Regulation (CFR). The following types of MRLs are **not** included in the database:

- Tolerances with regional registrations
- Time-limited and temporary tolerances
- US Section 18 tolerances
- US import tolerances explicitly noted in the CFR
- Tolerances for indirect residues
- Tolerances explicitly noted in the CFR as lacking a current US registration

Fungicides and Their Effects on Non-Target Organisms, Especially Honey Bees

Fungicides are currently the “state of the art” in the management of flower, foliar, and fruit diseases of many crops worldwide. For example, in almond, stone fruit, grapes, and other fruit and nut crops in California, some devastating diseases such as brown rot, shot hole, powdery mildew, and anthracnose have been managed using fungicides since these crops were introduced into the state. Furthermore, several fungicide chemistries, i.e., benzimidazoles, dicarboximides, and DMIs with unique modes of action have been used for over 40, 60, and 25 years, respectively. All these diseases initiate their disease cycles during host flowering. Thus, without the use of fungicides for managing bloom and foliar diseases, these diseases would be limiting to crop production. Some may argue that developing host resistance is the best approach; however, developing host resistance in perennial tree and vine crops to these diseases is very difficult requiring many years. Furthermore, crop characteristics selected by the breeder to meet consumer demands often result in higher disease susceptibility of the crop.

In their registration process, all pesticides are extensively evaluated for their efficacy against diseases and their effect against non-target organisms. Toxicity data for new pesticides are required from each registrant and data are evaluated at federal (US Environmental Protection Agency) and state (California Department of Pesticide Registration) regulatory agencies. Organisms required to be tested include European honey bees, aquatic invertebrates (e.g., *Daphnia* spp.), aquatic plants and vertebrates (e.g., fish), birds, and mammals. For honey bees, the tests are directed to determine acute, short-term toxicity levels by contact and ingestion by adults. If a fungicide is found to be toxic to the adult honey bee then additional tests are required against the brood. If any toxicity to non-target organisms is found then a warning or prohibition is placed on the label to limit or restrict usage. Currently registered fungicides are either non-toxic or are practically non-toxic to adult honey bees exposed to extremely high levels of the fungicides. All fungicides registered have been approved only after these requirements have been met.

Recently, European honey bees have been affected by Colony Collapse Disorder (CCD) where worker bees suddenly disappear, leaving the hive without a sustained source of honey and pollen. The cause of this disorder is still unknown. Numerous factors have come into scrutiny, including exposure to pesticides. With their longstanding regulatory requirements for pesticides to protect beneficial insects such as honey bees, the US-EPA, however, has no data demonstrating that any EPA-registered pesticide used according to the label instructions has caused CCD. Recent research indicates that more likely a combination of factors including poor nutrition, parasites (e.g., varroa mite), new diseases (e.g., Israeli Acute Paralysis virus, Nosema), as well as changes in bee management (e.g., insect and mite control with pesticides inside the hives and migratory stress and drought, etc. brought about by moving honey bees long distances) may be responsible for the disorder (<http://www.epa.gov/pesticides/about/intheworks/honeybee.htm>). Other considerations include changes to honey bee populations due to breeding programs that render hives more susceptible to environmental stress, pests, and pathogens.

In the last few years many new insecticides have been introduced with high toxicity to honey bees and systemic activity in plants. The systemic neonicotinoids and phenylpyrazoles represent two groups that can directly affect honey bee health. Although new application methods help to minimize direct exposure of bees to these compounds, the potential negative outcome is that honey bees may instead be exposed over extended periods of time to these pesticides in pollen, nectar, and plant exudates such as water guttation from leaves (Johnson et al. 2010, <http://entomology.unl.edu/faculty/ellispubs/Pesticides.pdf>). Additionally, the regulatory system governing pesticide use directly in bee hives may also contribute to the problem. Some of the older miticides have become ineffective and thus, new hive-applied pesticides have been recently introduced that may contribute to honey bee management stress.

Chronic exposures to neurotoxic insecticides and their combinations with other pesticides, including fungicides, are known to increase the toxicity of the insecticides and elicit reductions in honey bee fitness. Still, no direct association of these pesticide combinations has been shown with CCD. The following guidelines aim to minimize exposure of bees to bloom-time fungicide sprays were adapted from Mussen and Brandi, 2010 (http://www.extension.org/mediawiki/files/7/77/UCapiariesNovDec_2010.pdf) and combined with some current fungicide use strategies:

- 1) Choose fungicides applied at bloom that do not accumulate in pollen or honey bee products (e.g., bee bread, etc.). These fungicides can be used after bloom for other foliar and fruit diseases during the season. According to Johnson et al. 2010, fungicides that may accumulate to high levels in pollen are

chlorothalonil, captan, and iprodione. Overall, rotational spray programs during the season also minimize the selection of resistance in pathogen populations.

- 2) Do not apply fungicides when honey bees are in flight in orchards. Contaminated foraging worker bees will carry the fungicide back to the hive where other worker bees will clean them and contaminate the hive's food supply.
- 3) Do not apply fungicides when pollen is available. Pollen is released when temperatures reach 13°C (55°F) in the morning and is often removed by honey bees by late afternoon. Thus, between late afternoon until very early the next morning, the amount of fresh pollen available is at the lowest levels of the day.
- 4) Apply fungicides in the evening or at night or when temperatures are less than 13°C (55°F).
- 5) Follow UC guidelines with a single delayed bloom application at 20-30% bloom, if environmental conditions are not conducive for disease development to minimize the total number of fungicide applications during bloom.

DISEASE AND PATHOGEN NAMES

Disease	Pathogen(s)	Host(s)
Alternaria late blight	<i>Alternaria alternata</i> , <i>A. arborescens</i> , <i>A. tenuissima</i> ¹	Pistachio
Alternaria leaf spot	<i>Alternaria alternata</i> , <i>A. arborescens</i> , <i>A. tenuissima</i> ¹	Almond
Angular leaf spot	<i>Xanthomonas fragariae</i> (bacterium)	Strawberry
Anthracnose	<i>Colletotrichum acutatum</i>	Almond, peach, strawberry
Black foot	<i>Cylindrocarpon destructans</i> / <i>C. liriodendron</i>	Grapevine
Black measles (Esca)	<i>Phaeoacremonium aleophilum</i>	Grapevine
Black root rot complex	<i>Cylindrocarpon destructans</i> , <i>Pythium ultimum</i> , <i>Rhizoctonia</i> spp.	Strawberry
Bot canker	<i>Botryosphaeria</i> spp.	Grapevine
Botryosphaeria panicle and shoot blight	<i>Botryosphaeria dothidea</i> (<i>Fusicoccum</i> sp.) ²	Pistachio
Botrytis blossom blight	<i>Botrytis cinerea</i>	Cherry
Botrytis blossom and shoot blight	<i>Botrytis cinerea</i>	Pistachio
Botrytis fruit rot	<i>Botrytis cinerea</i>	Kiwifruit
Brown rot	<i>Monilinia fructicola</i> , <i>M. laxa</i>	Almond and other stone fruits
Bunch rot	<i>Botrytis cinerea</i>	Grapevine
Common leaf spot	<i>Ramularia tulasnii</i>	Strawberry
Crown rot	<i>Phytophthora</i> spp.	Strawberry
Downy mildew	<i>Plasmopora viticola</i>	Grapevine
Esca (Black measles)	<i>Togninia</i> spp. (<i>Phaeoacremonium</i> spp.)	Grapevine
Eutypa dieback	<i>Eutypa lata</i>	Apricot, grapevine
Fire blight	<i>Erwinia amylovora</i> (bacterium)	Pome fruit (apple, pear, quince, etc.)
Gray mold	<i>Botrytis cinerea</i>	Strawberry
Jacket rot/Green fruit rot	<i>Botrytis cinerea</i> , <i>Monilinia laxa</i> , <i>Monilinia fructicola</i> , <i>Sclerotinia sclerotiorum</i>	All stone fruits
Leaf blight	<i>Seimatosporium lichenicola</i>	Almond
Leaf spot	<i>Blumeriella jaapii</i>	Cherry
Leaf curl	<i>Taphrina deformans</i>	Peach, nectarine
Leather rot	<i>Phytophthora cactorum</i>	Strawberry
Mucor rot	<i>Mucor piriformis</i> and other species	Pome and stone fruit; strawberry
Phomopsis blight	<i>Phomopsis</i> sp.	Pistachio

¹ These species are members of the *Alternaria alternata* complex and are the most prevalent in diseases of almond and pistachio. Other closely related species of *Alternaria*, however, may also be involved.

² Other species of *Botryosphaeria* and their anamorphs have been recently identified in addition to *B. dothidea*.

Disease and Pathogen Names, continued

Disease	Pathogen(s)	Host(s)
Phomopsis cane and leafspot	<i>Phomopsis viticola</i>	Grapevine
Phomopsis fruit rot and dieback	<i>Phomopsis amygdali</i>	Almond
Powdery mildew	<i>Erysiphe</i> (=Uncinula) <i>necator</i> <i>Podosphaera leucotricha</i> <i>Podosphaera clandestina</i> <i>Podosphaera tridactyla</i> <i>Podosphaera</i> (=Sphaerotheca) <i>macularis</i> <i>Podosphaera</i> (=Sphaerotheca) <i>pannosa</i>)	Grapevine Almond, Apple, peach, nectarine Cherry Apricot, plum, prune, peach Strawberry Apricot, peach, nectarine, plum
Red steele	<i>Phytophthora fragariae</i>	Strawberry
Rhizopus rot	<i>Rhizopus</i> spp.	Strawberry
Root rot	<i>Phytophthora</i> spp.	Pome and stone fruit crops including almond; pistachio, grapevine, strawberry, and walnut
Russet scab	Abiotic (rain during bloom)	Prune
Rust	<i>Tranzschelia discolor</i>	Almond, nectarine, peach, prune, plum
Scab	<i>Cladosporium carpophilum</i> (<i>Fusicladosporium carpophilum</i>)	Almond, nectarine, peach
Scab	<i>Venturia inaequalis</i>	Apple
Scab	<i>Venturia pirina</i>	Pear
Sclerotinia blight	<i>Sclerotinia sclerotiorum</i>	Almond, apricot, nectarine, peach, prune, pistachio
Shot hole	<i>Wilsonomyces carpophilus</i>	Almond, apricot, peach, nectarine
Silver leaf	<i>Chondrostereum purpureum</i>	Pome and stone fruit, including almond
Summer rot (sour rot of grape)	<i>Aspergillus carbonarius</i> , <i>A. niger</i> , <i>Alternaria tenuis</i> , <i>Botrytis cinerea</i> , <i>Cladosporium herbarum</i> , <i>Rhizopus arrhizus</i> , <i>Penicillium</i> sp., and others	Grapevine
Walnut blight	<i>Xanthomonas arboricola</i> pv. <i>juglandis</i> (bacterium)	Walnut

**FUNGICIDES LISTED BY CHEMICAL CLASS:
MISCELLANEOUS FUNGICIDES/BACTERICIDES**

ANTIBIOTICS

Trade name	Common name	Company	Activity
Ag Streptomycin	Streptomycin	Makhteshim Agan	systemic
AgriMycin	Streptomycin	NuFarm	systemic
FireWall	Streptomycin	AgroSource, Inc./Advan LLC	systemic
Kasumin*	Kasugamycin	Arysta LifeScience	systemic
Mycoshield	Oxytetracycline	NuFarm	systemic
FireLine	Terramycin	AgroSource, Inc./Advan LLC	systemic
FlameOut**	Terramycin	UPI	systemic

*Registration pending in California

**Label withdrawn

Mode of action: all are protein synthesis inhibitors but with specifically different modes of action.

Resistance risk: high

Growth effects: inhibit protein production and growth.

BIOLOGICALS

Trade name	Common name	Company	Activity
Actinovate AG	<i>Streptomyces lydicus</i>	Natural Industries, Inc.	contact
AQ10**	<i>Ampelomyces quisqualis</i>	Ecogen Inc.	contact
Arabesque*	<i>Muscodor albus</i>	AgraQuest Inc.	contact
BlightBan	<i>Pseudomonas fluorescens</i> A506	J.R. Simplot/Plant Health Tech.	contact
BloomtimeBiologicalFD	<i>Pantoea agglomerans</i> E/325	Northwest Ag Prod.	contact
Botry-Zen	<i>Ulocladium oudemansii</i>	BotryZen Ltd.	contact
Plant Shield	<i>Trichoderma harzianum</i>	CircleOne Organics	contact
Serenade	<i>Bacillus subtilis</i>	AgraQuest Inc.	contact
Sonata	<i>Bacillus pumilis</i>	AgraQuest Inc.	contact

*Registration pending in California

**Label withdrawn

Mode of action: antagonism, mycoparasitism, and/or site exclusion (no antibiosis)

Resistance risk: low

Growth effects: growth inhibition of pathogen by antagonism or mycoparasitism

NATURAL COMPOUNDS/OILS/INORGANIC SALTS

Trade name	Common name	Company	Activity
Armcarb	sodium bicarbonate		contact
B-Lock**	boric acid and latex paint	Nutrient Technologies	contact
Cinnacure	cinnamaldehyde		contact
JMS Stylet Oil	mineral oil	JMS Flower Farms	contact
Milstop	potassium bicarbonate	BioWorks	contact
M-Pede Insecticidal Soap	potassium salts	Dow AgroSciences	contact
Kaligreen	sodium bicarbonate	Toagosei/ArystaLifeSciences	contact
Omni Supreme	low range oil	Helena Chemical	contact
Prev-am	sodium tetraborohydrate	ORO Agri. Inc.	contact
Purespray	mineral oil	PetroCanada	contact
Quiponin*	<i>Quillaja saponaria</i>	Nor-Natur	contact
Regalia	<i>Reynoutria sachalinensis</i>	Marrone Bio Innovations	contact
Sporatec	natural oil blend	Brandt Inc.	contact
Timorex*	natural oil	Biomor	contact
Trilogy	neem oil	Certis USA	contact
VigorCal*	calcium metalosate	Agro-K	contact
VigorK*	potassium metalosate	Agro-K	contact
Vintre	orange oil	OroAgri Inc.	contact

*Registration pending in California

** Not registered, label withdrawn or inactive in California

Mode of action: various

Resistance risk: low
Growth effects: various

MINERALS

Trade name	Common name	Company	Activity
Copper and sulfur	various	various	contact

Mode of action: both are multi-site inhibitors: copper = FRAC¹ Group M1; sulfur = FRAC¹ Group M2
copper inactivates numerous enzyme systems; sulfur inhibits respiration

Resistance risk: low

Growth effects: inhibit spore germination; sulfur also inhibits mycelial growth of powdery mildews

Sporulation: no effect

SYSTEMIC ACQUIRED RESISTANCE (SAR)

Trade name	Common name	Company	Activity
Auxigro	GABA/L-glutamic acid	Emerald Bio	systemic
Elexa**	glucosamine protein	SafeScience Prod.	systemic
KeyPlex 350 DP*	yeast extract	Morse Enterprises	systemic
Messenger	harpin	Eden Bioscience	systemic

*Registration pending in California

**Not registered, label withdrawn or inactive

Mode of action: host resistance

Resistance risk: unknown

Growth effects: unknown

Sporulation: unknown

FUNGICIDES LISTED BY CHEMICAL CLASS:
SYNTHETIC FUNGICIDES
(Single Active Ingredients)

ANILINOPYRIMIDINES (AP)

Trade name	Common name	Company	Activity
Penbotec***	pyrimethanil	Janssen Pharmaceutica (Dist. by Cerexagri, Pace International, JBT, etc.)	slight (on most crops)
Scala	pyrimethanil	Bayer CropScience	slight (on most crops)
Vangard	cyprodinil	Syngenta Crop Protection	slight (on most crops)

*****Postharvest use only**

Mode of action: FRAC^I Group 9; single-site, methionine inhibitor; has "kick-back" activity against apple and pear scab and stone fruit fungi.

Resistance risk: high; to reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

Growth effects: APs inhibit mycelial growth and suppresses spore germination. More effective in spring (lower temperatures) than summer (higher temperatures)

Sporulation: no effect

AROMATIC HYDROCARBONS

Trade name	Common name	Company	Activity
Botran	dicloran	Gowan	systemic (local)
Allisan***	dicloran	Gowan	systemic (local)

*****Postharvest use only**

Mode of action: FRAC^I Group 14; mechanism unclear.

Resistance risk: medium

Growth effects: interrupt mycelial growth

Sporulation: little effect

METHYL BENZIMIDAZOLE CARBAMATE (MBC)

Trade name	Common name	Company	Activity
Mertect, Alumni***	thiabendazole (TBZ)	Syngenta Crop Protection	systemic (local)
T-Methyl	thiophanate-methyl	Arysta LifeScience	systemic (local)
Topsin-M	thiophanate-methyl	UPI	systemic (local)
Incognito	thiophanate-methyl	Makteshim Agan of North America, Inc.	systemic (local)

*****Postharvest use only**

Mode of action: FRAC^I Group 1; single-site inhibitors that interfere with nuclear division

Resistance risk: high; levels of resistant populations do not decline in absence of fungicide use; to reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

Growth effects: inhibit mycelial growth

Sporulation: inhibits

BENZAMIDE

Trade name	Common name	Company	Activity
Presidio	fluopicolide	Valent (Bayer CropScience)	systemic (local)

Mode of action: FRAC^I Group 43; delocalization of cellular spectrin-like proteins resulting in plasma membrane disfunction.

Resistance risk: high; the fungicide should be used following FRAC guidelines and used in mixtures and rotations with other fungicides effective against target plant pathogens; to reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; use labeled rates (preferably the upper range), and limit the total number of applications/season (less than 4).

Growth effects: inhibition of mycelial growth, and lysis of zoospores.

Sporulation: inhibits

BENZOPHENONE

Trade name	Common name	Company	Activity
Vivando (BAS560)	metrafenone	BASF	contact and systemic

Mode of action: FRAC¹ Group U8 (unknown- proposed as an actin disrupter); single-site; proposed mechanism is actin disruption.

Resistance risk: high?; to reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), follow protective application schedule, and limit the total number of applications/season.

Growth effects: abnormal spore germination, appressorium formation, and secondary hyphal growth (prevents plant infection).

Sporulation: inhibition of spore formation occurs if mycelium on leaf surfaces is treated.

CARBAMATES

Trade name	Common name	Company	Activity
<i>Ethylene bisdithiocarbamates (EBDC)</i>			
Dithane (coordinated product)	mancozeb	Dow AgroSciences	contact
Maneb**	maneb	UPI	contact
Manex**	maneb	DuPont	contact
Manzate (coordinated product)	mancozeb	DuPont	contact
Penncozeb (coordinated product)	mancozeb	UPI	contact
<i>Dimethyl dithiocarbamates (DMDC)</i>			
Thiram	thiram	Taminco	contact
Ziram	ziram	UPI	contact

**Not registered, label withdrawn or inactive

Mode of action: FRAC¹ Group M3; multi-site inhibitors that complex with enzymes probably inhibiting respiration.

Resistance risk: low

Growth effects: inhibit spore germination

Sporulation: no effect

CARBOXYLIC ACID AMIDES

Trade name	Common name	Company	Activity
Revus	mandipropamid	Syngenta Crop Protection	contact, systemic

Mode of action: FRAC¹ Group 40; interferes cell wall biosynthesis

Resistance risk: high; to reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

Growth effects: inhibits conidial germination and mycelial growth

Sporulation: reduces

CHLORONITRILES

Trade name	Common name	Company	Activity
Bravo	chlorothalonil	Syngenta Crop Protection	contact
Chlorothalonil	chlorothalonil	Arysta LifeScience	contact
Echo	chlorothalonil	Sipcam Agro USA	contact
Equus	chlorothalonil	Makteshim Agan of North America, Inc.	contact

Mode of action: FRAC¹ Group M5; multi-site inhibitor affecting various enzymes and other metabolic processes.

Resistance risk: low

Growth effects: inhibit spore germination

Sporulation: unknown

DEMETHYLATION (ERGOSTEROL OR STEROL BIOSYNTHESIS) INHIBITORS (DMI OR SBI)

Trade name	Common name	Sub-class	Company	Activity
Bayleton	triadimefon	Triazole	Taminco	systemic (local)
Bumper/Tilt	propiconazole	Triazole	Syngenta Crop Protection	systemic (local)
Elite**	tebuconazole	Triazole	Bayer CropScience	systemic (local)
Indar (Enable)	fenbuconazole	Triazole	Dow AgroSciences	systemic (local)
Inspire*	difenoconazole	Triazole	Syngenta Crop Protection	systemic (local)
Mentor***	propiconazole	Triazole	Syngenta Crop Protection	systemic (local)
Mettle	tetraconazole	Triazole	Sipcam Agro USA	systemic (local)
Orius	tebuconazole	Triazole	Makteshim Agan of North America, Inc.	systemic (local)
Procure/Viticure	triflumizole	Imidazole	Chemtura	systemic (local)
Quash	metconazole	Triazole	Valent USA	systemic (local)
Rally (Laredo)	myclobutanil	Triazole	Dow AgroSciences	systemic (local)
Rubigan	fenarimol	Pyrimidine	Dow AgroSciences	systemic (local)
Tebuzol****	tebuconazole	Triazole	UPI	systemic (local)
Topguard*	flutriafol	Triazole	Chemnova Inc.	systemic (local)

*Registration pending in California

**Not registered, label withdrawn or inactive

***Postharvest use on fruit only; check for Section 18 registration; registration pending in California

**** Label includes pre- and postharvest use on selected stone fruit crops.

Mode of action: FRAC¹ Group 3; single-site inhibitors; inhibit demethylation and other processes in sterol biosynthesis; most are absorbed quickly and move up but not down in the plant; all have little effect on spore germination, but interfere with other early developmental processes; all inhibit mycelial growth and may stop lesions from sporulating; many have "kick-back" activity against brown rot, rust, perhaps scab, and apple and pear scab. Systemic action was determined in leaves of annual plants. The requisite tests using radioactive labeled compounds on flowers, fruit and leaves of tree crops have not been conducted.

Resistance risk: high

Growth effects: inhibit mycelial growth

Sporulation: suppresses

DICARBOXIMIDES

Trade name	Common name	Company	Activity
Iprodione	iprodione	Arysta LifeScience	systemic (local)
Rovral	iprodione	Bayer CropScience	systemic (local)
Nevado	iprodione	Makteshim Agan of North America, Inc.	systemic (local)

Mode of action: FRAC¹ Group 2; multi-site

Resistance risk: low with low frequency of application; none reported in California; where resistance occurs, no crop losses reported on stone fruits; resistant populations are less fit and decline in absence of fungicide use.

Growth effects: inhibits mycelial growth and to a lesser extent spore germination

Sporulation: inhibits

GUANIDINES

Trade name	Common name	Company	Activity
Syllit	dodine	Aceto Ag. Chemicals Corp.	systemic (local)

Mode of action: FRAC¹ Group M7; disrupts membranes.

Resistance risk: high

HYDROXYANILIDES

Trade name	Common name	Company	Activity
Elevate	fenhexamid	Arysta LifeScience	contact
Judge	fenhexamid	Pace International	contact

Mode of action: FRAC¹ Group 17; unknown, probably single-site and related to sterol biosynthesis inhibition.

Resistance risk: high; to reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

Growth effects: inhibits spore germination and mycelial growth

Sporulation: no effect

PHENYLAMIDES

Trade name	Common name	Company	Activity
FarmSaver Mefenoxam 2EC	mefenoxam	Makhteshim Agan of North America, Inc.	contact, systemic
Ridomil Gold EC	mefenoxam	Syngenta Crop Protection	contact, systemic

Mode of action: FRAC¹ Group 4; interferes with activity of a nuclear RNA polymerase template complex.

Resistance risk: high; to reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

Growth effects: inhibits mycelial growth, sporangial development, and zoospore viability

Sporulation: reduces

PHENYLPYRROLES

Trade name	Common name	Company	Activity
Scholar***	fludioxonil	Syngenta Crop Protection	contact (except cherry-systemic)

***Postharvest use only

Mode of action: FRAC¹ Group 12; single-site; interferes with regulatory enzymes of oxidation, osmoregulation, and possibly respiration.

Resistance risk: high

Growth effects: inhibits mycelial growth and germination

Sporulation: reduces

PHOSPHONATES

Trade name	Common name	Company	Activity
Aliette	fosetyl-aluminum	Bayer CropScience	systemic
Legion	fosetyl-aluminum	Makhteshim Agan of North America, Inc.	systemic

Mode of action: FRAC¹ Group 33; reports indicate variable effects on both plant and organism physiology.

Resistance risk: low

Growth effects: may inhibit phosphorus deficiency signaling in the plant.

Sporulation: suppresses sporulation of *Phytophthora* spp.

PHTHALIMIDES

Trade name	Common name	Company	Activity
Captan	captan	various	contact

Mode of action: FRAC¹ Group M4; multi-site inhibitor that complexes with enzymes probably inhibiting respiration.

Resistance risk: low

Growth effects: inhibits spore germination

Sporulation: no effect

POLYOXINS

Trade name	Common name	Company	Activity
Ph-D or Endorse	polyoxin-D	Arysta LifeScience	contact

Mode of action: FRAC¹ Group 19; single-site inhibitor of chitin synthase.

Resistance risk: medium

Growth effects: inhibits spore germination and mycelial growth.

Sporulation: no effect

QUINOLINES

Trade name	Common name	Company	Activity
Quintec	quinoxifen	Dow AgroSciences	contact

Mode of action: FRAC¹ Group 13; probably single-site inhibitor; disrupts early cell signaling events.

Resistance risk: medium

Growth effects: suppresses spore germination, early germ tube development and/or appressorium formation

Sporulation: no effect

STROBILURINS (QoIs)

Trade name	Common name	Company	Activity
Abound	azoxystrobin	Syngenta Crop Protection	contact and systemic
Cabrio	pyraclostrobin	BASF	contact and systemic
Flint/Gem ²	trifloxystrobin	Bayer CropScience	contact and systemic
Sovran	kresoxim methyl	BASF	contact and systemic

***Registration pending in California**

²Gem registered on stone fruit and tree nuts; Flint registered on pome fruit and grape.

Mode of action: FRAC¹ Group 11; single-site; blocks respiration by interfering with cytochrome b.

Resistance risk: high; to reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

Growth effects: inhibit spore germination

Sporulation: no effect

SUCCINATE DEHYDROGENASE INHIBITORS (SDHIs)

Trade name	Common name	Company	Activity
Endura	boscalid	BASF	contact
Fontelis (DPX-LEM17)*	penthiopyrad	DuPont	contact
Luna Privilege *	fluopyram	Bayer CropScience	contact
Xemium (BAS700)*	fluxapyroxad	BASF	contact

***Registration pending in California**

Mode of action: FRAC¹ Group 7; unknown mechanism, probably multi-site; registrant indicates that in general the fungicide deprives the fungal cell of its energy source and eliminates the availability of chemical building blocks for synthesis of essential cellular components.

Resistance risk: high

Growth effects: reduced mycelial growth

Sporulation: unknown

Unknown mode of actions

Trade name	Common name	FRAC	Company	Activity
Torino*	cyflufenamid	U6	Gowan	contact

***Registration pending in California**

Mode of action: FRAC¹ Group U6; unknown mechanism.

MULTIPLE ACTIVE INGREDIENTS IN PRE-MIXTURES

DMI/SDHI

Trade name	Common name	Company	Activity
Luna Experience*	tebuconazole/fluopyram	Bayer CropScience	contact and systemic

*Registration pending in California

Mode of action: FRAC¹ Groups 3 and 7; DMI single-site inhibitors (tebuconazole) target demethylation and other processes in sterol biosynthesis; whereas SDHI fungicides inhibit succinate dehydrogenase (fluopyram). Most DMI fungicides most are absorbed quickly and move up but not down in the plant; all have little effect on spore germination, but interfere with other early developmental processes; all inhibit mycelial growth and may stop lesions from sporulating; many have post-infection or "kick-back" activity against brown rot, rust, perhaps scab, and apple and pear scab.

Resistance risk: medium to high; rating is a result of only partial overlap in the spectrum of activity of the two active ingredients. To reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

Growth effects: unknown for SDHI; DMI inhibits only growth

Sporulation: unknown for SDHI; DMI inhibits sporulation.

DMI/STROBILURIN (QoI)

Trade name	Common name	Company	Activity
Adament	tebuconazole/trifloxystrobin	Bayer CropScience	contact and systemic
Quadris Top	difenoconazole/azoxystrobin	Syngenta Crop Protection	systemic (local)
Quilt Xcel	propiconazole/azoxystrobin	Syngenta Crop Protection	systemic (local)

Mode of action: FRAC¹ Groups 3 and 11; both single-site inhibitors; DMIs (difenoconazole, propiconazole, tebuconazole) inhibit demethylation and other processes in sterol biosynthesis; strobilurins (azoxystrobin, trifloxystrobin) block respiration by interfering with cytochrome b.

Resistance risk: medium to high; rating is a result of only partial overlap in the spectrum of activity of the two active ingredients. To reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

Growth effects: DMIs inhibit mycelial growth; strobilurins inhibit spore germination.

Sporulation: DMIs suppress sporulation; strobilurins have no effect.

DMI/ANILINOPYRIMIDINE (AP)

Trade name	Common name	Company	Activity
Inspire Super	difenoconazole/cyprodinil	Syngenta Crop Protection	contact and systemic

Mode of action: FRAC¹ Groups 3 and 9; both single-site inhibitors; DMIs (e.g., tebuconazole) inhibit demethylation and other processes in sterol biosynthesis pathway; whereas AP fungicides are methionine inhibitors (e.g., cyprodinil).

Resistance risk: medium; rating is a result of only partial overlap in the spectrum of activity of the two active ingredients. To reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

Growth effects: APs inhibit mycelial growth and suppresses spore germination; DMIs inhibit mycelial growth.

Sporulation: APs have no effect; DMIs suppress sporulation.

SDHI/STROBILURIN (QoI)

Trade name	Common name	Company	Activity
Merivon (BAS703)*	fluxapyroxad/pyraclostrobin	BASF	contact and systemic
Luna Sensation*	fluopyram/trifloxystrobin	Bayer CropScience	contact and systemic
Pristine	boscalid/pyraclostrobin	BASF	contact and systemic

*Registration pending in California

Mode of action: FRAC¹ Groups 7 and 11; Succinate dehydrogenase inhibitors possibly multi-site; whereas QoIs are single-site. The QoIs (pyraclostrobin, trifloxystrobin) block respiration by interfering with cytochrome b; SDHI fungicides inhibit succinate dehydrogenase (boscalid, fluopyram).

Resistance risk: medium to high; rating is a result of only partial overlap in the spectrum of activity of the two active ingredients. To reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

Growth effects: strobilurins inhibit spore germination; unknown for SDHI

Sporulation: no effect for strobilurins; unknown for SDHI

ANILINOPYRIMIDINE/STROBILURIN (QoI)

Trade name	Common name	Company	Activity
Distinguish**	pyrimethanil/trifloxystrobin	Bayer CropScience	contact/systemic

****Not registered, label withdrawn or inactive**

Mode of action: FRAC¹ Groups 9 and 11; both single-site, anilinopyrimidines (pyrimethanil) inhibit methionine; strobilurins (trifloxystrobin) block respiration by interfering with cytochrome b.

Resistance risk: medium to high; rating is a result of only partial overlap in the spectrum of activity of the two active ingredients. To reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

Growth effects: anilinopyrimidines inhibit mycelial growth and suppresses spore germination; strobilurins inhibit spore germination.

Sporulation: no effect.

ANILINOPYRIMIDINE/PHENYLPYRROLE

Trade name	Common name	Company	Activity
Switch	cyprodinil/fludioxonil	Syngenta Crop Protection	contact/slightly systemic

Mode of action: FRAC¹ Groups 9 and 12; both single-site, anilinopyrimidines (cyprodinil) inhibit methionine; phenylpyrroles (fludioxonil) interfere with regulatory enzymes of oxidation, osmoregulation, and possibly respiration.

Resistance risk: high

Growth effects: both inhibit mycelial growth and germination

Sporulation: reduction

MBC/PHENYLPYRROLE

Trade name	Common name	Company	Activity
Scholar MP***	TBZ/fludioxonil	Syngenta Crop Protection	contact/slightly systemic

*****Postharvest use only**

Mode of action: FRAC¹ Groups 1 and 12; both single-site, MBC (TBZ) binds to beta-tubulin; phenylpyrroles (fludioxonil) interfere with regulatory enzymes of oxidation, osmoregulation, and possibly respiration.

Resistance risk: medium to high (if TBZ resistance already exists)

Growth effects: both inhibit mycelial growth and germination

Sporulation: reduction

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to a fungicide with a different mode of action Group number.

ALMOND: FUNGICIDE EFFICACY

Fungicide	Resistance risk (FRAC) ¹	Brown rot	Jacket rot	Anthrax-nose	Shot hole	Scab ³	Rust ³	Leaf blight	Alternaria leaf spot ³	PM-like ⁵	Silver leaf
Adament	high (3/11) ³	++++	++	++++	+++	+++	+++	ND	++	+++	----
Bumper/Tilt ⁴	high (3)	++++	+/-	++++	++	++	+++	ND	++	+++	----
Distinguish**	high (9/11)	++++	++++	++++	++	ND	ND	ND	ND	ND	----
Indar	high (3)	++++	+/-	+++	++	++	NL	ND	+	ND	----
Inspire XT*	high (3/3)	++++	+	ND	++	+++	ND	ND	+++	+++	----
Inspire Super ⁴	high (3/9)	++++	++	ND	++	+++	+++	ND	+++	ND	----
Luna Sensation*	medium (7/11) ^{3,7}	++++	++++	++++	++++	++++	+++	ND	+++	+++	----
Pristine	medium (7/11) ^{3,7}	++++	++++	++++	++++	++++	+++	ND	+++	+++	----
Quash ⁴	high (3)	++++	++	++++	+++	+++	++++	ND	++++	+++	----
Quadris Top	medium (3/11) ³	++++	++++	++++	+++	++++	++++	ND	+++	+++	----
Quilt Xcel	medium (3/11) ³	++++	++++	++++	+++	++++	++++	ND	+++	+++	----
Rovral + oil ⁸	low (2)	++++	++++	----	+++	+/-	++	ND	+++ ⁹	ND	----
Scala ³	high (9) ^{3,7}	++++	++++	ND	++	----	ND	ND	+	----	----
Tebuzol (Elite**)	high (3)	++++	+/-	+++	++	++	+++	ND	+	ND	----
Topsin-M/T-Methyl/Incognito ²	high (1) ^{2,7}	++++	++++	----	----	+++ ⁸	+	+++ ⁶	----	++	----
Vanguard	high (9) ^{3,7}	++++	++++	ND	++	----	ND	ND	+ ⁹	----	----
Fontelis*	high (7) ⁴	++++	++++	ND	++++	+++	----	ND	+++	ND	----
Abound ⁴	high (11) ^{3,7}	+++	----	++++	+++	++++	++++	+++	+++ ¹⁰	+++	----
Elevate	high (17) ⁷	+++	++++	----	+	ND	ND	ND	ND	ND	----
Gem ⁴	high (11) ^{3,7}	+++	----	++++	+++	++++	++++	+++	+++ ¹⁰	+++	----
Laredo	high (3)	+++	----	++	++	----	+	+++	----	+++	----
Rovral/Iprodione /Nevado	low (2)	+++	+++	----	+++	----	----	ND	+++ ⁹	----	----
Bravo/Chlorothalonil/Echo /Equus ^{11,12}	low (M5)	++	NL	+++	+++	+++	++++	NL	NL	----	----
Captan ^{4,12}	low (M4)	++	++	+++	+++	++	----	+++ ⁶	+	----	----
CaptEstate*	low (M4/17)	+++	+++	+++	+++	+++	----	+++	+	----	----
Maneb**	low (M3)	++	+	++	++	++	+++	++	----	----	----
Ph-D	medium (19)	++	+++	----	++	+++	+++	ND	++++	ND	----
Syllit*	Medium (M7)	+	----	ND	+++	++++	ND	ND	+	ND	----
Rally ¹³	high (3)	+++	----	++	+/-	----	+	+++	----	+++	----
Ziram	low (M3)	++	+	+++	+++	+++	----	++	+	----	----
Copper ¹⁴	low (M1)	+/-	+/-	----	+	+ ¹⁵	----	----	ND	----	ND
Copper + oil ¹⁴	low (M1)	ND	ND	----	+	+++ ¹⁵	----	----	ND	----	ND
Lime sulfur ¹²	low (M2)	+/-	NL	----	+/-	+ ¹⁵	++	NL	NL	----	NL
Sulfur ^{4,12}	low (M2)	+/-	+/-	----	----	++	++	----	----	+++	----
PlantShield	low	----	----	----	----	----	----	----	----	----	+++***

Rating: ++++ = excellent and consistent, +++ = good and reliable, ++ = moderate and variable, + = limited and/or erratic, +/- = minimal and often ineffective, ---- = ineffective, NL = not on label, and ND = no data

* Registration pending in California

**Not registered, label withdrawn or inactive

*** Section 24C (special local needs) registration approved in California.

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action Group number.

² Strains of the brown rot fungi *Monilinia laxa* and *M. fructicola* resistant to Topsin-M and T-Methyl have been found in some California almond orchards. MBC-resistant strains of the jacket rot fungus, *Botrytis cinerea* and powdery mildew fungi, have been reported in California on crops

Continued on next page . . .

Almond: Fungicide Efficacy, continued

- other than almond and stone fruits and may have the potential to develop in almonds with overuse of fungicides with similar chemistry. MBC-resistant strains of the scab fungus, *Cladosporium carpophilum*, have been found in California.
- ³ Field resistance of *Alternaria* sp. and *Cladosporium carpophilum* to QoI and SDHI fungicides has been detected in almond orchards. AP-resistant populations of *Monilinia* spp. have been found on other stone fruit crops in California.
- ⁴ Of the materials listed, only sulfur, Abound, Gem, and some of the DMI fungicides (FRAC Group No. 3) are registered for use in late spring and early summer when treatment is recommended.
- ⁵ PM-like refers to a powdery mildew-like disease on almond fruit that is managed with fungicides with activity against powdery mildew fungi.
- ⁶ Excellent control obtained when combinations of Topsin-M or T-Methyl and Captan are used.
- ⁷ To reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.
- ⁸ Oil recommended is a "light" summer oil, 1-2% volume/volume.
- ⁹ Not registered for use later than 5 weeks after petal fall.
- ¹⁰ Efficacy reduced at high temperatures and relative humidity; experimental for Alternaria.
- ¹¹ Bravo Ultrex, Bravo WeatherStik, Echo, Echo Ultimate, and Chlorothalonil are currently registered.
- ¹² Do not use in combination with or shortly before or after oil treatment.
- ¹³ Efficacy is better in concentrate (80-100 gal/acre) than in dilute sprays.
- ¹⁴ The low rates necessary to avoid phytotoxicity in spring reduce the efficacy of copper.
- ¹⁵ "Burns out" scab twig lesions when applied at delayed dormant.

ALMOND: TREATMENT TIMING

Note: Not all indicated timings may be necessary for disease control.

Disease	Dormant	Bloom			Spring ¹		Summer	
		Pink bud	Full bloom	Petal fall	2 weeks	5 weeks	May	June
Alternaria	----	----	----	----	----	++	+++	+++
Anthracnose ²	----	++	+++	+++	+++	+++	+++	++
Brown rot	----	++	+++	+	----	----	----	----
Green fruit rot	----	----	+++	----	----	----	----	----
Leaf blight	----	----	+++	++	+	----	----	----
Scab ³	++	---	---	++	+++	+++	+	---
Shot hole ⁴	+ ⁵	+	++	+++	+++	++	----	----
Rust	----	----	----	----	----	+++	+++	+ ⁶

Rating: +++ = most effective, ++ = moderately effective, + = least effective, and ---- = ineffective

- ¹ Two and five weeks after petal fall are general timings to represent early postbloom and the latest time that most fungicides can be applied. The exact timing is not critical but depends on the occurrence of rainfall.
- ² If anthracnose was damaging in previous years and temperatures are moderate (63°F or higher) during bloom, make the first application at pink bud. Otherwise treatment can begin at or shortly after petal fall. In all cases, application should be repeated at 7- to 10-day intervals when rains occur during periods of moderate temperatures. Treatment should, if possible, precede any late spring and early summer rains. Rotate fungicides, using different fungicide classes, as a resistance management strategy.
- ³ Early treatments (during bloom) have minimal effect on scab; the 5-week treatment usually is most effective. Treatments after 5 weeks are useful in northern areas where late spring and early summer rains occur. Dormant treatment with liquid lime sulfur improves efficacy of spring control programs.
- ⁴ If pathogen spores were found during fall leaf monitoring, apply a shot hole fungicide during bloom, preferably at petal fall or when young leaves first appear. Re-apply when spores are found on new leaves or if heavy, persistent spring rains occur. If pathogen spores were not present the previous fall, shot hole control may be delayed until spores are seen on new leaves in spring.
- ⁵ Dormant copper treatment seldom reduces shot hole infection but may be useful in severely affected orchards and must be followed by a good spring program.
- ⁶ Treatment in June is important only if late spring and early summer rains occur.

ALMOND: SUGGESTED DISEASE MANAGEMENT PROGRAMS BY FUNGICIDE FRAC¹ GROUPS

Note: Not all indicated timings may be necessary for disease control (*see Treatment Timing Table*). If treatments are needed based on host phenology, weather monitoring, inoculum models, or environmental-disease forecasting models, suggested fungicide groups are listed for each timing.

How to use this table:

- 1) Identify the disease(s) that need(s) to be managed. Know the disease history of the orchard especially from the previous season.
- 2) Select one of the suggested fungicide groups. *Numbers separated by slashes are pre-mixtures, whereas numbers grouped by pluses are tank mixtures.* If several diseases need to be managed, select a group that is effective against all diseases. Refer to fungicide efficacy table for fungicides belonging to each FRAC group. Group numbers are listed in numerical order within the suggested disease management program.
- 3) Rotate groups for each application within a season and, if possible, use each group only once per season, except for multi-site mode of action materials (e.g., M2) or natural products/biological controls (NP/BC).

Disease	Dormant	Bloom			Spring		Summer	
		Pink bud	Full bloom	Petal fall	2 weeks	5 weeks	May	June
Alternaria	----	----	----	----	----	2	3, 3/9, 3/11 7/11 11 19	3, 3/9, 3/11 7/11 11, 19
Anthracnose	----	3, 3/9, 3/11	3, 3/9, 3/11 7/11 11	3, 3/9, 3/11 11 M3 M4	3, 3/9, 3/11 7/11 11 M3 M4	3, 3/9, 3/11 7/11 11 M3 M4	3, 3/9, 3/11 7/11 11 M3 M4	3, 3/9, 3/11 7/11 11 M3 M4
Brown rot	----	1 ² 2 (+oil) 3, 3/9, 3/11 9	1 ² 2 (+oil) 3, 3/9, 3/11, 9 7/11 11	1 ² 2 (+oil) 9 7/11	----	----	----	----
Green fruit rot	----	----	1 ² 2 (+oil) 3/9, 9 7/11	----	----	----	----	----
Leaf blight	----	----	1 ² 2 3, 3/9, 3/11 11	1 ² 2 3, 3/9, 3/11 11 M3 M4	3, 3/9, 3/11 11 M3 M4	----	----	----
Scab ⁴	M1+oil, M2 ³	----	----	1 ² , 3/9, 7/11 ² 11 ² M3 M4 M5	1 ² , 3/9, 7/11 ² 11 ² M3 M4 M5	3, 3/9, 3/11 7/11 ² , 11 ² M2 ³ M3 M4	M2 ³ M4	----
Shot hole	M1	2 3, 3/9, 3/11 9	2 3, 3/9, 3/11 7/11 9, 11	2 3, 3/9, 3/11 7/11 9 11	7/11 11 M3 M4 M5	7/11 11 M3 M4 M5	----	----

Continued on next page . . .

Almond: Suggested Disease Management Programs, continued

Disease	Dormant	Bloom			Spring		Summer	
		Pink bud	Full bloom	Petal fall	2 weeks	5 weeks	May	June
Rust	----	----	----	----	----	3, 3/11 7/11 11, 19 M3	3, 3/11 7/11 11, 19	3, 3/11 7/11 11, 19

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>). Group numbers are listed in numerical order within the suggested disease management program. Fungicides with a different group number are suitable to alternate in a resistance management program. Refer to the fungicide efficacy table for fungicides belonging to each FRAC group.

² Strains of *Monilinia fructicola* and *M. laxa* resistant to Topsin-M, and T-Methyl are present in some California almond orchards. Resistant strains of the jacket rot fungus, *Botrytis cinerea*, and powdery mildew fungi have been reported in California on crops other than almond and stone fruits and may have the potential to develop in almond with overuse of fungicides with similar chemistry.

³ Use liquid lime sulfur in dormant applications and wettable sulfur at and after pre-bloom.

⁴ Apply petal fall treatments based on twig-infection sporulation model.

APPLE AND PEAR: FUNGICIDE EFFICACY

Fungicide	Resistance risk (FRAC#) ¹	Scab		Powdery mildew (apple only)
		Protectant	Eradicant	
Adament	medium (3/11)	++++	++++	++++
Bayleton	high (3)	----	----	+++
Distinguish**	medium (9/11)	+++	+++	+++
Inspire Super	medium (3/9)	++++	++++	++++
Flint ²	high (11) ³	++++	++++	++++
Fontelis*	High (7)	++++	----	+++
Pristine	medium (11/7)	++++	----	+++
Procure ⁴	high (3)	++++	++++	++++
Rally ⁵	high (3)	++++	++	++++
Rubigan ⁴	high (3)	++++	++++	+++
Scala	high (9) ³	+++	+++	+
Sovran	high (11) ³	+++	+++	+++
Syllit	medium (M7)	+++	+++	----
Tebuzol	high (3)	+++	+++	+++
Topsin-M/T-Methyl /Incognito ³	high (1) ³	+++	+++	+++
Vanguard	high (9) ³	+++	+++	+++
Ph-D	medium (19)	+	+	+++
Captan ⁶	low (M4)	+++	----	----
Dithane/Manzate/ Penncozeb ⁶	low (M3)	+++	----	----
Maneb**	low (M3)	+++	----	----
Thiram ⁵	low (M3)	++	----	----
Ziram ⁶	low (M3)	++	----	----
Copper ⁶	low (M1)	++ ⁷	----	----
Lime sulfur ^{6,8}	low (M2)	----	++++ ⁸	+++ ⁹
Sulfur ⁷	low (M2)	++	----	++++

Bactericide/ Biological	Resistance risk	Fire blight ¹¹		Phytotoxicity
		Contact	Systemic	
Ag Streptomycin/Agri-Mycin /Firewall	high	++++	+++	+/-
MycoShield/FireLine ¹⁰ (FlameOut**)	high	+++	+++	+/-
Copper ⁷	low (M1)	+++	----	+
Captan ⁶	low (M4)	++	----	----
Dithane/Manzate/ Penncozeb ⁶	low (M3)	++	----	----
Blight Ban	low	++	----	+/-
Bloomtime Bio	low	+++	----	+/-

Rating: ++++ = excellent and consistent, +++ = good and reliable, ++ = moderate and variable, + = limited and/or erratic, +/- = minimal and often ineffective, ---- = ineffective.

* Registration pending in California

**Not registered, label withdrawn or inactive

*** - Postharvest fruit registrations include: TBZ, Alumni, Penbotec, Scholar, and Scholar MP.

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action Group number.

Continued on next page . . .

Apple and Pear—Fungicide Efficacy, continued

² Label withdrawn on pears because of resistance development.

³ To reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

⁴ On pear, use only **before** white bud and **after** full bloom.

⁵ Labeled on apple only in California.

⁶ These materials show some efficacy and should be used in mixtures with antibiotics as a component of resistance management programs. Captan is registered on apples, whereas Dithane is registered on apples and pears.

⁷ Copper, though effective for scab and blight control, causes fruit scarring.

⁸ "Burns out" scab twig lesions when applied at delayed dormant and disrupts pseudothecial (or ascostroma) development when applied to leaves in fall. **CAUTION: LIME SULFUR IS INCOMPATIBLE WITH MOST OTHER PESTICIDES WHEN USED AFTER BUDBREAK. CHECK BEFORE USE.**

⁹ In-season application eradicates powdery mildew.

¹⁰ Labeled on pear but not on apple.

¹¹ Growth regulators such as prohexadione calcium (Apogee) can be used in an integrated approach to reduce host susceptibility but do not have antibiotic activity against fire blight. Thus, Apogee was not included in the fire blight activity ratings.

APPLE AND PEAR: TREATMENT TIMING

Note: Not all indicated timings may be necessary for disease control.

Disease	Fall	Delayed dormant	Green tip	Pink bud	Spring
Scab ¹	++ ²	++ ²	+++	+++	+++
Powdery mildew ³	----	----	----	+++	+++
Fire blight	----	----	----	+++	+++ ⁴

Rating: +++ = most effective, ++ = moderately effective, + = least effective, and ---- = ineffective

¹ Protection of early tissue is important. Additional applications should be made according to infection periods as determined by the Mills table.

² Disruption of pseudothecial (or ascostroma) development (fall) and inactivation of overwintering twig lesions (delayed dormant) occurs; effects of these treatments on disease control uncertain.

³ Early application is most effective; added treatments are made if mildew continues.

⁴ Start management program at the beginning of bloom and continue through bloom including "rat-tail" bloom throughout spring. Several models are available for forecasting infection periods and treatment timing. Models include: Maryblyt, Cougar Blight, etc.

APRICOT: FUNGICIDE EFFICACY

Note: Do not use sulfur at any time on apricot trees or use captan preharvest on apricot fruit.

Fungicide	Resistance risk (FRAC#) ¹	Brown rot ²		Jacket rot	Powdery mildew ²	Shot hole	Eutypa
		Blossom	Fruit				
Adament	medium (3/11)	++++	++++	++	+++	+++	----
Bumper/Tilt	high (3)	++++	++++	----	+++	+/-	----
Distinguish**	medium (9/11)	++++	+++	++++	+++	+++	----
Elite/Tebuzol	high (3)	++++	++++	+	+	+	----
Indar	high (3)	++++	++++	----	ND	----	----
Inspire Super	high (3)	++++	++++	++++	+++	+++	----
Quash	high (3)	++++	++++	++	+++	++	----
Luna Sensation*	medium (7/11) ⁴	++++	++++	+++	+++	++++	----
Pristine	medium (7/11) ⁴	++++	++++	+++	+++	++++	----
Quadris Top	medium (3/11)	++++	++++	+	+++	+++	----
Quilt Xcel	medium (3/11)	++++	++++	++	+++	+++	----
Rovral ⁵ + oil ⁶	low (2)	++++	NL	++++	----	+++	----
Scala ⁷	high (9) ^{3,4}	++++	+++ ⁷	+++ ⁸	ND	++	----
Topsin-M/T-Methyl/ Incognito ³	high (1) ⁴	++++	++++	++++	+++	----	+++
Vanguard ⁷	high (9) ^{3,4}	++++	+++ ⁷	+++ ⁸	ND	++	----
Fontelis*	high (7)	++++	+++	++++	++++	++++	----
Quintec	high (13)	----	----	----	++++	----	----
Rally	high (3)	+++	+++	----	+++	----	----
Rovral/Iprodione/ Nevado ⁵	low (2)	+++	NL	+++	----	+++	----
Elevate	high (17) ⁴	+++	++	+++	++	+	----
Abound	high (11) ⁴	++	+	----	ND	+++	----
Botran	medium (14)	++	++	+++	ND	ND	----
Bravo/Chlorothalonil/ Echo/Equus ^{9,10}	low (M5)	++	++	++	----	+++	----
Captan ^{10,11}	low (M4)	++	----	++	----	+++	----
Gem	high (11) ⁴	++	+	----	ND	+++	----
Copper	low (M1)	+/-	----	----	----	++	----
Ziram	low (M3)	+/-	----	+	----	++++	----

Rating: ++++ = excellent and consistent, +++ = good and reliable, ++ = moderate and variable, + = limited and/or erratic, +/- = minimal and often ineffective, ---- = ineffective, ND = no data, and NL = not on label

* Registration pending in California

**Not registered, label withdrawn or inactive

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action Group number.

² Do not use fungicides with the same FRAC number and high resistance risk more than twice in one year.

³ Strains of *Monilinia fructicola* and *M. laxa* resistant to Topsin-M and T-Methyl have been reported in some California apricot orchards. Resistant strains of the jacket rot fungus, *Botrytis cinerea*, have been reported in California on crops other than almond and stone fruits and may have the potential to develop in apricots with overuse of fungicides with similar chemistry. Sub-populations of both *Monilinia* spp. have been shown to be resistant to AP (FRAC 9) fungicides on prune in CA.

⁴ To reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

⁵ Blossom blight only; not registered for use after petal fall.

⁶ The oil is a "light" summer oil, 1-2% volume/volume.

⁷ High summer temperatures and relative humidity reduce efficacy.

⁸ Has not been tested on apricot but is effective against the jacket rot pathogens.

⁹ Do not use after jacket (shuck) split.

¹⁰ Do not use in combination with or shortly before or after oil treatment.

¹¹ Causes fruit browning or staining as a preharvest spray.

APRICOT: TREATMENT TIMING

Note: Not all indicated timings may be necessary for disease control.

Disease	Dormant	Red bud	Popcorn	Full bloom	Until pit hardening	Preharvest 1 to 3 weeks
Brown rot ¹	----	+++	+++	+++	----	+++
Eutypa	+ ⁴	----	----	----	----	----
Jacket rot	----	----	----	+++	----	++
Powdery mildew	----	----	----	+++	+++ ²	----
Shot hole ³	----	----	----	++	+++	----

Rating: +++ = most effective, ++ = moderately effective, + = least effective, and ---- = ineffective

¹ Begin at red bud, add one or two more sprays if weather favors disease.

² Repeated treatment at 7- to 14-day intervals may be necessary; earlier treatments are most effective.

³ If pathogen spores were found during fall leaf monitoring, apply a shot hole fungicide during bloom, preferably at petal fall or when young leaves first appear. Re-apply when spores are found on new leaves or if heavy persistent spring rains occur. If pathogen spores were not present the previous fall, shot hole control may be delayed until spores are seen on new leaves.

⁴ Applications are made to pruning cuts.

CHERRY: FUNGICIDE EFFICACY

Fungicide***	Resistance risk (FRAC#) ¹	Brown rot ²		Botrytis Blossom/ Fruit	Jacket rot/ Green fruit rot	Powdery mildew ²	Eutypa
		Blossom	Fruit				
Adament	medium (3/11)	++++	++++	++	++	+++	----
Bumper/Tilt	high (3)	++++	++++	----	----	+++	----
Elite**/Orius/Tebuzol	high (3)	++++	++++ ¹²	++	++	++	----
Indar	high (3)	++++	+++	----	----	+++	----
Luna Sensation*	medium (7/11) ⁵	++++	++++	+++	+++	+++	----
Pristine	medium (7/11) ⁵	++++	++++	+++	+++	+++	----
Quash	high (3)	++++	++++	++	++	+++	----
Quadris Top	medium (3/11)	++++	++++	++	++	+++	----
Quilt Xcel	medium (3/11)	++++	++++	++	++	+++	----
Rovral ⁶ + oil ⁷	low (2)	++++	NL	++++	++++	++	----
Topsin-M/T-Methyl/ Incognito ⁴	high (1) ⁵	++++	NL	++++	++++	+++	+++ ⁴
Fontelis*	high (7) ⁴	++++	+++	++++	++++	++++	----
Abound	high (11) ⁵	+++	+	----	----	++	----
Cabrio	high (11) ⁵	+++	++	----	----	++	----
Elevate	high (17) ⁵	+++	+++	++++	++++	+	----
Gem	high (11) ⁵	+++	++	----	----	++	----
Procure ⁸	high (3)	+++	+++	----	----	++++	----
Quintec	medium (13)	ND	ND	ND	ND	++++	----
Rally ⁸	high (3)	+++	+++	----	----	++++	----
Rovral, Iprodione, Nevado ⁶	low (2)	+++	NL	+++	+++	----	----
Rubigan	high (3)	+++	+++	----	----	++++	----
Botran	medium (14)	++	++	+++	+++	----	----
Bravo/Chlorothalonil/ Echo /Equus ^{9,10}	low (M5)	++	NL	++	++	----	----
Captan ¹⁰	low (M4)	++	++	++	++	----	----
Copper	low (M1)	+/-	----	----	----	----	----
Sulfur ¹⁰	low (M2)	+/-	----	----	----	+++	----
Ziram	low (M3)	+/-	NL	----	----	----	----

Rating: ++++ = excellent and consistent, +++ = good and reliable, ++ = moderate and variable, + = limited and/or erratic, +/- = minimal and often ineffective, ---- = ineffective, ND = no data, NL = not on label, and ? = insufficient data or unknown

*** Registration pending in California**

**Not registered, label withdrawn or inactive

*** - Postharvest fruit registrations include: Allisan, Judge, Penbotec, Scholar, and Tebuzol

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action Group number.

² Do not use the same fungicide or fungicides with similar chemistry more than twice in one year.

³ Shot hole and leaf spot occur infrequently on cherry in California; control usually is not necessary.

⁴ Strains of *Monilinia fructicola* resistant to Topsin-M and T-Methyl are present in some California cherry orchards. Resistant strains of the jacket rot fungus, *Botrytis cinerea*, and powdery mildew fungi have been reported in California on crops other than almond and stone fruits and may have the potential to develop in sweet cherry with overuse of fungicides with similar chemistry.

⁵ To reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

⁶ Blossom blight only; not registered for use after petal fall

⁷ Oil to use is a "light" summer oil, 1-2% volume/volume.

⁸ More effective when applied as a concentrate (80-100 gal/acre) than as a dilute spray.

⁹ Do not use after jacket (shuck) split.

¹⁰ Do not use in combination with or shortly before or after oil treatment.

CHERRY: TREATMENT TIMING

Note: Not all indicated timings may be necessary for disease control.

Disease	Late					
	Budbreak/ Pre-bloom	Popcorn	Full bloom	Petal fall	2-3 weeks later	Preharvest 1-10 days ¹
Botrytis	----	+++	+++	++	----	+++
Brown rot ²	----	+++	+++	++	----	+++
Jacket rot/ Green fruit rot	----	----	+++	++	----	----
Powdery mildew	++ ³	++	+++	+++	+++	+

Rating: +++ = most effective, ++ = moderately effective, + = least effective, and ---- = ineffective

¹Select broad-spectrum fungicides (or combinations) that have activity against both brown rot and Botrytis fruit rots.

²Begin at popcorn and repeat every 10 to 14 days through bloom if rains continue.

³Use sulfur at late bud break and other fungicides for later treatment. Treat immediately if mildew is found on shoots or leaves on inner scaffolds.

CHERRY: SUGGESTED DISEASE MANAGEMENT PROGRAMS BY FUNGICIDE FRAC¹ GROUPS

Note: Not all indicated timings may be necessary for disease control (*see Treatment Timing Table*). If treatments are needed based on weather monitoring or environmental monitoring models, suggested fungicide groups are listed for each timing.

How to use this table:

- 1) Identify the disease(s) that need(s) to be managed. Know the disease history of the orchard especially from the previous season.
- 2) Select one of the suggested fungicide groups. *Numbers separated by slashes are pre-mixtures, whereas numbers grouped by pluses are tank mixtures.* If several diseases need to be managed, select a group that is effective against all diseases. Refer to fungicide efficacy table for fungicides belonging to each FRAC group. Group numbers are listed in numerical order within the suggested disease management program.
- 3) Rotate groups for each application within a season and, if possible, use each group only once per season, except for multi-site mode of action materials or natural products/biological controls (i.e., M2, NP/BC).

Disease	Dormant	Prebloom	White Tip /Popcorn	Full bloom	Petal fall	2-3 weeks later	Preharvest 1-10 days
Botrytis blossom blight/Gray mold fruit decay	----	----	1 ³ 2 (+oil) (3) ⁴	1 ³ 2 (+oil) (3) ⁴ 3/11 3+17 7/11 17	2 (+oil) 7/11 17	----	(3) ⁴ 3+17 7/11 17
Brown rot blossom blight/Fruit rot	----	----	1 ³ 2 (+oil) 3 3/11	1 ³ 3 3+17 3/11 7/11 17	----	----	3 3/11 7/11 17
Powdery mildew	M2 ²	M2 ²	2 (+oil), 3	1 ³ 3 3/11 7/11 13	13 M2 ² NP/BC ⁵	3, 3/11 11 13 M2 ² NP/BC ⁵	3 3/11 3+17 7/11 11

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>). Groups numbers are listed in numerical order within the suggested disease management program. Fungicides with a different group number are suitable to alternate in a resistance management program. Refer to the fungicide efficacy table for fungicides belonging to each FRAC group.

² Use liquid lime sulfur in dormant applications and wettable sulfur at and after prebloom.

³ Strains of *Monilinia fructicola* resistant to Topsin-M, and T-Methyl are present in some California cherry orchards. Resistant strains of the jacket rot fungus, *Botrytis cinerea*, and powdery mildew fungi have been reported in California on crops other than almond and stone fruits and may have the potential to develop in sweet cherry with overuse of fungicides with similar chemistry.

⁴ Among the group 3 fungicides, Elite/Tebuzol/Orius and Quash have some activity against *Botrytis cinerea*.

⁵ NP/BC = Natural Products/Biological Controls such as copper, sulfur, potassium bicarbonate (Kaligreen), *Streptomyces lydicus* (Actinovate AG), *Bacillus pumilus* (Sonata), and *Bacillus subtilis* (Serenade).

GRAPEVINE: FUNGICIDE EFFICACY – Conventional Chemistry

Fungicide	Resistance risk (FRAC#) ¹	Powdery mildew	Downy mildew	Bunch rot			
				Botrytis	Summer	Phomopsis	Eutypa
Abound	high (11) ²	++++	++++	+	----	+++	NR
Adament	medium (3/11)	++++	+	++	++	++	NR
Flint ³	high (11) ²	++++	+++	++	++	++	NR
Elite**/Orius/Tebuzol	high (3)	++++	----	++	++	----	NR
Inspire*	high (3)	++++	----	----	----	----	NR
Inspire Super	medium (3/9)	++++	----	++++	++	----	NR
Luna Experience*	medium (3/7)	++++	----	++++	++	----	NR
Mettle	high (3)	++++	----	----	+	----	NR
Pristine	medium (7/11) ²	++++	++++	++++	+++	+++	NR
Procure	high (3)	++++	----	----	----	----	NR
Quintec	high (13)	++++	----	----	----	----	NR
Rally	high (3)	++++	----	----	----	----	+++
Rally+Topsin-M ⁵	high (1/3)	++++	----	----	----	++++	++++
Rubigan	high (3)	++++	----	----	----	----	NR
Sovran	high (11) ²	++++	++++	++	++	++++	----
Sulfur	low (M2)	++++	----	----	----	----	NR
Topguard*	high (3)	++++	----	----	----	----	NR
Topsin-M/T-Methyl/Incognito	high (1) ²	++++	----	++	++	+	++++
Torino*	high (3)	++++	----	----	----	----	----
Vivando	high (U8)	++++	----	----	----	----	----
Bayleton	high (3)	++	----	----	----	----	NR
Copper	low (M1)	++	+++	++	+++	+	----
Elevate	high (17) ²	++	----	++++	++	----	NR
Ph-D*	medium (19)	++	----	+++	+++	ND	NR
Rovral + Oil ⁴	low (2)	++	----	++++	----	----	NR
Scala	high (9) ²	++	----	++++	++	----	NR
Switch	low (9/12)	++	----	++++	+++	----	----
Vanguard	high (9) ²	++	----	++++	++	----	NR
Captan	low (M4)	----	+	+++	+++	+++	NR
CaptEvate*	low (M4/17)	----	+	+++	+++	+	----
Dithane/Manzate/Penncozeb/(Maneb**)	low (M3)	----	----	++	----	+++	----
Presidio	high (43)	----	++++	----	----	----	----
Revus	high (40)	----	++++	----	----	----	----
Ridomil Gold/(Mefenoxam**)	high (4)	----	++++	----	----	----	----
Rovral/Iprodione/Nevado	low (2)	----	----	+++	----	----	----
Ziram	low (M3)	----	++	+	+	+++	----

Rating: ++++ = excellent and consistent, +++ = good and reliable, ++ = moderate and variable, + = limited and/or erratic, +/- = minimal and often ineffective, ---- = ineffective; and NR = not recommended.

* Registration pending in California

**Not registered, label withdrawn or inactive

GRAPEVINE: FUNGICIDE EFFICACY – Soft Chemistry (Biological and Natural Products)

Fungicide	Resistance risk (FRAC#) ¹	Powdery mildew	Downy mildew	Bunch rot			
				Botrytis	Summer	Phomopsis	Eutypa
Armicarb	low	+++	----	----	----	----	----
Cinnacure	low	+++	----	----	----	----	----
Elexa**	low	+++	----	----	----	----	----
JMS Stylet oil4	low	+++	----	+++	++	----	NR
Kaligreen	low	+++	----	----	----	----	----
Milstop	low	+++	----	----	----	----	----
Regalia	low	+++	----	----	----	----	----
Serenade	low (44)	+++	----	++	+	----	----
Sonata	low	+++	----	++	NR	----	----
Purespray	low	+++	----	----	----	----	----
Vintre	low	++	----	----	----	----	----
Actinovate	low	++	----	----	----	----	----
HiPeak*	low	++	----	----	----	----	----
Messenger	low	++	----	----	----	----	----
Prev-am ⁴	low	++	----	----	----	----	++
Sporan	low	++	----	----	----	----	----
Timorex* ⁴	low	++	----	----	----	----	----
VigorCal*	low	++	----	----	----	----	----
VigorK*	low	++	----	----	----	----	----
Sporatec	low	+	----	----	----	----	----

Rating: ++++ = excellent and consistent, +++ = good and reliable under low to medium disease pressure (high disease pressure will result in reduced efficacy with a rating of +/+++), ++ = moderate and variable, + = limited and/or erratic, +/- = minimal and often ineffective, ---- = ineffective; and NR = not recommended

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action Group number.

² To reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

³ Causes severe phytotoxicity on Concord grape.

⁴ Phytotoxic if used within 2 weeks of Captan or sulfur.

⁵ Tank mixture applied post-pruning (dormant or delayed dormant).

GRAPEVINE: TREATMENT TIMING

Note: Not all indicated timings may be necessary for disease control.

Disease	Dormant	Bud break	Full bloom	Pre-close	Veraison	Preharvest/ Postharvest
Botryosphaeria canker	+++	----	----	----	----	----
Botrytis	+++ ²	----	+++ ¹	+++ ¹	+++ ¹	+++ ¹
Downy mildew	----	+++	+++	----	----	----
Esca	+++ ²	----	----	----	----	----
Eutypa	+++	----	----	----	----	----
Powdery mildew	+++ ²	+++ ³	+++ ³	+++ ⁴	----	----
Phomopsis	+++	+++	----	----	----	----
Summer bunch rot (sour rot)	----	----	----	----	+++ ¹	+++ ¹

Rating: +++ = most effective, ++ = moderately effective, + = least effective, and ---- = ineffective

¹ Apply only if rain is forecasted.

² Use 10 gal lime sulfur per acre in at least 100 gal water.

³ Apply bud break and full bloom treatments every year.

⁴ Apply as needed (a disease risk assessment model is available to help determine need for spray).

GRAPEVINES: SUGGESTED DISEASE MANAGEMENT PROGRAMS BY FUNGICIDE FRAC¹ GROUPS

Note: Not all indicated timings may be necessary for disease control (*see Treatment Timing Table*). If treatments are needed based on weather monitoring or environmental monitoring models, suggested fungicide groups are listed for each timing.

How to use this table:

- 1) Identify the disease(s) that need(s) to be managed. Know the disease history of the orchard especially from the previous season.
- 2) Select one of the suggested fungicide groups. *Numbers separated by slashes are premixtures, whereas numbers grouped by pluses are tank mixtures.* If several diseases need to be managed, select a group that is effective against all diseases. Refer to fungicide efficacy table for fungicides belonging to each FRAC group. Group numbers are listed in numerical order within the suggested disease management program.
- 3) Rotate groups for each application within a season and, if possible, use each group only once per season, except for multi-site mode of action materials or natural products/biological controls (i.e., M2, NP/BC).

Disease	Dormant	Bud break	Full bloom	Pre-close	Veraison	Preharvest
Botryosphaeria canker	NP ⁶ (lime sulfur) ³	----	----	----	----	----
Botrytis	----	----	3/7, 3/9 7/11 ² , 9/12, 9, 17 19, M4	3/7, 3/9 7/11 ² 9/12, 9, 17 19	3/7, 3/9 7/11 ² 9/12, 9, 17 19	3/7, 3/9 7/11 9/12, 9, 17 19
Downy mildew		NP, 4, 40, 43	4,40,43	----	----	----
Esca	NP ⁶ (lime sulfur) ³	----	----	----	----	----
Eutypa	NP ⁶ (B-Lock ^{**}) 1	----	----	----	----	----
Powdery mildew ^{4,5}	NP ⁶ (lime sulfur) Oil	M2 Oil	3/7, 3/9 7/11 13 17+11 19 U8	3, 3/7, 3/9 11 13, U8 BC ⁶ NP ⁶ M4	3, 3/7, 3/9 11 13, 19 M4 U8	----
Phomopsis cane and leafspot	----	2 11 M4/M3	----	----	----	----
Summer bunch rot (sour rot)	----	----	----	3/9, 7/11 9, 9/12 Oil, M1	3/9, 7/11 9, 9/12 M1	3,9, 7/11 ⁷ 9 ⁷ , 9/12 M1 ⁷

****Not registered, label withdrawn or inactive**

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>). Groups numbers are listed in numerical order within the suggested disease management program. Fungicides with a different group number are suitable to alternate in a resistance management program. Refer to the fungicide efficacy table for fungicides belonging to each FRAC group.

² Apply only if rain is forecasted. When using one class do not follow with the same class.

³ Use 10 gal lime sulfur per acre in at least 100 gal water. Use liquid lime sulfur in dormant applications and wettable sulfur at and after prebloom.

⁴ Apply bud break and full bloom treatments every year.

⁵ Apply as needed (a disease risk assessment model is available to help determine need for spray).

⁶ NP/BC = Natural Products/Biological Controls such as B-Lock, Sonata, Serenade, Kaligreen, Cinnacure, etc.

⁷ Apply when insect and bird damage present or when rainfall is forecasted.

KIWIFRUIT: FUNGICIDE EFFICACY

Fungicide	Resistance risk (FRAC number) ¹	Botrytis Fruit Rot
Vanguard ²	high (9) ³	+++
Judge ⁴	high (17) ³	+++
Scholar ⁴	high (12)	+++

Rating: ++++ = excellent and consistent, +++ = good and reliable, ++ = moderate and variable, + = limited and/or erratic, +/- = minimal and often ineffective, ---- = ineffective; and NR = not recommended

* Registration pending in California

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action Group number.

² Vanguard preharvest registration for California is approved for the 2010 fall season as of Feb. 2010.

³ To reduce the risk of resistance development, start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

⁴ Judge and Scholar are for postharvest use only.

KIWIFRUIT: TREATMENT TIMING

Note: Not all indicated timings may be necessary for disease control.

Disease	Bud break	Full bloom	Preharvest Interval ¹			Postharvest
			14 day	7 day	1 day	
Botrytis fruit rot	----	++ ²	++	+++	++++	++++

Rating: +++++ = most effective, ++++ = highly effective, ++ = moderately effective, + = least effective, ---- = ineffective

¹ Apply as needed. A predictive model BOTMON is available using ONFIT methods for disease detection.

² Apply only if rain is forecasted.

PEACH AND NECTARINE: FUNGICIDE EFFICACY

Fungicide	Resistance Risk (FRAC#) ¹	Brown rot ²		Powdery mildew ²	Scab	Rust	Leaf curl	Shot hole
		Blossom	Fruit					
Adament	medium (3/11)	++++	+++	+++	---	+++	---	+/-
Bumper/Tilt	high (3)	++++	++++	+++	++	+++	---	+/-
Distinguish**	medium (9/11)	++++	+++	++	+++	+++	---	++
Elite**/Orius/Tebuzol	high (3)	++++	++++	+++	++	+++	---	+
Indar	high (3)	++++	++++	+++	++	ND	---	+/-
Inspire XT*	high (3/3)	++++	++++	+++	++	ND	---	+/-
Inspire Super	high (3/9)	++++	++++	+++	++	ND	---	+/-
Quash	high (3)	++++	++++	+++	ND	+++	---	+++ ^{10,12}
Pristine	medium (7/11) ⁴	++++	++++	+++	+++	ND	ND	++++ ^{10,12}
Luna Sensation*	medium (7/11) ⁴	++++	++++	+++	+++	---	ND	++++ ^{10,12}
Quadris Top	medium (3/11)	++++	++++	+++	---	+++	---	+/-
Quilt Xcel	medium (3/11)	++++	++++	+++	---	+++	---	+/-
Rovral ⁵ + oil ⁶	low (2)	++++	NL	+	+	++	---	++
Scala ⁷	high (9) ^{3,4}	++++	+++ ⁷	ND	ND	ND	---	+
Topsin-M /T-Methyl /Incognito	high (1) ^{3,4}	++++	++++	+++	+++	+	---	---
Vanguard ⁷	high (9) ^{3,4}	++++	+++ ⁷	ND	ND	ND	---	+
Fontelis*	high (7) ⁴	++++	+++	++++	+++	ND	---	+++ ^{10,12}
Elevate	high (17) ⁴	+++	+++	ND	ND	ND	ND	ND
Rally	high (3)	+++	+++	++++	---	---	---	---
Rovral/Iprodione /Nevado ⁵	low (2)	+++	NL	---	---	---	---	---
Abound	high (11) ⁴	++	+	++	++++	+++	---	++
Botran	medium (14)	++	+	ND	ND	ND	ND	ND
Bravo/Chlorothalonil /Echo/Equus ^{8,9}	low (M5)	++	---	---	+++	+	+++	+++
Captan ⁹	low (M4)	++	++	---	+++	---	---	+++ ^{10,12}
Gem	high (11) ⁴	++	+	++	++++	+++	---	++
Quintec	high (13)	---	---	++++	---	---	---	---
Syllit ¹¹	medium (M7)	+	---	---	+++	---	++++	+++
Copper	low (M1)	+/-	---	---	---	---	+++	+++
Sulfur ⁹	low (M2)	+/-	+/-	+++	+++	+++	---	---
Thiram	low (M3)	+/-	---	---	+++	---	++++	+++
Ziram	low (M3)	+/-	---	---	+++	---	++++	+++

Rating: ++++ = excellent and consistent, +++ = good and reliable, ++ = moderate and variable, + = limited and/or erratic, +/- = minimal and often ineffective, --- = ineffective, ND = no data, and NL = not on label

* Registration pending in California.

**Not registered, label withdrawn or inactive

*** - Postharvest fruit registrations include: Allisan, Judge, Penbotec, Scholar, and Mentor (Section 18).

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action Group number.

² Do not use fungicides with the same FRAC number and high resistance risk more than twice in one year.

³ Strains of *Monilinia fructicola* resistant to Topsin-M and T-Methyl are present in some peach and nectarine orchards. Resistant strains of the jacket rot fungus, *Botrytis cinerea*, and powdery mildew fungi have been reported in California on crops other than almond and stone fruits and may have the potential to develop in peach and nectarine with overuse of fungicides with similar chemistry. Sub-populations of both *Monilinia* spp. have been shown to be resistant to AP (FRAC 9) fungicides on prune in CA.

⁴ To reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

⁵ Blossom blight only; not registered for use after petal fall.

⁶ Oil is a "light" summer oil, 1-2% volume/volume.

⁷ High summer temperatures and relative humidity reduce efficacy.

⁸ Do not use after jacket (shuck) split.

⁹ Do not use in combination with or shortly before or after oil treatment.

¹⁰ Not effective if used as a dormant treatment.

¹¹ For use on peach only; not registered on nectarine.

¹² For shot hole management, dormant treatments with copper, ziram, and dodine are highly effective. Petal fall treatments should be used to complement the management program.

PEACH AND NECTARINE: TREATMENT TIMING

Note: Not all indicated timings may be necessary for disease control.

Disease	Dormant	Bloom		3-6 weeks postbloom	Preharvest ¹	
		20-40%	80-100%		3 weeks	1 week
Brown rot	----	++	+++	+	++	+++
Powdery mildew	----/ND	++	+++	+++ ²	----	----
Leaf curl ³	+++	+	----	----	----	----
Rust	+ ⁴	----	----	+++	++	----
Scab	----	+	++	+++	----	----
Shot hole ⁵	+++	+	+	++	----	----

Rating: +++ = most effective, ++ = moderately effective, + = least effective, ---- = ineffective, and ND = no data but needs to be evaluated.

¹ Timing not exact; weather conditions determine need for treatment.

² Apply until pit hardening.

³ Treatment should be made before bud break and preferably before bud swell.

⁴ Dormant treatment with liquid lime sulfur.

⁵ Fall application before winter rains begin is the most important; additional spring sprays are seldom required but may be needed to protect the fruit if heavy persistent spring rains occur.

PEACH AND NECTARINE: SUGGESTED DISEASE MANAGEMENT PROGRAMS BY FUNGICIDE FRAC¹ GROUPS

Note: Not all indicated timings may be necessary for disease control (see Treatment Timing Table). If treatments are needed based on weather monitoring or environmental monitoring models, suggested fungicide groups are listed for each timing.

How to use this table:

- 1) Identify the disease(s) that need(s) to be managed. Know the disease history of the orchard especially from the previous season.
- 2) Select one of the suggested fungicide groups. *Numbers separated by slashes are pre-mixtures, whereas numbers grouped by pluses are tank mixtures.* If several diseases need to be managed, select a group that is effective against all diseases. Refer to fungicide efficacy table for fungicides belonging to each FRAC group. Group numbers are listed in numerical order within the suggested disease management program.
- 3) Rotate groups for each application within a season and, if possible, use each group only once per season, except for multi-site mode of action materials or natural products/biological controls (e.g., M2, NP/BC).

Disease	Dormant	Bloom		3-6 weeks postbloom	Preharvest	
		20-40%	80-100%		3 weeks	1 week
Brown rot	----	1 ³	1 ³	3	3	3 ⁴
		2 (+oil)	2 (+oil)	3/11	3/11	3/11
		3	3 ⁴	7/11	7/11	7/11
		3/11	3/11	9/11	9/11	9/11
		9	7/11	17	17	17
		9/11	9			
Powdery mildew	----/M2 ²	1 ³	1 ³	3	----	----
		2+oil	3	7/11		
		3	7/11	11		
				M2 ²		
				NP/BC ⁵		
Leaf curl	M1, M3 M5, M7	M3	----	----	----	----
		M5				
Rust	M2 ²	----	----	1 ³	3	----
				3	7/11	
				7/11	11	
				11	M2 ²	
				M2 ²		
Scab	----	1 ³	1 ³	1 ³	----	----
		3	3	3		
		3/11	3/11	3/11		
		7/11	7/11	7/11		
		9/11	9/11	9/11		
		M3	M4	11		
		M4	M5	M2 ²		
		M7	M7	M4, M7		
Shot hole	M1 M3 M5 M7	2	2	7/11	----	----
		M3	7/11	11		
		M4	M3	M4		
		M5	M4			
		M7	M5			

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>). Group numbers are listed in numerical order within the suggested disease management program. Fungicides with a different group number are suitable to alternate in a resistance management program. Refer to the fungicide efficacy table for fungicides belonging to each FRAC group.

Peach and Nectarine—Disease Management Programs, continued

² Efficacy of liquid lime sulfur in dormant applications has not been determined for powdery mildew. Use liquid lime sulfur in dormant applications and wettable sulfur at and after pre-bloom.

³ Strains of *Monilinia fructicola* resistant to Benlate (label withdrawn), Topsin-M, and T-Methyl are present in some California cherry orchards. Resistant strains of the jacket rot fungus, *Botrytis cinerea*, and powdery mildew fungi have been reported in California on crops other than almond and stone fruits and may have the potential to develop in sweet cherry with overuse of fungicides with similar chemistry. Subpopulations of both *Monilinia* spp. have been shown to be resistant to AP (FRAC 9) fungicides on prune in CA.

⁴ Among the group 3 fungicides, only Elite/Tebuzol/Orius and Quash have some activity against *Botrytis cinerea*.

⁵ NP/BC = Natural Products/Biological Controls such as copper, sulfur, potassium bicarbonate (Kaligreen), *Streptomyces lydicus* (Actinovate AG), *Bacillus pumilus* (Sonata), and *Bacillus subtilis* (Serenade)

PISTACHIO: FUNGICIDE EFFICACY

Fungicide	Resistance risk (FRAC#) ¹	Alternaria late blight	Botrytis blossom & shoot blight	Botryosphaeria panicle & shoot blight
Adament	medium (3/11) ³	++	+++	++
Abound	high (11) ^{2,3}	+++	----	+++
Bravo/Chlorothalonil/(Echo**)	low (M5)	++	----	++
Bumper/Tilt	high (3)	++	+	++ ⁵
Cabrio	high (11) ^{2,3}	+++	----	+++
Distinguish**	medium (9/11)	++	++	----
Inspire Super	medium (3/9)	++	+++	+++
Elevate	high (17) ³	ND	++++	ND
Gem	high (11) ^{2,3}	+++	----	+++
Quash	high (3)	++	+++	+++ ⁵
Luna Sensation*	medium (7/11) ³	++++ ⁴	++++	++++
Pristine	high (7/11) ³	++++ ⁴	++++	++++
Fontelis*	high (7)	++++	++++	++++
Ph-D (Polyoxin-D)	medium (19)	+++	ND (++)	+++
Quadris Top	medium (3/11) ³	+++	----	+++
Quilt Xcel	medium (3/11) ³	+++	----	+++
Scala	high (9) ³	++	++	+++ ⁶
Switch	high (9/12) ³	+++	+++	++
Tebuzol	high (3)	+++	+	+++ ⁵
Topsin-M/T-Methyl/Incognito ⁷	high (1)	----	++	++
Copper	low (M1)	+	----	----
Liquid lime sulfur ⁸	low (M2)	----	----	+/-

Rating: ++++ = excellent and consistent, +++ = good and reliable, ++ = moderate and variable, + = limited and/or erratic, +/- = minimal and often ineffective, ---- = ineffective, and ND = no data

* **Registration pending in California.**

****Not registered, label withdrawn or inactive.**

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action Group number.

² Field resistance of *Alternaria* spp. to Abound and to other strobilurin fungicides (Gem and Cabrio) is widespread in pistachio orchards.

³ To reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

⁴ Resistance to the SDHI (succinate dehydrogenase inhibitor) boscalid has been detected in high levels (80-90%) in some orchards; Pristine should not be applied if resistance to this fungicide is detected in an orchard. Cross-resistance of SDHI fungicides (FRAC Group 7) may occur.

⁵ Do not apply Bumper/Tilt within 60 days of harvest, Quash within 25 days of harvest, or Tebuzol within 35 days before harvest.

⁶ Under low and moderate disease pressure.

⁷ Registered for bloom treatment only.

⁸ Dormant treatment only.

PISTACHIO: TREATMENT TIMING

Disease	Dormant	Bloom/terminal shoot ½-1 inch. (April)	Succulent shoot growth /before shell lignification (May)	Early Fruit development /after shell lignification (June) ¹	Fruit development /kernel development (July)	Fruit maturation (August) ²
Alternaria ³	----	----	----	+++	+++ ¹	+?
Botryosphaeria ⁴	+	+++ ⁵	+++ ⁵	+++	+++	++
Botrytis	----	+++	----	----	----	----

Rating: +++ = most effective, ++ = moderately effective, + = least effective (+/? under revision), and ---- = ineffective

¹ If only one application is done, the best timing is late June to early July.

² Sprays not later than the first week in August.

³ Three applications during the season are recommended.

⁴ Treat once at bloom when the terminals on female trees are 1-2 inches long. Begin summer applications in late May or early June. Treat at 2-3 week intervals until mid-August. For resistance management, do not apply consecutive applications of any strobilurin (Abound, Flint/Gem or Cabrio) or strobilurin-containing fungicides (Pristine), and make no more than two applications of a strobilurin or strobilurin-containing fungicide per season.

⁵ Early season sprays timed before and/or after rains are effective timings in April and May.

PLUM: FUNGICIDE EFFICACY

Note: Spring brown rot and shot hole control is not necessary for most plum cultivars in California.

Fungicide	Resistance risk (FRAC#) ¹	Brown rot		Powdery mildew ³	Shot hole ⁴
		Blossom ²	Fruit		
Adament	medium (3/11) ⁵	++++	++++	+++	ND
Bumper/Tilt	high (3)	++++	++++	+++	ND
Distinguish**	medium (9/11)	++++	+++	++	ND
Elite ⁶ /Tebuzol ^{6****}	high (3)	++++	++++ ⁶	+++	ND
Indar	high (3)	++++	++++	+++	ND
Inspire XT*	high (3/3)	++++	++++	+++	ND
Inspire Super	high (3/9)	++++	++++	+++	ND
Fontelis*	high (y)	++++	++++	+++	ND
Luna Sensation*	medium (7/11) ⁵	++++	++++	+++	ND
Pristine	medium (7/11) ⁵	++++	++++	+++	ND
Quash	high (3)	++++	++++	+++	ND
Quilt Xcel	medium (3/11) ⁵	++++	++++	+++	ND
Quadris Top	medium (3/11) ⁵	++++	++++	+++	ND
Rovral ⁷ + oil ⁸	low (2)	++++	NL	----	ND
Scala ⁹	high (9) ^{5,10}	++++	+++ ⁹	ND	ND
Topsin-M/T-Methyl/ Incognito ⁵	high (1) ⁵	++++	++++	+++	ND
Vangard ⁹	high (9) ^{5,10}	++++	+++ ⁹	ND	ND
Quintec	high (13)	----	----	++++	----
Rally	high (3)	+++	+++	+++	ND
Rovral/Iprodione/ Nevado ⁷	low (2)	+++	NL	----	ND
Abound	high (11) ⁵	++	+	ND	ND
Botran	medium (14)	++	++	ND	ND
Bravo/Chlorothalonil/ Echo/Equus ^{11,12}	low (M5)	++	++	----	ND
Captan ¹²	low (M4)	++	++	----	ND
Gem	high (11) ⁵	++	++	ND	ND
Copper	low (M1)	+/-	----	----	ND
Sulfur ¹²	low (M2)	+/-	+/-	+++	ND

Rating: ++++ = excellent and consistent, +++ = good and reliable, ++ = moderate and variable, + = limited and/or erratic, +/- = minimal and often ineffective, ---- = ineffective, NL = not on label, and ND= no data

* Registration pending in California.

** Not registered, label withdrawn or inactive

**** - Postharvest fruit registrations include: Allisan, Judge, Penbotec, Scholar, and Tebuzol.

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action Group number.

² Brown rot blossom blight is seldom observed on most plum cultivars and usually does not require treatment during bloom.

³ Powdery mildew seldom is observed on most plum cultivars and control usually is unnecessary.

⁴ Shot hole disease rarely occurs on plums in California. The small holes often observed on leaves in spring are caused by either a genetic disorder or by other agents including environmental factors.

⁵ To reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

⁶ Registered for pre- and postharvest applications on plum.

⁷ Blossom blight only; not registered for use after petal fall.

⁸ The oil is a "light" summer oil, 1-2% volume/volume.

⁹ High summer temperatures and relative humidity reduce efficacy.

¹⁰ Strains of the brown rot fungus *Monilinia fructicola* resistant to Topsin-M and T-Methyl are found in other stone fruit orchards in California. Brown rot is so seldom found in plum orchards that the resistance levels in plum orchards have not been assessed. Subpopulations of both *Monilinia* spp. have been shown to be resistant to AP (FRAC 9) fungicides on prune in CA.

¹¹ Do not use after jacket (shuck) split.

¹² Do not use in combination with or shortly before or after oil treatment.

PLUM: TREATMENT TIMING

Note: Not all indicated timings may be necessary for disease control.

Disease	Dormant	Green bud	Popcorn	Full bloom	Until pit hardening	Preharvest
Brown rot ¹	----	+	++	+++	----	+
Powdery mildew	----	+	+	+++	+++	----
Shot hole ²	----	----	----	----	----	----

Rating: +++ = most effective, ++ = moderately effective, + = least effective, and ---- = ineffective.

¹ One early application should suffice; a second treatment should not be needed.

² No treatment is recommended for shot hole because the shot holes found on plum leaves only rarely are caused by the shot hole fungus.

PRUNE (DRIED PLUM): FUNGICIDE EFFICACY

Fungicide	Resistance risk (FRAC#) ¹	Brown rot		Russet scab	Rust
		Blossom	Fruit ²		
Adament ^{2,7}	medium (3/11)	++++	++++	----	+++
Bumper/Tilt ²	high (3)	++++	++++	----	+++
Distinguish**	medium (9/11)	++++	++	----	++
Elite**/Tebuzol ^{2,7}	high (3)	++++	++++	----	+++
Indar ²	high (3)	++++	++++	----	+++
InspireXT* ²	high (3/3)	++++	++++	----	+++
Inspire Super	high (3/9)	++++	++++	----	+++
Luna Sensation* ²	medium (7/11) ⁴	++++	++++	ND	ND
Pristine ²	medium (7/11) ⁴	++++	++++	ND	ND
Quash ²	high (3)	++++	++++	----	+++
Quadris Top ²	medium (3/11) ⁴	++++	++++	ND	++++
Quilt Xcel ²	medium (3/11) ⁴	++++	++++	ND	++++
Rovral + oil ^{2,5}	low (2)	++++	NR	----	NR
Scala ⁶	high (9) ^{3,4}	++++	+++ ⁶	----	ND
Topsin-M /T-Methyl/Incognito+ oil ^{2,4}	high (1) ⁴	++++	++++	----	----
Vanguard ⁶	high (9) ^{3,4}	++++	+++ ⁶	----	ND
Fontelis*	high (3)	++++	+++	----	ND
Elevate ^{2,7}	high (17) ⁴	+++	+++	ND	----
Rovral/Iprodione /Nevado ²	low (2)	+++	NR	----	NR
Topsin-M/T-Methyl/Incognito ^{2,3}	high (1) ⁴	+++	+/-	----	----
Abound	high (11) ⁴	++	+	----	+++
Botran	medium (14)	++	++	ND	ND
Bravo/Chlorothalonil/Echo/Equus ^{8,9,10}	low (M5)	++	++	++	---- ⁹
Captan ^{7,8,10}	low (M4)	++	++	+++	----
Gem ⁷	high (11) ⁴	++	+	----	+++
Rally ²	high (3)	++	++	----	----
Sulfur ¹⁰	low (M2)	+/-	+/-	----	++

Rating: ++++= excellent and consistent, +++= good and reliable, ++= moderate and variable, += limited and erratic, +/- = often ineffective, ---- = ineffective, ? = insufficient data or unknown, NR=not registered after bloom, and ND=no data

* Registration pending in California.

**Not registered, label withdrawn or inactive

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action Group number..

² Fruit brown rot treatments for fungicides in FRAC Groups 1,2, 3, 17, 7/11 are improved with the addition of 2% light summer oil. The oil is "light" summer oil (1-2% vol/vol). If applied in summer, fruit will lose their waxy bloom and look red. They will dry to normal color.

³ Strains of *Monilinia fructicola* and *M. laxa* resistant to Topsin-M and T-Methyl have been reported in some California prune orchards. No more than two applications of Topsin-M or T-Methyl should be made each year. Resistant strains of the jacket rot fungus, *Botrytis cinerea*, and powdery mildew fungi have been reported in California on crops other than almond and stone fruits and may have the potential to develop in prune with overuse of fungicides with similar chemistry. Subpopulations of both *Monilinia* spp. have been shown to be resistant to AP (FRAC 9) fungicides on prune in CA.

⁴ To reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

⁵ Blossom blight only; not registered for use after petal fall.

⁶ High summer temperatures and relative humidity reduce efficacy.

⁷ Registered for use on fresh prunes only.

⁸ Do not use in combination with or shortly before or after oil treatment.

⁹ Do not use after jacket (shuck) split.

¹⁰ Do not use sulfur, captan, or chlorothalonil in combination with or shortly before or after oil treatment.

¹¹ Quash, Elite, Tebuzol, Gem, Scala and Pristine are registered for plums and prunes (dried plum) in California.

PRUNE (DRIED PLUM): TREATMENT TIMING

Note: Timings listed are effective but not all may be required for disease control. Timings used will depend upon orchard history of disease, length of bloom, and weather conditions each year.

Disease	Green bud	White bud	Full bloom	May	June	July
Brown rot ¹	+++	+++	+++	----	+	++
Russet scab ²	----	----	+++	----	----	----
Rust ³	----	----	----	+	++	+++

Rating: +++ = most effective, ++ = moderately effective, + = least effective, and ---- = ineffective

¹ Flowers are susceptible beginning with the emergence of the sepals (green bud) until the petals fall but are most susceptible when open.

² A physiological disorder; no pathogens involved.

³ More severe when late spring rains occur.

STRAWBERRY: FUNGICIDE EFFICACY

Fungicide	Resistance risk (FRAC) ¹	Powdery mildew	Gray mold	Anthracnose	Angular leaf spot	Common leaf spot	Mucor rot	Rhizopus rot	Leather rot	Crown rot	Red steele
Bumper/Tilt	high (3)	++++	----	++	----	+++	----	----	----	----	----
Mettle*	high (3)	++++	NR	ND	ND	ND	ND	ND	----	----	----
Procure	high (3)	++++	----	+	----	----	----	----	----	----	----
Quilt Xcel	medium (3/11)	++++	++	+++	----	----	ND	+	ND	ND	ND
Rally	high (3)	++++	----	++	----	+++	----	----	----	----	----
Topsin-M/T-Methyl/Incognito	very high (1) ²	+++	+++	----	----	++	----	----	----	----	----
Copper	low (M1)	----	----	----	+++ ⁵	----	----	----	----	----	----
Sulfur	low (M2)	+++	----	----	----	----	----	----	----	----	----
Quadris	medium (11) ²	+++	++	++	----	----	ND	ND	ND	ND	ND
Pristine	medium (7/11) ²	+++	++++	ND	----	----	ND	ND	ND	ND	ND
Ph-D	medium (19)	+++	++	++	ND	ND	----	----	----	----	----
Cinnacure	low	+	----	----	----	----	----	----	----	----	----
Elevate	high (17) ^{2,6}	+/-	++++ ₆	+++	----	----	----	----	----	----	----
M-Pede	low	+	----	----	----	----	----	----	----	----	----
Quintec	high (13)	++++	----	----	----	----	----	----	----	----	----
Rovral/Iprodione/Nevado	low (2)	----	+++	----	----	----	++	----	----	----	----
Switch	high (7/12)	----	++++	+++	----	----	+	+++	----	----	----
Captan	very low (M4)	----	+++	+++	----	----	+	----	----	----	----
Thiram	low (M3)	----	++	++	----	----	----	----	----	----	----
Aliette/Legion ³	low (33)	----	----	----	----	----	----	----	+++	++	++
Ridomil Gold SL ⁴	high (4) ²	----	----	----	----	----	----	----	+++ ⁴	++	++

Rating: +++++ = excellent and consistent, +++ = good and reliable, ++ = moderate and variable, + = limited and/or erratic, +/- = minimal and often ineffective, ---- = ineffective, NR = not registered, and ND = no data

*Registration pending in California

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action Group number.

² To reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

³ Foliar applications provide systemic treatment.

⁴ Ridomil Gold SL is the only formulation registered. If the GR formulation is applied to a previous crop that must be removed, it has a 0-day plantback interval.

⁵ Greater than 4 applications causes severe stunting.

⁶ Nonpersistent resistant populations of *Botrytis cinerea* to fenhexamid occur with repeated use of FRAC Group 17 fungicides.

STRAWBERRY: TREATMENT TIMING

Note: Not all indicated timings may be necessary for disease control.

Disease	Preplant fumigation ²	Clean nursery stock	At Planting		Preharvest ¹	
			Dips or water washing	Before overhead irrigations	Foliar	Fruit
Anthracnose ³	+++	+++	+++	+	+	+++
Botrytis fruit rot ³	----	----	----	+	++	+++
Mucor fruit rot	----	----	----	+	+	+++
Rhizopus rot	----	----	----	----	----	+++
Angular leaf spot	+	+++	+	+++	+	----
Common leaf spot ³	+	+++	++	+++	+++	+
Powdery mildew ³	----	+++	----	----	+++	+
Leather rot ⁴	+++	----	----	++	----	++
Phytophthora crown rot ⁴	+++	+	----	++	+	----
Red steele ⁴	++	++	----	+	++	----
Verticillium wilt	+++	++	----	----	----	----

Rating: +++ = most effective, ++ = moderately effective, + = least effective, and ---- = ineffective.

¹ Preharvest treatments include applications of fungicides before heavy fog, dews, or rain.

² Preplant fumigation includes methyl bromide/chloropicrin, 1,3-dichloropropene/chloropicrin or chloropicrin followed by metam sodium or metam potassium or solitary applications of 1,3-dichloropropene/chloropicrin or chloropicrin.

³ Integrated programs required for management including rotation of fungicides of different classes.

⁴ Inseason, foliar treatments include phosphite or fosetyl-aluminum products or soil applications

WALNUT: BACTERICIDE EFFICACY

Material	Resistance risk (FRAC#) ¹	Walnut blight ²	Phytotoxicity
Actinovate	low (biological)	++	NP
Bordeaux ²	low (M1)	+++	NP
Fixed coppers ²	medium (M1)	+++	++ ³
Copper-maneb**	low (M1/M3)	++++	NP
Copper-mancozeb* ⁴	low (M1/M3)	++++	NP
Copper-maneb-surfactant (single application)**	low (M1/M3)	+	NP
Regalia	low (natural product)	++	NP
Serenade	low (44)	+	NP
Zinc-Copper Bordeaux	low (M1)	+++	NP

Rating: ++++ = excellent and consistent, +++ = good and reliable, ++ = moderate and variable, + = limited and erratic, and NP = not phytotoxic.

* **Registration pending in California (Section 18 available, see Footnote 4 below)**

****Not registered, label withdrawn or inactive**

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action Group number.

² Copper resistance occurs within sub-populations of *Xanthomonas axenopodis* pv. *juglandis*.

³ Phytotoxicity of fixed coppers can be reduced with the addition of lime or agricultural oils to the tank mixture.

⁴ Currently (2011), a Section 18 Emergency registration has been approved for mancozeb under the label Manzate Prostick 75DF or Manzate Flowable.

⁵ A single application with a surfactant is not recommended because of build up of populations on buds that may increase disease in subsequent years.

WALNUT: TREATMENT TIMING

Note: Timings listed are effective but not all may be required for disease control. Timings used will depend upon orchard history of disease and weather conditions each year.

Disease	Catkin emergence	Terminal bud break	1 week after bud break	7-10 day intervals ¹	May ²
Walnut blight ³	++	+++	+++	++ ¹	+

¹ A temperature-leaf wetness model (e.g., XanthoCast) is available for determining optimum timing of bactericide applications.

² Late spring rains are less conducive to disease provided bloom is not delayed by low chilling.

³ Male and female flowers are susceptible beginning with their emergence, depending on wetness and temperatures conducive to disease development.