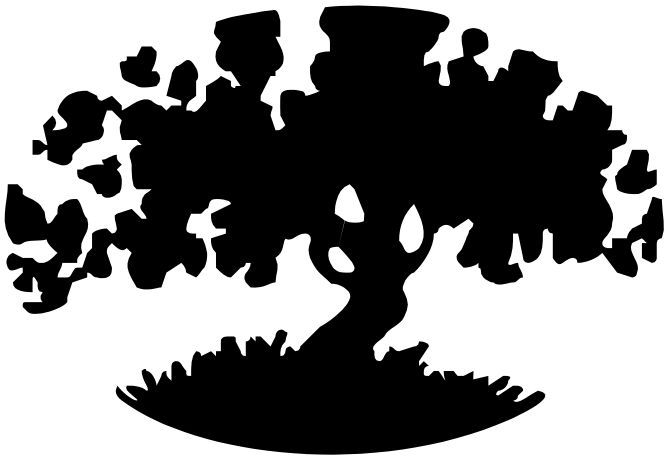
FUNGICIDES, BACTERICIDES, AND BIOLOGICALS FOR DECIDUOUS TREE FRUIT, NUT, STRAWBERRY, AND VINE CROPS 2013



ALMOND	***PEAR***
APPLE	***PISTACHIO***
APRICOT	***PLUM***
CHERRY	***POMEGRANATE***
GRAPE	***PRUNE***
KIWIFRUIT	***STRAWBERRY***
PEACH/NECTARINE	***WALNUT***

JimAdaskaveg, 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

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

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FUNGICIDES AND BACTERICIDES

fun·gi·cide ('fənjə¸sīd). n. A chemical that destroys fungi.
bac·te·ri·cide (bak-tîrə -sīd). n. A chemical that destroys bacteria.

Fungicides and bactericides prevent or mitigate damage otherwise caused by fungi and bacteria to living organisms such as people, animals, plants including agricultural crops, as well as physical structures such as buildings and plant products (e.g., wood). They are developed from natural sources or are chemically synthesized. In general, pesticides used in modern agriculture had a critical role in the development of our society by improving crop yields and reducing labor needed to produce food. This enabled society to diversify and endeavour into activities other than food production. Overall, the benefits of pesticides far outweigh the risks associated with using them, especially when they have been thoroughly evaluated and characterized.

REGULATION OF PESTICIDES

In the United States, the Environmental Protecion Agency (EPA) oversees and regulates all pesticides including fungicides and bactericides. In accordance with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), the Federal Food, Drug, and Cosmetic Act (FFDCA), and the Food Quality Protection Act (FQPA), the EPA regulates the manufacturing, transport, and use of all pesticides in the United States to protect humans and the environment from potential adverse effects that may be associated with pesticide exposure. In California and several other states, additional laws and government agencies are involved in the regulation and oversight of pesticides. Federal and state laws establish the legal authority of pesticide labels to prohibit the use of these materials that is inconsistent with the instructions and general guidelines provided on such labels.

The EPA is responsible for determining the "risk" associated with pesticides and for establishing limits or "tolerances" on the amount of pesticide residues that may remain on food marketed in the United States to meet safety standards with "reasonable certainty of no harm" to the general population. A 'safe risk' is defined as a reasonable certainty that no harm will result from exposure to a pesticide residue from all anticipated dietary or other potential sources over a human lifetime based on reliable scientific information. Thus, FQPA established an "aggregate risk" assessment to take into account pesticide exposure from all possible sources: food, drinking water, and structural sources including buildings, public facilities, and landscaping. Additionally, FQPA established the evaluation of "cumulative risk" or exposure to a pesticide within a chemical class of materials that have the same toxic effect or a common mode of action. The law also established a 10-fold safety factor to account for pre- and post-natal toxicity, as well as to ensure completeness of pesticide toxicology information to account for pesticide exposure of infants and children.

When all three components - safe, aggregate, and cumulative risks - are put together, this determines the amount of a pesticide that can be used each year in the United States or "the risk cup". Safer materials inherently have a larger cup (i.e., can be used more) while less safe materials have a smaller cup (i.e., should be used less). Some materials such as those that are derived from natural sources or are known to be generally safer than others are classified as "reduced risk". These materials generally have a lower toxicity to humans and non-target organisms, have a lower environmental impact (e.g., are non-persistent in soil or water), and/or enhance integrated pest management (IPM) practices.

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

Residue tolerances are established for all pesticides registered on agricultural commodities. For synthetic pesticides and materials that are produced by fermentation and which 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" (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 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) on each commodity that is considered an absolute minimal risk to the consumer. Generally, the MRL level is two or more 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 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 in addition to individual commodities (e.g., for stone fruit instead for peaches). These crop group MRLs are shown along with MRLs of individual commodities of the crop group. A pop-up note indicates 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 (US FIFRA Section 24C)
- Time-limited and temporary tolerances
- Emergency registration tolerances (US FIFRA Section 18)
- US import tolerances explicitly noted in the CFR
- Tolerances for indirect residues (contamination from handling, packaging, etc.)
- Tolerances explicitly noted in the CFR as lacking a current US registration

FUNGICIDE PERFORMANCE

Fungicides are registered and labeled for agricultural use only after numerous trials and years of testing and disease evaluations that demonstrate the activity of the product. In California and in some other states, efficacy data has to be submitted as part of the registration process. Most fungicides perform generally well under environmental conditions that occur in California. Still, their performance is dependent on many factors including physical and chemical properties of the fungicide, as well as the environmental and biological conditions in the agricultural system where they are used. Factors

including deposition (e.g., application methods, rates, intervals, and coverage of plant surfaces) and depletion (rate of degradation from water, sunlight, microbial enzymatic breakdown, volatilization, systemic action, plant growth, etc.) will determine the persistence of fungicides on plant surfaces and contribute to the overall performance.

The disease triangle determines the disease pressure in any agro-system. Susceptibility of plant cultivars and the conduciveness of environmental conditions before, during, and after fungicide application will affect disease development and ultimately, the performance of the fungicide. Furthermore, the sensitivity of the pathogen to the fungicide may change or "shift" with usage over time through adaptation or genetic resistance and thus, this greatly influences the success or failure of any fungicide product used under field conditions.

In this document, we rated the performance of synthetics, natural products, and biologicals for managing major diseases caused by fungi and bacteria of temperate tree crops, grapevines, and strawberries that are major fruit and nut crops in California. The ratings are based on direct experience from research trials evaluating the performance of the tested products under field conditions. Environmental conditions may greatly influence the performance of the materials. Thus, the performance ratings are relative in comparison to other products and may change as experience is gained in using the individual products. Attributes or deficiencies of a product are noted where information is available. For example, the resistance potential (presence of resistant pathogen populations in California) and persistence or degradation rate is cited for individual products when this information is known. Most materials are labeled for the management of the diseases for which ratings are presented. However, some products have been tested but are not labeled for managing a specific disease. Always consult the product label to ensure that the fungicide is currently registered for a specific use.

FUNGICIDES AND THEIR EFFECTS ON NON-TARGET ORGANISMS, ESPECIALLY HONEY BEES

Fungicides are currently the "state of the art" tool in the management of flower, foliar, and fruit diseases of many crops worldwide, especially when cultivars with natural host resistance are not available. 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., dicarboximides, benzimidazoles, and DMIs with unique modes of action have been used for over 60, 40, and 30 years, respectively. Many of 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. One may argue that developing host resistance is the best approach; however, this is very difficult in perennial tree and vine crops and requires many years. Furthermore, crop characteristics selected by the breeder to meet consumer demands often result in higher disease susceptibility of the crop.

In registration processes, 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 sometimes at 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 are 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, as well as apicultural practices that place bee hives next to highways with high traffic.

In the last few years many new insecticides were 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 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 fungicides applied during flowering of fruit and nut crops. This information was adapted from Mussen and Brandi, 2010 (http://www.extension.org/mediawiki/files/7/77/UCapiariesNovDec_2010.pdf), Mussen (U.C. Apiaries Newsletter– Jan/Feb 2012), and combined with current fungicide use strategies.

Use of fungicides during flowering of agricultural commodities

1) Choose fungicides 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.
2) Most fungicides are formulated with adjuvants including wetting agents, spreaders, and stickers. Unless a registrant specifically indicates on the product label that an adjuvant should be added, most fungicide products do not need additional adjuvants mixed into the sprayer tank to improve performance. With few exceptions, adjuvants do not statisitically improve the efficacy of fungicides for managing diseases of fruit and nut commodities. Although there is limited information on the interaction of adjuvants and fungicides with honey bees, it is best to follow a conservative approach. Because adjuvants may increase the wettability of bees and subsequently the potential toxicity of fungicides, adjuvants should not be used in fungicide applications during bloom or when there is high honey bee activity in the field.
3) 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.

4) 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.
5) Apply fungicides in the evening or at night or when temperatures are less than 13°C (55°F).
6) 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.
7) Follow UC guidelines on fungicide resistance management to limit honey bee exposure to any one fungicide product by following the "RULES" (*see* Fungicide Resistance).

FUNGICIDE RESISTANCE

Fungicide resistance is a relative term that describes the reduction in sensitivity to a fungicide in a fungal population beyond natural variation. The natural variation of a fungal pathogen population is described as the baseline sensitivity. Baseline sensitivities are derived from a sample of pathogen individuals that were never exposed to the fungicide. Generally, a normal distribution of variation occurs that may be skewed based on the pathogen and type of chemistry or selection pressure. Resistance is an inheritable genetic trait that is distinguished from adaptation where the same individual reverts back to sensitivity to the fungicide after some period of absence of exposure. Field-resistance (practical resistance) is the reduction in sensitivity in the pathogen that is accompanied by crop losses.

Resistance frequency is the relative incidence of a less sensitive variant within a population of individuals that has the ability to survive under the selection pressure of a fungicide. Variants arise from genetic mutations that are continuously and spontaneously occurring within populations of organisms. Some mutations are detrimental, whereas others may allow survival of inidivisuals under a specific stress such as the presence of a toxicant (i.e, fungicide). Resistance frequencies are generally very low numbers (e.g. 1 in millions) and as such, resistance is a rare event. Still, fungi are able to reproduce in great numbers. Thus, although fungicides may eliminate most of the population, a few survivers can replace the sensitive population in a relatively short time. Once resistance is selected, then the resistance factor or the magnitude of resistance can be calculated as compared to the baseline sensitivity level.

Fungicide resistance can be further characterized into two types: qualitative and quantitative. Qualitative resistance (monogenic resistance) is when an abrupt change in a sensitive fungal population occurs that results in a distinct sub-population that is resistant to the fungicide at field use rates. The benzimidazoles typically show this type of resistance. Different levels of resistance (i.e., resistance factors) can still occur in individuals reflecting different mutations in the target β-tubulin gene. These changes result in substituions of different amino acids and subsequent different binding potential of the fungicide to the β-tubulin molecule. Quantitative resistance (polygenic resistance) is when mutations of several genes each contribute to the development of resistance. Fungal populations respond to the fungicide selection pressure in a continuous shift from sensitive to resistant to highly resistant populations. This is because these mutations can be additive, resulting in an increased resistance factor. This results in decreased efficacy over time. The DMI fungicides typically show this type of resistance. Both types of resistance, qualitative and quanitative can occur in a single fungal species responding to fungicides with different modes of action. *Monilinia fructicola* and *Podosphaera* (*Uncinula*) *necator* show qualitative resistance to the benzimidazole and quanitative resistance to the DMI fungicides.

Kendall and Holloman (1998) stated that "Unlike insecticide resistance, with fungicides cross-resistance patterns generally follow modes-of-action, presumably reflecting target site alterations rather than uptake and detoxification changes." Thus, the most effective way to combat fungicide resistance is to mix or alternate fungicides with different modes of action (classes of fungicides) and, if possible, at least one rotational mix partner should be a multi-site material. For this reason, the Fungicide Resistance Action Committee (FRAC) has promoted a number system that is used to group fungicides within the same chemical class and with the same mode of action. This system simplifies resistance management practices to rotating fungicide usage between FRAC group numbers.

Factors determining the risk of fungicide resistance development in a pathogen population include: 1) fungicide chemistry; 2) fungal species; and 3) the interaction of the pathogen and the fungicide in the disease triangle. Specific components of these factors can be outlined as follows for a pathogen causing disease on a susceptible host:

Factors determining the risk of fungicide resistance development

1) *Fungicide*
   - Single-site vs. multi-site mode of action compounds.
   - Selection pressure: number of applications or the exposure frequency.
   - Selection pressure: rate effect may be involved with certain types of fungicide, resistance such as quantitative resistance as opposed to qualitative resistance.
2) *Pathogen*
   - Inherent resistance frequency in the population (e.g., 10^{-4}, 10^{-6}, etc.)
   - Comparative fitness of sensitive and resistant strains (survival attributes of the resistant population)
     a) Pathogenicity and virulence
     b) Propagation and survival
   - Low efficacy, competition, and slow dispersal *may* help reduce but not prevent the development of resistance.
3) *Conclusion*: Resistance development is a complex process and has to be determined for each Pathogen-Fungicide combination in the disease triangle.

The "recipe for resistance development" follows a general procedure in the lab: expose large numbers of propagules of the pathogen, expose the same population repeatedly to the same mode of action, and use low concentrations of the fungicides that may favor quanitative-types of resistance development. In the field, a parallel situation may occur:

1) Highly susceptible varieties under favorable environmental conditions generally support high populations of primary or secondary inoculum of the pathogen.
   a. Improper timing of fungicide application in respect to host stage, environmental conditions, or both.
   b. Application of fungicide after an epidemic occurs (high populations of the pathogen)
2) Improper fungicide rate is applied. Off-label rates are used or occur due to alternate row applications. These may be improperly timed because environmental conditions prevent 3- day re-application intervals. This results in pathogen populations that are repeatedly exposed to low fungicide concentrations. This allows for survivors and resistance.
3) Repeated use of the same fungicide mode of action (Using one FRAC group repeatly in a growing season).

UC guidelines on fungicide resistance management can be described as following the "RULES" -

a. ***R***otate between different fungicide modes of action as indicated by the FRAC number on each fungicide product (e.g., FRAC 7 should not be followed by FRAC 7; instead use FRAC 7, then follow with FRAC 3 or FRAC 3/11, FRAC 3/9, and FRAC 7/11).
b. ***U***se labeled rates – Fungicide labels often provide a range of rates: use the upper range for high disease pressure and the lower range for low disease pressure.
c. ***L***imit the total use of any single-site mode of action fungicide to ideally one or two per growing season.
d. ***E***ducate yourself about the mode of action, spectrum of activity, recommended rates, and the performance of a fungicide against various diseases. This information is found later in this document.
e. ***S***tart a fungicide spray program with a multi-site mode of action fungicide, pre-mixture, or tank mixture to reduce the total fungal population that is exposed to any single-site mode of action fungicide used later in a sequence of fungicide applications. NOTE: Never use a single-site mode of action fungicide or a pre-mixture when high levels of disease already occur. The possibility of selecting fungicide resistant individuals is more likely to occur when high populations of a pathogen are being exposed to the selection pressure.

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 (U12)	Yes	Unknown (Single-site?)	Medium
thiabendazole	Alumni/TBZ	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 Super	DMI[5]-triazole (3)	Yes?	Single-site	High
fenarimol	Rubigan/Vintage	DMI-pyrimidine (3)	Yes?	Single-site	High
fenbuconazole	Indar (Enable)	DMI-triazole (3)	Yes?	Single-site	High
flutriafol	Rhyme*	DMI-triazole (3)	Yes?	Single-site	High
metconazole	Quash	DMI-triazole (3)	Yes?	Single-site	High
myclobutanil	Rally**	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
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
quinoxyfen	Quintec	Quinoline (13)	No	Single-site	Medium
dichloran	Botran/	Aromatic hydrocarbon (14)	Slight	Single-site	Medium
fenhexamid	Elevate/Judge	Hydroxyanilide (17)	No	Single-site	High[4]
polyoxin-D	Ph-D/ OSO, Tavano (Endorse)	chitin synthesis inhibitor (19)	No?	Single-site	Medium
potassium phosphite, phosphorous acid	Fungi-Phite, Prophyt	Phosphorous acid and salts (33)	Yes	Unknown (Multi-site?)	Low
polyphosphite	K-Phite	Polyphosphite (33)	Yes	Unknown	Low
fosetyl-Al	Aliette/Legion**	Ethyl phosphonates (33)			
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?

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

Multiple active ingredients (Premixtures)	Trade name	Class (FRAC number) [1]	Systemic action	Mode of action	Resistance potential
captan/ fenhexamid	CaptEvate	Phthalamide (M4)/ hydroxyanilde (17)	No	Multi-site/Single-site	Low
tebuconazole/ trifloxystrobin	Adament	DMI-triazole (3)/QoI (11)	Yes?	Single-site Single-site	Medium
difenoconazole/ cyprodinil	Inspire Super	DMI-triazole (3)/ AP (9)	Yes?	Single-site/ Single-site	Medium
fluopyram/tebuconazole	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
fluopyram/ pyrimethanil	Luna Tranquility	SDHI (7)/QoI (11)	Yes?	Single-site/ Single-site	High
pyraclostrobin / boscalid	Pristine	SDHI (7)/QoI (11)	Yes?	Single-site / Single-site	High
pyraclostrobin / fluxopyroxad	Merivon**	SDHI (7)/QoI (11)	Yes?	Single-site / Single-site	High
penthiopyrad / picoxystrobin	Q8Y78**	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, Salts, 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
Actigard*	acibenzolar-S-methyl	SAR	Yes	Host resistance	Unknown
Actinovate AG	*Streptomyces lydicus* WYEC 108	biological	No	Various	Low
AgriMycin/FireWall/ Ag Streptomycin	streptomycin	antibiotic	Yes	Protein Synthesis(25)	High
Apogee	prohexadione calcium	plant growth regulator	Yes	PGR-inhibitor	Low
Armicarb, Kaligreen, Milstop	potassium bicarbonate	inorganic salt	No	Various	Low
Kasumin*	kasugamycin	antibiotic	Yes	Protein Synthesis(24)	High
Mycoshield/FireLine/ (FlameOut**)	oxytetracycline	antibiotic	Yes	Protein Synthesis(41)	High
AQ-10**	*Ampelomyces quisqualis*	biological	No	Various	Low
Arabesque*[1]	*Muscodor albus*	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	*Pseudomonas fluorescens* A506	biological	No	Various	Low
BloomtimeBiological FD	*Pantoea agglomerans* E/325	biological	No	Various	Low
Blossom Protect	*Aureobasidium pullulans* DSM14940/14941 (Used with Buffer Protect)	biological	No	Various	Low
Botector*	*Aureobasidium pullulans*	biological	No	Various	Low
Botry-Zen**	*Ulocladium oudemansii*	biological	No	Various	Low
Cinnacure	cinnamaldehyde	natural product	No	Various	Low
Citrox BC**	blend of fruit acids, flavonoids, chelators, & wetting agents	plant extract	No	Various	Low
Double Nickel LC*	*Bacillus amyloliquefaciens* D747	biological	No	Various	Low
Elexa**	glucosamine protein	SAR[2]-protein	Yes	Host resistance	Unknown
JMS Stylet oil	mineral oil	oil	No	Various	Low
KeyPlex 350 OR	yeast extract	SAR[2]-protein	Yes	Host resistance	Unknown
Messenger**	harpin	SAR[2]-protein	Yes	Host resistance	Unknown
M-Pede	potassium salts	inorganic salt	No	Various	Low
Omni Supreme	low range oil	oil	No	Various	Low
OxiDate/StorOx/ Perasan	hydrogen dioxide in acetic acid (peroxyacetic acid)	oxidizer	No	Oxidation	Very low
Plant Shield	*Trichoderma harzianum*	biological	No	Various	Low
Prev-am	sodium tetraborohydrate	inorganic salt	No	Various	Low
ProAlexin**	plant host defense activator	plant extract	Yes	Bioflavonoid stimulator	Low
Problad Plus**, Fracture*	plant product	natural product	Yes	Various	Low
Purespray	low range oil	oil	No	Various	Low
Quiponin*	*Quillaja saponaria*	natural product	No	Various	Low
Regalia	*Reynoutria sachalinensis*	natural product	No	Various	Low

Trade name	Active Ingredient	Class	Systemic action	Mode of action (FRAC number)[1]	Resistance potential
Saf-T-Side*	petroleum oil	oil	No	Various	Low
Serenade	*Bacillus subtilis*	microbial	No	Various	Low
Sonata	*Bacillus pumilis*	microbial	No	Various	Low
Sporatec	natural oil blend	oil	No	Various	Low
Sporan	plant oils (clove, rosemary, thyme)	natural product	No	Various	Low
Timorex*	natural oil	oil	No	Various	Low
Trilogy	neem oil	oil	No	Various	Low
Valero**	cinnamaldehyde	natural product	No	Various	Low
VigorCal*	calcium metalosate	inorganic salt	No	Various	Low
VigorK*	potassium metalosate	inorganic salt	No	Various	Low
Vitaseal*	essential oils	oil	No	Various	Low

*** Registration pending in California**

***[1] Registration inactive 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

DISEASE AND PATHOGEN NAMES

Disease	Pathogen(s)	Host(s)
Alternaria late blight	*Alternaria alternata, A. arborescens, A. tenuissima*[1]	Pistachio
Alternaria leaf spot	*Alternaria alternata, A. arborescens, A. tenuissima*[1]	Almond
Angular leaf spot	*Xanthomonas fragariae* (bacterium)	Strawberry
Anthracnose	*Colletotrichum acutatum*	Almond, peach, strawberry
Anthracnose	*Marssonia leptostyla*	Walnut
Band canker	*Botryosphaeria dothidea* (*Fusicoccum* sp.)[2]	Almond
Botrytis decay	*Botrytis cinera*	Strawberry, stone and pome fruit, kiwifruit, pomegranate, strawberry
Black foot	*Cylindrocarpon destructans/C. liriodendron*	Grapevine
Black root rot complex	*Cylindrocarpon destructans, Pythium ultimum, Rhizoctonia* spp.	Strawberry
Bot canker	*Botryosphaeria* spp.	Grapevine, pomegranate
Botryosphaeria panicle and shoot blight	*Botryosphaeria dothidea* (*Fusicoccum* sp. and *Neofusicoccum* sp.)[2]	Pistachio, walnut
Botrytis blossom blight	*Botrytis cinerea*	Cherry
Botrytis blossom and shoot blight	*Botrytis cinerea*	Pistachio
Botrytis fruit rot	*Botrytis cinerea*	Kiwifruit
Brown rot	*Monilinia fructicola, M. laxa*	Almond and other stone fruits
Brown spot	*Cladosporium cladosporioides*	Grape fruit rot
Bunch rot	*Botrytis cinerea*	Grapevine
Cankers (Eutypa, Cytospora, and Calosphaeria cankers)	*Eutypa lata, Leucostroma persoonii, Calosphaeria pulchella*	Cherry
Common leaf spot	*Ramularia tulasnii*	Strawberry
Crown rot	*Phytophthora* spp.	Strawberry
Downy mildew	*Plasmopora viticola*	Grapevine
Esca (Black measles)	*Togninia* spp. (*Phaeoacremonium* spp.), *Phaeomoniella chlamydospora*	Grapevine
Eutypa dieback	*Eutypa lata*	Apricot, grapevine, cherry, almond, apple, blueberry
Fire blight	*Erwinia amylovora* (bacterium)	Pome fruit (apple, pear, quince, etc.)
Gray mold	*Botrytis cinerea*	Strawberry, stone and pome fruit, kiwifruit, pomegranate
Internal (Heart) fruit rot	*Aspergillus niger* or *Alternaria* sp.	Pomegranate

(Continued next page)

Disease	Pathogen(s)	Host(s)
Jacket rot/Green fruit rot	*Botrytis cinerea, Monilinia laxa Monilinia fructicola*, *Sclerotinia sclerotiorum*	All stone fruits
Leaf blight	*Seimatosporium lichenicola*	Almond
Leaf spot	*Blumeriella jaapii*	Cherry
Leaf curl	*Taphrina deformans*	Peach, nectarine
Leather rot	*Phytophthora cactorum*	Strawberry
Mucor rot	*Mucor piriformis* and other species	Pome and stone fruit; strawberry
Phomopsis blight	*Phomopsis* sp.	Pistachio
Phomopsis cane and leafspot/canker	*Phomopsis viticola, Phomopsis spp.*	Grapevine
Phomopsis fruit rot and dieback	*Phomopsis amygdali*	Almond
Powdery mildew	*Erysiphe* (=*Uncinula*) *necator* *Podosphaera leucotricha* *Podosphaera clandestina* *Podosphaera tridactyla* *Podosphaera (=Sphaerotheca) macularis* *Podosphaera (=Sphaerotheca) pannosa*	Grapevine Almond, Apple, peach, nectarine Cherry Apricot, cherry, plum, prune, peach Strawberry Apricot, peach, nectarine, plum
Red steele	*Phytophthora fragariae*	Strawberry
Rhizopus rot	*Rhizopus* spp.	Strawberry
Root rot	*Phytophthora* spp.	Pome and stone fruit crops including almond; pistachio, grapevine, strawberry, and walnut
Russet scab	Abiotic (rain during bloom)	Prune
Rust	*Tranzschelia discolor*	Almond, nectarine, peach, prune, plum
Scab	*Fusicladium carpophilum* (*Cladosporium carpophilum*)	Almond, nectarine, peach
Scab	*Venturia inaequalis*	Apple
Scab	*Venturia pirina*	Pear
Sclerotinia blight	*Sclerotinia sclerotiorum*	Almond, apricot, nectarine, peach, prune, pistachio
Shot hole	*Wilsonomyces carpophilus*	Almond, apricot, peach, nectarine
Silver leaf	*Chondrostereum purpureum*	Pome and stone fruit, including almond
Summer rot (sour rot of grape)	*Aspergillus carbonarius, A. niger, Alternaria tenuis, Botrytis cinerea, Cladosporium herbarum, Rhizopus arrhizus, Penicillium* sp., and others	Grapevine
Walnut blight	*Xanthomonas arboricola* pv. *juglandis* (bacterium)	Walnut

[1] These species are members of the *Alternaria alternata* complex (*A. tenuissima, A. arboricola, A. alternata*) 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*.

FUNGICIDES LISTED BY CHEMICAL CLASS: BACTERICIDES/BIOLOGICALS

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	Oxytetracycline, terramycin	AgroSource, Inc./Advan LLC	systemic
FlameOut**	Oxytetracycline, 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	*Streptomyces lydicus*	Natural Industries, Inc.	contact
AQ10**	*Ampelomyces quisqualis*	Ecogen Inc.	contact
Arabesque**	*Muscodor albus*	AgraQuest Inc.	contact
BlightBan	*Pseudomonas fluorescens*A506	J.R. Simplot/Plant Health Tech.	contact
Bloomtime Biological FD	*Pantoea agglomerans* E/325	Northwest Ag Prod.	contact
Blossom Protect	*Aureobasidium pullulans* DSM14940/14941 (Used with Buffer Protect)	Westbridge Ltd.	contact
Botector*	*Aureobasidium pullulans*	Westbridge Ltd.	contact
Botry-Zen**	*Ulocladium oudemansii*	BotryZen Ltd.	contact
Double Nickel LC	*Bacillus amyloliquefaciens* D747	Certis USA, L.L.C.	contact
Plantshield	*Trichoderma harzianum*	CircleOne Organics	contact
Serenade	*Bacillus subtilis*	AgraQuest Inc.	contact
Sonata	*Bacillus pumilis*	AgraQuest Inc.	contact

***Registration pending in California**
****Not registered, label withdrawn, or inactive**
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
Armicarb	sodium bicarbonate	Helena Chemical Co.	contact
B-Lock**	boric acid and latex paint	Nutrient Technologies	contact
Cinnacure	Cinnamaldehyde	Pro-Guard, Inc	contact
Citrox BC**	Plant extract	Citrox Limited	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
ProAlexin**	plant extract	Citrox Limited	systemic
Prev-am	sodium tetraborohydrate	ORO Agri. Inc.	contact
Problad Plus** (Fracture*)	plant extract	FMC	contact
Purespray	mineral oil	PetroCanada	contact
Quiponin*	*Quillaja saponaria*	Nor-Natur	contact
Regalia	*Reynoutria sachalinensis*	Marrone Bio Innovations	contact
Saf-T-Side*	petroleum oil	Brandt Consolidated, Inc.	contact
Sporan	plant oils	EcoSMART Technologies	contact
Sporatec	natural oil blend	Brandt Consolidated, Inc.	contact
Timorex*	natural oil	Biomor	contact
Trilogy	neem oil	Certis USA	contact
VigorCal*[1]	calcium metalosate	Agro-K	contact
VigorK*	potassium metalosate	Agro-K	contact
Vitaseal*	essential oils	Emerson	contact

***Registration pending in California**
**** Not registered, label withdrawn or inactive in California**
[1] fertilizer
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 = **FRAC[1] Group M1; sulfur = FRAC[1] 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) STIMULATORS

Trade name	Common name	Company	Activity
Actigard*	acibenzolar-S-methyl	Syngenta Crop Protection	systemic
Apogee	prohexadione calcium	BASF	systemic
KeyPlex 350 OR	yeast extract	Morse Enterprises	systemic
Messenger**	harpin	Eden Bioscience	systemic
ProAlexin**	plant host defense activator	Citrox Limited	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 – FRAC Group (FG)
(*Single Active Ingredients*)

ANILINOPYRIMIDINES (AP) (FG 9)

Trade name	Common name	Company	Activity
Penbotec[1]	pyrimethanil	Janssen Pharmaceutica (Dist. by Cerexagri, Pace International, JBT, etc.)	slightly systemic (on most crops)
Scala	pyrimethanil	Bayer CropScience	slightly systemic (on most crops)
Vangard	cyprodinil	Syngenta Crop Protection	slightly systemic (on most crops)

[1]Postharvest use only
Mode of action: FRAC[1] Group 9; single-site, methionine biosynthesis inhibitor (protein disruption); 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 (FG 14)

Trade name	Common name	Company	Activity
Botran	dicloran	Gowan	systemic (local)
Allisan**[1]	dicloran	Gowan	systemic (local)

****Not registered, label withdrawn or inactive**
[1]Postharvest use only
Mode of action: FRAC[1] Group 14; mechanism unclear, but lipid peroxidation (disruption of membrane integrity) was proposed.
Resistance risk: medium
Growth effects: interrupt mycelial growth
Sporulation: little effect

METHYL BENZIMIDAZOLE CARBAMATES (MBC) (FG 1)

Trade name	Common name	Company	Activity
Alumni[1]	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)

[1]Postharvest use only

Mode of action: FRAC[1] Group 1; single-site inhibitors that interfere with with β-tubulin assembly and mitosis (nuclear division disruption)
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

BENZAMIDES (FG 43)

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

Mode of action: FRAC[1] Group 43; delocalization of cellular spectrin-like proteins resulting in disruption of cell division.
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

DITHIOCARBAMATES AND RELATIVES (FG M3)
CARBAMATES

Trade name	Common name	Company	Activity
Ethylene bisdithiocarbamates (EBDC)			
Dithane (coordinated product)	mancozeb	Dow AgroSciences	contact
Manzate (coordinated product)	mancozeb	DuPont	contact
Penncozeb (coordinated product)	mancozeb	UPI	contact
Dimethyl dithiocarbamates (DMDC)			
Thiram	thiram	Taminco	contact
Ziram	ziram	UPI	contact

****Not registered, label withdrawn or inactive**
Mode of action: FRAC[1] 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 (FG 40)

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

Mode of action: FRAC[1] Group 40; interferes with cellulose synthase and 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 (FG M5)

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: FRAC[1] 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) (FG 3)

Trade name	Common name	Sub-class	Company	Activity
Bayleton*	triadimefon	Triazole	Taminco	systemic (local)
Bumper	propiconazole	Triazole	Makteshim Agan of North America, Inc.	systemic (local)
Elite	tebuconazole	Triazole	Bayer CropScience	systemic (local)
Indar (Enable)	fenbuconazole	Triazole	Dow AgroSciences	systemic (local)
Inspire Super	difenoconazole	Triazole	Syngenta Crop Protection	systemic (local)
Mentor[1]	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**	myclobutanil	Triazole	Dow AgroSciences	systemic (local)
Rubigan/Vintage	fenarimol	Pyrimidine	Gowan Co.	systemic (local)
Tebuzol[2]	tebuconazole	Triazole	UPI	systemic (local)
Tilt	propiconazole	Triazole	Syngenta Crop Protection	systemic (local)
Rhyme*	flutriafol	Triazole	Cheminova Inc.	systemic (local)

***Registration pending in California**

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

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

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

Mode of action: FRAC[1] 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 (FG 2)

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

Mode of action: FRAC[1] Group 2; osmotic signal transduction (MAP / histidine kinase (os-1, Daf1)

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

HYDROXYANILIDES (FG 17)

Trade name	Common name	Company	Activity
Elevate	fenhexamid	Arysta LifeScience	contact
Judge	fenhexamid	Pace International	contact
Protexio*	fenpyrazamine	Valent USA	systemic (local)

***Registration pending in California**
****Not registered, label withdrawn or inactive**
Mode of action: FRAC[1] 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 (FG 4)

Trade name	Common name	Company	Activity
Ultra Flourish	mefenoxam	Nu Farm Chemical	contact, systemic
Ridomil Gold	mefenoxam	Syngenta Crop Protection	contact, systemic

***Registration pending in California**
****Not registered, label withdrawn or inactive**
Mode of action: FRAC[1] Group 4; interferes with activity of a nuclear RNA polymerase.I
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[1]	fludioxonil	Syngenta Crop Protection	contact (except cherry-systemic)

[1]**Postharvest use only**
Mode of action: FRAC[1] Group 12; single-site; interferes with regulatory enzymes of oxidation and osmotic signal transduction (MAP / histidine kinase (os-2, HOG-1)).
Resistance risk: high
Growth effects: inhibits mycelial growth and germination
Sporulation: reduces

PHOSPHONATES (FG 33)

Trade name	Common name	Company	Activity
Aliette	fosetyl-aluminum	Bayer CropScience	systemic
Fungi-Phite	potassium phosphite	Plant Protectants, LLC	systemic
K-Phite	polyphosphite	Plant Food Systems, Inc.	systemic
Phostrol	fosetyl-aluminum	NuFarm Chemical	systemic
ProPhyt	potassium phosphite	Helena Chemical Company	systemic

***Registration pending in California**
****Not registered, label withdrawn or inactive**
Resistance risk: low
Growth effects: may inhibit phosphorus deficiency signaling in the plant.
Sporulation: suppresses sporulation of *Phytophthora* spp.
Note: K-phite is reported to be active against fungal and bacterial diseases (e.g., *Xanthomonas* spp,) has higher rates registered than other phosphonates, and is compatible with copper.

PHTHALIMIDES (FG M4)

Trade name	Common name	Company	Activity
Captan	captan	various	contact

Mode of action: FRAC[1] Group M4; multi-site inhibitor that complexes with enzymes probably inhibiting respiration.
Resistance risk: low
Growth effects: inhibits spore germination
Sporulation: no effect

POLYOXINS (FG 19)

Trade name	Common name	Company	Activity
Oso, Tavano	polyoxin-D	Certis	contact
Ph-D	polyoxin-D	Arysta LifeScience	contact

Mode of action: FRAC[1] Group 19; single-site inhibitor of chitin synthase (disruption of cell wall biosynthesis).
Resistance risk: medium
Growth effects: inhibits spore germination and mycelial growth.
Sporulation: no effect

QUINOLINES (FG 13)

Trade name	Common name	Company	Activity
Quintec	quinoxyfen	Dow AgroSciences	contact

Mode of action: FRAC[1] Group 13; probably single-site inhibitor; disrupts early cell signaling events (signal transduction).
Resistance risk: medium
Growth effects: suppresses spore germination, early germ tube development and/or appressorium formation
Sporulation: no effect

STROBILURINS (QoIs) (FG 11)

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
YT669*	picoxystrobin	DuPont	contact and systemic

***Registration pending in California**
[2]**Gem registered on stone fruit and tree nuts; Flint registered on pome fruit and grape.**
Mode of action: FRAC[1] Group 11; single-site; blocks respiration by interfering with cytochrome bc1 (ubiquinol oxidase) at Qo site.
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
Sporulation: no effect

SUCCINATE DEHYDROGENASE INHIBITORS (SDHIs) (FG 7)

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: FRAC[1] Group 7; single-site; blocks respiration by interfering with complex II (succinate dehydrogenase). Several sub-groups have different activity and resistance potential. Examples include: pyridine-carboxamides (boscalid), pyrazole-4-carboxamides (penthiopyrad, fluxapyroxad, isopyrazam), and pyridinyl-ethyl benzamides (fluopyram).
Resistance risk: high
Growth effects: reduced mycelial growth
Sporulation: unknown

Unknown modes of action

BENZOPHENONE (FG U8)

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

Mode of action: FRAC[1] Group U8); 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

PHENYL-ACETAMIDES (FG U6)

Trade name	Common name	Company	Activity
Torino	cyflufenamid	Gowan	contact

Mode of action: FRAC[1] Group U6; unknown mechanism.

GUANIDINES (FG U12)

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

Mode of action: FRAC[1] Group U12; membranes disruption.
Resistance risk: high

MULTIPLE ACTIVE INGREDIENTS IN PRE-MIXTURES

DMI/SDHI (FG 3/7)

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

***Registration pending in California**

Mode of action: FRAC[1] 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) (FG 3/11)

Trade name	Common name	Company	Activity
Quadris Top	difenoconazole/azoxystrobin	Syngenta Crop Protection	systemic (local)
Quilt Xcel	propiconazole/azoxystrobin	Syngenta Crop Protection	systemic (local)

Mode of action: FRAC[1] 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) (FG 3/9)

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

Mode of action: FRAC[1] 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) (FG 7/11)

Trade name	Common name	Company	Activity
Merivon*	fluxapyroxad/pyraclostrobin	BASF	contact and systemic
Luna Sensation	fluopyram/trifloxystrobin	Bayer CropScience	contact and systemic
Pristine	boscalid/pyraclostrobin	BASF	contact and systemic
Q8Y78*	Penthiopyrad/picoxystrobin	DuPont	contact and systemic

***Registration pending in California**

Mode of action: FRAC[1] Groups 7 and 11; Succinate dehydrogenase inhibitors possibly multi-site; whereas QoIs are single-site. The QoIs (pyraclostrobin, trifloxystrobin, picoxystrobin) block respiration by interfering with cytochrome b; SDHI fungicides inhibit succinate dehydrogenase (boscalid, fluopyram, penthiopyrad, fluxopyroxad).

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/PHENYLPYRROLE (9/12)

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

Mode of action: FRAC[1] 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 (FG 1 and 12)

Trade name	Common name	Company	Activity
Scholar MP**[1]	TBZ/fludioxonil	Syngenta Crop Protection	contact/slightly systemic

[1]**Postharvest use only**
Mode of action: FRAC[1] 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	Anthrac -nose	Shot hole	Scab[3]	Rust[3]	Leaf blight	Alternaria leaf spot [3]	PM-like[5]	Hull rot[16]
Bumper/Tilt[4]	high (3)	++++	+/-	++++	++	++	+++	ND	++	+++	++
Indar	high (3)	++++	+/-	+++	++	++	NL	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	+++	+++	+++
Merivon*	medium (7/11)[3,7]	++++	++++	++++	++++	++++	+++	ND	++++	++++	+++
Quash[4]	high (3)	++++	++	++++	+++	+++	++++	ND	++++	+++	+++
Luna Experience	medium (3/7)[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]	----	++	----
Vangard	high (9)[3, 7]	++++	++++	ND	++	----	ND	ND	+[9]	----	----
Fontelis	high (7)[4]	++++	++++	++	++++	+++	+++	ND	+++	ND	----
Abound[4]	high (11)[3, 7]	+++	----	++++	+++	++++	++++	+++	+++[10]	+++	+++
Elevate	high (17)[7]	+++	++++	----	+	ND	ND	ND	ND	ND	----
Protexio*	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/Chloro-thalonil/Echo /Equus[11,12]	low (M5)	++	NL	+++	+++	+++[15]	++++	NL	NL	----	----
Captan[4,12]	low (M4)	++	++	+++	+++	++	----	+++[6]	+	----	----
CaptEvate**	low (M4/17)	+++	+++	+++	+++	+++	----	+++	+	----	----
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	----	----
Copper + oil[14]	low (M1)	ND	ND	----	+	+++[15]	----	----	ND	----	----
Lime sulfur[12]	low (M2)	+/-	NL	----	+/-	++[15]	++	NL	NL	----	----
Sulfur[4,12]	low (M2)	+/-	+/-	----	----	++	++	----	----	+++	----
PlantShield***[17]	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 for silver leaf disease of almond.

[1] Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (fo r 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.

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[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,
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. Recent information suggests an *Acremonium* species is involved.
[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] Oils recommended include "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 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. (Chlorothalonil can be applied with dormant oil during tree dormancy).
[16] Hull rot ratings are for the disease caused by *Rhizopus stolonifer*. Ratings for the disease caused by *Monilinia* spp. will be provided in the future.
[17] Active ingredient, *Trichoderma harzianum* Rifai strain KRL-AG2, provides control of Silver leaf disease.

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	----	----	+++	----	----	----	----	----
Hull rot[7]	—	—	—	—	—	—	—	+++
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.
[7] Make application at 1-5% hull split to manage hull rot caused by *Rhizopus stolonifer*.

ALMOND: SUGGESTED DISEASE MANAGEMENT PROGRAMS BY FUNGICIDE FRAC[1] 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 the 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, 7, 3/9, 3/7, 3/11, 7/11 11 19	3, 7, 3/7, 3/9, 3/11, 7/11 11, 19
Anthracnose	----	3, 7, 3/7, 3/9, 3/11	3, 7, 3/7, 3/9, 3/11 7/11 11	3, 3/9, 3/7, 3/11 11 M3 M4	3, 7, 3/9, 3/11, 3/7 7/11 11 M3 M4	3, 7, 3/7, 3/9, 3/11 7/11 11 M3 M4	3, 7, 3/7, 3/9, 3/11 7/11 11 M3 M4	3, 7, 3/7, 3/9, 3/11 7/11 11 M3 M4
Brown Rot	----	1[2] 2 (+Oil) 3, 3/7, 3/9, 3/11 9	1[2] 2 (+Oil) 3, 7, 3/9, 3/11, 9 3/7, 7/11 11	1[2] 2 (+Oil) 7, 9, 3/11 7/11	----	----	----	----
Green Fruit Rot	----	----	1[2] 2 (+Oil) 3/7, 3/9, 7, 9 3/11, 7/11	----	----	----	----	----
Leaf Blight	----	----	1[2] 2 3, 3/7, 3/9, 3/11 11	1[2] 2 3, 3/7, 3/9, 3/11 11 M3 M4	3, 3/7, 3/9, 3/11 11 M3 M4	----	----	----
Scab[4]	M1+Oil, M2[3]	----	----	1[2], 3/7, 3/9, 7, 7/11[2] 3/11, 11[2] M3 M4, M5	1[2], 3/7, 3/9, 7, 7/11[2] 3/11, 11[2] M3 M4, M5	3, 3/7, 3/9, 3/11 7, 7/11[2], 3/11, 11[2] M2[3] M3, M4	M2[3] M4	----
Shot Hole	M1	2 3, 3/7, 3/9, 3/11, 7, 9, 11	2 3, 3/7, 3/9, 3/11 7, 7/11 9, 11	2 3, 3/7, 3/9, 3/11 7, 7/11 9 11	7, 7/11 11 M3 M4 M5	7, 7/11 11 M3 M4 M5	----	----

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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, 7, 3/7, 3/11 7/11 11, 19 M3	3, 7, 3/7, 3/11 7/11 11, 19	3, 7, 3/7, 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	
Bayleton**	high (3)	----	----	+++
Inspire Super	medium (3/9)	++++	++++	++++
Flint[2]	high (11)[3]	++++	++++	++++
Fontelis	high (7)	++++	++	+++
Luna Sensation[5]	Medium (7/11)	++++	++	++++
Pristine	medium (7/11)	++++	----	+++
Procure[4]	high (3)	++++	++++	++++
Rally[5]	high (3)	++++	++	++++
Rubigan/Vintage[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]	+++	+++	+++
Vangard	high (9)[3]	+++	+++	+++
Ph-D	medium (19)	+	+	+++
Captan[6]	low (M4)	+++	----	----
Dithane/Manzate/ Penncozeb[6]	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	Growth Regulator/SAR
		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)	++	----	----	----
Kasumin*	high	++++	++++	+/-	----
BlightBan	low	++	----	+/-	
Bloomtime Bio	low	+++	----	+/-	----
Blossom Protect	low	+++	----	+/-	----
Actigard*	low	----	----	----	+?[11]
Apogee	low	----	----	----	++[11]

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.

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[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 might be necessary for disease control.

Disease	Fall	Delayed dormant	Green tip /White bud	Pink bud	Petal Fall/ Cover Sprays
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				
Bumper/Tilt	high (3)	++++	++++	----	+++	+/-	+++
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]	++++	++++	+++	+++	++++	----
Luna Experience*	medium (3/7)	++++	++++	+	+++	+++	----
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]	++++	++++	++++	+++	----	++++
Vangard[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/Chlorotha-lonil/Echo/Equus[9,10]	low (M5)	++	++	++	----	+++	----
Captan[10,11]	low (M4)	++	----[11]	++	----	+++	----
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] Blossom	Brown rot [2] Fruit	Botrytis Blossom/ Fruit	Jacket rot/ Green fruit rot	Powdery mildew [2]	Eutypa
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)	++++	++++	++	++	+++	----
Luna Experience*	medium (3/7)	++++	++++	+++	+++	++++	----
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/Vintage	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)	+/-	----	----	----	+++	----
Vitiseal	low (?)	----	----	----	----	----	++++
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

[1] Select broad-spectrum fungicides (or combinations) that have activity against both brown rot and Botrytis fruit rots.
[2] Begin at popcorn and repeat every 10 to 14 days through bloom if rains continue.
[3] Use 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 FRAC[1] 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, 7/11 17	----	(3)[4] 3+17 7/11 17
Brown rot blossom blight/Fruit rot	----	----	1[3] 2 (+oil) 3, 7 3/11	1[3] 3, 7 3+17 3/11 7/11 17	----	----	3, 7 3/11 7/11 17
Powdery mildew	M2[2]	M2[2]	2 (+oil), 3	1[3] 3,7 3/11 7/11 13	7, 7,11, 13 M2[2] NP/BC[5]	3, 7, 3/11 11, 7/11 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/ 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		*Phomopsis* cane and leaf spot	Eutypa dieback	Bot Canker	Dead Arm (*Phomopsis* sp.)
				Botrytis	Summer				
Abound	high (11)[2]	++++	++++	+	----	+++	NR	----	----
Flint[3]	high (11)[2]	++++	+++	++	++	++	NR	----	----
Elite/Orius/Tebuzol	high (3)	++++	----	++	++	----	NR	----	----
Quadris Top	high (3/11)	++++	+	++	++	++	NR	----	----
Inspire Super	medium (3/9)	++++	----	++++	++	----	NR	----	----
Luna Experience	medium (3/7)	++++	----	++++	++	----	NR	----	----
Luna Tranquility	medium (7/9)	++++	----	++++	++	----	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/Vintage	high (3)	++++	----	----	----	----	NR	----	----
Sovran	high (11)[2]	++++	++++	++	++	++++	----	----	----
Sulfur	low (M2)	++++	----	----	----	----	NR	----	----
Rhyme*	high (3)	++++	----	----	----	----	NR	----	----
Topsin-M/T-Methyl/Incognito	high (1)[2]	++++	----	++	++	+	++++	----	----
Torino	high (U6)	++++	----	----	----	----	----	----	----
Vivando	high (U8)	++++	----	----	----	----	----	----	----
Bayleton**	high (3)	++	----	----	----	----	NR	----	----
Copper	low (M1)	++	+++	++	+++	+	----	----	----
Elevate	high (17)[2]	++	----	++++	++	----	NR	----	----
Protexio**	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)	++	----	++++	+++	----	----	----	----
Vangard	high (9)[2]	++	----	++++	++	----	NR	----	----
Captan	low (M4)	----	+	+++	+++	+++	NR	----	----
CaptEvate**	low (M4/17)	----	+	+++	+++	+	----	----	----
Dithane/Manzate/Penncozeb	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		Phomopsis cane and leaf spot	Eutypa dieback	Bot Cankerer	Dead Arm
				Botrytis	Summer				
Armicarb	low	+++	----	----	----	----	----	----	----
B-Lock**	low	----	---	----	-----	-----	++++	++	NR
Cinnacure	low	+++	----	----	----	----	----	----	----
Elexa**	low	+++	----	----	----	----	----	----	----
JMS Stylet oil4	low	+++	----	+++	++	----	NR	----	----
Kaligreen	low	+++	----	----	----	----	----	----	----
Milstop	low	+++	----	----	----	----	----	----	----
Regalia	low	+++	-----	----	----	----	-----	----	----
Serenade	low (44)	+++	----	++	+	----	----	----	----
Sonata	low	+++	----	++	NR	----	----	----	----
Purespray	low	+++	----	----	----	----	----	----	----
Actinovate	low	++	-----	----	----	----	-----	----	----
HiPeak*	low	++	----	----	-----	-----	-----	----	----
Messenger**	low	++	----	----	----	----	----	----	----
Sporan	low	++	----	----	----	----	----	----	----
Timorex*[4]	low	++	----	----	----	----	----	----	----
VigorCal*[6]	low	++	----	----	----	----	----	----	----
VigorK*	low	++	----	----	----	----	----	----	----
Sporatec	low	+	----	----	----	----	----	----	----
Vitiseal	low	----	----	----	----	----	++++	----	----

*** Registration pending in California**

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

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.

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

[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).

[6] Fertilizer

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 (Bot canker)	+++	----	----	----	----	----
Botrytis Bunch Rot	+++[2]	----	+++[1]	+++[1]	+++[1]	+++[1]
Brown spot	----	----	----	+++	+++	+++
Dead arm	+++	+++	----	----	----	----
Downy mildew	----	+++	+++	----	----	----
Esca (Black measles)	+++[2]	----	----	----	----	----
Eutypa Dieback	+++	----	----	----	----	----
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).
[5] Preharvest treatments for postharvest decay control.

GRAPEVINES: SUGGESTED DISEASE MANAGEMENT PROGRAMS BY FUNGICIDE FRAC[1] 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
Vangard[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] Vangard 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] 14 day	7 day	1 day	Postharvest
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] Blossom	Brown rot[2] Fruit	Powdery mildew[2]	Scab	Rust	Leaf curl	Shot hole
Bumper/Tilt	high (3)	++++	++++	+++	++	+++	----	+/-
Elite/Orius/Tebuzol	high (3)	++++	++++	+++	++	+++	----	+
Indar	high (3)	++++	++++	+++	++	ND	----	+/-
Inspire Super	high (3/9)	++++	++++	+++	++	ND	----	+/-
Quash	high (3)	++++	++++	+++	ND	+++	----	+++[10,11]
Pristine	medium (7/11)[4]	++++	++++	+++	+++	ND	ND	++++[10,11]
Luna Sensation*	medium (7/11)[4]	++++	++++	+++	+++	----	ND	++++[10,11]
Luna Experience*	medium (3/7)	++++	++++	+++	----	+++	----	+/-
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]	++++	++++	+++	+++	+	----	----
Vangard[7]	high (9)[3,4]	++++	+++[7]	ND	ND	ND	----	+
Fontelis	high (7)[4]	++++	+++	++++	+++	ND	----	+++[10,11]
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)	++	++	----	+++	----	----	+++[10,11]
Gem	high (11)[4]	++	+	++	++++	+++	----	++
Quintec	high (13)	----	----	++++	----	----	----	----
Syllit	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 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 FRAC[1] 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] 2 (+oil) 3 3/11 9 9/11	1[3] 2 (+oil) 3[4] 3/11 7/11 9 9/11 17	3 3/11 7/11 9/11 17	3 3/11 7/11 9/11 17	3[4] 3/11 7/11 9/11 17
Powdery mildew	----/M2[2]	1[3] 2+oil 3	1[3] 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 7/11 11 M2[2]	3 7/11 11 M2[2]	----
Scab	----	1[3] 3 3/11 7/11 9/11 M3 M4 M7	1[3] 3 3/11 7/11 9/11 M4 M5 M7	1[3] 3 3/11 7/11 9/11 11 M2[2] M4, M7	----	----
Shot hole	M1 M3 M5 M7	2 M3 M4 M5 M7	2 7/11 M3 M4 M5	7/11 11 M4	----	----

[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] 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 peach/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/nectarine 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
Abound	high (11) [2,3]	+++	----	+++
Adament**	medium (3/11)[3]	++	+++	++
Bravo/Chlorothalonil/(Echo)	low (M5)	++	----	++
Bumper/Tilt	high (3)	++	+	++[5]
Cabrio	high (11) [2,3]	+++	----	+++
Inspire Super	medium (3/9)	++	+++	+++(+)
Elevate	high (17)[3]	ND	++++	ND
Fontelis	high (7)	++++	+++	+++(+)
Gem	high (11) [2,3]	+++	----	+++
Quash	high (3)	++++	+++(+)	+++[5]
Luna Experience	medium (3/7)	++++	++++	++++
Luna Sensation	medium (7/11)[3]	++++[4]	++++	++++
Merivon***	high (7/11)	++++	++++	++++
Pristine	high (7/11)[3]	++++[4]	++++	++++
Ph-D (Polyoxin-D)	medium (19)	+++	++++	+++
Quadris Top	medium (3/11)[3]	+++	----	+++(+)
Quilt Xcel	medium (3/11)[3]	++++	----	+++(+)
Regalia	low (natural product)	++	----	++[9]
Scala	high (9)[3]	++	+++	+++[6]
Switch	high (9/12)[3]	+++	+++	++
Tebuzol	high (3)	+++	+	+++[5]
Topsin-M/T-Methyl/ Incognito[7]	high (1)	----	++	++
Vangard	high (9)[3]	+++	++++	----
Copper	low (M1)	+	----	----
K-Phite	low (33)	ND	ND	++(+)[9]
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.**

***** Federal and California registration pending.**

[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.

[9] Tested only under low disease pressure.

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]	+++[6]	+++[6]	+++	+++	+?
Botrytis	----	+++	+[7]	----	----	----

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, Luna Sensation, Merivon*), and make no more than two applications of a strobilurin or strobilurin-containing fungicide per season.
[5] Liquid lime sulfur: some efficacy in some trials, whereas no efficacy in other trials.
[6] Early season sprays timed before and/or after rains are effective timings in April and May.
[7] Protect young clusters if rain and cool weather occurs.
* Registration pending.

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		
Bumper/Tilt	high (3)	++++	++++	+++	ND
Elite[6]/Tebuzol[6****]	high (3)	++++	++++[6]	+++	ND
Indar	high (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
Luna Experience*	medium (3/7)[5]	++++	++++	+++	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] Oil = "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	medium (3/11)	++++	++++	----	+++
Bumper/Tilt[2]	high (3)	++++	++++	----	+++
Distinguish**	medium (9/11)	++++	++	----	++
Elite/Tebuzol[2,7]	high (3)	++++	++++	----	+++
Indar[2]	high (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)	++++	++++	----	+++
Luna Experience*	medium (3/7)[4]	++++	++++	ND	++++
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]	++++	++++	----	----
Vangard[6]	high (9)[3,4]	++++	+++[6]	----	ND
Fontelis	high (3)	++++	+++	----	+++
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 loose 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	Anthrac-nose	Angular leaf spot	Common leaf spot	Mucor rot	Rhizopus rot	Leather rot	Crown rot	Red steele
Copper	low (M1)	----	----	----	+++[5]	----	----	----	----	----	----
Sulfur	low (M2)	+++	----	----	----	----	----	----	----	----	----
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]	+++	+++	----	----	++	----	----	----	----	----
Abound	medium (11)[2]	+++	++	++	----	----	ND	ND	ND	ND	ND
Pristine	medium (7/11)[2]	+++	++++	ND	----	----	ND	ND	ND	ND	ND
Ph-D*, Tavano	medium (19)	+++	++	++	ND	ND	----	----	----	----	----
Fontelis	high (7)	+++	++++	ND	ND	ND	ND	ND	ND	ND	ND
Cinnacure	low	+	----	----	----	----	----	----	----	----	----
Elevate	high (17)[2,6]	+/-	++++[6]	+++	----	----	----	----	----	----	----
Protexio*	high (17)[2,6]	+/-	++++[6]	+++	----	----	----	----	----	----	----
M-Pede	low	+	----	----	----	----	----	----	----	----	----
Quintec	high (13)	++++	----	----	----	----	----	----	----	----	----
Rovral/Iprodione/Nevado	low (2)	----	+++	----	----	----	++	----	----	----	----
Switch	high (9/12)	----	++++	+++	----	----	+	+++	----	----	----
Captan	very low (M4)	----	+++	+++	----	----	+	----	----	----	----
Thiram	low (M3)	----	++	++	----	----	----	----	----	----	----
Aliette+Phosgard[3, 7]	low (33)	----	----	----	----	----	----	----	+++	++	++
Fungi-Phite, K-Phite, Prophyt	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**

** Plant dip or foliar spray.[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.

[7] A fertilizer, can be tank mixed with some 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] In-season foliar treatments include phosphite or fosetyl-aluminum products or soil applications

WALNUT: BACTERICIDE AND FUNGICIDE EFFICACY

Material	Resistance risk (FRAC#)[1]	Walnut blight[2]	Phytotoxicity	Anthracnose	Botryosphaeria blight***
Actinovate	low (biological)	++	NP	----	----
Bordeaux[2]	low (M1)	+++	NP	----	----
Fixed coppers[2]	medium (M1)	+++	++[3]	----	----
Fontelis	high (7)	----	----	ND	----
Copper-mancozeb*[4]	low (M1/M3)	++++	NP	----	----
Copper-mancozeb–surfactant[5]	low (M1/M3)	+	NP	----	----
Kasumin*	High (24)	+++	NP	----	----
Kasumin-copper*	low (24/M1)	++++	NP	----	----
Kasumin-mancozeb*	low (24/M3)	++++	NP	----	-----
K-Phite	Low (33)	+?	+	ND	----
Luna Experience	medium (3/7)	----	NP	++++	----
Luna Sensation	medium (7/11)	----	NP	ND	----
Pristine	medium (7/11)	----	NP	++++	----
Quadris Top	medium (3/11)	----	NP	ND	----
Quash	high (3)	----	NP	ND	----
Quilt Xcel	medium (3/11)	----	NP	++++	----
Regalia	low (natural product)	++	NP	ND	----
Regalia-Copper	low (natural product)	++	NP	----	----
Serenade	low (44)	+	NP	ND	----
Zinc-Copper Bordeaux	low (M1)	+++	NP	----	

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

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

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

*****Research is ongoing to determine the most efficacious materials and the optimum timing of treatments for management of Botryosphaeria blight of walnut. Thus, no ratings are provided at this time. For general guidelines for management of this disease, see the "Pistachio Efficacy Table".**

[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 arboricola* pv. *juglandis*.

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

[4] Currently (2011-2013), a Section 18 Emergency registration has been approved for mancozeb under the label Manzate Prostick 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.