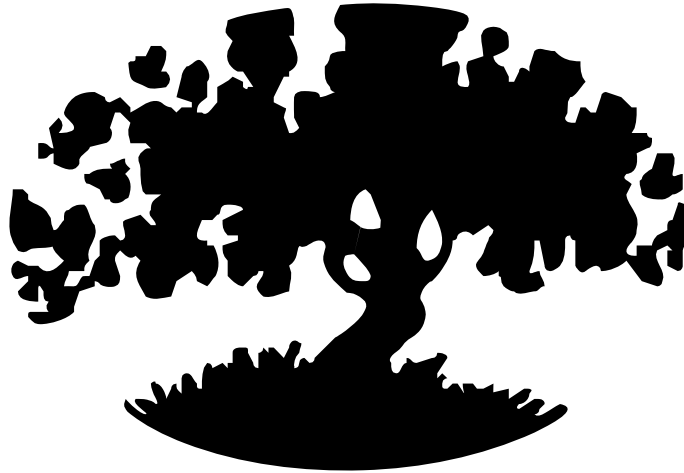


**EFFICACY AND TIMING OF FUNGICIDES,
BACTERICIDES, AND BIOLOGICALS
FOR
DECIDUOUS TREE FRUIT, NUT CROPS,
AND GRAPEVINES
2006**

(updated 7-10-06)



*ALMOND
APPLE AND PEAR
APRICOT
CHERRY
GRAPE*

*PEACH
PISTACHIO
PLUM
PRUNE
WALNUT*

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General Properties and Efficacy of Registered and Experimental Fungicides Used on Deciduous Tree Fruit and Nut Crops and Grapevines in California

Trade name	Fungicide	Class	Systemic action	Mode of action (FRAC number) ¹	Resistance potential
various	copper	Inorganic	No	Multi-site (M1)	Low
various	sulfur	Inorganic	No	Multi-site (M2)	Low
Maneb	maneb	Carbamate (EBDC) ^a	No	Multi-site (M3)	Low
Manex	Maneb	Carbamate (EBDC) ^a	No	Multi-site (M3)	Low
Thiram	thiram	Carbamate (DMDC) ^b	No	Multi-site (M3)	Low
Ziram	ziram	Carbamate (DMDC) ^b	No	Multi-site (M3)	Low
Rovral	iprodione	Dicarboximide	Yes	Multi-site (2)	Low
Penbotec ^c	pyrimethanil	Anilinopyrimidine	Yes	Single-site (9)	High
Scala	pyrimethanil	Anilinopyrimidine	Yes	Single-site (9)	High
Vanguard	cyprodinil	Anilinopyrimidine	Yes	Single-site (9)	High
Botran	dichloran	Aromatic hydrocarbon	Slight	Single-site (14)	High
Allisan ^c	dichloran	Aromatic hydrocarbon	Slight	Single-site (14)	High
Bravo	chlorothalonil	Aromatic nitrile	No	Multi-site (M5)	Low
Echo	chlorothalonil	Aromatic nitrile	No	Multi-site (M5)	Low
Benlate**	benomyl	Benzimidazole	Yes	Single-site (1)	Very high
Topsin-M	thiophanate-methyl	Benzimidazole	Yes	Single-site (1)	Very high
Endura*	boscalid	Carboxyanilide	Yes?	Multi-site (7)	Low
Syllit***	dodine	Guanidine	Yes	Few - multi-site (M7)	Medium
Elevate	fenhexamid	Hydroxyanilide	No	Single-site (17)	High
Judge ^c	fenhexamid	Hydroxyanilide	No	Single-site (17)	High
Captan	captan	Phthalamide	No	Multi-site (M4)	Low
Quintec	quinoxifen	Quinoline	No	Single-site (13)	Medium
Scholar ^c	fludioxonil	Phenylpyrrole	Contact	Few - multi-site (12)	Low
Bayleton	triadimefon	DMI ^d -Triazole	Yes?	Single-site (3)	High
Elite	tebuconazole	DMI-Triazole	Yes?	Single-site (3)	High
Eminent*	tetraconazole	DMI-Triazole	Yes?	Single-site (3)	High
Funginex**	triforine	DMI-Piperazine	Yes?	Single-site (3)	High
Indar	fenbuconazole	DMI-Triazole	Yes?	Single-site (3)	High
Orbit	propiconazole	DMI-Triazole	Yes?	Single-site (3)	High
Bumper*	propiconazole	DMI-Triazole	Yes?	Single-site (3)	High
Mentor ^c	propiconazole	DMI-Triazole	Yes?	Single-site (3)	High
Procure	triflumizole	DMI-Imidazole	Yes?	Single-site (3)	High
Rally/Laredo	myclobutanil	DMI-Triazole	Yes?	Single-site (3)	High
Rubigan	fenarimol	DMI-Pyrimidine	Yes?	Single-site (3)	High
Score*	difconazole	DMI-Trizole	Yes?	Single-site (3)	High
Abound	azoxystrobin	Strobilurin	Yes?	Single-site (11)	High
Cabrio	pyraclostrobin	Strobilurin	Yes?	Single-site (11)	High
Evito*	fluoxastrobin	Strobilurin	Yes?	Single-site (11)	high
Flint/Gem	trifloxystrobin	Strobilurin	Yes?	Single-site (11)	High
Sovran	kresoxim-methyl	Strobilurin	Yes?	Single-site (11)	High
Pristine	pyraclostrobin + boscalid	Strobilurin + Carboxyanilide	Yes? Yes?	Single-site (11) Multi-site (7)	Medium Low
Switch	fludioxonil + cyprodinil	Phenylpyrrole + Anilinopyrimidine	Contact Yes	Single-site (12) Single-site (9)	Medium High

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions. Fungicides with a c resistance management program. For more information, see <http://www.frac.info/>.

* Experimental; registration pending

** Label withdrawn

*** Registered on pears in California

^a EBDC = ethylene bisdithiocarbamate

^b DMDC = dimethyl dithiocarbamate

^c Postharvest use only

^d DMI = demethylation (sterol) inhibitor

? = not confirmed on stone fruit and nut crops using radioactive labeled compounds

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

Trade name	Treatment	Class	Systemic action	Mode of action	Resistance potential
Agrimycin	streptomycin	antibiotic	Yes	Protein Synthesis	High
Kasumin* ^a	kasugamycin	antibiotic	Yes	Protein Synthesis	High
Mycoshield	terramycin	antibiotic	Yes	Protein Synthesis	High
AQ-10**	<i>Ampelomyces quisqualis</i>	biological	No	Various	Low
Arabesque* ^b	<i>Muscodor albus</i>	biological	No	Various	
BlightBan	<i>Pseudomonas fluorescens</i> A506	biological	No	Various	Low
BloomtimeBiologicalFD	<i>Pantoea agglomerans</i> E/325	biological	No	Various	Low
Plant Shield****	<i>Trichoderma harzianum</i>	biological	No	Various	Low
Serenade	<i>Bacillus subtilis</i>	biological	No	Various	Low
Sonata	<i>Bacillus pumilis</i>	biological	No	Various	Low
Messenger	harpin	SAR - Protein***	Yes	Host resistance	Unknown
JMS Stylet oil	low range oil	oil	No	Various	Low
Omni Supreme	low range oil	oil	No	Various	Low
Timorex	natural oil	oil	No	Various	Low
Armicarb	sodium bicarbonate	inorganic salt	No	Various	Low
Kaligreen	sodium bicarbonate	inorganic salt	No	Various	Low
Prev-am	sodium tetraborohydrate	inorganic salt	No	Various	Low
VigorCal	calcium metalosate	inorganic salt	No	Various	Low
VigorK	potassium metalosate	inorganic salt	No	Various	Low
Cinnacure	cinnamaldehyde	natural product	No	Various	Low
Quiponin****	<i>Quillaja saponaria</i>	natural product	No	Various	Low

*Experimental; registration pending

**Label withdrawn

***SAR – Systemic acquired resistance induced in host.

****Not registered in California

^a – Import tolerance established September, 2005

^b – Postharvest use.

EFFICACY: TREE CROPS

Fungicide	Brown rot	Jacket rot (Botrytis)	Shot hole	Powdery mildew	Rust	Scab		Anthracnose	Alternaria
						Almond	Apple/pear		
CONVENTIONAL FUNGICIDES									
Abound ^a	++	----	+++	++	+++	++++	+++	++++	+++
Benlate ^b	+++ ^c	+++	----	+++	++	+++	+++	----	----
Botran	++	+++	ND	NR	NR	NR	NR	NR	NR
Bravo/Echo	++	++	+++	----	++	+++	NR	++++	++
Cabrio ^e	++	----	NR	++	NR	NR	NR	NR	NR
Captan	++	++	+++	----	+	+++	++	++	----
Elevate/Judge	+++	++++	+	+	ND	ND	ND	ND	ND
Elite	++++	++	+/-	+++	+++	NR	NR	+++	++
Eminent ^e	++	----	ND	ND	ND	ND	ND	+	ND
Evito ^e	++	----	ND	ND	ND	ND	ND	ND	ND
Flint/Gem	++	----	+++	++	ID	++++	++++	++++	+++
Funginex ^c	+++	----	----	++	+	----	+++	ND	ND
Indar	+++	----	+	ND	ND	+++	----	+	----
Laredo	+++	----	++	++++	++	----	NR	++	----
Maneb	+	+	++	----	+++	++	++	++	+
Manex	+	+	++	----	+++	++	++	++	+
Orbit (Bumper)	+++	----	+/-	+++	+++	NR	NR	+++	----
Penbotec ^f	+++ ^{hi}	++++	++	ND	ND	ND	ND	ND	++
Pristine	++++	+++	++++	+++	ND ^d	++++	ND	+++	+++
Procure	++	----	+/-	+++	ND	ND	++++	ND	ND
Quintec ^e	----	----	----	++++	----	----	----	----	----
Rally	++	----	+/-	++++	++	----	++++	++	----
Rovral	+++	+++	+++	----	----	----	NR	----	+++
Rovral + oil	++++	++++	+++	+	++	----	NR	----	+++
Rubigan	+++	----	----	++++	++	NR	++++	ND	ND
Sovran ^e	ND	ND	ND	+++	++	ND	+++	ND	ND
Scala ⁱ	+++ ^{hi}	++++	++	ND	ND	ND	ND	ND	++
Scholar ^f	++++	++++	----	----	----	----	----	----	----
Score ^e	+++	----	+/-	+++	+++	NR	NR	+++	+++
Switch ^e	ND	+++	ND	ND	ND	ND	ND	ND	+++
Thiram	+	+	ND	----	----	NR	++	ND	ND
Topsin-M	+++ ^g	+++	----	+++	++	+++	+++	----	----
Vanguard ⁱ	++++ ^h	++++	++	ND	ND	----	+++	ND	++
Ziram	+	+	+++	----	----	+++	++	+++	+

BIOLOGICALS, NATURAL COMPOUNDS, SARs

Copper	+	+	++	----	----	----	----	----	+
Quillya	----	----	----	++	ND	ND	ND	ND	ND
Serenade	----	+	----	++	ND	ND	ND	ND	ND
Sulfur	+	+	----	+++	+++	++	++	+	----

Rating: ++++ = excellent; +++ = very good; ++ = good; + = fair; +/- = minimal or often ineffective; - = ineffective; NR = not registered; ND = no data

^a Causes severe phytotoxicity on some apple cultivars.

^b Label withdrawn.

^c No active label for tree or vine crops.

- ^d Strobilurin fungicides generally have very good to excellent efficacy against rust diseases
- ^e Registration pending (Eminent and Score). Cabrio and Quintec are registered only on cherry, Switch is only registered on pistachio, and Sovran only on pome fruit crops.
- ^f Postharvest use only.
- ^g Resistant populations of target organisms occur in California.
- ^h High summer temperatures and relative humidity reduce efficacy.
- ⁱ Phytotoxicity to leaves reported on cherry; not registered for this crop.

EFFICACY: GRAPEVINES

Fungicide	Powdery	Downy	Bunch rot		Phomopsis	Eutypa
	mildew	mildew	Botrytis	Summer		
CONVENTIONAL FUNGICIDES						
Abound	++++	++++	+	----	+++	----
Bayleton	++	----	----	----	----	----
Captan	----	+	+++	+++	+++	----
Elevate	++	----	++++	+++	----	----
Elite	++++	----	++	++	----	----
Flint/Gem ^a	++++	+++	++	++	++	----
JMS Stylet Oil ^b	++++	----	+++	++	----	----
Maneb	----	----	++	----	+++	----
Pristine	++++	++++	++++	+++	+++	----
Procure	++++	----	----	----	----	----
Quintec	++++	----	----	----	----	----
Rally	++++	----	----	----	----	----
Ridomil Gold	----	++++	----	----	----	----
Rovral	----	----	++++	----	----	----
Rovral + oil	+++	----	++++	----	----	----
Rubigan	++++	----	----	----	----	----
Scala	++	----	++++	++	----	----
Sovran	++++	++++	++	++	++++	----
Vanguard	++	----	++++	++	----	----
Ziram	----	----	++	----	++	----
BIOLOGICALS, NATURAL COMPOUNDS, SARs						
AQ10 ^c	++	----	----	----	----	----
Armicarb	+++	----	----	----	----	----
Copper	++	+++	++	+++	+	----
Cinnacure	+++	----	----	----	----	----
Kaligreen	+++	----	----	----	----	----
Messenger	+++	----	----	----	----	----
Prev-am ^d	++	----	----	----	----	----
Serenade	+++	----	++	+	----	----
Sonata	+++	----	NR	NR	----	----
Sulfur	++++	----	----	----	----	----
Timorex	++	----	----	----	----	----
VigorCal	++	----	----	----	----	----
VigorK	++	----	----	----	----	----

Rating: +++++ = excellent; ++++ = very good; ++ = good; + = fair; +/- = slight; ---- = ineffective, and NR = not recommended.

^a Causes severe phytotoxicity on Concord grapevines.

^b Phytotoxic if used within 2 weeks of captan or sulfur.

^c Label withdrawn.

^d Not registered in California.

DISEASE AND PATHOGEN NAMES

Disease	Pathogen(s)	Host(s)
Alternaria late blight	<i>Alternaria alternata</i> complex	Pistachio
Alternaria leaf spot	<i>Alternaria alternata</i> complex	Almond
Anthraco nose	<i>Colletotrichum acutatum</i>	Almond, peach
Black Foot	<i>Cylindrocarpon destructans</i>	Grapevine
Black Measles (Esca)	<i>Pheoacremonium aleophilum</i>	Grapevine
Botryosphaeria panicle and shoot blight	<i>Botryosphaeria dothidea</i> (<i>Fusicoccum</i> sp.)	Pistachio
Botrytis blossom and shoot blight	<i>Botrytis cinerea</i>	Pistachio
Brown rot	<i>Monilinia fructicola</i>	Stone fruits
Brown rot	<i>Monilinia laxa</i>	Almond, apricot, prune
Bunch rot	<i>Botrytis cinerea</i>	Grapevine
Downy mildew	<i>Plasmopora viticola</i>	Grapevine
Eutypa dieback	<i>Eutypa lata</i>	Apricot, Grapevine
Fire blight	<i>Erwinia amylovora</i> (bacterium)	Pome fruit (apple, pear, quince, etc.)
Jacket rot	<i>Botrytis cinerea</i> <i>Monilinia laxa</i> <i>Monilinia fructicola</i> <i>Sclerotinia sclerotiorum</i>	All stone fruits
Leaf blight	<i>Seimatosporium lichenicola</i>	Almond
Leaf spot	<i>Blumeriella jaapii</i>	Cherry
Leaf curl	<i>Taphrina deformans</i>	Peach, nectarine
Phomopsis dieback	<i>Phomopsis viticola</i>	Grapevine
Phomopsis blight	<i>Phomopsis</i> sp.	Pistachio
Phomopsis fruit rot	<i>Phomopsis amygdali</i>	Almond
Powdery mildew	<i>Podosphaera leucotricha</i> <i>Podosphaera clandestina</i> <i>Podosphaera tridactyla</i> <i>Sphaerotheca pannosa</i> <i>Erysiphe</i> (= <i>Uncinula</i>) <i>necator</i>	Apple, peach, nectarine Cherry Apricot, plum, prune, peach Apricot, peach, nectarine, plum Grapevine
Russet scab	Abiotic (rain during bloom)	Prune
Rust	<i>Tranzschelia discolor</i>	Almond, nectarine, peach, prune, plum
Scab	<i>Cladosporium carpophilum</i>	Almond, nectarine, peach
Scab	<i>Venturia inaequalis</i>	Apple
Scab	<i>Venturia pirina</i>	Pear
Sclerotinia blight	<i>Sclerotinia sclerotiorum</i>	Almond, apricot, nectarine, peach, prune, pistachio
Shot hole	<i>Wilsonomyces carpophilus</i>	Almond, apricot, peach, nectarine

Walnut blight	<i>Xanthomonas juglandis</i> (bacterium)	Walnut
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MISCELLANEOUS FUNGICIDES

ANTIBIOTICS

Trade name	Common name	Company	Activity
Agri-Mycin	Streptomycin	NuFarm	systemic
Agricultural Streptomycin	Streptomycin	FarmSaver	systemic
Kasumin	Kasugamycin	Arysta	systemic
Mycoshield	Terramycin	NuFarm	systemic

Mode of action: Both are protein synthesis inhibitors

Resistance risk: High

Growth effects: Inhibits protein production and growth.

BIOLOGICALS

Trade name	Common name	Company	Activity
AQ10*	<i>Ampelomyces quisqualis</i>	Ecogen Inc.	contact
Arabesque***	<i>Muscodor albus</i>	AgraQuest Inc.	contact
BlightBan	<i>Pseudomonas fluorescens</i> A506	J.R. Simplot/Plant Health Tech.	contact
BloomtimeBiologicalFD**	<i>Pantoea agglomerans</i> E/325	Northwest Ag Prod.	contact
Plant Shield***	<i>Trichoderma harzianum</i>	Circle One Organics	contact
Quiponin***	<i>Quillaja saponaria</i>	Nor-Natur	contact
Serenade	<i>Bacillus subtilis</i>	AgraQuest Inc.	contact
Sonata**	<i>Bacillus pumilis</i>	AgraQuest Inc.	contact

* label withdrawn

**label pending

***not registered in California

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

Trade name	Common name	Company	Activity
Armicarb	sodium bicarbonate	Helena Chemical	contact
Cinnacure	cinnamaldehyde	ProGuard Inc	contact
JMS Stylet Oil	low range oil	JMS Flower Farms	contact
Kaligreen	sodium bicarbonate	Toagosei	contact
Omni Supreme	low range oil	Helena Chemical	contact
Prev-am	sodium tetraborohyrate	ORO Agri. Inc.	contact
Purespray	low range oil	PetroCanada	contact
Timorex	natural oil	Biomor	contact
Trilogy	neem oil	Certis USA	contact
VigorCal	calcium metalosate	Agro-K	contact
VigorK	potassium metalosate	Agro-K	contact

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 inactivates numerous enzyme systems
 Sulfur inhibits respiration

Resistance risk: Low

Growth effects: Inhibits spore germination: Sulfur also inhibits mycelial growth of powdery mildews

Sporulation: No effect

SAR*

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

*Systemic Acquired Resistance

Mode of action: host resistance

Resistance risk: unknown

Growth effects:

SYNTHETIC FUNGICIDES

ANILINOPYRIMIDINE

Trade name	Common name	Company	Activity
Scala	pyrimethanil	Bayer CropScience	not systemic
Vanguard (see also Switch)	cyprodinil	Syngenta	not systemic (on most crops)

Mode of action: FRAC¹ Group 9; single-site, methionine inhibitor; has “kick-back” activity against apple and pear scab and stone fruit fungi.

Resistance risk: high

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

Sporulation: no effect

ANILINOPYRIMIDINE AND PHENYLPYRROLE

Trade name	Common name	Company	Activity
Switch	fludioxonil/cyprodinil	Syngenta	contact

Mode of action: FRAC¹ Groups 12 and 9; single-site, interferes with respiration (fludioxonil); methionine inhibitor (cyprodinil).

Resistance risk: high

Growth effects: inhibits mycelial growth and germination

Sporulation: reduces

AROMATIC HYDROCARBON

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

Mode of action: FRAC¹ Group 14; mechanism unclear.

Resistance risk: high

Growth effects: interrupts mycelial growth

Sporulation: little effect

BENZIMIDAZOLE

Trade name	Common name	Company	Activity
Benlate*	benomyl	DuPont	systemic (local)
Mertect	thiabendazole (TBZ)	Syngenta	systemic (local)
Topsin-M	thiophanate-methyl	Cerexagri	systemic (local)

***label withdrawn**

Mode of action: FRAC¹ Group 1; single-site inhibitors that interfere with nuclear division.

Resistance risk: high; levels of resistant populations do not decline in absence of fungicide use

Growth effects: inhibits mycelial growth

Sporulation: inhibits

CARBAMATE

Trade name	Common name	Company	Activity
Ethylene bisdithiocarbamates (EBDC)			
Dithane	mancozeb	Dow Agrosiences	contact
Maneb	maneb	Cerexagri	contact
Manex	maneb	DuPont	contact
Dimethyl dithiocarbamates (DMDC) ²			
Thiram	thiram	Taminco	contact
Ziram	ziram	Cerexagri	contact

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

Resistance risk: very low

Growth effects: inhibit spore germination

Sporulation: no effect

² Ferbam, a DMDC, is not registered in California

CARBOXYANILIDE

Trade name	Common name	Company	Activity
Endura	boscalid	BASF	unknown

(see also Pristine)

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

Resistance risk: low

Growth effects: reduced mycelial growth

Sporulation: unknown

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

Trade name	Common name	Sub-class	Company	Activity
Bayleton	triadimefon	Triazole	Taminco	systemic (local)
Elite	tebuconazole	Triazole	Bayer CropScience	systemic (local)
Eminent*	tetraconazole	Triazole	Sipcam Agro USA	systemic (local)
Indar	fenbuconazole	Triazole	Dow Agrosciences	systemic (local)
Orbit	propiconazole	Triazole	Syngenta	systemic (local)
Bumper*	propiconazole	Triazole	Makhteshim-Agan	systemic (local)
Procure	triflumizole	Imidazole	Uniroyal	systemic (local)
Rally (Laredo)	myclobutanil	Triazole	Dow Agrosciences	systemic (local)
Rubigan	fenarimol	Pyrimidine	Dow Agrosciences	systemic (local)
Score*	difenconazole	Triazole	Syngenta	systemic (local)

* Registration pending

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

DICARBOXIMIDE

Trade name	Common name	Company	Activity
Rovral	iprodione	Bayer CropScience	systemic (local)

Mode of action: FRAC¹ Group 2; multi-site

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

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

Sporulation: inhibits

GUANIDINE

Trade name	Common name	Company	Activity
Syllit	dodine	Platte Chemical Co.	systemic (local)

Mode of action: FRAC¹ Group M7; disrupts membranes.

Resistance risk: high

HYDROXYANILIDE

Trade name	Common name	Company	Activity
Elevate	Fenhexamid	Arysta	contact
Judge	fenhexamid	Arysta	contact

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

Resistance risk: high

Growth effects: inhibits spore germination and mycelial growth

Sporulation: no effect

ISOPHTHALONITRILE

Trade name	Common name	Company	Activity
Bravo	chlorothalonil	Syngenta	contact
Echo	chlorothalonil	Sipcam Agro USA	contact

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

Resistance risk: low

Growth effects: inhibits spore germination

Sporulation: unknown

PHENYLAMIDE

Trade name	Common name	Company	Activity
Ridomil Gold EC	mefenoxam	Syngenta	contact, systemic

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

Resistance risk: high

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

Sporulation: reduces

PHENYLPYRROLE

Trade name	Common name	Company	Activity
Scholar	fludioxonil	Syngenta	contact (except cherry-systemic)
Switch	fludioxonil/cyprodinil	Syngenta	contact

Mode of action: FRAC¹ Group 12; single-site; interferes with respiration (fludioxonil); methionine inhibitor (cyprodinil).

Resistance risk: high

Growth effects: inhibits mycelial growth and germination

Sporulation: reduces

PHTHALIMIDE

Trade name	Common name	Company	Activity
Captan	captan	various	contact

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

Resistance risk: very low

Growth effects: inhibits spore germination

Sporulation: no effect

QUINOLINE

Trade name	Common name	Company	Activity
Quintec	quinoxifen	Dow AgroSciences	contact

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

Resistance risk: medium

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

Sporulation: no effect

STROBILURIN

Trade name	Common name	Company	Activity
Abound	azoxystrobin	Syngenta	contact and systemic
Cabrio	pyraclostrobin	BASF	contact and systemic
Evito*	fluoxastrobin	Arysta	contact and systemic
Flint/Gem**	trifloxystrobin	Bayer CropScience	contact and systemic
Pristine	pyraclostrobin + boscalid	BASF	contact and systemic
Sovran	kresoxim methyl	BASF	contact and systemic

* = registration pending; ** = Gem will replace Flint for tree fruit registrations.

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

Resistance risk: high

Growth effects: inhibits spore germination

Sporulation: no effect

STROBILURIN + CARBOXYANILIDE

Trade name	Common name	Company	Activity
Pristine	pyraclostrobin/boscalid	BASF	contact and systemic

Mode of action: FRAC¹ Groups 11 and 7; see above for strobilurin; unknown for carboxyanilide.

Resistance risk: low (combination of different chemistries)

Growth effects: see above for strobilurin; unknown for carboxyanilide

Sporulation: see above for strobilurin; unknown for carboxyanilide

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions. Fungicides with a different group number are suitable to alternate in a resistance management program. For more information, see <http://www.frac.info/>.

ALMOND—FUNGICIDE EFFICACY

Fungicide	Resistance risk (FRAC#) ¹	Brown Rot	Jacket rot	Anthrac -nose	Shot hole	Scab	Rust ²	Leaf blight	Alternaria	Silver leaf
Benlate ³	high (1)	++++	++++	----	----	+++	+	++++ ⁸	----	----
Pristine ²	medium (7/11)	++++	++++	++++	++++	++++	+++	ND	+++ ¹⁰	----
Rovral + oil ⁴	low (2)	++++	++++	----	+++	+/-	++	ND	+++ ¹⁰	----
Scala	high (9)	++++	++++	ND	++	----	ND	ND	+ ¹⁰	----
Topsin-M ³	high (1)	++++	++++	----	----	+++	+	+++ ⁸	----	----
Vangard	high (9)	++++	++++	ND	++	----	ND	ND	+ ¹⁰	----
Abound	high (11)	+++	----	++++	+++	++++	+++	+++	+++ ¹¹	----
Elevate	high (17)	+++	++++	----	+	ND	ND	ND	ND	----
Flint/Gem	high (11)	+++	----	++++	+++	++++	+++	+++	+++ ¹¹	----
Laredo	high (3)	+++	----	++	++	----	+	+++	----	----
Rovral	low (2)	+++	+++	----	+++	----	----	ND	+++ ¹⁰	----
Bravo/Echo ^{5,6}	low (M5)	++	NR	+++	+++	+++	NR	NR	NR	----
Captan ⁶	low (M4)	++	++	+++	+++	+++	----	+++	----	----
Maneb	low (M3)	++	+	++	++	++	+++	++	----	----
Rally ⁷	high (3)	++	----	++	+/-	----	+	+++	----	----
Ziram	low (M3)	++	+	+++	+++	+++	----	++	+	----
Copper	low (M1)	+/-	+/-	----	+ ⁸	----	----	----	ND	ND
Lime sulfur ¹³	low (M2)	+/-	NR	----	+/-	++	NR	NR	NR	NR
Sulfur ⁶	low (M2)	+/-	+/-	----	----	++	++	----	----	----
PlantShield (NR)	low	----	----	----	----	----	----	----	----	+++

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

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions. Fungicides with a different group number are suitable to alternate in a resistance management program. For more information, see <http://www.frac.info/>.

² Of the materials listed, only sulfur, Abound, and Flint are registered for use in late spring and early summer when treatment is recommended. Applications of Pristine only at 5 weeks after petal fall will not adequately control late-season diseases. Registration change for Pristine to allow 24-day preharvest interval is pending.

³ Benlate label withdrawn. Strains of the brown rot fungi *Monilinia laxa* and *M. fructicola* resistant to Benlate and Topsin have been found in some California almond 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 almonds with overuse of fungicides with similar chemistry. Resistant strains of the scab fungus, *Cladosporium carpophilum*, have been reported on other crops but not in California.

⁴ Oil is a "light" summer oil, 1-2% volume/volume.

⁵ Bravo Ultrex, Bravo Weather Stik, Echo, and Echo Ultimate are currently registered.

⁶ Do not use in combination with or shortly before or after oil treatment.

⁷ Efficacy is better in concentrate (80-100 gal/acre) than in dilute sprays.

⁸ Excellent control obtained with combination of Benlate and Captan; activity of Topsin should be similar to that of Benlate.

⁹ The low rates necessary to avoid phytotoxicity in spring reduce the efficacy of copper.

¹⁰ Not registered for use later than 5 weeks after petal fall.

¹¹ Efficacy reduced at high temperatures and relative humidity; experimental for Alternaria.

¹² Field resistance of *Alternaria* sp. to strobilurin fungicides has been detected in almond orchards.

¹³ “Burns out” scab twig lesions when applied at delayed dormant.

ALMOND—TREATMENT TIMING

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

Disease	Dormant	Bloom			Spring ^a		Summer	
		Pink bud	Full bloom	Petal fall	2 weeks	5 weeks	May	June
Alternaria	----	----	----	----	----	+++	+++	+++
Anthracnose ^b	----	++	+++	+++	+++	+++	+++	++
Brown rot	----	++	+++	+	----	----	----	----
Green fruit rot	----	----	+++	----	----	----	----	----
Leaf blight	----	----	+++	++	+	----	----	----
Scab ^c	+	+	+	+	+++	+++	++	+
Shot hole ^d	+ ^e	+	++	+++	+++	++	----	----
Rust	----	----	----	----	----	+++	+++	+ ^f

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

- a. 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.
- b. 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.
- c. 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.
- d. 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.
- e. 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.
- f. Treatment in June is important only if late spring and early summer rains occur.

APPLE AND PEAR—FUNGICIDE EFFICACY

Fungicide	Resistance risk (FRAC#) ¹	Scab		Powdery mildew (apple only)
		Protectant	Eradicant	
Bayleton	high (3)	----	----	+++
Benlate ²	high (1)	+++	+++	+++
Flint	high (11)	++++	++++	++++
Procure ³	high (3)	++++	++++	++++
Rally ⁴	high (3)	++++	++++	++++
Rubigan ³	high (3)	++++	++++	+++
Scala	high (9)	+++	+++	+
Sovran	high (11)	+++	+++	+++
Topsin-M	high (1)	+++	+++	+++
Vanguard	high (9)	+++	+++	+++
Captan ⁶	low (M4)	++	----	----
Maneb ⁶	low (M3)	++	----	----
Thiram ⁴	low (M3)	++	----	----
Ziram ⁶	low (M3)	++	----	----
Copper	low (M1)	++ ⁷	----	----
Lime sulfur ^{6,8}	low (M2)	----	++++ ⁸	+++ ⁹
Sulfur ⁶	low (M2)	++	----	++++

Bactericide/ Biological	Resistance risk ¹	Fire blight		Phytotoxicity
		Contact	Systemic	
Agricultural streptomycin	high	++++	+++	+/-
MycoShield ⁵	high	+++	+++	+/-
Copper ⁷	low	+++	----	+
Blight Ban	low	++	----	+/-
Bloomtime Bio	low	+++	----	+/-

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

1. Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions. Fungicides with a different group number are suitable to alternate in a resistance management program. For more information, see <http://www.frac.info/>.
2. Label withdrawn.
3. On pear, use only **before** white bud and **after** full bloom.
4. Labeled on apple but not on pear.
5. Labeled on pear but not on apple.
6. These are important components of resistance management programs.
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 development when applied to leaves in fall. **CAUTION: LIME SULFUR IS INCOMPATIBLE WITH MOST OTHER PESTICIDES. CHECK BEFORE USE.**
9. In-season application eradicates powdery mildew.

APPLE AND PEAR—TREATMENT TIMING

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

Disease	Fall	Delayed dormant	Green tip	Pink bud	Spring
Scab ^a	++ ^b	++ ^b	+++	+++	+++
Powdery mildew ^c	----	----	----	+++	+++
Fire blight	----	----	----	+++	+++ ^d

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

- a. Protection of early tissue is important. Additional applications should be made according to infection periods as determined by the Mills table.
- b. Disruption of pseudothecial development (fall) and inactivation of overwintering twig lesions (delayed dormant) occurs; effects of these treatments on disease control uncertain.
- c. Early application is most effective; added treatments are made if mildew continues.
- d. 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
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
		Blossom	Fruit			
Benlate ³	high (1)	++++	++++	++++	+++	----
Indar	high (3)	++++	++++	----	ND	----
Orbit (Bumper)	high (3)	++++	++++	----	+++	+/-
Pristine	medium (7/11)	++++	++++	+++	+++	++++
Rovral ⁴ + oil ⁵	low (2)	++++	NR	++++	----	+++
Scala	high (9)	++++	+++ ⁹	+++ ¹⁰	ND	++
Topsin-M ³	high (1)	++++	++++	++++	+++	----
Vanguard	high (9)	++++	+++ ⁹	+++ ¹⁰	ND	++
Rally	high (3)	+++	+++	----	+++	----
Rovral ⁴	low (2)	+++	NR	+++	----	+++
Elevate	high (17)	+++	++	+++	++	+
Abound	high (11)	++	+	----	ND	+++
Flint/Gem	high (11)	++	+	----	ND	+++
Botran	high (14)	++	++	+++	ND	ND
Bravo/Echo ^{6,7}	low (M5)	++	++	++	----	+++
Captan ^{7,8}	low (M4)	++	---- ¹¹	++	----	+++
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 NR = not registered.

1. Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions. Fungicides with a different group number are suitable to alternate in a resistance management program. For more information, see <http://www.frac.info/>.
2. Do not use with the same FRAC number and high resistance risk more than twice in one year.
3. Benlate label withdrawn. Strains of *Monilinia fructicola* and *M. laxa* resistant to Benlate and Topsin-M 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.
4. Blossom blight only; not registered for use after petal fall.
5. The oil is a “light” summer oil, 1-2% volume/volume.
6. Do not use after jacket (shuck) split.
7. Do not use in combination with or shortly before or after oil treatment.
8. Causes fruit browning as a preharvest spray.
9. High summer temperatures and relative humidity reduce efficacy.
10. Has not been tested on apricot but is effective against the jacket rot pathogens.

11. May cause staining on fruit.

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 ^a	----	+++	+++	+++	----	+++
Jacket rot	----	----	----	+++	----	++
Powdery mildew	----	----	----	+++	+++ ^c	----
Shot hole ^b	----	----	----	++	+++	----

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

- a. Begin at red bud, add one or two more sprays if weather favors disease.
- b. 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.
- c. Repeated treatment at 7- to 14-day intervals may be necessary; earlier treatments are most effective.

CHERRY--FUNGICIDE EFFICACY

Fungicide	Resistance risk (FRAC#) ¹	Brown rot ²		Botrytis	Powdery mildew ²	Shot hole Leaf spot ³
		Blossom	Fruit			
Benlate ⁴	high (1)	++++	++++	++++	+++	ND
Elite	high (3)	++++	++++	++	++	ND
Indar	high (3)	++++	+++	----	+++	ND
Orbit (Bumper)	high (3)	++++	++++	----	+++	ND
Pristine	medium (7/11)	++++	++++	+++	+++	ND
Rovral ⁵ + oil ⁶	low (2)	++++	NR	++++	++	ND
Topsin-M ⁴	high (1)	++++	NR	++++	+++	ND
Abound	high (11)	+++	+	----	++	ND
Cabrio	high (11)	+++	++	----	++	ND
Elevate	high (17)	+++	+++	++++	+	ND
Flint/Gem	high (11)	+++	++	----	++	ND
Procure ⁷	high (3)	+++	+++	----	++++	ND
Quintec	medium (13)	ND	ND	ND	++++	ND
Rally ⁷	high (3)	+++	+++	----	++++	ND
Rovral ⁵	low (2)	+++	NR	+++	----	ND
Rubigan	high (3)	+++	+++	----	++++	ND
Botran	high (14)	++	++	+++	----	ND
Bravo/Echo ^{8,9}	low (M5)	++	NR	++	----	ND
Captan ⁹	low (M4)	++	++	++	----	ND
Copper	low (M1)	+/-	----	----	----	ND
Sulfur ⁹	low (M2)	+/-	----	----	+++	ND
Ziram	low (M3)	+/-	NR	----	----	ND

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

1. Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions. Fungicides with a different group number are suitable to alternate in a resistance management program. For more information, see <http://www.frac.info/>.
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 (ND = no data available).
4. Benlate label withdrawn. Strains of *Monilinia fructicola* resistant to Benlate and Topsin-M are present in some California cherry orchards.
5. Blossom blight only; not registered for use after petal fall.
6. Oil is a "light" summer oil, 1-2% volume/volume.
7. More effective when applied as a concentrate (80-100 gal/acre) than as a dilute spray.
8. Do not use after jacket (shuck) split.
9. 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	Popcorn	Full bloom	Petal fall	2-3 weeks later	Preharvest 1-10 days ^a
Botrytis	----	+++	+++	++	----	+++
Brown rot ^b	----	+++	+++	++	----	+++
Powdery mildew ^c	++	++	+++	+++	+++	----

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

- a. Select broad-spectrum fungicides (or combinations) that have activity against both brown rot and Botrytis fruit rots.
- b. Begin at popcorn and repeat every 10 to 14 days through bloom if rains continue.
- c. Use sulfur at late budbreak, other fungicides for later treatment. Treat immediately if mildew is found on shoots or leaves on inner scaffolds.

GRAPEVINE—FUNGICIDE EFFICACY

Fungicide	Resistance risk (FRAC#) ¹	Powdery mildew	Downy mildew	Bunch rot		Phomopsis	Eutypa
				Botrytis	Summer		
Abound	high (11)	++++	++++	+	----	+++	----
Flint ²	high (11)	++++	+++	++	++	++	----
Elite	high (3)	++++	----	++	++	----	----
JMS Stylet oil ³	low	++++	----	+++	++	----	----
Pristine	high (7/11)	++++	++++	++++	+++	+++	----
Procure	high (3)	++++	----	----	----	----	----
Quintec	high (13)	++++	----	----	----	----	----
Rally	high (3)	++++	----	----	----	----	----
Rubigan	high (3)	++++	----	----	----	----	----
Sovran	high (11)	++++	++++	++	++	++++	----
Sulfur	low (M2)	++++	----	----	----	----	----
Topsin-M	high (1)	++++	----	++	++	+	++++
Armicarb	low	+++	--	----	----	----	----
Kaligreen	low	+++	----	----	----	----	----
Messenger	low	+++	----	----	----	----	----
Rovral + Oil ³	low (2)	+++	----	++++	----	----	----
Serenade	low	+++	----	++	+	----	----
Sonata	low	+++	----	NR	NR	----	----
Copper	low (M1)	++	+++	++	+++	+	----
Bayleton	high (3)	++	----	----	----	----	----
Elevate	high (17)	++	----	++++	++	----	----
Scala	high (9)	++	----	++++	++	----	----
Vanguard	high (9)	++	----	++++	++	----	----
VigorCal	low (++	----	----	----	----	----
VigorK	low	++	----	----	----	----	----
Timorex ³	low	++	----	----	----	----	----
Prev-am ³	low	++	----	----	----	----	----
Captan	low (M4)	----	+	+++	+++	+++	----
Maneb	low (M3)	----	----	++	----	+++	----
Ridomil Gold	high (4)	----	++++	----	----	----	----
Rovral	low (2)	----	----	+++	----	----	----

Rating: +++++ = excellent and consistent, +++ = good and reliable, ++ = 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. Fungicides with a different group number are suitable to alternate in a resistance management program. For more information, see <http://www.frac.info/>.
2. Causes severe phytotoxicity on Concord grape.
3. Phytotoxic if used within 2 weeks of Captan or sulfur.

GRAPEVINE—TREATMENT TIMING

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

Disease	Dormant	Bud break	Full bloom	Pre-close	Veraison	Preharvest
Botrytis	----	----	+++ ^a	+++ ^a	++ ^a	+++ ^a
Downy mildew	----	+++	+++	----	----	----
Eutypa	+++	----	----	----	----	----
Powdery mildew	+++ ^b	+++ ^c	+++ ^c	+++ ^d	+++ ^d	----
Summer rot	----	----	+++ ^a	+++ ^a	++ ^a	+++ ^a

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

- a. Apply only if rain is forecast.
- b. Use 10 gal lime sulfur per acre in at least 100 gal water.
- c. Apply bud break and full bloom treatments every year.
- d. Apply as needed (a disease risk assessment model is available to help determine need for spray).

PEACH AND NECTARINE—FUNGICIDE EFFICACY

Fungicide	Resistance risk (FRAC#) ¹	Brown rot ²		Powdery mildew ²	Scab	Rust	Leaf curl	Shot hole
		Blossom	Fruit					
Benlate ³	high (1)	++++	++++	+++	+++	+	----	----
Elite	high (3)	++++	++++	+++	++	+++	----	+/-
Indar	high (3)	++++	++++	+++	+++	ND	----	+/-
Orbit (Bumper)	high (3)	++++	++++	+++	----	+++	----	+/-
Pristine	medium (7/11)	++++	++++	+++	+++	ND	ND	++++
Rovral ⁴ + oil ⁵	low (2)	++++	++++	+	+	++	----	++
Scala ⁸	high (9)	+++++	+++ ⁸	ND	ND	ND	----	+
Topsin-M ³	high (1)	++++	++++	+++	+++	+	----	----
Vanguard	high (9)	++++	+++ ⁸	ND	ND	ND	----	+
Elevate	high (17)	+++	+++	ND	ND	ND	ND	ND
Rally	high (3)	+++	+++	++++	----	----	----	----
Rovral ⁴	low (2)	+++	+++	----	----	----	----	----
Abound	high (11)	++	+	++	++++	+++	----	++
Botran	high (14)	++	+	ND	ND	ND	ND	ND
Flint/Gem	high (11)	++	+	++	++++	+++	----	++
Bravo/Echo ^{6,7}	low (M5)	++	----	----	+++	+	+++	+++
Captan ⁷	low (M4)	++	++	----	+++	----	----	+++ ⁹
Copper	low (M1)	+/-	----	----	----	----	+++	+++
Sulfur ⁷	low (M2)	+/-	+/-	+++	+++	+++	----	----
Ziram	low (M3)	+/-	----	----	+++	----	++++	+++

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

1. Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions. Fungicides with a different group number are suitable to alternate in a resistance management program. For more information, see <http://www.frac.info/>.
2. Do not use fungicides with the same FRAC number and high resistance risk more than twice in one year.
3. Benlate label withdrawn. Strains of *Monilinia fructicola* resistant to Benlate and Topsin are present in some peach and nectarine orchards.
4. Blossom blight only; not registered for use after petal fall.
5. Oil is a “light” summer oil, 1-2% volume/volume.
6. Do not use after jacket (shuck) split.
7. Do not use in combination with or shortly before or after oil treatment.
8. High summer temperatures and relative humidity reduce efficacy.
9. Not effective if used as a dormant treatment.

PEACH AND NECTARINE—TREATMENT TIMING

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

Disease	Dormant	Bloom		3-6 weeks postbloom	Preharvest ^a	
		20-40%	80-100%		3 weeks	1 week
Brown rot	----	++	+++	+	++	+++
Powdery mildew	----/ND	++	+++	+++ ^e	----	----
Leaf curl ^b	+++	+	----	----	----	----
Rust	+ ^c	----	----	+++	++	----
Scab	----	+	++	+++	----	----
Shot hole ^d	+++	+	+	++	----	----

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

- a. Timing not exact; weather conditions determine need for treatment.
- b. Treatment should be made before bud break and preferably before bud swell.
- c. Dormant treatment with liquid lime sulfur.
- d. 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.
- e. Apply until pit hardening.

PISTACHIO—FUNGICIDE EFFICACY

Fungicide	Resistance risk (FRAC#) ¹	Alternaria	Botrytis	Botryosphaeria
Abound ²	high (11)	+++	----	+++
Benlate ³	low (1)	----	+++	++
Bravo	low (M5)	++	----	++
Cabrio	high (11)	+++	----	+++
Echo ⁴	low (M5)	NR	----	NR
Elevate	high (17)	ND	++++	ND
Flint/Gem	high (11)	+++	----	+++
Pristine	medium (7/11)	++++	++++	++++
Scala	high (9)	++	++	+++ ⁵
Switch	medium (9/12)	+++	+++	++
Topsin-M ⁶	high (1)	----	+++	++
Copper	low (M1)	+	----	----
Liquid lime sulfur ⁷	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.

- Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions. Fungicides with a different group number are suitable to alternate in a resistance management program. For more information, see <http://www.frac.info/>.
- Field resistance of *Alternaria* spp. to Abound and to other strobilurin fungicides (Flint and Cabrio) has been detected in pistachio orchards.
- Benlate label withdrawn. Previously registered for bloom treatment only.
- Label was withdrawn for pistachio due to phytotoxicity.
- Under low and moderate disease pressure.
- Registered for bloom treatment only.
- Dormant treatment only.

PISTACHIO—TREATMENT TIMING

Disease	Dormant	April	June ^c	July ^c	August
Alternaria ^a	----	----	+++	+++	++
Botryosphaeria ^b	+	++	+++	+++	++
Botrytis	----	+++	----	----	----

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

- Three applications during the season are recommended.
- Treat with Topsin-M 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, no more than three consecutive applications of any strobilurin (Abound, Flint or Cabrio) are allowed.
- If only one application is done, the best timing is late June to early July.

PLUM—FUNGICIDE EFFICACY

Note: Disease control in spring and preharvest 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		
Benlate ⁵	high (1)	++++	++++	+++	ND
Orbit (Bumper)	high (3)	++++	++++	+++	ND
Pristine	medium (7/11)	++++	++++	+++	ND
Rovral ⁶ + oil ⁷	low (2)	++++	NR	----	ND
Scala	high (9)	++++	+++ ¹⁰	ND	ND
Topsin-M ⁵	high (1)	++++	++++	+++	ND
Vanguard	high (9)	++++	+++ ¹⁰	ND	ND
Rally	high (3)	+++	+++	+++	ND
Rovral ⁶	low (2)	+++	NR	----	ND
Abound	high (11)	++	+	ND	ND
Botran	high (14)	++	++	ND	ND
Bravo/Echo ^{8,9}	low (M5)	++	++	----	ND
Captan ⁹	low (M4)	++	++	----	ND
Flint/Gem	high (11)	++	++	ND	ND
Copper	low (M1)	+/-	----	----	ND
Sulfur ⁹	low (M2)	+/-	+/-	+++	ND

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

1. Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions. Fungicides with a different group number are suitable to alternate in a resistance management program. For more information, see <http://www.frac.info/>.
2. Brown rot 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. Benlate label withdrawn. Strains of the brown rot fungus *Monilinia fructicola* resistant to Benlate and Topsin 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.
6. Blossom blight only; not registered for use after petal fall.
7. The oil is a “light” summer oil, 1-2% volume/volume.
8. Do not use after jacket (shuck) split.
9. Do not use in combination with or shortly before or after oil treatment.
10. High summer temperatures and relative humidity reduce efficacy.

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 ^a	----	+	++	+++	----	+
Powdery mildew	----	+	+	+++	+++	----
Shot hole ^b	----	----	----	----	----	----

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

- a. One early application should suffice; a second treatment should not be needed.
- b. 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 (OR DRIED PLUM)—FUNGICIDE EFFICACY

Material	Resistance risk (FRAC#) ¹	Brown rot		Russet scab	Rust
		Blossom	Fruit		
Benlate ² + oil ³	high (1)	++++	++++	----	----
Orbit (Bumper)	high (3)	++++	NR	----	NR
Pristine	medium (7/11)	++++	++++	ND	ND
Rovral ⁴ + oil ³	low (2)	++++	NR	----	NR
Scala	high (9)	++++	+++ ⁷	----	ND
Topsin-M ² + oil ³	high (1)	++++	++++	----	----
Vangard	high (9)	++++	+++ ⁷	----	ND
Benlate ²	high (1)	+++	+/-	----	----
Elevate	high (17)	+++	+++	ND	----
Rovral ⁴	low (2)	+++	NR	----	NR
Topsin ²	high (1)	+++	+/-	----	----
Abound	high (11)	++	+	----	+++
Botran	high (14)	++	++	ND	ND
Flint/Gem	high (11)	++	+	----	+++
Bravo/Echo ^{5,6}	low (M5)	++	++	++	---- ⁶
Captan ⁵	low (M4)	++	++	+++	----
Rally	high (3)	++	++	----	----
Sulfur	low (M2)	+/-	+/-	----	++

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

1. Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions. Fungicides with a different group number are suitable to alternate in a resistance management program. For more information, see <http://www.frac.info/>.
2. Benlate label withdrawn. Strains of *Monilinia fructicola* and *M. laxa* resistant to Benlate and Topsin-M have been reported in some California prune orchards. No more than two applications of Benlate and Topsin should be made each year.
3. The oil is "light" summer oil, 1-2% volume/volume. If applied in summer causes fruit to lose bloom and look red. They dry to normal color.
4. Blossom blight only; not registered for use after petal fall.
5. Do not use in combination with or shortly before or after oil treatment.
6. Do not use after jacket (shuck) split.
7. High summer temperatures and relative humidity reduce efficacy.

PRUNE (OR DRIED PLUM)—TREATMENT TIMING

Note: Timings listed are effective but not all may be required for disease control.

Disease	Green bud	White bud	Full bloom	May	June	July
Brown rot ^a	+++	+++	+++	----	+	++
Russet scab ^b	----	----	+++	----	----	----
Rust ^c	----	----	----	+	++	+++

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

Timings used will depend upon orchard history of disease, length of bloom, and weather conditions each year.

- a. Flowers are susceptible beginning with the emergence of the sepals (green bud) until the petals fall but are most susceptible when open.
- b. A physiological disorder; no pathogens involved.
- c. More severe when late spring rains occur.

WALNUT—BACTERICIDE EFFICACY

Material	Resistance risk (FRAC#) ¹	Walnut blight*	Phytotoxicity
Bordeaux	low (M1)	+++	NP
Fixed coppers	medium (M1)	+++	++**
Copper-maneb	low (M1/M3)	++++	NP
Copper-maneb-surfactant	low (M1/M3)	+	NP
Zinc-Copper Bordeaux	low (M1)	+++	NP
Serenade	low	+	NP

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

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

1. Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions. Fungicides with a different group number are suitable to alternate in a resistance management program. For more information, see <http://www.frac.info/>.

WALNUT—TREATMENT TIMING

Note: Timings listed are effective but not all may be required for disease control.*

Disease	Catkin emergence	Terminal bud break	1 week after bud break	7-10 day intervals ^b	May ^c
Walnut blight (on fruit/nuts) ^a	++	+++	+++	++ ^b	+

* Timings used will depend upon orchard history of disease and weather conditions each year.

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

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

c. Late spring rains are less conducive to disease.