FUNGICIDE EFFICACY AND TIMING FOR DECIDUOUS TREE FRUIT AND NUT CROPS AND GRAPEVINES

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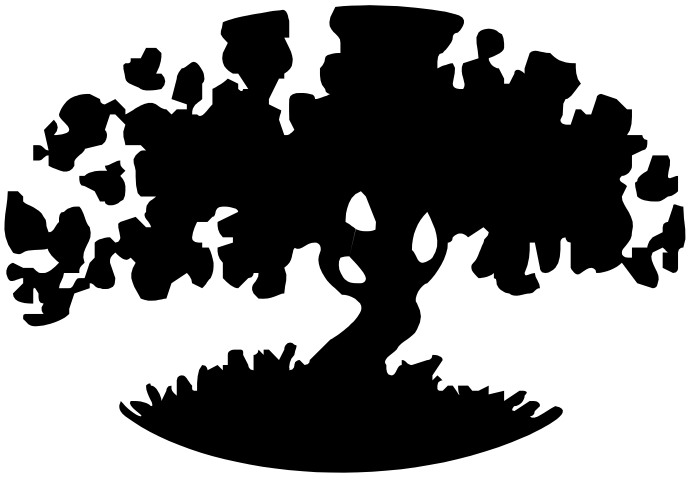

ALMOND
APPLE AND PEAR
APRICOT
CHERRY
PEACH
PISTACHIO
PLUM
PRUNE
GRAPE

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TABLE OF CONTENTS

Fungicide Efficacy and Timing for Deciduous Fruit and Nut Tree Crops and Grapevines

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

PROPERTIES

Trade name	Fungicide	Class	Systemic action	Mode of action	Resistance potential
ML[a]	copper	Inorganic	No	Multi-site	Low
ML	sulfur	Inorganic	No	Multi-site	Low
Maneb	maneb	Carbamate (EBDC)[b]	No	Multi-site	Low
Thiram	thiram	Carbamate (DMDC)[c]	No	Multi-site	Low
Ziram	ziram	Carbamate (DMDC)[c]	No	Multi-site	Low
Rovral	iprodione	Dicarboximide	Yes	Multi-site	Low
Scala*	pyrimethanil	Anilinopyrimidine	No	Single-site	High
Vangard	cyprodinil	Anilinopyrimidine	Yes	Single-site	High
Botran	dichloran	Aromatic hydrocarbon	Slight	Single-site	High
Bravo	chlorothalonil	Aromatic nitrile	No	Multi-site	Low
Benlate**	benomyl	Benzimidazole	Yes	Single-site	Very high
Topsin-M	thioph.-methyl	Benzimidazole	Yes	Single-site	Very high
Syllit*	dodine	Guanidine	Yes	Few to multi-site	Medium
Elevate	fenhexamid	Hydroxyanilide	No	Single-site	High
Captan	captan	Phthalamide	No	Multi-site	Low
Quintec*	quinoxyfen	Quinoline	No	Single-site	Medium
Scholar[d]	fludioxonil	Phenylpyrrole	Contact	Few to multi	Low
Bayleton	triadimefon	DMI[e]-Triazole	Yes?	Single-site	High
Elite	tebuconazole	DMI-Triazole	Yes?	Single-site	High
Funginex**	triforine	DMI-Piperazine	Yes?	Single-site	High
Indar	fenbuconazole	DMI-Triazole	Yes?	Single-site	High
Orbit (Break)	propiconazole	DMI-Triazole	Yes?	Single-site	High
Procure	triflumizole	DMI-Imidazole	Yes?	Single-site	High
Rally/Laredo	myclobutanil	DMI-Triazole	Yes?	Single-site	High
Rubigan	fenarimol	DMI-Pyrimidine	Yes?	Single-site	High
Abound	azoxystrobin	Strobilurin	Yes?	Single-site	High
Cabrio	pyraclostrobin	Strobilurin	Yes?	Single-site	High
Flint	trifloxystrobin	Strobilurin	Yes?	Single-site	High
Sovran	kresoxymethyl	Strobilurin	Yes?	Single-site	High
AQ10	*Ampelomyces quisqualis*	Biological	No	Mycoparasite	Low
Serenade	*Bacillus subtilis*	Biological	No	Various	Low
JMS Stylet oil	low range oil	---	No	---	Low
Valero	cinnamic aldehyde	---	No	---	Low

* Experimental; registration pending
** Label withdrawn

a ML=many labels
b EBDC = ethylene bisdithiocarbamate
c DMDC = dimethyl dithiocarbamate
d Post harvest use only
e DMI, demethylation (sterol) inhibitor

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

EFFICACY: TREE CROPS

Fungicide	Brown rot	Jacket rot (Botrytis)	Shot hole	Powdery mildew	Rust	Scab		Anthracnose	Alternaria
						Almond	Apple/pear		
Abound [a]	++	----	+++	++	+++	+++	+++	++++	+++
Benlate [b]	+++ [e]	+++	----	+++	++	+++	+++	----	----
Botran	++	+++	?	?	?	?	?	?	?
Bravo	++	++	+++	----	++	NR	NR	+++	++
Captan	++	++	+++	----	+	+++	++	++	-----
Copper	+	+	++	----	----	+/-	----	----	+
Elevate	+++	++++	+	ND	ND	ND	ND	ND	ND
Elite	++++	++	+/-	+++	+++	+/-	+++	+++	++
Flint	++	----	+++	ND	ID	+++	+++	ND	+++
Funginex [c]	+++	----	----	++	+	----	+++	ND	ND
Indar	+++	----	+	ND	ND	+++	----	+	----
Laredo	+++	----	+	++++	++	----	++++	++	----
Maneb	+	+	++	----	+++	++	++	++	+
Orbit (Break)	+++	----	+/-	+++	+++	NR	NR	+++	-----
Procure	++	----	+/-	+++	ND	ND	++++	ND	ND
Rally	++	----	+/-	++++	++	----	++++	++	----
Rovral	+++	+++	+++	----	----	----	NR	----	+++
Rovral + oil	++++	++++	+++	+	++	----	NR	----	+++
Rubigan	+++	----	----	++++	++	NR	++++	ND	ND
Scala (NR)	++	+++	ND	ND	ND	ND	ND	ND	ND
Scholar [d]	++++	++++	----	----	----	----	----	----	----
Sulfur	+	+	----	+++	+++	++	++	+	-----
Thiram	+	+	ND	----	----	NR	++	ND	ND
Topsin M	+++ [e]	+++	----	+++	++	+++	+++	----	----
Vangard	++++ [f]	++++	++	ND	ND	----	++++	ND	+++
Ziram	+	+	+++	----	----	+++	++	++	+

++++ = excellent; +++ = very good; ++ = good; + = fair; +/- = slight; - = ineffective; ID = incomplete data, 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 Postharvest use only.
e Resistant populations of target organisms occur in California.
f High summer temperatures and relative humidity reduce efficacy.

EFFICACY: GRAPEVINES

Fungicide	Powdery mildew	Downy mildew	Bunch rot		Phomopsis	Eutypa
			Botrytis	Summer		
Abound	++++	++++	---	---	+++	---
AQ10	+++	---	---	---	---	---
Bayleton	++	---	---	---	---	---
Benlate [a]	++++	---	++	++	+	+++
Captan	---	+	++	++	+++	---
Copper	++	+++	++	+++	+	---
Elevate	---	---	+++	++	---	---
Elite	++++	---	++	++	---	---
Flint [b]	++++	+	++	++	++	---
JMS Stylet oil	++++	---	++++	++	---	---
Maneb	---	---	++	---	+++	---
Procure	++++	---	---	---	---	---
Quintec (NR)	++++	---	---	---	---	---
Rally	++++	---	---	---	---	---
Ridomil Gold	---	++++	---	---	---	---
Rovral	---	---	+++	---	---	---
Rovral + oil	---	---	+++	---	---	---
Rubigan	++++	---	---	---	---	---
Serenade	+++	---	++	+	---	---
Sovran	++++	++++	++	++	++++	---
Sulfur	+++	---	---	---	---	---
Thiram (NR)	---	---	++	---	---	---
Valero	+++	---	---	---	---	---
Vangard	---	---	++++	++	---	---
Ziram	---	---	++	---	++	---

++++ = excellent; +++ = very good; ++ = good; + = fair; +/- = slight; - = ineffective; NR = not registered

a Label withdrawn.

b Causes severe phytotoxicity on Concord grapevines.

DISEASE AND PATHOGEN NAMES

Disease	Pathogen(s)	Host(s)
Alternaria late blight	*Alternaria alternata*	Pistachio
Alternaria leaf spot	*Alternaria alternata*	Almond
Anthracnose	*Colletotrichum acutatum*	Almond, peach
Botryosphaeria panicle blight	*Botryosphaeria dothidea*	Pistachio
Botrytis shoot blight	*Botrytis cinerea*	Pistachio
Brown rot	*Monilinia fructicola*	Stone fruits
Brown rot	*Monilinia laxa*	Almond, apricot, prune
Bunch rot	*Botrytis cinerea*	Grapevine
Downy mildew	*Plasmopora viticola*	Grapevine
Eutypa dieback	*Eutypa lata*	Apricot Grapevine
Jacket rot	*Botrytis cinerea* *Monilinia laxa* *Monilinia fructicola* *Sclerotinia sclerotiorum*	All stone fruits
Leaf blight	*Seimatosporium lichenicola*	Almond
Leaf spot	*Blumeriella jaapii* *(Coccomyces hiemalis)*	Cherry
Leaf curl	*Taphrina deformans*	Peach, nectarine
Phomopsis dieback	*Phomopsis viticola*	Grapevine
Phomopsis blight	*Phomopsis* sp.	Pistachio
Phomopsis fruit rot	*Phomopsis amygdali*	Almond
Powdery mildew	*Podosphaera leucotricha* *Podosphaera clandestina* *Podosphaera tridactyla* *Sphaerotheca pannosa* *Uncinula necator*	Apple, peach, nectarine Cherry Apricot, plum, prune Apricot, peach, nectarine, plum Grapevine
Russet scab	Abiotic (rain during bloom)	Prune
Rust	*Tranzschelia discolor*	Almond, nectarine, peach, prune, plum
Scab	*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

FUNGICIDES

INORGANIC

Copper and sulfur
Both are contact fungicides

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

ANILINOPYRIMIDINE

Trade name	Common name	Company	Activity
Scala	pyrimethanil	Aventis	
Vangard	cyprodinil	Syngenta	not systemic (on most crops)

Mode of action: 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

AROMATIC HYDROCARBON

Trade name	Common name	Company	Activity
Botran	dichloran	Gowan	Systemic (local)

Mode of action: Unclear
Resistance risk: High.
Growth effects: Interupts mycelial growth
Sporulation: Little effect

BENZIMIDAZOLE

Trade name	Common name	Company	Activity
Benlate	benomyl	duPont	systemic (local)
Topsin	thiophanate methyl	Cerexagri	systemic (local)

Mode of action: 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	maneb	Dow Agrosciences	contact
Maneb	maneb	Cerexagri	contact
Manex	maneb	Griffin	contact
Dimethyl dithiocarbamates (DMDC)			
Thiram	thiram	Cerexagri	contact
Ziram	ziram	Cerexagri	contact

Mode of action: Multi-site inhibitors that complex with enzymes probably inhibiting respiration
Resistance risk: Very low
Growth effects: Inhibit spore germination
Sporulation: No effect

DEMETHYLATION (ERGOSTEROL BIOSYNTHESIS) INHIBITORS ("DMI")

Trade name	Common name	Company	Activity[x]
Bayleton	triadimefon	Bayer	systemic (local)
Elite	tebuconazole	Bayer	systemic (local)
Indar	fenbuconazole	Dow Agrosciences	systemic (local)
Laredo	myclobutanil	Dow Agrosciences	systemic (local)
Orbit (Break)	propiconazole	Syngenta	systemic (local)
Procure	triflumizole	Uniroyal	systemic (local)
Rally	myclobutanil	Dow Agrosciences	systemic (local)
Rubigan	fenarimol	Dow Agrosciences	systemic (local)

Mode of action: Single-site inhibitors--Inhibit demethylation and other processes in sterol biosynthesis. Most are absorbed quickly and move up but not down in the plant. Funginex degrades rapidly in plant. All have little effect on spore germination, but interfere with other early developmental processes. Can stop lesions from sporulating. Inhibit mycelial growth. Many have "kick-back" activity against apple and pear scab and stone fruit fungi.

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	Aventis	systemic (local)

Mode of action: 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 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	Aventis	systemic (local)

Mode of action: Disrupts membranes

Resistance risk: High

HYDROXYANILIDE

Trade name	Common name	Company	Activity
Elevate	fenhexamid	Tomen Agro	contact

Mode of action: Unknown, probably single-site
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

Mode of action: 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	metalaxyl	Syngenta	contact, systemic

Mode of action: Interferes with activity of a nuclear RNA polymerase template complex
Resistance risk: High
Growth effects: Inhibits mycelial and development
Sporulation: Reduces

PHENYLPYRROLE

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

PHTHALAMIDE

Trade name	Common name	Company	Activity
Captan	captan	Makhteshim-agan Tomen Ag	contact

Mode of action: Multi-site inhibitors that complex 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	quinoxyfen	Dow AgroSciences	contact

Mode of action: Probably single-site inhibitor; disrupts early cell signaling events.
Resistance risk: Medium
Growth effects: Suppresses spore germination, early germ tupe 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
Flint	trifloxystrobin	Bayer	contact and systemic
Sovran	kresoxim methyl	BASF	contact and systemic

Mode of action: Single-site; blocks respiration by interfering with cytochrome b
Resistance risk: High
Growth effects: Inhibits spore germination and mycelial growth
Sporulation: No effect

ALMOND—FUNGICIDE EFFICACY

Fungicide	Resistance risk	Brown rot	Jacket rot	Leaf blight	Shot hole	Scab	Rust[1]	Anthracnose	Alternaria
Benlate [2]	high	++++	++++	++++ [6]	----	+++	+	----	----
Rovral + oil[3]	low	++++	++++	?	+++	+/-	++	----	+++[8]
Topsin M [2]	high	++++	++++	+++ [6]	----	+++	+	----	----
Vangard	high	++++	++++	?	++	----	?	?	+++[9]
Abound	high	+++	-----	+++	+++	++++	+++	++++	+++
Elevate	high	+++	++++	?	+	?	?	----	?
Flint	high	+++	-----	+++	+++	++++	+++	++++	+++
Laredo	high	+++	----	+++	+	----	+	++	----
Rovral	low	+++	+++	?	+++	----	----	----	+++ [8]
Captan [5]	low	++	++	+++	+++	+++	----	++	----
Maneb	low	++	+	++	++	+++	+++	++	----
Rally [4]	high	++	----	+++	+/-	----	+	++	----
Ziram	low	++	+	++	+++	+++	----	+++	+
Copper	low	+/-	+/-	----	+ [7]	----	----	----	?
Sulfur	low	+/-	+/-	----	----	+++	++	----	----

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

1. Of the materials listed, only sulfur Abound and Flint are registered for use in late spring and early summer when treatment is recommended. Application only at 5 weeks after petal fall will not adequately control the disease.

2. 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. Resistant strains of the scab fungus, *Cladosporium carpophilum*, have been reported on other crops but not in California.

3. Oil is a "light" summer oil, 1 to 2% volume/volume.

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

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

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

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

8. Not registered for use later than 5 weeks after petal fall; three spring applications improve the effectiveness of Abound summer treatments.

9. Experimental for Alternaria.

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	2W	5W	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 (2W) and five (5W) weeks after petal fall are general timings to represent early post bloom and the latest time that most fungicides can be applied. The exact timing is not critical but depends more on the occurrence of rainfall.

b. If anthracnose was damaging in previous years and temperatures are moderate (63F 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 occurs during periods of moderate temperatures. Treatment should, if possible, precede any late spring and early summer rains. Alternate fungicides, using different fungicide classes, as a resistance management strategy.

c. Early treatments (during bloom) have minimal effect on scab; the 5W treatment usually is most effective. Treatments after 5W 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.

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 [1]	Scab		Powdery mildew (apple only)
		Protectant	Eradicant	
Bayleton	high	----	----	+++
Benlate [2]	high	+++	+++	+++
Flint	high	++++	++++	++++
Procure [3]	high	++++	++++	++++
Rally [4]	high	++++	++++	++++
Rubigan [3]	high	++++	++++	++++
Topsin M	high	+++	+++	+++
Vangard	high	+++	+++	+++
Captan [5]	low	++	----	----
Maneb [5]	low	++	----	----
Thiram [5]	low	++	----	----
Ziram [5]	low	++	----	----
Copper	low	++ [6]	----	----
Lime sulfur [7]	low	----	++++ [7]	+++ [8]
Sulfur	low	++	----	+++

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

1. Do not use the same fungicide or fungicides with similar chemistry and high resistance risk more than twice during a season.

2. Label withdrawn.

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

4. Labeled on apple but not on pear.

5. These are important components of resistance management programs.

6. Copper, though effective for scab control, causes fruit scarring.

7. "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.

8. 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]	----	----	----	++++	+++

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.

APRICOT—FUNGICIDE EFFICACY

Fungicide	Resistance risk	Brown rot [1]		Jacket rot	Powdery mildew [1]	Shot hole
		Blossom	Fruit			
Benlate [2]	high	++++	++++	++++	+++	----
Indar	high	++++	++++	----	?	----
Orbit (Break)	high	++++	++++	----	+++	+/-
Rovral[3] + oil [4]	low	++++	++++	++++	----	+++
Topsin M [2]	high	++++	++++	++++	+++	----
Vangard	high	++++	+++ [10]	+++ [9]	?	++
Rally	high	+++	+++	----	+++	----
Rovral [3]	low	+++	+++	+++	----	+++
Abound	high	++	+	----	ND	+++
Botran	high	++	++	+++	?	?
Bravo [5,6]	low	++	++	++	----	+++
Captan [6,7]	low	++	---- [8]	++	----	+++
Copper	low	+/-	----	----	----	++
Ziram	low	+/-	----	+	----	++++

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

1. Do not use the same fungicide or fungicides with similar chemistry and high resistance risk more than twice in one year.
2. Benlate label withdrawn. Strains of *Monilinia fructicola* and *M. laxa* resistant to Benlate and Topsin 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.
3. Blossom blight only; not registered for preharvest use.
4. The oil is a "light" summer oil, 1-2% volume/volume.
5. Do not use after shuck split.
6. Do not use in combination with or shortly before or after oil treatment.
7. Causes fruit browning as a pre harvest spray.
8. May cause staining on fruit.
9. Has not been tested on apricot but is effective against the jacket rot pathogens.
10. High summer temperatures and relative humidity reduce efficacy.

DO NOT USE SULFUR AT ANY TIME ON APRICOT TREES

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	Brown rot [1]		Botrytis	Powdery mildew [1]	Shot hole Leaf spot [2]
		Blossom	Fruit			
Benlate [3]	high	++++	++++	++++	+++	
Elite	high	++++	++++	++	+++	
Indar	high	++++	+++	----	?	
Orbit (Break)	high	++++	++++	----	+++	
Rovral [4] + oil [5]	low	++++	++++	++++	++	
Topsin M [3]	high	++++	++++	++++	+++	
Abound	high	+++	+	----	ND	
Elevate	high	+++	++++	++++	ND	
Rally [6]	high	+++	+++	----	++++	
Rovral [4]	low	+++	+++	+++	----	
Rubigan	high	+++ [9]	+++ [9]	----	++++	
Botran	high	++	++	+++	?	
Bravo [7,8]	low	++	?	++	----	
Captan [8]	low	++	++	++	----	
Copper	low	+/-	----	----	----	
Sulfur	low	+/-	----	----	+++	
Ziram	low	+/-	?	----	----	

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

1. Do not use the same fungicide or fungicides with similar chemistry more than twice in one year.
2. Shot hole and leaf spot occur infrequently on cherries in California; control usually is not necessary.
3. Benlate label withdrawn. Strains of *Monilinia fructicola* resistant to Benlate and Topsin are present in some California cherry orchards.
4. Blossom blight only; not registered for preharvest use.
5. Oil is a "light" summer oil, 1-2% volume/volume.
6. More effective when applied as a concentrate (80-100 gal/acre) than as a dilute spray.
7. Do not use after shuck split.
8. Do not use in combination with or shortly before or after oil treatment.
9. Not registered for brown rot.

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 bud break, other fungicides for later treatment. Treat immediately if mildew is found on shoots or leaves on inner scaffolds.

GRAPEVINE—FUNGICIDE EFFICACY

Fungicide	Resistance	Powdery	Downy	Bunch rot		Phomopsis	Eutypa
	risk	mildew	mildew	Botrytis	Summer		
Abound	high	++++	++++	+	---	+++	---
Bayleton	high	++	---	---	---	---	---
Benlate [1]	high	++++	---	++	++	+	+++
Flint	high	++++	++++	+	---	+++	---
Elevate	high	---	---	++++	++	---	---
Elite	high	++++	---	++	++	---	---
Procure	high	++++	---	---	---	---	---
Rally	high	++++	---	---	---	---	---
Ridomil Gold	high	---	++++	---	---	---	---
Rubigan	high	++++	---	---	---	---	---
Sovran	high	++++	++++	++	++	++++	---
Vangard	high	---	---	++++	++	---	---
AQ10 [2]	low	+++	---	---	---	---	---
Captan	low	---	+	++	++	+++	---
JMS Stylet oil [3]	low	++++	---	++++	++	---	---
Maneb	low	---	---	++	---	+++	---
Rovral	low	---	---	++++	++	---	---
Serenade	low	+++	---	++	+	---	---
Copper	low	++	+++	++	+++	+	---
Sulfur	low	+++	---	---	---	---	---

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

1. Benlate label withdrawn.

2. Effective early in the season when disease pressure is low. Should be used only in an integrated program with other chemistries. Is compatible with DMI fungicides, Vangard, Rovral and all insecticides. Do not tank mix with Abound or sulfur.

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	Pre-harvest
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	Brown rot[a]		Powdery mildew [1]	Scab	Rust	Leaf curl	Shot hole
		Blossom	Fruit					
Benlate [2]	high	++++	++++	+++	+++	+	----	----
Elite	high	++++	++++	+++	++	+++	----	+/-
Indar	high	++++	++++	?	+++	?	----	+/-
Orbit (Break)	high	++++	++++	+++	----	+++	----	+/-
Rovral [3]+ oil [4]	low	++++	++++	+	+	++	----	++
Topsin [2]	high	++++	++++	+++	+++	+	----	----
Vangard	high	++++	+++ [8]	ND	?	?	----	+
Elevate	high	+++	+++	?	?	?	?	?
Rally	high	+++	+++	+++	----	----	----	----
Rovral [3]	low	+++	+++	----	----	----	----	----
Abound	high	++	+	++	++++	+++	----	++
Botran	high	++	+	?	?	?	?	?
Bravo [5,6]	low	++	----	----	+++	+	+++	+++
Captan [6]	low	++	++	----	+++	----	----	+++ [7]
Copper	low	+/-	----	----	----	----	+++	+++
Sulfur	low	+/-	+/-	+++	+++	+++	----	----
Ziram	low	+/-	----	----	+++	----	++++	+++

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

1. Do not use the same fungicide or fungicides with similar chemistry and high resistance risk more than twice in one year.
2. Benlate label withdrawn. Strains of *Monilinia fructicola* resistant to Benlate and Topsin are present in some peach and nectarine orchards.
3. Blossom blight only; not registered for pre harvest use.
4. Oil is a "light' summer oil, 1-2% volume/volume.
5. Do not use after shuck split.
6. Do not use in combination with or shortly before or after oil treatment.
7. Not effective if used as dormant treatment.
8. High summer temperatures and relative humidity reduce efficacy.

PEACH AND NECTARINE—TREATMENT TIMING

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

Disease	Dormant	Bloom		3-6 weeks post bloom	Preharvest [a]	
		20-40%	80-100%		3 weeks	1 week
Brown rot	----	++	+++	+	++	+++
Powdery mildew	----	++	++	+++	----	----
Leaf curl [b]	+++	+	----	----	----	----
Rust	+ [c]	----	----	+++	++	----
Scab	----		++	+++	----	----
Shot hole [d]	+++	+	+	++	----	----

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

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.

PISTACHIO—FUNGICIDE EFFICACY

Fungicide	Resistance risk	Alternaria	Botrytis	Botryosphaeria
Abound	high	+++	----	+++
Benlate [1]	low	----	+++	++
Rovral	low	++++ [2]	?	++
Copper	low	+	----	----
Liquid lime sulfur [3]	low	----	----	+/-

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

1. Benlate label withdrawn. (Registered for bloom treatments only.)

2. With "light" oil.

3. Dormant treatment only.

PISTACHIO—TREATMENT TIMING

Disease	Dormant	April	June	July	August
Alternaria [a]	----	----	+++	+++	+++
Botryosphaeria [b]	+	++	+++	++	++
Botrytis	----	+++	----	----	----

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

a. Three applications during the season are recommended.

b. Treat with Benlate 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 Abound are allowed.

PLUM—FUNGICIDE EFFICACY

Note: Disease control in spring and pre harvest is not necessary for most plum cultivars in California.

Fungicide	Resistance risk	Brown rot [1]		Powdery mildew [2]	Shot hole [3]
		Blossom	Fruit		
Benlate [4]	high	++++	++++	+++	
Orbit (Break)	high	++++	++++	+++	
Rovral [5] + oil [6]	low	++++	++++	----	
Topsin [4]	high	++++	++++	+++	
Vangard	high	++++	+++ [9]	ND	
Rally	high	+++	+++	+++	
Rovral [5]	low	+++	+++	----	
Abound	high	++	+	ND	
Botran	high	++	++	?	
Bravo [7,8]	low	++	++	----	
Captan [8]	low	++	++	----	
Copper	low	+/-	----	----	
Sulfur	low	+/-	+/-	+++	

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

1. Brown rot is seldom observed on most plum cultivars and these usually do not require treatment during bloom.
2. Powdery mildew seldom is observed on most plum cultivars and control usually is unnecessary.
3. Shot hole disease rarely occurs on plums in California. The small holes often observed in leaves in spring are caused by genetic or other agents.
4. 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.
5. Blossom blight only; not registered for preharvest use.
6. The oil is a "light" summer oil, 1-2% volume/volume.
7. Do not use after shuck split.
8. Do not use in combination with or shortly before or after oil treatment.
9. 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—FUNGICIDE EFFICACY

Material	Resistance risk	Brown rot		Russet scab	Rust
		Blossom	Fruit		
Benlate [1] + oil [2]	high	++++	++++	----	----
Orbit (Break)	high	++++	++++	----	?
Rovral [3] + oil [2]	low	++++	++++	----	+++
Topsin [1] + oil [2]	high	++++	++++	----	----
Vangard	high	++++	+++ [7]	----	?
Benlate [1]	high	+++	+/-	----	----
Elevate	high	+++	+++	?	?
Rovral [3]	low	+++	+/-	----	----
Topsin [1]	high	+++	+/-	----	----
Abound	high	++	+	----	+++
Botran	high	++	++	?	?
Bravo [4,5]	low	++	++	++	---- [6]
Captan [4]	low	++	++	+++	----
Rally	high	++	++	----	----
Sulfur	low	+/-	+/-	----	++

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

1. Benlate label withdrawn. Strains of *Monilinia fructicola* and *M. laxa* resistant to Benlate and Topsin have been reported in some California prune orchards. No more than two applications of Benlate and Topsin should be made each year.
2. 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.
3. Blossom blight only; not registered for preharvest use.
4. Do not use in combination with or shortly before or after oil treatment.
5. Do not use after shuck split.
6. Effective but cannot use at proper timing (summer).
7. High summer temperatures and relative humidity reduce efficacy.

PRUNE—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	+++	+++	++++	----	+	++
Russet scab	----	----	+++	----	----	----
Rust	----	----	----	+	++	+++

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

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

Russet scab: A physiological disorder, no pathogens involved.

Rust: More severe when late spring rains occur.