Epidemiology and Management of Brown Rot, Gray Mold, Shot Hole, Rust, and Hull Rot of Almond

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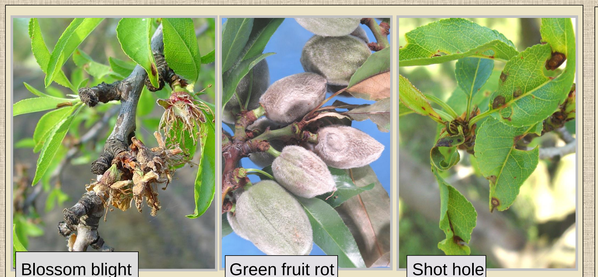


New fungicide developments and management strategies for almond

Newly registered: Kenja (FG 7), Merivon (FG 7/11), Syllit (U12), Viathon (FG 3+33), Manzate (M3), Toledo (FG 3)
Pending: Bravo – new PHI and rate,
Exempt Status: Ph-D (FG 19)

Integrated annual 6- to 7-spray management programs for the main flower, foliar, and fruit fungal diseases (brown rot, shot hole, jacket rot, scab, rust, Alternaria leaf spot, hull rot) and pests are being developed (*see* Almond Scab and Alternaria Leaf Spot poster)

No new fungicide resistance outbreaks!

Fungicides for Managing Almond Diseases

Inorganics and Conventional Synthetics

- Inorganics: M1+2 — Copper, Sulfur — 1960s
- Dithiocarbamates: M3 — Ziram, Manzate, Dithane — 1940s
- Phthalimides: M4 — Captan — 1950s
- Isophthalonitriles: M5 — Bravo, Echo, Equus — 1960s
- Guanidines: U12 — Syllit — 1960s
- Benzimidazoles: 1 — Topsin-M, T-Methyl — 1970s
- Dicarboximides: 2 — Rovral, Iprodione, Nevado, Meteor — 1980s
- Sterol inhibitors (DMIs): 3 — Rally, Indar, Tilt, Bumper, Quash, Inspire, Tebuzol, Toledo — 1970s - 1980s
- SDHIs: 7 — Xemium, Luna Privilege, Kenja, Fontelis — 1960s
- Anilinopyrimidines: 9 — Vangard, Scala — 1990s
- QoIs: 11 — Abound, Gem, Headline, — 1990s
- Hydroxyanilides: 17 — Elevate — 1990s
- Polyoxins: 19 — Ph-D — 1960s
- Phosphonates: 33 — ProPhyt, K-Phite, Fungi-phite, *Aliette, Linebacker (non-bearing)* — 1980s

Pre-mixtures

- Inspire Super — 3+9
- Quadris Top, Quilt Xcel — 3+11
- Pristine, Luna Sensation, Merivon — 7+11
- Luna Experience — 3+7
- Viathon — 3+33

Multi-site mode of action | Single-site mode of action | Reduced-risk fungicides | FRAC group

Natural Products and Biocontrols

Actinovate, Botector, Fracture, Ph-D, Regalia, Serenade Opti, Serenade Max

Natural products/biocontrols for organic almond production

Polyoxin-D has an exempt status!

Brown Rot Blossom Blight, Jacket Rot, and Shot Hole

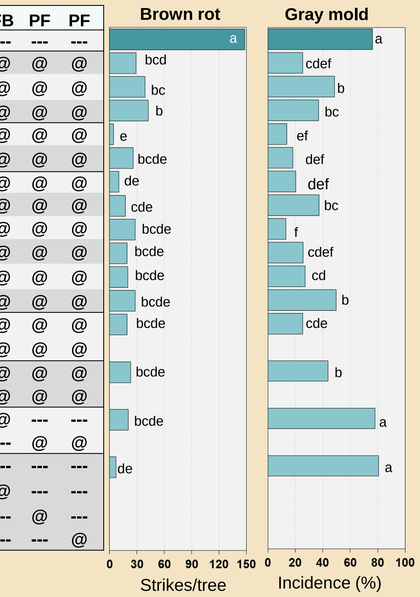
Efficacy of new and registered fungicides

Trial 1 – Brown rot and gray mold
cv. Drake, UCD – high disease pressure

New highly effective fungicides:
EXP-1, EXP-2, EXP-3

Gray mold assay

No.	Treatment*	Rate/A	PB	FB	PF	PF
1	Control	---	---	---	---	---
2	EXP-1	4 fl oz	@	@	@	@
3	Fontelis	20 oz	@	@	@	@
4	Kenja	13.7 fl oz	@	@	@	@
5	Kenja + IB18220	10.3 + 6.9 fl oz	@	@	@	@
6	Kenja + IB18121	8.6 + 12.9 fl oz	@	@	@	@
7	Luna Experience + NIS	6 fl oz	@	@	@	@
8	Luna Sensation + NIS	5 fl oz	@	@	@	@
9	EXP-2	7 fl oz	@	@	@	@
10	EXP-3	7 fl oz	@	@	@	@
11	EXP-3	8.5 fl oz	@	@	@	@
12	Merivon	5.5 fl oz	@	@	@	@
13	Syllit	1.5 lb	---	@	@	@
	Tebuconazole	4 fl oz	@	@	@	@
14	Syllit	2 lb	---	@	@	@
	Tebuconazole	4 oz	@	@	@	@
15	Indar 2F + surf	6 + 16 fl oz	@	@	---	---
	Dithane + surf	144 + 16 fl oz	---	---	@	@
16	Vangard	5 oz	@	---	---	---
	Quadris Top + NIS	14 fl oz + 16 fl oz	---	@	---	---
	Bravo	64 fl oz	---	---	@	---
	Inspire EC	7 fl oz	---	---	---	@



Best treatments

Brown rot
- Most effective: Dicarboximides (FG 2), DMIs (FG 3), SDHIs (FG 7), APs (FG 9).
- Pre-mixtures: FG 3+7, 3+9, 3+11, and 7+11.
- Pre-mixtures provide highest efficacy, consistency, and resistance management.

Gray mold
- Most effective: SDHIs (FG 7) and APs (FG 9). New: EXP-1, a new effective botryticide.
- Effective pre-mixtures: FG 3+7, 3+9, 3+11, 7+11, and 3+33. New: EXP-2, EXP-3.

Shot hole
- Most effective: M3-M5; pre-mixtures of FG 3+7, 3+9, 3+11, 7+11, mixture U12+FG 3.

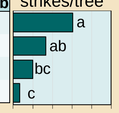
Natural products (OMRI approved for organic farming)
- Fracture and Botector: activity against blossom blight in lab studies.

Ph-D – exempt status (no tolerance needed)
- Very good activity against gray mold, scab, Alternaria leaf spot

Timing of bloom applications:

Determining factors	PB or FB application	PB and FB application
Environmental conditions (rain)	Less favorable	Highly favorable
Fungicide properties	Locally systemic action	With or without locally systemic action

Treatment	Rate/A	PB 23-Feb	FB 28-Feb
Control	---	---	---
Quadris Top	14 fl oz	@	---
Quadris Top	14 fl oz	---	@
Quadris Top	14 fl oz	@	@



Hull Rot - Causal agents: *Rhizopus stolonifer* and *Monilinia fructicola*

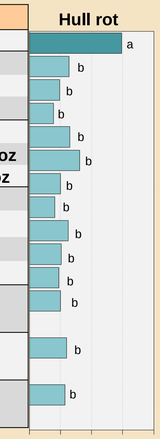
Hull rot caused by 1) *Rhizopus stolonifer* or 2) *Monilinia fructicola.* 3) Dieback associated with hull rot.

Inoculum of *Rhizopus stolonifer* is omnipresent (soil). Inoculum of *Monilinia fructicola* originates from almond and possibly other stone fruits (i.e., peaches, cherries). (Blossom blight can be caused by *M. laxa* and *M. fructicola*). The two hull rot pathogens require different management strategies and the severity of the disease is reported to be related to fumaric acid production by *R. stolonifer*.

Field efficacy trials for management of hull rot

Trial 1: cv. Nonpareil, San Joaquin Co. – Fungicides and basic fertilizers

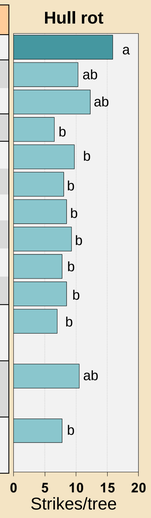
Treatment	Rate/A
Control	-----
Double OK 0-0-30	3 gal / 64 fl oz*
Di-potassium phosphate	32 oz / 48 oz**
Inspire	7 fl oz
Quash + S-2200	3.36 oz + 3.36 fl oz
Double OK 0-0-30 + Qu Top + Dyn.	384/ 64 fl oz* + 14 + 16 fl oz
Di-K phosphate + Qu Top + Dyn.	32 / 48 oz** + 14 + 16 fl oz
Quadris Top + DyneAmic	14 + 16 fl oz
Merivon	6.5 fl oz
EXP-2	7 fl oz
EXP-3	7 fl oz
Ph-D + Quash + NF-P	6.2 + 3 oz + 8 fl oz
Ph-D + Abound + NF-P	6.2 oz + 12 + 8 fl oz
Luna Experience	6 fl oz
Luna Sensation	5 fl oz
Luna Sensation	5 fl oz
Luna Experience	6 fl oz



*- Used 384 fl oz in the first and 64 fl oz in the second application.
**- Used 32 fl oz in the first and 48 oz in the second application.

Trial 2: cv. Nonpareil, Colusa Co. – Fungicides and soil treatments for inoculum reduction

Treatment	Rate/A	5/12	6/11	7/20
Control	-----	---	---	---
Calcium sulfate*	45 lb	@	@	---
Inspire	7 fl oz	---	@	@
Quash + S-2200	3.36+3.36 fl/ oz	---	@	@
Quadris Top + Dyn.	14 fl oz+16 fl oz	---	@	@
Luna Experience	6 fl oz	---	@	@
EXP-2	7 fl oz	---	@	@
EXP-3	7 fl oz	---	@	@
Merivon	6.5 fl oz	---	@	@
Viathon	64 fl oz	---	@	@
Ph-D + Quash + NF-P	6.2+3+8 fl /oz	---	@	---
Ph-D + Abound + NF-P	6.2+12+8 fl/ oz	---	---	@
Luna Experience	6 fl oz	---	@	---
Luna Sensation	5 fl oz	---	---	@
Luna Sensation	5 fl oz	---	@	---
Luna Experience	6 fl oz	---	---	@



Calcium sulfate was applied to the soil under the tree canopy by spraying (1 gal/tree).

Alkaline treatments were evaluated to possibly neutralize fumaric acid that is released by *R. stolonifer* into host tissues.
- Foliar applications of alkaline fertilizers were similarly effective as some of the fungicide treatments (Trial 1).

Inoculum reduction treatments:
- Soil treatments with calcium sulfate (Trial 2) or liquid lime sulfur (Trial 3) to reduce inoculum of *R. stolonifer* were not effective.
- Most fungicides performed similarly and significantly reduced the amount of disease as compared to the control.

Summary

Hull can be managed with fungicides and possibly with alkaline foliar fertilizers

- **For *Rhizopus* hull rot**, early hull split applications when susceptibility is high should be done. (*R. stolonifer* generally infects injured - hull split or senescent tissues). Fungicides are applied most effectively with NOW applications.
- **For *Monilinia* hull rot,** applications should be done earlier in late spring (*M. fructicola* infects immature and mature hull tissues).
- **Both pathogens are usually present at varying frequencies among locations and years.** Recommendations: 1-2 treatments should be applied in early/mid-June, and another one at early hull split.
- **Effective treatments**: FG 3+7, 3+9, 7+11, 3+11, 3+19.
- **For the most effective integrated management of hull rot**, fungicides should be integrated with proper water management (i.e., deficit irrigation) and restricted nitrogen fertilization (applied before cut-off date, i.e., estimated to be early May for Nonpareil).

Trial 3: cv. Nonpareil, San Joaquin Co. – Fungicides and soil treatments with liquid lime sulfur for inoculum reduction

Sub-plot appl.	6/12	Control		Luna Experience		Quadris Top + Dyn		Merivon		Inspire		Main plot
	7/14	Control		Luna Sensation		Quadris Top + Dyn		Merivon		Inspire		Treatment Avg
Main Plot	Appl. Date	Dis. Inc.^	LSD^^	Dis. Inc.	LSD	Dis. Inc.	LSD	Dis. Inc.	LSD	Dis. Inc.	LSD	Dis. Inc.	LSD
Control	---	22.6	A a	12.0	AB a	8.3	B a	12.5	AB a	7.8	B a	15.4	a
LLS 15 gal/A	5-7/6-3	23.5	A a	9.3	B a	6.8	B a	9.7	B a	9.7	B a	14.3	a
Sub-plot trt avg		23.1	A	10.4	B	7.4	B	10.8	B	8.9	B		

Disease values are the number of hull rot strikes counted per tree. ^^- Values followed by the same number are not significantly different based on ANOVA and LSD mean separation (P > 0.05). Statistical comparisons for values by column are with lower case letters, those by row are with upper case letters. Main plot treatment averages are values for treatments over all sub-plots and are statistically compared by column. Sub-plot averages are values for each of the main plots and are statistically compared within the row.