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

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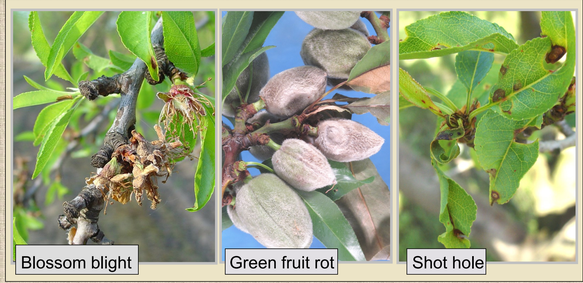


New fungicide developments and management strategies for almond

Newly registered: Merivon (FG 7/11), Syllit (U 12), Viathon (FG 3+33), Manzate (M3), Dithane (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**: Copper, Sulfur (M1+2) 1960s
- **Dithiocarbamates**: Ziram, Manzate, Dithane (M3) 1940s
- **Phthalimides**: Captan (M4) 1950s
- **Isophthalonitriles**: Bravo, Echo, Equus (M5) 1960s
- **Guanidines**: Syllit (U12) 1960s
- **Benzimidazoles**: Topsin-M, T-Methyl (1) 1970s
- **Dicarboximides**: Rovral, Iprodione, Nevado, Meteor (2) 1980s
- **Sterol inhibitors (DMIs)**: Rally, Indar, Tilt, Bumper, Quash, Inspire, Tebucon, Toledo (3) 1970s - 1980s
- **SDHIs**: Xemium, Luna Privilege, Fontelis (7) 1960s
- **Anilinopyrimidines**: Vangard, Scala (9) 1990s
- **Qols**: Abound, Gem, Headline, (11) 1990s
- **Hydroxyanilides**: Elevate (17) 1990s
- **Polyoxins**: Ph-D (19) 1960s
- **Phosphonates**: ProPhyt, K-Phite, Fungi-phite, *Aliette, Linebacker (non-bearing)* (33) 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

Regalia, Actinovate, Ph-D, Serenade Optimum, Serenade Max

Natural products/biocontrols for organic almond production

Polyoxin-D has an exempt status!

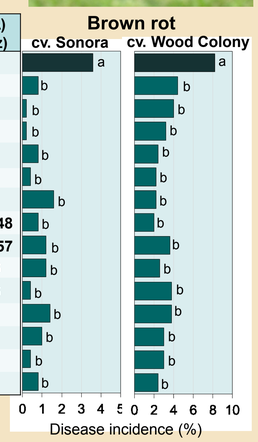
Brown Rot Blossom Blight, Jacket Rot, and Shot Hole

Efficacy of new and registered fungicides

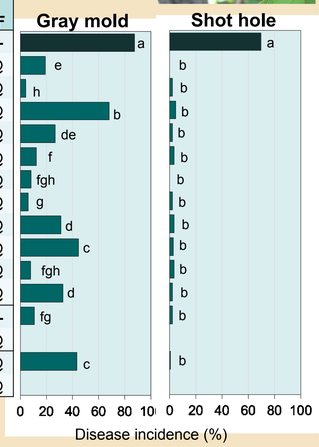
Trial 1 – Brown rot
cvs. Sonora and Wood Colony, KARE – low disease pressure

Trial 2- Gray mold and shot hole
cv. Drake, UC Davis – low disease pressure (high incidence, but low severity)

Treatment	Rate (/A) (oz/fl oz)
Control	---
Ph-D	10
Indar 2F + Breakthru	4 + 16
Rhyme	7
Fontelis + Latron	20 + 7
EXP-1	5.14
Syllit + Tilt	24 + 4
EXP-1 + Headline	3.43 + 5.48
EXP-1 + EXP-2	3.43 + 4.57
Quadris Top + DyneAmic	14 + 16
Inspire Super + DyneAmic	20 + 16
Luna Experience	6
Luna Sensation	5
Merivon	5.5
Viathon	32



Treatment	Rate (/A) (oz/fl oz)	PB	FB	PF	PF
Control	---	---	---	---	---
Rhyme	7	@	@	@	@
Quash	3	@	@	@	@
Fontelis	20	@	@	@	@
Isofetamid	17	@	@	@	@
EXP-1	5.14	@	@	@	@
EXP-1 + Headline	3.43 + 5.48	@	@	@	@
EXP-1 + EXP-2	3.43 + 4.57	@	@	@	@
Isofetamid + IB18111	10.3 + 5.57	@	@	@	@
Isofetamid + IB18121	10.3 + 11	@	@	@	@
Luna Experience + surf	6 + 6	@	@	@	@
Luna Sensation + surf	5 + 6	@	@	@	@
Viathon	32	@	@	---	---
Catamaran	64	---	---	@	@
Bumper	4	@	@	@	@
Syllit	24	---	@	@	@



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.
- New FG 7/11 pre-mixture: Merivon

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

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

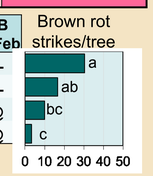
Natural products
- Serenade Optimum, Taegro, and Botector: activity against blossom blight in lab studies.

Ph-D – exempt status
- Very good activity against gray mold, scab, Alternaria leaf spot

Considerations for 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*

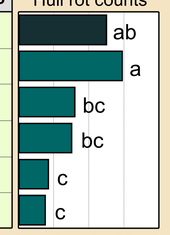
1) and 2): Hull rot caused by *Rhizopus stolonifer* with infected fruit. Sporulation may cover the fruit under high humidity conditions. 2) Hull rot caused by *Monilinia fructicola* and dieback.

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.

1. Timing studies to control hull rot cv. Nonpareil, Stanislaus, San Joaquin, and Colusa Co.

Hull rot caused mostly by *M. fructicola* but also *R. stolonifer*

4-4	4-25	6-6	7-13
---	---	---	---
---	---	---	@
@	---	---	---
---	@	---	---
---	---	@	---
@	@	@	---

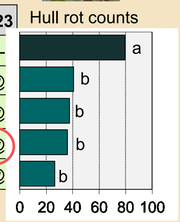


Critical timing

2012: Luna Experience 8 fl oz was used. In Stanislaus Co., 9.5 mm (0.37 in) precipitation. Full split on 7-13-12.

Hull rot mostly caused by *R. stolonifer*

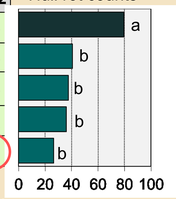
6/10	6/24	7/10	7/23
---	---	---	---
@	---	---	@
---	@	---	@
---	---	@	@
@	@	@	@



Critical timings

Hull rot caused mostly by *R. stolonifer*

6/10	7/9	7/22
---	---	---
@	---	---
---	@	---
---	---	@
@	@	@



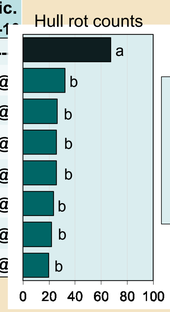
Critical timings

2014: Ph-D 6.2 oz + Quash 3 oz + NuFilm-P 8 fl oz. was used. No precipitation in San Joaquin (left) or Colusa (right) Co. Full split on 7-23-14.

Pathogen = *M. fructicola*: Pre-hull split applications (early/mid June)
Pathogen = *R. stolonifer*: Early to late hull split applications but earlier applications at pre-hull split also help to manage the disease.
Both pathogens: Applications in early/mid June and at early hull split.

2. Fungicide comparison: Test plot with mainly *R. stolonifer*

Treatment	Rate (/A) (oz/fl oz)	Applic. 6-5	7-1
Control	-----	-----	---
Quash + S2200	3.36 + 3.36	@	@
Luna Experience	8	@	@
Ph-D + Tebucon*	6.2 + 8 + 8	@	@
Inspire Super*	20 + 16	@	@
Quadris Top*	14 + 16	@	@
Ph-D + Quash*	6.2 + 3 + 8	@	@
Luna Sensation	5	@	@



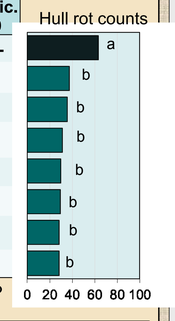
cv. Nonpareil, San Joaquin Co.
* Added DyneAmic or NuFilm-P

Numerous effective treatments available: FG 3, 7, 19, 3/7, 3/11, 7/11. Reduction of disease up to 70%.

3. Evaluation of potential enhancing treatments

Alkaline treatments were evaluated to possibly neutralize fumaric acid that is released by *R. stolonifer* into host tissues.

Treatment	Rate (/A) (oz/fl oz)	Applic. 7-9
Control	----	-----
Lime	130	@
Quadris Top*	14 + 16	@
Baking soda + Ph-D + Quash*	130 + 6.2 + 3	@
Luna Sensation	5	@
Baking Soda	130	@
Baking soda + Quadris Top*	130 + 14 + 16	@
Baking soda + Luna Sensation	130 + 5	@



cv. Nonpareil, San Joaquin Co.,* Added DyneAmic or NuFilm-P

- Lime and baking soda were similarly effective as several fungicides indicating that acid substances released by the pathogen are involved in pathogenesis.
- Lime and baking soda did not increase fungicide efficacy when used in mixtures.

Management of hull rot - Summary -

Fungicide treatments can be effective in reducing hull.

- **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 replacement nitrogen fertilization (before cut-off date, estimated early May for Nonpareil).