Sacramento Valley Almond News

Winter, 2024

University of California
Agriculture and Natural Resources | Cooperative Extension

In This Issue

Franz Niederholzer
UCCE Advisor
Colusa, Sutter, Yuba Counties

2024 Sacramento Valley Orchard Meeting Save the Dates!

Tue Jan 30 8:00 to Noon	Almond Meeting, Arbuckle	Arbuckle Golf Club
Tue Jan 30 1:00 PM to 5:00 PM	Almond Meeting, Woodland	Norton Hall, Woodland
Wed Jan 31 7 AM - Noon	North Valley Nut Conference	Silver Dollar Fairgrounds Chico, CA
Th Feb 1 7:30 AM to Noon	Northern Sacramento Valley Prune Day	Elk's Lodge Red Bluff, CA
Fri Feb 9 8:30 AM - 12:30 PM	Sutter-Yuba Peach Day	UCCE Sutter-Yuba Office Yuba City, CA
Tue Feb 20 7:30 AM to Noon	North Sac Valley Olive Day	Orland, CA
Wed Feb 21 8:00 AM to Noon	Sacramento Valley Pistachio Meeting	Norton Hall, Woodland
Wed Feb 28 7:30 AM - 2:00 PM	Sutter-Yuba Walnut Day	UCCE Sutter-Yuba Office Yuba City, CA
Tue Feb 27 8:00 AM to Noon	South Sacramento Valley Prune Day	UCCE Sutter-Yuba Office Yuba City, CA
Th Feb 29 7:30 AM to Noon	Northern Sacramento Valley Walnut Day	Elk's Lodge Red Bluff, CA

Details for events at: **sacvalleyorchards.com/events**

Almond Orchard Management Considerations – Pre-bloom through March

Becky Wheeler-Dykes, UCCE Farm Advisor, Glenn, Tehama and Colusa Counties

Irrigation maintenance: A thorough checkup of your well, pump, and irrigation system components is critical ahead of bloom to ensure the ability to mitigate frost damage. Growers in Tehama, Butte, Glenn and Shasta Counties can utilize free irrigation evaluations through the Tehama Resource Conservation District Mobile Irrigation Lab. Growers in the southern Sacramento Valley should contact the Yolo/Sutter Mobile Irrigation Lab. This lab provides free services to growers in Yolo, Colusa, Sutter, and Yuba Counties.

NOW sanitation: High 2023 populations of navel orangeworm could provide an abundance of overwintering NOW. This year, orchard sanitation will be more crucial than it has been in years. Reduce mummy nuts to no more than 2 mummies/tree on average by early February. Blow/sweep nuts into middles and flail mow or otherwise destroy the downed nuts by March 1.

Sanitation is more effective with community management – encourage your neighbors to sanitize as well. Don't overlook volunteer almonds along fence lines as well. Read more on the importance of sanitation in articles by Joe Connell and Sudan Gyawaly in this newsletter.

Weed management: Prepare your preemergent herbicide program with your PCA. Material applied in mature orchards can be minimized by narrowing the weed-free strip and relying more heavily on mowing in the middles. Preemergent herbicide is much more effective when applied to bare ground than when soil is covered by dead leaves or weed cover, so clean strips as much as possible before application.
Weeds are particularly competitive in young orchards, where sunlight, water, and nutrients are abundant. Make sure young trees are adequately protected by cartons or sleeves and keep up on weed management programs. A table detailing currently registered herbicides is included in this newsletter. If you observe reduced herbicide efficacy and suspect a new herbicide resistant weed population, contact UCCE Farm Advisor Becky Wheeler-Dykes at bawheeler@ucanr.edu.

Disease management: check spray equipment and calibrate to prepare for bloom sprays. Be ready to protect trees against bloom diseases based on predicted weather. The most recent fungicide efficacy and timing tables are included in this newsletter. 2022/2023 winter conditions led to outbreaks of bacterial blast affecting almond bloom – check Jaime Ott's newsletter article for more information on management of bacterial blast. Talk with your beekeeper and use tools such as the BeeWhere system through CalAgPermits to check for bee hive locations off your farm and employ best practices to ensure honey bee safety.

Frost protection: Low temperatures in orchards can be manipulated by implementing several tactics during bloom. Tall vegetation on the orchard floor can negatively affect heat storage of soil, lowering air temperatures during frost events. Vegetation should be maintained at 2 inches or shorter to keep temperatures warmer in the orchard. A moist soil surface helps to store heat more effectively during the day, so if soils are dry, irrigate to bring the top foot of soil to near field capacity. Be sure irrigation systems are ready for deployment. If using sprinkler irrigation for frost control, turn-on sprinklers when wet bulb temperature is above the critical temperature for the bloom stage in the orchard and turn off the sprinkler when the wet bulb temperature has recovered to above critical.

Insect pests: Hang NOW traps in March to determine biofix. If using mating disruption, deploy dispensers by late March or early April. Although expensive upfront, UC research has shown that mating disruption can passively work in the background all season long, and yield a positive return on investment.

Biofix dates for other pests should also be established by trapping. San Jose Scale and Oriental Fruit Moth traps should be hung by mid- to late-February. Peach Twig Borer traps should be placed by mid-March.
Nutrition: Nitrogen and potassium used by the crop should be replaced each year to maintain yields and long-term health of trees, even in lean price years. Approximately 68 pounds of nitrogen and 80 pounds of actual potassium should be applied for every 1,000 pounds of kernel yield removed from the field the previous year. Be sure to consider the right time, place, material, and amount for all fertilizer applications. Check with your farm advisor and/or your CCA regarding best management practices for nitrogen and potassium use in almond.

Efficacy of a Hull Split Spray vs. Sanitation for NOW Control

Joseph Connell, Farm Advisor Emeritus, Butte County

Navel orangeworm (NOW) is most effectively controlled with the cultural practice of winter sanitation. Winter shaking almond trees to remove mummy nuts has proven to decrease next year's NOW damage better than any other approach. The reason for this is clear. NOW overwinters as larvae in mummy nuts left in the tree after harvest and it is in these nuts the population carries over into the next season. Adult moths emerge in spring, mate, and lay eggs on mummies that are still in the trees as the females can't find the new crop nuts until hull split. The second generation will then put direct pressure on the new crop nuts at hull split and the third generation will chew the nuts up during the harvest period.

The way almond prices have been going recently, there's no doubt that everyone is going to have to spend dollars as wisely as possible for the foreseeable future. Although cleaning the trees of mummies during the winter isn't cheap, it is the method of NOW control where you clearly get the most bang for the buck spent. **We're really playing a numbers game here, and this is one practice that is stacked in our favor by the biology of this pest.**

For example, let's assume a potential of 50 mummies per tree and 30 of them each have 1 NOW larvae. Half of those are female, and each female lays approximately 85 eggs. At harvest in late July we're into the third generation, and for arguments sake let's assume there's no natural mortality.

Look at what could theoretically happen to the worm population in one Nonpareil tree with 30 infested over-wintering mummies and no control:

- 1^{st} generation: 15 females x 85 eggs/female = 1,275 larvae
- 2^{nd} generation: 1,275/2 (half female) x 85 eggs = 54,188 larvae
- 3^{rd} generation: 54,188/2 x 85 = 2,302,990 larvae per tree at harvest!!!

(Thankfully, there **<u>IS</u>** natural mortality or else we'd be knee deep in worms!)

Now, look at the impact of a hull split spray aimed at the second NOW generation. We know that sprays give at best about 60 percent control. This reduces the population but is not nearly as good as sanitation as you will see.

- 2^{nd} generation: 54,188 larvae x 40% survival after the spray = 21,675 larvae
- 3^{rd} generation: 21,675/2 x 85 = 921,196 larvae per tree to attack the crop at harvest.

Now, look at what sanitation does in comparison. Start with the same 30 infested mummies per tree, then winter clean down to 2 mummies per tree. One is female, one is male.

- 1^{st} generation: 1 female x 85 eggs/female = 85 larvae
- 2^{nd} generation: 85/2 (half female) x 85 eggs = 3,613 larvae
- 3^{rd} generation: 3,613 larvae/2 x 85 = 153,531 larvae per tree at harvest.

(If you can beat the 3^{rd} generation by an early harvest you're even further ahead.)

So, a hull split spray reduced the worm population by 60 percent, but sanitation by itself, without spraying, reduced the population by 94 percent! When more NOW larvae make it through the winter, more egg laying will occur next season regardless of what else you do. In relation to the number of mummies left in the tree**, expensive chemical treatments next season will only slow the rate of worm damage increase**.

If you have scarce dollars to spend on NOW control, spend them this winter when they will do the most good in a sanitation program. If the entire neighborhood works at this, the positive effect will be multiplied many times over for everyone. If you've got neighbors that don't seem to get it, cleaning your orchard will still be a tremendous help to you. If you have no mummies, the first generation in the spring won't be able to build up and establish a population in your orchard. You'll benefit since they'll have to fly in from the neighbors after hull split before they can begin to hurt your crop.

- Be sure to finish the job by destroying the infested nuts once they're on the ground. Mow and shred the mummies next spring before March 1^{st} so NOW moths don't have a chance to emerge. When you're enjoying mowing during bloom next spring, take personal satisfaction in seeing the chips and pieces of almond fragments and mangled worm parts fly out from under your mower!

Wet winter concerns: *Phytophthora* and waterlogging

Jaime Ott, UCCE Tehama, Shasta, Glenn, and Butte Counties

We had bountiful rain last winter, and orchards with standing water were a common sight. This year, we could get a wet late winter or spring, so it is well worth preparing for flooding. Excessive water, caused by rain, flooding, or even overirrigation, is a challenge for orchards and can cause two very different problems: waterlogging and *Phytophthora* infection.

The Bottom Line

- Take photos/notes of flooded sections of your orchard. Even with no standing water, dig down with a shovel or auger to monitor soil saturation in the top 2 feet.
- Check stem water potential using a pressure chamber before starting irrigation in the spring. Beginning irrigation too early in the season will compound the problem of excess winter water.
- Symptoms of *Phytophthora* infection and waterlogging overlap. Work with your farm advisor or PCA to submit samples and determine if you are dealing with *Phytophthora*.
- For waterlogging: the only solution is to remove the excess water (or wait for it to dry out).
- For *Phytophthora*: Phosphonate applied as a foliar spray in the fall can protect trees for up to 5 months. Mefenoxam (Ridomil Gold), Oxathiapiprolin (Orondis), and Fluopicolide (Presidio) are effective treatments, but expensive. Other fungicides will not work. See 2024 Fungicide Efficacy and Timing tables at the end of the newsletter for more information.

For the future

- Plant trees high (on mounds, islands, or berms) to keep the root crown out of saturated soil.
- Maintain your drains and ditches to move water out of the orchard.
- If flooding is an issue in your orchard, plant on rootstocks tolerant of wet feet such as Krymsk 86 or Rootpac-R (Rootstock Comparison Chart).

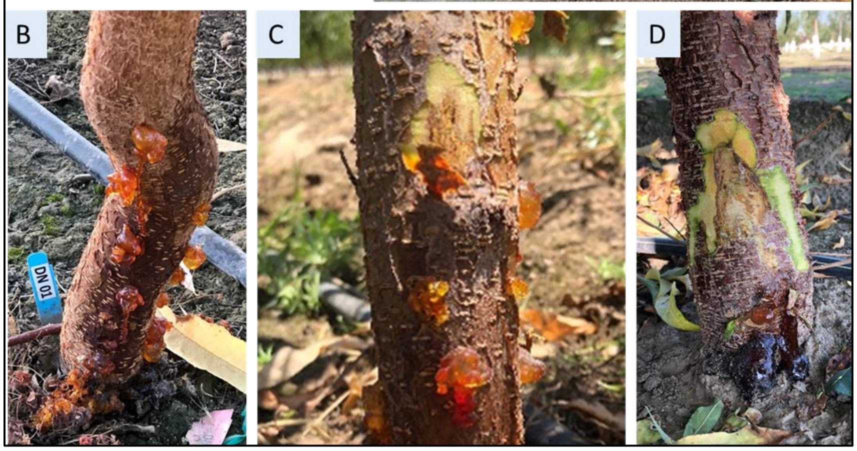
The Context

Waterlogging is a physiological problem which happens when the soil in the root zone of the tree (the top 2 feet or so) is saturated with water for extended periods of time. Roots need oxygen to survive, but saturated soil cannot hold much oxygen. Eventually the roots suffocate and die: fine roots die first, but larger roots can also die if the saturated conditions persist for long enough. Trees are most sensitive to excess water when they are actively growing and the weather is warm. Waterlogging can lead to leaf yellowing, poor vigor, lack of fine roots, defoliation, and (over an extended period) tree death. **These symptoms will generally improve once the excess water is gone and the tree has had a chance to regrow the fine roots that it lost.**

Phytophthora infection, on the other hand, is caused by an aggressive pathogen taking advantage of soil saturation. When orchards are flooded, or soil is saturated with water for more than 24 hours, any *Phytophthora* living in the soil can produce spores which sense and swim towards a tree, where they initiate infection. Symptoms of *Phytophthora* infection depend on where the tree has been infected. Root infections lead to leaf yellowing, poor vigor, lack of fine roots, and eventual tree death. Trunk infections lead to leaf yellowing, poor vigor, amber-colored gumming on the trunk, and sudden tree collapse after bud push or when the weather warms up (see photos below). Under normal circumstances trunk infections will start below the soil line, but if an orchard has been exposed to flooding, infections can start as high as the water level was on the trunk or scaffolds. **Once the tree is infected, symptoms can progress even without the presence of excessive water.**

Symptoms of *Phytophthora* infection in almond.
Phytophthora infection can cause tree collapse (A). Commonly, amber-colored gum will be visible on the trunk (B,C,D) at the edges and center of the region of infected tissue. This dead or infected tissue is known as a canker. Peeling away the bark will expose the canker. The canker can appear reddish-brown (C) or yellowish with a dark brown edge(D). Note that other diseases and disorders can cause gumming and cankers in almond, so it is important to reach out to your local farm advisor or PCA for sampling to confirm *Phytophthora* infection.

Photo credit: Greg Browne



Winter sanitation critical for reducing insect pest damage risk to almonds in 2023-2024

Sudan Gyawaly, Area IPM Advisor, Butte, Colusa, Yuba-Sutter, Glenn, and Tehama Counties

The California nut industry experienced alarmingly high navel orangeworm (NOW) damage this past year. Sacramento Valley growers were not an exception, and many growers in our area experienced levels of damage not seen since the early 1980s. Statewide, insect (NOW) damage in processor reports is expected to be at least 4% with actual damage at least 8% of the total crop. On average, NOW cost California growers hundreds of dollars per acre. NOW is probably the most challenging pest to control in almond production. Various biological (ability to reproduce large numbers of offspring per generation over multiple generations per season, for example) and behavioral (ability to reproduce and survive on multiple and poor-quality hosts, ability to fly among crops/orchards) characteristics of this pest and its relationship to crop phenology (i.e., hullsplit) make it difficult to predict its risks and the effectiveness of management practices in a particular year. For pests like NOW, which can cause substantial damage if unchecked, minimizing the risk of damage requires using multiple management tactics. These practices are winter sanitation, mating disruption, well-timed insecticide sprays, and timely harvest.

Winter sanitation is the practice of removing and destroying unharvested ("mummy") nuts and is widely recognized as the foundation of NOW management. Mummy nuts support NOW by providing a shelter for overwintering larvae and serve as the only habitat for egg laying and survival of the first generation NOW in an orchard. With high pest pressure in the fall of last year, mummies likely had a higher NOW infestation rate than in "normal" years. Performing winter sanitation properly helps check NOW population build-up, and thus the damage, both by directly killing NOW worms that shelter in the mummy nuts during winter and by depriving NOW adults and larvae of the shelter and food during spring.

Determining winter sanitation needs and sanitation methods.
To determine the need for sanitization, count the number of mummy nuts in 20 trees, including all varieties, in each block once leaves are off the trees. In the Sacramento Valley, UC IPM recommends sanitizing to fewer than two nuts/tree on average (fewer than 40 nuts total on the 20 trees). However, in the southern San Joaquin Valley, where NOW pressure is usually higher than in the Sacramento Valley, UC IPM recommends sanitizing mummies to 1 per 5 trees (0.2 nuts/tree, or 4 nuts total on the 20 trees) and eight or fewer mummies on the ground in order to reduce NOW damage in the next crop. Given that NOW damage in our region this year was comparable to the southern San Joaquin Valley, practicing more stringent sanitization is essential, especially if you encountered a high level of NOW damage this year. Remove mummy nuts from trees by shaking trees (and/or hand polling if necessary) to remove nuts before bud swell. In a recent study shaking was done into early February without reducing yield. Finally, blow or sweep fallen nuts into orchard middles and flail mow by mid-March. Confirm successful sanitation by counting remaining mummies in trees and on the ground after shaking and mowing.

Mummy shaking in action at Nickels almond orchard, Arbuckle, CA (December 21, 2023)

Winter sanitation can help reduce the risk of other pests.
Recently, an invasive insect pest known as carpophilus beetle has been detected attacking almonds and pistachios in multiple San Joaquin Valley counties (Stanislaus, Merced, Madera, and Kings). This beetle can also attack walnuts, based on reports from other countries, including Italy, Chile, and recently Australia.

Carpophilus beetle (Scientific name, *Carpophilus truncatus*) is a tiny insect (~ 1/10th of an inch long) that has become a key pest of almonds in Australia since 2013. The carpophilus beetle attacks nut crops by infesting nut kernels. Infested kernels, especially almonds, can sometimes have 'oval tunnel' and 'fine powdery frass' on the nutmeat that may indicate carpophilus beetle infestation. The fine powdery frass on the surface of the kernel also resembles pin hole damage caused by first instar NOW larvae. Oval tunnels, powdery frass, and lack of webbings in the kernel are strong indicators of beetle infestations.

Adult carpophilus beetles (left) and oval hole on almond kernel made by beetle feeding (right), Photos: Jhalendra Rijal (left) and Houston Wilson (right)

There are a lot of unknowns about this pest, such as its damage potential and monitoring and management methods in California. However, available information indicates this beetle relies on nuts on the ground and in trees for their survival, so the removal and destruction of mummies is the only effective way to minimize the chances of establishment and damage by this pest.

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Preventing Bacterial Blast Damage in 2024

Jaime Ott, UCCE Tehama, Shasta, Glenn, and Butte Counties

In 2023, the cold, wet weather during bloom and leaf-out resulted in [bacterial blast damage] in many Sacramento Valley almond orchards. If conditions this year are cold and wet during bloom, we may see a recurrence of blast: make a plan now to keep blast damage to a minimum.

The Bottom Line:

- Bacterial blast can be a problem when cold, wet conditions coincide with bloom or leaf-out.
- Copper resistance is common in the pathogen: spraying copper is ineffective for preventing blast in many orchards.

- Frost protection is the most economical prevention option and will help prevent damage from both frost and bacterial blast.
- The antibiotic kasugamycin (Kasumin®) is effective for preventing blast when applied up to 7 days before cold, wet weather. It will likely be available this year under an emergency exemption registration (Section 18) but is not currently labeled for almond under a full registration (Section 3).

The Details:

Pseudomonas syringae pv. syringae (*Pseudomonas*) is a bacterium which can infect all aboveground parts of an almond tree. If leaves, flowers, or spurs are infected, the resulting disease is bacterial blast. *Pseudomonas* is ubiquitous in orchards, so bacterial blast is likely to develop whenever environmental conditions are cold and wet, which favors this disease. *Pseudomonas* is spread by water hitting the trees, either from rain or sprinklers. If this wetting occurs at the same time as frost damage, *Pseudomonas* can enter the tree through cells damaged by freezing. Trees are especially susceptible to frost damage during bloom and leaf-out, when tender new growth is exposed to cold temperatures.

Preventing infection by *Pseudomonas* is the only way to control bacterial blast. Frost protection in an orchard is your best defense and your most inexpensive prevention strategy: if the trees are not damaged by frost, *Pseudomonas* will not be able to enter the tree to cause disease. As a second line of defense, research has shown that kasugamycin (Kasumin®) is effective for preventing bacterial blast when applied no more than 7 days before cold, wet weather. Note that kasugamycin is currently not labeled for use in almond and will only become available when a Section 18 exemption is approved for this year (Feb. 1). If it is approved for use, and if the weather warrants treatment, kasugamycin can be used as a preventative spray up to two times during bloom. For this spray, complete coverage is crucial for control: all tender new growth must be covered in a protective layer of the antibiotic for it to be effective. Any tissue left uncovered will be unprotected.

What about copper? Current work by UC researchers shows that copper-resistance is common in *Pseudomonas* throughout the state. Many of the orchards heavily affected by blast in 2023 received multiple dormant sprays containing copper. In some cases, mixing mancozeb with copper may provide some level of control, but research shows that this mixture is not as effective as kasugamycin and the copper can cause phytotoxicity.
For more information on bacterial blast, check out these articles at sacvalleyorchards.com

Bacterial blast/canker: What do we know? - an update on the factors predisposing orchards to damage by bacterial blast, and more details about control strategies for bacterial blast

Bacterial Blast and Canker - a good description of the various symptoms seen with bacterial blast.

Dead leaf bundles, spotted and misshapen leaves, dead flowers, and aborted nuts are symptoms of bacterial blast, caused by *Pseudomonas syringae pv. syringae*. These symptoms only become apparent after trees are infected and the damage is done.

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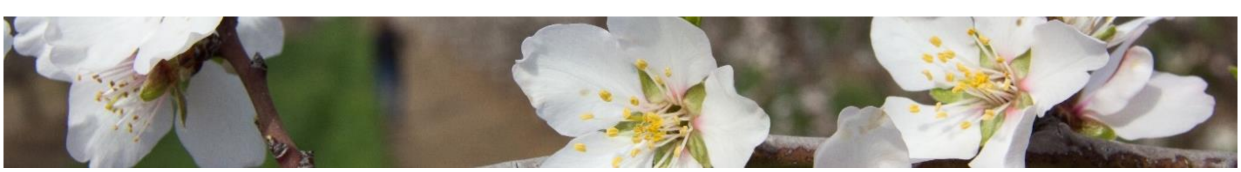
2024 UCCE Yolo-Solano-Sacramento Almond Meeting

January 30, 2024

Norton Hall, 70 Cottonwood St, Woodland 1:00 pm – 5:00 pm

3.0 hours of DPR CE hours requested (0.5 L&R, 2.5 Other)
3.0 CCA CE hours requested (2.5 hrs IPM, 0.5 hrs PD)
(Note: Many of the same presentations will be made in Arbuckle the morning of Jan 30^{th})

1:00 PM	**Almond pest management in lean times** David Haviland, UCCE Kern County
1:45 PM	**Managing bacterial and fungal pathogens in almonds in lean times** Jim Adaskaveg, UC Riverside
2:30 PM	**Resource Conservation Incentive Opportunities**
2:45 PM	**Break**
3:00 PM	**Lean weed management in almonds** Brad Hanson, UC Davis
3:30 PM	**Laws & Regulations Update** Molly Matthews, Yolo County Agricultural Commissioner's Office
4:00 PM	**Carpophilus beetle: A new pest to watch for in almonds** Houston Wilson, UC Riverside
4:30 PM	**Feedback Session: What trainings would be valuable for your employees** Kat Jarvis-Shean, UCCE Sacramento-Solano-Yolo
5:00 PM	**Adjourn**



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2024 UCCE Colusa Region Almond Grower Meeting

Tuesday, January 30, 2024
Arbuckle Golf Club, 5918 Hillgate Rd, Arbuckle
8:00 am – 12:00 pm

2.0 hrs 'Other' and 0.5 hrs Laws & Regs PCA CE hours *requested*
3.0 hours of CCA CE hours *requested* (includes 0.5 hr Sustainabilty + 2.5 hrs IPM)

Thank you, **UPL Ltd** for meeting sponsorship

8:00 AM	**Regenerative Ag in almonds** *Amelie Gaudin, Plant Sciences Department, UC Davis*
8:30 AM	**Managing bacterial and fungal pathogens in almonds in lean times.** *Jim Adaskaveg, Plant Pathology Department, UC Riverside*
9:15 AM	**Sac Valley insect IPM concerns in 2024: orchard sanitation and a new pest** *Sudan Gyawaly, UC IPM Advisor, Sacramento Valley*
9:45 AM	**Break**
10:00 AM	**Almond pest management in lean times** *David Haviland, UCCE Kern County*
10:45 AM	**Lean year weed management in almonds.** *Brad Hanson, UC Davis*
11:30 AM	**Laws and Regulations Update** *Colusa County Ag Commissioners office*
12:00 PM	**Adjourn**

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Excerpt from Adaskaveg et al. "Fungicides, bactericides, biocontrols, and natural products for deciduous tree fruit and nut, citrus, strawberry, and vine crops in California – 2024" UC IPM, Agricultural Pests and Diseases.

ALMOND: FUNGICIDE EFFICACY - CONVENTIONAL

Fungicide	Resistance risk (FRAC)[1]	Brown rot	Jacket rot	Anthrac-nose	Shot hole	Scab[3]	Rust[3]	Leaf blight	Alternaria leaf spot [3]	PM-like[5]	Hull rot[16]
Adament	medium (3/11)	5	4	4	5	4	5	ND	4	4	4
Bumper, Tilt, Propicure, Propiconazole[4]	high (3)	5	1	5	3	3	4	ND	3	4	3
Cevya	high (3)	5	1	5	5	3/4	4	ND	4	ND	4
Fontelis[3]	high (7)	5	5	3	5	3	3	ND	4	ND	0
Kenja[4]	high (7)	5	5	3	5	4	0	ND	4	ND	0
Tesaris	high (7)	5	5	3	5	4	ND	ND	4	ND	0
Indar	high (3)	5	1	4	3	3	NL	ND	2	ND	0
Inspire	high (3)	5	3	5	3	4	5	ND	5	ND	4
Protocol[2]	med.-high (1/3)	5	5	ND	4	4	5	ND	3	ND	2
Inspire Super	medium (3/9)	5	5	ND	4	4	5	ND	5	ND	4
Luna Experience[3]	medium (3/7)	5	4	5	4	5	5	ND	5	4	4
Fervent	medium (3/7)	5	4	5	4	5	5	ND	5	4	4
Luna Sensation[3,7]	medium (7/11)	5	5	5	5	5	5	ND	5	4	4
Miravis Duo	medium (3/7)	5	4	5	4	5	5	ND	5	4	4
Miravis Prime	medium (7/12)	5	4	5	5	5	5	ND	5	5	4
Merivon[3,7]	medium (7/11)	5	5	5	5	5	4	ND	5	5	4
Pristine[3,7]	medium (7/11)	5	5	5	5	5	4	ND	4	4	4
Quadris Top, Acadia ESQ [3]	medium (3/11)	5	5	5	4	5	5	ND	4	4	4
Quilt Xcel, Avaris2XS, AxoxyPropi [3]	medium (3/11)	5	4	5	4	5	5	ND	4	4	4
Quash[4]	high (3)	5	3	5	4	4	5	ND	5	4	4
Rovral + oil[8, 9]	low (2)	5	5	0	4	1	3	ND	4	ND	0
Scala[3, 7, 10]	high (9)	5	5	ND	3	0	ND	ND	2	0	0
Tebucon, Toledo, Teb, Tebuconazole	high (3)	5	1	4	3	3	4	ND	2	ND	3
Viathon	medium (3/ P07,33)	5	1	4	3	3	4	ND	2	ND	3
Topsin-M, T-Methyl, Incognito, Cercobin[2,6,7,8]	high (1)	5	5	0	0	4	2	4	0	3	0
Vangard[3, 7,9, 10]	high (9)	5	5	ND	3	0	ND	ND	2	0	0
Axios Cion	medium (9/52)	5	5	ND	4	3	ND	ND	3	0	0
Abound, Acadia[3], Quadris	high (11)	4	2	5	4	5	5	4	4	4	4
Aproach[3,4,7]	high (11)	4	2	5	4	5	5	4	4	4	4
CaptEvate*	low (M4/17)	4	4	4	4	4	0	4	2	0	0
Elevate[7]	high (17)	4	5	0	2	ND	ND	ND	ND	ND	0
Gem[3,4, 7]	high (11)	4	0	5	4	5	5	4	4	4	4
Laredo, Rally[13]	high (3)	4	0	3	3	0	2	4	0	4	0
Luna Privilege	high (7)	4	3	3	3	4	4	ND	4	3	3
Rovral, Iprodione, Nevado[9]	low (2)	4	4	0	4	0	0	ND	3	0	0
Regev	high (3/BM 02)	5	2	4	3	4	4	ND	4	ND	4
Rhyme	high (3)	4	1	ND	2	3	ND	ND	3	ND	ND
Bravo, Chlorothalonil, Echo, Equus [11, 12, 15]	low (M5)	3	NL	4	4	4	5	NL	NL	0	0
Captan[4, 6, 12]	low (M4)	3	3	4	4	3	0	4	2	0	0
Mancozeb	low (M3)	3	3	4	4	3	4	4	2	0	0
Ph-D/Oso	medium (19)	3	4	0	3	4	4	ND	5	ND	4
Ziram	low (M3)	3	2	4	4	4	0	3	2	0	0
Syllit	medium (U12)	2	0	ND	4	5	ND	ND	2	ND	0
Copper[14,15]	low (M1)	1	1	0	2	2	0	0	ND	0	0
Lime sulfur[12,15]	low (M2)	1	NL	0	1	3	3	NL	NL	0	0
Sulfur[4,12]	low (M2)	1	1	0	0	3	3	0	0	4	0
PlantShield[17]	low (BM 02)	0	0	0	0	0	0	0	0	0	0
Copper + oil[14,15]	low (M1)	ND	ND	0	2	4	0	0	ND	0	0

*** Registration pending in California.**
****Not registered, label withdrawn or inactive in California.**

Rating: 5 = excellent and consistent, 4 = good and reliable, 3 = moderate and variable, 2 = limited and/or erratic, 1 = minimal and often ineffective, 0 = ineffective, NL = not on label, and ND = no data.

FUNGICIDE EFFICACY – PHYTOPTHORA ROOT AND CROWN ROT (PRCR) USING CONVENTIONAL TREATMENTS

Fungicide	Resistance risk (FRAC code)[1]	PRCR
Orondis	high (49)	5
Revus**	high (40)	5
Presidio	high (43)	4
Ridomil, Metalaxyl	high (4)	3
Ridomil Gold, Mefenoxam	high (4)	4
Aliette, ProPhyt, Fungi-Phite, K-Phite	low-medium (P07, 33)	4

[1] Code numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://www.frac.info/). Fungicides with a different Code number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-actions (MOA) with high resistance risk before rotating to a fungicide with a different MOA (Code number); for other fungicides, make no more than two consecutive applications before rotating to fungicide with a different MOA (Code number).

[2] Strains of the brown rot fungi *Monilinia laxa* and *M. fructicola* resistant to Topsin-M and T-Methyl have been found in some California almond orchards. MBC-resistant strains of the jacket rot fungus, *Botrytis cinerea* and powdery mildew fungi, have been reported in California on crops other than almond and stone fruits and may have the potential to develop in almonds with overuse of fungicides with similar chemistry. MBC-resistant strains of the scab fungus, *Venturia* (*Fusicladium, Cladosporium*) *carpophila*, have been found in California.

[3] Field resistance of *Alternaria* sp. and *Fusicladium carpophilum* to QoI and SDHI fungicides has been detected in almond orchards. AP-resistant populations of *Monilinia* spp. have been found on other stone fruit crops in California.

[4] Of the materials listed, only sulfur, Captan (FRAC Code M2, M4), Kenja (FRAC Code 7), Abound, Gem, Aproach (FRAC Code 11), and some of the DMI fungicides (FRAC Code No. 3) are registered for use in late spring and early summer when treatment is recommend.

[5] PM-like refers to a powdery mildew-like disease on almond fruit. Information suggests an *Acremonium* species is involved.

[6] Excellent control obtained when combinations of Topsin-M or T-Methyl and Captan are used.

[7] To reduce the risk of resistance development, start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications per season.

[8] Oils recommended include "light" summer oil, 1-2% volume/volume.

[9] Not registered for use later than 5 weeks after petal fall.

[10] Efficacy reduced at high temperatures and relative humidity.

[11] Bravo Ultrex, Bravo WeatherStik, Echo, Echo Ultimate, and Chlorothalonil are currently registered.

[12] Dormant applications with oil are highly effective against scab, Do not use in-season combinations with oil or shortly before or after oil treatment.

[13] Efficacy is better in concentrate (80–100 gal/acre) than in dilute sprays.

[14] The low rates necessary to avoid phytotoxicity in spring reduce the efficacy of copper.

[15] "Burns out" scab twig lesions when applied at delayed dormant. (Chlorothalonil can be applied with dormant oil during tree dormancy).

[16] Hull rot ratings are for the disease caused by *Rhizopus stolonifer*. Ratings for the disease caused by *Monilinia* or *Aspergillus* spp. will be provided in the future.

[17] PlantShield is best used for wood-exposing wounds to prevent silverleaf and wood decay.

ALMOND: FUNGICIDE EFFICACY - BIOCONTROLS AND NATURAL PRODUCTS

Trade name	Biological or natural product (FRAC code)[1,5]	Brown rot	Jacket rot	Anthrac-nose	Shot hole	Scab	Rust	ALS	Hull rot	PM-like	Silver leaf	Bac. spot
Botector/Blossom Protect	*Aureobasidium pullulans* (BM 02)	3	2	NL	NL	NL	NL	NL	NL	NL	NL	3
Double Nickel 55	*Bacillus amyloliquefaciens* D747 (BM 02)	2	2	ND	2	NL	NL	NL	NL	NL	NL	2
Serifel	*B. amyloliquefaciens* MBI600 (BM 02)	2	2	ND	2	3	1	1	1	ND	ND	2
Taegro 2	*B. amyloliquefaciens* FZB (BM 02)	2	2	ND	2	NL	NL	NL	NL	NL	NL	NL
Sonata	*B. pumilis* QST2808 (BM 02)	2	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL
Serenade	*B. subtilis* QST 713 (BM 02)	3	3	2	2	1	1	1	NL	ND	NL	3
Aviv	*B. subtilis* IAB/BS03 (BM 02)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dart	capric and caprylic acids (BM 01)	3	2	ND	2	1	1	2	2	ND	0	3
Cinnacure, Seican	cinnamaldehyde (BM 01)	2	2	NL	NL	NL	ND	NL	NL	ND	NL	2
Cinnerate	cinnamon oil (BM 01)	2	2	NL	NL	NL	ND	NL	NL	ND	NL	2
Procidic	citric acid	ND	ND	ND	NL	NL	NL	ND	NL	NL	NL	NL
EF400	clove, rosemary, peppermint oils (BM 01)	1	2	1	NL	ND	NL	NL	NL	NL	NL	NL
Vectorite HB, BB	*Clonostachys rosea* CR-7	4	2	ND	2	ND	ND	ND	ND	ND	ND	ND
Guarda, Thymeguard	essential oil (thyme oil) (BM 01)	2	2	ND	2	ND	ND	ND	ND	ND	ND	3
Kasumin	kasugamycin (24)[1]	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	4
ProBLAD Verde	*Lupinus albus* (BM 01)	3	3	0	0	2	0	0	0	0	0	3
Timorex (Act, Gold)	natural oil (BM 01)	1	1	2	1	2	2	1	ND	2	NL	NL
Trilogy, Rango	neem oil (BM 01)	1	1	1	1	1	2	1	ND	2	NL	NL
Oxidate, Perasan	peroxyacetic acid (oxidizer)	1	2	1	1	NL	NL	1	ND	ND	NL	2
Oso/Ph-D	medium (19)	3	4	0	3	4	4	5	4	ND	NL	NL
Armicarb, Milstop	potassium bicarbonate (NC)	NL	NL	NL	NL	1	NL	NL	ND	3	NL	NL
All Phase	potassium sorbate/sodium lauryl sulfate (NC)	NL	NL	NL	NL	2	NL	NL	NL	NL	NL	NL
Howler	*Pseudomonas chlororaphis*AFS009(BM02)	2	1	NL	NL	NL	NL	NL	NL	NL	NL	3
Regalia	*Reynoutria sachalinensis* (P 05, BM 01)	2	2	1	1	1	1	1	ND	2	NL	3
Actinovate AG	*Streptomyces lydicus* (BM 02)	1	1	NL	NL	NL	NL	NL	NL	1	NL	2
EcoSwing	*Swinglea glutinosa* (BM 01)	3	2	NL	NL	1	NL	1	NL	ND	NL	ND
Vintec	*Trichoderma atroverde* (BM 02)[6]	NL	NL	NL	NL	NL	NL	NL	NL	NL	4	0
PlantShield	*Trichoderma harzianum* (BM 02)	NL	NL	NL	NL	NL	NL	NL	NL	NL	4	0
YSY (pending)	*Papiliotrema terrestris* PT22AV (BM 02)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Rating: 5 = excellent and consistent, 4 = good and reliable, 3 = moderate and variable, 2 = limited and/or erratic, 1 = minimal and often ineffective, 0 = ineffective, NC = not coded in FRAC, NL = not on label, and ND = no data.

*** Registration pending in California.**
**** Not registered, label withdrawn or inactive in California.**

[1] Alphabetically arranged organic treatments. Note that kasugamycin is a fermentation (natural) product, but not an organic treatment.
[2] ALS = Alternaria Leaf Spot caused by *Alternaria alternata* and *A. arboresscens*.
[3] PM-like refers to a powdery mildew-like disease.
[4] Hull rot ratings are for the disease caused by *Rhizopus stolonifer*.
[5] FRAC Codes are also provided as BM- or P-number codes. In general, sulfur compounds are fungicidal and may affect applications of fungal biocontrols (e.g., Botector); whereas copper may affect applications of bacterial biocontrols (e.g., Actinovate, Double Nickel 55, and Serenade). Rotations must consider these factors.
[6] Labeled for *Eutypa* sp., *Botryosphaeria* sp., *Cytospora* sp., and other trunk diseases of almond.

ALMOND: TREATMENT TIMING

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

Disease	Dormant	Bloom			Spring[1]		Summer	
		Pink bud	Full bloom	Petal fall	2 wks	5 wks	May	June/ July
Alternaria	0	0	0	0	0	2	3	3
Anthracnose[2]	0	2	3	3	3	3	3	2
Bacterial spot	1	0	2	3	3	2	1	0
Brown rot	0	2	3	1	0	0	0	0
Green fruit rot	0	0	3	2	0	0	0	0
Hull rot[7]	0	0	0	0	0	0	0	3
Leaf blight	0	0	3	2	1	0	0	0
Rust	0	0	0	0	0	3	3	1[6]
Scab[3]	2	0	0	2	3	3	1	0
Shot hole[4]	1[5]	1	2	3	3	2	0	0

Disease	At planting	Spring root flush	Summer	Fall root flush
Phytophthora root and crown rot	3	3	2	3

Rating: 3 = most effective, 2 = moderately effective, 1 = least effective, and 0 = ineffective

[1] Two and five weeks after petal fall are general timings to represent early postbloom and the latest time that most fungicides can be applied. The exact timing is not critical but depends on the occurrence of rainfall.

[2] If anthracnose was damaging in previous years and temperatures are moderate (63°F or higher) during bloom, make the first application at pink bud. Otherwise, treatment can begin at or shortly after petal fall. In all cases, application should be repeated at 7- to 10-day intervals when rains occur during periods of moderate temperatures. Treatment should, if possible, precede any late spring and early summer rains. Rotate fungicides, using different fungicide classes, as a resistance management strategy.

[3] Early treatments (during bloom) have minimal effect on scab; the 5-week treatment usually is most effective. Treatments after 5 weeks are useful in northern areas where late spring and early summer rains occur. Dormant treatment with liquid lime sulfur improves efficacy of spring control programs.

[4] If pathogen spores were found during fall leaf monitoring, apply a shot hole fungicide during bloom, preferably at petal fall or when young leaves first appear. Reapply when spores are found on new leaves or if heavy, persistent spring rains occur. If pathogen spores were not present the previous fall, shot hole control may be delayed until spores are seen on new leaves in spring.

[5] Dormant copper treatment seldom reduces shot hole infection but may be useful in severely affected orchards and must be followed by a good spring program.

[6] Treatment in June is important only if late spring and early summer rains occur.

[7] Make application at 1 to 5% hull split to manage hull rot caused by *Rhizopus stolonifer*; use earlier June timings for hull rot caused by *M. fructicola.* Apply a second application, mid-way through hull split especially if hull split is progressing slowly.

ALMOND: SUGGESTED DISEASE MANAGEMENT PROGRAMS BY FRAC[1] CODES - CONVENTIONAL GROWERS

Note: Not all indicated timings may be necessary for disease control (*see* Treatment Timing Table). If treatments are needed based on host phenology, weather monitoring, inoculum models, or environmental-disease forecasting models, suggested fungicide Codes are listed for each timing.

How to use this table:

1) Identify the disease(s) that need(s) to be managed. Know the disease history of the orchard, especially from the last season.
2) Select one of the suggested fungicide Codes. *Numbers separated by slashes are pre-mixtures, whereas numbers separated by pluses are tank mixtures.* If several diseases need to be managed, select a Code that is effective against all diseases. Refer to the fungicide efficacy table for fungicides belonging to each FRAC Code. Code numbers are listed in numerical order within the suggested disease management program.
3) Rotate Codes for each application within a season and, if possible, use each Code only once per season, except for multi-site mode-of-action materials (e.g., M2).

Disease	Dormant	Bloom			Spring		Summer	
		Pink bud	Full bloom	Petal fall	2 weeks	5 weeks	May	June/July
Alternaria	----	----	----	----	----	2	3, 3/7, 3/9, 3/11, 3/33, 7, 7/11, 7/12, 11, 19	3, 3/7, 3/9, 3/11, 3/33, 7, 7/11, 7/12, 11, 19
Anthracnose	----	3, 3/7, 3/9, 3/11, 3/33, 7	3, 3/7, 3/9, 3/11, 3/33, 7, 7/11, 11	3, 3/9, 3/7, 3/11, 3/33, 11, M3, M4, M5	3, 3/9, 3/11, 3/7, 3/33, 7, 7/11, 11, M3, M4, M5	3, 3/7, 3/9, 3/11, 3/33, 7, 7/11, 11 M3, M4, M5	3, 3/7, 3/9, 3/11, 3/33, 7, 7/11, 11, M4	3, 3/7, 3/9, 3/11, 3/33, 7, 7/11, 11, M4
Bacterial spot	M1, M1+M3	----	M1, M1+M3	M1, M1+M3	M1, M1+M3	M1, M1+M3	M1	----
Brown rot	----	1[2], 2 +oil, 3, 3/7, 3/9, 3/11, 3/33, 9	1[2], 2 +oil, 3, 3/7, 3/9, 3/11, 3/33, 7, 7/11, 7/12, 9, 9/52, 11, 19	1[2], 2 +oil, 3/11, 3/33 7, 7/11, 7/12, 9, 9/52, 19	----	----	----	----
Jacket rot	----	----	1[2], 2 +oil, 3/7, 3/9, 3/11, 7, 7/11, 7/12, 9, 9/52, 19	12, 2 +oil, 3/7, 3/9, 3/11, 7, 7/11, 7/12, 9, 9/52, 19	----	----	----	----
Hull rot[5]	----	----	----	----	----	----	3, 3/7, 3/9, 3/11, 7/11, 7/12, 11, 19	3, 3/7, 3/9, 3/11, 7/11, 7/12, 11, 19
Leaf blight	----	----	1[2], 2, 3, 3/7, 3/9, 3/11, 3/33, 11	1[2], 2, 3, 3/7, 3/9, 3/11, 3/33, 11, M3, M4, M5	3, 3/7, 3/9, 3/11, 3/33, 11, M3, M4, M5	----	----	----
Rust	----	----	----	----	----	3, 3/7, 3/11,3/33[1], 7, 7/11, 7/12, 11, 19, M3	3, 3/7, 3/11, 3/33, 7, 7/11, 7/12, 11, 19, M2	3, 3/7, 3/11, 3/33, 7, 7/11, 7/12, 11, 19, M2
Scab[4]	M1+oil, M2[3], M5+oil	----	----	1[2], 3/7, 3/9, 3/11, 3/33, 7, 7/11[2], 7/12, 52, 11[2], M3, M4, M5	1[2], 3/7, 3/9, 3/11, 3/33, 52, 7, 7/11[2], 7/12, 11[2], M3, M4, M5	3, 3/7, 3/9, 3/11, 3/33, 7, 52, 7/11[2], 7/12, 11[2], M2[3], M3, M4	M2[3], M4	----
Shot hole	M1	2, 3, 3/7, 3/9, 3/11, 7, 9, 11	2, 3, 3/7, 3/9, 3/11,7, 7/11, 9, 9/52, 11, 19	2, 3, 3/7, 3/9, 3/11, 7, 7/11 9, 11, 19	7, 7/11, 11, 19, M3, M4, M5	7, 7/11,11, 19, M3, M4, M5	----	----

1 Code numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://www.frac.info/). Code numbers are listed in numerical order within the suggested disease management program. Fungicides with a different Code number are suitable to alternate in a resistance management program. Refer to the fungicide efficacy table for fungicides belonging to each FRAC Code. Note: FC 33 is currently P 07.

2 Strains of *Monilinia fructicola* and *M. laxa* resistant to Topsin-M and T-Methyl are present in some California almond orchards. Resistant strains of the jacket rot fungus, *Botrytis cinerea*, and powdery mildew fungi have been reported in California on crops other than almond and stone fruits and may have the potential to develop in almond with overuse of fungicides with similar chemistry.

3 Use liquid lime sulfur in dormant applications and wettable sulfur at and after pre-bloom.

4 Apply petal-fall treatments based on twig-infection sporulation model.

[5] Effective hull rot management is dependent on integrated strategies including dust control, reduced irrigation, and limiting nitrogen fertilization prior to and during hull split, as well as ensuring adequate air circulation (appropriate pruning or hedging practices) in the orchard.

ALMOND: SUGGESTED DISEASE MANAGEMENT PROGRAMS BY FRAC[1] CODES - ORGANIC GROWERS

Note: Not all indicated timings may be necessary for disease control (*see* Treatment Timing Table). If treatments are needed based on host phenology, weather monitoring, inoculum models, or environmental-disease forecasting models, suggested fungicide Codes are listed for each timing.

How to use this table:

1) Identify the disease(s) that need(s) to be managed. Know the disease history of the orchard, especially from the last season.
2) Select one of the suggested fungicide Codes. If several diseases need to be managed, select a Code that is effective against all diseases. Refer to the fungicide efficacy table for fungicides belonging to each FRAC Code. Code numbers are listed in numerical order within the suggested disease management program.
3) Rotate Codes for each application within a season and, if possible, use each Code minimally per season.

Disease	Dormant	Bloom			Spring		Summer	
		Pink bud	Full bloom	Petal fall	2 weeks	5 weeks	May	June/July
Alternaria	----	----	----	----	----	BM 01, BM 02, oxidizer	BM 01, BM 02, oxidizer	BM 01, BM 02, oxidizer
Anthracnose	----	BM 01, BM 02, P 05, oxidizer	BM 01, BM 02, P 05, oxidizer	BM 01, BM 02, P 05, oxidizer	BM 01, BM 02, P 05, oxidizer	BM 01, BM 02, P 05, oxidizer	BM 01, BM 02, P 05, oxidizer	BM 01, BM 02, P 05, oxidizer
Bacterial spot	M1 + BM 01 (oil)	----	BM 01, BM 02, M1, oxidizer	BM 01, BM 02, M1, oxidizer	BM 01, BM 02, M1, oxidizer	BM 01, BM 02, M1, oxidizer	BM 01, BM 02, M1, oxidizer	----
Brown rot	----	BM 01, BM 02, P 05, oxidizer	BM 01, BM 02, P 05, oxidizer	BM 01, BM 02, P 05, oxidizer	----	----	----	----
Jacket rot	----	----	BM 01, BM 02, P 05, oxidizer	BM 01, BM 02, P 05, oxidizer	----	----	----	----
Hull rot[2]	----	----	----	----	----	----	----	BM 01, BM 02
Leaf blight	----	----	BM 01, BM 02, P 05, oxidizer	BM 01, BM 02, P 05, oxidizer	BM 01, BM 02, P 05, oxidizer	----	----	----
Rust	----	----	----	----	----	BM 01, BM 02, P 05, M2	BM 01, BM 02, P 05, M2	BM 01, BM 02, P 05, M2
Scab[3,4]	M1 + BM 01 (oil), M2	----	----	BM 01, BM 02, P 05, NC	BM 01, BM 02, P 05, NC	BM 01, BM 02, P 05, NC	BM 01, BM 02, P 05, NC	----
Shot hole	M1 + BM 01 (oil)	M1+BM 01 (oil)	BM 01, BM 02, P 05, oxidizer	BM 01, BM 02, P 05, oxidizer	BM 01, BM 02, P 05, oxidizer	BM 01, BM 02, P 05, oxidizer	----	----

[1] Code numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://www.frac.info/). Code numbers are listed in numerical order within the suggested disease management program. Fungicides with a different Code number are suitable to alternate in a resistance management program. Refer to the fungicide efficacy table for fungicides belonging to each FRAC Code.

[2] Effective hull rot management is dependent on integrated strategies including dust control, reduced irrigation, and limiting nitrogen fertilization prior to and during hull split, as well as ensuring adequate air circulation (appropriate pruning or hedging practices) in the orchard.

[3] Use liquid lime sulfur in dormant applications and wettable sulfur at and after pre-bloom.

[4] Apply petal-fall treatments based on twig-infection sporulation model.