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ALMOND NEWS

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2019 IPM Breakfast Meetings

May 7, 2019—Nickels Field Day 8:30-12:10

Full color articles and photos are available on our Website: cetehama@ucanr.edu

Pre- and Post-Herbicide Performance on Threespike Goosegrass in Tree Nut Orchards

Drew Wolter, Junior Specialist Horticulture Intern, UCCE Sutter-Yuba Counties; and Brad Hanson, Weed Science Specialist, UC Davis

Threespike goosegrass was first reported in California in 1967. Since then, this species has become a significant concern in almonds and other orchard cropping systems throughout the Central Valley and growers have observed poor control with glyphosate. Tufted perennial grasses such as threespike goosegrass are particularly problematic during the first four years of tree nut establishment due to their ability to reduce tree growth by competing for water, nutrients, and sunlight. Thick stands can also interfere with the distribution and uniformity of irrigation and once the trees reach fourth leaf, established plants can reduce harvest efficiency by making it more difficult to recover nuts from the orchard floor at harvest.

Threespike goosegrass is a low-growing, coarsely tufted, warm season perennial grass, which has a prominent fold at the mid rib in young leaves that flatten when mature. The most distinguishable attribute of this species is its finger-like spikes (digitate inflorescence, Fig. 1, left). This species is often misidentified due to its common name and for being closely related to the highly successful invasive, goosegrass. However, there are some major phenological and morphological differences. Goosegrass is a large stature and erect annual with larger spikes, generally having five to eight spikes which are 1.5 to 6 inches long (Fig. 1, right). Threespike goosegrass is a low-growing tufted perennial that has a more compact inflorescence and fewer spikes (two to four) which are shorter, typically 0.4 to 1.2 inches.

When selecting an integrated weed management strategy for this species, options may vary from orchard to orchard and may be influenced by geographic location, climatic conditions, soil texture and profile, irrigation practices, topography, cost, and grower preferences. A good orchard weed management program is composed of preventative strategies, orchard floor management (including cultural, mechanical, chemical, and biological methods), and weed monitoring. The proper use of pre- and postemergence herbicides and timely discing and cultivation are important factors in weed management.

For this study, two field trials to evaluate the performance of several pre-emergent (PRE) and post-emergent (POST) herbicides on threespike goosegrass were conducted in 2018: one in a walnut orchard at the Chico State University Farm in Chico, CA and the other in a commercial almond orchard near Livingston, CA. Both locations had medium-to-high infestations. Herbicide treatments were applied with a CO2 pressurized backpack sprayer, calibrated to deliver 30 GPA at 30 PSI through three TeeJet XR11003 flat fan nozzles. The herbicide treatments (Tables 1 & 2) were applied in a five-foot band on both sides of the tree row.

Data collection included visual assessments at monthly intervals for PREs, starting one month after the January 2018 application and continued for five months. One treatment included an additional PRE-application in March as part of a sequential herbicide program. The purpose of this sequential approach was to apply a second PRE-herbicide closer to germination and emergence of this warm season grass, rather than relying on a single winter application. POST treatments were applied in May 2018 and control assessments were conducted at weekly intervals, starting one week after application for approximately one month. Threespike goosegrass control was estimated using a 0 to 100 scale, where 0 means no control and 100 means plants were completely killed.

Multiple PRE herbicides (Table 1) in these trials, including Alion, Prowl H2O, and Pindar GT provided adequate control of seedling threespike goosegrass. The greatest control of this warm season perennial was obtained with the sequential application of Alion followed by Prowl H2O, presumably due to the second PRE-herbicide applied late March closer to germination and emergence of this warm season grass, rather than relying on a single winter application. Results from this study suggest that a management plan utilizing a PRE-herbicide applied later in the spring may minimize seedling recruitment of this species.

POST herbicide data collected (Table 2) in the 2018 field trials confirmed that threespike goosegrass is extremely tolerant to glyphosate. Even when Roundup Weathermax was applied at the higher rate of 2 qt/A, threespike goosegrass control did not exceed 54% and many plants recovered and later produced new shoots and panicles (Fig. 2). The graminicides tested, Fusilade, SelectMax, and Poast provided the greatest POST control of threespike goosegrass. Of these, Fusilade provided the greatest level of control in this study, resulting in up to 92% control five weeks after treatment (Fig. 3).

Overall, the field trials conducted in this study determined that in areas where this warm season grass species was the most concerning, the greatest control was obtained by shifting some of the PRE herbicide components to target the germination of the summer species, rather than trying to achieve summer weed control with only the PRE herbicides applied in the winter. We also found a number of effective post-emergent herbicides to keep in the toolbox.

The take home messages here are to carefully consider the biology of the weed, weed control goals, and the weed management tools at disposal. Remember to rotate herbicide modes of action and to monitor after herbicide application to prevent the appearance of herbicide-resistant or tolerance, such as the high level of tolerance exhibited by threespike goosegrass to glyphosate treatments shown in this study. You can find more information on these subjects at the links bellow:

- For more information on integrated weed management please visit the UC ANR website: https://www2.ipm.ucanr.edu/agriculture/almond/Integrated-Weed-Management/.
- For more information on herbicides registered for California tree and vine crops and modes of action: https://wric.ucdavis.edu/PDFs/T&V_herbicide_registration_chart.pdf
- For weed science research updates and information visit the Weed Research and Information Center: https://wric.ucdavis.edu

Table 1. PRE-emergent treatments* (Applied January 2018)

Active Ingredient	Trade Name	Rate (product/A)	Herbicide Efficacy 5 MAT**
Flazasulfuron	Mission	2.85 oz	47.8
Rimsulfuron	Matrix	4 oz	50.3
Oryzalin	Surflan	4 qt	54.3
oxyfluorfen + oryzalin	Goal + Surflan	5 pt + 4 qt	60.3
penoxsulam + oxyfluorfen	Pindar GT	2 pt	61.3
indaziflam + rimsulfuron	Alion + Matrix	3.5 fl oz + 4 oz	62.8
Indaziflam	Alion	3.5 fl oz	65.8
flumioxazin + pendimethalin	Chateau + Prowl H2O	10 oz + 4 qt	69.8
Pendimethalin	Prowl H2O	4 qt	71.8
penoxsulam + oxyfluorfen	Pindar GT	3 pt	73.8
Indaziflam	Alion	5 fl oz	74.5
indaziflam fb pendimethalin***	Alion fb Prowl H2O***	3.5 fl oz + 3 qt	90.1

* AMS (1% v/v), NIS (0.25 % v/v), and Rely 280 (32 fl oz/A) were added to treatments according to label recommendations.
** MAT= Months After Treatment.
***** fb = "followed by" applied in March.**

Table 2. POST-emergent treatments* (Applied May 2018)			
Active Ingredient	**Trade Name**	**Rate (product/A)**	**Herbicide Efficacy 5 WAT****
glyphosate + rimsulfuron	WM + Matrix	1 qt + 2 oz	37.4
glyphosate (1X)	Roundup Weathermax (WM)	1 qt	45.5
glyphosate (2X)	Roundup WM	2 qt	54.4
glyphosate + oxyfluorfen	WM + GoalTender	1 qt + 0.5 pt	57.3
glyphosate + glufosinate	WM + Rely280	1 qt + 2 qt	67.4
sethoxydim	Poast	2 pt	75.5
clethodim	SelectMax	12 fl oz	82.5
fluazifop	Fusilade	12 fl oz	90.9

* NIS (0.25 % v/v) **OR** MSO (1% v/v) were added to treatments according to label recommendations.

** WAT= Weeks After Treatment.

Figure 1. Digitate inflorescence – or spike – comparison. Threespike goosegrass (E. tristachya) on the left, goosegrass (E. indica) on the right.

Figure 2. Threespike goosegrass 3 weeks after a 2 qt/A Roundup Weathermax treatment. Plant exhibits regrowth and ability to flower.

Figure 3. Heavily tillered threespike goosegrass 5 weeks after Fusilade treatment. Full necrosis achieved.

The Many Possible Causes of "Gummy Nuts" in Almonds

Emily J. Symmes, Sacramento Valley Area IPM Advisor, UCCE Statewide IPM Program

There are several biological factors and non-biological conditions that cause "gumming" in almonds. "Gummy nuts" may refer to different symptoms depending on which part of the fruit is affected. In this article, the term "hull gummosis" refers to the exudates (typically clear to amber in color) that are visible on the outside of the fruit. Depending on the cause and extent of fruit damage, we may also observe gumming on the shell and in the kernel.

In general, dissection of the fruit, as well as a holistic approach to assessing the orchard and surrounding landscape is necessary to determine the cause of symptom expression and crop damage. Often, once hull gummosis or gummosis with underlying kernel damage are observed, the opportunity to mitigate the cause of damage has passed for that season. However, identifying the cause of symptoms, relationships to other orchard factors that lead to the development of symptoms and damage, and the timing of initial onset will allow you to develop improved monitoring and crop protection strategies.

Diseases. With hull gummosis arising from disease infection, there will typically be signs and disease symptoms apparent on other parts of the plant. Orchard history of disease, timing of symptom development, cultivars affected, and weather patterns can help distinguish the cause(s) of symptoms. Anthracnose and bacterial spot are the most common pathogen-induced infections that lead to hull gummosis.

Anthracnose. When small nuts are infected, they shrivel and turn a rusty orange color. When larger nuts are infected, they exhibit round, sunken, orangish lesions and profuse hull gummosis as the infection progresses into the kernel. Anthracnose gummosis is typically amber in color with multiple exudate sites on the hull (Photo 1). Eventually, infected nuts die and remain attached to the spur as mummies. Symptom development on the outside of the fruit (i.e., hull gummosis) is dependent on the timing of initial infection and rate of disease progression. In most years, it is evident by mid- to late-April.

Other signs and symptoms of anthracnose infection may be evident, including blossom blight, marginal leaf necrosis, and dieback of shoots and branches later in the season beyond infected nut attachments. Prolonged warm (>59°F), rainy weather extending into spring, are most conducive to disease. All varieties are susceptible, with Butte, Fritz, Monterey, Peerless, Price, and Winters among the most susceptible. Nonpareil is less likely to be infected unless adjacent to a heavily infected pollenizer.

Bacterial spot. Typically, hull lesions begin as small water-soaked circular spots on nuts. Infections enlarge and become necrotic, with lesions developing into the hull, shell, and kernel (Photo 2A). Infection sites on the hull exhibit profuse amber colored gumming, often from multiple exudate sites (Photo 2B). Early-season infections can cause fruit drop. Hull gummosis symptoms are first visible one to three weeks after initial infection, usually by mid- to late-April.

Leaf and shoot symptoms may occur, but are less common than fruit symptoms. Leaf lesions become chlorotic then necrotic, leaving irregular shaped holes (Photo 2C). Twig lesions may develop on green shoots. High moisture conditions and warm temperatures (> 68°F) favor infection. Severe infections are most common with frequent periods of rainfall or irrigation during fruit development. Fritz is highly susceptible, whereas varieties such as Butte, Carmel, Monterey, Nonpareil, Padre, and Price generally exhibit less disease severity.

Insects. Several types of insects cause hull gummosis. Hemipteran insects, or "true bugs" (i.e., those with piercing-sucking mouthparts), particularly leaffooted bugs and stink bugs are generally responsible for the hull gummosis that is associated with crop damage. Feeding by a number of other "bugs" (e.g., box elder bugs, Phytocoris species, Calocoris species) and feeding by Lepidopteran (worm) pests may also cause hull gummosis. The key factors causing different fruit symptoms involves the length of insect mouthparts and the fruit tissue they can reach. The mouthpart factor differs with species, and among adults and nymphs. The fruit tissue factor differs with hull thickness and shell hardness (both vary in time and among varieties), and stage of kernel development when feeding occurs.

With insect-caused hull gummosis, shell, and kernel damage, darkened feeding channels are evident upon dissection into the hull. Probing may extend into the shell and kernel (based on the factors noted above). The most accurate way to distinguish which bug species are causing the damage is by visual observation of the presence of the insects themselves (adults, nymphs, or egg masses), but other factors such as timing, extent of damage, and landscape characteristics can assist in the evaluation.

Leaffooted Bugs (Family Coreidae). Leaffooted bug (LFB) feeding on young fruit prior to shell hardening can cause the kernel to wither and abort, and may lead to nut drop. LFB feeding impacts lessen as shells harden, but may still cause dark spots on the kernel, gumming of the kernel, or wrinkled and misshapen kernels. Hull gummosis caused by LFB feeding is clear to light-yellow, originating from each feeding site. LFB often produces exudates from multiple feeding sites on individual nuts. The extent of kernel damage depends on whether feeding made it through the shell and into the kernel. Soft shell almond varieties are more susceptible to kernel damage for a longer period during the season. LFB damage typically occurs in a distinct window of time, usually during March and April. Hull gummosis caused by LFB manifests 3 to 10 days after the initial feeding. LFB feeding decreases in May and June, while stink bug feeding increases at that time. Base treatment decisions on the presence of LFB adults, nymphs, and egg masses (Photo 3) from March to early May, because LFB may have moved out of the orchard by the time hull gummosis or aborted nuts are obvious.

Stink Bugs (Family Pentatomidae). A number of species of stink bugs can be found in almond orchards. These include green stink bug (most commonly encountered), red-shouldered stink bug, Uhler stink bug, and rough stink bug. Be aware that rough stink bugs are not plant pests; they are predators of other insects. More recently, the invasive brown marmorated stink bug (BMSB) has been reported in a few almond orchards in the northern San Joaquin Valley.
Stink bug feeding in almond orchards typically occurs from May through July. Movement into orchards in spring occurs when other weed or crop hosts dry down, so this can be earlier in years with dry winters/ springs. The appearance of stink bug feeding is similar to LFB but timing is a key factor in separating the two, since stink bug feeding occurs later in the season than LFB feeding. Feeding typically only extends into the hull, so nut abortion and kernel damage are rare. Stink bugs are less mobile than LFB, so feeding tends to be more localized (clustered) in the orchard. Visual evidence of stink bug adults (Photo 4), nymphs, and barrel-shaped egg masses, can indicate whether they were the likely cause of fruit symptoms.

Brown Marmorated Stink Bug. BMSB has been present in California since 2008 but has only recently begun to move into some agricultural commodities (commercial kiwifruit detection beginning in 2014, peach in 2016, and almond in 2017). To date, reports of serious infestation and damage in almond have been limited to a few orchards in Stanislaus and Merced counties. Evidence of feeding (hull gummosis from multiple feeding sites) and shell and kernel damage by BMSB seems to be similar to LFB (if occurring early, before shell hardening) or other stink bugs (if occurring later, after shell hardening). Severity of damage may be greater for BMSB due to larger numbers clustered in areas of orchards.

Recent research by UCCE Area IPM Advisor Jhalendra Rijal indicates that BMSB begins feeding on almonds as early as mid-March, and may continue well into summer. Fortunately, there are traps and lures available for BMSB. Visual observations of adults, nymphs, and egg masses and location of the damage may help indicate the source if occurring during the same time period as either LFB or other stink bugs. For BMSB, pay particular attention to border rows next to overwintering sites (structures, wood piles), other known hosts (Tree of Heaven harbors high populations of BMSB), and riparian areas.

Other Causes of Hull Gummosis. Other factors can result in hull gummosis including hail or equipment striking fruit (tractor blight), boron deficiency, herbicide damage, and physiological responses.

Boron deficiency produces clear gummosis on the sides of the hull or at the suture line. Copious internal gumming and discoloration of the developing kernel will be visible upon dissection (Photo 5). Fruit drop may occur, or if nuts remain in the tree, internal gumming will harden and cause misshapen kernels. Boron status can be evaluated by analyzing hull samples.

Physiological processes such as rapid expansion of the growing kernel, causing increased pressure on the shell and hull can produce hull gummosis. Dissection of the fruit will show a water-soaked gummy area on the outside of the shell, clear gummosis exuding from the suture line or side of hull, and no apparent feeding channel (indicating bugs as the culprit). Kernels appear healthy and affected nuts often remain on the tree with no negative impacts.

In summary, hull gummosis in almonds can be caused by a number of different biological and non-biological factors. More severe crop damage occurs if kernels are impacted, but this is not always the case. Understanding how to identify the source of symptoms is a key component for effective integrated pest management and crop production programs.

More detail on identification and management of the potential causes of hull gummosis, shell, and kernel gumming can be found in the UC Statewide IPM Programs Pest management Guidelines for Almonds (ipm.ucanr.edu/PMG/selectnewpest.almonds.html), and in multiple posts at the Sacramento Valley Orchard Source Website (http://www.sacvalleyorcards.com/) and the Almond Doctor Blog (thealmonddoctor.com/).

2019 IPM Breakfast Meetings

Join Area IPM and Farm Advisors to discuss current pest management and production issues. We will largely focus on orchard crops (but everything is on the table for discussion!). These meetings are open to all interested growers, consultants, PCAs, CCAs, and related industry.

Meetings will be held the **second** Friday of each month (8:00-9:30am ***note new start time***) from March through October and will cover a wide range of timely pest and orchard management topics. Meeting locations will be rotated throughout the Sacramento Valley each month. Please contact Emily Symmes to request topics or bring your questions to the meeting!

2019 meeting dates:

- April 12th, 2019 (Yuba-Sutter-Colusa Counties): Dancing Tomato Caffé, Yuba City
- May 10th, 2019 (Tehama County): Field Meeting, Location TBA
- June 14th, 2019 (Glenn County): Field Meeting, Location TBA
- July 12th, 2019 (Butte County): Field Meeting, Location TBA
- August 9th, 2019 (Yuba-Sutter-Colusa Counties): Field Meeting, Location TBA
- September 13th, 2019 (Tehama County): Rockin' R Restaurant, Red Bluff
- October 11th, 2019 (Glenn County): Berry Patch Restaurant, Orland

Additional details will be posted on the events page at sacvalleyorchards.com

RSVPs required at (530) 538-7201 or ejsymmes@ucanr.edu

DPR and CCA Continuing Education hours requested

Industry Partners: Sponsorships for venue and refreshment costs are welcome and appreciated. If you would like to sponsor one or more of these meetings, please contact Emily Symmes to inquire.

Photo 1. Anthracnose lesions and gumming on almond hull. Photo Credit: B. Holtz, University of California Cooperative Extension.

Photo 2A

Photo 2. (A) Necrotic lesions inside almond hull caused by bacterial spot infection. (B) Bacterial spot gumming on almond hulls. (C) Necrotic bacterial spot foliar symptoms. Photo Credits: B. Holtz, University of California Cooperative Extension.

Photo 2C

Photo 2B

Photo 3. Leaffooted bug egg mass on almond. Photo Credit: Integral Ag, Inc.

Photo 4. Adult green stink bug on almond. Photo Credit: Integral Ag, Inc.

Photo 5. Boron deficiency causes gummy almond kernels. Photo Credit: D. Lightle, University of California Cooperative Extension.

Almond Management Considerations: Spring & Early Summer

Katherine Jarvis-Shean, UCCE Orchard Advisor, Sacramento, Solano and Yolo Counties
Emily Symmes, UC Area IPM Advisor, Sacramento Valley

APRIL

- ✓ Monitor for signs of **alternaria** through June, looking on exposed leaves for large, brown spots which then turn black, watching the most susceptible varieties (Carmel, Sonora, Monterey, Winters and Butte). You can also use the Disease Severity Value model to time fungicide applications, based on temperature and leaf wetness. See more at http://ipm.ucanr.edu/PMG/r3101611.html.

- ✓ Watch for **scab** lesions on green, 1-year-old twigs. Once twig lesions have sporulated, protective fungicide applications should occur prior to the next significant rain. Additional treatment may be warranted if frequent rains continue into spring. Leaf lesions will initially appear as small yellow specks in late spring which develop into grey diffuse lesions, sometimes followed by defoliation in early summer when the disease is severe. Some shot hole sprays will also control scab. Be aware that in some orchards, scab resistance to FRAC Group 7 and/or 11 fungicides has been documented. Treat following UC IPM guidelines at http://ipm.ucanr.edu/PMG/r3100411.html.

- ✓ **Anthracnose** may be a problem if rainy weather persists though April and temperatures are warm, especially in orchards with a history of the disease. Anthracnose infects nuts and causes marginal leaf necrosis and branch dieback to the point where an infected nut is attached. Be sure to alternate fungicides to avoid resistance development. More on treatment options at http://ipm.ucanr.edu/PMG/r3101111.html.

- ✓ Monitor **shot hole** leaf lesions for spore development (a small dark speck in the middle of the leaf lesions). UC guidelines suggest applying treatment prior to additional rain as soon as spores are evident since that's when the disease can become epidemic. Additional treatment may be necessary if rainy, wet conditions persist through spring. See more at http://ipm.ucanr.edu/PMG/r3100211.html.

- ✓ Watch for **shoot strikes caused by PTB or OFM** starting in mid-April, primarily in first leaf orchards, where you're encouraging shoot elongation to establish tree structure. There's no consensus threshold of how much damage warrants treatment in young trees, but keep in mind that damage at the tip of a primary scaffold will stop that branch from growing longer and shift growth into side branching, impacting the trees structure and making primary scaffold selection more difficult in the first dormant pruning. See pictures and more on management at http://ipm.ucanr.edu/PMG/C003/m003fcshootstrik.html.

- ✓ **NOW monitoring.** Traps (egg, pheromone, bait-bag) should have gone out by first week of April, if not sooner. Check egg traps twice weekly to determine biofix. Many experienced practitioners in the Sacramento Valley use the first NOW eggs found in traps as the biofix. This differs from common practices in the San Joaquin Valley because our population pressure is often lower. Pheromone and bait-bag traps can be used to track male and female flights and relative abundance. Additional details on NOW management at https://www2.ipm.ucanr.edu/agriculture/almond/Navel-Orangeworm/

- ✓ Manage **gophers** before their reproductive pulse – usually between March and May. While flooding may have increased winter mortality, increased rain fed vegetation could increase reproduction this spring. See more on gopher control at http://www.sacvalleyorchards.com/blog/almonds-blog/options-for-gopher-management/.

- ✓ About a third of crop **nitrogen** use will occur by early April this year (that's adjusting for our late start). With all the rain, this is a tricky year for keeping nitrogen in the root zone where trees can use it.

- ✓ Re-evaluate your “Right Source” of nitrogen if rain persists. Nitrate and urea leach easily with excessive rainfall or irrigation, whereas ammonium based fertilizers will not (though un-used ammonium can be transformed to nitrate by soil bacteria after a few weeks in the soil). If you are worried your orchard may be nitrogen deficient, consider taking early season leaf samples by 45 (±6) days after full bloom. Careful following of leaf sampling protocol will provide a good estimate of how summer leaf levels will look. See sampling details at the http://thealmonddoctor.com/2013/04/16/april-leaf-sampling-protocol/.

- ✓ **Before you start irrigating,** consult plant and soil moisture sensors, and compare stored soil moisture and rainfall with this season’s evapotranspiration (ET) so far. See http://www.sacvalleyorchards.com/almonds/irrigation/early-season-irrigation-do-we-know-when-to-start/ for more guidance.

- ✓ Begin monitoring for large bugs (leaffooted bugs in April, stink bugs in May). See “Gummy Nut” article in this issue for more detail and links.

MAY

- ✓ Continue **leaf monitoring for Alternaria Leaf Spot, Shot Hole, Rust, Scab and Anthracnose** if rainy weather persists. Consider a follow up rust treatment *before* symptoms are visible if orchard history and conditions indicate high vulnerability. Rotate the material’s site of action (FRAC Group) to avoid development of pesticide resistance.

- ✓ Continue watching for **PTB or OFM shoot strikes** in first leaf orchards. Once sufficient growth for primary scaffold extension has occurred, this is no longer a concern.

- ✓ Monitor for **spider mites and their predators** (especially six-spotted thrips and predaceous mites) at least weekly, watching hot spot areas that are often dusty or water-stressed. Find more on treatment decisions at http://ipm.ucanr.edu/PMG/r3400211.html and http://www.sacvalleyorchards.com/almonds/insects-mites/approaches-to-spider-mite-management-in-almonds/.

- ✓ Survey **weeds** to see which weeds were not controlled by fall or winter treatment. The UC Weed ID Tool at http://weedid.wisc.edu/ca/weedid.php can help with identification. Also see Herbicide chart in this newsletter.

JUNE

- ✓ Continue monitoring for **spider mites and their predators.**

- ✓ Assess your crop set, consider leaf sample results from last July and/or this spring and adjust the amount of **nitrogen** application needed before harvest – if any is needed at all. Of the total crop N use, trees use 20% between first week of June and harvest. For the whole season, mature trees use 68 lbs of N for every 1,000 kernel lbs produced. In orchards with high July leaf N and a history of hull rot, under-shooting this rate will help decrease hull rot risk (see article in this newsletter).

- ✓ In orchards with a history of **hull rot**, regulated deficit irrigation and maintaining July leaf nitrogen levels below 2.6% will decrease orchard susceptibility to this damaging disease (see article in this newsletter). If you’ve had problems with *Rhizopus,* which produces black spores inside the hull after hull split, fungicide treatment at early hull split can significantly reduce hull rot. For best control of *Monilinia* hull rot, present as a tan lesion on the outside of the hull, spray in early June as hull split timing does not effectively control this hull rot source. For orchards with a history of hull rot, Dr. Jim Adaskaveg (UC Riverside), recommends an integrated program combining targeted irrigation reduction in early hull split, early N cut off (May), and 1 to 2 fungicides (depending on the hull rot pressure and infection source). See more at http://ipm.ucanr.edu/PMG/r3101811.html.

Hull Split Timing and Sprayer Practices for Best Pest Control Results

Franz Niederholzer, UCCE Farm Advisor, Colusa and Sutter/Yuba Counties

Early hull split, when the hull begins to open at the suture, is a don't-want-to-miss timing in almond production. The crack in the hull does two things: releases nut volatiles so the navel orangeworm (NOW) female can find the nut (and lay eggs), and gives wound pathogens like *Rhizopus* and *Aspergillus* an opening to infect the hull. Spraying at the right time (b2 stage, see photo below) when hull split first begins (in the upper, southwest side of the tree) is critical to effective hull rot and NOW management throughout the orchard. Because it takes time to get across orchards, consider starting spraying just before nuts get to this stage.

Spraying the suture is the key. That's where the NOW females prefer to lay eggs and that's where the hull rot spores can infect. Delivering a good cover spray to tree crops is a lot like painting a large house. For good weather protection of house siding, even paint coverage (no gaps), is needed. In almonds at hull split, the whole canopy, leaves and all, must be evenly sprayed to protect the nuts —to leave no gaps you have to "paint the whole house". There are 4-8 acres of leaf surface area in an acre of mature, vigorous almond trees. Multiple studies in almonds from Colusa to Fresno have shown that 150-200 gallons per acre (GPA) spray volume delivers better NOW control than 100 GPA.

Additional steps help deliver the best coverage possible. Slow tractor speed -- 2 MPH – gives the sprayer fan time to move the spray material throughout the canopy. Spraying in dry, warm air (relative humidity below 40% and temperatures above 80^{o}F) can reduce spray coverage 50% in the tree tops as spray evaporates.

For the best possible spray coverage and NOW and hull rot control in mature almonds at hull split, use 150-200 GPA, drive 2 MPH, and spray when relative humidity is above 50% and temps below 80oF. [If this approach sounds too expensive and time consuming, try it out where you have the most NOW and hull rot pressure.]

Hull split is a critical timing for pest control in almonds. NOW and hull rot pressure have increased the last few years. Proper spray timing and delivery will help make reject sheet reading less painful and almond growing more profitable.

Target stage (b2 stage of early hull split) for first NOW and hull rot (*Rhizopus*) spray.

Hull Rot Management

Dani Lightle, UCCE Farm Advisor Glenn, Butte and Tehama Counties
Franz Niederholzer, UCCE Farm Advisor Colusa, Sutter and Yuba Counties

Hull rot can be an extremely damaging disease hitting almond orchards in late spring through hull split (HS). It can cost growers hundreds of dollars per acre in lost crop and clean up (winter sanitation), and is a growing problem for almond growers in the Sacramento Valley.

Hull rot is a general term for hull infection by one of several pathogens. Infected nuts don't shake off at harvest and must be removed by winter sanitation to eliminate future navel orangeworm (NOW) feeding sites. Often the infection of the hull results in death of the spur and attached shoot, reducing bearing surface of the tree. The list of hull rot pathogens is growing, and now includes *Rhizopus, Monilinia, Aspergillus*, and *Phomopsis* (see tables and photos below). *Aspergillus* infections can lead to staining of the kernel and reduction in nut quality. The most susceptible varieties commonly planted include: Nonpareil, Monterey, and Wood Colony. UC research is underway, supported by the Almond Board of California, to look at one of the new pathogens on this list -- *Aspergillus* – as well as continuing efforts to manage *Monilinia* and *Rhizopus* hull rot infections.

Identification of the specific causal pathogen may help with management for the following growing season. Hull rot is traditionally caused by *Monilinia* and *Rhizopus* (Figures 1-2). Over the last 2-3 years, the pathogens *Aspergillus niger* and a species of *Phomopsis* have also been isolated from stick-tight nuts (Figure 3-4). In the case of a bad hull rot infection in 2019, it may be wise to send sticktights to a pathology lab to confirm the species involved. A summary of the symptoms and known control measures for each species are listed in Table 1.

Orchards with high leaf nitrogen (N) levels and good irrigation practices often show symptoms at harvest compared to orchards with lower N status and less than perfect irrigation. Multiple research studies have documented reductions in hull rot strikes when 1) moderate water stress is imposed for a limited time just prior to start of hull split and 2) orchard nitrogen levels are in the moderate range (2.4-2.6% N in summer samples).

2018 was a "banner year" for hull rot. We've had multiple PCAs and growers who have been involved in the almond industry for many years tell us this is the highest density of sticktights they have seen. Why was last year so bad for hull rot? Higher humidity from fire smoke is one possibility. If irrigation sets weren't adjusted down (less water applied) in response to reduced orchard water use during the smoky period, that could have increased orchard soil moisture and orchard vulnerability to hull rot. Also, in orchards hit by frost last February, if fertilizer N rates weren't reduced to match the crop loss, they could have had higher orchard N levels and higher hull rot risk.

The best, current approach to hull split management includes three parts.

1. *Moderate water stress approaching hull split*: The target is -14 to -18 bars stem water potential (SWP) for two weeks beginning just before ANY hull split (late June). The goal is to gradually reach this goal by reducing the hours of each irrigation set, not the number of irrigations. After 2 weeks at that moderate stress level, return irrigation to full ET. To hit that target, growers must start reducing irrigation at different dates, depending on soil water holding capacity (texture). Growers on heavy ground (clay loam) may need to begin to back off on irrigation as early as June 1, up to 30 days before expected HS. Growers on lighter, sandier ground may be able to wait closer to HS before easing up on the water. The key to successful hull rot management with irrigation is getting the orchard to -14 to -18 bars **just before the suture starts any separation and keeping it there for 2 weeks,** then return to full ET irrigation. This moderate stress in a short period does not reduce yield. Use a pressure chamber (pressure bomb) to make sure water stress reaches the target on time, but doesn't exceed the target. If you don't reach the target water stress before hull split, you won't help control.

2. *Careful nitrogen management.* Adequate, but not excessive orchard N helps control hull rot. The target is <2.6% summer leaf N. Don't apply N between May 15 and harvest in orchards with hull rot history.

3. *Fungicide application*. To control *Rhizopus* hull rot with fungicides, the best spray timing is 2b hull split stage – the same as for NOW sprays using softer, long lasting insecticides like Intrepid® and Altacor®. FRAC group fungicides 3, 11, and 19 provide "good and reliable" control when carefully applied (see article in this newsletter on spray coverage). Check UC Fungicide Efficacy and Timing publication listed in Table 1 above. For *Monilinia* hull rot, early June is the best timing.

Hull rot is a major disease of almonds and seems to be getting worse. Careful attention to nitrogen fertilization and irrigation programs, with timely fungicide sprays (in a combined approach/package deal) are the best way to control this damaging disease.

This is the target (2b hull split stage) for both reaching target water stress (-14 to -18 bars) and fungicide application for *Rhizopus* hull rot. No opening to the shell is visible.

Table 1. Summary of the symptoms and known control measures for hull rot causing fungal spe-

Species	Symptoms	Control
Monilinia	Tan lesions on out-	Focus on N and water management
Rhizopus	Multitude of black spores between shell and hull	Focus on N and water management Spray at early HS (can combine with NOW spray) Multiple options for good (not excellent) control[1]
Aspergillus	Flat black spores between shell and hull	Preliminary data indicates higher susceptibility once nuts are past a deep V split Relationship to N and water is unclear Chemical control materials or timings unknown
Phomopsis	Ambiguous; apparently varies by cultivar	Suspect infections may be occurring earlier in the season but no data to confirm Relationship to N and water is unknown Chemical control materials or timings unknown

[1]Efficacy tables for *Rhizopus stolonifer* are available at: ipm.ucanr.edu/PDF/PMG/fungicideefficacytiming.pdf

Currently, no efficacy for hull rot caused by *Monilinia, Aspergillus,* or *Phomopsis* are included.
HS = hull split

Figure 1. Hull rot caused by *Monilinia* causes a tan lesion on the outside of the hull. This symptom is hard to see once hulls dry.

Figure 2. Hull rot caused by *Rhizopus stolonifer*.

Figure 3. Symptoms of hull rot caused by *Aspergillus niger*. Flat, jet-black spores are present in-between the shell and the hull. Photo credit: M. Yaghmour

Figure 4. Symptoms of hull rot caused by *Phomopsis* differ by cultivar. These photos, from the same orchard, show fully split nuts on cv. Mission (left), and unsplit nuts on cv. Butte (right). Sticktights from both trees tested positive for *Phomopsis*. Photo credit: D. Lightle.

Nickels Soil Lab Annual Field Meeting

Tuesday, May 7, 2019

Registration 8:30
Program 9:00 am – 12:10 pm
Arbuckle, CA

CCA credit will be requested
Please call 530 822-7515 for more information.

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