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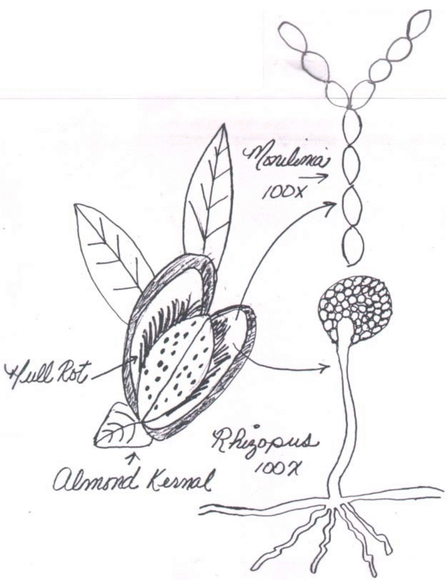
Hull Rot Management on Almonds

by Brent Holtz, Ph.D., University of California Pomology Advisor



Many growers noticed this spring that their Nonpareil, Sonora, Butte, or Monterey almond varieties lacked bloom in the lower half of their trees along with a lot of dead fruiting spurs while other varieties like Carmel displayed normal bloom and growth in the lower tree canopy. Most of the orchards I observed with these symptoms I attribute to hull rot infections that took place the previous growing season after hull split. Many growers confuse hull rot with shading out since both can produce dead wood in the lower canopy. I believe that hull rot actually enhances shading out as the tree abandons infected wood in the lower canopy for healthy wood receiving sunlight at the top of the canopy. I also believe that hull rot is the single greatest yield reducer of vigorous young almond orchards in the central San Joaquin Valley that are entering their prime production years!!! Irrigation management is the only practical control for Hull Rot and the following article addresses hull rot management.

As almond trees approach harvest, at about mid hull split, clusters of dry leaves begin to appear scattered through the tree canopy. Individual spurs, small shoots or entire small branches may collapse due to hull rot infections. The loss of fruiting wood, especially in the lower parts of the tree, can negatively affect yield for years to come. Nonpareil is usually the most severely affected cultivar though Sonora and Kapareil can also sustain extensive damage.

Hull rot is caused by either of two fungi, *Monilinia fructicola* or *Rhizopus stolonifer*. *Monilinia fructicola* is best known as one of the brown rot fungi and *R. stolonifer* is often called the bread mold fungus, and will turn bread left out black and moldy. In the southern San Joaquin Valley I believe that *Rhizopus* is the primary pathogen responsible for hull rot while *Monilinia* may be more important in the Sacramento Valley. These two organisms are very different but can cause similar disease symptoms on almond. As the name implies, a lesion or dryish rotted area develops on the hull, and dense masses of *Rhizopus* spores produce a powdery dark gray to black growth between the hull and the shell. *Monilinia* spores are buff-colored and can be seen on inner and outer hull surfaces. The nut meat is not damaged, but a toxin produced in the infected hull moves from the hull into the neighboring leaves and shoots causing death of these tissues.

Neither *Monilinia* nor *Rhizopus* are able to invade the healthy outer hull surface. Only after hull split begins can spores gain access to the inside of the hull and initiate infections. Once hull split starts, trees are at risk of becoming infected. One or both pathogens may be present in an orchard, but Monilinia hull rot is less common in southern San Joaquin Valley orchards than in other almond growing regions of the state. Leaves may become infected near infected nuts and sometime the hole spur or shoot can die as well. Clusters of dead leaves can become visible in the summer scattered among healthy green foliage. Spur and leaf die-back are attributed to fumaric acid which is produced by the pathogens and transported to the leaves and shoots. The black vascular tissues in the dead spurs and wood can be traced back to a pedicel or infected fruit. The nut kernel is not harmed but the death of the fruiting wood reduces bloom and yield in subsequent years. Sometimes infected fruit does not fall during mechanical harvest and must be removed by hand poling and can also provide overwintering sites for navel orangeworm (NOW).

Cultural practices play a crucial role in determining the severity of hull rot in an orchard. Vigorous, heavily-cropped, well-watered and fertilized orchards suffer the most damage. I have often referred to hull rot as the "good growers disease" since the disease is often worse in well maintained orchards. Beth Teviotdale calls hull rot the "gout of almond diseases–too much food and drink is bad for almonds just like it is bad for us." The reasons for this are not clear. The association with heavy crops might be simply a matter of numbers: more infected fruit means more toxin produced which results in more leaf and shoot death.

Research by Drs. Beth Teviotdale, David Goldhammer, and Mario Viveros have shown that hull rot can be reduced by inflicting mild water stress on trees during early hull split. In experiments in Kern County, hull rot incidence was lessened by half or more when half the normal amount of water was delivered to trees for two weeks during early hull split. Eliminating irrigation during the two weeks preceding harvest reduced hull rot by 400-500%, but completely denying trees water for two weeks may be dangerous and less drastic irrigation reductions may also reduce disease and stress trees less. In their research they irrigated almond trees at 70, 85, and 100% of potential evapotranspiration (Etc). There were two types of deficit irrigation: sustained and regulated. The sustained irrigation was just reduced irrigation the whole season while the regulated started the year at normal irrigation but then drastically reduced irrigations (50% Etc) during the period preceding and during hull split. For Kern county those dates included 50% Etc from 1-15 July (85% season Etc reduction) or 1 June- 31 July (70% season Etc reduction). The regulated deficit irrigations were much more effective at reducing hull rot than the sustained deficit irrigations.

The University of California tested several approaches to reduce water use under different irrigation strategies and soil types. In a large cooperative trial lead by Dr. Ken Shackel in Pomology at UC Davis and farm advisors, we used midday stem water potentials to monitor deficit irrigation in almond in order to reduce hull rot without severely stressing trees. We use a pressure bomb to monitor midday stem water potentials (SWP) through the season in order to keep fully irrigated trees between stem water potentials of -7 to -9 bars. Then during hull split we tried to irrigate less in order to achieve stem water potentials between -14 to -18 bars. The higher the negative number, the more water stress. Figure 1 shows a graph of our 2002 data where the grower standard is our RDI reduced deficient irrigation treatment (-14 to -18 bars) while the control consists of fully irrigated trees (-7 to -9 bars). Hull rot in the fully irrigated treatment averaged 44.4 strikes per trees while the RDI treatment averaged only 17.7 in 2002. In 2003 hull rot in the fully irrigated treatment averaged 17.7 strikes per trees while the RDI treatment averaged only 2.0 (figure 2). In both years the differences were significant.

By using the pressure bomb to monitor tree stem water potentials we are imposing enough stress to reduce hull rot and not over stress the trees so that they are susceptible to mite damage or defoliation. Soils can vary greatly throughout the state and irrigation management can be very difficult. For instance, in some orchard experiments we could withhold water and reach -14 bars in just a few days while in other orchards with deep, well-drained soils it might take as long as 20-30 days to achieve -14 bars in stress. This is why irrigation management using mid day stem water potentials and a pressure bomb is in my belief the only real management strategy for hull rot control. Other benefits of hull split stress are more uniform nut maturity and earlier harvest which will have a significant impact on Navel Orange Worm (NOW) control and damage. Experiments in Stanislaus County demonstrated that hull rot severity increases with increasing amounts of nitrogen. Nitrogen should not be applied in excess of that needed for tree health and productivity. The nitrogen content of the irrigation water should be included in calculations of required added fertilizer.

Figure 1

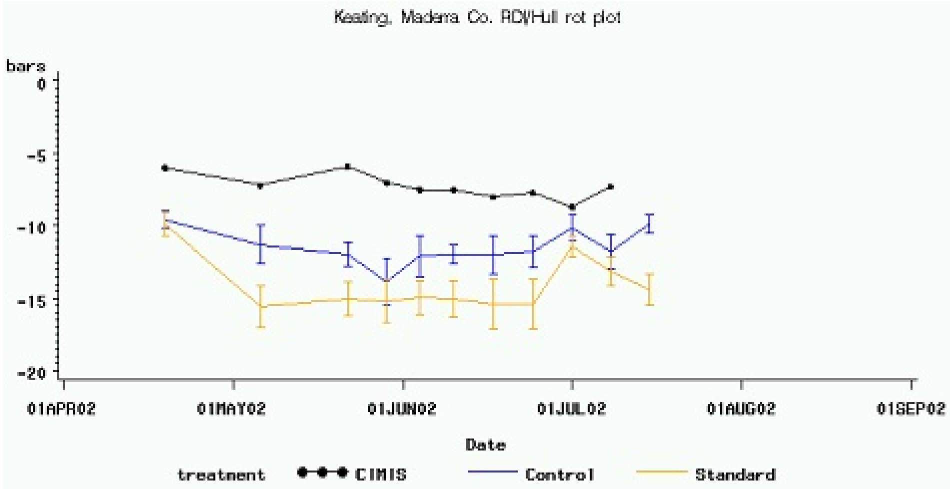
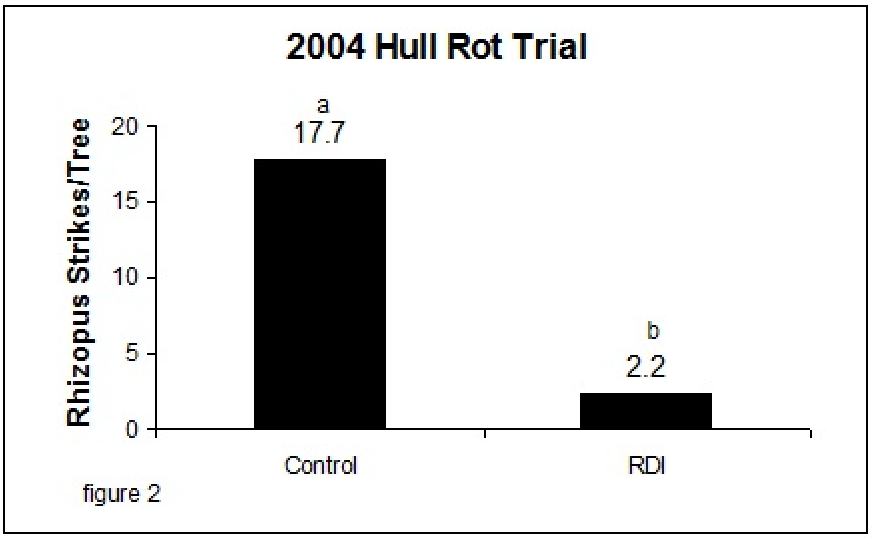


Figure 2



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Sincerely,

Brent A. Holtz, Ph.D.
Pomology Farm Advisor

For special assistance regarding our programs, please contact us.

2008 Almond Irrigation and Hull Rot Field Meeting

Tuesday, June 24, 2008
J.M. Lasgoity Orchard
Road 16 between Avenues 18 1/2 and 14
8:30 AM - 12:00 Noon

8:30 a.m. **PCA and continuing education credits sign-up**
Tome Martin Duvall, SRA II, UCCE Madera County

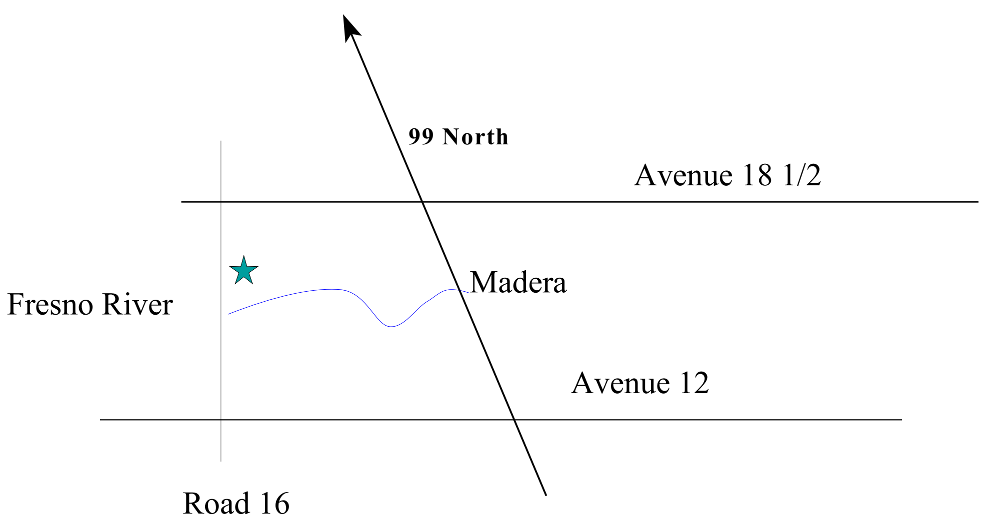
9:00 a.m. **Hull rot disease management in almond orchards**
Brent Holtz, PhD, Farm Advisor, UCCE Madera County

10:00 a.m. **Plant based measurements to schedule irrigation and manage hull rot**
Bruce Lampinen, PhD, Almond and Walnut Specialist, UC Davis

11:00 a.m. **Pressure bomb demonstration**
Jeff Hamel, Manager, PMS Instrument Company, Albany, OR
Bruce Lampinen, PhD, Almond and Walnut Specialist, UC Davis

12:00 p.m. **Adjourn**

2.0 hours of PCA, CCA and Private Applicators Credit have been requested.
Meeting Sponsored by the University of California
Refreshments provided by PMS Instrument Company, www.pmsintrument.com



J.M. Lasgoity orchard is just north of the Fresno River, on the east side of Road 16

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Non-infectious Bud Failure Effects and Management

Joe Connell, UC Farm Advisor, Butte County.

This year is shaping up to be a bad one for the expression of Non-infectious bud failure (BF) symptoms. Anyone who has followed BF for awhile recognizes that some years are much worse than others.

It's well known that non-infectious bud failure is a genetic disorder that occurs in many almond varieties in California. Nonpareil or any variety with Nonpareil parentage in its genetic background can be affected by the disorder. The problem is usually more severe in warmer areas of the state and in a spring following a hot June the previous year.

BF does not affect the flower buds. Flowers form and bloom normally although the bloom time is usually delayed by four to seven days. It is the vegetative shoot buds that actually fail.

Yield losses occur because fruit wood development is reduced and possibly because more limited leaf surface reduces carbohydrate production. On individual shoots affected by BF the basal or terminal buds are more likely to survive since they grow during cooler times of the season. Pruning won't eliminate the problem. Re-growth that occurs following pruning has at least the same potential to develop BF that the tree had prior to pruning.

Various sources of a variety have differences in BF potential. The key element of control is the selection of single-tree sources whose low BF potential is determined by growing progeny trees under orchard conditions in a high temperature area. If BF is initially expressed in trees early in their training stage (up to 4 years), expression is severe because a large part of the tree is affected. If symptoms are initiated later, lesser expression results and affected parts are confined to smaller areas in the top or periphery of the tree. This is the basis of recommending BF trees be removed if symptoms develop during the early orchard development period.

Options. There are three options for dealing with a BF problem in your orchard. First, you can simply continue to maintain the BF trees (this is usually the best option in older trees). Second, it's possible to top work the affected trees by budding or grafting using wood with a lower BF potential. This takes considerable attention to detail but may be a good choice if the trees are noticed in the second to fifth leaf. Finally, replacing the tree by replanting is another option. This is reasonable between the second and fifth leaf (the sooner the better). Once trees are mature, replacing the tree should be done only if there is sufficient time left in the orchard's life to recoup the cost of the new tree and the yield lost from the BF tree while the replacement tree is coming into bearing.

In a study done in the early 1970's by Gerdts,et.al., Nonpareil yields from normal trees were compared to yields of both mildly affected BF trees and severely affected trees. Mild BF was defined as BF found only in several secondary branches. After three years of data collection, the average Nonpareil yield on mildly affected BF trees was 91% of normal. Such trees actually out produced normal trees in one orchard in some years due to later bloom and better pollination weather. Severe BF trees displayed BF in at least one major scaffold with other symptoms showing throughout tree. In these trees, the three-year average Nonpareil yield was 64% of normal. The researchers found decreases in kernel weight and in kernel numbers and they also observed a trend toward more double kernels.

In a companion study by Browne, et al., a UC agricultural economist calculated the break-even point for replacing BF trees by replanting or top working assuming hypothetical yield curves representing 90, 60, and 40 percent of a normal 1500 pound per acre orchard yield. Break even occurs when the increased returns of grafted or replanted trees finally offset the increased cost and loss of income from having the BF tree out of production.

At the 90% yield level, replacing a BF tree didn't result in breaking even until after more than 50 years had passed! At the 60% yield level, the break-even point occurred at 14 years (this level of yield reduction is typical for severely affected BF trees). If BF reduced the yield to 40% of normal it still took 9 years to break even by replanting. At all yield levels, top working a BF tree provided a one-year advantage compared to replanting assuming that top working was successful.

Overall, the severity of BF is the major factor in determining when the break-even point occurs. Orchard yield and price per pound are minor factors since different yield levels require a similar time to reach the break-even point. Generally, the orchard must have more than 10 years of life remaining to justify replacing a BF tree.

Shackel, et al. studied BF effects on yield of young Carmel almonds in a Kern County orchard planted in 1991. Yields for three years, 1994 through 1996 (4th-6th leaf) were collected from normal trees, from very mildly affected BF trees, from trees with moderate BF, from trees with severe BF, and from trees with very severe BF. Three year average yields from the very mildly affected trees were scarcely different from the normal trees and in some cases were actually greater. Moderately affected BF trees produced a 3-year average yield that was about 89% of normal. Trees severely affected by BF yielded 62% on average of what was produced by normal healthy trees. These results are similar to the findings on Nonpareil that were discussed earlier. Carmel yields from very severely affected trees were reduced even further to 50% of normal.

Early BF diagnosis is critical in reducing the time to a break-even yield. The first opportunity to observe BF in a new orchard is the spring of the second leaf. Observations must be made in March or April when symptoms are clearly visible since new growth from the surviving buds can mask BF later in the season. Replanting or top working any tree showing even mild symptoms at that time should have beneficial yield effects in four to five years. Mild BF symptom expression after the fourth leaf may not warrant tree replacement. Severe BF may continue to warrant replacement until about the eighth or ninth leaf.

***What to do*.** BF has the greatest impact on future productivity when second through fourth leaf trees are affected. **Make a major effort to detect BF in the second to fourth leaf** and replant as soon as possible or top work affected trees using bud wood with low BF potential.

For trees five to six years old, replace the trees only if BF is affecting the main framework of the tree. If you find trees like this it means you probably overlooked them when they first showed subtle signs of the disorder in their second or third leaf. Mild BF affecting only the upper canopy may not seriously affect yield.

When older trees become affected, do nothing. The cost of replacement and the yield loss following tree removal will not be offset by increased production before the orchard is removed. When BF is restricted to upper portions of the canopy there's less impact on productivity.

Avoid any stress in the orchard that can raise canopy temperatures. Anything that can cause defoliation such as water stress, mites, scab, or leaf rust could contribute to higher canopy temperatures and possibly aggravate BF.

Sources:

Browne, L.T., M. Gerdts, E.A. Yeary, Replacing Bud Failure Trees, California Agriculture, March, 1975, pg.15.

Gerdts, M., W.C. Micke, D. Rough, K.W. Hench, L.T. Browne, G.S. Sibbett, Almond Yield Reduction, California Agriculture, March, 1975, pg.14.

Shackel, Ken, Tom Gradziel, Dale Kester, Mario Viveros, Warren Micke, Mike Cunningham. Non-infectious bud-failure, 1996 Annual Report to the Almond Board, Project No. 96-K23, Spring 1997, 7 pgs.

COMING EVENTS:

Pistachio Production Short Course: November 3 - 6, 2008. Visalia Convention Center. Contact Louise Ferguson at 530-752-0507