Almond Hull Rot – Cultural and Chemical Management

David Doll[1] and Brent Holtz[2],
University of California Cooperative Extension, Merced County[1], San Joaquin County[2]

Hull Rot is an infection of the hulls caused by either *Rhizopus stolinifer* or *Monilinia fructicola*. Upon infection, the pathogens release toxins that are translocated into the fruiting wood, which kills the wood and causes crop loss. These pathogens are common throughout the environment and are, in this case, serving as opportunistic pathogens. Once the hull splits, the perfect micro-climate for fungi is created as the hull is full of nutrients and water. Since the spores of these fungi are found within the orchard environment, they invade the newly split tissue, infecting, and completing their life cycle. By making conditions less favourable for the fungi, the number of hull rot strikes can be reduced. Strategies include reducing the water and nutrient content of the hull.

Nitrogen and Irrigation Management Can Reduce Hull Rot Incidence.

Hull rot often affects high vigour orchards. The highest incidence occurs on 'Nonpareil' with fewer strikes on other varieties (Table 1). Research conducted in 1990-2000 has shown that hull rot incidence can be reduced with adequate, but not excessive, nitrogen applications, and the application of a water deficit at the initiation of hull split.

Table 1: Almond varietal differences in hull rot occurrence

Variety	Strikes per tree	Susceptibility
Nonpareil	>500	Very High
Butte	>200	High
Winters	>200	High
Price	100-200	Medium
Sonora	100-200	Medium
Aldrich	10-100	Low
Wood Colony	10-100	Low
Mission	10-100	Low
Ruby	10-100	Low
Livingston	10-100	Low
Padre	10-100	Low
Fritz	0-10	Very Low
Carmel	0-10	Very Low
Monterey	0-10	Very Low

Excessive nitrogen within the tree increases susceptibility to hull rot infection. In two long term studies performed by University of California researchers, there was a positive linear relationship between nitrogen rates and hull rot incidence. In other words, the more nitrogen applied, the higher the incidence of hull rot. Trees with nitrogen application rates above 250 lbs/acre were the most severely affected, and hull rot strikes were higher in low crop years. In order to reduce hull rot, nitrogen rates should be modified based upon crop load to keep the trees sufficient. Analysis of leaf nitrogen content should be conducted to determine nitrogen status. If properly sampled, the critical value for mid-summer leaf nitrogen percentage is 2.2-2.5%.

Data suggest that summer nitrogen applications increases hull rot incidence. Nitrogen should not be applied after kernel development is completed. This is typically in late spring, but in abnormal years, it may extend into early summer. Applications made after this point will be directed to the hull, making the hull more conducive to infection. Nitrogen applications can resume in the post harvest period. Data suggests that nitrogen source does not influence hull rot.

Research by Teviotdale and colleagues (2001) has shown that a slight to moderate water stress at the onset of hull-split can reduce hull rot. Irrigation should occur when the average stem water potential is four bars more negative than baseline. This measurement is taken using a pressure chamber and is usually between -14 and -16 bars, depending on weather. The period of deficit irrigation should be carried out for two weeks. After the two weeks, full irrigation should resume until the harvest dry-down period. In managing the application of this stress, duration of the irrigation should be reduced, not the frequency. Typically, a 10-20% reduction in applied water will be needed, but this depends on the soil and irrigation system and will have to be determined on an orchard basis. A properly timed and applied deficit can reduce hull rot by 80-90%. Throughout the duration of the study, the application of this properly timed, regulated irrigation deficit did not affect yield or kernel size. It also appeared to have some effect of evening up hull split and subsequent harvest.

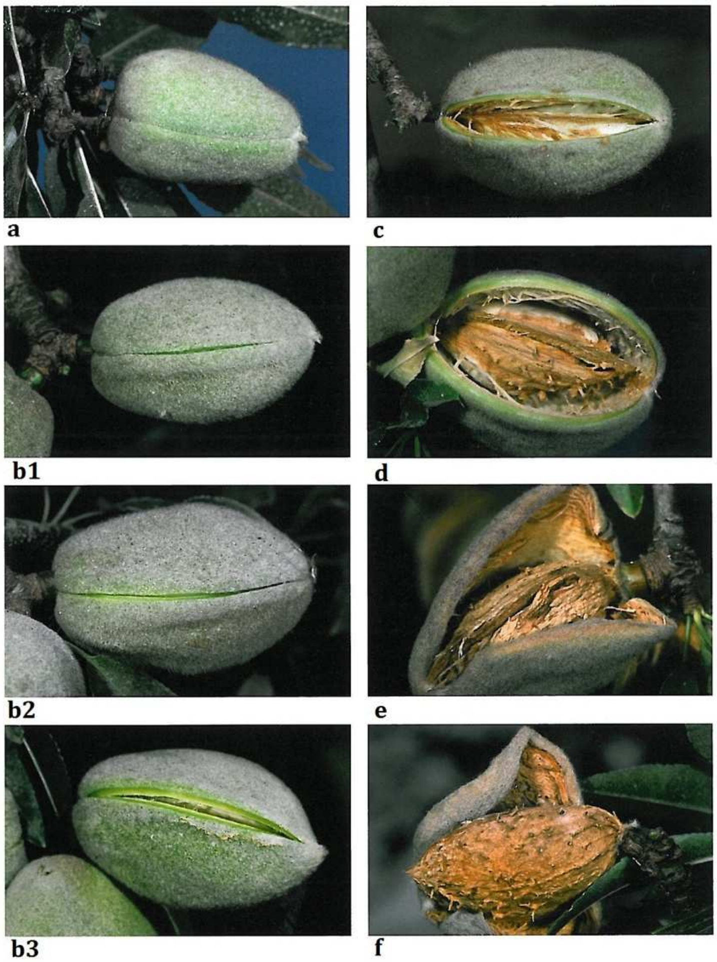

Figure 4: Stages of hull split. a. unsplit hull, b1. initial separation, b2.deep V split, b3. deep V split, but nut pops when squeezed, c. split, but less than 1 cm, d. split, more than 1 cm, e. initial drying stages, f. completely dry.

Stages of Hull Split and Fungicide Timing.

Work by Dr. Jim Adaskaveg (2010), UC Riverside, has found that *R. stolonifer* is only able to infect almond hulls during a brief period of nut development. Since the pathogen is not able to infect healthy tissues, it needs an injury in order to infect the hull. This wounding naturally occurs during the hull-split process. His studies elucidated that the highest incidence of infection occurred during the initiation of hull-split, when only a very small crack of the hull is present. This is classified as stage b2 (Figure 4) within the UC IPM manual. Later stages resulted in fewer infected fruit, and he concludes that the susceptibility differences of the stages are due to differences in hull moisture content.

Further work by Dr. Adaskaveg has found that sprays timed to the b2 stage will decrease hull rot incidence. Due to the variability of hull-split progression within the field, fungicides should be applied at 10-20% of hull-split. Both DMIs (FRAC 3) and strobilurin (FRAC 11) fungicides are effective. These sprays are additive to the reductions shown by the cultural management practices of irrigation and nitrogen management. It is important to note that increased populations of other foliar fungi that occur at this hull split spray timing increases the risk of developing fungicide resistance, so fungicide sprays for hull rot should be used as a last resort. Fungicides applied at this time do not work on hull rot caused by *Monilinia fructicola*. Maximum residue levels (MRLs) of the fungicide chemistry used should be discussed with the processor/handler to determine the most up-to-date information, and pre-harvest intervals should be followed.

Hull Rot Management: Bringing it all together.

Successful management of hull rot will rely on both cultural and chemical control strategies. Proper implementation of these practices must take in account the localized growing conditions. A late season rain may reduce the effectiveness of deficit irrigation or prevent the application of a fungicide spray. A late frost may lead to reduced crop load and an over-fertilized tree. Heavier and coarser soil types make the implementation of proper level of tree stress challenging; one requires a longer period of dry-down while the other may become dry too quickly. Even with varying environmental conditions, applications of the mentioned strategies have been shown to reduce hull rot in both field studies and grower's operations. Success and proper application will be dependent upon the monitoring of tree status through stem water potential readings, leaf tissue analysis, and observations of hull split timing.

Sources:

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Teviotdale, B. L., Goldhamer, D. A., and Viveros, M. 2001. Effects of deficit irrigation on hull rot disease of almond trees caused by Monilinia fructicola and Rhizopus stolonifer. Plant Dis. 85:399-403.

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N.B. Months quoted in this Californian article apply to the Northern Hemisphere. Ed.