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Proceedings editors and co-authors of this summary are Benjamin H. Beard, Research Geneticist and Research Leader, Oilseed Crops Production, Agricultural Research Service, USDA, at Davis, and Milton D. Miller, Extension Agronomist, Emeritus, U.C. Division of Agricultural Sciences.

Search continues for control of almond hull rot

L. Todd Browne ▪ Joseph M. Ogawa ▪ Bashier Gashaira

Almond hull rot, caused by two genera of fungi, can result in severe dieback on vigorous, productive trees. Research is under way to find effective measures for controlling the disease.

Nonpareil almond tree showing blight of leaves and shoots caused by the bread mold fungus.

Hull rot is an almond disease that has become increasingly important to California producers. It is caused by two genera of fungi that invade the hull and produce a toxin that kills adjacent spurs and shoots. No control has yet been found. Industry support has recently been provided, which we hope will enable us to develop effective control measures.

The disease was recognized in California during the early 1950s and found to be caused by the brown rot fungus, *Monilinia*, and the bread mold fungus, *Rhizopus*. Studies in the late 1950s revealed that *Rhizopus* was more commonly isolated (43 percent) from rotted hulls than was *Monilinia* (20 percent). Fifteen other fungus types were isolated, including the grey mold fungus, *Botrytis* (14 percent). The pathogenic role of *Rhizopus* and *Monilinia* was established. Further studies with *Rhizopus circinans* demonstrated that fumaric acid produced in rotted hulls is translocated to twigs and leaves, killing twigs and causing leaf blight.

Our studies during 1975 revealed that hull rot is very damaging to trees. Dieback can be severe on vigorous and productive trees. Young and middle-aged trees with dense canopy, receiving ample nitrogen and zinc, appear most severely affected. Any rainfall between hull split and harvest promotes extremely rapid disease development. In determining spur wood killed, it was found that 25 percent of a tree's producing area could be ruined in one bad hull-rot year (table 1).

The importance of hull rot to almond production is related to loss of fruit wood, unharvested nuts, and overwintering of the navel orangeworm on sticktights, with additional costs for nut removal during the winter. Also, knocking to bring down all nuts requires much more effort and force. This can result in occasional bark damage, where another fungus pathogen, *Ceratocystis fimbriata*, can enter and kill limbs.

The first sign of hull rot appears about a month before knocking begins. Leaves in the middle and lower parts of the tree begin to wither. Close inspection of a cluster will reveal at least one nut with a rotting hull. The sooty-appearing *Rhizopus* or the buff-colored brown rot fungus can be recognized by the sporulation. Streaks of brown necrotic wood can be seen when the killed stem is cut open below a strike with a pocket knife.

Later, small boils of gum appear on affected spurs and shoots and sometimes occur on larger wood 2 to 4 inches in diameter. These gum boils appear to be the result of hull-rot toxin.

By harvest, affected trees look as if they were scorched by fire (see photo). Large groups of leaves have turned from green to tan or light brown, and some of the smaller wood is dead. Nut kernels are sound, but nuts can be very hard to remove, because the abscission cells are killed before abscission occurs.

Nonpareil is one of the most severely affected cultivars, and diseased trees exhibit all of the symptoms described. Jordanolo and IXL are similarly affected. Merced, Thompson, and Ne Plus Ultra are frequently affected, but less severely, and may not die back excessively. The nuts of Thompson and Merced, often difficult to knock under normal conditions, may become nearly impossible to dislodge after hull rot. Mission, Davey, and Drake cultivars are seldom affected. (See table 2.)

Our main objective is to obtain information so that we can make recommendations on hull rot control in diseased orchards and ascertain which orchards do not require control measures. Surveys are in progress to determine the percentages of the different hull rot organisms present in the hull-rot complex in California's major almond-producing areas. This information will be related to the varietal susceptibility tests.

Studies indicate the soft-shelled varieties are more susceptible and that infections first occur not on the hull tissue but in the soft outer shell (endocarp) tissues. Inoculation of the outer shell tissue with fungi at time of hull split shows that this tissue can support germination and growth of *Rhizopus* and *Monilinia*.

Because certain orchards have severe hull rot while others do not have this problem, differences in environmental factors among these orchards will be studied. Climatological data will be collected from orchards in Fresno, Merced, and Butte counties. Studies on cultural factors, such as irrigation, fertilization, crop density, planting distances, and soil characteristics, will be made to determine if they are related to hull rot incidence and severity.

L. Todd Browne is Farm Advisor, Fresno County; Joseph M. Ogawa is Professor of Plant Pathology, and Bashier Gashaira is graduate student, Department of Plant Pathology, University of California, Davis. *This study is supported by the Almond Control Board. The authors thank Dale Morrison, Director—Special Projects, Almond Control Board, and members of the research advisory committee for their suggestions and cooperation, and growers Otis Freeman and Bill Boos, Fresno County, and Fred Nottelmann, Butte County, who provided their orchards for the 1975 studies.*

TABLE 1. FRUITING WOOD OF NONPAREIL CULTIVAR KILLED BY ALMOND HULL ROT

Tree number	Inches of fruiting wood killed in each quadrant of tree: Northwest	Northeast	Southwest	Southeast	Percent killed per tree
I	145	70	126	113	18.9
II	106	101	228	202	26.5
III	173	117	188	180	27.4
Percent killed*	23	16	30	27	

*A total of 600 inches of fruiting wood was examined in each tree quadrant in Fresno County on September 5, 1975.

TABLE 2. SUSCEPTIBILITY AND KILL OF TWIGS BY INOCULATION OF ALMOND HULLS ON MERCED AND MISSION CULTIVARS AT HULL SPLIT

Cultivar and fungus pathogen	Percent infection or disease*: Hull	Peduncle	Twig symptoms
MERCED			
Monilinia fructicola	24	22	8
Monilinia laxa	24	20	12
Rhizopus stolonifer	17	24	6
MISSION			
Monilinia fructicola	18	0	0
Monilinia laxa	16	0	0
Rhizopus stolonifer	11	0	0

*Three replications of 10 fruit inoculated at hull split with 70,000 spores/ml of *Monilinia* and 232,000 spores/ml of *Rhizopus* on October 7; data obtained on October 15, 1975.