Management of Hull Rot in Almond

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San Joaquin County
UNIVERSITY OF CALIFORNIA
HULL ROT

MONILINIA FRUCTICOLA

RHIZOPUS STOLONIFER
Update on Hull Rot Control

• Caused by *Rhizopus stolonifer* or by *Monilinia fructicola*
• Both pathogens infect fruit and cause dieback

*Rhizopus stolonifer*  
*Monilinia fructicola*

• Inoculum of *Rhizopus stolonifer* is omnipresent (soil)
• Inoculum of *Monilinia fructicola* originates from other stone fruits (peaches, cherries) or almond. Blossom blight can be caused by *M. laxa* (North) and *M. fructicola* (South regions).
<table>
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<tr>
<th>Cultivar</th>
<th>Strikes/Tree</th>
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<tr>
<td>Kapareil</td>
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<td>Nonpareil</td>
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<td>Butte</td>
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<tr>
<td>Winters (13-1)</td>
<td>216</td>
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HULL ROT

CULTIVAR SUSCEPTIBILITY

100-200 STRIKES/TREE

JOHYN    PRICE

JENETTE   2-19 E

SONORA    25-75
HULL ROT

CULTIVAR SUSCEPTIBILITY

1-100 STRIKES/TREE

CHIPS          2-43 W          MISSION
KAHL           MORLEY          ROSSETA
SANO           ALDRICH         RUBY
YOKUT          JIML            LIVINGSTON
PLATEAU        1-87            PADRE
10102 W        WOOD COLONY
HULL ROT

CULTIVAR SUSCEPTIBILITY

0 STRIKES/TREE

SAVANA
FRITZ
DONNA

CARMEL
MONTEREY
HULL ROT

VIGOROUS, PRODUCTIVE ORCHARDS

AMPLE WATER & NITROGEN

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HULL ROT

THE GOUT OF ALMOND TREES

TOO MUCH FOOD & DRINK

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HULL ROT

RESPONDS DRAMATICALLY TO CULTURAL CONTROL
HULL ROT MANAGEMENT
NITROGEN IRRIGATION FUNGICIDES?
HULL ROT: NITROGEN

COMPARED FOUR RATES (LBS/ACRE)

• 500
• 250
• 125
• 0
HULL ROT: NITROGEN

LEAF NITROGEN CONTENT (%)

LINEAR $P =$

1992 0.003
1993 0.001
1994 0.010
1995 0.020
Nitrogen Effect 2011-
by tagged spurs

144 trees were selected with different N treatments (125, 200, 350 lbs/acre). In each selected tree a total of 11 non-fruiting spurs (NF), 11 one fruiting spurs (F1), and 11 two fruiting spurs (F2) were labeled for a total of 4,752 labeled spurs. **Hull rot incidence** was determined after harvest as the proportion of spurs out of total tagged spurs that were experiencing blight and dieback.

High levels of N have significantly more hull rot incidence than lower levels, mainly due to a higher incident in F2 spurs.
Nitrogen fertilizer effect on hull rot count A=125 lbs N/ac B=200 lbs N/ac, C=275 lbs N/ac, D=350 lbs N/ac.

Blighting was estimated by counting the number of spurs or shoots that had dry leaves. Each treatment comprised 60 trees.
HULL ROT MANAGEMENT

NITROGEN USAGE

- AVOID EXCESSIVE LEVELS
- IDEAL: leaf petiole 2.2-2.5%
HULL ROT MANAGEMENT

IRRIGATION

- EARLY CUT-OFF
- REGULATED DEFICIT
HULL ROT: IRRIGATION

EARLY CUT-OFF: STRIKES PER TREE

DAYS BEFORE HARVEST

1990
1991
HULL ROT: IRRIGATION

REGULATED DEFICIT
### Regulated Deficit Irrigation Schedule

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<th>Gray</th>
<th>Purple</th>
<th>Blue bar</th>
<th>Blue</th>
<th>Rose</th>
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HULL ROT: IRRIGATION

REGULATED DEFICIT - WATER

INCHES WATER APPLIED TO 15 AUGUST 1994
HULL ROT: IRRIGATION

REGULATED DEFICIT - STRIKES

39 Gray
34 Purple
   Blue bar
   Blue
28 Rose
   Red
   Green
22 White
   Orange
   Orange bar

STRIKES PER TREE TO 15 AUGUST 1994

0  5  10  15  20
HULL ROT: IRRIGATION

REGULATED DEFICIT - DEAD WOOD

INCHES DEAD WOOD TO 15 AUGUST 1994

39  Gray
34  Purple Blue bar
     Blue
28  Rose Red Green
22  White Orange Orange bar

0  10  20  30  40

a  bc  cd  d
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HULL ROT
IRRIGATION
MILD STRESS AT EARLY HULL SPLIT
REDUCES HULL ROT
What is worse? Pacific Spider Mite? or Hull Rot?
• Rhizopus can only infect almond hulls after hull split—not before!!
HULL ROT: VALIDATION

WILL DEFICIT IRRIGATION WORK WITH?

• MICROSPRINKLER
• FLOOD
• DOUBLE-LINE DRIIP
HULL ROT: VALIDATION

GOAL

ACHIEVE -14 BARS

PREDAWN LEAF WATER POTENTIAL

BY EARLY HULL SPLIT
Deficit Irrigation Management During Hull-Split

OR,

An Almond RDI “Clinical Trial”

Project leader: Ken Shackel, Pomology, UC Davis

Sub-Project Leaders:
Rick Buchner, Joe Connell, John Edstrom, Allan Fulton, Brent Holtz, Bruce Lampinen, Bill Krueger, Wilbur Reil, Larry Schwankl, Mario Viveros
Proposed benefits of RDI for almonds during hull split:
1) Reduce Hull rot
2) Reduce Sticktights (Improve Harvestability)
3) Save Water

**Prescription:**
1) Measure stress using midday Stem Water Potential (SWP)
2) Prior to hull split: **-7 to -9 bars** SWP (fully irrigated baseline)
3) During hull split: **-14 to -18 bars** SWP (mild to mod. stress)
4) After hull split: **-7 to -9 bars** (as close to harvest as possible)
Pressure chamber method for measuring SWP (schematic)

Water Coming Out (Artist's conception)

Magnifying Glass

(Pressure Gauge)

(Plastic bag)

Air Pressure
Bagged Leaf

- Leaves are bagged with a small bag that will block out sun light for at least 15 minutes before the measurement is taken.
HULL ROT MANAGEMENT

MEASUREMENTS

SAMPLING THE ORCHARD

- UNIFORMLY
- MOST REPRESENTATIVE AREA
- AVERAGE OF SEVERAL AREAS
HULL ROT MANAGEMENT

MID-DAY STEM WATER POTENTIAL

WHEN: 1:00 TO 3:00 P.M.
WHERE: LOWER CANOPY NEAR TRUNK
WHAT: HEALTHY, MATURE, SHADED LEAF
NUMBER: ONE TO THREE PER TREE
HULL ROT MANAGEMENT

MID-DAY STEM WATER POTENTIAL

- COVER LEAF WITH OPAQUE PLASTIC BAG
- REMOVE BAG 10-15 MINUTES LATER
- SNAP LEAF FROM TREE, RE-CUT
- IMMEDIATELY INTO PRESSURE BOMB
- OBSERVE FOR DROPLET ON CUT PETIOLE
Hand held pressure bomb

- Leaf is placed in the pressure bomb with the leaf blade protruding out of the chamber
When water potential is reached, water bubbles out the leaf stem.
## Midday Stem Water Potential

### Fully Irrigated Almond Trees

<table>
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<tr>
<th>Temperature (°F)</th>
<th>Air Relative Humidity (RH, %)</th>
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<td>10</td>
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<tr>
<td>70</td>
<td>-6.8</td>
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<td>75</td>
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<td>115</td>
<td>-15.1</td>
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Effect of RDI on Hull Rot 2003

Strikes per tress

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<th>RDI</th>
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<td>Strikes</td>
<td>17.7</td>
<td>2.2</td>
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Agriculture and Natural Resources

Healthy Food Systems • Healthy Environments • Healthy Communities • Healthy Californians
HULL ROT: VALIDATION

WILL IT WORK IN OTHER SITUATIONS?

YES
HULL ROT: VALIDATION

14-DAY (MICRO-SPRINKLERS)

1997 IRRIGATION DEFICIT:

- FULL
- NONE
HULL ROT: VALIDATION

14 DAYS (MICROSPRINKLER)

MEANING:
IT TOOK 14 DAYS IN THIS ORCHARD TO REACH THE GOAL OF –14 BARS
HULL ROT: VALIDATION

14 DAYS (MICROSPRINKLER)

DOES NOT MEAN:
USE A 14-DAY DEFICIT IN ALL MICROSPRINKER ORCHARDS
HULL ROT: VALIDATION

36-DAY (FLOOD)

1997 IRRIGATION DEFICIT:

- FULL
- NONE

1. STRIKES: dead wood kernel dry wt (g)
2. KERNEL DRY WT (g)
3. PRE-DAWN LWP

Legend: a, b
HULL ROT: VALIDATION

36 DAYS (FLOOD)

MEANING:
IT TOOK 36 DAYS IN THIS ORCHARD TO REACH THE GOAL OF –14 BARS
HULL ROT: VALIDATION

36 DAYS (FLOOD)

DOES NOT MEAN:
USE A 36-DAY DEFICIT IN FLOOD IRRIGATED ORCHARDS
HULL ROT: VALIDATION

49-DAY (DOUBLE-LINE DRIP)

IRRIGATION DEFICIT:  FULL  PARTIAL  NONE

STRIKES  DEAD WOOD  KERNEL DRY WT(g)  PRE-DAWN LWP
HULL ROT: VALIDATION

49 DAYS (DOUBLE LINE DRIP)

MEANING:
IT TOOK 49 DAYS IN THIS ORCHARD TO REACH THE GOAL OF –14 BARS
HULL ROT: VALIDATION

49 DAYS (DOUBLE LINE DRIP)

DOES NOT MEAN:
USE A 49-DAY DEFICIT IN DOUBLE LINE DRIP ORCHARDS
HULL ROT: VALIDATION

NOT: PRESCRIPTIONS
ARE: EXAMPLES
THAT HULL ROT CONTROL
CAN BE ACHIEVED IN
DIFFERENT SITUATIONS
HULL ROT MANAGEMENT

REDUCE WATER AT EARLY HULL SPLIT
HULL ROT MANAGEMENT

REDUCE WATER AT EARLY HULL SPLIT

Intuition
Measurements

University of California
Agriculture and Natural Resources

HEALTHY FOOD SYSTEMS • HEALTHY ENVIRONMENTS • HEALTHY COMMUNITIES • HEALTHY CALIFORNIANS
HULL ROT MANAGEMENT

INTUITION

- KNOW YOUR ORCHARD
- SOIL
- WATER USE
- GROWTH
HULL ROT MANAGEMENT

MEASUREMENTS

- EVAPORATIVE DEMAND
- SOIL MOISTURE
- MID-DAY STEM WATER POTENTIAL
HULL ROT MANAGEMENT

MEASUREMENTS

MID-DAY STEM WATER POTENTIAL
FULLY IRRIGATED: -7 TO -9 BARS
MILDLY STRESSED: -14 TO -18 BARS
HULL ROT MANAGEMENT

IRRIGATION

- MAINTAIN ORCHARD AT -7 to -9 BARS
- AT FIRST HULL SPLIT, STOP WATER
- RESUME IRRIGATION AT -14 TO -18 BARS
HULL ROT MANAGEMENT

SLIGHT WATER STRESS AT HULL SPLIT

- REDUCES HULL ROT
- MORE UNIFORM HULL SPLIT
- SHORTENS LENGTH OF HULL SPLIT
- SHORTENS PERIOD OF SUSCEPTIBILITY
- IMPROVES NUT REMOVAL
- CAN REDUCE NAVAL ORANGE WORM
HULL ROT MANAGEMENT

FUNGICIDE APPLICATIONS
Hull rot caused by *R. stolonifer* can be managed with early hull split applications of selected fungicides. Typically, 70% reduction with a single application.
Management of hull rot caused by *Monilinia fructicola* - 2011

cv. Nonpareil, Stanislaus Co.

<table>
<thead>
<tr>
<th>Application</th>
<th>Hull rot Incid. (%)</th>
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<tbody>
<tr>
<td>Control</td>
<td>a</td>
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<tr>
<td>Ph-D 11.2DF 6.2 oz</td>
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<tr>
<td>Quash 50WG 3.5 oz</td>
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<tr>
<td>Inspire Super + Surf. 20 fl oz</td>
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<tr>
<td>Luna Sensation 5 fl oz</td>
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</table>

Hull rot caused by *M. fructicola* is **not** managed with early hull split applications of selected fungicides.
Hull rot caused by *M. fructicola* or by both pathogens is managed by late-spring applications. This study will be repeated in 2013 using different fungicides.

**Applications with Luna Experience**

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Hull rot counts

[Graph showing results with bars labeled a, b, c, and ab, bc, c.]

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cv. Nonpareil, Stanislaus Co.
Knowledge on the management of hull rot is accumulating.

Fungicide treatments can be effective in reducing hull rot caused by *R. stolonifer* and by *M. fructicola*.

- For *Rhizopus* hull rot, early hull split applications when susceptibility is high should be done. Fungicides are applied most effectively with NOW applications.
- For *Monilinia* hull rot, applications should be done earlier (late spring). *This needs further evaluation.*

For the most effective integrated management of hull rot, hull split should be induced simultaneously with proper water management (i.e., deficit irrigation).
A = <1% hull split, B => 1% hull split, C = 40% hull split, rated 8/26/02
Spring Rating in 2003

A = <1% hull split, B = >1% hull split, C = 40% hull split, rated 5/9/2003
HULL ROT MANAGEMENT

NITROGEN
LEAF N CONTENT MAX OF 2.5%

IRRIGATION
MILD STRESS AT HULL SPLIT
EARLY HARVEST

FUNGICIDES AT HULL SPLIT
Good Luck!!!