Concealed Damage/Stockpile Best Management Practices

Presenter

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Update on Concealed Damage and Stockpiling
Research and BMPs

By Bob Curtis—Almond Board of California
Almond Quality & Food Safety Symposium
July 23, 2014
Concealed Damage
Field Studies

Franz Niederholzer (UCCE Cooperative Extension), Project Leader

• Objectives
  1. What conditions in the field affect concealed damage development in almond?
     ▪ Determine the threshold for CD appearance under specific kernel moisture content / temperature / time and field management scenarios.
     ▪ Determine how “short the fuse is” for action under different field, handling, temperature, and moisture scenarios
  2. What field practices could minimize concealed damage in almond?
Evaluating Concealed Damage in Almonds

Alyson Mitchell (UCD, Food Science and Technology), Project Leader

• Objectives
  1. Identify chemical markers of CD in almond kernels
  2. Evaluate the influence of temperature and moisture levels on the development of CD in almonds.
     In parallel to the field studies, studies will be done under controlled conditions, and field samples are submitted
     ▪ At various constant moisture contents (6% or less, 8%, 10-12% and 14%)
     ▪ Subjected to various temperatures (110 °F, 120 °F, 140 °F).
     ▪ Samples will be pulled at intervals (every other day) and assessed for chemical markers of CD
  3. Evaluate the influence of CD on shelf-life.
Concealed Damage
Concealed Damage Field Work

Monterey variety
Nickels Soil Lab
Samples to Mitchell lab at UC Davis for analysis
2011
• “Rained” on conditioned or unconditioned windrows.
2012
• “Rained” on conditioned or unconditioned windrows. Conditioned or not after rain.
Concealed Damage Field Work
2011 Harvest CD Field Studies

Windrow

10 days
Almonds already rained on – 1.14”: kernel moisture content 19%
Rewetted almonds – additional 1.5” water applied
Conditioning = “Drop chuted”
Ambient temp. did not exceed 85°F and temp. in windrows did not exceed ambient

4 treatments
1. CD - Rained on and conditioned
2. CW - Rained on + rewetted and conditioned
3. UCD - Rained on and not conditioned
4. UCW - Rained on + rewetted and not conditioned

Sampled October 28
- Hulled, shelled, kernel moisture taken, and delivered to lab
2011 Lab handling of CD study field samples

Kernels stored ambient uncovered either 1 week or 4 weeks
Light roasted 120°C for 90 minutes
## 2011 Windrow

<table>
<thead>
<tr>
<th>Sample</th>
<th>% Kernel MC 10-28-11 Pick-up</th>
<th>% Kernel MC Lab</th>
<th>% Discolor Roast</th>
<th>% Kernel MC Lab</th>
<th>% Discolor Roast</th>
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<td>5.4</td>
<td>1.7</td>
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* Mold growth made it impossible to evaluate CD

3 reps per treatment
2012 Field Studies

• Field dried
• Start of experiment: Initial hull moisture = 11.3%, initial kernel moisture = 5.7%
• Placed in 30 - 1.5 bushel laundry baskets
• 5 treatments (six reps each treatment) placed back in orchard drive rows
• Conditioning = remove dirt, sticks leaves
• Rain = 1” water applied
• Lab analyses to be done

<table>
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<tr>
<th>TREATMENT</th>
<th>Conditioned before 1” water</th>
<th>Conditioned after 3 days after 1” rain</th>
<th>Conditioned 5 days after 1” rain</th>
<th>Conditioned 8 days after 1” rain</th>
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### Table 3: Percent kernel and hull moisture over time for each treatment in 2012 study. Artificial rain (1") applied on Oct 5.

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<td>12.2</td>
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Figure 1. Example of hourly temperatures for four of the treatments in 2012 “windrow” experiments following 1” artificial rain.
2011 and 2012 Field Work Results and Conclusions

• Conditioning reduced damage in the 2011 trial.
• Conditioning reduced temperatures in 2012 trial.
• Conditioning the crop before and after the “rain” in 2012 produced the most rapid drying. Most “singular” benefit was see with conditioning after rain.
• In 2012, temperature of the wet unconditioned nuts in “windrows” increased 20-30°F after one week in comparison to other treatments.
• In 2012, nut drying weather was excellent, so conditioned nuts, regardless of pre-wetting treatment (conditioned vs. unconditioned) dried rapidly. Unconditioned crop lagged behind in drying.
• Weather prior to “rain” affected the to what extent the windrows dried. As a result BMPs for concealed damage may have to reflect this.
Coping with Rain at Harvest

Protecting the almond harvest from rain. (Table 36.1 Almond Production Manual, UC ANR pub. 3364)

Table of prescribed actions when 5-day forecast predicts different weather situations -- Table originally developed by Larry Reinhart, former manager North State Hulling

Coping with rain at harvest
Franz Niederholzer, UCCE Farm Advisor, Colusa/Sutter/Yuba Counties
http://cesutter.ucanr.edu/news_204522/Pomology_Notes/?newsitem=43822
Stockpile Management

Bruce Lampinen (UC Davis, Plant Sciences), Project Leader
Project Objectives

- Examine temperature and moisture conditions in stockpiles
- Develop recommendations for stockpiling which minimize potential for growth of *Aspergillus* and resulting aflatoxin contamination
- Develop methods for sampling in-hull moisture content and rH
Procedures

Conditions monitored throughout storage (84-150 days) every 3 minutes with dataloggers

- Piles outfitted with temperature and rH sensors and placed at 4 locations throughout piles:
  - Top, upper mid-pile, lower mid-pile & bottom edge
- Ambient temperature and rH monitored

Samples taken from piles at start, during and at end of storage

- Moisture content
- Mold growth
- Aflatoxin analyses:
  - in-shell nuts, hulls & mummies

Sampling
Key Findings

There are clearly stockpile conditions under which *Aspergillus* can grow with resulting aflatoxin contamination

- Stockpiling of high moisture content in-hull almonds can lead to problems
- Specifically, problems arise when the **total fruit** (in-hull almond) moisture content is at and above 9%
- Most problematic is the outer portions of piles where there is significant condensation on tarps and moisture accumulation
- Not a uniform problem throughout high moisture content piles because the equilibrium rH within the piles came to a steady state below maximum limits recommended for storage
2007 Studies – Specific Outcomes

Initial moisture content low – minimal mold growth & no aflatoxin

- Inshell nut 3.5% + hull 7.9% ~ *Total fruit 5.7% mc*
- Inshell nut 3.1% + hull 5.7% ~ *Total fruit 4.4% mc*
2007 Studies – Specific Outcomes

Initial moisture content high

- Significant mold growth (various types) at surface & aflatoxin
- Inshell nut 5.2% + hull 13.1% ~ **Total fruit 9.2% mc**
- Inshell nut 7.3% + hull 12.0% ~ **Total fruit 9.7% mc**
Mold Examples

Green mold new crop

Green Aspergillus & fruiting bodies

Green mold mummies & new crop

Black molds
rH Equilibrium in Piles

Aspergillus “green mold” growth and aflatoxin associated only with outer wetter portions of piles

Within piles, relative humidity came to **steady state equilibrium below 65-70%**, which is recommended **maximum rH for almond storage**

rH
1) Ambient
2) Near pile surface
3) Lower mid-pile

![Graph showing rH data over time with labels for ambient, near pile surface, and lower middle of pile.]
Determining the appropriate rH / moisture of in-hull almonds to be stockpiled

Measure equilibrium rH of samples with a relative humidity moisture meter and mini probe

- Approximate cost is $1,420 (Rotonics commercial supplier)
- Use air-tight container
- Equilibrate to constant temperature in office or lab
Stockpiling Guidelines -- Relating Moisture Content to rH

Do not stockpile if either the hull moisture content exceeds 12% or the in-shell kernel moisture content exceeds 6% ~ in-hull (total fruit) moisture content 9%

• See following chart, “Relationship between relative humidity (rH, also called water activity) vs. moisture content of in-hull almonds, hulls and in-shell almonds”:
  • In-shell kernels + hulls
  • Hulls
  • In-shell kernels
**rH (water activity) vs. moisture content of in-hull almonds, hulls and in-shell almonds**

The relationship between relative humidity (and water activity) for in-shell kernels plus hulls, hulls, and in-shell kernels. Green shaded area indicates moisture contents that are acceptable for stockpiling. However, it should be noted that relationship between water content and water activity has been shown to vary depending on how wetting/drying cycles are produced. This suggests that the most accurate measurement is water activity since it is directly related to microorganism growth potential. Red shaded area indicates moisture contents that are too wet for stockpiling and yellow areas are boarder line.

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[www.almondboard.com](http://www.almondboard.com) (grower site) > orchard management > harvest > Stockpiling Guidelines > Stockpile Management to Prevent Aflatoxin with Moisture Level Guile for Stockpiling
2007 Studies – Specific Outcomes

Initial moisture content high

- Significant mold growth (various types) at surface & aflatoxin
- Inshell nut 5.2% + hull 13.1% ~ **Total fruit 9.2% mc**
- Inshell nut 7.3% + hull 12.0% ~ **Total fruit 9.7% mc**
Sampling across the orchard floor

• There is variability in drying on orchard floor – depends on
  • Light / temperature – canopy cover

• Sampling should account for these differences
  Sampling prior to sweeping
  • Across orchard floor – from trunk to middle of drive row
  • Along tree row – north to south
wettest samples
driest samples
North
Windrow sampling – more moisture on bottom

7 days drying – moisture content ~ 2% higher on bottom

\[ \text{Equilibrium RH (\%)} \]

\[ \text{Average moisture (\%)} \]

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<th>Sample</th>
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<td>middle</td>
<td>34 b</td>
<td>6.2 a</td>
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<td>bottom</td>
<td>40 c</td>
<td>6.7 a</td>
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Overall \( r^2 = 0.72 \)
Impact of different tarp materials on stockpile conditions
Impact of different tarp materials on stockpile conditions

Temp. top of pile

- White better and white on black tarps much better than clear
- Less day-to-night temperature fluctuations
- Less condensation
Impact of Different Tarps - Clear

Kern County Dry Clear Tarp Stockpile 2009

- top
- 3 feet down
- valley
- ambient

clear tarp
Impact of Different Tarps – White on Black

Kern County Dry White on Black Tarp Stockpile 2009

Temperature (degC)

- top
- 3 feet down
- valley
- ambient

white on black tarp
White on Black Tarp Uncovered
Clear Tarp Uncovered
Pile Guidelines

Stockpiles should be formed on firm surface, preferably raised slightly to avoid water puddling around edges.
Pile Guidelines

Orientation of piles can influence condensation problems- mold growth tends to be worse on north side of piles with long axis oriented east/west

North/south orientation is better
Pile Guidelines

Shape of piles can influence condensation problems - avoid peaks and valleys.

Condensation runs down valleys and collects causing mold
Pile Guidelines

Flattening out tops of stockpiles can help to minimize sagging of tarps and resulting concentration of condensation
Summary

- There are clearly stockpile conditions under which *Aspergillus* can grow with resulting aflatoxin contamination.
- Stockpiling at a “total fruit” (in-hull almond) moisture content greater than 9% is problematic. This leads to an rH greater than 65% within the pile.
  - New table relates rH (water activity) to moisture content of in-hull almonds, hulls and in-shell almonds
- There is variability of drying of nuts on orchard floor and in windrow and sampling should take this variability into account.
- Orientation and shape of pile both can play an important role in minimizing mold growth potential.
  - Long axis of pile north/south is best
  - Smooth tops on pile helps minimize concentration of condensate and resulting mold growth
Summary

- Results show tarp type/color can play an important role in minimizing temperature fluctuations and condensation potential.
  - White on black is best to minimize temperature fluctuations. Consider using for piles having high moisture content in-hull product.
  - Clear produces the highest temperature fluctuations, but is fine for dry in-hull product.
  - White is intermediate between clear and white-on-black.
- If piles are stacked too wet, it is important to open them up in the daytime when the relative humidity is lower and close them at night when the relative humidity is high.
- New GAP guide booklets.