Impact of hail damage on grain quality

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and
Steve Ensley
Acknowledgements

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Northeast storm

- July 24, 2009
- ~400,000 acres damaged
- Estimated 10% of acreage had 100% yield loss
“Sac to Grundy” storm

- August 9, 2009
- Travelled ~150 miles; 900,000 acres
- Hail swath ~10 miles wide; middle 3 miles (~30%) had 100% damage
Hail damage, Sac County, 8-09-2009

Photos courtesy: Mark Licht, ISU Extension
Hail damage, Callendar area, August 2009

Photos courtesy: John Holmes, ISU Extension
1. How much does hail damage increase susceptibility to ear rots?

2. What is the severity of mycotoxin risk associated with hail-damaged grain?

3. How does hail damage affect grain quality characteristics (test weight, seed weight, moisture, protein, oil, starch and density)?
Methods

1. Fields identified

2. 24 ears collected within 48 hours of harvest
   i. ears from 8 locations per field
   ii. @ each location: 3 ears from three consecutive plants
   iii. Husks intact
   iv. Grain sample (~10lb) from combine

3. Ears placed in a box/paper bag

4. Overnight shipped to campus
Field information required

• Location
• Hybrid
• Storm details:
  ✓ Date
  ✓ Size of hail stones
  ✓ Duration
• Percent damage to crop
• Growth stage of crop at time of storm
• Fungicide applied
Assessments

Sample received and ID number assigned

Field information captured

Visual assessment of ear sample:

a. percent hail damage
b. percent ear rot severity
c. molds present
Hail damage assessments - percent damage

3%

10%

25%
Ear rot assessments – percent severity; rot present

- Cladosporium
- Gibberella
- Fusarium
- Penecillium
- Trichoderma
Assessments

Sample shelled and aspirated (Kice Lab Aspirator)

Simulate combine

- clean grain subsample
- liftings subsample

For each subsample:
- test weight (G,L)
- seed weight
- moisture (G,L)
- density
- protein
- oil
- starch
Clean grain vs liftings
Assessments

Subsamples (G, L) dried to <15% moisture

Ground (G, L) (Romer mill)

Mycotoxin analysis (G, L) (lateral flow strips and HPLC)
  i. aflatoxin
  ii. fumonisins
  iii. DON (vomitoxin) → ZEN
RESULTS

103 samples received:

- 63 ear samples from hail damaged fields:
  - 7 from July storms
  - 56 from Sac-to-Grundy storm
  - 2 from other early August storms
- 26 “background” ear samples
- 2 ear samples from bird damage
- 12 grain samples
RESULTS

• Hail stones: 1/4” to golf ball
• Length of storm: 30s to 30 min
• Growth stage: V18 to R3
• % damage to crop: 2 to 100
# Ear Rot Summary

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>High</th>
<th>Low</th>
<th>Ear rot*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hail samples</strong> (N=63)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hail damage (%)</td>
<td>3.9</td>
<td>24.3</td>
<td>0.0</td>
<td>Fusarium, Gibberella</td>
</tr>
<tr>
<td>Ear rot severity (%)</td>
<td>11.3</td>
<td>53.4</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td><strong>Background samples</strong> (N=26)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ear rot severity (%)</td>
<td>3.2</td>
<td>16.4</td>
<td>0.0</td>
<td>Cladosporium</td>
</tr>
</tbody>
</table>

* Predominant ear rots present
Ear rot severity (%) increased with greater hail damage (%)

\[ y = 2.198x + 2.8098 \]

\[ R^2 = 0.6678 \]
Effect of storm duration, stone size, and growth stage on percent ear rot severity

$H_0$: duration, stone size and growth stage have no linear effect on ear rot

<table>
<thead>
<tr>
<th></th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>0.21</td>
</tr>
<tr>
<td>Size</td>
<td>0.06</td>
</tr>
<tr>
<td>Growth stage</td>
<td>0.01</td>
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</tbody>
</table>

Ear rot severity (%) was affected by growth stage
Hail damage at R3 increases
In (percent ear rot severity) 1.5 units

<table>
<thead>
<tr>
<th>Phenology</th>
<th>Estimate</th>
<th>Standard error</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1 (silking)</td>
<td>0.10</td>
<td>0.83</td>
<td>0.91</td>
</tr>
<tr>
<td>R2 (blistcr)</td>
<td>-0.56</td>
<td>0.83</td>
<td>0.51</td>
</tr>
<tr>
<td>R3 (milk)</td>
<td>1.46</td>
<td>0.66</td>
<td>0.03</td>
</tr>
<tr>
<td>R4 (dough)</td>
<td>0.91</td>
<td>1.00</td>
<td>0.37</td>
</tr>
<tr>
<td>VT (tasseling)</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mycotoxin Summary</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hail</strong></td>
<td><strong>Total No. samples</strong></td>
<td><strong>No. positive</strong></td>
<td><strong>Mean</strong></td>
</tr>
<tr>
<td>DON Yes</td>
<td>55</td>
<td>54</td>
<td>1.71</td>
</tr>
<tr>
<td>(ppm) No</td>
<td>5</td>
<td>3</td>
<td>0.67</td>
</tr>
<tr>
<td>ZEN Yes</td>
<td>55</td>
<td>43</td>
<td>0.31</td>
</tr>
<tr>
<td>(ppm) No</td>
<td>5</td>
<td>2</td>
<td>0.02</td>
</tr>
<tr>
<td>Fum Yes</td>
<td>55</td>
<td>40</td>
<td>0.25</td>
</tr>
<tr>
<td>(ppm) No</td>
<td>5</td>
<td>3</td>
<td>0.05</td>
</tr>
</tbody>
</table>
FDA Advisory Limits for Fumonisins

- 5 ppm for horses and other equine
- 10 ppm for swine
- 50 ppm for cattle and poultry (except for turkeys where there is not sufficient data to determine the proper levels)
- 4 ppm – human food corn products except
- 3 ppm - popcorn
FDA Advisory Limits for DON

• No advisory limit for raw wheat

• 1 ppm for finished wheat products for human consumption

• 5 ppm for swine and other animals (except cattle and chickens); not to exceed 20% of swine diet and 40% for other animals.

  ➔ Therefore threshold for DON in swine feed = 1 ppm of total ration

• 10 ppm for beef and feedlot cattle older than 4 months and for chickens; not to exceed 50% of the diet
ISU guidelines for ZEN

Diet should contain:

• <1 ppm for prepubertal gilts
• <3 ppm for sexually mature sows, bred sows
• <20 ppm for young boars
• <100 ppm for mature boars
• <10 ppm for virgin heifers

# Quality Summary

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>High</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Wt.</td>
<td>51.6</td>
<td>58.9</td>
<td>42.3</td>
</tr>
<tr>
<td>Protein %@15M</td>
<td>7.7</td>
<td>10.1</td>
<td>6.4</td>
</tr>
</tbody>
</table>
## Correlations

<table>
<thead>
<tr>
<th></th>
<th>ZEN</th>
<th>Fum</th>
<th>Test Wt.</th>
<th>Protein</th>
<th>Hail Damage</th>
<th>Ear rot Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>DON</td>
<td>0.74</td>
<td>0.06</td>
<td>-0.35</td>
<td>0.31</td>
<td>0.53</td>
<td>0.72</td>
</tr>
<tr>
<td>ZEN</td>
<td>0.32</td>
<td>-0.25</td>
<td>0.49</td>
<td></td>
<td>0.57</td>
<td>0.69</td>
</tr>
<tr>
<td>Fum</td>
<td></td>
<td>-0.06</td>
<td>0.39</td>
<td></td>
<td>0.57</td>
<td>0.11</td>
</tr>
<tr>
<td>Test Wt.</td>
<td></td>
<td></td>
<td>-0.35</td>
<td></td>
<td>-0.47</td>
<td>-0.43</td>
</tr>
<tr>
<td>Protein</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.65</td>
<td>0.61</td>
</tr>
<tr>
<td>Hail Damage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.85</td>
</tr>
</tbody>
</table>

Indicates highly significant relationship (p<0.01)
When there was DON, there was ZEN

Vomitoxin (DON) and Zearalenone (ZEN), Hail Study Corn 2009

\[ y = 0.1745x + 0.0408 \]

\[ R^2 = 0.5437 \]

-- Test Kit Limits
Test Weight did not predict DON well

![Graph showing the relationship between Vomitoxin and Test Weight](image)

The graph illustrates the relationship between Vomitoxin (in ppm) and Test Weight (in lb/bu) from the Hail Study Corn 2009. The equation of the trend line is:

\[ y = -0.2636x + 15.701 \]

The coefficient of determination, \( R^2 \), is 0.1257, indicating a weak correlation between the two variables.
Low Test Weight is not low protein

Test Weight and Protein, Hail Study Corn 2009

$y = -0.0874x + 12.158$

$R^2 = 0.1375$
Visual count and severity - best indicators

**DON vs Percent hail damage, ear rot severity (%)**

- DON, ppm vs Damage (%); Severity (%)
- **y = 0.2758x + 1.3988**  
  - $R^2 = 0.2791$
- **y = 0.1431x + 1.078**  
  - $R^2 = 0.5126$

Legend:
- • Hail damage (%)
- ★ Ear rot severity (%)
Summary

• Hail damage predisposed ears to ear rots.
• Milk stage (R3) was most susceptible to damage/ear rot.
• Gibberella and Fusarium ear rots were most prevalent.
Summary

• Visually damaged samples had detectable toxin levels (DON, ZEN, FUM); positive correlation.

• ~10% over FDA advisory values for corn.

• ~50% over ethanol concentration limit.
Summary

• Physical, chemical properties were poor predictors of toxin presence.
• Preharvest evaluation was the best indicator of toxin presence.
• Does this mean that toxin levels in stored corn are correlated with Total Damage?
Thank You

Photos courtesy: Mark Licht, ISU Extension