Integrated Pest Management (IPM): Mistakes and Solutions

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Pest control versus management

- **Control** = elimination
  - Hard to measure or accomplish in “real world” situations
  - “absence of evidence is **NOT** evidence of absence”
- **Management** = maintain populations at acceptable levels
- Management is with reference to an action level
  - Is my pest level above or below an established threshold?
  - Do we have action levels for pests in grain and processing facilities?
  - There is zero level for some pests (Is this realistic or can this be measured with some level of certainty?) [Sampling issue]
1. Not correctly identifying the pest
Pest identification

• Helps in knowing more information about its biology, ecology, behavior, and response to pesticides or pesticide alternatives
• Information can be accessed from the web
• Information can be obtained from professionals in the field
• There are people who help in identification of pests (mostly at universities)
2. Not understanding what species are associated with raw and processed grain
Raw grain storage structures

Steel bins

Concrete silos
Poor storage structures - Africa

From: Dr. E. N. Nukenine

Wetter Regions

- Foulde
- Barn, across ethnic groups
- Improved crib, many ethnic groups

Dryer Regions

- Kanouri
- Massa
- Duru
- Guiziga
- Moundang
Loulis flour mill, Greece
Internal feeders
Rice weevil is predominantly in whole grain.

Good, N. E. (1937)
Internal feeders
Females lay eggs outside kernels

Borer

Moth

Female moth lays egg on grain kernel. The larva emerging from egg gnaws a hole, no larger than a pin prick, through which it enters the kernel.

Kernel cut showing entrance channel. Larva feeds and grows, enlarging cavity.

The full-grown larva is as long as kernel in which it has eaten out a large cavity.

The pupa is the stage between larva and adult moth.

The moth leaves kernel by round hole shown.

Figure 11.—Life cycle of the Angoumois grain moth on wheat.
Lesser grain borer is predominantly in whole grain

**R. dominica**
External feeders

Red and confused flour beetles (*Tribolium* species)
Flour beetles are found in all mill streams

Source: N. E. Good (1937)
Means followed by different letters are significant ($P < 0.05$; lsmeans test)
3. Not understanding the importance of sanitation
### Insects in Grain Residues at Elevators
( Arthur et al. 2006)

Data from 9 elevators and 1,575 samples. Total number of pest insects found = 46,725.

<table>
<thead>
<tr>
<th>Location</th>
<th>Sitophilus</th>
<th>Cryptolestes</th>
<th>Tribolium</th>
<th>Typhaea stercorea</th>
<th>Rhyzopertha dominica</th>
<th>Oryzaephilus</th>
<th>Ahasverus advena</th>
<th>Total</th>
<th>% Infested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boot pit</td>
<td>40.08 ± 7.90a</td>
<td>9.31 ± 2.80ab</td>
<td>10.94 ± 5.73a</td>
<td>0.14 ± 0.06a</td>
<td>0.70 ± 0.35a</td>
<td>1.23 ± 0.56a</td>
<td>0.11 ± 0.08ab</td>
<td>62.54 ± 12.92a</td>
<td>71.1</td>
</tr>
<tr>
<td>Dump pit</td>
<td>8.52 ± 1.54b</td>
<td>6.50 ± 1.66bc</td>
<td>1.11 ± 0.27b</td>
<td>0.43 ± 0.29a</td>
<td>0.44 ± 0.19a</td>
<td>0.14 ± 0.04b</td>
<td>0.02 ± 0.02b</td>
<td>17.16 ± 2.56b</td>
<td>45.3</td>
</tr>
<tr>
<td>Headhouse</td>
<td>3.38 ± 1.44c</td>
<td>6.88 ± 2.74bc</td>
<td>1.47 ± 0.48b</td>
<td>0.09 ± 0.04a</td>
<td>0.23 ± 0.08a</td>
<td>0.07 ± 0.04b</td>
<td>0.01 ± 0.01b</td>
<td>12.10 ± 3.48b</td>
<td>29.7</td>
</tr>
<tr>
<td>Rail line</td>
<td>8.16 ± 2.41b</td>
<td>2.61 ± 1.42c</td>
<td>4.76 ± 4.30b</td>
<td>1.17 ± 1.07a</td>
<td>0.14 ± 0.10a</td>
<td>1.01 ± 0.95b</td>
<td>0.05 ± 0.04b</td>
<td>17.89 ± 5.96b</td>
<td>35.4</td>
</tr>
<tr>
<td>Tunnel</td>
<td>37.09 ± 8.49a</td>
<td>33.97 ± 20.94a</td>
<td>11.31 ± 8.20a</td>
<td>0.01 ± 0.01a</td>
<td>0.80 ± 0.65a</td>
<td>0.67 ± 0.54b</td>
<td>0.43 ± 0.27a</td>
<td>84.28 ± 25.24a</td>
<td>53.1</td>
</tr>
</tbody>
</table>
Impact of Sanitation of Bins (Reed et al. 2003)

<table>
<thead>
<tr>
<th>Species</th>
<th>Bins cleaned prior to filling</th>
<th>Bins not cleaned prior to filling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean number/kg ± standard error</td>
<td>% of population</td>
</tr>
<tr>
<td><em>Cryptolestes</em> spp.</td>
<td>0.7 ± 0.31*</td>
<td>14.4</td>
</tr>
<tr>
<td><em>Rhyzopertha dominica</em></td>
<td>1.1 ± 1.10</td>
<td>22.6</td>
</tr>
<tr>
<td><em>Oryzaephilus</em> spp.</td>
<td>0 ± 0**</td>
<td>0</td>
</tr>
<tr>
<td><em>Sitophilus</em> spp.</td>
<td>2.9 ± 1.44</td>
<td>60.3</td>
</tr>
<tr>
<td><em>Tribolium</em> spp.</td>
<td>0.1 ± 0.05</td>
<td>2.1</td>
</tr>
<tr>
<td>All pest species</td>
<td>4.9 ± 2.01**</td>
<td>2.1</td>
</tr>
<tr>
<td>All natural enemies</td>
<td>0.02 ± 0.01</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Data from 11 elevators, samples from 25 – 138 bins at each elevator.
Spillage

Prevent unsanitary conditions
KSU pilot flour mill data, June 15 – October 12, 2002

<table>
<thead>
<tr>
<th>No. product samples examined</th>
<th>Percentage of samples with insects</th>
<th>No. samples with insects after 8 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>439</td>
<td>53.8</td>
<td>80.1%</td>
</tr>
</tbody>
</table>

________________________

Sanitary design aspects
Sanitary Design Aspects
• Eliminate standing water through good design and repair of grounds outside and inside the mill
4. Not having an established threshold for pests and a pest sampling program
Defect action levels

http://www.fda.gov/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/Sanitation/ucm056174.htm

• GIPSA standard for infested grain
  – Wheat, rye, and triticale
  – 2 live insects/kg of grain
  – Barley, canola, corn, oats, sorghum, soybeans, sunflower seeds, mixed seeds
  – 1 live weevil, or other 5 live injurious insects, 10 or more live injurious insects

• At time of sale
  – 32 IDK/100 grams (wheat)

• In processed food
  – 75 insect fragments/50 g of flour (wheat)
Grain bulk

- Probe sampler
- Spear or trier
Vacuum probe for bulk-stored grain
Pitfall Cone Trap

- 95 mm x 125 mm cone-shaped with holes
- Very sensitive
- For surface area of the grain bulk
Probe traps

- 370 mm x 27 mm
- Funnel and collecting tube
- Can be inserted into the grain bulk
Trap retrieval is critical!
Automated counts of insects in grain (OPIsystems.com)

Stormax Insector
5. Not understanding that pests are also present outdoors
Flour Mill 1: Inside and Outside Mill
Allen & Subramanyam, 2004; unpubl. data)

<table>
<thead>
<tr>
<th>Species</th>
<th>Inside traps</th>
<th>Outside traps</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMM=Indianmeal moth</td>
<td>40%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RFB=Red flour beetle</td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HFB=Hairy fungus beetle</td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRP=Confused flour beetle</td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRG=Warehouse beetle</td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CFB=Sawtoothed grain beetle</td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FGB=Foreign grain beetle</td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LGB=Lesser grain borer</td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>20%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Product totals = 0.34 insects/gram
Inside trap totals = 216.6 insects
Outside trap totals = 260.4 insects

IMM=Indianmeal moth, RFB=Red flour beetle, HFB=Hairy fungus beetle, RGB=Rusty/flat grain beetle, FGB=Foreign grain beetle, TRG=Warehouse beetle, CFB=Confused flour beetle, LGB=Lesser grain borer, STGB=Sawtoothed grain beetle, CAD=Cadelle
Insects Outdoors

*Trogoderma variabile*
Warehouse beetle

*Plodia interpunctella*
Indianmeal moth

Average daily capture rate from 6/7/00 to 10/11/00

Source: Jim Campbell (unpublished data)
Pest Entry Points

- No open doors
- Screen windows
- Seal entry points
A good pest exclusion practice
Another exclusion practice
Tight seals around loading dock doors
Netting to Exclude Birds
Tactile Deterrents for Birds

- Spikes
- Coils
- Ledge wires
6. Applying a liquid pesticide to infested grain
Calibration is essential
7. Poor fumigation/pesticide application practices
Fumigation

Gas monitoring and personal protective equipment are essential
8. Not selecting a reliable pest management service provider
Good Service Characteristics

- Professional
  - Ethical
  - Neat
  - Clean
  - Client confidentiality

Courtesy: Ole Dosland
Good Service Characteristics

- Reputable
  - Knowledgeable
  - Experienced
  - Honest
  - Listens

Courtesy: Ole Dosland
Good Service Characteristics

- Communication
  - Documentation
  - In person
  - On phone

Courtesy: Ole Dosland
9. Having a light above the door
Lighting

- Place lights away from buildings
- High pressure sodium lights near buildings
- No lights near doors and windows
Have good lighting everywhere
10. Poor trash disposal practices
Improper garbage disposal promotes pest activity

Keep dumpster on a concrete pad
Weekly garbage disposal
11. Poor inspection practices
Transport vehicles

- Inbound inspection
- Seals in place
- Trailers/cars clean
Warehouse and mill

- Pallets
- Used equipment
- Live plants in offices
- Food prep.; receiving
- Grain products
- Spillage on drums
- Mill for sanitation issues
12. Not monitoring fumigant gas concentrations or pest numbers over time
Traps and Mechanical Devices
A = Wild bird food  B = Small animal food  C = Cat and dog food  
D = Food bar table
Indianmeal Moths in a Retail Store

Sequential contour maps
Aluminum Phosphide
Different formulations for different uses

- Tablets
  - 3 g, releases 1 g of phosphine
- Pellets
  - 0.6 g, releases 0.2 g of phosphine
- Sachets
  - 34 g, releases 11 g of phosphine
- Linear gas generation until 80%, then the generation becomes nonlinear
- Gas release differences among formulations
  - Pellets > tablets > sachets
Phosphine Can be Used to Treat Commodities in Various Storage Structures
Choice of formulation and sealing can help hold an effective concentration.
Whole facility treatments for mills

Methyl bromide
Heat treatment
Sulfuryl fluoride
K-State Flour Mill
Gas Concentration: MB1

- HLT ≈ 111 hr
- HLT ≈ 16.4 hr
- HLT ≈ 10.2 hr

Graph showing gas concentration over elapsed time (hr) with markers indicating different HLT values.
Gas Concentration: SF1

HLT ≈ 19.7 hr
Heat treatment: Raising the ambient air temperature to 122-140°F (50-60°C), and maintaining these temperatures for 24-36 hours.
Red flour beetle adult and young larval survival as a function of temperature

Aug 31-Sep 2, 2007

$n = 10$ HOBOs

Temperature (°C) vs. Time (h)

Insect survival (%) vs. Temperature (°C)

- Temperature
- Adult survival
- Larval survival
Total Number of Male Moths Captured 
Before and After Heat Treatments 
(KSU Pilot Flour Mill, June 23-December 23, 1999)

Day of the year, 1999

Total number of moths/160 traps

0
50
100
150
200
250
300
350
400

0
50
100
150
200
250
300
350
400

150
200
250
300
350
400

Day of the year, 1999
Captures of Red Flour Beetles (*Tribolium castaneum*)

Mean number of adults/trap/week

<table>
<thead>
<tr>
<th>Date</th>
<th>Press room (n=35)</th>
<th>Flour room (n=10)</th>
<th>Outside (n=5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/30/2006</td>
<td>0.46</td>
<td>0.40</td>
<td>0.50</td>
</tr>
<tr>
<td>6/14/2006</td>
<td>0.20</td>
<td>0.42</td>
<td>0.65</td>
</tr>
<tr>
<td>6/28/2006</td>
<td>0.32</td>
<td>0.65</td>
<td>0</td>
</tr>
<tr>
<td>7/11/2006</td>
<td>0 (100%)</td>
<td>0.09 (86%)</td>
<td>0</td>
</tr>
<tr>
<td>7/25/2006</td>
<td>0.03</td>
<td>0.10</td>
<td>0.38</td>
</tr>
<tr>
<td>8/8/2006</td>
<td>0</td>
<td>0.05</td>
<td>0.50</td>
</tr>
<tr>
<td>8/23/2006</td>
<td>0.01</td>
<td>0.05</td>
<td>0.20</td>
</tr>
</tbody>
</table>
13. Not wearing proper protective apparel or clothing
Fumigation

Gas monitoring and personal protective equipment are essential.
14. Poor pallet spacing
Improper stocking or storage practices

Give 12 inches of space between the wall and pallets
Pallets, 6 inches off the floor
15. Not removing unused equipment or not being clean and organized

Sort, Set in order, Shine, Standardize, Sustain
Eliminate Flat Surfaces and Remove Unused Equipment

Flat surfaces

Storage of unused equipment
Conclusions

• Know your pests
• Know your facility
• Know how sanitation is related to pest activity
• Inspect and monitor pests
• Pest management service provider is NOT a magician
• Get yourself trained and familiar with sanitation and pest management
Thank you