Managing Insect Pests in Grain

Purdue Improved Crop Storage (PICS)

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PHL - high in developing countries

<table>
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<tr>
<th>Region</th>
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<th>Handling and Storage</th>
<th>Processing</th>
<th>Distribution and Market</th>
<th>Consumption</th>
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<td>Total</td>
<td>42%</td>
<td>25%</td>
<td>19%</td>
<td>15%</td>
<td>17%</td>
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Share of total food available that is lost or wasted
Causes of Post-harvest Losses

- Pests: Insects, rodents, ...
- Mechanical damage
- Diseases and pests
- Fungal growth - Aflatoxin

Impact of PHL: Economical, ...

- Quantitative loss - weight loss
- Qualitative loss - taste, smell
- Seed - viability loss
- Nutritional loss
- Excessive use of pesticides
- Loss of consumer confidence

Storage Losses
Sources of PHL

Major Sources of PHL in Maize Storage

- Ghana
- Benin
- Nigeria
- Ethiopia
- Uganda
- Tanzania


Low oxygen for management of Insect pests in Grain
Low oxygen to control stored product pests

- Effects of high CO₂ and low O₂ on insects have been studied widely

- Low oxygen can be achieved
  - Naturally (insect/grain respiration)
  - Gases N₂, CO₂, mixture

- They include
  - Modified atmospheres
  - Controlled atmospheres
  - Vacuum
  - Hermetic

Why Low oxygen in developing countries

Chemical control has *Not* been successful

- Limited efficacy
- High cost
- Limited accessibility
- Bad practices
  - adulteration
  - patchy application
  - indiscriminate use
Purdue Improved Crop Storage (PICS)

Led by Dr. Murdock a team of researchers developed a portfolio of non-chemical cowpea storage technologies

USAID CRSP Project (1987-2002) Goals

No protection

PICS bags
PICS bags protect several crops

1. Cowpea
2. Maize
3. Common bean
4. Pigeon pea
5. Sorghum
6. Millet
7. Chickpea
8. Wheat
9. Hibiscus
10. Bambara
11. Groundnut
12. Mung bean
13. Sesame
14. Rice

Research Efforts on PICS in Kenya

Laboratory trials
• Control of maize weevils, bean weevils and bean bruchids using PICS bags on maize, beans, pigeon pea and green gram

On-farm storage trials
• Control of maize pests and aflatoxin in rural on-farm stores

Testing of various hermetic storage devices
• 12 hermetic storage devices promoted in E. Africa tested for the larger grain borer
Common beans weight loss

Acoustic technology for management of Insect pests in Grain
Insect Detection and Monitoring methods

**FIELD techniques**
- Grain Probes and insect traps
- Pheromone traps
- Visual lures

**LAB techniques**
- Electrical conductance
- NIR spectroscopy
- X-ray imaging

**Both FIELD and LAB**
- Acoustic methods

Acoustic detection

Acoustic methods estimate
- Insect presence and
- Pest density in a grain mass
- Species diversity
- Mapping distributions

Why acoustics??

Acoustic detection is:
- Nondestructive
- Remote
- Automated
- Real-time
- Detection and monitoring

Useful for:
- Pest managers
- Regulators and
- Researchers
**Acoustic monitoring in the lab**

- We study acoustics of insects under
  - Normoxia
  - Hypoxia; and
  - Hermetic

- Acoustics helps with:
  - Species differentiation
  - Distinguish between insect sounds and background noise
  - Assessment of insect responses to treatments

**Design of anechoic chamber**
Acoustic monitoring under low oxygen

To assess the behaviour of *C. maculatus* and *S. zeamais* in low oxygen

- oxygen consumption patterns
- acoustic activity
- mortality

Insect Activity decline in low oxygen

![Graph showing insect activity decline over time](image)
Acoustic monitoring in the field

For the surveys we selected grain warehouses in 6 counties in Kenya:

- Nakuru
- Kigano
- Kirinyaga
- Sagana
- Kiambu
- Nairobi

Infestations in Kenyan Grain Stores
Future plans: Acoustic surveillance

- Acoustic technology can be incorporated in pest surveillance programs for
  - Conventional stores
  - Organic stores

- Sensors with detection ranges of 3-8 kHz can be developed with
  - Accurate precision
  - Background noise filtering
  - Detection of infestation size
  - ID of development stages of the target pests

- Arduino-based sensors with wifi and text (SMS) capabilities with the possibility to communicate remotely with the mobile phone of the store managers

Insect Management success through PICS Program
4 steps:
1. Awareness Building
2. Demonstration
3. Follow-up
4. Open-the-bag events

PICS Training Activities

OBC after 4-6 months of storage

Seeing is believing

PICS bags video Uganda

- https://www.youtube.com/watch?v=09DYuLtgsNs
PICS efforts Worldwide:
- 29 countries
- 57,000 villages reached
- 5 million+ farmers trained

www.picsnetwork.org

20 companies licensed

PICS Bag Supply Chain Developed from Project to Private Sector

14 M bags sold
Reasons for using PICS bags for maize storage in Kenya

- Food Security: 80%
- Income: 19%
- Animal feed: 0%
- Do not store: 1%

Climate resilient technology

How are farmers benefiting in Uganda?

One bag makes a household on average:

- **10 percentage points** more likely to plant hybrid maize next year
- **5 percentage points** less likely to use storage chemicals
Social-economic Impact of PICS Technology

Local Economy
- Farmers: $20 USD for 100kg/bag
- Private sector: $2.50/bag sold
- Margin: $1.00/bag sold

Investments: ~30 M USD
- Train 5 million farmers
- 14 M bags cumulative
- 4.2 M bags in 2017

Total Economic Impact
- Farmers: $514 Million USD
- Private sector: 19.5 Million USD

Use of hermetic storage technologies in Nigeria

- 2012
- 2014
- 2016