What do we know about Post-harvest quantity and quality losses in developing countries?

Jacob Ricker-Gilbert, PhD
Associate Professor
Department of Agricultural Economics, Purdue University

Presentation for the Invited Panel: “Food waste: Insights from recent research and policy perspectives”
IAAE Triennial Conference Vancouver, BC, CANADA
July 28 to August 2, 2018
Post-Harvest Loss (PHL) has ascended as an issue on development agenda

One of the SDG Goals is to reduce food loss and waste along the value chain.

Post-harvest is everything from harvesting of crop until it reaches the consumer
- **PH Stages:** harvesting, threshing, winnowing, transporting, drying, storing, processing
- **PHL Causes:** Insects, mold, rats, theft

**Many more development projects related to PH now vs. 10 years ago.**
- **Rockefeller Foundation:** YieldWise project = $130 million investment with strong emphasis on PH.
- **USAID** funds two PH innovation labs (Purdue and Kansas State)
- **ADM** Post-Harvest Institute (U of Illinois)
- **BMGF** – PICS projects, promoting improved storage (> $18 million at Purdue) & funding APHLIS network.
- Many more.........
Some estimates for PH loss are very high

• > 20% of cereal production in SSA (FAO 2011).
• $4 billion lost annually on-farm in SSA (World Bank 2011).
• Entomology studies have even higher loss estimates, up to 30% loss in stored grain after 6 months (Boxall 2002).

Studies based on self-reported household survey data find lower losses.

• 1.4-5.9% of production lost in storage using LSMS data in Malawi, Tanzania and Uganda (Kaminski and Christiaensen 2014).
• 3.7 – 6.9% of stored maize and 2.5 – 7.3% stored legume lost across Benin, Ghana, Nigeria, Ethiopia and Tanzania (Abdoulaye et al. 2016).
• 5% PHL in maize, 8% loss in soya and 12% in groundnut in Malawi, most losses during harvesting, threshing, winnowing (Ambler et al. 2017)

Some might conclude that PHL not an important issue based on HH studies.
Relatively low estimates doesn’t mean PHL not a problem!

• PHL is the result of optimizing behavior.
• People adapt to abate PHL to the point where MB = MC.
Relatively low estimates doesn’t mean PHL not a problem!

- PHL is the result of optimizing behavior.
- People adapt to abate PHL to the point where MB = MC.

**Adaption strategy 1 = use storage chemicals.**

<table>
<thead>
<tr>
<th>Country</th>
<th>Ghana</th>
<th>Benin</th>
<th>Nigeria</th>
<th>Ethiopia</th>
<th>Uganda</th>
<th>Tanzania</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>38%</td>
<td>26%</td>
<td>37%</td>
<td>40%</td>
<td>12%</td>
<td>67%</td>
</tr>
<tr>
<td>Most important legume</td>
<td>12%</td>
<td>40%</td>
<td>77%</td>
<td>12%</td>
<td>51%</td>
<td></td>
</tr>
</tbody>
</table>

People more likely to apply chemicals on maize they intend for sell in Benin (Kadjo et al. 2018)
Relatively low estimates doesn’t mean PHL not a problem!

- PHL is the result of optimizing behavior.
- People adapt to abate PHL to the point where MB = MC.

**Adaption strategy 1 = use storage chemicals.**

<table>
<thead>
<tr>
<th>Percent who Applied Storage Chemicals</th>
<th>Ghana</th>
<th>Benin</th>
<th>Nigeria</th>
<th>Ethiopia</th>
<th>Uganda</th>
<th>Tanzania</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>38%</td>
<td>12%</td>
<td>26%</td>
<td>37%</td>
<td>12%</td>
<td>37%</td>
</tr>
<tr>
<td>Most important legume</td>
<td>26%</td>
<td>37%</td>
<td>40%</td>
<td>24%</td>
<td>30%</td>
<td>51%</td>
</tr>
</tbody>
</table>

Source: Abdoulaye et al. (2016)

People more likely to apply chemicals on maize they intend for sell in Benin (Kadjo et al. 2018)

**Adaptation strategy 2 = sell early (at low price).**

- Smallholders in Uganda: Why do you sell maize at harvest rather than storing for sale later in the year?

- 75% Earn cash to pay expenses
- 5% avoid insect and mold damage

Source: PICS3 baseline survey (2014)

If constraints can be relieved, people may be better-off.
Technology Intervention: Traditional Vs Improved

Courtesy: Murdock et al., 2014

Exterior woven bag - polypropylene or nylon
Middle bag - polyethylene
Inner bag - polyethylene

Toba Omotilewa (oomotile@purdue.edu)
Impacts of PICS bags on PHL and other outcomes.

Omotilewa et al. (2018) JDE

48 Villages Sampled at Baseline

- Randomly assigned village demonstrations
- Sample size per village: 25 households
- 10 households randomly selected within each demo village to receive 1, 100 kg bag each, store 1/6 of average harvest.

Village level

24 Non-Demo

24 Demo

Treated with demonstrations

Household level

No bag

Bag

1= subsidized

2= exposed

Treated with bags (10/25 households)

Groups: 3= pure control
Main question was impact of bag on hybrid adoption next year

• Higher yielding, dent varieties don’t store as well as lower yielding local flint varieties (open husks and softer kernels).
  • Rational trade-off between high yielding but pest susceptible hybrid varieties and lower yielding but more pest resisting traditional (local) varieties.

• Can PICS bags break the link and encourage hybrid adoption?

• Also want to know intermediate impacts
  • Storage chemical reduction
  • Quantity of sale
  • Length of storage
  • PHL reduction
# Main Causal Impacts

<table>
<thead>
<tr>
<th>Outcome variables</th>
<th>DiD</th>
<th>FE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did household plant a hybrid maize variety? (0/1)</td>
<td>0.10**</td>
<td>0.10**</td>
</tr>
<tr>
<td></td>
<td>(0.048)</td>
<td>(0.045)</td>
</tr>
<tr>
<td>Share of hybrid maize area (%)</td>
<td>10.25**</td>
<td>10.29**</td>
</tr>
<tr>
<td></td>
<td>(4.727)</td>
<td>(4.727)</td>
</tr>
</tbody>
</table>

- Suggests link between improved post-harvest technologies and investing in modern seeds the next year.
- Development projects should consider this.

Robust standard errors, clustered at the village level, are shown in parentheses.

*** p<0.01, ** p<0.05, * p<0.1
Estimated Causal Pathways

<table>
<thead>
<tr>
<th>Dependent variables</th>
<th>DiD</th>
<th>FE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of storage for consumption (weeks)</td>
<td>3.01***</td>
<td>3.00***</td>
</tr>
<tr>
<td></td>
<td>(0.77)</td>
<td>(0.78)</td>
</tr>
<tr>
<td>Length of storage for sales (weeks)</td>
<td>0.62*</td>
<td>0.69*</td>
</tr>
<tr>
<td></td>
<td>(0.37)</td>
<td>(0.35)</td>
</tr>
<tr>
<td>Household used storage chemical on maize? (0/1)</td>
<td>-0.04***</td>
<td>-0.04**</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.02)</td>
</tr>
<tr>
<td>Self-reported postharvest losses (%)</td>
<td>-2.40**</td>
<td>-3.34***</td>
</tr>
<tr>
<td></td>
<td>(0.94)</td>
<td>(0.87)</td>
</tr>
</tbody>
</table>

Robust standard errors, clustered at the village level, are shown in parentheses. 

*** p<0.01, ** p<0.05, * p<0.1

- Most people used hermetic bag to store maize, rather than legumes.
- Profitability of maize storage in hermetic bags not as high as most legumes
- Suggests that most peoples’ first motive for storing is food security, (quality and food safety from fewer chemicals on food).
Regardless Quality losses may be a bigger problem

Maize and Aflatoxin

Levels safe for human consumption
US standard is < 20 ppb
EU standard is < 10 ppb

May have physical quantity available: but unsafe to eat, and quality (aflatoxin) Problem is unobservable.
Could inhibit market participation (Hoffman and Gatobu 2014).

Observable aflatoxin
Unobservable aflatoxin 51 ppb

Organized symposium on this on Wednesday at 4:30pm
What Should Farmers be Doing to Prevent Aflatoxin Contamination?


$3.25 per 5x2 m²

Training on good post harvest practices

Hygrometer $2.00

$2.22
### Mean aflatoxin levels by treatment group

<table>
<thead>
<tr>
<th>Aflatoxin Levels (ppb)</th>
<th>Treatment Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.40</td>
<td>1) Control</td>
</tr>
<tr>
<td>16.49</td>
<td>2) Drying only</td>
</tr>
<tr>
<td>16.74</td>
<td>3) Hygrocart</td>
</tr>
<tr>
<td>19.41</td>
<td>4) 3 + Tarp</td>
</tr>
<tr>
<td>11.55</td>
<td>5) 3 + PICS</td>
</tr>
</tbody>
</table>

- **1.** Aflatoxins are a big problem in stored maize in our sample.
  - 28% of control above US legal limit of 20 ppb
  - 32% of control above Senegal/EU limit of 10 ppb

- **2.** Our drying and storage interventions had a significant impact reducing aflatoxin levels.

- **3.** Biggest impact from including PICS bags intervention.
  - Could be a link in farmers’ minds between good storage technologies and good drying practices.
  - Development projects need to do both drying and storage together.
Conclusions and Policy Relevance

• Post-Harvest issues rising on development agenda
  • Household survey estimates suggest lower losses than some “official” estimates
  • Lower PHL estimates does not mean it is not a problem!

• People adapt to mitigate losses (apply chemicals and sell early)
  • Improved storage technology can reduce losses and improve health and food security
  • Follow-on effect between improved storage technologies and hybrid maize planting

• Unobserved quality loss (aflatoxin) issues likely a bigger problem than observable quantity losses.
  • Little to no market mechanism to reward quality in rural markets
  • May inhibit market participation
  • Strategies exist to reduce aflatoxin and other food safety risk
  • Tighter supply chains, and potential role for government intervention to provide public good of health food supply.
Thank you!

jricketg@purdue.edu
References

Cumulative Distribution Functions of Aflatoxin Levels by Treatment Group

Numbers in parentheses after legend entries are mean aflatoxin levels. For the 134 samples measuring > 100 ppb, we use the value of 100 ppb.