Post-Harvest Crop Losses 101

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Post Harvest Losses

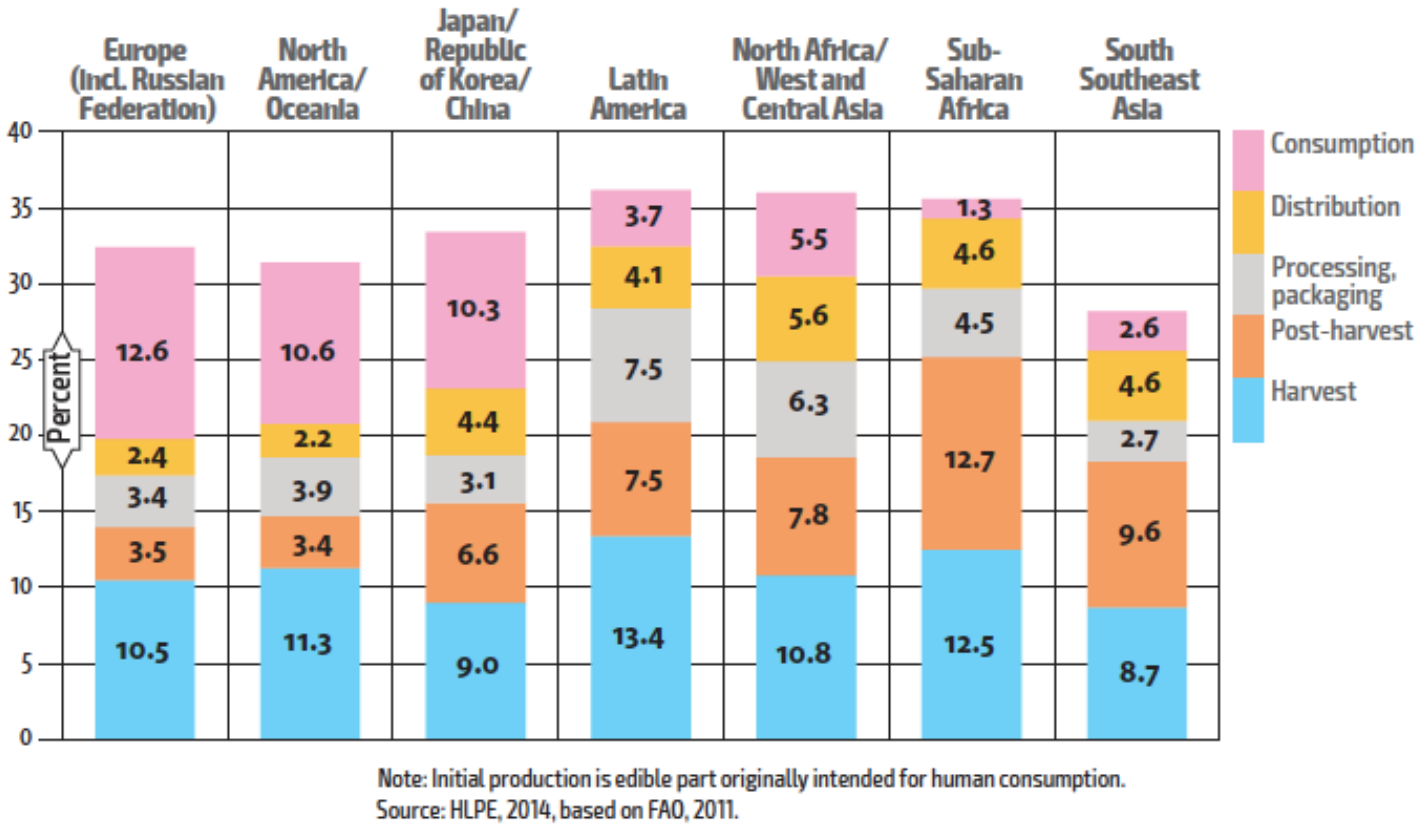
- Quantity: kg lost
- Quality: broken, damaged/ bruised, chemical, bacterial and mycotoxin contamination, off-flavours, changes in colour, nutrient losses

Where do post-losses occur?

a. In the field during harvesting (dropped, shattered): 4-8%.
b. During transport from the field to the homestead: 2-4%
c. During drying: 1-2%
d. Threshing, shelling: 1-3%
e. Winnowing: 1-3%
f. On-farm storage: 1-4% (30% for some storage pests)
g. Transport to bulking stores/ local markets: 1-2%
h. Transport to distant markets
i. Handling in markets: 2-4%
j. Expired / damaged in retail.

c & d not automatically losses from the system as the fallen grains will probably be eaten by the chickens

FAO estimates of Post Harvest Losses



Note: Initial production is edible part originally intended for human consumption.
Source: HLPE, 2014, based on FAO, 2011.

Volumes lost?

- Post harvest losses are a black box and data needs to be treated with caution.
- Estimates of Cereal losses on smallholder farmers in Africa range from. 15%- 30% (APHLIS reports 13 million tonnes per year[1]).
- over 30% recorded in trials due to infestations with the Larger Grain Borer (Prostephanus truncatus). Double crop loss estimates when LGB is present.
- https://www.aphlis.net/#/
- Tables: https://www.aphlis.net/page/1/crop-tables#/datatables/crops-losses?metric=prc&year=2011

Reducing Post Harvest Losses: the quick win?

- Reducing post harvest losses – this season's new black?
- Clearly there is no point in increasing crop production without addressing losses.
- Addressing losses would reduce the need for expansion of ag.
- But:
- Very limited uptake of of technologies to address storage losses by smallholder farmers.
- Here in Ireland Teagasc reports the lowest uptake of techniques to reduce post-harvest losses.

On-Farm Storage Losses

- Early harvesting
- Rodents
- Storage insect pests: primary and secondary
- Fungi. *Aspergillus*, *Fusarium*
- Leakage/ damage: ?
- Humans: crime, or the perceived threat of crime, is probably the greatest determinant of storage practices in many communities.

Storage Insect Pest: Primary pests

- Lay eggs in or on stored products.
- Larva feed on grains.

Primary Insect Pests: Borers, Bostrichidae

Larger Grain Borer,
Prostephanus truncatus

Lesser Grain Borer,
Rizopertha dominica

Comparison between Larger and Lesser Grain Borers

Dinoderus minutus

Primary Insect Pests: weevils

rice weevil (*Sitophilus oryzae*)

Maize weevil (*Sitophilus zeamais*)

Wheat weevil (*Sitophilus granarius*)

Primary Insect pests: Bean Beetles, Bruchids

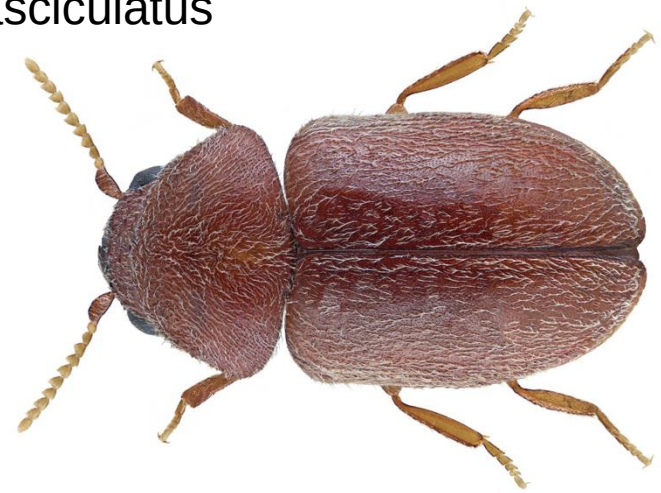
Cowpea beetle*, Callosobruchus maculatus*

Bean weevil, *Acanthoscelides obtectus*

Zabrotes subfasciatusB a common pest of kidney beans and butter beans, and seldom attacks other pulses.

Primary Insect pests:

Coffee Bean Weevil, Araecerus fasciculatus



Cigarette beetle/ cigar beetle/ tobacco beetle, ***Lasioderma serricorne***,

Storage Insect Pest: Secondary pests

- Cannot bore into grains – eat the flour produced by 1°pests.
- Flour beetles & Warehouse moths

Secondary Pests: flour beetles

The red flour beetle, *Tribolium castaneum*

Tribolium confusum

Tribolium castaneum

Rusty Grain Beetle *Cryptolestes ferrugineus*

Secondary Pests

Khapra beetle, *Trogoderma* granarium.

Trogoderma granarium is a very serious beetle pest of cereal grains and oil seeds and in many countries is listed as a ‘quarantine’ pest *Oryzaephilus* spp. are moderately small (2.5-3.5 mm) rather flat, parallel-sided beetles, attack cereals, cereal products, oilseeds, copra, spices, nuts and dried fruit.

Secondary Pests: Moths

Indian Meal Moth, *Plodia interpunctella*

Angoumois grain moth - *Sitotroga cerealella*

Cadra cautella is a common and important secondary moth pest of cereals, cereal products, cocoa, dried fruit, nuts and many other commodities.

Reducing Storage Losses

- Dry to ≈12-13% moisture.
- Clean stores
- Raise sacks off the floor
- Rat guards and rodent control
- Protect from damp.
- Chemical treatment
- Non-chemical treatments
- Hermetic storage.
- Solarisation
- Processing: Solar drying, smoking, salting, pickling, fermenting,

Non Chemical Treatments

- Rice husk ash
- Diatomaceous Earth
- Sand
- Turning sacks
- Vegetable oil (oil-soaked dhal)
- Botanicals: neem leaves
- Solarisation
- CO_2/ nitrogen

Chemical treatments

- **Fumigation**: Toxic gasses. Phosphine (*phostoxin*, aluminium phosphide, calcium phosphide, zinc phosphide). Methyl bromide (banned)
- Non-persistent. Does not prevent re-infection.
- CO_2 fumigation OK for organic crops.
- Equipment: gas-proof sheets, breathing apparatus, gas detectors. Professionals only.
- Fumigation Certification required for supplying WFP.
- **Powder or EC formulations**: Permethrin + pyrimiphos methyl.
- Powder mixed with grain, EC sprayed on bags/ stacks.
- Persistent.

Traditional Seed Stores

- Traditionally jute was used for sacks almost entirely replaced by woven polypropylene sacks except for some high value crops and triple layer hermetic storage
- Traditional stores/ granaries
- Issues: condensation leads so hot-spots.

Hermetic storage

- CIMMYT bins
- Grain Pro sacks: 25-100 kg
- Perdue Improved Cowpea Sacks (PICS)
- Triple bagging.
- Shipping container stuffing bags.
- Blue plastic drums

M&E: On Farm storage losses due to insects and molds

Measurement tools	**100 grain test, Sample bags, Hand lens, Grain sampling spear**
How to measure it	Randomly sample grains from all bags or parts of the store (bottom, middle, sides, top). A grain sampling spear will make this easier. If grain sampling spears are not available from an ag equipment dealer they can be made by a village tinsmith from mabati off-cuts. Put the samples from each store into a clearly labelled bag. Mix all the samples from one store together and make a heap. Divide the heap into 2 parts. Put 1 half back into the store. Mix the other half and divide again. Keep mixing and halving the pile until you have a heap of slightly more than 100 grains. Count out 100 grains. Using a hand lens, examine each grain and sort grains into 4 piles: broken grains, insect damaged grains, grains showing signs of mould, discoloured, good grains. broken grains + insect damaged grains, + grains showing signs of mould = % post-harvest losses during storage. Calculate the averages for each type of store promoted.

Strengths & Limitations	Strengths:
	• A simple quantitative indicator that does not rely on farmer recall.
	Limitations:
	• This test does not take into account losses due to rodents or thieves.
	• This test only measures storage losses and does not take into account post-harvest losses:
	  ○ During harvest (left in the field due to shattering)
	  ○ Carrying the harvest from the field to the homestead
	  ○ Threshing at the homestead
	  ○ During transport to markets

Recent Data from Karonga District, Malawi

Maize Grain Status	Percentage	Number of farmers visited	
Broken grains	**10.4%**	Males	80
Damaged by insects	**16.5%**	Females	38
Grains showing signs of moulds	**21.2%**	Total	118
Good Grains	**52.0%**		

Damage status	Maximum	Minimum
Broken	39%	0%
Insect damaged	40%	4%
Moulds	56%	3%

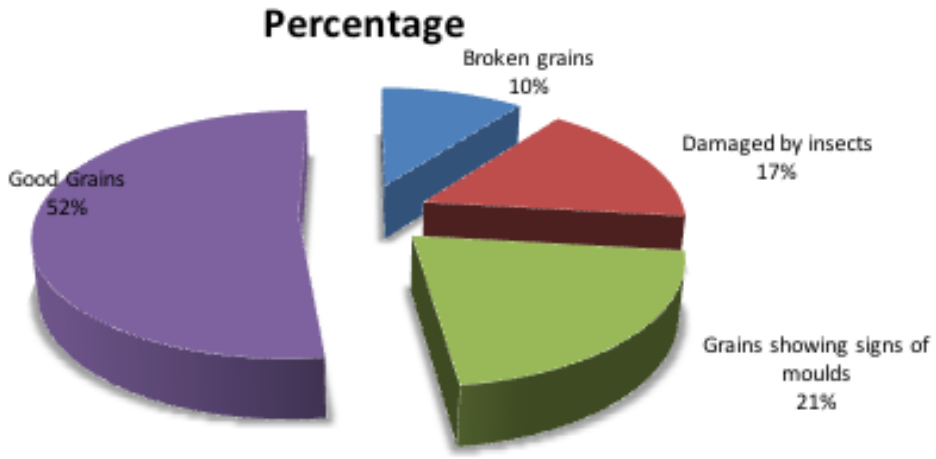


Table 5.1: East African maize standard

Quality variable		Maximum limits	
		Grade 1	Grade 2
Moisture content %		13.5	13.5
Foreign matter total %		0.5	1.0
of which	Inorganic matter %	0.25	0.5
	Filth %	0.1	0.1
Broken grain %		2.0	4.0
Defective grain, total %		4.0	5.0
of which	Pest damaged grain %	1.0	3.0
	Rotten and diseased grain %	2.0	4.0
	Discoloured grain %	0.5	1.0
	Immature/shrivelled grain %	1.0	2.0
Other grain %		0.5	1.0
Aflatoxin contamination (total)		10 ppb	10 ppb
of which	aflatoxin B1	5 ppb	5 ppb

M&E: On Farm storage losses due to rodents

Measurement tools	Rodent exclusion Test: Metal bin, Sacks, Spring balance
Level of Disaggregation	Storage practices/ structures, Agro-ecological conditions, crops
What does it measure	This test provide a quantitative measure of losses due to rodents during on-farm storage
How to measure it	Take a sample of grains and weight out into two equal samples of (50kg or 30kg) into standard polypropylene maize/rice sacks. Place one sack in the store (treatment sample) and one sack in the metal bin (control sample). Reweight the sacks at specific intervals. The difference in the weights is due to rodent losses.

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	• Rodent populations will vary with season, the environment around the homestead and the crops stored. Samples should therefore be weighted at the same time and the source of each sample carefully recorded.

M&E: Grain Moisture

Grain Moisture: 12-16%, Hygrometer: <65%

John Deere Moisture Check Plus Grain Moisture Tester

Dickey-John mini GAC

Farmex Grain Moisture Tester MT-16

Grain sampling spear

Milling

- Significant losses during milling at village level
- Add an additional cyclone.
- Regular cleaning and maintenance.

Mycotoxins

- Mycotoxins =Toxins produced by fungi.
- Our interest/ concern is in mycotoxins that enter the food chain, particularly those that affect stored grains, staple foods and foods used for children..
- *Aspergillus flavus* and *A. parasiticus* produce **aflatoxins** B1, B2, G1, and G2. “B” and “G”
- *Fusarium graminearum/ Gibberella zeae*, ear rot: produces mycotoxins: deoxynivalenol, zearalenone, zearalenol
- *Fusarium moniliforme/ Gibberella fujikuroi*): produces fumonisins
- Ocratoxins
- Deoxynnivalenol (DON)
- Zearalenone
- T-2/HT-2 toxins.
- Others toxins from fungi in food crops: ergot - egometrine, patulin (apples), etc.

Aflatoxins

- Aflatoxin B1 is one of the most potent naturally occurring chemical liver carcinogens known.
- Strong correlation with retarded growth (stunting) in West Africa (BMJ)
- Retarded mental development in children.
- Effects on child health are so sever that the limits are revised downwards as each research paper is published.
- Widespread: groundnuts, maize, coffee, wheat, barley.
- Key issues for NGOs:
    - Possible effects of aflatoxins on child growth and development, leading to stunting (chronic malnutrition).
    - Possible increased severity of AIDS-related infections.

Aflatoxin levels

- Results of a Post harvest survey carried out by Concern Afghanistan

Location	Grain Type	Average ppb	Remark
Takhar North province	Wheat Lalmi	6.6	Considering that this sample was taken from current season, ppb levels are relatively high – meaning contamination happened during harvest.
	Pea Lalmi	5.7	
	Almond	5.6	
Last season results			
Takhar South Province	Pistachio	7.46	Apart from Corn, the rest had high levels of ppb due to prolonged duration in storage.
	Walnut	13.06	
	Corn/maize	4.43	

- Range of limits set for different foods and trading blocks for B1, B2 (*Aspergillus flavus*) 2µg/kg – 20 µg/kg (µg/kg = ppb).
- EU: 4 µg/kg
- Codex Alimentarius 10 µg/kg
- USA: 20 ppb
- Zambia FRA: 10 ppb

Diagnostics and sampling

- Units: One part per billion is 1,000 times smaller than 1 ppm. One second in 32 years is 1 ppb.
- UV light: A coarsely ground sample of fresh maize kernels (<3 months) is exposed to intense UV light at about 365nm in a thin layer, on a black tray in a darkened room. Bright Greenish Yellow Fluorescence (BGYF) is caused by the presence of kojic acid, produced by *Aspergillus*, an indicator of the POSSIBLE presence of aflatoxin-producing moulds.
- Neogen Europe: **Reveal Q+ for Aflatoxin Green -** range 2-150 ppb, 25 samples, £150.00) + **Accuscan Pro reader**, £1,080.00
- Mobile Assay Inquiry Smartphone/tablet reader.



Agronomic Control Options

- These are a selection of agronomic practices reported to reduce the risk of *Aspergillus f.* infection in the field:
- Seed treatment before planting (fungicide seed dressing).
- Adjust planting dates to avoid moisture stress.
- Resistant varieties (maize, groundnuts).
- Infect with non-pathogenic *Aspergillus* "Aflasafe" from IITA. 80-90% reduction in Nigeria. Available in Kenya, Nigeria, Zambia. Afla-Guard from Syngenta/ USDA.
- Fungal antagonists*: Trichoderma viridis*

Agronomic Control Options

- Lime application can reduce aflatoxin contamination by 72%
- Farm Yard Manure (FYM) by 47%
- Cereal crop residue by 28%
- Combination of FYM and lime by 84%,
- Combination of lime and residue by 82%,
- Combination FYM, and residue by 53%
- **Combination of FYM, crop residues and lime by 85%**
- **(**source: ICRISAT**)**

Solution? Health, happy, unstressed plants that can fight-off *Aspergillus* infections?

Post Harvest Control Measures

- Aflatoxin production in storage, are favoured by high humidity (>85%), high temperature (>25 ◦C) and insect or rodent activity
- Crop drying off the ground (Humidity: 13-14% maize, 12% coffee, 7% groundnuts).
- Hand picking (up to 80% reduction in aflatoxins in groundnuts reported),
- Storage, store hygiene,
- Improved threshing and shelling.
- Avoid soaking groundnuts in water to soften the shells.
- Lye (potassium hydroxide) treatment of shell groundnuts.
- Natural fibre bags (jute, sisal & hemp rather than woven polypropylene).
- Insect and rodent control.
- Anaerobic storage (CIMMYT grain bins, double/triple wrapped “Purdue” Bags, Grainpro bags)

Control Measures in Small / Medium Scale Processing

- Hand sorting.
- Clean maize and rice mills daily.
- What happens to infected/ rejected crops? Risk to children? Ideally burry/ burn but is this realistic?
- Ozone treatment of contaminated grains (portable treatment units?)
- Aflatoxins can be filtered out of vegetable oil through bentonite filters.

Diet

- Some evidence that including montmorillonite clays in the diet prevents the update of aflatoxins from contaminated food – but probably inhibits the uptake of micro-nutrients as well.

- **Solution?**
- **a diverse diet will reduce overdependence on a potentially contaminated crop**