

# Reaping the benefits

## Technical Guidance on Reducing Post-harvest Losses in Smallholder Farming Systems



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Photograph: Joni Kabana

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# Why reducing post-harvest losses is important

*This guide gives practical advice on post-harvest losses and key resources for further reading.*

## Improving household food security and smallholder farmer profits

**Around one third of food is lost or wasted after harvest.<sup>1</sup>**

Losses can reach 50%, particularly in fruits, vegetables, and root crops.

**Losses can have a major economic impact on household food security and income levels.**

Post-harvest losses are expressed in *quantity* (measured in weight) and *quality* (measured in appearance, taste, texture, and nutritional or economic value).

The quantity and/or quality of loss is affected by practices at all stages of the value chain. To reduce losses, it is essential to encourage farmers, processors, traders, and transporters to improve practices **before, during** and **after harvest**.

This means improved food security and increased profits for farmers.

**Every gram of food saved at any stage of the value chain is food available for consumption or sale.**

It is also crucial to promote the cultivation and consumption of a variety of fruits and vegetables to increase dietary diversity.

**Reducing post-harvest losses of fruits and vegetables at the household level is critical to the goal of improving nutrition.**

**This guidance is mainly for project staff working with smallholder farmers**, such as those targeted by USAID/Food for Peace (FFP)-funded programs.

The challenge for programs is to stimulate the use of good agricultural practices to reduce post-harvest losses.

### Value chain

The full range of activities required to bring a product or service from its conception to final consumers and disposal.

## Key tools

■ *Training manual for improving grain postharvest handling and storage*

Hodges R, Stathers T. 2012. Natural Resource Institute, UK. World Food Programme manual on post-harvest practices.

■ *Prevention of post-harvest food losses: A training manual.* 1985.

Food and Agriculture Organization (FAO) Training series 17/1.

■ *Prevention of post-harvest food losses in fruits, vegetables and root crops.* 1989. FAO Training series 17/2.

Manuals on prevention of food losses, particularly grain crops, fruits, vegetables, roots and tubers.

■ *Small-scale postharvest handling practices: A manual for horticultural crops (4th Ed)* Kader A, Kitinoja L.

University of California, Davis.

Postharvest Technology Research and Information Center manual.

■ [www.aphlis.net](http://www.aphlis.net)

African Post Harvest Losses

Information System. Resource site for post-harvest management of grains and cereals.



Photograph: Pichest, istockphoto.com

# Causes of food losses

*Post-harvest losses are affected by practices at each stage of the value chain*

## **Post-harvest losses are affected before, during, and after harvest.**

There are many causes of losses at these different stages.

The following are some of the most common.

### **Before harvest**

- Poor plant or livestock management
- Poor soil and seed quality
- Incorrect moisture levels during growth
- Pest infestations and diseases during growth

### **During harvest**

- Premature harvesting
- Physical damage during harvest

### **After harvest**

- Poor storage facilities after harvest
- Damage during transport, packaging, and marketing

These factors affect yields, storage life, and final product quality negatively, with impact on both the quality of food consumed in the household and its market value, resulting in financial loss.

### **Key points along the value chain where losses occur<sup>2</sup>**

- Pre-production/planning
- Production
- Harvest
- Transport
- Assembly/sorting/packing
- Storage
- Processing
- Distribution



Photograph: Sean Sheridan



**Identifying where key problems lie is essential to help farmers:**

- overcome constraints during and after production
- get the benefit of support services
- achieve a more efficient farming system that creates more and higher quality food.

**Problems can be identified from a number of sources, including:**

- value-chain actors (farmers, farm managers, farm laborers, transporters, traders, market dealers, and consumers)
- agricultural and market literature (newspapers, journals, and trade magazines)
- websites and databases.



Photograph: Fitria Rinawati

# Practices that can reduce losses

*Different crops require different best practices to reduce losses*

**Best practices for reducing food loss differ from crop to crop, and at different stages of the value chain.**

## Best practices before harvest

Key areas to focus on are:

- seed quality
- soil fertility
- soil moisture
- pests and diseases.

### Seed quality

Seeds must be high quality to produce a nutritious and abundant harvest.

**Best practices to ensure seed quality include:**

- purchasing seeds from good quality input suppliers
- selecting seeds with care, when using seeds from the previous harvest
- treating seeds with ash, or an ash and cow-dung combination, to reduce pest infestation
- drying seeds to the correct moisture level before storing
- storing seeds in dry, cool containers, safe from pests
- using zeolite-based drying beads to reduce the amount of moisture in seeds (developed by Rhino Research)<sup>3</sup>
- testing seeds before storage and planting, whether the seeds were purchased from an input dealer or saved from previous harvests.

*Seeds may not germinate even though they look fine because they are too old or were stored improperly. A simple **seed germination test** on a sample will indicate whether the seeds are acceptable to sow.*

### Soil fertility

Crops need adequate amounts and proportions of essential plant nutrients and soil water to produce harvests of good quality and high quantity. *Soil fertility* refers to the ability of the soil to provide both in accessible forms.

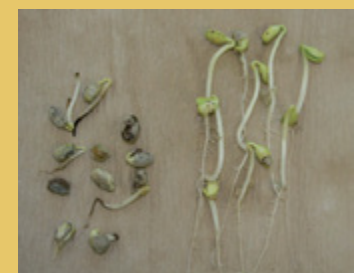
A fertile soil has a good structure and pH, is rich in nutrients, and contains micronutrients, soil organic matter, and microorganisms. Soil fertility can be influenced during soil preparation and crop growth.

### A simple seed germination test to use before storage and planting

- 1** Place 10 seeds on a piece of damp tissue or paper.
- 2** Roll or fold the tissue up, so the seeds are all in contact with the damp surface.
- 3** Put the tissue and seeds inside a plastic bag, and store in a warm place.
- 4** Check every few days to see if the seeds have started to germinate. Germination normally occurs within a week.
- 5** Once they have started to germinate, count how many of the seeds have germinated.
- 6** Multiply the number by 10 to get a percentage.

If the result is less than 50%:

- use new seeds and test those seeds too, or
- sow extra seeds to reach a good germination rate in the field.



Photograph: Paul Sommers



**Best practices to improve and maintain soil fertility include:**

- using soil and water conservation practices to slow and infiltrate water
- applying organic matter to build soil structure and provide nutrients
- keeping the soil covered (with cover crops or mulch), especially during the off-season, to protect the soil and provide nutrients
- avoiding heavy equipment to limit the amount the soil is compacted
- tilling as little as possible, or not at all, to conserve soil structure.



Photograph: Benny Manser

## Soil moisture

Correct soil water content maximizes plant growth and reduces the probability of disease. It is important to have enough soil moisture and water throughout the crop cycle, but not too much. Too much moisture can increase the risk of aflatoxins in certain crops (for instance, groundnuts and maize) and other crop diseases. Too little moisture can cause crop failure.

### **Best practices to ensure correct soil moisture include:**

- using raised beds for vegetable production to help control soil moisture, if too much moisture is a concern
- using mulch to reduce the likelihood of the soil drying out, particularly in hot, dry conditions
- constructing berms and basins on contours (boomerang berms) to catch water, slow it down, and spread it out to increase infiltration.

**Aflatoxins** are naturally occurring toxins produced primarily by two closely related fungi, *Aspergillus flavus* and *Aspergillus parasiticus*.

Contaminated crops result in significant **health issues** when consumed by both humans and livestock, and large **economic losses** when discarded.

Aflatoxins are generally found in the soil in warmer climates and transferred to crops through contact with the soil, decaying vegetation, hay, and grains. Aflatoxins affect a number of staple crops including maize, millet, groundnuts, and sorghum.

Aflatoxin contamination occurs before harvest, particularly in dry weather near crop maturity, during harvest if there is high moisture, and after harvest through inadequate sorting, drying, and storage of crops.

### **Best practices to reduce the risk of aflatoxins include:**

- planting at the right times (not during the dry season if possible)
- avoiding harvesting when moisture levels are high
- using bio-control methods such as nontoxigenic fungal strains of *A. flavus* and *A. parasiticus*
- drying crops to the right level of moisture content after harvest
- removing any moldy grains before storage
- storing in airtight containers to prevent fungal growth.

### **Berm**

A mound of earth or other material.

### **Berm and basin**

A water-harvesting earthwork laid on a slope, consisting of an excavated basin with a berm just below it on the slope.

### **Boomerang berm**

A semicircular berm on a slope; open to the slope above, and harvesting incoming runoff from it.

### **Contour berm**

A berm and basin constructed along a contour line.

*See Rainwater harvesting for drylands and beyond. Vol 1 & 2 2014. Lancaster B.*



## Pests and diseases

Pests and diseases can have a significant negative impact on yield and can sometimes decimate crops, particularly in tropical environments.

**Best practices to manage pests and diseases are necessary during the entire production cycle, and include:**

- identifying pests and diseases
- learning their life cycle and encouraging natural biological controls (such as predatory insects that eat pests)
- using pest-resistant plant varieties
- using cultivation, fertilization, and irrigation methods that reduce pest habitats
- removing dead plants and other materials that show signs of disease, which can attract pests to the fields
- leaving organic matter with no signs of disease in fields to decompose and help fertilize the soil for next season
- monitoring fields and crops consistently, and acting accordingly (for instance, it is easier to reduce the impact of pests if they caught early in an infestation)
- using chemical pesticides if necessary, ensuring strict procedures are followed for application and safety.



Photograph: Lorraine Swanson, istockphoto.com

*The best time to harvest will be determined by the variety of crop and the local context*

## Best practices during harvest

Key areas to focus on are:

- timing
- handling.

### Timing

*It is important to harvest at the best time to maximize quality and quantity for consumption and sale. This will be determined by the crop variety and the local context.*

If harvested too early, a crop will not be ripe enough. If harvested too late, it may spoil.

Each crop should be harvested at a specific time based on days since planting, size, shape, firmness, and color. Other factors are also relevant, for instance, cereals should be harvested when it is dry, and preferably cool.

#### **Best practices for timing harvest include:**

- following standard harvest guidelines for each crop  
*(information is available online, at extension offices, input supply companies, or from other farmers<sup>4</sup>)*
- maintaining production records to keep track of planting times for different crops and help plan harvest times for a diverse crop mix.

### Handling

*Damaging a crop while harvesting can reduce its quality and storage life.*

Any punctures or bruising, especially on soft fruits and vegetables, will decrease the amount of water in the crop and increase the crop's susceptibility to disease. Bruises during harvest will also decrease the life of the crop.

#### **Best practices for handling produce include:**

- using tools and techniques that minimize damage during harvest
- creating or finding a shady spot in the field to store horticultural crops while they are being harvested and keeping them in the shade post-harvest if possible
- using cartons, wooden crates, and plastic containers.

*Containers can be more expensive, but are often cost effective if produce is for the domestic market. Reusable and easy to wash, they may prolong the life of the product in storage and potentially increase the sale price.*

Harvesting at the right time and minimizing damage to produce can greatly reduce post-harvest losses.



Photograph: Thatcher Cook



## Best practice after harvest

Key areas to focus on are:

- shelling
- drying
- sorting
- transporting
- storing
- marketing.

### Shelling

*Care should be taken to minimize damage during shelling.*

Where available, and when properly operated, mechanical shelling can reduce damage. Hand tools can also be used for dried maize. Otherwise, cereals should be gently shelled by hand.

### Drying

*Harvested crops need to be dried to the right moisture content before storage.*

**Best practices to reduce loss when drying produce include:**

- exposing the produce to the sun in an open, well-ventilated space
- ensuring that drying produce does not mix with dirt and pests by keeping it off the ground, for instance on a raised drying platform
- using more advanced solar-drying technologies.<sup>5</sup>

### Sorting

*Harvested crops need to be sorted to remove damaged, diseased, moldy, and over-ripe produce, and pests.*

This will help to reduce spoilage during transport and storage.

### Transporting

*Produce at the bottom of packaging can be damaged by the weight of produce above. Rough handling also causes damage.*

If produce is transported by vehicle, it may be damaged by uncontrolled temperatures and excessive shaking on rough roads.



*Contamination in a storage container will rapidly spread throughout the container*

**Best practices to reduce loss when transporting produce include:**

- avoiding stacking produce too high
- using reusable boxes or crates that can be stacked without putting weight on produce at the bottom
- using straw or something soft between layers of produce to reduce the amount of rubbing
- preventing produce from overheating.

## Storing

*Produce can be damaged during storage by mold, insects, bacteria, disease, and over-ripening.<sup>6</sup>*

Produce from smallholder farming systems is commonly stored:

- for domestic consumption
- for later sale
- during transport to market
- for longer periods by traders for sale in markets.

Farmers often store produce in local granaries or in their homes.

Many smallholder farmers store their crops in woven bags that are tied with string or rope at the top and are highly susceptible to weevils, rodents, and other pests or mold. When a bag is contaminated with a disease, fungus, or pest, it is difficult to keep it from spreading throughout the entire bag.

**Best practices to reduce loss when storing produce include:**

- storing produce at the lowest temperature possible to deter pests
- using improved crop storage, for instance Purdue Improved Crop Storage (PICS) bags
- if using woven bags, double or triple bagging them to provide extra barriers to moisture and pests
- storing produce in metal or plastic containers with locking lids to prevent pests from breaking into the container
- keeping storage bags off the ground and away from any walls.

*If they touch the walls or ground, moisture may seep in and contaminate whole bags with mold.*

### **PICS bags<sup>7</sup>**

Purdue Improved Crop Storage (PICS) bags were developed to provide farmers in West and Central Africa an affordable, hermetically sealed bag for crop storage that can defend against weevils.

PICS bags prevent the need for insecticide because they use three bags, two of which are polyethylene.



Photograph: Andrea Mottram



## Marketing

Markets can take many forms: wholesale markets, assembly markets (where farmers sell to small traders), farmers' markets, and retail outlets.

### **Marketing is the final, decisive element in the post-harvest system.**

Any losses and damage before, during, and after harvest determine the price paid for the product in the market. The price paid in the market affects all the other financial interactions, right down to the producer level.

Most of the losses associated with marketing result from the product moving from production to processing, and on to market, in addition to spoilage in the market itself.

### **Best practices when marketing produce include:**

- identifying the points in the system where damage is being caused by particular people or methods before, during, and after harvest, and addressing them to improve the market price
- preventing fruits and vegetables from drying out in open-air markets by shading them, not stacking them too high, and keeping them moist.



Photograph: Andrea Mottram

# Success story

*Tools to reduce losses in four critical areas of post-harvest handling*

## Postharvest Training and Services Center in Tanzania

**The Postharvest Training and Services Center in Arusha, Tanzania was opened by a team led by the USAID-funded Horticulture Innovation Lab to improve post-harvest practices among horticultural farmers.**

Demonstrations at the center highlight many tools to improve practices in four critical areas of post-harvest handling of fruits and vegetables, which can reduce losses significantly.

- *Gentle harvest and handling*  
using equipment that can prevent damage from dumping and piling produce on the ground.
- *Improved packing and containers*  
including using smaller bags or crates, liners for rough wooden crates, and standardized packing practices.
- *Cooling*  
as the single most important factor in maintaining the quality of produce, starting with shade.
- *Processing and solar drying fruits and vegetables*  
to add value, reduce waste, preserve food, and potentially increase profits.

### Cooling methods

The Zero Energy Cooling Chamber can provide passive cooling options.

A CoolBot-equipped, air-conditioned room can provide active cooling to reduce the temperature of produce.

*Technologies for horticultural development. CoolBot provides inexpensive, effective cooling. Horticulture Innovation Lab Fact sheet. 2014. University of California, Davis.*



Photograph: Kyla Yeoman, Mercy Corps





Photograph: Sean Sheridan

# Further reading

- ADM Institute for the Prevention of Postharvest Loss.  
University of Illinois at Urbana-Champaign.  
[postharvestinstitute.illinois.edu](http://postharvestinstitute.illinois.edu)  
The ADM Institute for the Prevention of Postharvest Losses is an international information and technology hub for evaluating, creating, and disseminating economically viable technologies, practices, and systems that reduce post-harvest loss in staple crops such as corn, wheat, and oilseeds.
- *Aflatoxin impacts and potential solutions in agriculture, trade, and health. An introduction to aflatoxin impacts in Africa.*  
2013. Partnerships for Aflatoxin Control in Africa (PACA).  
Short resource summarizing the impact of aflatoxin.
- Post-Harvest Education Foundation  
[www.postharvest.org](http://www.postharvest.org)  
The Postharvest Education Foundation is a nonprofit public benefit corporation. It holds meetings and training events on post-harvest losses and has a resource section on its website.
- *Practical instructions for reducing cereal losses after harvest*  
[www.erails.net/FARA/aphlis/aphlis/practical-tips-for-reducing-losses](http://www.erails.net/FARA/aphlis/aphlis/practical-tips-for-reducing-losses)  
African Post-harvest Losses Information System (APHLIS) Africa.  
This is a network of cereal grain experts in East and Southern Africa. It maintains a database and post-harvest loss calculator that together facilitate estimates of annual post-harvest losses of cereal grains in East and Southern African countries, by province. It also provides practical tips on reducing losses.
- *Strategies to control aflatoxin in groundnut value chains*  
Florkowski W, Kolavalli S, IFPRI Discussion Paper 01369 August 2014.  
Summary of the groundnut value chain in Ghana and aflatoxin control strategies.



# Endnotes

**1** *Global food losses and food waste*

Gustavsson J, Cederberg C, Sonesson U, van Otterdijk R, Meybeck A. 2011. Food and Agriculture Organization of the United Nations (FAO), Rome .

**2** Based on *A commodity systems assessment methodology for problem and project Identification*

La Gra, Jerry. 1995. Postharvest Institute for Perishables  
College of Agriculture, University of Idaho.

**3** *Technologies for horticultural development: Drying beads save high-quality seeds.*

Horticultural Innovation Lab, 2014. University of California, Davis.

**4** *Prevention of post-harvest food losses fruits, vegetables and root crops.*  
A training manual.

Food and Agriculture Organization of the United Nations (FAO), 1989.  
FAO, Rome.

**5** *Solar drying technology for food preservation.*

Green MG, Schwarz D. August 2001. GTZ-GATE, Germany.

**6** *Post-harvest losses: discovering the full story: overview of the phenomenon of losses during the post-harvest system.*

Grolleaud M. [www.fao.org/docrep/004/ac301e/AC301e00.htm](http://www.fao.org/docrep/004/ac301e/AC301e00.htm)

**7** *Cowpea storage without chemical using PICS Bags.*

Purdue University. [www.picsnetwork.org](http://www.picsnetwork.org).

