

APPROPRIATE POSTHARVEST PRACTICES FOR IMPROVED GRAIN STORAGE



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Contents

Foreword.....	iii
Authors	iv
1. Introduction.....	1
1.1. Some Postharvest Challenges	1
1.2. Objectives of the manual	1
2. Postharvest Handling of Dry Grains	1
3. Harvest Maturity.....	2
3.1. Signs of maturity	2
4. Drying and Safe Moisture Content	3
4.1. How to determine grain moisture	3
4.2. Safe moisture content.....	4
5. Managing Grain Moulds and Aflatoxins.....	5
5.1. Predisposing Factors	5
5.2. Simple tips to reduce moulds and aflatoxins	5
6. Grain Storage Operations.....	6
6.1. Types of storage methods.....	6
6.2. General Tips for storing most grain.....	7
7. Hermetic Grain Storage.....	7
7.1. Purdue Improved Cowpea Storage (PICS) system.....	7
7.1.1. How to use PICS bags.....	8
7.1.2. Steps to use the PICS bags.....	8
8. Conclusion.....	10
References.....	11

Foreword

Postharvest grain losses are significantly high among smallholder farmers in Sub-Saharan Africa. Grains of various crops are prone to quality deterioration and damage due to improper storage. In fact, it is common for a farmer to lose one-third of his or her crop because of bad storage practices or facilities and pest infestation. Prevention of pests is important as losses during storage adversely affect household food security and income. Post-harvest losses, which may be as high as 30 percent of the agricultural production, can be reduced by using appropriate post-harvest handling practices, and this may lead to a significant improvement in smallholder farmers' food and nutrition security and can have a positive economic impact.

The Modernizing Agriculture in Ghana (MAG) Project which is funded by the Canadian Government forms part of efforts by the Government of Ghana to reverse the declining growth of the agriculture sector over the past years. In addition, the project geared towards the modernisation of Ghana's agriculture and ensure food security for the country. It is spearheaded by the Ministry for Food and Agriculture (MoFA). The Research-Extension Farmer Linkage Committees (RELCs) are supposed to create a bridge between research, extension, farmers and agribusiness. Also they are to encourage active participation, enhance interaction and bring decision making in technology development and dissemination closer to farmers and agribusiness. The RELCs purport to disseminate improved methods and technologies on key aspects of conservation agriculture, such as appropriate seed varieties, irrigation, storage systems, land and water use and good agricultural practices, with the hope that they may serve different stakeholders to improve their resilience-building efforts. A multi-sectoral approach and solid partnerships are seen as key to the success of resilience-building work.

This manual which is an output of the RELCs in Northern and Upper West Regions is designed to provide basic knowledge on the key aspects of a good storage environment, including a proper storage facility, and the execution of prestorage activities such as harvesting, drying, threshing or cleaning in order to help farmers to meet appropriate conditions to maintain the quality and quantity of stored grain. The production of this material has been supported with funding by MAG Project from the Global Affairs Canada (GAC). The target audience for this brief includes NGO staff, agricultural extension workers, community development leaders and government officials. We sincerely hope that it will provide the needed technical support to assist farmers to ensure safer grain and seed storage and reduce losses, therefore increasing their resilience to natural hazards and their ability to rapidly recover after a shock. The content of this guide can be reproduced and reused without permission provided the authors are acknowledged.

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1. Introduction

The majority of Ghanaian smallholder farmers rely heavily on crops such as maize, sorghum, rice, cowpea, groundnuts, soybean and millet. They contribute greatly to the income of rural households. Despite their potential towards poverty reduction, food security and household nutrition, yields of farmers' are usually below the optimum due to a myriad of biotic and abiotic stresses. Poor access to improved varieties, pests and diseases infestation, low soil fertility and erratic rainfall are largely responsible for the low on-farm productivity. One of the challenges farmers grapple with is post-harvest storage losses due to insects. Farmers are forced to sell their grains at harvest at very low prices rather than risk a total loss.

In addition, high postharvest losses (PHL) have been reported in all districts of Ghana because farmers use different traditional storage methods which vary in capacity and efficiency. Often times, such methods are relatively simple and inexpensive to construct and maintain, but are unable to protect the produce from insect pests, rodents, disease pathogens and moisture absorption. Effective storage plays a role in stabilizing food supply and prices by widening seasonal availability. Basic knowledge on the key aspects of a good storage environment, including a proper storage facility, and the execution of prestorage activities such as harvesting, drying, threshing or cleaning, will help farmers to meet appropriate conditions to maintain the quality and quantity of stored grain and seed.

Reducing food losses therefore offers an important pathway of availing food, alleviating poverty, and improving nutrition. A significant economic benefit of safe grain storage is that hazard-affected farmers will not be put under pressure to sell their produce in order to meet their immediate needs; this increases farmers' bargaining power, as they have the option to delay selling while negotiating a better price. This will help farmers get a fair price for their produce and limit the role of middlemen and intermediaries. Further, safe storage can also help farmers to access credit: farmers can pool their produce, store it and then sell as a group enabling them to market good quality and large volumes.

1.1. Some Postharvest Challenges

- ✓ Delay in harvesting
- ✓ Manual and drudgery postharvest operations
- ✓ Problem of drying due to the release of extra-early maturing varieties
- ✓ Climate change in relation to rainfall, moisture, relative humidity and temperature
- ✓ Susceptible to several insects during storage
- ✓ Aflatoxins contamination in maize and groundnut
- ✓ Use of indigenous storage methods
- ✓ High storage losses at on-farm
- ✓ Low adoption of improved storage methods
- ✓ Indiscriminate use of grain protectants
- ✓ Limited knowledge on best postharvest management practices for different crops.

1.2. Objective of the manual

- ✓ To ensure that many farmers are adopting improved storage technologies and practices to improve household food security
- ✓ To reduce postharvest loss and improve on food quality.
- ✓ To provide basic information on best grain storage practices
- ✓ To make technical information accessible to end-users through researchers, extension staff and development partners.

2. Postharvest handling of dry grains (durable crops)

Dry grains can be stored for several years once they are harvested on time, dried to safe moisture content and properly conditioned for storage.

Examples of dry grains: Rice, maize, groundnut, millet, sorghum, cowpea, soybean, bambara groundnut, Pigeon Pea (*Cajanus cajan*).

Characteristics of durable crops

- ✓ They have small grains
- ✓ Grains have hard texture
- ✓ They can be dried to low moisture content (< 15% mc)
- ✓ They have low respiration rate at storage
- ✓ They can be stored from months to years
- ✓ Losses are due external factors such as insects, moulds and rodents

General principle for successful storage

The chain of activities to successful storage should include:

1. Observe good agronomic practices before harvest
2. Observe for signs of maturity
3. Harvest timely at maturity
4. Delay in harvest leads to pest infestation, grain moulds, termites and lodging.
5. Dry grain to safe content
6. Properly clean and winnow grain for storage
7. Select appropriate storage method
8. Use recommended grain protectants where insect infestation is suspected
9. Store grain in a good store room or warehouse.

3. Harvest Maturity

Physiological maturity: means the crop, organ or fruit has attained optimum stage of growth (morphological, physiological, nutritional or sensory) for consumption. This may be associated with changes in colour, texture, flavour or size that make them attractive and palatable for eating.

Harvest maturity: means the crop, organ or fruit has completed growth and sufficiently cured or dried for harvesting.

NB: This definition depends on the end-use of the crop.

3.1. Signs of maturity

This may vary in different crops. For example.

- i. Yellowing and drying of leaves
- ii. Drying of maize cob,
- iii. Yellowing and drying in cowpea or soybean pods
- iv. Yellowing, drying and dropping of sorghum heads
- v. Yellowing and browning in rice



a. Maize at physiological maturity



b. Maize at harvest maturity



a. Sorghum at physiological maturity



b. Sorghum at harvest maturity

4. Drying and Safe Moisture Content

Generally, the moisture of stored grain is the most important factor for storage longevity. It is therefore important to determine the initial moisture content particularly in large scale warehouse operations. Note the following:

- ✓ Safe grain moisture content vary in different crops and varieties of same crops.
- ✓ Safe moisture vary in different agro-ecologies
- ✓ Safe moisture content may vary depending the method of storage- eg. more dried grain is recommended in hermetic storage systems
- ✓ Anticipated length of storage- e.g. more dried grain for prolonged storage
- ✓ Ventilation system of the storage house
- ✓ Degree of contamination by foreign materials and plant debris

4.1. How to determine grain moisture

Moisture test for dry maize can be done using salt in nylon. Put small quantity of salt and 10-15 maize grains into nylon and shake. If the maize grain is not dry, you will see wet stains on

the nylon or put some grain in a container (tin), close the container and shake. The louder the noise the dryer the maize grain. You can also put the grain in-between your teeth, if it breaks easily; it means the maize grain is dried. If available, moisture meters can be used.

1. By hand-feel based on experience
2. By grain sound based on experience
3. By biting the grain based on experience
4. By using glass and salt test
5. Simple oven drying (laboratory)
6. Use of grain moisture meters.



Multi-crop grain moisture meter



4.2. Safe moisture content

It has been well established that for any crop and given temperature, there is a definite relation between grain moisture content and relative humidity (RH) of the air with which it is in moisture equilibrium. Relative humidity is the percentage of water vapour in the air between the grains, and represents the equilibrium between the humidity of the air and the moisture content of the grain. The grain moisture content in equilibrium with a given RH is called the equilibrium moisture content at that temperature. If the RH of the air is increased, the grain will absorb moisture. Accordingly, grains that are exposed to a thin layer of air with fluctuating humidity absorb and give off moisture, tending at all times to reach equilibrium with the air. If the relative humidity exceeds 65 percent, mould and storage insects can develop and stored grain and seed are susceptible to deterioration.

- ✓ For the dry cereals, when the grain have been dried to safe moisture content or below the safe moisture level, the grain can be stored for several months or years under a range of temperature. However, grain moisture must be monitored to minimize moisture rise or manage such fluctuations.
- ✓ Sufficiently dried grain is less susceptible to insect infestation and grain moulds.
- ✓ The safe moisture content vary in different crops, and may vary slightly depending on the variety.
- ✓ Also moisture contents are valid for given temperature ranges. Higher temperatures may require lower grain moisture.

Table 1: Approximate safe moisture content for selected grain at 27°C and 70% relative humidity

Crop (grain)	Safe moisture content (% mc wb)
White maize	13.5
Yellow maize	13.0
Paddy rice	14.0
Milled rice	12.0
Sorghum	14
Millet cowpea	14.5
Cowpea	14.5
Soybean	13.5
Cajanus, Bambara groundnut	14.0
Groundnut (shelled)	7.0

5. Managing Grain Moulds and Aflatoxins

Mould (fungi growth) growth and their metabolic activities are a problem during grain storage in the humid and arid tropical areas. Mould growth can lead to quality losses such as colour, nutrition, flavour, cooking properties, loss of seed viability and consumer allergies. Of late, the issue of aflatoxins have also emerged as a major food safety challenge.

The primary cause of mould deterioration of storage grain is the presence of excessive water. This leads to relative humidity exceeding 70% in the air within the bulk of grain in the store room. Many fungal mycelia will develop at this relative humidity, thus leading to increase in biological activity and rapid quality deterioration.

5.1. Predisposing factors

- ✓ Poor soil conditions and fertility
- ✓ Use of local varieties
- ✓ High humidity (> 85%), high temperatures (> 25 °C) at growth and storage
- ✓ Intermittent and end of season droughts,
- ✓ Insects, termites, millipede and rodent activities,
- ✓ Delayed harvest and poor drying conditions
- ✓ intermittent rains during harvest period
- ✓ Use of improper and traditional storage methods

5.2. Simple tips to reduce moulds and aflatoxins

- ✓ Timely harvesting is essential
- ✓ Reduce the harvesting-threshing interval in order to minimize the risk of wet weather after harvesting

- ✓ Harvested produce should be quickly dried to safe storage moisture
- ✓ The inverted windrowing for drying groundnut pods ensures exposure to direct sunlight and circulating air. This method can be used for late harvested groundnut only.
- ✓ Dry on clean platforms or tarpaulin
- ✓ Store in PICS bags at a dry and ventilated store room
- ✓ Sort out damaged and mouldy grains/nuts after shelling/threshing
- ✓ Do not eat mouldy grains/nuts.

Grain Storage Operations

The main purpose of storage is to keep any produce in excess of immediate consumption or sale at conditions that maintain grain quality for future use. Any part of harvested food that is desired for consumption but fail to reach the final consumer is considered as a loss. During the movement of food from the farm to market or store or consumer table, several types of losses may occur. These include losses in quality, nutrition, taste and flavour, viability or economic value. The function of storage is to minimize these losses as much as possible.

5.3. Types of storage methods

1. Traditional methods (Mud-silo, maize barn, crib, baskets)
2. Improved traditional methods (jute bags, poly-bags, mud-silo)
3. Improved small scale methods (e.g. PICS bags, plastic drum, metal silos, community bags, Zero-fly bags)
4. Large scale method (grain silo, metal silo, large warehouse)



Mud silo



Mud silo



Improve mud-silo



Traditional seed millet storage



Grain storage in jute bags



Storage in plastic drum

5.4. General tips for storing most grains

- ✓ Observe proper field drying, solar drying and sun drying
- ✓ Grain should be dried on a clean platform, cemented floor or tarpaulin sheet
- ✓ Store at safe moisture content (11-13.5% moisture).
- ✓ Select appropriate storage option
- ✓ The use of PICS bags or plastic drums is now recommended.
- ✓ For storage of cowpea beyond 3 months or maize, sorghum or millet beyond 6 months, the use of PICS bags should be adopted.
- ✓ Clear and clean your store room or warehouse.
- ✓ Disinfect or clean old storage bags thoroughly before use
- ✓ If the store unit was previously infested, spray or fumigate before loading fresh produce
- ✓ After threshing, clean the grain by thorough winnowing
- ✓ Do not mix old and newly harvested grain
- ✓ Do not put bags on bare floor
- ✓ Use only recommended food-grade chemicals with short persistence (e.g. Actellic Super (*Pyrimiphos-methyl and Permethrin*), or Phostoxin under air-tight conditions).
- ✓ Adhere to recommended dose on chemical label.
- ✓ Seek advice from your Agric. Extension Agent.
- ✓ Conduct regular monitoring and take measures if pest infestation is detected
- ✓ Monitor market price and sell at appropriate time if price is good.

6. Hermetic Grain Storage

Hermetic grain storage systems try to eliminate all gaseous exchanges between the inside and outside of a grain storage container. If the gas exchange is low enough, living organisms such as insects within the container will deplete oxygen and produce carbon dioxide until they die or become inactive due to the low oxygen. Hermetic grain storage can be an appropriate method for many subsistence farmers. It eliminates the need for insecticides, which are costly and may not be available to farmers. Misuse of insecticides by farmers is common and can cause health and environmental problems. At low moisture content (below 13 % MC), storage fungi can be controlled as well.

6.1. Purdue Improved Cowpea Storage (PICS) system

A team of scientist at Purdue University developed the Purdue Improved Cowpea Storage to reduce losses in Western Africa. The program uses a triple plastic bagging system developed for storage of cowpeas in West and Central Africa. It was anticipated that up to 50% of the farmers will stored cowpea in hermetic storage without insecticides by 2012 (Baribusta et al., 2010).

Procedure

PICS technology uses plastic bags to achieve hermetic storage of cowpeas and other grains. Threshed cowpea, maize, millet or sorghum grain, dried to an appropriate moisture content and free of crop debris, is placed into 50 or 100 kg capacity high-density polyethylene bags with 80-µm thickness. A first bag is filled completely, but with a 20- to 30-cm neck, which is tied securely. Then, this bag is surrounded by a second bag with the same thickness. The second bag's neck is also tied securely. Finally, these two bags are placed in a third woven nylon or polypropylene bag used for its strength. With the third bag tied securely, the container can be handled without bursting the inner bags, and is readily accepted by grain handlers who are accustomed to handling cowpea in this type of woven bag.

6.1.1. How to use PICS bags

Which grain can be stored?

- ✓ All shelled grain can be stored (except paddy rice),
- ✓ E.g. Maize, cowpea, soybean, millet, sorghum

Advantages

- ✓ High quality grain after storage (insect free grain)
- ✓ Does not require the addition of chemicals
- ✓ Grain can be stored for 1-3 three years
- ✓ Does not affect seed viability

Disadvantages

- ✓ High cost of bags
- ✓ Problem of re-usability
- ✓ Not available at many districts and communities

6.1.2. Steps to use the PICS bags

Step 1:

- ✓ Obtain PICS bags from input dealers
- ✓ Store only properly dried grain
- ✓ Clean grain thoroughly be winnowing
- ✓ Remove plant debris by hand.



Step 2:

- ✓ Separate the 3 bags apart
- ✓ Check the 2 inner plastic bags to ensure there is no perforation
- ✓ Do not use bags that have perforations.



Step 3

- ✓ Fill the inner bag with grain to the neck
- ✓ Start with small quantity of grain, shape gently to allow for proper filling
- ✓ Make sure there is no air pocket at bottom
- ✓ Hand press gently to remove all air bubbles
- ✓ Allow some space to enable tying of bags



Step 4

- ✓ Twist, fold and tie the inner bag first
- ✓ Pull up the second bags and follow same steps for 2nd and 3rd layers.
- ✓ You may tie with a robe or clean cloth.



Step 5

- ✓ Store in cool dry room.
- ✓ Do not store bags on a bare floor.
- ✓ Do not open bags regularly
- ✓ Monitor prices of grain in markets
- ✓ Sell your grain when prices are good



Do not store bags on a bare floor



Store on raised wooden platform or racks.

7. Conclusion

Postharvest grain loss is a significant barrier to household food nutrition security across Ghana. These losses can be aggravated in times of natural disasters such as drought, floods or pests, leading to devastating effects at household level, undermining the capacity of rural communities to overcome these crises and impeding an early recovery after the shock. The implementation of appropriate storage systems, both methods and facilities, have therefore an important role in an increased resilience for rural communities.

The storage of grain and seed needs to be addressed from a value-chain perspective, as some of the main factors that impact storage start in the field (preharvest) and in the handling of the produce before the storage (postharvest handling). To ensure the right execution of prestorage activities such as harvesting, drying, threshing or cleaning, among other operations, will help farmers to meet appropriate storage conditions, as well as reduce the risk of insects being taken inside the storage facility.

An important part of the efforts to reduce insect infestation and mould development in the stored grain are centred on ensuring stable and appropriate conditions of low temperature and relative humidity inside the storage facility, as well as keeping the moisture content of the stored grain and seed under safe thresholds.

As a complement to this, the implementation of preventive principles of IPM and appropriate conception and construction of storage facilities will help to reduce the risk of a pest infestation and the associated losses, leading to a significant improvement of small-scale farmers' economy and food and nutrition security

References

For more information on PICS, contact Purdue Improved Cowpea Storage Project (ICS), IPIA, Purdue University, West Lafayette, IN 47907, USA (email: pics@purdue.edu).

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