

Post Harvest Management Guide for Common Beans

A guide for farmers and extension



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Acknowledgments

The work on beans at the Alliance of Bioversity International and CIAT is supported by diverse funding partners under the CGIAR Trust. This work is implemented under the Pan African Bean Research Alliance (PABRA) in collaboration with the One CG Initiatives, Ukama Ustawi-Diversification in East and Southern Africa and Gender and Social Inclusion (HER+).

Citation: Waswa B, Nchanji E, Karanja D, Rubyogo JC (2024). Post Harvest Management Guide for Common Beans: A guide for farmers and extension. Alliance of Bioversity International and CIAT, Nairobi, Kenya.

Alliance of Bioversity International and CIAT, Nairobi, Kenya



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Preamble

A third of all food produced for human consumption is lost or wasted. The losses and waste occur from the farm to the fork along the food value chain. Post-harvest losses have significant impacts on food and nutrition security, health, and finances for both consumers and farmers, particularly affecting women who manage post-harvest activities.

- Globally, according to FAO et al. (2022), food loss and waste contribute to about **US\$940 billion** per year in economic losses.
- More than **690** million people in the world are still going to bed hungry.
- More than **250** million of these hungry population lives in Africa.
- According to the FAO, globally, **30%** of food produced for human consumption is lost or wasted along the supply chain every year.
- In Africa, the losses are even higher, ranging between **30%** and **50%**.
- This equates to **1.3 billion metric tons** of food that fails to reach consumers.
- The lost or wasted food could be used to feed approximately **1.6 billion** people every year.
- Food loss and waste exacerbates food insecurity and malnutrition.
- Food loss has a high carbon footprint as it leads to unnecessary deforestation, land conversion, and the wastage of water, nutrients, biodiversity and other resources.

Post harvest management contributes to achieving SDGs 1- End poverty, SDG 2- End hunger and SDG 12- Ensure sustainable consumption and production patterns. In particular, the third target under SDG 12 calls for cutting in half per capita global food waste at the retail and consumer level, and reducing food losses along production and supply chains (including post-harvest losses) by 2030.



This guide is designed to provide you with information on post-harvest management for beans. This will enable you make the informed decisions about reducing losses and wastage for your beans.

An estimated **940B** is lost every season due to



limited investment in addressing food waste and losses.



690M people in the world are still going to bed hungry



Over **3B**



people do not have regular access to safe, nutritious and sufficient food.



Source: Food and Agriculture Organization (FAO)



Objectives

- Enhance your understanding of the post-harvest management in beans for better decision making
- Explain the various post-harvest practices for reducing losses in beans
- Enhance your skills in using the post-harvest management practices



Learning outcomes:

The expected outcome from this manual are as follows:

- You will understand what causes post-harvest loss in beans
- You will understand why we need to reduce post-harvest losses for beans
- You will learn and understand various post-harvest management practices for beans



Target

The target beneficiaries of this guide would be farmers, extension officers, collection point managers and trainers. The manual's content is designed to address the specific needs and challenges faced by farmers ensuring that they can effectively apply the principle of post-harvest loss management, leading to reduced loss, improved food and nutrition security, better incomes, and improved livelihoods.

1.

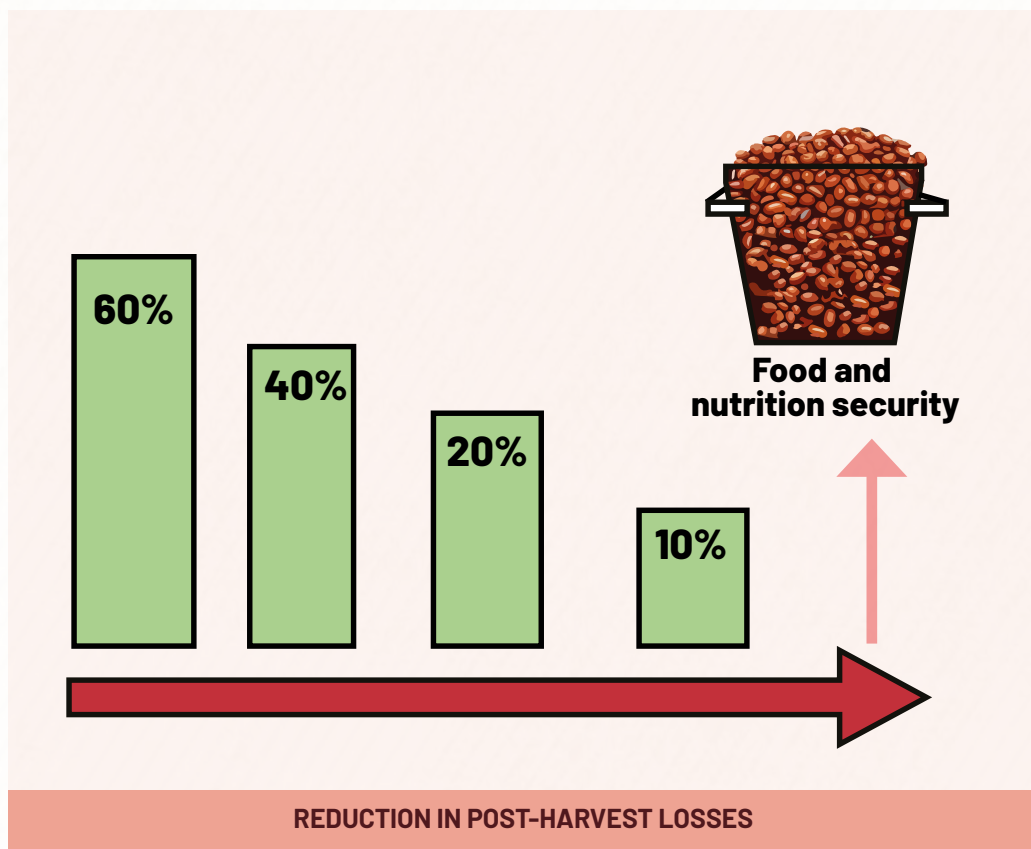
FOOD LOSS IN SUB-SAHARAN AFRICA

Globally, one-third of all food produced for human consumption is lost or wasted, equivalent to 1.3 billion tons. These translate to an economic value of about US\$940 billion per year. In the weeks after harvest, Sub-Saharan Africa alone loses 20 million metric tons of food each year, valued at over US\$4 billion, according to a 2011 study by the UN's Food and Agriculture Organization (FAO). The loss can feed about 48 million people. Post-harvest food loss is a leading cause of food insecurity for millions of families across the world.



Food losses can be reduced by adopting post-harvest management and storage practices, along the commodity value chain. By preventing smallholder farmers and other value chain actors from losing large portions of their crops after harvest, we can help increase the availability of food and beat hunger, increase incomes, reduce costs of food production, reduce economic loss of grain, conserves the environment, and empower households, especially women.

Post-harvest management influences all four pillars of food security – availability, access, utilization and stability. A food secure community is resilient to external shocks and threats, and good post-harvest management can bolster that resilience. Reducing food loss is a vital step towards meeting the Sustainable Development Goals.



Impacts of Post Harvest Management



Increases Food Availability; More Food to the Market



Reduces Costs; More Funds for Investment



Increases Income: More Control of Decisions



Preserves Environments Sustainable Future



Empowers Women: More Income, More Choices

2.

POST-HARVEST LOSS AND MANAGEMENT

What is post-harvest loss and management?

Post-harvest refers to time farm produce leaves the field, after maturity, to the time of preparation of food for consumption. Usually harvesting operation is considered part of the post-harvest period because the decisions taken at harvesting have impact on successive operations.

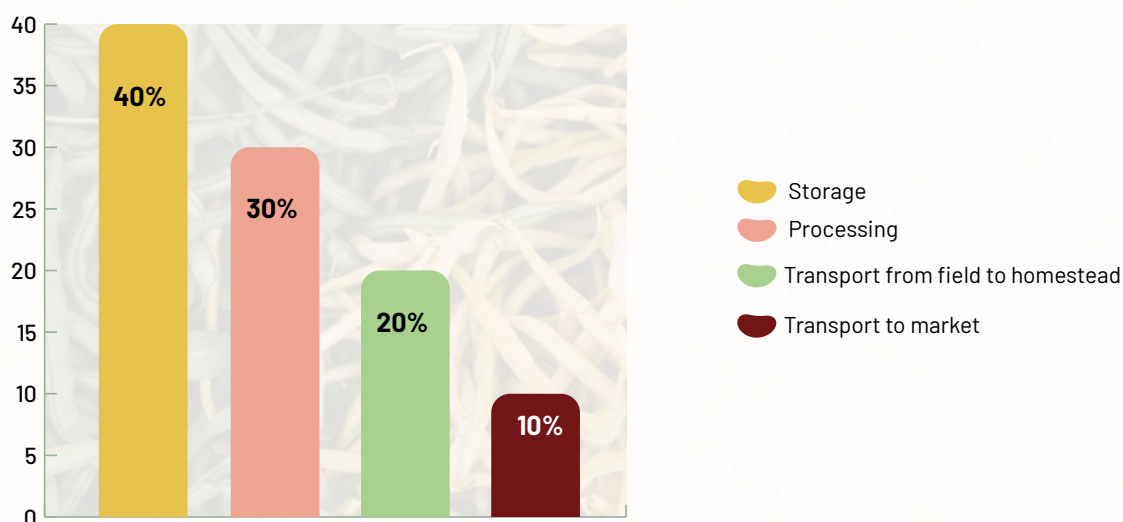
Post-harvest system encompasses the delivery of the produce from the time and place of harvest to the time and place of consumption. The term “system” denotes a dynamic set of logically interconnected functions laid out in succession.

Post-harvest losses refer to the quantitative and qualitative loss of food between harvest and human consumption.

Post harvest management is a system of handling, storing, and transporting agricultural commodities after harvest.

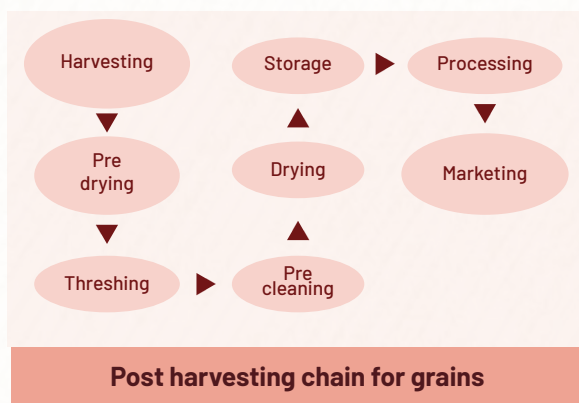
How big is post-harvest losses?

Post-harvest losses of cereals from harvest to market sale are believed to amount to around 30%. Approximately 40% of these losses occur during storage at the farm and market, 30% during processing (drying, threshing, and winnowing), 20% in transport from the field to the homestead/farm, and the remaining 10% during transport to market.



Where do the losses occur?

The post-harvest chain for beans starts from harvesting to the market.



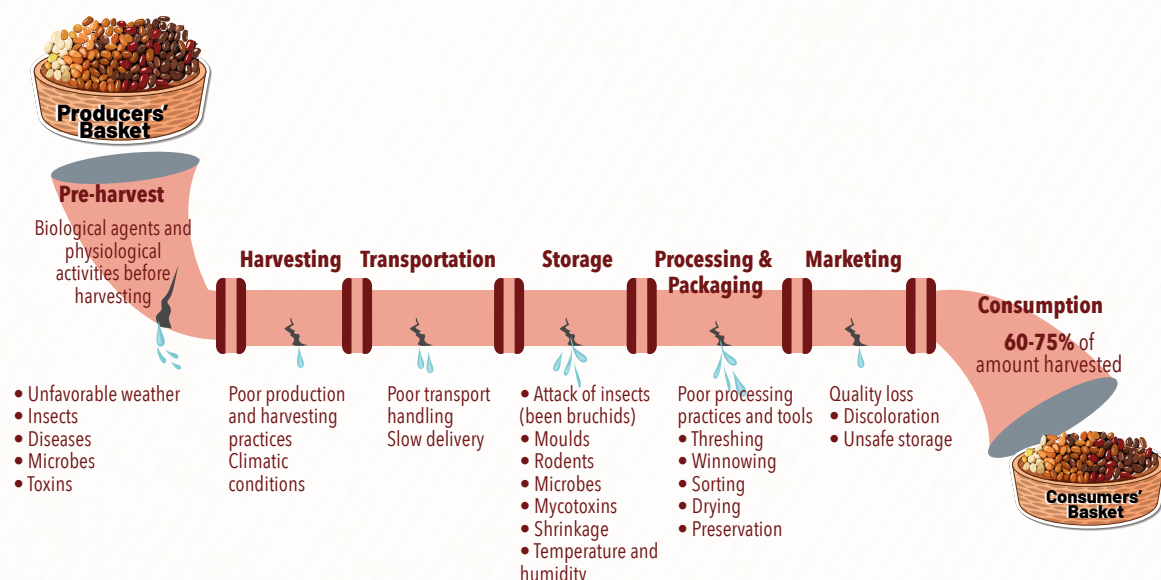
Grains may be lost in the pre-harvest, harvest, and post-harvest stages.

Pre-harvest losses occur before the process of harvesting begins, and may be due to insects, weeds, and diseases. Good agronomic practices will help reduce pre-harvest losses.

Harvesting losses occur at crop harvesting when the crop maturity and include shattering and scattering, mixing varieties, contamination with soil, spillage during transportation

Post-harvest losses occur between harvest and the moment of human consumption. They include on-farm losses, such as when grain is threshed, winnowed, and dried. Other on-farm losses include inadequate harvesting time, climatic conditions, practices applied at harvest and handling, and challenges in marketing produce.

Significant losses are caused by inadequate storage conditions as well as decisions made at earlier stages of the supply chain, including transportation, storage, and processing, which predispose products to a shorter shelf life.





Types of post-harvest losses



Quantity and quality losses

Quantitative loss is measurable loss in physical quantity, such as weight and volume.

Weight loss can be caused by leakage, during transport for example, if sacks have holes or are insecurely attached. It also arises from infestation by insects, rodents and birds or poor packaging.

Qualitative loss is concerned with attributes of safety, nutritional content and economic value.

Quality criteria cover a wide range of characteristics and are concerned with physical features such as shape and size, sensory features such as odor and taste, chemical features such as nutritional values and safety elements, and other attributes such as processing quality

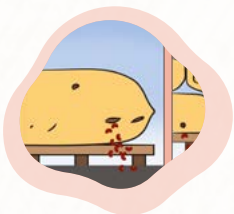
Cleanliness and healthy condition of a product are obvious concerns for the market

Examples of impurities in grain: bad grain, scraps of straw or other plant residue, soil, pebbles, bits of glass, excreta of pests, pesticides etc



Damage

Damage is a clear deterioration in the product, e.g. broken or pitted grain, which affects more of the quality, and can in the longterm result in a definite loss. Both damage and loss should be quantified in terms of weight and cost.



Direct and indirect losses

Direct losses occur when the disappearance of a foodstuff is caused by leakage, for example, pilferage or theft, spillage from bags or feeding of pests (insects, rodents, birds)

Indirect losses occur when a reduction in quality leads to the consumer's refusal to purchase.



Commercial loss

Commercial loss or economic loss is the translation of the various types of loss listed above into economic and monetary terms. Although the price of a foodstuff is usually based on weight, many other factors play a role. This applies especially to the qualitative elements emphasized above, starting with cleanliness and purity, which will be all the more sought after if supplies are abundant in the market-place



Biological causes of post-harvest losses

Biological agents of post-harvest loss include insects, rodents and fungi

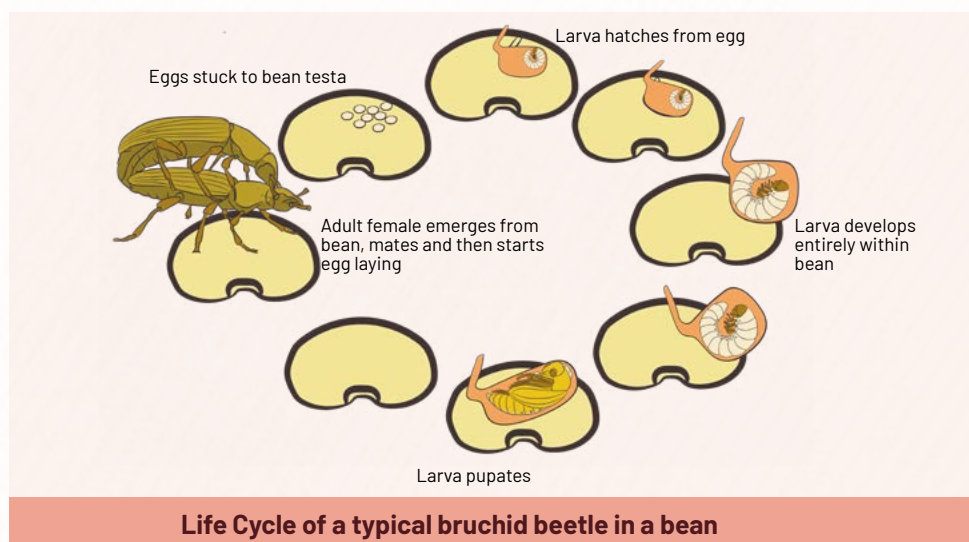
a. Insects

The common bean weevil, the bruchids, is the most significant cause of post harvest loss in beans.

Common Bean Weevil/Bean bruchid (*Acanthoscelides obtectus*)

The bean bruchid is a major post-harvest pest of beans. Bruchids can cause losses of excess of 40% of the harvested crop. The damage caused has a negative impact on the value and marketability of the crop and can even change some quality characteristics of the crop, including the taste. The holes made by the larvae often make the crop unmarketable. Grain infested by insects loses value for consumption or planting. Due to fear of loss, farmers tend to sell their beans immediately at harvest thus fetching very low prices for their produce.

Bruchid infestation begins in the field, but becomes a major problem after harvest, when the holes left in the beans reduce the value of the crop.





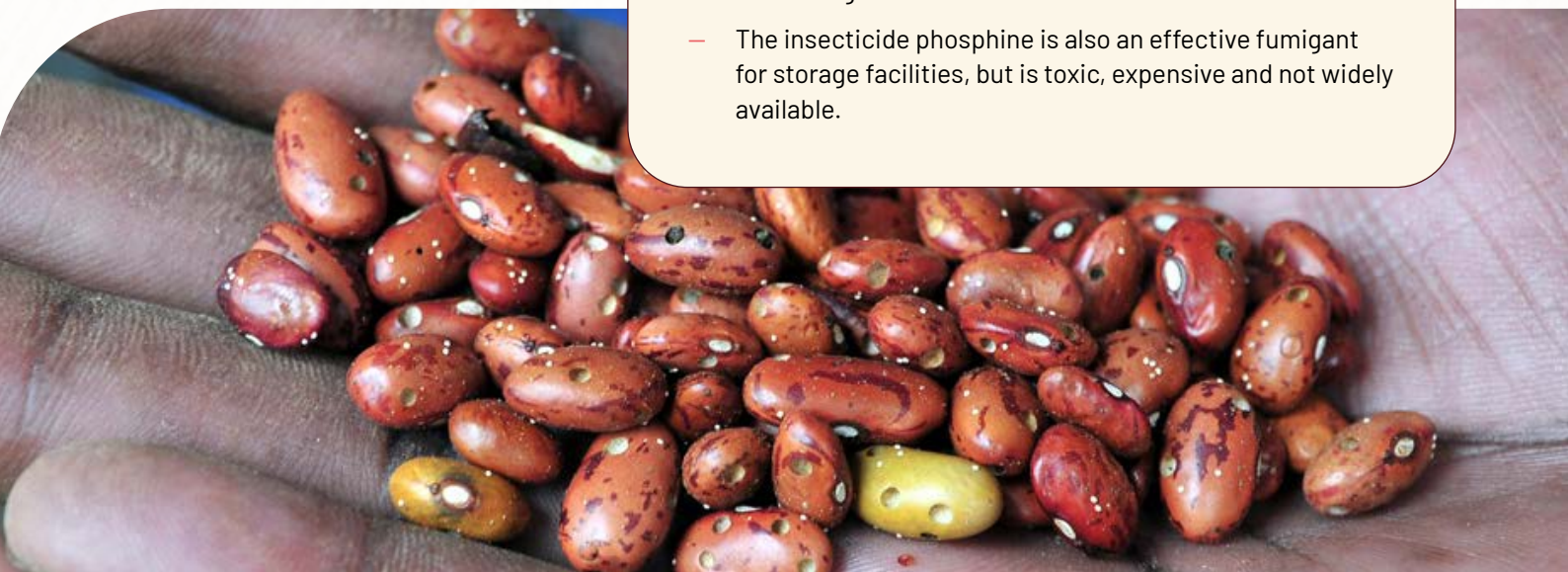
Management of bean bruchids

Cultural approaches for bruchid prevention:

- Use bruchid resistant varieties reduces infestations in the field
- Harvest beans as soon as they are mature to reduce the risk of heavy field infestation.
- Air-dry the beans to a moisture level of 13% or lower before storage
- Remove and destroy all infested crop residues immediately after harvest.
- Practice crop rotation
- Clean the storage facility prior to storage, using a disinfectant if necessary.
- Do not store old beans with newly harvested beans.
- Store beans in air-tight containers if possible, such as in plastic sealable bags, drums, or clay pots.

Chemical approaches for bruchid control:

- Mixing beans with vegetable oils, neem seed powder, wood ash or *Beauveria bassiana* (a fungus) can protect the stored beans and reduce losses.
- Use preservatives such as Actellic before grain bagging and storage
- The insecticide phosphine is also an effective fumigant for storage facilities, but is toxic, expensive and not widely available.





b. Rodents

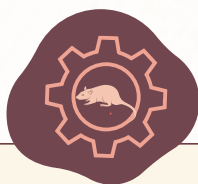
Rats have been estimated to damage more than 1% of the world cereal crops and, in developing countries, estimates of 3–5% have commonly been reported. In beans, rodents mainly cause damage to storage facilities, bags and also cause contamination of the grain.

There are around 50 diseases which can be transferred to humans by rodents, including typhoid, paratyphoid, and scabies.

Damage caused by rodents

Rats and mice cause losses in a number of ways:

- *Feeding on stored produce:* Rats consume about 25 gm of food per day and mice eat approximately 3–4 gm per day. Besides eating stored produce, rodents contaminate a lot of the stored produce with urine, faeces, hair and pathogenic agents. Contaminated grain is often declared unfit for human consumption.
- *Damage to material and equipment:* Rodents damage tarpaulins, bags, pallets, sprayers and to the store itself (cables, doors) and equipment e.g. scales and store records.



Management of rodents

Good store management and preventive measures taken as part of an integrated control program can help to deal with these factors.

- Keep the store absolutely clean. Remove any spilt grain immediately as it attracts rodents.
- Store bags in tidy stacks set up on pallets, ensuring that there is a space of 1 meter all round the stack
- Store any empty or old bags and fumigation sheets on pallets, and if possible in separate stores!
- Keep the store free of rubbish in order not to provide the animals with any places to hide or nest!
- Keep the area surrounding the store free of tall weeds so as not to give the animals any cover! They have an aversion to crossing open spaces.
- Keep the area in the vicinity of the store free of any stagnant water and ensure that rainwater is drained away, as it can be used as source of drinking water.
- Use traps
- Cats can help eliminate the rodents from the stores
- In extreme infestation, use rodenticides to eliminate the pests



c. Moulds (Fungi)

Infection of common bean by fungi can occur both in the field and after harvest in storage.

Field fungi are those that infect the crops throughout the vegetation phase of plants and they include plant pathogens such as *Alternaria*, *Fusarium*, *Cladosporium*, and *Botrytis* species.

Storage fungi infect grains after harvesting, during storage. The storage fungi include *Aspergillus*, *Penicillium*, *Rhizopus* and *Mucor* genera.

The moulds found on stored grain initially grow on the surfaces of grain and then slowly penetrate and destroy them.

Moisture and temperature are the most important factors that influence fungal colonization of grains.

Fungal contamination can cause damage in beans, including:

- Softening and rotting
- Heating and caking of the grain
- Grain discoloration
- Formation of pathogenic or allergenic propagules
- Low germination

Mycotoxins

Mycotoxins are toxic compounds that are naturally produced by certain types of moulds (fungi).

The most well-known is aflatoxin, which can be found in a wide variety of foodstuffs including cereals, pulses, and oilseeds. This is produced by some strains of the mould *Aspergillus flavus* and is regarded as the most important mycotoxin in developing countries.

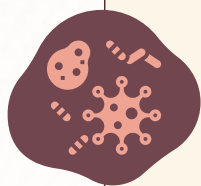
Mycotoxins may move in the food chain so that the possible concentration of mycotoxins in processed bean products such as flours, canned and precooked beans, could be a further source of danger to consumers.

Bean contamination with harmful fungi can cause acute and chronic toxicities to humans and animals such as:

- Food poisoning
- Diarrhoea
- Liver cancer
- Death

Management of moulds

- Harvest crop when fully matured and dried
- Ensure grain is properly dried before storage
- Avoid dampness of the store– keep store dry with no leakage of roof
- Place sack on raised racks to minimize dampness
- Ensure store is well ventilated and aerated to maintain appropriate temperature
- Eliminate all insect infestations in the grain



3.

KNOW YOUR COMMON BEANS

The diversity of beans is very wide:

- Beans come in various varieties, colour, shape and size
- The diversity of beans influences consumer and market preferences, taste, growth characteristics
- Different beans fetch different market prices
- The major bean classes are red mottled, red kidney, speckled sugar, rosecoco, small red, navy whites, yellows and pinto.
- Other unique bean classes include kablankeet, purple, black, stripped, grey



Red mottled



Red kidney



Speckled sugar



Rosecoco



Navy (white)



Yellows



Small red



Pinto



Photo of mixed beans

Why you should not mix different bean varieties

- The diversity of beans influences consumer and market preferences, taste, growth characteristics, prices
- Mixing beans varieties reduces market prices
- It increases cost of sorting and separating.
- It distorts the unique nutritional and cooking properties of the beans
- Mixing distorts uniformity of your seed and grain

How to avoid mixing bean types

- Start your bean production by growing same variety of uniform seed
- Avoid mixing beans by growing beans of different bean types in separate plots
- Separate and properly mark the plots used to grow beans of different classes
- Rogue or pull-out beans of different types (off types) from the farm to ensure uniformity. You can differentiate beans of different classes by the colour of flowers
- Practice crop rotation with cereal crop to reduce chances of mixing beans from volunteer plants
- Harvest the different beans at different times or days
- Thresh the beans as per the varieties
- Dry the beans on separate tarpaulins or mats
- Place and store beans in well labeled bags

4.

GOOD QUALITY BEANS FOR BETTER MARKETS

Why do we need to have good quality beans?

We need **good quality beans** for:

- Safe and healthy foods
- Better market prices



Quality factors for bean grain

Quality factors considered when grading beans

Foreign matter and filth

Grain may be contaminated with foreign matter that is either organic (e.g. bean stalks) or inorganic (e.g. stones, sand). Examples of filth are rodent dropping and dead insects. Careful sieving can reduce much of the foreign matter content.

Broken

Most broken grain comes from poor postharvest handling especially threshing.



Damaged by insect pests

Insects make holes in grains and hollow

Damaged by rodents

Rodents chewed grain

Mould damaged

Mouldy grains have been dried too slowly or allowed to become wet. They have patches of mould growth on them and may also be discoloured. Some moulds also produce mycotoxins that are dangerous poisons, e.g. aflatoxin

Discoloured

Grain may be discolored due to moisture or natural discoloration during storage grain drying and storage.

Smells bad (off-odours)

Poor handling, especially slow drying or contamination or storage near fertilizer or other agrochemicals can give grain off odours that are unacceptable

Variety mixing

Whereas variety mixing may not reduce physical quality, it reduces economic value, increase time and cost of sorting and reduces grain quality for specialized processing. Mixed grains fetch lower prices.

5.

STEPS IN POST-HARVEST BEAN MANAGEMENT

1.

Preparing for the harvest

Proper planning is needed prior to harvesting your beans

- Plan when to harvest allowing for sufficient time to avoid overworking and drudgery
- Have your harvesting and post-harvest equipment ready and in good condition
- Set aside appropriate grain drying and threshing areas
- Clean storage sacks and the storage area

NB:

Good hygiene is a very important activity to prevent postharvest losses, the new harvest should never be placed on, or with, grain from the previous season as this will encourage the movement of pests from the old to the new

2.

Harvesting

- Harvest beans at physiological maturity and when pods are dry- turning brown
- Do not delay harvesting dried beans from the field. Delays in harvesting can cause shuttering and loss of grain, infestation by bean bruchids and wetting leading to discolouration
- Harvest the beans on a sunny day, preferably in the morning to reduce shuttering and grain loss
- Since beans may mature at different times, harvest only the dried plants
- Uproot the beans shaking off any loose soil from the roots
- Heap the beans on a tarpaulin, mat or directly into a bag

3.

Transport the crop from the field to the homestead

- The harvest should be transported to the homestead as soon as possible
- Transport the beans from the far to the homestead using appropriate means of transport and correct bags to minimize losses as a result of spillage

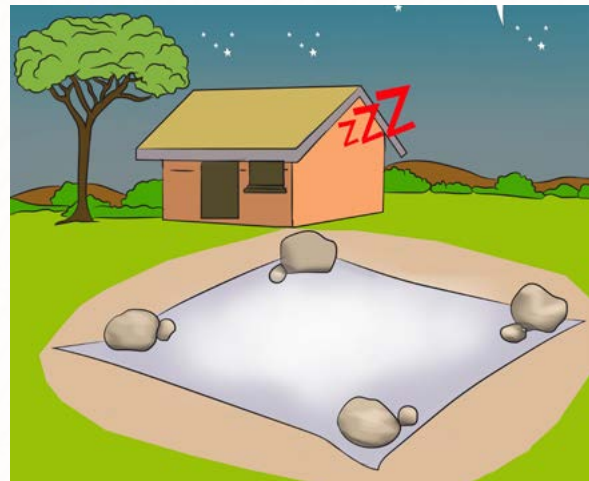
5.

Dry the beans

- Dry the beans on a mat, tarpaulin or concrete floor. The crop should not be placed in direct contact with the soil
- Crop should be kept away from farm animals, otherwise the grain may be scattered or contaminated with animal droppings
- Spread out the beans to ensure speedy drying
- Keep turning the heap of beans at regular intervals to ensure all plants dry out ready for threshing
- Dry your beans for 2-3 days or until dry enough ready to thresh
- In areas experiencing cloudy weather and some rainfall at the time of drying, it is important to keep a watch on the drying crop and cover it with a tarpaulin prior to any rainfall.
- Cover the beans at night to protect from rain and mist



Don't let drying grain get wet, cover with a tarpaulin if it is about to rain, or at night time.



5.

Threshing the beans

Threshing is the process of separating the grain from the pods.

- Thresh the beans when pods have properly dried

Manual Threshing

- Traditionally threshing of beans is done by beating with sticks, mainly by women and children.
- This is labour intensive, time consuming, leads to breakages, and physical loss through scattering.

Trampling using tractor or roller

- Using tractor or roller to trample on the beans.
- This can cause breakage of beans



Manual Threshing



Trampling using a tractor or roller

Minimize the damage done to grain during threshing as damaged grain is much more prone to attack by insects and fungi and less desirable for market.

Consequently, threshing techniques that crush and damage grains such as beating with sticks or trampling by cattle or tractor, are not recommended.

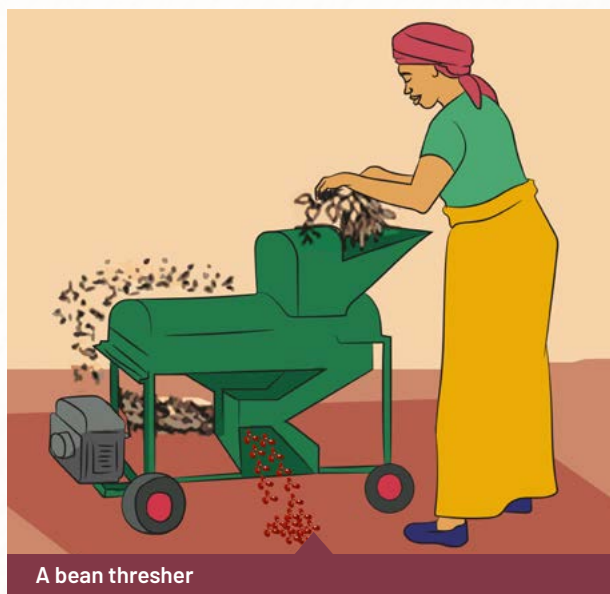
Innovative threshing methods need to be used that reduce drudgery, reduce losses and ensure high quality grain for the market.

Threshing rack

- Thresh the beans by beating the crop placed on a threshing platform that has high sides that prevent the loss of grain by scattering. Using manual threshing is slow and tedious

Bean Threshers

- You can also use a calibrated mechanical thresher.
- Use of threshers is faster, labour saving and improves quality of grain
- Some thresher models will also clean the threshed grain using shaking screens and/or blower fans



A bean thresher

6.

Cleaning and Winnowing:

Cleaning grain can substantially improve its quality and hence its grade and price. Cleaning involves the removal of foreign matter such as stones, plant material from harvesting such as husks, pods etc and broken grain and dust produced during threshing. At the same time it is possible to remove insect damaged and mouldy grains by hand picking.

a. Winnowing

Cleaning is often done manually by winnowing. This involves tossing the grain into the wind which carries off the lightest impurities, while the heavier grain falls onto a mat. However, this does not separate the heavier impurities.



Winnowing beans

NB:

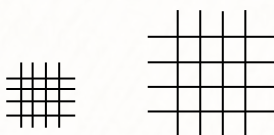
Some threshers have capacity to winnow beans thus saving on time and labour.

b. Cleaning sieve

For this method, the grain is retained on the sieve and smaller heavier impurities fall through it. Such a sieve can be either single or double handed. The double handed sieve can be operated by two people, who rock it back and forth.

The mesh sizes of sieves varies according to the size of the grain being cleaned but typically for beans a 4.5mm mesh is used. Specific sieve sizes can also be used to achieve certain grades of beans.

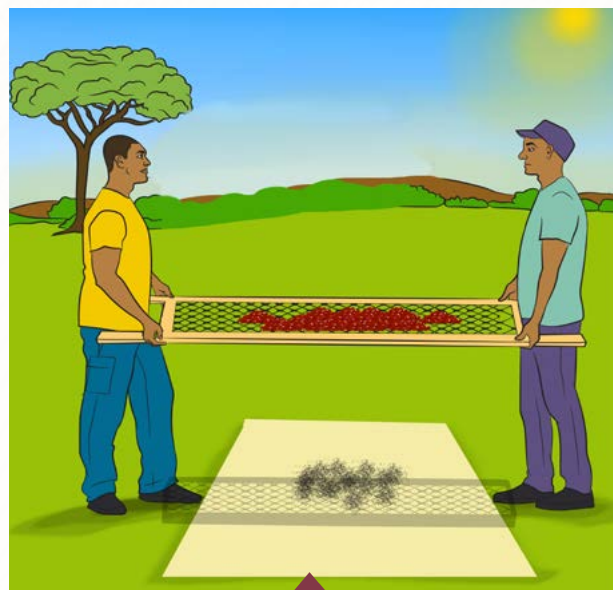
- Winnow/Sieve grain to remove any impurities: chaff, dust, stones, broken grain and other foreign materials from the grain before sales, storage or consumption
- Use threshers with blowing capability to winnow or a sieving rack
- Where manual winnowing is involved, ensure safety by carrying only manageable weights.



A 2 mm mesh and a 4.5 mm mesh



Winnowing the grain to remove light foreign material



Using a two-handed sieve to remove broken grain and foreign matter

7.

Sorting:

- Hand sort to remove damaged, broken, diseased, discolored, mouldy grain, insects and grains of other varieties
- Separate good quality grain from bad quality grain in order to improve grain quality and price
- Use the raised rack for personal safety and comfort

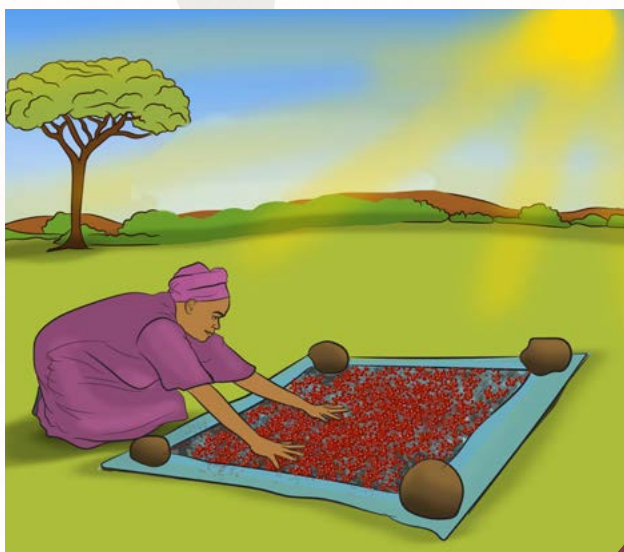


Sorting beans on a raised rack

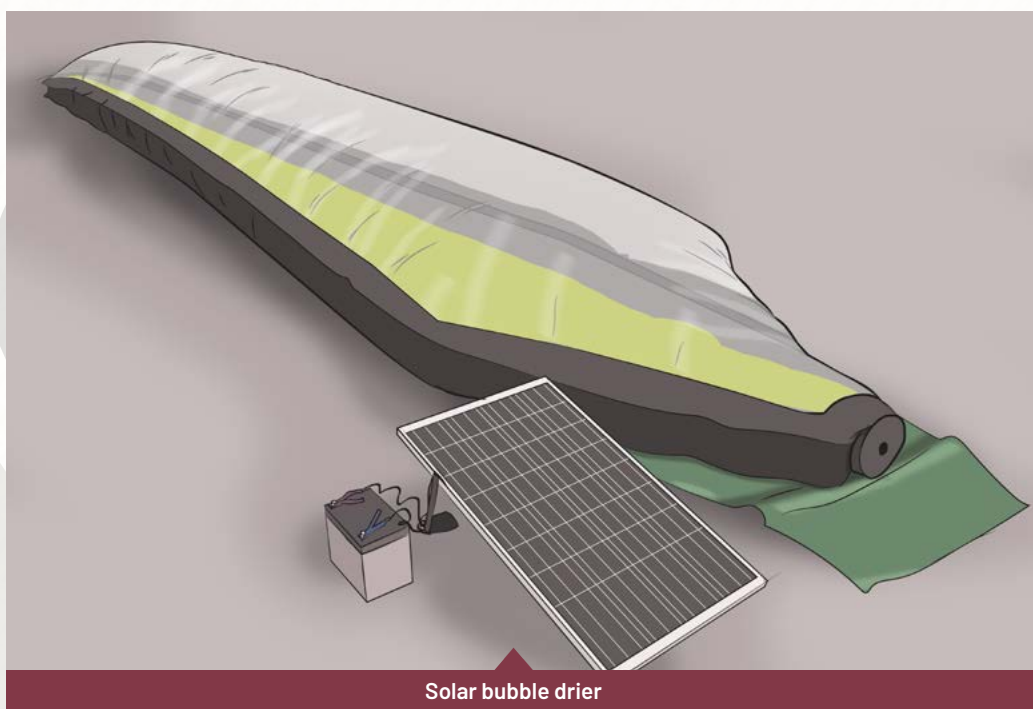
8.

Drying:

- Spread the beans on a mat, tarpaulin or concrete floor to dry
- Dry the grain in the sun. You may also use a solar driers
- Keep turning the grain to ensure that all the beans dry uniformly.
- Dry the beans to the recommended moisture content of 13% for pulses



Beans on tarpaulin under the sun



Solar Bubble Drier (SBD)

- The Solar Bubble Drier (SBD) is a low-cost drying technology that aims to provide a simple and flexible alternative to sun drying.
- The SBD is a tunnel-type dryer made of transparent paper designed to dry agricultural commodities while protecting them against sudden rains and unpredictable weather.
- The drier uses solar energy.
- The heated air in the bubble evaporates moisture content in grain.
- Using this solution, grain can be dried in 6-8 hours at a moisture content of 22% to 14%.
- The grain is protected from rain and can be dried even during cloudy days, it uses green or natural energy from the sun and does not produce smoke.
- It saves labour used to cover grain when rain suddenly comes.
- The SBD improves the traditional sun-drying process and eliminates all losses due to spillage, animals, the weather, and vehicles running over the grains.
- Compared to a mechanical dryer, the SBD is more flexible, requires lower investment, and does not need fuel for heating the air or for running the blower.
- The SBD is mobile and completely independent of fuel or the power grid, and is therefore very cheap to operate.
- It comes in different sizes, with current models having a 0.5- or 1-ton batch capacity.
- The SDB is a climate smart technology.

Checking for moisture content

Grain should be stored when properly dry. It is recommended that beans be dried and stored at a moisture content of 13% or lower.

Inaccurate but inexpensive methods

Onfarm methods for testing moisture content where farmers do not have access to a moisture meter include:

- Grain hardness
- The biting or pinching method. Dry grain will crack and split. Grain not dry will be soft and gummy.
- By the different sound the grain makes when pouring or rattling it

NB:

These methods are subjective and ineffective if the farmer is not experienced



Moisture determination by the biting test

Salt and bottle method to determine moisture content in beans

Dry salt will absorb moisture from grain. This principle can be used to help determine whether a grain sample has a moisture content of above or below 15%. This method is more objective than the biting, pinching and testing for noise

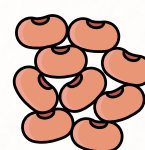
Materials required



- A clean dry glass bottle of about 750ml capacity, with a cap that makes it airtight



- Some common salt

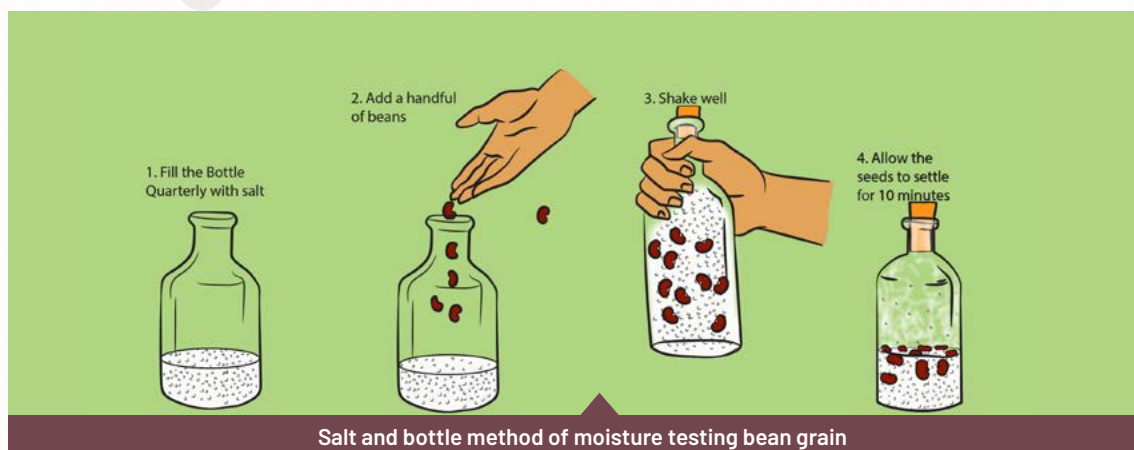


- The grain to be stored



How to do it

1. It is important to make sure the salt is dry. Place the salt in hot sun in a thin layer on some plastic sheeting, until the salt is hard at least 3 or 4 hours. Turn the salt at intervals during this time. Alternatively, you can use an oven to dry the salt. Store the dry salt in a sealed container.
2. Fill one third of the dry bottle with the grain sample (250g to 300g).
3. Add 2 or 3 tablespoons of salt (20g or 30g).
4. Close the bottle tightly with its cap.
5. Shake the bottle vigorously for 1 minute.
6. Leave the bottle to rest for 15 minutes.



Salt and bottle method of moisture testing bean grain

How do we know the grain is dry?

- If after 15 minutes the salt sticks to the side of the bottle then the moisture content of the grain is above about 13-15% and so is not safe for storage.
- Continue drying the grain and repeat the salt test
- If the salt does not stick to the bottle then the moisture content is below 15% and so the grain is safe for storage.

Accurate but more expensive methods

a. Moisture meters and probes

- The moisture meter is a scientific measure of grain moisture.
- It is more accurate compared to the salt and biting methods
- Moisture meters are quick, portable, simple to use and relatively accurate.
- They are often used for routine moisture measurement in grain at the grain offtaking stores.



Note:

All moisture meters must be calibrated before use.

b. Oven moisture determination

This is the most accurate method and all other methods are calibrated against this. A sample is weighed and then heated in the oven for between 2 and 16 hours and the loss in weight measured. This is more accurate. It is expensive as it requires an oven.

9.

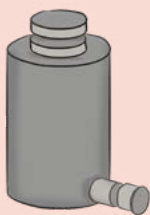
Bagging and packaging

Once grain is sufficiently dry and cleaned it should be put in storage. Grain may be stored on farm for different length of time as follows:

- Short term (e.g. <3 months)- before it is moved to the next link in the market chain e.g collection point of the Farmer Organization or Cereal Board or School
- Medium to long term (3-12 months)- where farmers keep grain for household consumption or for sale at a time when the process are more favorable

There are many options available to farmers for storing their grain and protect it against pest attack.

Storage types for safe storage of grain by smallholder households

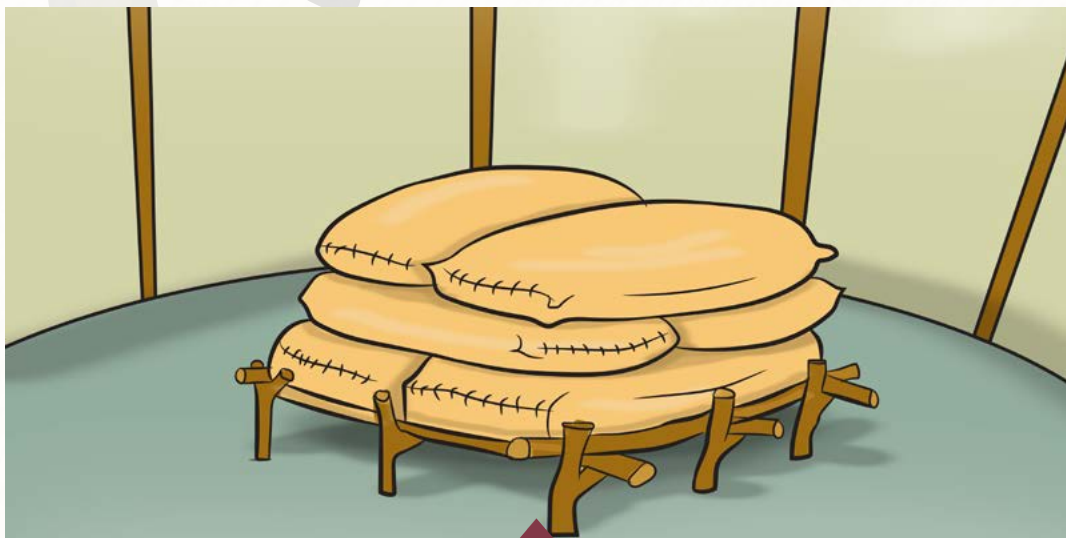
	Storage type	Storage period	Pest control	Weaknesses	Lifespan
Unprotected	Open weave sacks (Jute, sisal, polypropylene bags) 	0-6 months	If >3 months storage then admix insecticide	If used >6 months, grain quality declines than in tother store types	3 years
	Improved mud silos 	3- 12 months	If >3 months storage then admix insecticide	- Shorter life than metallic silo - Very heavy so can not be moved to new location - Takes up fixed space in the house whether full or empty	5 years
Insect Proof	Metallic silos 	3- 12 months	- Make hermitic then use lighted candle Or - Admix insecticide/ grain preservative	Extra sealing needed to make it hermitic, then no access for 2 weeks	15 years

	Storage type	Storage period	Pest control	Weaknesses	Lifespan
Insect Proof	Polythene bags (1 liner + sack) 	3- 12 months	- Solarization if grain is not for seed Or - Admix insecticide/ grain preservative	- Best for small quantities - Susceptible to sharp objects and rodent attack	2 years
	Metallic /plastic drums 	3- 12 months	Hermitic seal kills insects	Drum to be nearly full and no access for first 6 weeks of storage	20 years
Insect proof and hermetic	Tripple bags (2 liner + 1 sack) 	3- 12 months	Hermitic seal kills insects	- Susceptible to sharp objects and rodent attack - No access for the first 6 weeks of storage	3 years
	Super grain (1 liner + 1 sack) bags 			- Susceptible to sharp objects and rodent attack - No access for the first 6	2 years

a. Storage in open weave sacks

For marketing or keeping grain on farm for periods of three months or less, open weave sacks are the most convenient option.

- Sacks may be made of polypropylene, jute or sisal.
- Typically, 50kg bags are favoured since these are more easily handled than say 100kg bags; most 50kg bags are made of open weave polypropylene.
- If second-hand bags are to be used then they must be thoroughly cleaned before use, this is most easily done by plunging them in boiling water and then allowing them to dry, before filling with grain.
- The bags should not be overfilled with grain, after filling they should be closed by hand stitching or by using a stitching machine.
- Before stitching, fold the mouth of the bag inwards by 5 to 10 cm, this creates a valve that helps to prevent grain being forced out of sacks when they are piled on top of each other.
- Before delivery to the Collection Point, the sacks of grain should be kept in a secure location, such as in the house.
- The sacks must be prevented from making contact with the floor or walls of the house, from which they might absorb moisture, causing the grain to rot.
- Place the bags on pallets made of sticks and/or stones so they are suspended at least 12 cm above the floor (if no pallets can be constructed then a plastic sheet could be used) and away from contact with the wall.
- If bean grain are stored in open-weave sacks for periods exceeding 3 months, then there is a danger that insect infestation may cause significant damage
- To avoid such damage, beans that are to be stored for more than 3 months should be admixed with a suitable insecticidal dust at the manufacture's recommended dosage rate



Sacks in a house placed on a pallet made of sticks, with good clearance from the walls



Making a heap of grain to which the insecticidal preservative dust is added



Shovel the grain between two places until the dust is evenly mixed into the grain

b. Insect-proof and hermetic stores

Besides open-weave sacks there are a variety of other store types that can be used to keep grain in the house. The efficient types are insect-proof and, even better, they may shut so tightly that they are also airtight (hermetic).

Insect proof - means that the store shuts tightly enough that insects can't enter.

Hermetic - means that the store shuts so tightly that neither insects nor air can enter.

When hermetic stores are filled with grain and closed, the oxygen in the store is gradually depleted and the concentration of carbon dioxide increases. This happens due to the biological activity of the grain and any insect pests that are present will be killed. This is very convenient since pest control can be achieved without the use of insecticides that might otherwise have to be purchased.

Some insect proof or hermetic stores are made of metal. If these make contact with the ground then the moisture from the ground may result in corrosion. It is therefore important to raise them up from the ground by placing them on palleting



Insect-proof and hermetic stores should be raised off the ground and placed inside a shelter so they are completely shaded from the sun.

● Metal silos

Metal silos are insect-proof but can be made hermetic by tying rubber from a bicycle inner tube very tightly around the grain input and output ports.

In order to have a quick change in gas composition, a light candle may be placed on the grain surface at the time the inlet and outlet ports are sealed. The candle will burn the oxygen and in so doing create carbon dioxide, this will extinguish the candle and within two weeks will kill any insects that are present. Do not open the silos until after two weeks as this will let in fresh air and the insects will survive.

Alternatively, sealed metal silos can be fumigated with phosphine gas (generated from aluminium phosphide tablets) but this may not be a practical option as in many countries farmers are prohibited from purchasing and using the tablets or simply do not have access to them.



● Single layer polythene sacks

Polythene sacks (continuous sheet not open weave) can be used to store grain that is at a safe moisture content. The bag should be tightly shut by twisting then folding over the mouth of the bag and tying it shut with string. This will prevent the entry of insects (so this store is insect-proof) but a single layer polythene bag is still fairly permeable to the gases in air, so they are not hermetic. This means that when the bag is shut the gas composition does not change sufficiently to kill any insects that may be present.

To prevent insect infestation in the single layer polythene sack then grain may be solarised before storage alternatively insecticidal dust may be admixed

Polythene bags are not very strong and holes may be made in them by sharp object or by rodents. To give them further protection it is best to place them in an open weave polypropylene bag, that way there will be two layers of protection. This will involve extra expense but this will be repaid by the long life of the bag and reduced failure rate.

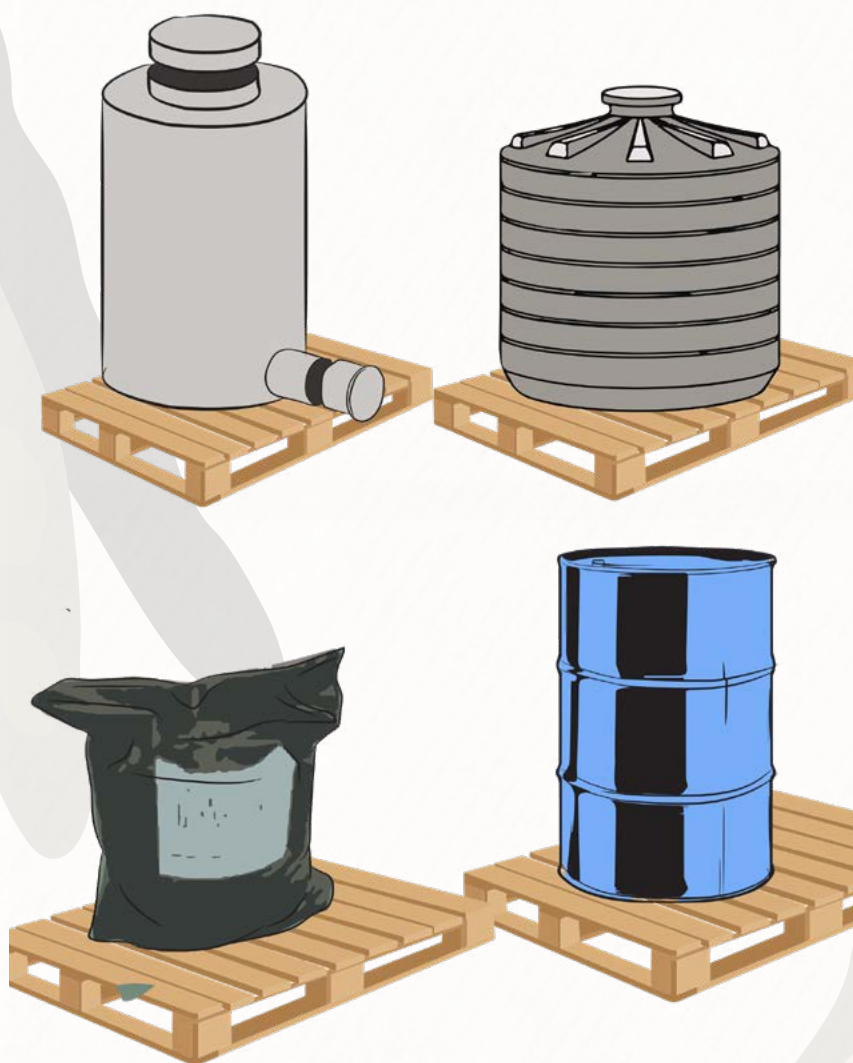
● Hermetic plastic bags

Some plastic bags are hermetic, these are the 'triple bags' and 'Superbags'. Hermetic plastic bags are recommended for grains stored for not less than 6 weeks

The grain should be at most 13% moisture content when entering storage.

● Metal and plastic drums

Plastic and metal drums that close so tightly that they are hermetic, make very good stores. These need to be more or less completely filled with clean dry grain, to displace as much air as possible before closure. The drums are then kept tightly shut for at least six weeks. During this time the oxygen will be depleted and the carbon dioxide rises so that any insects present will be killed. If old oil drums are to be used then they must be thoroughly cleaned.



Different kinds of hermetic storage containers available for use by small holder farmers

Triple bagging

The triple bagging is widely used for the storage of cowpea, but could be used for other pulses and cereals. The bags should remain sealed for at least six weeks after they are filled and after opening they should be resealed quickly to prevent entry of pests.

- Hermetic bags may come with single or double layers of air-tight polyethylene liners placed inside an outer sack. The outer sack is only to enable ease of handling and help protect against damage.
- Triple bagging is easily adopted by farmers, provides a very high level of insect control
- The bags may be used for as long as 3 years before they become too damaged and so need to be replaced

Example of hermetic storage bags



Hermetic bags with single (left) and double (right) layers of air-tight polyethylene liners placed inside an outer sack. The outer sack is only to enable ease of handling.



How to use the hermetic storage bags:

1. Separate the three bags. Check the integrity of the two inner liners for holes and tears. Assess whether the bottom of both liners are well sealed. Don't use PICS bags with holes; they will be less effective.
2. Pour a small amount of grain into the first liner to allow it to be more easily inserted into the second liner; then put both liners into the woven sack. Fold the lips of the three bags together - from inside out.
3. Fill the inner bag with grain while shaking gently to eliminate pockets of air. Make sure no grain gets between the liners. Ensure a lip remains at the top for tying. Pack the grain tightly to remove air.
4. Tie the linings starting from the inner one to the outer woven sack:



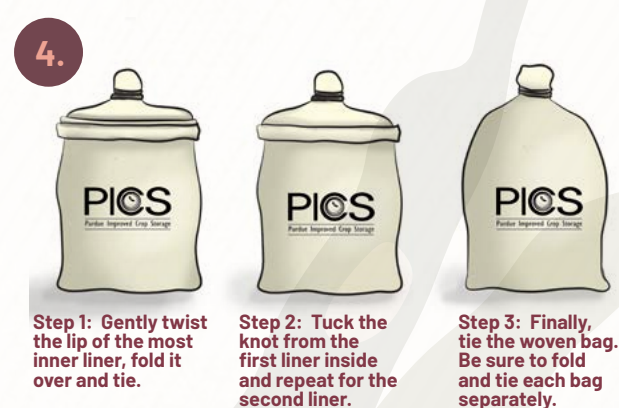
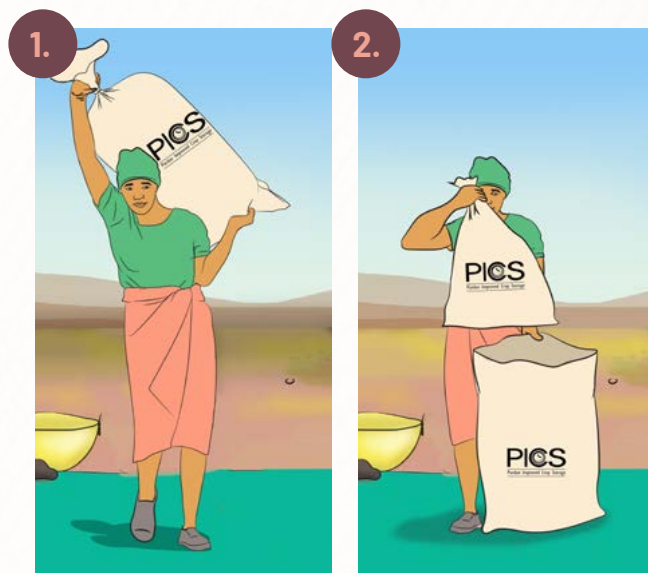
Remember:

- Store the hermetic bags away from sunlight or extreme heat. Exposing bags to sunlight for long periods of time may damage the woven bag and reduce its durability/usefulness.
- Store hermetic bags on an elevated platform and away from walls to facilitate inspection and minimize rodent attacks.
- Inspect hermetic bags at least once a month.
- Keep the hermetic bag sealed at all times during grain storage. If grain must be removed for home use or sale, ensure that excess air is pressed out and the bag is resealed.

● Superbags

Hermetic sacks (e.g. GrainPro Superbags) are made of a multi-layer polythene material that incorporates a gas barrier that restricts oxygen and water vapour movement.

- These hermetic sacks are made in a variety of sizes that can hold 50kg to 3 tonnes of grain/seed.



- Farmers can place the 50kg Superbag in an open weave polypropylene or jute bag to give it some protection and so extend its life.
- Studies have demonstrated that farmers are able to maintain seed germination viability for a much longer periods, control grain pests without using chemicals and maintain grain quality for a longer period using Superbags

c. Moving the grain to the collection point

The grain will need to be moved from the homestead to the Collection Point or Cereals Board. This can be by hired motorised transport, by bicycle, pack animal, cart, barrow or even headload. Ensure that carts and sacks are clean before loading your grain into them otherwise it might become infested.



6.

GRAIN STORE MANAGEMENT

Farmers store their grain in a Collection Point or warehouse prior to delivery to a customer. The grain collection point provides the first official check on grain quality. The farmer organization must set the minimum grade at which grain will be accepted. When grain has been accepted then the staff must be able to look after it so that there is no deterioration in quality before delivery to the buyer. This process of receiving and managing grain is what we call **grain store management**.

The Collection Point should be staffed by people who can practice good grain management and are trusted. It is important that they are able to:

- Check that the quality of grain entering the store is of at least the minimum acceptable grade.
- Weigh and record the number of bags of grain entering or leaving the store.
- If necessary, condition and rebag grain to meet buyer requirements.
- Maintain the store and its contents so that the grain is secure from quality decline and theft.

Main features of the Collection Point

The collection point should be accessible by road for most of the year and that the store has:

- a roof that does not leak.
- a smooth concrete floor that preferably has a damp-proof membrane and is free of cracks
- doors that are large enough to allow easy access for moving bags in and out (preferably metal double sliding doors)
- close fitting doors enough to prevent rodent access
- Store should be secure and lockable to keep away thieves
- Ventilators at the eaves that can be opened and closed easily, fitted on the outside with anti-bird grills
- No vegetation close to the exterior in which rodents and insects can hide, nor have any nearby trees which rodents can jump from and then enter the store via roof eaves etc.

Essential items and equipment of a Collection Point

The store must be provided with certain essential items and equipment, these include:

- Pallets on which bag stacks are to be built
- A set of well calibrated weighing scales to weigh grain in and out
- A sampling spear to check grain quality
- Brooms used to keep the store clean

- Tarpaulins that can be used to cover bag stacks to prevent insect infestation moving from one stack to another and as a base on which to do grain conditioning operations
- Spare sacks to replace any that are torn and to contain spilt grain that has been swept up from the floor
- Ledgers to record the movement of grain in and out of the store
- Moisture meter to check moisture content
- A torch for the inspection of dark areas in the store.
- Wall posters clearly showing the acceptable quality criteria for grain

Preparation for receiving grain in store

i. Remove all the old harvest from the store

Before the new harvest arrives in store it is best to ensure that all the old harvest has been removed or sold. If it cannot be removed then it would be helpful to isolate it from the new harvest by covering with a tarpaulin. This will help reduce the movement of insects from old infested grain to the new grain.

ii. Sweep the store thoroughly

The store should then be thoroughly swept, to remove all grain residues from the floor, any cracks and crevices, or sliding door runners. The grain residues should be taken out of the store and burnt or fed to animals.

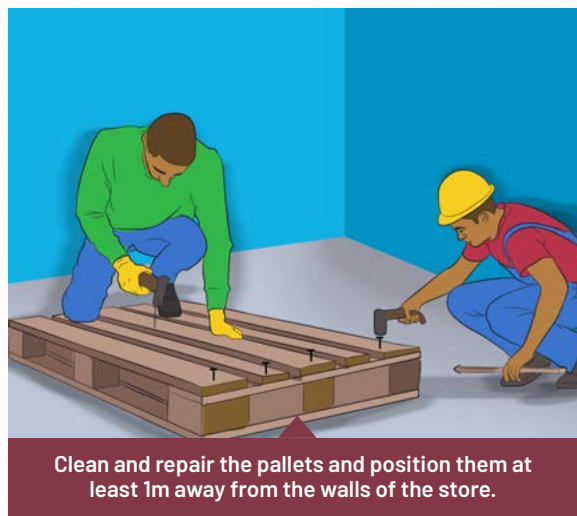
iii. Make sure the floor is in good condition

The floor should be thoroughly inspected for cracks and if any are found they should be filled with cement. Cracks in walls should also be filled



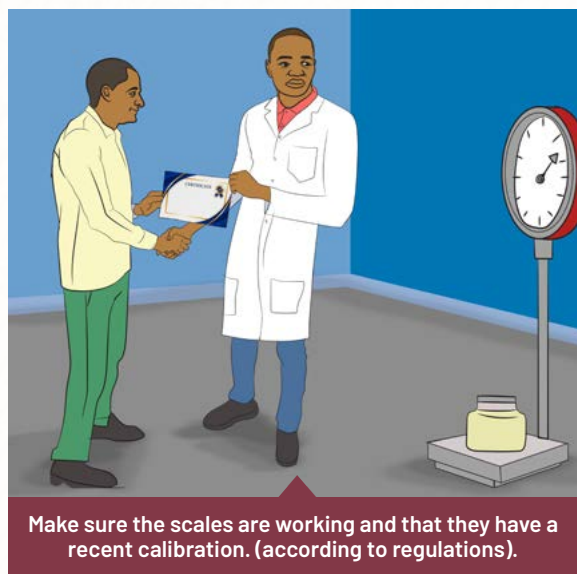
iv. Lay out the pallets and make sure they are in good order

Once the store is clean the pallets should be laid out to receive the incoming crop, with a gap of 1m from the store walls. The pallets should be brushed clean to remove any old grain or grain dust. They should be checked for any protruding nails, which might tear grain sacks, any nails should be removed or hammered in.



v. Get the weighing scales ready for use

In order to weigh the incoming crop it is important that the weighing scales have had their calibration checked. This needs to be done by the appropriate authority (usually the Bureau of Standards) and at the frequency specified by them (usually every year). It is also advisable to have a test weight kept in the store to check the accuracy of scales every day.



Inspecting grain for quality and weight at entry into store

i. Reference sample of quality grain

- To help farmers understand the quality of grain required at the Collection Point, a sample of grain at the minimum grade acceptable to the farmer organization should be available in a transparent plastic bag. This will be shown to those farmers who wish to deposit their grain.
- Beyond quality, also check the type of bean variety. This is critical to ensure no mixing and storing similar varieties in their batches and sections



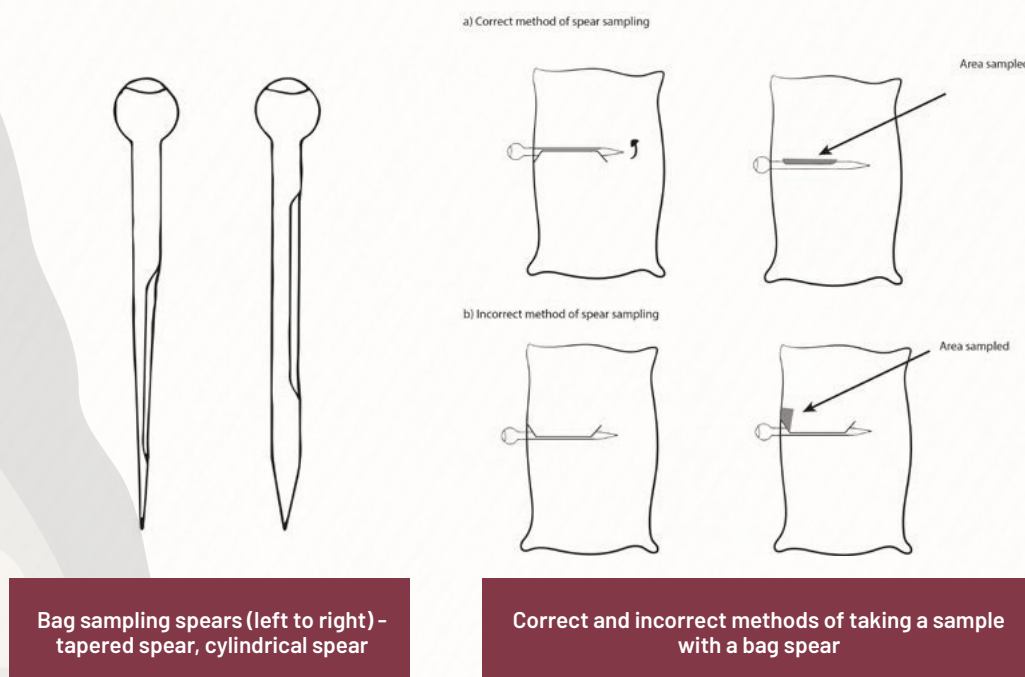
Farmers must be informed of the required grain quality.

ii. Weigh and record the grain

- The weighing scales should be positioned at the store entrance or just outside the store in a covered area

iii. Sample the grain for quality assessment

- Each sack arriving should be placed on the scale and its weight recorded.
- Collect a sample of the grain using a sampling spear – take 25g from 50kg bags or 50g from 100kg bags.
- Samples should be taken at random from anywhere in the sack. A tapered grain sampling spear should be used to take a sample from bags of grain.

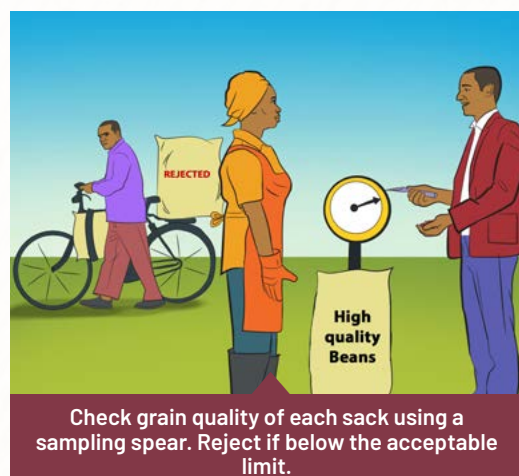


Caution!

The sampling spear should not be used on hermetic triple bags as this will perforate and damage them. For grain in hermetic bags, pour out the grain and inspect for quality then repack the grain.

iv. Assess for quality and moisture content

- Each sample should be examined by a store manager with experience in judging the required grain quality, moisture content and variety type.
 - The sample should be compared to a standard sample supplied in a clear plastic container for comparison purposes.
 - Recommend correction measure if grain does not meet quality standards
- v. Any sack of grain that does not meet the required grade or is too moist should be rejected and the samples taken returned to the farmer or discarded.
- vi. For each farmer the number and weight of bags accepted must be recorded against their own name in the official ledger.



Grain Collection Card			
Stack Number			
Commodity/Type:			
Harvest Date:			
	Intake		
Date	Reference Number/ Farmer name	Bags In	Weight In

How to place grain in the bag store

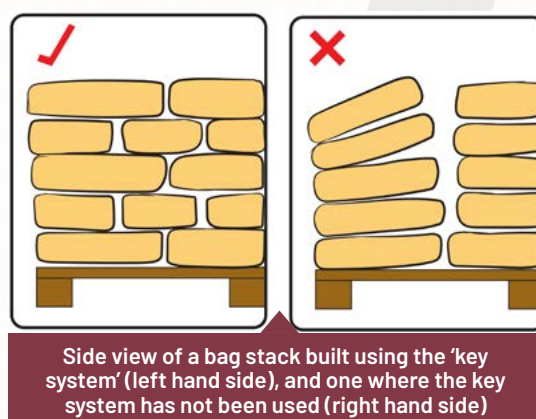
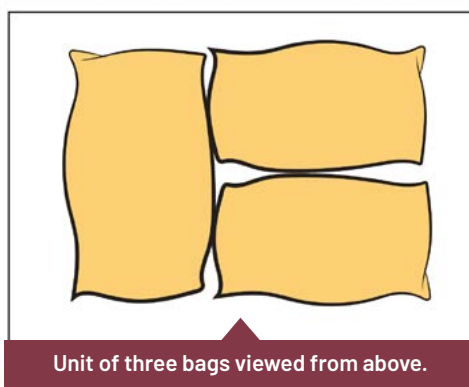
The sacks entering the store should be placed on pallets. Make sure the pallets are clean, level and have no protruding nails.



Arranging the sacks on the pallets

Build the bags into a stack on the pallets using a key system, with units of three bags.

Side view of a bag stack built using the 'key system' (left hand side), and one where the key system has not been used (right hand side)



Record keeping of bags in the store

- Each bag stack in a store should have its own stock card.
- Each time bags of grain are added or removed from this bag stack then this should be recorded and the new balance of weight of grain and number of bags adjusted.
- The stock card should be positioned prominently, ideally at eye level, on each stack

Warehouse Stock Card						
Stack Number						
Commodity/Type:						
Harvest Date:						
	Intake		Discharge		Stock Balance	
Date	Bags In	Weight In	Bags Out	Weight Out	Bags	Weight

Stock card to record grain movement

Importance of stock cards recording:

- Stock cards is a record for tracking the stock of grain in the warehouse
- Stock cards provide the opportunity to record any information relevant to the particular stack, for example, dates and details of pest control, any problems with packaging, roof leaks, etc.
- A good documentation system will provide a brief, reliable account of all that takes place in the store insofar as it may affect the age, quality and quantity of the goods stored
- Adequate documentation and regular physical audits provides protection against fraud and theft.



Cleaning and sorting grain that is below quality

Some grain delivered to the collection point can be sorted to improve its quality. This can be done manually or mechanically.

a. Manual cleaning of grain

Manual cleaning of grain can be done by passing the grain over an inclined sieve. A sack of grain is emptied onto the sieve. The grain is then moved across the sieve by hand so that broken grain and dust fall through it and collect in a container below the sieve. The grain retained by the sieve can be handpicked to remove discoloured, rotten and diseased grain. The grain is gradually pushed down the sieve into the sack that is suspended at the lower end.

b. Mechanical grain cleaners

Mechanical grain cleaners are available that can clean up to 20 grain ton/h.

- Sieving: This removes impurities such as sand stones, plant residues, and also grades the beans by size
- Colour sorters: This sorts the beans by colour
- Destoners: This removes stones

NB:

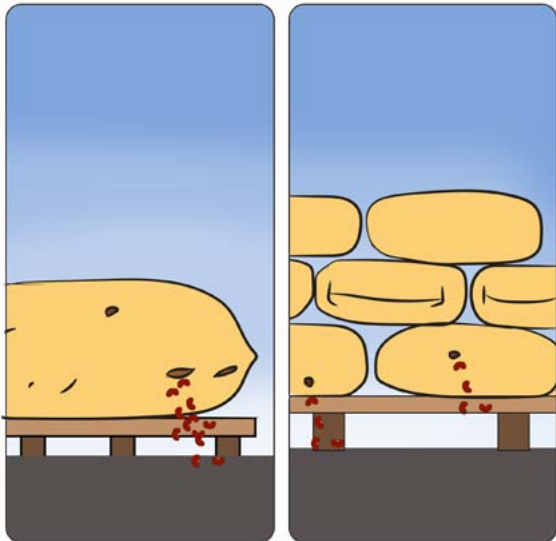
Sorting can be expensive, laborious and lead to huge losses. It is much better that farmers sort their beans before delivering them to the collection point.



Routine inspection of the grain in the store

It is important to regularly inspect the inside of the store.

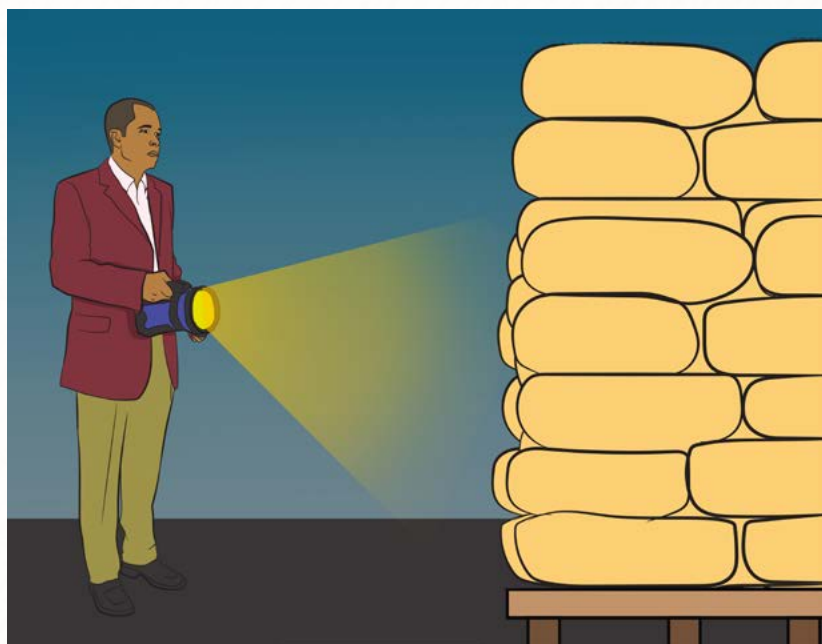
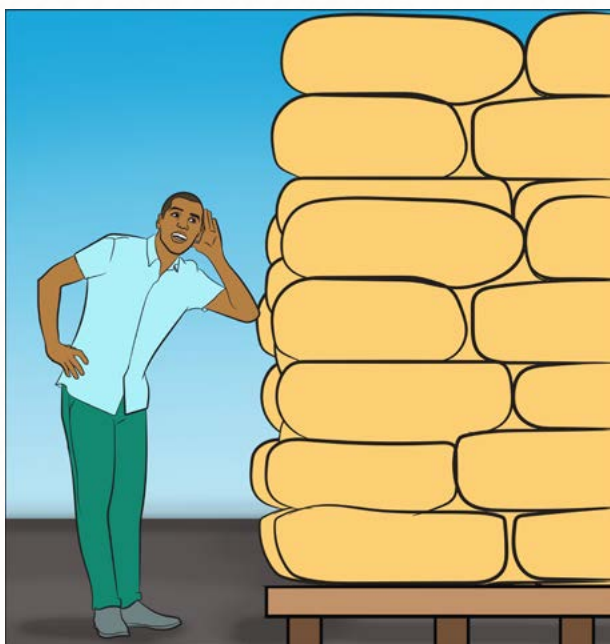
- At the start of each day check the store for signs of water leakage, check the floor and tops of bag stacks for signs of damage (rodent or insect) e.g. grains under or around pallets



- Check for holes in the bags that need to be repaired

- Check for insects in the store, inspect for moving insects in the late afternoon (16.00h), check the 'ears' of bags and crevices between bags, listen for the sounds of insects eating grain, and use a torch to inspect the dark areas of the store.





7.

BEAN GRAIN QUALITY STANDARDS

In a formal grain market, cereals and grain pulses are bought and sold according to specific quality grades; these are usually determined by national or regional authorities. When seeking to purchase grain, a buyer will usually specify a particular quality grade in order to meet a particular end-use. For example, this could be for international export or food aid where high quality grain is required, for local consumption where reasonable but not such high quality is demanded, or for animal feed that requires only relatively low quality.

When talking about commodity quality grades, people also refer to '**commodity standards**'.

A standard is a set of one or more quality grades that are enforced, usually by law.

The East Africa Community (EAC) has developed standards to harmonize trade and ensure trade in quality beans. These standards have been enacted by the member countries.

Adhering to good postharvest management will enable farmers to meet the highest standards. This is beneficial as farmer will be able to tap on diverse markets and earn higher income from their produce.

Bean grading

Dry beans are graded into three grades (**Grade 1, Grade 2 and Grade 3**)

Bean Grades

Specific requirements				
Characteristics	Maximum limits			Method of test
	Grade 1	Grade 2	Grade 3	
Foreign matter, % m/m	0.5	0.75	1	ISO 605
Inorganic matter, % m/m	0.1	0.2	0.3	
Other edible grains, % m/m	0.1	0.2	0.5	
Pest damaged grains, % m/m	1	2	3	
Heat Damaged grains, % m/m	0.1	0.2	0.5	
Contrasting varieties %m/m	0.5	1	1.5	
Broken/split % m/m	1	2	3	
Discoloured %m/m	1	1	1	
Total Defectives Grains, % m/m	2	3.5	5.5	
Filth, % m/m	0.1	0.1	0.1	
Moisture, % m/m	13.0	13.0	13.0	ISO 24557
Total Aflatoxin (AFB1+AFB2+AFG1+AFG2), ppb max	10			ISO 16050
Aflatoxin B1 only, ppb max	5			
Fumonisin ppm max	2			

Ungraded dry beans are dry beans which do not fall within the requirements of Grades 1, 2, and 3 of this standard but are not rejected dry beans.

Reject grade dry beans are beans which are musty, sour, heating, materially weathered, or weevily; which have any commercially objectionable odour; which contain insect webbing or filth, animal filth, any unknown foreign substance, broken glass, or metal fragments; or which are otherwise of distinctly low quality. Rejected grade is regarded as unfit for human or animal consumption.

Beans are required to be free from microorganisms (Yeasts and moulds, *Salmonella aureus*, *E. coli*, *Salmonella*) in amounts which may represent a hazard to health.

The beans should also be within the maximum limits for heavy metals, pesticide residue and mycotoxins contamination.

Microbial, heavy metals, pesticides and mycotoxins contaminations are determined through laboratory testing.

7.

GENDER INCLUSION AND POST HARVEST MANAGEMENT OF BEANS



Both men and women participate in bean seeding and weeding, but more responsibility in post-harvest activities, including harvesting, threshing, drying, sorting and winnowing is taken over by women. These activities are labour intensive and time consuming. The practices can cause health issues due to prolonged bending and lifting heavy loads.

Post harvest management practices for beans should therefore be gender sensitive in order to reduce drudgery, ensure safe and compensate investments made by men, women and youth in an equitable manner.

Opportunities for making the post-harvest gender sensitive are summarized in the table.

Stage	Concern	Gender sensitive consideration
Capacity strengthening along the bean value chain	- Timing of trainings - Exclusion of women, youth and other marginalized groups in trainings	- Deliberate targeting of women and youth in the bean capacity strengthening initiatives - Proper scheduling of trainings to fit women work - Involvement and dialogues with men, women and youth in gender sensitive post-harvest trainings
Pre-harvest	Drudgery during planting, weeding, pest and disease management	- Friendly working hours - Use mechanized planters, weeders, sprayers where available - Ensure use of personal safety gears during operations e.g. spraying
Harvesting	- Prolonged bending during harvesting - Long working hours during harvesting - Harsh climatic conditions	- Provide child care support (creche) for breast feeding mothers - Provide for rest time breaks during harvesting - Use mechanized harvesting where available - Use protective hats and long-sleeved shirts/overalls to minimize sun burns
Transportation	Carrying heavy loads of harvested beans	Use appropriate equipment eg wheel burrows, forklifts, oxcarts or tractors to move heavy loads
Processing and Packing	- Manual threshing with sticks - Drudgery during winnowing - Prolonged bending during sorting - Carrying heavy loads of processed beans - Manual loading and offloading - Disrupted childcare	- Use mechanized threshers - Use protective dust masks where needed - Use threshing and sorting racks - Use solar bubble driers - Adherence to standard bagging weights of 50kg - Use of moving and loading equipment - Provision of childcare support (creches)
Marketing	Dispossession of women of income	- Support women and youth led enterprises along the bean value chain - Digital inclusion to enable youth and women engage in bean value chain

Reflective Questions

What do you understand as the meaning of post-harvest loss?

Why do we need to reduce post-harvest losses in beans?

At what stage of the bean value chain do you experience highest post-harvest losses?

Which are the main post harvest losses you experience on your farm, store, household or business?

How do you control the post-harvest losses for beans?

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We would like to thank all funders who support this research through their contributions to the CGIAR Trust Fund. www.cgiar.org/funders.

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