Appropriate Seed and Grain Storage Systems for Small-scale Farmers

KEY PRACTICES
for DRR Implementers

Humanitarian Aid
and Civil Protection

Appropriate Seed and Grain Storage Systems for Small-scale Farmers: Key Practices for DRR Implementers

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This brief is part of the series, *A Field Guide for Disaster Risk Reduction in Southern Africa: Key Practices for DRR Implementers*, coordinated by the FAO Subregional Office for Disaster Risk Reduction/Management for Southern Africa. This series has been produced with contributions from COOPI, FAO, OCHA and UN-Habitat, and comprises the following technical briefs:

- Information and Knowledge Management (COOPI)
- Mobile Health Technology (COOPI)
- Safe Hospitals (COOPI)
- Disaster Risk Reduction for Food and Nutrition Security (FAO)
- Appropriate Seed Varieties for Small-scale Farmers (FAO)
- Appropriate Seed and Grain Storage Systems for Small-scale Farmers (FAO)
- Farmer Field Schools (FAO)
- Irrigation Techniques for Small-scale Farmers (FAO)
- Management of Crop Diversity (FAO)
- Community-based Early Warning Systems (OCHA and FAO)
- Disaster Risk Reduction Architecture (UN-Habitat)

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Humanitarian Aid and Civil Protection

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Foreword by ECHO

The southern Africa and Indian Ocean region is extremely vulnerable to cyclones, floods, droughts and tropical storms. These recurrent climate-related shocks negatively affect the highly sensitive livelihoods and economies in the region, and erode communities' ability to fully recover, leading to increased fragility and vulnerability to subsequent disasters. The nature and pattern of weather-related disasters is shifting, becoming unpredictable, and increasing in frequency, intensity and magnitude as a result of climate change. Vulnerability in the region is further compounded by prevailing negative socio-economic factors, such as high HIV rates, extreme poverty, growing insecurity and demographic growth and trends (including intra-regional migration and increasing urbanization).

The European Commission's Office for Humanitarian Affairs (ECHO) has actively engaged in the region through the Disaster Preparedness ECHO (DIPECHO) programme since 2009, supporting multi-sectorial disaster risk reduction interventions in food security and agriculture, infrastructure and adapted architecture, information and knowledge management, water, sanitation and hygiene, and health. This programme operates with two objectives, notably:

- Emergency preparedness by building local capacities for sustainable weather-hazard preparedness and management, including seasonal preparedness plans, training, emergency stocks and rescue equipment, as well as Early Warning Systems.
- Empowering communities through multi-sectorial and multi-level approaches with DRR mainstreamed as a central component and improved food and nutrition security as an outcome.

This is done in alignment with national and regional strategies and frameworks.

For DIPECHO, one of the main measures of success is replicability. To this end, technical support through guidelines established for DRR implementers is a welcome output of the DIPECHO interventions in the region. ECHO has supported regional partners, namely COOPI, FAO, UN-Habitat and UN-OCHA, to enhance the resilience of vulnerable populations in southern Africa by providing the funding to field-test and establish good practices, and to develop a toolkit for their replication in southern Africa. It is the aim of the European Commission Office for Humanitarian Affairs and its partners to fulfil the two objectives sustainably and efficiently through the practices contained in this toolkit to ensure the increased resilience of the most vulnerable populations in the region.

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Foreword by FAO

The southern Africa region is vulnerable to a diverse array of hazards, largely linked to environmental causes (such as drought, cyclones and floods); human, animal and plant diseases and pests; economic shocks; and in some areas socio-political unrest and insecurity, among others. The region's risk profile is evolving, with new factors becoming gradually more prominent, including a trend towards increased urbanization, migration and mobility, among others. Natural hazards will be progressively more influenced by trends in climate change. Disasters in the region are often composite and recurrent, and have a dramatic impact on livelihoods and on southern African countries' economy and environment, often undermining growth and hard-won development gains.

Increasing the resilience of livelihoods to threats and crises constitutes one of the Strategic Objectives of FAO's Strategic Framework (Strategic Objective 5, or SO5). FAO specifically aims at building resilience as it relates to agriculture and food and nutrition security, which are among the sectors most severely affected by natural hazards. The impact of shocks and disasters can be mitigated and recovery can be greatly facilitated if appropriate agricultural practices are put in place; improving the capacity of communities, local authorities and other stakeholders is therefore central to resilience building.

Together with partners, FAO is undertaking intensive work in southern Africa to consolidate the resilience of hazard-prone communities; this is leading to an improved knowledge base and to documentation of good practices. This toolkit purports to disseminate improved methods and technologies on key aspects of agriculture, such as appropriate seed varieties, irrigation, storage systems, land and water use and Farmer Field Schools, in 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. For this reason, this toolkit also includes non-agricultural aspects of good resilience practices, contributed by FAO partners: the UN-OCHA, UN-HABITAT and COOPI, which certainly strengthen this collection.

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Acronyms and Abbreviations

DRR/M	disaster risk reduction/management
FAO	Food and Agriculture Organization of the United Nations
GHS	Globally Harmonized System
INPHO	Information Network on Post-harvest Operations
IPM	integrated pest management
kg	kilogram
mc	moisture content
MT	metric tonne
NGO	non-governmental organization
WHO	World Health Organization

1. Introduction

This brief provides practical guidelines on storage practices and methodologies to assist southern African farmers prone to natural hazards, mainly cyclones, droughts and floods. Indeed, suboptimal storage of agricultural products can lead to important losses resulting in increased vulnerability of these farmers in normal conditions, but the combined effect of natural disasters and poor storage practices may lead to tremendous losses for small farmers, with devastating effects both from economic and food security points of view.

The target audience for this brief includes NGO staff, extension workers, community development leaders and government officials who work in development, relief or disaster risk reduction (DRR) projects and programmes in hazard prone rural areas in southern Africa.

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. Post-harvest losses, which may be as high as 30 percent of the agricultural production, can be reduced by using simple, good post-harvest and storage practices, and this may lead to a significant improvement in small-scale farmers' food and nutrition security and can have a positive economic impact.

This brief includes a review of the main factors that cause grain and seed deterioration in storage, a description of the main storage pests in southern Africa, and some good practices to reduce the impact of storage pests that follow the principles of integrated pest management (IPM), as well as some examples of traditional and modern storage methods and facilities.

Bad storage practices or facilities may create a conducive environment for mould and pest proliferation that are responsible for significant losses at household level. However, these losses can be mitigated and reduced by appropriate post-harvest handling practices. Appropriate storage facilities also play an important role in reducing seed and grain losses when hazard events, like floods or cyclones, occur. When small-scale farmers implement these practices, they will be able 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.

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.

2. Instructions for the Implementation of Small-Scale Storage Practices

To be effective, storage management requires a supply chain approach since the crop is still in the field (preharvest) until the stored seed or grain is removed from storage for utilization. The key principles and activities to be considered in small-scale storage practices are the following:

- Physical factors that affect grain or seed in storage;
- Common storage pests (insects, rodents and termites) and mould;
- Prestorage handling;
- Integrated pest management; and
- Small-scale storage facilities.

Physical factors that affect grain in storage

The principal physical factors which interact to create a storage micro environment are the moisture content of stored grain, and the temperature, relative humidity, oxygen and carbon dioxide in the storage facility. For our purpose, the focus will be on temperature, moisture content and relative humidity, the factors that can be easily manipulated to create a suitable storage environment by small farmers.

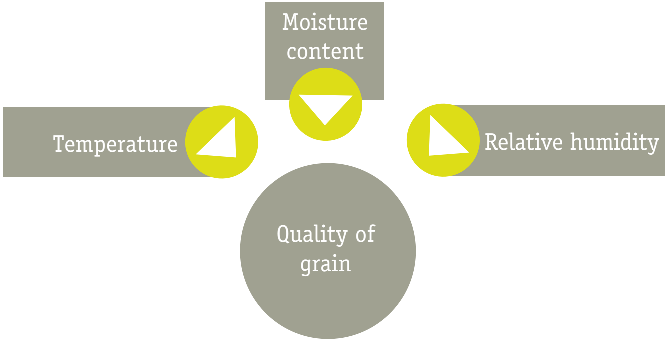

Figure 1: The three key physical factors of storage

- Temperature: Storage insects and mould thrive within an optimal temperature range: between 25 °C and 34 °C for most storage insects, and between 15 °C and 30 °C for the development of mould. Beyond this range (colder or hotter), the development of these threats to the stored products is limited, and therefore the losses as a result are negligible.
- Moisture content is described as the quantity of water bound in the grain kernels expressed as a percentage by weight of the grain or seed sample. The moisture content of dry grain ranges from 6 to 15 percent depending on the type of grain. Moisture content is a determining factor in the proliferation of mould and storage pests.

DETERMINING MOISTURE CONTENT

Moisture meters may be available for small-scale farmers at extension services or public grain storage facilities, but most often farmers will use indicative methods to find out if grain or seed are sufficiently dry, such as biting the grain with the teeth, pinching it between the fingers or shaking it. If the grain cracks and the kernels feel hard or make sharp sounds, the grain is dry enough for harvest (if still on the plant) or storage. If the grain is soft, it could mean it is still wet and needs further drying.

Another simple method is to shake a sample of grain with dry salt in a clean dry glass jar for several minutes. If the salt sticks to the sides of the glass jar, it means the grain moisture content is above the safe moisture content level. If the jar surface is clear of salt, it means the grain is dry enough to be put in storage.

- 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. If the relative humidity exceeds 65 percent, mould and storage insects can develop and stored grain and seed are susceptible to deterioration.

In a fully stocked store unit, the stored grain itself largely determines and stabilizes the temperature and humidity conditions in the store. Moisture and relative humidity are also interrelated: if grain loses moisture due to increased temperature or insufficient drying before storage, this moisture is released and goes into the air increasing the relative humidity in the storage facility. This is why it is so important that products are properly dried before been stored, especially in hot and wet/damp conditions which frequently occur in southern Africa. Each type of grain has its own equilibrium of moisture content level, above which the grain may release moisture into the surrounding air increasing the relative humidity.

In southern Africa, at temperatures above 25° C and relative humidity above 65 percent or moisture content above the safe levels listed above, storage pests and mould can thrive and damage the stored grain and seed. As a general rule, the lower the temperature, relative humidity and moisture content, the lower the risk of grain damage and seed losing its germination capacity.

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Figure 2: Suboptimal practices for drying and storage

Common storage pests

Storage insects are categorized as either primary or secondary pests. Primary insect pests are those which are capable of invading an undamaged grain and establishing an infestation, although they are also able to feed on damaged grain. Most primary pests are also able to commence their attack in the field before harvest. Secondary insect pests attack or establish themselves on grains which have already been damaged or attacked by primary storage pests.

As a general rule, high temperatures and relative humidity significantly increase the changes of insect infestation of both primary and secondary storage pests. Conditions combining temperatures between 25 °C and 34 °C and around 70 percent of relative humidity are considered at risk.

The moisture content (mc) of the stored grain is also fundamental to prevent insect infestation. Grain dried to below 12 percent moisture content inhibits the development of most species of insect pests, although a few species such as grain borers remain of considerable importance even on exceptionally dry grain (<8 percent mc).

Many other insects may occur quite commonly and sometimes abundantly on stored cereal grains, especially when they are insufficiently dried or have been heavily infested by the major pests. In this brief we will focus on the insects that create most devastating losses in southern Africa.

CONDITIONS FOR SEED STORAGE

In hot and humid conditions, the seed may quickly lose its ability to germinate; the rate of deterioration varies among crop types. Starchy seeds, for instance those of cereals like maize, generally have a slower rate of deterioration compared to those of legumes like groundnuts and soybeans, which are oily and have high protein content. The moisture content of the seed and the temperature of the building where they are stored are the most critical factors that affect the rate of deterioration. The lower the temperature and relative humidity, the longer the seeds can be safely stored.

The following table shows the minimum germination percentage and the safe storage moisture content levels for storage of seeds of the main crops produced in southern Africa, as per the FAO Quality Declared Seed Standards (revision 2006).

Crop	Germination (minimum percent)	Moisture content (maximum percent)*
Beans	60	10
Groundnut	60	10
Maize	80	13
Millet	70	13
Pigeon pea	70	10
Rice	75	13
Sorghum	70	13

* Maximum moisture content recommended for safe storage. These values may vary according to local conditions, in particular with environmental relative humidity and temperature. Local standards should be applied

Primary insect pests

The grain weevil (*Sitophilus* spp.)

Characteristics: It is one of the most dangerous pests for whole grains. It is characterised by a narrow snout (rostrum) as an extension of the head and has a tan brown to dark brown body.
Crops attacked: It attacks cereals, mainly maize, sorghum, rice and wheat. It does not attack small grains like millet as the larva cannot develop fully in small grains. It can also feed on dried cassava and processed food.
Damage: Infestation usually starts in the field, when eggs are laid in undamaged grain. After the harvest, the grain is taken to the storage facility, where the larvae chew their way out of the grain leaving a characteristic hole. Both adults and larvae cause damage, but most of it is due to the larvae.

The larger grain borer (*Prostephanus truncatus*)

Characteristics: It is a wood-boring beetle indigenous to Central America that spread in Africa during the early 1980s after accidental introductions; it has become one of the most important storage pests in tropical and subtropical regions. It is dark brown or black in colour. It breeds in dry food commodities, maize stalks, cob remnants and timber.
Crops attacked: It is a highly destructive primary pest for maize, especially maize stored on the cob. The impact has been so high in farming systems in Africa, that in several countries the storage of cobs has been discouraged and substituted by the storage of shelled maize, which is often treated. The larger grain borer may also feed on dried cassava and cereal flour.
Damage: Infestation often starts in the field before harvest and continues through storage, especially in unshelled maize. Both larvae and adults bore into the grains through neat round holes and feed on the grain producing large quantities of dust. Average losses go up to 30 percent for stored maize.

Figure 3 (left to right): Female maize weevil (*Sitophilus zeamais*), male maize weevil, larger grain borer (*Prostephanus truncatus*)

The lesser grain borer (*Rhyzopertha dominica*)

Characteristics: Originating from South America, it is now found in all warmer parts of the world. These small dark brown to black beetles are very voracious.

Crops attacked: It is a destructive pest to most stored cereal grains including millet, although not generally common in maize. It can also be found feeding on cassava and other flour products.

Damage: Infestation starts in the field and larvae are introduced in storage systems inside the grains, where larvae develop. Adults and larvae bore into grains and eat the endosperm. This process creates a lot of dust which, if present, can be used as an indicator of high infestation. They have a long life span and can destroy grain equal to their body weight daily.

The grain moth (*Sitotroga cerealella*)

Characteristics: A dangerous post-harvest insect, commonly found in grain stores of cobs in southern Africa, especially soon after harvest. Adults have strongly curved labial palps and are pale greyish brown with a wingspan of 12 to 14 mm. The caterpillars feed and pupate inside the grains.

Crops attacked: Like the lesser grain borer, it is a considerable pest for millet as well as all the larger cereal grains, including wheat, barley, maize and sorghum; it inflicts severe damage on unhusked rice paddy as well. It is able to cause substantial primary damage to the grain kernel.

Damage: Attacks ripening grain standing in the field, and is usually transported inside the grain to the storage facilities. The larvae, upon hatching, bore into a grain and complete their development entirely within a single grain. Infestations produce abundant heat and moisture that may encourage mould growth as well as secondary pests.

The cowpea weevil (*Callosobruchus maculatus*)

Characteristics: A reddish-brown beetle of the family of the dried bean beetles (*Bruchids*) that occurs in tropical and subtropical

Figure 4 (left to right): The lesser grain borer (*Rhyzopertha dominica*), the grain moth (*Sitotroga cerealella*)

Africa. Although mainly a field pest, eggs and larvae are taken to storage after harvest inside the grains, after the eggs are laid on drying pulses, and the young larvae burrow into the grain or seeds. *Crops attacked:* All pulses produced in southern Africa, such as common beans, chickpeas and cowpeas, are susceptible to *Bruchids* in general and by the cowpea weevil in particular. *Bruchids* also a considerable pest of cereal-based animal feeds, flours and high-protein milling offal.

Damage: The bean beetle commonly attacks dried pulses. The infestation may begin in the field where eggs are laid loosely on the ripening pods. The larvae stage is the primary cause of damage which can affect up to 90 percent of stored pulses. The infestation cycle must be broken in the field by crop rotation, i.e. avoiding the same crop being cultivated in the same field during consecutive seasons.

Secondary insect pests

Secondary insect pests are associated with commodities that have suffered previous physical damage caused by a primary infestation or during the milling or handling process. The most common secondary pest insects are *Tribolium* spp and *Esphestia* spp.

The red rust flour beetle (*Tribolium* spp.)

Characteristics: It is found in most tropical and subtropical regions, including southern Africa. It is a reddish-brown beetle, and larvae are yellowish-white.

Crops attacked: It attacks maize, groundnuts, rice, beans, peas, sorghum and wheat. It prefers damaged grain but will also attack intact wheat kernels.

Damage: Both the adult and larvae feed first on the germ and later on the endosperm. This pest is typically found in poor storage

Figure 5 (left and centre): The cowpea weevil (*Callosobruchus maculatus*)

Figure 6 (right): The red rust flour beetle (*Tribolium castaneum*) conditions, which allow insects to thrive and lead to an increase in the temperature in the storage facility that further permits pest development. Food may acquire a pinkish tinge when a large number of insects are present.

The tropical warehouse moth (*Ephestia* spp.)

Characteristics: This moth is commonly found in stored products and food storage facilities in a wide range of climates. The colour of the outer half of their forewings is bronze, copper or dark grey, while the upper half is yellowish-grey, with a dark band at the junction between the two.

Crops attacked: It infests all types of dried food such as maize, rice and wheat.

Damage: The larvae feed externally on grains but most of the damage to stored products is through contamination with the massive amounts of silk spun by the moth, which also accumulates faecal pellets, cast skins and egg shells.

Mould

Several thousand species of mould (microfungi) are known and are present mostly everywhere due to very effective propagation through spores. The spores are disseminated widely by the wind, and when they fall on substrates with the right warm and humid conditions, they develop extremely quickly. Mould is extremely ubiquitous, and can grow in aerobic environments, as well as in conditions with very little oxygen, and some mould is anaerobic.

Mould growth occurs on staple agricultural products both in the field and during storage, causing enormous damage. The main effects of a mould infestation are loss of nutrients, alterations in colour and smell, caking of grains, and deterioration of the

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germination capacity in the case of seeds. Many types of mould are known to naturally produce mycotoxins, which are a potential hazard if consumed by humans or animals. The most dangerous mycotoxins are aflatoxins, which can be lethal. Aflatoxins can be found in all grains that have been attacked by mould, and cannot be destroyed or removed by cooking or heating the grain. There are simple field kits to test the presence of aflatoxins in stored grains.

The optimum conditions for mould growth are temperatures of between 21 and 32 °C and relative humidity of between 65 and 90 percent. The easiest method to prevent the development of mould for small farmers is to dry the products to be stored to safe moisture content levels.

However, reduced temperature in combination with low moisture is more effective in preventing mould bio-deterioration than just drying. This can be achieved by correct ventilation and aeration, which will help to cool the storage facility and reduce the possibility of moisture transfer between grains. This should be taken into account when choosing a storage facility.

Termites (*Macrotermes* spp.)

'Termite' is a common name for numerous species of social insects that can damage stored grain and wooden structures such as

Figure 7: Mould on maize grain

furniture or wooden parts of buildings. Termites have thick waists and soft bodies and undergo incomplete metamorphosis.

Termite damage is very costly because it does not affect the storage product alone, but also the storage infrastructure. While termites do not specifically seek grain (they will only eat the grain that they find in their path); they can seriously damage storage structures constructed from grass, twigs, wood, timber or mud, which may collapse leading to significant losses.

Rodents

Rodents are responsible for a considerable percentage of the losses experienced throughout the post-harvest chain. Indeed, rats or mice are considered to be formidable crop pests because of their high reproductive rate and ubiquity, very often inside houses or storage facilities; rodents are very difficult to control or eradicate. Rodents can also cause severe damage to the storage facility or packaging materials, and can be vectors for the spread of diseases such as toxoplasmosis, leptospirosis, rickettsia and Hantaan fever.

Birds

The main damage caused by birds is when they feed on standing crops, mainly small cereals such as pearl millet. While birds are not a major problem in closed storage structures, they can also cause losses in open storage structures in field like drying racks, and they can contaminate grains through their droppings and urine and be vectors in the spread of diseases such as salmonella.

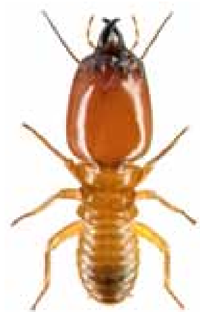

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Figure 8 (left): Termite damage to maize stalks

Figure 9 (right): Termite (*Macrotermes* spp.)

Integrated pest management in the control of storage insects

Integrated pest management (IPM) means the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions at levels that are economically justified, and reduce or minimize risks to human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms.

First of all, it is important to stress that the presence of pests does not automatically require control measures. Second, it must be stated that it is very difficult and expensive to completely eradicate storage pests. In rural communities in southern Africa where grain is stored for domestic use or sale in local markets, it is advisable to promote good storage practices, in order to limit the damage caused by pests so that they are not economically significant.

In many cases, the use of pesticides is still unacceptably high, uneconomic and unsustainable. The wide availability of inexpensive insecticides has often led to an overuse and dependence on chemicals, neglecting the importance of the non-chemical, often traditional, pest-management techniques that are available for safe and non-hazardous storage at household level. Where possible, reliance on pesticides should be reduced through promotion of an IPM approach, which considers traditional practices of

good husbandry as the fundamental basis of pest control. These practices include:

1. Prestorage pest management: Starting storage pest control while the crop is still in the field minimizes the transfer of primary storage insect pests from the field to storage. This involves:
- Cleaning and drying to be done as thoroughly as possible, especially when grain is to be stored for a long period.
- Control of grain quality before storage, not taking evidently infested, unclean or damaged grain inside the storage.

2. Storage management: Greatly influences pest development and control through the location of stores, the storage periods and the expected quality for stored commodities. Considerations include:
- Control of the storage environment: As noted above, in a fully loaded store it is the stored grain itself which largely determines and stabilizes the temperature and humidity conditions. However, the appropriate moisture content of the grain prior to the introduction in the storage or the right aeration or ventilation of the facility will delay insect infestation.
- The storage of maize cobs, sorghum and paddy rice panicles, millet heads and cowpea pods (before the grain is shelled or threshed) can delay the infestation by some pests, but does not prevent it entirely; further, this may open the opportunity for other pests, such as the grain moth which prefers to attack unthreshed grains to threshed grains. Ventilated cribs for the storage of maize on the cob and other grains on the head or in the pod can help to finalize the drying process inside the storage facility.
- Storing bulk grain may also reduce infestations or facilitate pest control.
- Pest population levels and grain damage should be regularly monitored to implement the most cost-effective timing of pest control actions.

3. Other possibilities for integrated pest management:
- Biological control[1] measures, including the use of predators, parasites, insect diseases and sterile males, the use of pheromones for pest monitoring, mating disruption or enhanced mass trapping, can support pest management.
- The use of crop varieties which are resistant to storage insect pests as well as preharvest pests. Resistant/tolerant varieties will generally delay the increase of infestation and grain damage, thereby prolonging the period in which damage remains relatively low. This is the case of some maize varieties, which produce sheathing leaves completely enclosing the entire cob providing considerable protection against grain weevils. The use of a particular variety needs to be properly analyzed, as

1 Biological control definition: Pest control strategy making use of living natural enemies, antagonists or competitors and other self-replicating biotic entities (IPPC: ISPM Pub. No. 3, 2005).

REQUIRED CONDITIONS FOR SEED TREATMENT IN AN FAO-SUPPORTED INTERVENTION

At the seed treatment facility:

- The pesticide products applied must be cleared by FAO's Plant Production and Protection Division and must be registered with the relevant national authority in the country/countries concerned.
- The company providing the pesticides has to declare that they are observing the FAO Code of Conduct on Pesticide Management, especially its provisions on labelling, as well as packaging and transport of pesticides.
- Users of pesticides applied as seed treatment must adhere to the necessary precautionary measures described on the product labels (e.g. wearing a protective mask, goggles and gloves).
- The treatment of seeds must be done in an appropriately equipped facility that ensures full containment of the pesticides.
- Users of seed treatment equipment should be provided with suitable application equipment and instructed on calibration, use and cleaning of the equipment.
- Treated seeds must be dyed an unusual and unpalatable colour to discourage consumption.
- All packages containing treated seeds must be clearly marked "Not for human or animal consumption" and with the skull and crossbones symbol for poison.

At the point of use of the treated seeds:

- Those handling treated seeds should be informed that the seeds are treated with pesticides, which can have toxic effects on their health, the health of others and on the environment.
- Handlers should be advised to wear clothes that fully cover their body (long sleeves, long trousers/skirt and closed shoes), and the distribution kits should include gloves and dust masks with instructions on their use; handlers must wash themselves and their clothes after handling the seed.
- Packaging from treated seeds should not be reused for any purpose.

high-yielding varieties are often more susceptible to damage by storage insects.
- Most storage insect pests will die in hermetic storage when the oxygen is reduced, although suitable hermetic containers are expensive.

Although these practices may not prevent insect infestation, they can delay it and reduce the losses experienced to acceptable thresholds.

Use of pesticides[2]

Insecticides and fungicides used to treat grain are either synthetic or organic. Synthetic insecticides/fungicides are chemical pesticides that have been artificially formulated to control pests, while organic or natural pesticides contain chemicals produced by a plant (i.e. naturally) to ward off insects, fungi and other predators.

Natural pesticides are generally a safer, more ecofriendly alternative for home and garden pest control, as they use natural components to control pests. Because of the often negative effects of synthetic pesticides on the environment and people, it is strongly recommended to use natural insecticides, particularly for small-scale farmers, local communities and schools, and by vulnerable segments of the population that are likely to be poorly trained and unequipped to use pesticides.

Natural insecticides include traditional materials, such as abrasive mineral dusts, natural desiccants like wood ash, plant materials with repellent or insecticidal properties (such as parts of the Neem tree, *Azadirachta indica*), or vegetable cooking oils (palm, groundnut or coconut oil).

However, in areas where storage pests are prevalent and result in important losses – often as a result of common preharvest infestation or poor storage facilities – preventive disinfestation of the grain before storage may be required.

2 The overall framework for sound pest and pesticide management is provided by the *International Code of Conduct on Pesticide Management* and its accompanying technical guidelines, on regulatory practices, packaging and storage of pesticides, labelling of pesticide products/containers, disposal of waste pesticide materials, etc. (http://www.fao.org/agriculture/crops/thematic-sitemap/theme/pests/code/list-guide-new/en/)

In this case, it is important to mention that treated grain or seed cannot be consumed, neither by humans nor animals, because of its high toxicity. Treated seeds must be dyed with an unusual and unpalatable colour for identification purposes and to discourage consumption, and all packages containing treated seeds must be clearly marked 'Not for human or animal consumption' and with the skull and crossbones symbol for poison.

While using pesticides as seed treatment, users must adhere to the necessary precautionary measures described on the product labels (e.g. wearing a protective mask, goggles and gloves).

- Treatments must be done in an appropriately equipped facility that ensures that the pesticides are fully contained.
- When insecticide treatment kits are distributed, the kits should include the suitable application equipment for users, who should receive instruction on calibration, use and cleaning of the equipment.

The weight of the grain to be treated should be determined to calculate the amount of chemical to be used (based on the dosage rate indicated on the container/package label, where the concentration of the insecticide's active ingredient must be also shown). Where the farmer is in doubt, assistance should be sought from the local extension officer.

The following table shows weight of common grain per cubic metre. This weight helps in determining the amount of insecticide to be applied.

Table 1: Weights of common grains per cubic metre

Grain	Kg per cubic metre
Maize cobs	500 kg
Maize grain	800 kg
Paddy	500 kg
Unshelled groundnuts	352 kg
Rice	864 kg
Millet	624 kg

After establishing the amount of chemical to be used, there are two main methods for treatment: the admixture method (for shelled or loose grain) or the sandwich method (for maize cobs):

- The admixture method intends to obtain a homogenous mixture of loose grain and a suitable contact insecticide, which will be later stored or packaged in bags or containers. This method is suitable for small-scale farmers because dusting powders are available in suitable packs locally and ready to use. The advantages of insecticide admixture treatments are that they are generally inexpensive and a single correct application of an effective insecticide, at the right dosage, will control an existing insect infestation all stages of development and will protect the grain against re-infestation for several months.
- The sandwich method is used for maize on cobs or loose grain and the treatment is done in layers of insecticide sprinkled after every layer of 20 cm for unshelled grain (cob) or 10 cm for shelled or loose grain. Once the quantity of grain to be stored is known,

the total amount of insecticide to be used is determined based on the dosage rate on the label. The amount of insecticide to be put at every layer is established by dividing the total amount of chemical by the number of 20-cm or 10-cm layers of the container. The number of layers is obtained by dividing the height of the storage structure by 10 cm or 20 cm depending on whether the grain to be stored is shelled or on the cob (20 cm for cobs and 10 cm for grain). The inside walls and the floor of the storage will also be sprinkled with a layer of insecticide, as well as the top layer that closes the storage facility.

When seed protection measures are deemed necessary, the non-chemical pest management techniques that are available should be the first option irrespective of their cost and technical complexity.

Safety precautions

Pesticides require special attention because they are toxic; therefore, their distribution and use should always involve managing the risks to human health and the environment. Furthermore, inappropriate use of pesticides may reduce agricultural productivity and result in pesticide residue levels that become a constraint to a crop's marketability both on domestic and export markets.

Although most countries have pesticide legislation, many may still lack the capacity to ensure that pesticides are appropriately selected, managed, used and disposed of. Circumstances in developing countries often make it difficult for farmers to follow recommended practices regarding personal protection, use and cleaning of application equipment, storage of pesticides, and disposal of obsolete pesticides and empty containers.

SELECTION AND PROCUREMENT OF PESTICIDES

If pesticides are deemed to be the best – or only – option, then the selection process for these products should be careful and informed. Factors to consider include: efficacy, and whether the target organism is likely to be or become resistant to the product. The most important consideration is reducing negative effects on human health and the environment. The main criteria when considering a pesticide are:

1. The product should not be subject to the Stockholm Convention on Persistent Organic Pollutants. The list of pesticides concerned can be found at: www.pops.int/

2. The product should be registered in the country of use. If specified in the registration decision, the product should be permitted for the crop-pest combination concerned.

3. Users should be able to manage the product within margins of acceptable risk. Pesticides that fall in WHO Hazard Class Ia or Ib or Globally Harmonized System (GHS) Class 1 and 2 should not be used. Pesticides that fall in WHO Hazard Class II or GHS Class 3 can only be provided if less hazardous alternatives are not available and it can be demonstrated that users adhere to the necessary precautionary measures.*

4. Less hazardous, more selective and less persistent products are preferred, as are application methods that are less hazardous, better targeted and requiring less pesticides. Avoid products listed in Annex 3 of the Rotterdam Convention.

* The hazard classification concerns the formulated product. Formulations with a low concentration of active ingredient are less hazardous than formulations with a high concentration of the same active ingredient. The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification (http://www.inchem.org/documents/pds/pdsother/class.pdf) classifies technical products based on acute oral and dermal toxicity. It includes a conversion table that allows determination of the hazard class for the pesticide formulation under consideration. This list was replaced in 2008 by the Globally Harmonized System of Classification and Labelling of Chemicals, which in addition to acute toxicity also takes into consideration chronic health risks and environmental risks (http://www.unece.org/trans/danger/publi/ghs/ghs_welcome_e.html). The term 'pesticide formulation' means the combination of various ingredients designed to render the product useful and effective for the purpose claimed; the form of pesticide as purchased by users. The term 'active ingredient' means the biologically active part of the pesticide.

PESTICIDE MANAGEMENT

The following requirements apply to all pesticides that are being supplied directly by FAO and to pesticides supplied by others within the framework of FAO projects.

1. A thorough risk assessment should precede pesticide procurement; this should lead to adequate measures to reduce health and environmental risks to acceptable levels.

2. Procurement quantities should be based on an accurate assessment of actual needs in order to avoid overuse or accumulation of stockpiles that may become obsolete. Pesticides should not be provided as fixed components of input packages of projects, credit schemes or emergency assistance.

3. Appropriate application equipment and protective gear should be provided in adequate quantities along with the pesticides, unless it is explicitly confirmed that the recommended equipment and gear is already sufficiently available.

4. Users may need to be trained to ensure they are capable of handling the supplied pesticides in a proper and responsible manner.

5. Proper storage of pesticides in accordance with FAO guidelines should be ensured for all supplies.

Everyone who may be directly or indirectly affected by the chemical treatments should be familiar with the recommended procedures and should observe all appropriate precautions. It is particularly important that the persons involved in pest control have the right equipment necessary for application and protection. It is very important to avoid the re-use of empty containers of chemicals.

In addition, the specific precautions recommended by pesticide manufacturers for the use of their products, should be clearly drawn to the attention of the user on all product labels. Local sales agents should be required to ensure that hazardous materials are not retailed to users who may be unable to read or understand the accompanying information on application rates and safety precautions. Safety should be the highest priority when toxic chemicals are used in pest control.

Termite control

Termite infestations are difficult to control; although termite nests can be destroyed, often they are deep in the ground or difficult to locate. Termite control chemicals are very toxic and should not come into contact with storage grain; therefore, efforts should be directed towards preventive measures to avoid the infestation, mainly when the storage facility is being constructed. The precautions to consider include:

Figure 10: Storage with poles and metal baffles to prevent rodent infestation

- The site for the construction of the storage should be on high ground where the water table is low, as termites need soil moisture to develop.
- Storage should be near the houses to rapidly detect any termite activity.
- Non-wood materials (blocks, stones) should be used for foundations in areas where termites are common.
- The wood for the storage can be protected or treated through chemicals, and in rural areas engine oil can be used for this purpose.
- Hygiene is very important; the area surrounding the storage system should be clean, free of plants and debris, and at least one metre from the nearest tree or building.
- Stores with support legs made of compacted mud should rest on a concrete block or large stones to help deter termite access.

Rodent control

Farmers or store keepers should be able to identify the presence and extent of a rodent infestation using the following guidelines:

- Live rodent seen during the day shows a heavy infestation, as they are nocturnal creatures.
- Appearance of droppings can provide information of the species of rodent and the degree of infestation.
- Runs, tracks or dark greasy stains along the foot of walls show high infestation.
- Rats and mice leave footprints and tail marks in the dust.
- Damage in the form of fragments of grain, doors, cables or other material that has been nibbled shows rodent activity.
- Burrows and nests inside the store in corners as well as in the roof area are indicative of rodents.

Active methods of rodent control involve non-chemical and chemical control strategies. Non-chemical control involves the use of preventive measures and chemical control involves the use of poisons, normally mixed with palatable bait. This brief will focus on methods of non-chemical control to prevent rodent infestations, as the use of rodenticides (rodent poison) is very toxic and can be dangerous for humans or other animals if inadvertently ingested.

Non-chemical rodent control

Sealing the storage facility to impede rodents' access is often difficult, but placing barriers or rodent guards on access points can be sufficient. Most rodent entry points can be revealed after a careful survey of the exterior and interior of the store. Some practical recommendations to prevent rodents´ access are:

- Place metal plates at the base of the doors to prevent rodent entry through badly fitting or rotting hinged doors. Metal plates will also prevent rodents from gnawing to enlarge the openings.
- Fit metal baffles onto pole stands of storage structures and to pipes and cables that lead to the roof or window level. This will prevent rodents from accessing the upper part of a store.

- Place mesh wire on windows and in eaves – common rodent entry points.
- Paint the walls with a band of gloss paint on a smooth mortar from the ground until at least one metre high, to create a smooth barrier that rodents cannot climb. This is useful in brick or other rough walled buildings.
- Plaster the outer surface with mud. This helps to prevent rodent entry to grass or straw storage facilities.
- Place mousetraps inside the storage facility, especially needed when seed or grain is stored in bags, as rodents can also damage these.
- Use cats as a low cost and non-chemical rodent control measure.

Bird control

Birds can be controlled in the field to protect standing crops and those stacked for drying by using scare crows placed at strategic positions, or by literally guarding the field and chasing the birds away. For crops in a store, the best way to control birds is to have wire mesh in the eaves and on openings so to limit access in and out of the store. Sweep areas surrounding the storage facility daily to eliminate the grains that may have fallen.

Hygiene

Hygiene means keeping the storing facility and the surrounding area as clean as possible, eliminating any vegetation or rubbish that may provide breeding grounds for storage insects and rodents. Clearing the ground around the store will make it easier to spot termite trails as well. Livestock should be kept away from the store and not be allowed to browse or sleep under it; their droppings should be cleared as they may attract rodents.

Whenever the grain store or containers are empty they should be cleaned immediately. Any grain residues should be removed from sacks or bags, and these should be dipped into boiling water to kill any insects and then dried in the sun. Grass should be burnt inside solid-walled bins and mud-plastered baskets to kill off any insects and mould spores.

Prestorage handling

Prestorage handling activities include preharvesting (pest control in the field, decision on correct harvest time, etc.) and post-harvest activities (like harvesting, shelling, drying, cleaning and winnowing grain). If small-scale farmers implement good practices during prestorage handling, the risks of insects being taken to the storage facility will be reduced, and grain and seed can be stored under good conditions of low moisture content, cool temperatures and the absence of pests. These simple activities are a prerequisite for proper storage of food and seed grain.

Prestorage handling practices are not similar for all grains produced in southern Africa although the principles behind the activities are the same; in this brief we will focus on rice, groundnuts, maize, sorghum, millet and beans.

Prestorage handling of rice

Paddy is the name of the rice just harvested, enclosed in husks; once this paddy is milled and the husks are removed, the grain is the proper rice. The key issues in handling rice before storage are:
Harvesting: The timing of paddy rice harvest is a very important factor to determine grain quality and yield. The harvesting period

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Figure 11 (left): Rice growing in the fields

Figure 12 (right): Harvesting rice

should begin when 90 percent of the grains in the main panicles of plants are clear, firm and straw coloured. Grain moisture at time of harvest should be less than 20 percent. If harvesting is done too early, there will be many immature grains that will reduce yield and quality; if harvesting is done too late, many grains are lost before harvesting or cracked and broken during threshing and milling.

Threshing: Paddy rice should be threshed immediately after harvest, by hitting the panicles against a drum or a wooden surface, or on tarpaulin or canvas, but not directly on the ground.

Winnowing: All kinds of impurities from threshed grain such as insects, straws, chaff, soil, stones, leaves, etc. should be removed before storage. The removal of light and chaffy material through winnowing should be done immediately after threshing to avoid contamination and improve the quality of the milling output.

Drying: The drying of paddy rice should start just after threshing. Paddy should be spread in thin layers on tarpaulin or on the floor (not on concrete floors), and be stirred regularly for uniform drying. Drying should be done in four consecutive days; longer exposure will cause fast drying inside the grain that can cause cracks or breaking the grain during the milling process. Properly dried grain (around 15 percent of moisture content) breaks into two when bitten.

Shelling and husking: This step consists of removing the husks that protect the paddy rice to get to the grain. It can be done at rice mills, or using traditional methods such as pounding in wooden

Figure 13 (left to right): Threshing and drying rice

mortars, although this method breaks many grains. The husk will not be removed if seed is being produced, as the rice paddy is directly planted in the field.
Cleaning: Any impurities are removed, including broken or immature grains.

Prestorage handling of groundnuts

Harvesting: If groundnuts are harvested too early, the kernels will shrink when drying, resulting in a lower shelling percentage, poor seed quality and lower oil content. Groundnuts are mature when between 70 and 80 percent of the inside of the shell is spotted pale brown; it is enough to open some pods and verify that kernels are not small or immature. Groundnut seeds are protected by a shell, which acts as an excellent natural barrier against pests and diseases, if intact. Once mature, the whole plant will be lifted and put to dry.
Drying: Pods need to be dried rapidly to avoid the development of mould. The drying process can start in the field where the whole plant will be put to dry for several days, before stripping the pods and taking care to cover them if it rains. Overexposure to the sun can affect kernel quality.
Threshing: Should be done two to six weeks after harvesting, when the pod moisture content stabilizes at around 10 percent. The pods will be separated from the plant manually or by hitting the heap

Figure 14 (left to right): Groundnuts growing in the field and being shelled of groundnut plants with sticks, which leads to many pods being broken, that are then separated by winnowing.

Sieving: Most sieves are made of wire or metal bars and allow for separating impurities from the whole groundnuts. Sieving cannot eliminate empty or immature pods, which are cleaned manually.

Shelling: Shelling can either be done by hand or by a mechanical sheller, which is often manual. Some farmers in southern Africa soak the groundnuts or their hands in water to make the shelling easier, but this should be avoided as the moisture increases promotion of mould. This is particularly important, as groundnuts can develop mould that can lead to aflatoxin contamination.

Grading: Groundnuts can be stored shelled (without the shell) or unshelled (with the shell). For household food consumption, it is recommended to store the groundnuts unshelled and shell them only when they will be consumed. Groundnut seed should also be stored unshelled. Shelled nuts should be graded for storage, separating clean nuts from broken, shrivelled or rotten ones. Other impurities should also be eliminated.

Prestorage handling of maize

Harvesting: Maize should be harvested, when most of the maize husk cover turns to yellow and leaves turn slightly yellowish. Once the maize stalks are cut and stacked in heaps, they can be left in the field to dry for a couple of days before removing the husks of the cobs.

Shelling: Shelling (threshing) can be done with a simple hand-held sheller which is locally fabricated using metal or hard wood.

Figure 15 (left to right): Dried maize cobs, a healthy cob and a diseased cob

Drying: Maize is usually harvested with moisture content in the range of 18 and 26 percent and the full cobs or the shelled grains are further dried in the sun; if possible the maize should not be put directly on the ground to avoid contaminating the grain or cobs with soil or dirt. Polythene sheeting or sheets made out of nylon sacks are useful for drying. Grain must be turned often to ensure homogenous drying.

The principles of prestorage handling for sorghum and pearl millet are similar to the process followed for maize. While pearl millet can be stored in a cob or as grain, sorghum will be threshed before storage.

Prestorage handling of beans

Harvesting: Bean plants are ready for harvest when all leaves and pods are yellow. Bean pods will be harvested over a period of time from a single plant, as the individual pods mature.

Drying in pods: Beans can be easily infected with insects or pathogens found in the soil, and the drying process cannot be done in the field. Pods should be taken home and dried in the sun, on a mat, plastic sheet or tarpaulin for a couple of sunny days before threshing. If the drying is too long or too short, the beans will become either too dry or remain wet, which in both cases is not good for threshing.

Threshing: The beans should not break or be damaged during threshing. Threshing should not be done on the ground or in a

Figure 16 (left to right): Beans growing in the field and sorting dried beans gunny bag, as grains will easily be damaged and be susceptible to insect and mould infestation during storage. A threshing rack is recommended, and can be made locally using wood and mesh wire to form a screening tray.

Drying threshed beans: Threshed beans must be dried again, spread thinly on the drying surface to allow air circulation, and turned regularly to avoid overheating. In southern Africa, beans should be dry enough after three sunny days.

Grading/sorting: Winnowing will remove chaff, dust and other debris from the beans, and sorting will remove shrivelled, diseased, broken beans and beans of other varieties. Sorting is preferably done on a locally made platform sorter to make the work easier. Sorting is very important in southern Africa, as beans are cooked and eaten whole without processing and physical appearance will be very important for cooking or marketing; a few damaged kernels may greatly reduce the value of the overall harvest.

Figure 17: Grading beans

Small-scale storage facilities

A safe storage environment can be maintained if the grain or seed is stored in proper facilities and good practices are applied, in order to reduce the losses resulting from pests or mould, and to ensure that the seed's germination power is maintained throughout the storage period.

When discussing storage, it is important to distinguish between the storage of seed and the storage of food grain. The quantity of seed stored by small-scale farmers in southern Africa is determined by the size of the land they cultivate, which is relatively small in general. If we assume that small-scale farmers cultivate less than one hectare, we can estimate that the quantity of seed to be stored will be less than 20 kg.

In the majority of cases, farmers keep small quantities of seed at home, in suitable bags or small containers such as jars or traditional earthen pots, protected with traditional or chemical pesticides and safe from rodents and pilferage. Farmers usually manage to keep small quantities of seed in good conditions of low temperature and low moisture content, without incurring major losses in quality, quantity or germination potential.

Where larger quantities of seed have to be stored, especially after seed multiplication or seed pass-on programmes, then a larger storage structure has to be built. In such a case, although normal grain storage practices have to be implemented, it is critical to be aware of the extra care required in maintaining a specific safe storage environment for seed.

Unlike food grain, seed is very sensitive to changes in temperature, relative humidity and moisture content during storage. The result is that an adverse increase in these factors can cause a deterioration in the germination capacity of the stored seed. It is worth noting that, even without external physical grain damage from pests or mould, these three factors can still negatively affect the seed's germination power. Therefore it is important that seed storage facilities be protected from direct sunlight and humidity; in particular, storage facilities with metallic roofs must be covered to avoid overheating and sufficient ventilation should also be permitted to keep the air in and around the contents cool and dry.

The storage facilities discussed in the following paragraphs are mainly oriented towards food grain storage, and they have been categorized as either traditional or modern storage facilities. Where these facilities have been modified or used for seed storage, keeping low levels of temperature, moisture content and relative humidity should be a primary concern in order to preserve the germination power of the seed and being aware that the seed might need to be kept in storage for a longer period than food grain.

Traditional storage facilities

In traditional on-farm storage systems in southern Africa, bag-storage systems tend to predominate, although bulk storage occurs quite often at farm level. On-farm traditional storage facilities can be differentiated as open, semi-open and closed storage.

Open storage

Open-ended storage facilities are usually wooden structures that are suitable as temporary drying facilities for cobs or panicles, and sometimes the grain can stay there for longer periods in which case

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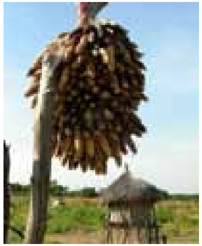

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Figure 18: Open storage

they become storage structures. Open storage systems are used in hot and humid climatic conditions or when grain has just been harvested at a higher moisture content. When grain is placed on these structures it dries quickly, as it is directly exposed to sunlight and natural ventilation. The rapid drying helps in preventing the development of moulds.

Open storage structures enable grain to be dried on the cob, stem or panicle, and the grain may continue to mature and fully ripen after harvesting. Also the elevation from the ground limits termite invasion.

These structures can be easily built at a very low cost. The main disadvantages are that they are open to insects, rodents and birds, and over exposure to sun or rain can damage the grain.

There are other forms of open storage that better protect the seed grain. This is when the seed is hanged as cobs or panicles under the house roof, eaves, frames or tree branches and also over fire places to dry and repel insects.

Semi–open storage

Semi-open storage structures (cribs) are structures which are usually made from timber, reeds or bamboo and are elevated using stone foundations or wooden frames (with baffles) to prevent damage from rodents, termites or soil moisture and have a straw roof to protect against the rain or excessive sunlight and allow sufficient ventilation.

Figure 19: Semi-open storage

These structures are normally used to store cobs or panicles that require further drying before threshing, as the openings or porous walls will allow continuous aeration during storage. Semi-open storage systems provide better protection against weather conditions than open ones but reduce aeration and do not prevent pests from entering.

Closed storage

Bancos are traditional closed storage containers made from mud (often mixed with chopped straw or twigs) or woven with grass, branches, bamboo, etc. and then insulated against pests with mud. *Bancos* have been used successfully in Malawi, Mozambique and Tanzania for storing grain and seed for sorghum, millet, pulses, paddy rice and peanuts. Wet grain cobs or panicles should not be stored in closed storage, as they will increase the humidity and condensation inside the container, leading to quality changes.

There are also other small containers made from clay, straw, wood or leather, which are sometimes buried or hung from trees or eaves. In some regions seed stores are constructed underground to protect against rodents and high temperatures.

Closed storage structures are suitable for storing seed because of the mud's excellent insulation capacity, which allows the maintenance of a stable temperature and humidity inside the container, preventing seed deterioration. Seed should be placed in the containers after it has been properly dried to the right moisture level.

Figure 20: *Bancos*

Modern storage facilities

The storage grain bag

The ordinary grain bag is the most common form of storage for shelled grain and seed in southern Africa among small-scale farmers. Grain bags are an excellent and affordable storage system that meets the main requirements of safe storage: they enable aeration, avoid spillage and prevent infestation.

Not all bags are suitable for storage; plastic bags (with the exception of specialized hermetic storage bags) are not suitable for storing grain or seed because plastic impedes the circulation of air. Tightly woven polypropylene bags are also not suitable because they do not allow sufficient ventilation, but they are often the easiest to find in the local markets. The best storage bags are jute bags or UV-stabilized polypropylene bags with a special weave, which is anti-slip and allows for aeration. Seed should be treated before being put in storage bags to protect it from insect infestation, although proper storage will reduce these risks.

Modern or adapted granaries

The construction of modern granaries is often not a cost-effective option for small-scale farmers who will prepare traditional and inexpensive storage facilities made with local means. Taking into account the limited production that can be expected from individual farmers in southern Africa, and therefore the little quantity to store at a household level, there is probably little use in promoting durably

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Figure 21: Grain stored in bags

constructed infrastructures. In hazard-prone areas, efforts should be dedicated to adapting traditional storage systems to reduce losses if a crisis occurs, such as elevated or hazard-resistant facilities.

However, in cases where farmers come together to pool their production in a single storage facility, either community warehouses, seed pass-on programmes or community gene banks or seed banks, the construction of specific facilities for storage may be justified. In the construction of community storages in hazard-prone areas, there is a need to have specific technical considerations, mainly regarding the site and orientation of the construction (e.g. avoiding lowland areas that may get flooded) as well as the construction methods (elevated platforms, reinforced walls and pillars in cyclone-prone areas, etc.)

While the construction of community storage facilities may be easily accomplished respecting basic technical specifications, the bottleneck is usually the management of these infrastructures by the community, assuring a fair representation of all the members of the community (including women and most vulnerable), and setting up management procedures and regulations that clearly define the roles and responsibilities of the individuals.

Modern cribs

The modern crib is an improved adaptation of the traditional crib: it stands on brick supports, it is more durable when built from hard wood and it is more protected with a solid roof, while maintaining good ventilation through a mesh wire surrounding the structure. Like

Figure 22 (left): Modern storage

Figure 23 (right): A modern crib

the traditional storage crib, it is semi-open and suitable for drying and storing cobs, and it has been successfully used in southern Africa.

Metal silo bins

Small metal silo bins (including recycled oil drums) which can hold 100 to 3 000 kg of grains or pulses, are developing as an efficient and low-cost storage system suitable for small-scale farmers. These silos are loaded from the top, and once closed they are inaccessible by rodents or insects, and can be properly sealed against water leaks. They are normally covered, raised from the ground and placed in a well-ventilated place to control both temperature and humidity.

Small metallic silos can also be used for seed storage, but they must be situated in a cool place, under a roof or in a shed to prevent overheating of the seed that can result in reduced germination power. Before placing the grain or seed inside the silos, it must be dried to a safe moisture level.

Apart from being effective in storing grain, the metal silo has also the advantage that it is portable, requires little space, and can be cheaply made from local material and expertise. The silo can last long if well maintained.

Hermetic bags

The hermetic bags are a relatively new development. These are hermetically sealed bags or cocoons of various sizes (50 kg–300 MT); they offer an interesting alternative to traditional storage. The hermetic bags work on the principal that grains release carbon dioxide which rapidly replaces the oxygen in the sealed container. Once oxygen is exhausted, the pests die and fungi cannot spread.

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Figure 24:
Metal silo bins

Basic steps for appropriate silo use

1. Place the silo under cover and on a pallet
2. Dry the grain to 14% moisture or less (according to type of grain) before placing it in the silo.
3. Clean and dry the inside of the silo
4. Seal the silo with adhesive tape or rubber bands
5. For every 225 litres of volume, place one aluminium phosphide tablet on the grain in an open paper bag
6. Introduce the grains or seeds to be stored
7. Check for three hours that there is no gas leakage and leave for at least five days
8. Inspect the condition of the grain every 30 days and replace the seal
9. Remove the grain as needed and replace the seal

For these sealed units to work effectively, they need to be completely filled quickly and only opened when the entire contents have to be used.

The hermetic bag is very suitable for seed storage, since it can be sealed airtight ensuring that a stable condition suitable for seed storage is maintained. To ensure that the seed does not absorb moisture during the long storage period, silica gel is added to absorb excess moisture. An indicator colourant is added to the silica gel so that it changes colour when it needs to be replaced.

Insecticide-treated bags

Insecticide-treated bags are woven polypropylene bags developed to store cereal grains, pulses, oilseeds and seeds. An insecticide is incorporated into the individual fibres, providing a powerful killing action against insects before they can infest the grain or seed in the bag. Although these bags have not been tried in the field in southern Africa, they are a promising storage solution for small-scale hazard-prone farmers, mainly for storing low volume, high value products like seed.

Small containers

Jars or tins that can be made airtight can be used to store well-dried seed. Such containers are feasible for storing vegetable seeds or other crops that require small amounts of seed. The bottles or tins of ordinary household products bought from local shops can be used for this purpose and candle wax can be used on the lid to make a good seal, creating a suitable micro-environment for the storage of small quantities of seed. Since the containers are small, they can easily be placed in a cool place where they are not accessible to rodents.

Figure 25 (left to right): A hermetic bag and small containers

3. Conclusion

Losses associated with inadequate post-harvest and storage practices have an important impact in the economy and the food and nutrition security of small-scale farmers in southern Africa. These losses can be aggravated in times of natural disasters such as floods, cyclones 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, and interventions in this regard need to be considered when implementing a disaster risk reduction programme in hazard-prone areas.

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.

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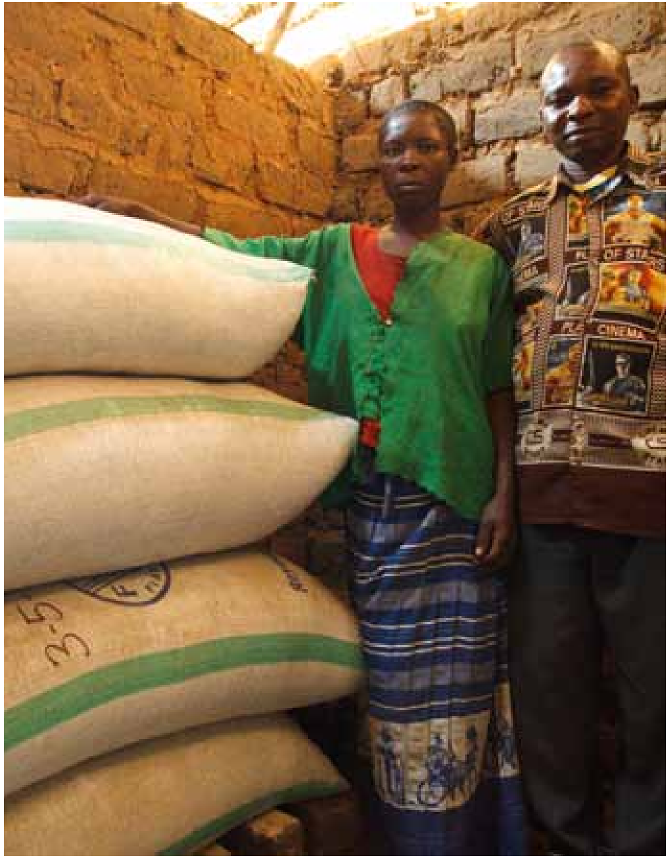

Annexes

Annex 1: Storage checklist

Storage site

Is the site generally clean and tidy?

Are the areas adjacent to the store clear of vegetation and refuse?

Is there evidence of rodent and termite activity?

Is drainage and flood water disposal satisfactory?

Warehouse – external

Are walls structurally sound?

Is the roof in good condition?

Are windows and ventilators in good condition and screened to prevent access by birds and rodents?

Are doors sound, well-fitting and secure?

Are rodent barriers in good condition and in place?

Are the ventilation openings protected against the penetration of insects, rodents and birds?

Are eaves and guttering free of birds' nesting materials?

Warehouse – internal

Are walls structurally sound, clean and as smooth as possible?

Is the roof inside in good repair?

Are windows and ventilators in good condition and screened to prevent access by birds and rodents?

Are doors sound, well-fitting and secure?

Are rodent barriers in good condition and in place?

Are floors smooth and crack-free?

Is there any evidence of insect infestation?

Storage practices

Are insecticides, fertilizers and other products stored separately from the grain?

Annex 2: Determining dosage rates for dusting powders

Small granaries, store or silos are best treated using dusting powders and this can be done layer by layer as the grain is put into the store or an admixture is done where the whole shelled grain is treated before putting the grain in storage.

The amount of insecticide used is based on the quantity of the grain to be treated. The following weights of common grains per cubic metre help in estimating the quantity of grains

Grain	Kg per cubic metre
Maize cobs	500 kg
Maize grain	800 kg
Paddy	500 kg
Unshelled groundnuts	352 kg
Rice	864 kg
Millet	624 kg

After establishing the quantity of grain to be treated, the amount of insecticide is determined as shown below:

- Note the application rate as shown on the label and calculate grams of dusting powder per 100 kg of grain.
- Divide the amount of grain to be treated (in kg) by 100.
- Multiply by the application rate for 100 kg.

Example:

Grain to be treated: 500 kg

The recommended application rate is: 50 g/100 kg

Calculation: (500 kg/100 kg) X 50 = 250

250 g of the dust formulation is required to treat 500 kg of maize

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