Pest management in farm granaries

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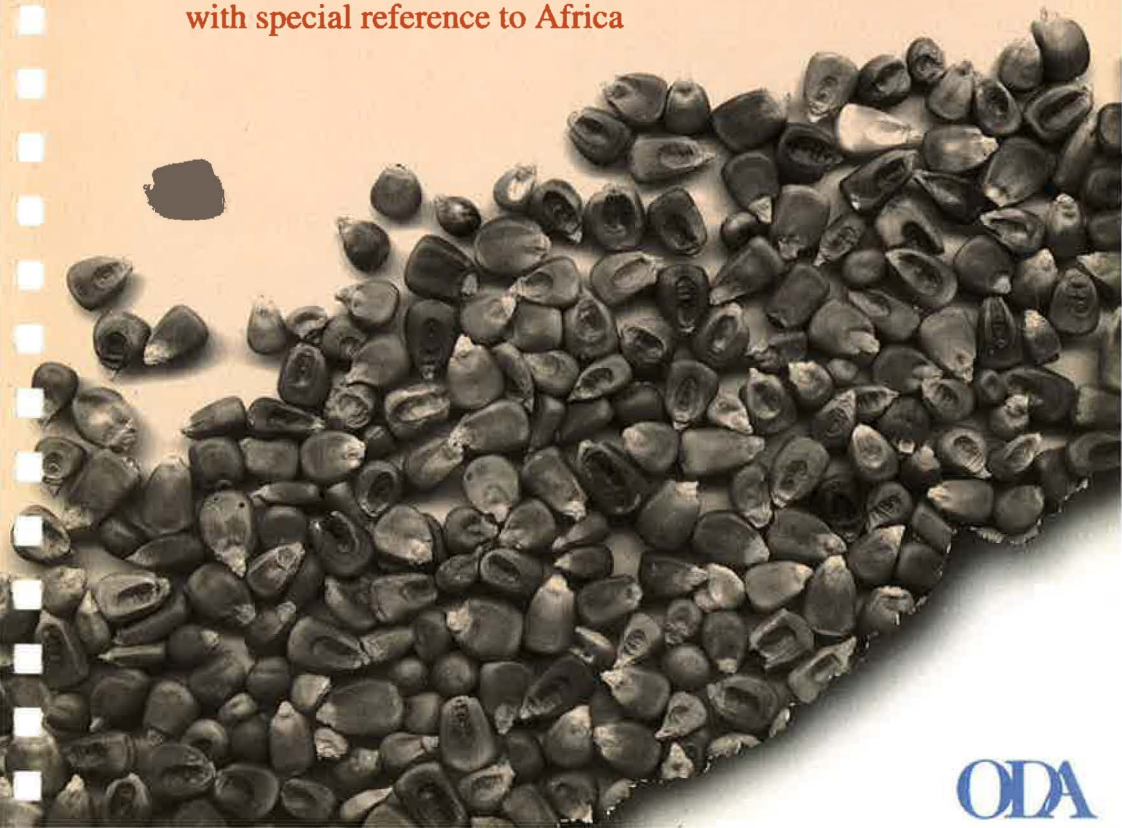
PEST MANAGEMENT IN FARM GRANARIES

with special reference to Africa



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PEST MANAGEMENT IN FARM GRANARIES

with special reference to Africa

Robin Boxall, Peter Golob and Robert Taylor

ODA

The Natural Resources Institute (NRI) is a scientific institute within the University of Greenwich, and is an internationally recognized centre of expertise in research and consultancy in the environment and natural resources sector. Its principal aim is to increase the productivity of renewable natural resources in developing countries in a sustainable way by promoting development through science.

Production of this publication was funded by the United Kingdom's Overseas Development Administration. However the Overseas Development Administration can accept no responsibility for any information provided or views expressed.

Price £7.50

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Natural Resources Institute
ISBN: 0 85954 490-7

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1. Introduction

It is estimated that between 60% and 80% of all grain produced in the tropics is stored on the farm. For small farmers the main purpose in storing grain is to ensure food supplies for the family. Farm storage also provides a saving to cover future cash needs through sale or for barter or gift-exchange. Small quantities of grain are also stored for seed. Farmers who produce a surplus may also store grain for sale later to take advantage of seasonal price rises.

Farm storage structures should provide maximum protection against deterioration caused by rain and ground moisture, provide a barrier to pest attack and deter theft.

Traditional farm storage systems have evolved over long periods to satisfy these requirements. Most are well adapted to their environment and losses are generally low, often below 5% of grain weight over a storage season. Higher losses may occur if the equilibrium of the traditional post-harvest system is disrupted. New, introduced crop varieties that do not possess the good storage characteristics of the traditional varieties may be more susceptible to pest attack. If they mature earlier in the season they may give rise to handling and drying problems. The newer high-yielding varieties grown by more progressive small-scale farmers may produce grain in quantities which exceed the traditional storage capacity. In the past, these farmers and larger-scale commercial farmers have depended upon parastatal grain marketing organizations and grain traders to take the surplus soon after harvest.

The introduction of grain market liberalization in many countries, especially in Africa, has resulted in a rapid decline or elimination of marketing organizations and the emergence of a more important private grain trade. The effect of this change on small-scale producers with grain surpluses is mixed. Farmers now have an opportunity to take advantage of seasonal price rises but the benefits can only be achieved if grain is held longer on the farm with no deterioration in quality. Thus the farmer now faces new problems associated with conserving grain safely on the farm and needs advice on the best type of storage system and methods of pest control to use.

Traditional storage systems may be able to cope with farmers' changing storage and marketing needs but in some cases modifications or entirely new storage systems or practices may be required.

Storage advice is generally available from the Agricultural Extension Services but usually as one or two basic messages or packages. Farmers now need advice which is tailored to match their individual and specific situations. If the agricultural extension officers are to meet this new challenge they must be able to assist farmers in analysing their particular storage requirements and personal circumstances, in order to identify an appropriate storage strategy. This means that the extension officer will require not only a knowledge of a range of storage management options, but also skills in analysing individual farmers' needs.

This manual is intended to help extension officers in giving the best advice to individual farmers on the safe storage of grains and pulses and it provides:

- guidance on how to analyse farmers' storage problems to be able to give the best advice
- information on the major causes of spoilage in stored grains and pulses and methods of prevention and control
- a summary of the basic principles of good storage practice
- descriptions of the more common methods of storing grains and pulses on the farm in Africa.

The word 'grain' is used here to include maize, sorghum, millet, wheat and rice when they are harvested. The word pulses refers to all kinds of legumes such as beans and cowpeas.

2. Analysing Farmers' Storage Problems

Farmers are sometimes criticized for not adopting improved storage techniques. This may be because extension services frequently limit the advice given to farmers to officially recommended practices. These are often derived from centrally organized research programmes that do not take account of farmers' different circumstances. The officially promoted options are usually formulated in packages of recommendations suitable for specific groups of farmers or farming systems. The recommendations may be technically sound but they may be unavailable, inappropriate, inconvenient or too expensive for some farmers. The majority of farmers will need good information about all the options available to them.

Examples of recommended storage packages

Medium and large-scale maize farmers (Ghana)

Grow a recommended high-yielding variety of maize; dehusk cobs at harvest; spray cobs with an approved insecticide; store in a narrow ventilated crib; shell when cobs are dry; mix with an approved insecticide and store in sacks.

Small-scale farmers (Togo)

Grow a recommended variety of maize with good husk cover, harvest at the recommended time; select only cobs with good husk cover; clean the store before putting in new maize; smoke the store when weevil infestation is seen.

These packages of recommendations assume that farmers are able to plan how they will manage their stored crop right from the start of the season. A few may be able to do this and for them the package of recommendations will be acceptable. However, most farmers, especially small-scale farmers, may adopt only parts of the package or none at all.

Small-scale farmers tend to make a series of decisions on how to manage their crop in sequence throughout the season based on the options and constraints at each point.

Examples of sequential storage decisions (Ghana)

Decision	*Options*
What type of store should I build?	Traditional crib; improved crib; basket; platform; kitchen loft.
What roof should it have?	Long/short thatch; metal sheet; plastic.
How should I store my maize?	Cob/shelled; husked/dehusked; selected/non-selected.
Should the store be smoked?	No; initially; occasionally; daily.
Should I use insecticide?	Which insecticide? how much? recommended commercial insecticide; traditional insecticide; ash; dusts.
I only have a little insecticide, how should I use it?	Apply thinly; apply to bottom layers of grain; apply to outside of store; do not use it as it may not work.
My maize cobs are infested with insects, what should I do?	Leave and shell later; remove and shell immediately; dehusk and select good cobs for keeping; use insecticide; sell some/all.
My shelled maize is infested with insects, what should I do?	Clean/select/sun-dry; sell; treat with insecticide and store/sell later.

Effective storage loss reduction programmes involve the farmers in the analysis of their storage problems and in identifying appropriate storage systems and storage management techniques.

The analysis of storage problems will include an assessment of:

- the post-harvest handling methods (harvesting, threshing, drying, transport) and constraints
- the advantages and disadvantages of traditional storage methods
- the causes, extent and value of storage losses
- what the farmer is already doing to minimize the loss
- why the farmer is storing and future expectations
- possible alternative methods of storage loss reduction
- the costs and benefits of existing and alternative methods of loss reduction (cash, material, labour inputs, anticipated market prices).

The extension officer will need to gather information both from groups of farmers and individuals. He/she will also need to supplement the information by his/her own observation of storage systems and other post-harvest practices. The ultimate goal is for the extension officer to be able to advise farmers on a particular option suitable for their individual circumstances.

The participatory approach of involving groups or individuals in deciding which storage management strategy to adopt will be more time consuming and more complex than promoting a single extension message. However, it is likely to be more effective and will result in a higher adoption rate of recommendations.

This manual is not intended to provide detailed advice on extension approaches. However, the following section draws attention to some basic principles which extension officers would be advised to follow when addressing farmers' storage problems.

Group discussions

Within each village community it is possible to identify a number of different groups including: women and men; the old and the young; the rich and the poor; chiefs and elders; ethnic groups; and religious groups.

Who should be involved in the discussions of farmers' storage problems?

At first, everyone should be invited to participate. Discussions involving representatives of all groups in the community allows the extension officer to put storage problems into perspective. It is necessary to understand just how important storage problems are in relation to other agricultural activities. There is little point in spending a lot of time in telling farmers how to store safely for long periods if the village only harvests small quantities of a particular crop.

These discussions can help to identify quickly the most serious problems and to decide on possible courses of action. It may be possible to recommend a single technique that can be adopted by the community as a whole or by the majority of farmers, at least as a first step. For example, in a village that is overrun with rats, the group may decide that a communal effort at rodent control is needed.

Advising individual farmers

The initial group (village) discussion may identify a need to continue the dialogue with smaller, more specific groups. However, individual farmers will also need help in selecting a technique that is suited to their own particular circumstances. For example, a group of farmers wishing to store more grain for longer periods may decide to adopt a similar improved method of storage but each individual may wish to pursue a different storage management strategy. Whilst some may control insects with insecticides, others may prefer to rely on traditional grain protectants, modifications to the storage structure, modified post-harvest handling techniques or a combination of these.

Multiple extension recommendations for storage loss reduction make heavier demands on extension officers who may be more used to delivering a single message to all farmers. The extension officer needs

skills in developing a dialogue with farmers, observation of stores and post-harvest operations, understanding the risks associated with decision making and even being able to perform simple cost-benefit analysis. Secondly extension officers need to be able to put these skills together to advise the farmer in specific storage decision situations.

Decision trees can be useful advisory tools in these circumstances (see pages 8 and 9). The decision tree takes the farmer through a logical series of questions and answers to arrive at a solution. However, decision trees are not the only ways of presenting decision-making information for extension staff. Information may be incorporated into advisory leaflets, summary sheets or tables.

Hints for holding discussions

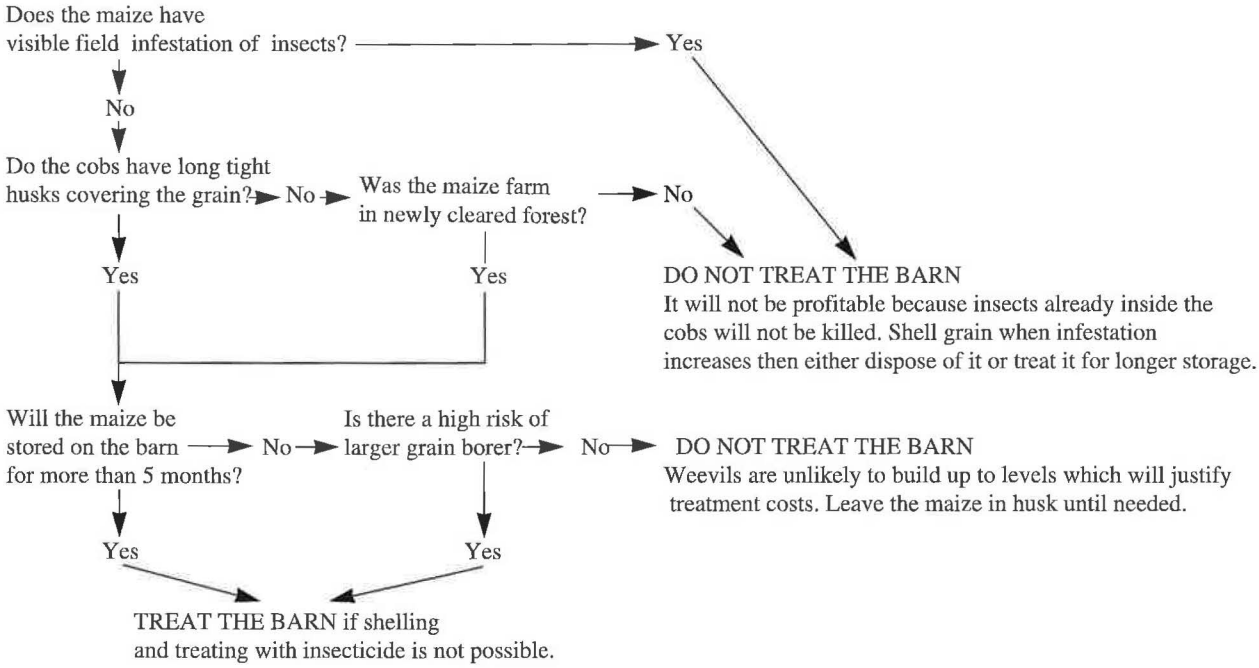
Approaching People

- Be informal but respectful. Know the local customs.
  Try not to stand out too much, for example, by the way you dress or the attitude you adopt.
- For group meetings—plan ahead and choose a time that is convenient for the participants.
- For discussion groups—keep groups small (5–10 people).
  In larger groups, some people may not participate.
- Sit together with the group, informally.
  Explain the purpose of the meeting carefully.

Examples of decision trees

1. Ghana - maize storage

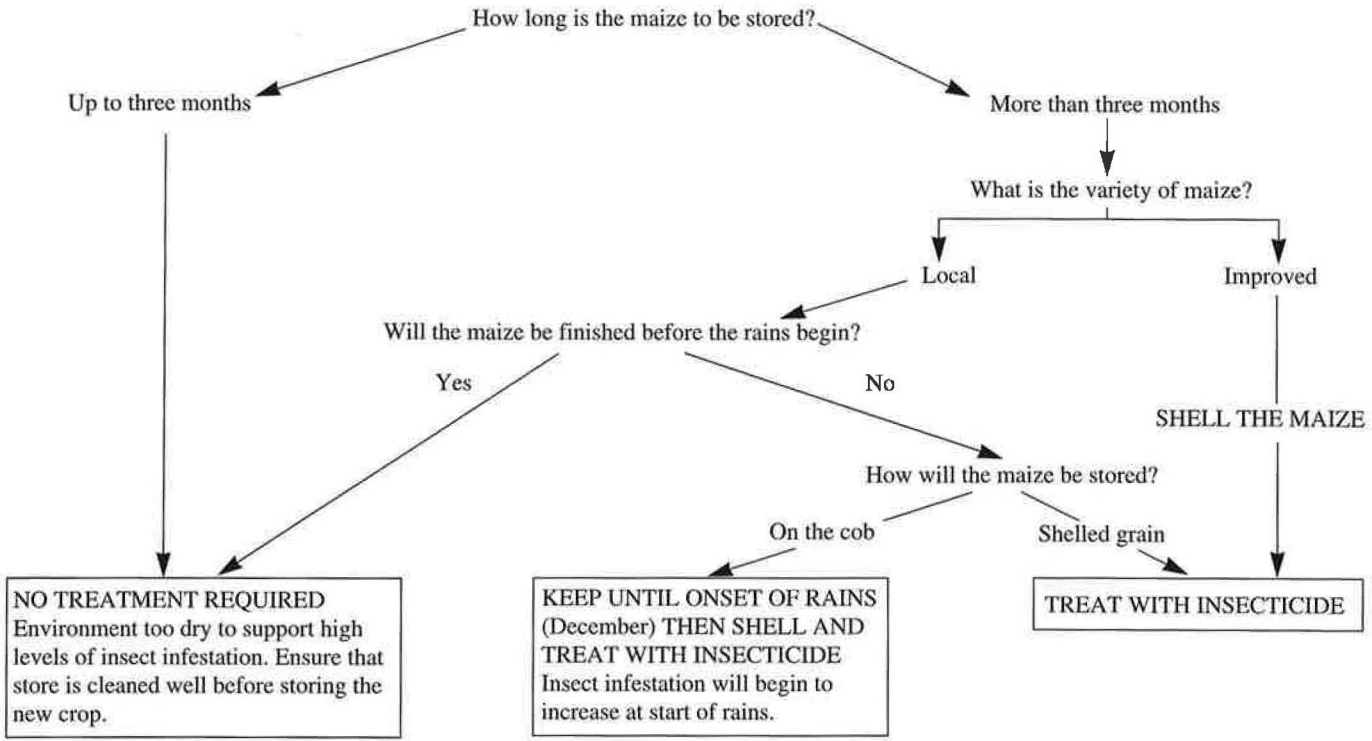
Decision - Should I treat the maize barn with insecticide?



Source: Compton. J. (1997) Managing applied research: experiences from a post-harvest pest control project in Ghana. *Nework Paper* 74 A, London: Overseas Development Institute Agricultural Research and Extension Network.

2. Southern Africa - maize storage

Decision - Should I treat my maize with insecticide?



During the Discussion or Interview

- Encourage farmers to talk while you listen actively, show the farmers you are interested in what they have to say.
- Do not patronize the farmer or make light of the issues raised.
- Avoid using leading questions when the answer is encouraged by the question; these do not help with problem identification.
  Example: 'Are insects the main cause of damage in your store?'
- Ask open questions when you do not show your opinion and there is no correct answer or those which allow the farmer to describe activities.
  Example: What does the insect look like?' or, 'Tell me about the problems in your store'.
- Try not to have preconceived ideas, for example, preferences for certain methods of storage. When visiting new villages do not rely on information provided by colleagues who previously worked there—it may be out-of-date and inappropriate. Experience gained in one district may not be relevant in another because of differences in climate and ethnic traditions.
- Use probing questions if the answer to your question does not give enough information.
  Example: 'You said that local maize was better than hybrid maize. In what way is it better?'
  (Be careful not to ask too many questions, especially if it is culturally discouraged, or if the subject is sensitive.)
- Encourage the farmer, be supportive but do not presume an answer. If not careful completely wrong impressions can be gained.
  Example:
  ***Farmer:** 'Last year I produced two sacks of cowpeas. I sold a lot just after harvest to pay regular debts, ate about half and stored the rest until the next planting season when the prices were high in the market. I had a lot of insect problems. This year I had a bad harvest and only produced two tinfuls.'*

  ***Extension Officer:** 'Oh, so this year you will not store for very long and insects will not matter?'*

***Farmer**: 'No, I will have to store most of the cowpeas in order to have seed to plant next year. I cannot afford to eat much for this reason but I will not sell any. I am really worried about insects because if they damage the grain I will not have any good seed to plant.'*

- Be respectful. Be patient. Do not interrupt, disagree or laugh. This will not encourage farmers to reveal what they really think. *Example: If the farmer says something that sounds strange instead of dismissing the idea you might say: 'That's interesting, I'd like to know more about that. I have never found it in other places where I have worked.'*

- Use observation. If you are advising on storage methods go and look at some stores. This will help to focus discussion, avoid confusion and may reveal 'errors' in what people say. People may not want to reveal certain things for social or status reasons. Do not tell people directly that they said something untrue.

Encouraging Participation in Discussions

Satisfactory analysis of farmers' storage problems can rarely be achieved simply through question and answer sessions. Farmers need to be fully involved and encouraged to take over the activity themselves with the extension officer acting more as a facilitator. There are a number of techniques or 'tools' that can be used to get people involved. Usually everyone will want to join in once they recognize that it is their own activity.

The tools help to show local knowledge and local ways of looking at things. They show differences between people and between groups. This can be useful in developing extension approaches and methods once solutions to problems have been identified. Tools are also a way of training people. People in a group learn from each other as well as providing the extension officer with information.

The following are examples of tools for gathering information for the analysis of storage problems.

- Ranking—Looking at Choices

  Which problems are the most important?
  Which storage technologies or management practices do people prefer?
  Example: List the post-harvest operations related to different crops and then list and rank the problems related to each operation.

- Calendars—Looking at Time

  Which are the busiest times of the year?
  What are the main events in the year?
  Does everyone do the same thing at the same time?
  When do people derive an income from their farming operations?
  Example: Finding the preferred or optimum time for shelling and treating maize with insecticide.

- Mapping—Getting the Picture

  Finding out about an area
  Seeing the farmers' ways of looking at things
  Where do different social groups live?
  Example: Locating stores with special storage problems such as larger grain borer infestation.

- Flows—How the System Works

  Describing the links in the post-harvest system and interaction with the general farming system
  Illustrating the marketing flows
  Identifying the causes and effects of events

- Transects—Short Cuts to Taking a Representative Sample

  Gathering general information on farmer storage practices
  Finding out how common a storage problem is within a community
  Monitoring adoption of rates for recommended techniques.

Providing Advice

- Remember that the identification of farmers' storage problems is the first step in providing advice. Avoid giving advice until the right moment. If farmers think you know best, you may not find out

what they really feel about things. At the end of the meeting you can give your suggestions to help farmers make their own decisions.

- Work in the local language. Avoid using English or technical terms: some farmers will understand but probably, some will not.
- It is useful to anticipate problems which may arise and have solutions to hand.
  Example: If there have been bad experiences with insect problems in the area it is useful for the extension officer to hand-carry samples of an appropriate insecticide to the village.

Extending Information to Groups

A variety of methods can be used to extend information to groups of farmers. Use informal teaching methods as far as possible. Avoid teaching by rote; although this is a traditional method of teaching in schools and colleges it is inappropriate here.

Some of the methods which can be used include:

- open discussions facilitated by the extension officer who provides relevant information as necessary: this allows farmers to draw their own conclusions and make their own decisions
- drama, song, poems; this can be accomplished with villagers participating as well as forming the audience
- demonstrations of solutions, for example, showing how to treat grain with insecticide dust
- illustrating problems and solutions with visual aids such as samples of insect pests, damaged and undamaged grain, packets of insecticide
- flip charts with diagrams or messages prepared beforehand and/or with blank sheets to record farmer responses
- posters and videos where equipment is available.

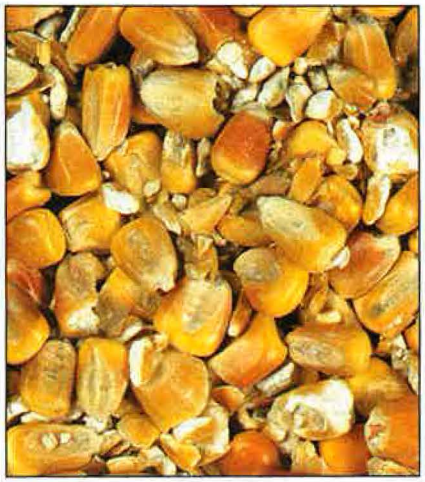
3. Spoilage of Stored Grains and Pulses and Methods of Prevention and Control

The principal causes of spoilage of stored grains and pulses are:

- moulds
- insects
- rodents
- birds.

Moulds

Moulds are growths that develop on the surface and inside of stored grains and pulses that have not been dried properly or become wet during storage. The grains become discoloured, caked together and eventually rot. Mould damaged grain has a bad, musty smell.



Grain spoilt by moulds should not be consumed. Moulds produce poisonous substances that can be hazardous to humans and livestock.

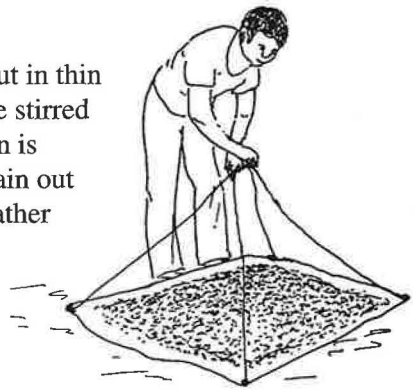
Prevention and control

The occurrence of moulds can be prevented by making sure that the

grain is dried as quickly as possible to a moisture content that is low enough for safe storage. Once in store it must be kept dry.

- Sun-drying

Grain can be dried by spreading it out in thin layers in the sun. The grain should be stirred during sun-drying so that all the grain is exposed to the sun. Spreading the grain out to dry on a sheet of cloth or plastic rather than on bare earth reduces contamination and enables grain to be gathered quickly and protected from rain.



- Field-drying

If the crop ripens during the rainy season, harvesting may be delayed to allow the crop to dry as much as possible in the field. The harvested crop should be heaped on a bed of straw, palm fronds, etc., and not directly on the ground before threshing. Remember that the longer the crop remains in the field the more likely it is to be attacked by storage insect pests.

- Drying frames or platforms

Unthreshed grains and pulses can be hung on a wooden frame or heaped on a platform to dry. Lighting a fire underneath the platform can help increase the rate of drying.

Some platforms are used for both drying and storage.

- Drying cribs

Open-sided cribs have a dual function of storage and drying. They are suitable for drying maize cobs and unthreshed sorghum.

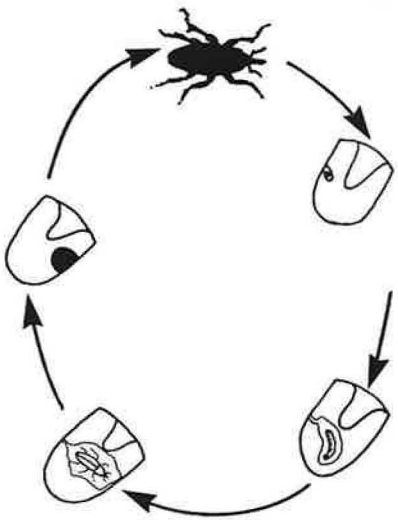
- Protecting the stored commodity

When the commodity has been put into store it must be kept dry. The roof must be rain-proof and the walls protected from driving rain to stop water entering. Grain must not be kept directly on the floor because moisture rising through the floor will be absorbed by the grain and it will spoil.

Insects

Insects are usually the most serious pests of stored grains and pulses. They cannot easily be excluded from stores.

Most damage due to insects is often caused by the immature (larval) stages which develop inside the grains, although it is the adult stage that is most commonly seen.



Life cycle of the weevil *Sitophilus* sp., a common grain pest

Insect infestation in stored grains and pulses causes weight loss and deterioration in quality. The insects produce heat and moisture and waste products during their development and this can create conditions suitable for further deterioration and the growth of moulds.

A new and destructive storage pest, the larger grain borer (*Prostephanus truncatus*) was introduced to sub-Saharan Africa in the early 1980s. The pest was first reported in Tanzania and has since spread to other countries including Kenya, Burundi, Malawi, Zambia, Ghana, Benin and Togo. The larger grain borer infests mainly maize and dried cassava and can easily result in losses double those caused by the usual storage pests.

It is important to be able to recognize the most important species of insect and to have a basic knowledge of their behaviour in order to choose the best method of control. Not all insects found in grains and pulses are pests and controlling them with insecticides will be a waste of money. Some insects are more difficult to kill than others.

Some common insect pests found in farm stores

Acanthoscelides obtectus
(Bean Beetle)

(Life size 3.0-4.5 mm)

***Callosobruchus* spp.**
(Pulse Beetles)

(Life size 2.0-3.5 mm)

Prostephanus truncatus
(Larger Grain Borer)

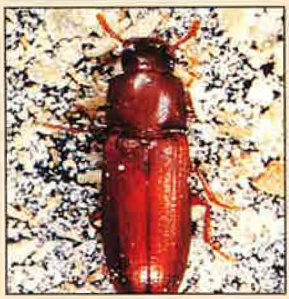
(Life size 3.0-4.5 mm)

Rhyzopertha dominica
(Lesser Grain Borer)

(Life size 2.0-3.5 mm)

***Sitophilus* spp.**
(Maize and Rice Weevils)

(Life size 2.5-4.5 mm)



Tribolium castaneum
(Rust-Red Flour Beetle)

(Life size 1.5-2.0 mm)

Sitotroga cerealella
(Angoumois Grain Moth)

(Life size 10-18 mm)

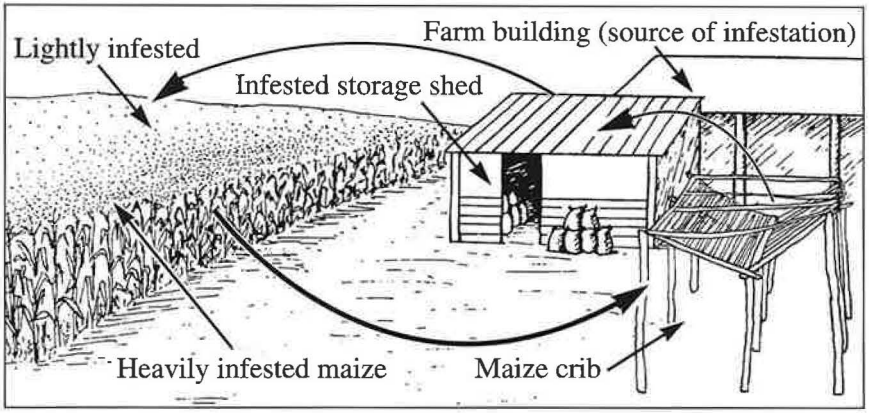
How do Insects get into Stored Grain?

Insects can get into grain in a number of ways.

Some storage insects lay their eggs on or in the grain as soon as it ripens before harvesting, or whilst the grain is drying between harvesting and storage. The larval stage develops inside the grain and the infestation will not be noticed when the crop is first put into store.

This field infestation can arise from grain residues left on the ground from the previous harvest. It can also arise when grain is stored near to the fields. Insects from the store can fly out to infest the ripening crop.

Some insects can fly from the fields into the grain store, especially if the store is close by. In the village they can also fly from store to store.



Farmers use the same store year after year. If the store is not cleaned cracks in the structure may fill up with dust and pieces of broken grains. Insects can live in these residues from one season to the next. They can then emerge and attack new grain that is put into the store.

Controlling Insects in Stored Grain and Pulses

- Early harvesting

The risk of storage insects attacking the crop in the field can be reduced by harvesting as early as possible after the crop has dried.

- Selection of pest resistant varieties

Local or traditional varieties of maize and pulses are usually less susceptible to insect pest attack than the new high yielding ones. Local varieties may be stored for longer periods whilst the high yielding varieties may be sold earlier. Experience will show which of the new varieties show resistance to pest attack and these can be chosen for longer term storage.

Maize cobs with good husk cover (thick, long and tight fitting husk) will suffer less insect damage. If maize is stored on the cob, selecting cobs with good husk cover at storage will help to reduce insect damage.

- Sun-drying

Insects can be killed by exposure to high temperatures during sun-drying. The infested produce should be spread out in a thin layer on a mat or other suitable floor covering. The layer should be thin enough to heat up all the way through. If the layer is too deep, insects will move down into the cooler layers and will not be killed.

Sun-drying will not kill all the insects present and the procedure may have to be repeated a few weeks later. Sun-drying is not effective against the larger grain borer.

- Admixing dusts or ashes

The mixing of ashes and dusts with threshed grains and pulses that are well dried is a popular traditional method of controlling insects.

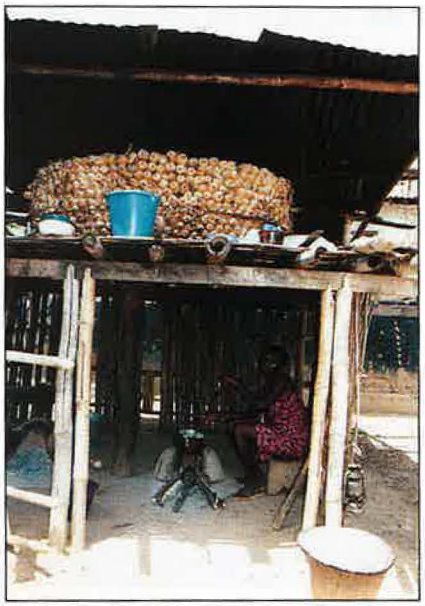
The ashes and dusts form a layer over the surface of the grains which prevents insect attack. They also fill the spaces between grains and act as a physical barrier. To be effective they should be used in large quantities, at least 20% by volume.

Before the grain is used the ash or dust must be removed by sieving, winnowing or washing.

- Treatment with oils

Some vegetable oils when mixed with grains and pulses provide some degree of protection against insect attack. Usually a large quantity of oil is needed which makes the treatment expensive, except for high value commodities. Treatment of pulses can be very effective.

- Smoking



Maize cobs, unthreshed grains and pulses can be stored on platforms or in the loft of the house above a fire. The smoke and heat from the fire may kill insects or drive them out of the grain. The method is not always effective and is certainly not effective against the larger grain borer.

- Mixing with plants

A traditional method of protection against insects is to mix dried or fresh leaves or other plant parts with grain and pulses before storage. Numerous plants are used in this way, common ones being neem and pepper. However the field effectiveness of many of the plant materials used as insecticides is not well known.

- Insecticides

Insecticides, when properly applied to stored grains and pulses can offer long-term protection against insect attack. Insecticides are usually

applied to dry, threshed or shelled grain. This minimizes the amount of insecticide required and provides good protection. It can be difficult and expensive to apply insecticides to maize stored on the cob or to unthreshed grains and pulses.

Insecticide Powders

Insecticide powders are recommended for use by the small-scale farmer because:

- they contain a low concentration of insecticide, making them safer to handle than some of the other concentrated formulations
- they are ready to use
- they are supplied in small packets making the calculation of dosages easier.

The instructions given on the packet will tell you how much powder to use. The packets usually contain sufficient powder to treat one or two bags of grain. Insecticides must be applied at the recommended rate of application stated in the instructions. If too little is used it will be ineffective. If more than the recommended amount is used it is wasteful, it will not kill more insects and the grain may not be safe to eat.

Use only the insecticide powders that are labelled for mixing with food grains; dusts labelled for treatment of seed grain should never be mixed with grain intended for food.

Powder Sprinklers

Insecticide powders must be applied evenly. They are best applied using an applicator made from a tin or a piece of sacking.

The powder sprinkler can be made from a clean tin with a well fitting lid; a dried milk tin is ideal. About ten holes should be made in the lid of the tin using a 5 cm (2 inch) nail or similar pointed tool.

The other type of sprinkler shown is a small bag about 30 x 40 cm (12 x 16 inch) made from an old sack. To make this bag cut off a piece of sacking 60 x 40 cm (24 x 16 inch). Fold the sacking in half and stitch the two opposite open sides to make a bag.

Insecticide applied from the tin or bag by gentle shaking will settle as a fine layer of dust on treated grain or store surfaces.

How to Mix Insecticide Powders With Threshed Grain

Make sure the grain is clean and dry.

If the grain is already infested, remove dust, insects and damaged grain by sieving and winnowing. Burn the rubbish.

Put aside any grain that will be needed for immediate use or consumption.

Estimate the amount of grain to be treated and work out how much insecticide will be needed.

Make a suitable powder sprinkler that can hold the right amount of insecticide.

There are two different methods for mixing insecticide powder with threshed or shelled grain: mixing with a shovel or layer by layer treatment.

- Mixing with a shovel

This is a quick, easy method for mixing powder with grain heaped on the floor. If the floor is concrete the mixing can be done on the floor itself. If the floor is earth the grain must be emptied onto a polythene or metal sheet or onto a tarpaulin spread on the floor and not onto the bare earth. Sweep the floor, sheet or tarpaulin before starting to mix the insecticide.

Treating one or two bags at a time

This method can be used to treat up to 180 kg (400 lb) at a time.

Pour the grain to be treated into a heap on a clean floor, sheet or tarpaulin.

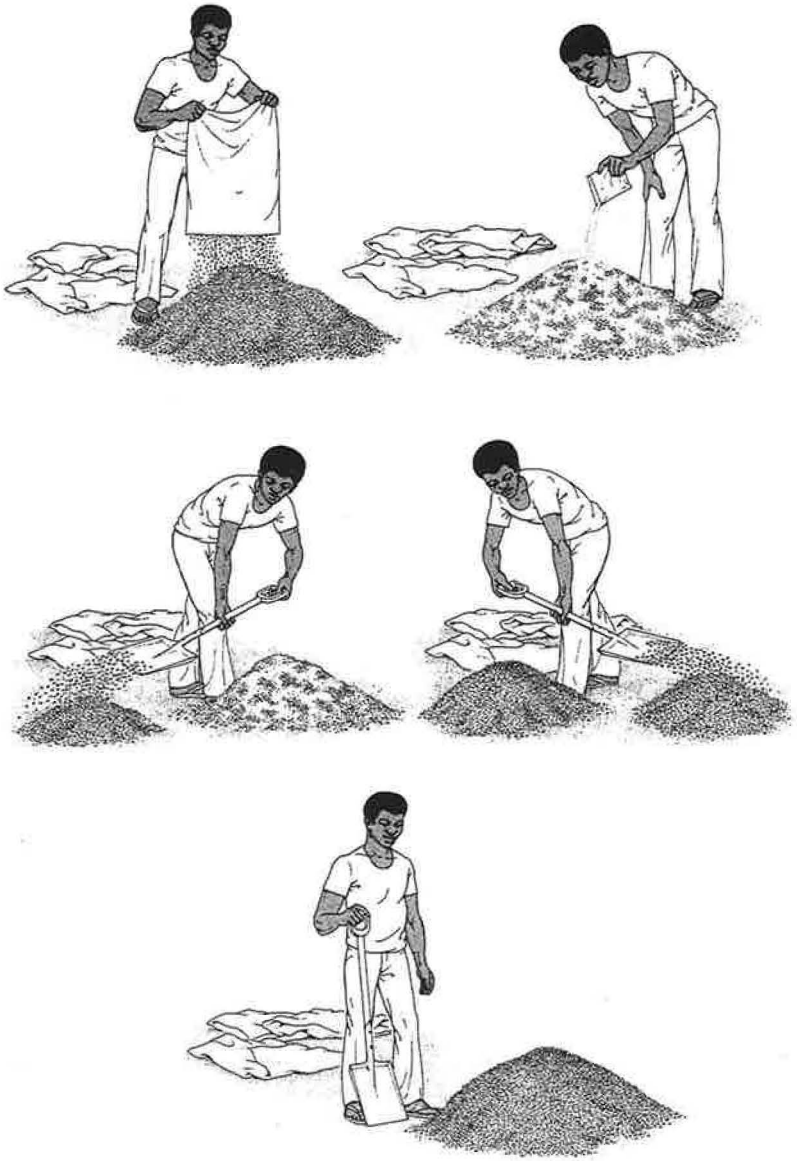
Sprinkle the correct amount of insecticide powder over the heap.

Gently mix the insecticide powder into the heap until all the grains are evenly coated. No patches of powder should be seen in the heap. Use a clean shovel, hoe, bowl or piece of flat wood to mix the insecticide into the grain.

Store the treated grain in a clean bag or container.

Treating larger quantities of grain

This method can be used to treat up to 1000 kg (2200 lb) at a time.



Pour the grain to be treated into a heap on a clean floor, sheet or tarpaulin.

Sprinkle the correct amount of insecticide powder over the heap.

Mix the insecticide powder into the heap of grain by shifting the heap from one spot to another using a clean shovel, hoe, bowl or piece of flat wood. Repeat this three or four times until the insecticide is properly mixed and no patches of powder can be seen.

Store the treated grain in clean bags, containers or stores.

- Layer by layer treatment

This method is suitable for treating grain while filling the store. The way to do this is similar to that described for treating maize on cobs (see below).

Sprinkle the inside walls and floor of the store with a layer of insecticide powder.

Pour the grain into the store and spread it to a depth of about 10 cm (4 inch).

Sprinkle the insecticide powder evenly over the layer of grain and add a second layer of grain about 10 cm (4 inch) deep.

Sprinkle this second layer with insecticide as before. Continue filling the store and applying insecticide as before until the store is full or until all the grain has been treated.

How to Apply Insecticide Powders to Maize Stored on the Cob

NOTE: This method can be used to treat other grains that are stored unthreshed, for example, finger millet, bulrush millet and sorghum stored on the head.

Treatment of cobs is recommended if the maize cannot be shelled and treated with insecticide. (Shelling and treating is better because it requires less insecticide and insects are controlled better.)

Clean the store and remove all old maize cobs, maize grains and rubbish.

Work out how much insecticide will be needed to treat the maize according to the manufacturer's recommendations.

If the maize cobs are not dehusked before storing, remove any cobs that have poor husk cover or show signs of damage. Store only clean cobs with good husk cover.

Treat the maize cobs layer by layer as they are stored rather than before putting them into store because this will avoid wasting insecticide.

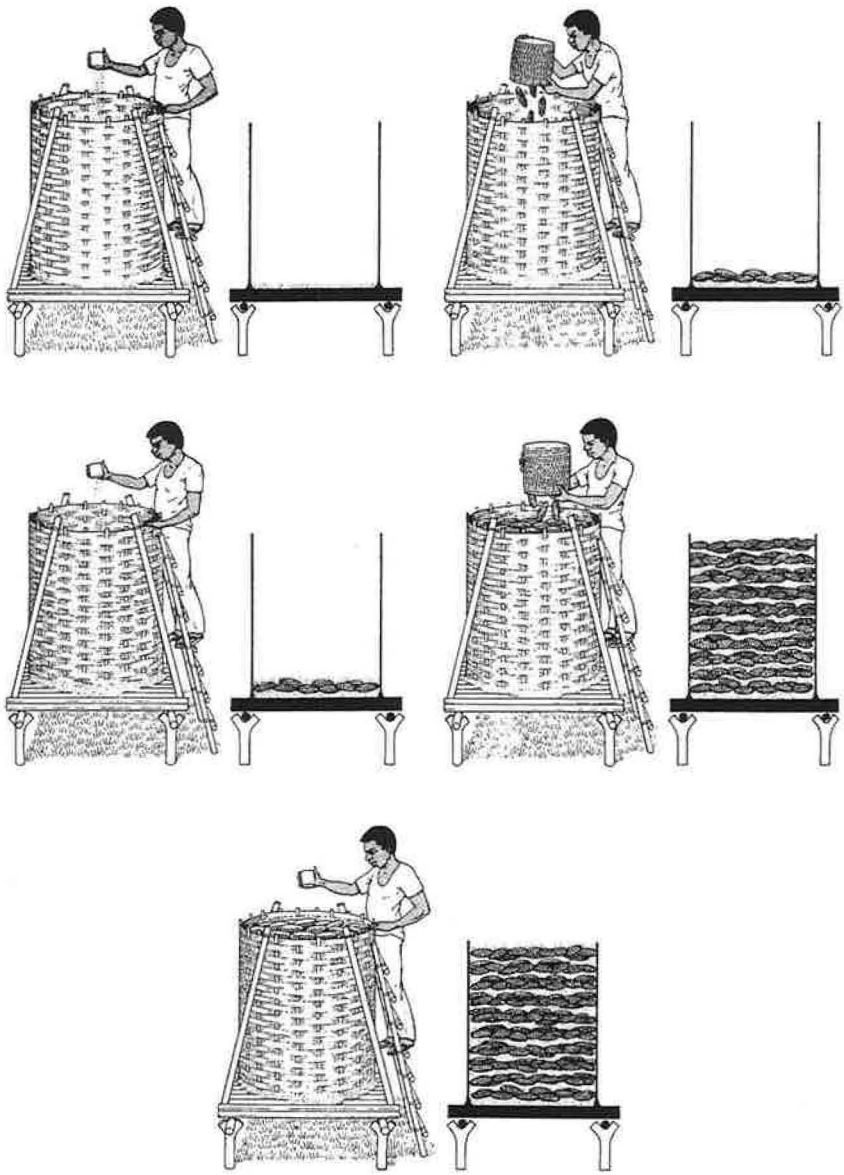
Sprinkle insecticide powder over the storage platform or the walls and floor of the store.

Stack a layer of cobs in the store and sprinkle insecticide powder evenly over the surface so that the cobs are covered with a fine layer of powder. Put another layer of cobs on top of the first and apply powder dust as before.

Continue filling the store with layers of cobs, sprinkled with insecticide powder until all the cobs are stored or the store is full.

Finally sprinkle insecticide powder on the top layer of cobs and close the store in the usual way.

If the cobs are stored on a platform in the open, cover the stack with a thatch roof.



How to Apply Liquid Insecticides to Maize stored on the Cob

It may be necessary to treat maize cobs of high yielding varieties with an insecticide when they are stored in cribs or baskets. Treatment is recommended if the maize cannot be shelled and treated with insecticide. (Shelling and treating is better because it requires less insecticide and insects are controlled better.)

Clean the store and remove all old maize cobs, maize grains and rubbish.

Work out how much insecticide concentrate will be needed to treat the maize according to the manufacturer's recommendations.

Mix the insecticide concentrate with the correct amount of water according to the manufacturer's recommendations.

Put the insecticide into a sprayer. Alternatively make a suitable applicator. Find a container with a well fitting screw lid. Punch small holes in the lid.

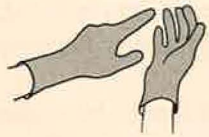
Spread the cobs to be treated in a single layer on the ground. Sort out and remove any cobs that show signs of damage. Store only clean cobs.

Apply the insecticide to the cobs using the sprayer or applicator.

Apply the insecticide to the inside of the store (crib or basket) before filling with treated cobs.

WORK SAFELY WITH INSECTICIDES

When handling and mixing insecticide concentrate avoid spilling the liquid onto the skin.
If possible wear rubber gloves.



Do not smoke, drink or eat while applying insecticides with grain.

When the treatment is finished—wash hands and face with soap and plenty of water.

Dispose of empty insecticide packets and containers carefully—burn or bury them.

Store any unused insecticide in closed airtight containers in a cool dry place, away from treated grain and where it cannot be reached by children or domestic animals.

Rodents

Rats and mice damage storage containers, eat some of the stored produce, carry some away to their nests and spoil much more with droppings, urine and hairs. They usually spoil more than they actually eat. They chew through bags allowing produce to spill out.

Rodents are good climbers and can jump very effectively. They can easily gain access to most traditional grain stores because the materials used for store construction provide little or no barrier.

Rodents can chew holes in baskets and woodwork of stores and burrow through mud floors and walls to get at stored grain.

Only stores constructed from metal, brick or concrete are likely to protect stored grain against rodents.

Control of Rodents

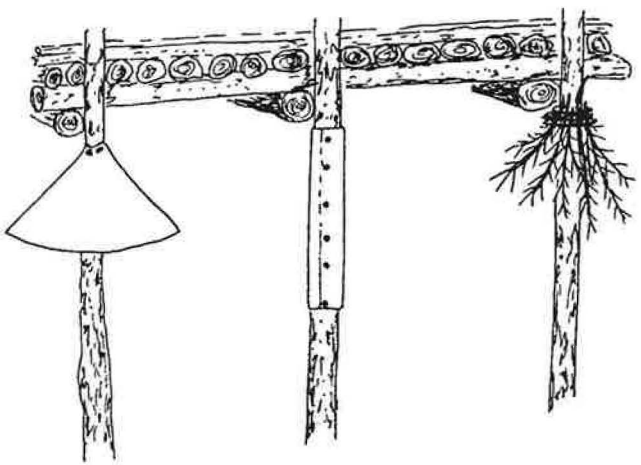
The most effective means of controlling rodents is to keep the store clean and tidy and to have adequate rodent proofing.

In the village, eliminate breeding sites for rodents. Keep the compounds and surroundings free from rubbish.

Rats and mice will stay in a grain store only if they can get food easily and find somewhere to make a nest. Keep the area around the store clean. Remove all spilt grain, rubbish, empty sacks and household items that may harbour rodents.

Put rat guards on the legs of grain stores. Rat guards will only work if the store is raised at least 1m off the ground and there are no plants or poles close to the store up which the rats and mice can climb. Build the store at least 1 m away from buildings and trees.

Cats and dogs will help to frighten rats away.



Use traps inside the house or store room. Rodents usually move round the base of the walls of a room so place traps on the floor by the walls or in the corners.

Poisoning of rodents with rodenticides is not recommended at the small-farm level in most cases. Although they kill rodents more may soon arrive.

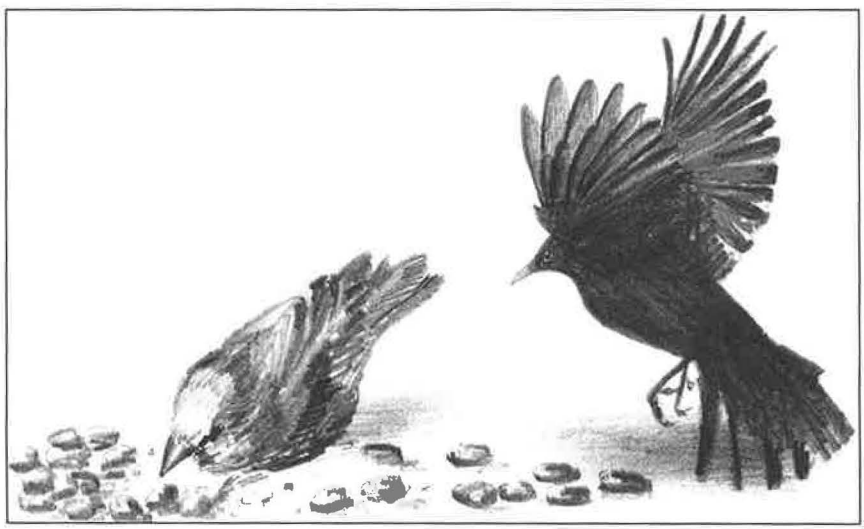
Many rodent poisons are dangerous chemicals and are a potential health hazard to man and animals unless used by a person with special training in rat control.

Birds

Some species of birds commonly feed on stored grain. Birds can consume large amounts of grain. They also contaminate the grain with their droppings and feathers.

Damage and loss of stored grain can be reduced by preventing birds from entering the store. Keep the store in good condition. Keep the entrance or door to the store closed.

Keep the area around the store and compound clean. Birds will be attracted by spilled grain.



4. Good Storage Practice

Good storage practice means:

- making sure that the crop is in good condition for storage
- keeping the store in good condition
- practising good storage hygiene
- making sure that the crop and the store remain in good condition throughout the season.

Making sure that the crop is in good condition for storage

Good quality grain is less likely to suffer insect attack than poor quality grain.

Check the grain in the field before harvest. Make sure the grain is free of insects and disease. At harvest time separate out grain which shows signs of infestation or damage. If infested or damaged grain is to be used then use this first.

Clean the grain carefully by sieving or winnowing. Remove straw, chaff, weed seeds, dirt and stones. These materials will hold water so grain will dry better when they are removed. Sweep up the rubbish and burn it.

Dry the grain well. Good drying is important. Damp grain will become mouldy. Properly dried grain is less likely to be attacked by insects. Keep the grain off the ground while it is drying. Place maize cobs, unthreshed millet and unthreshed sorghum on platforms or in cribs. Spread threshed grain on mats or trays to dry in the sun.

Sun-drying will help get rid of insects in the grain. Weevils will walk away from grain spread in the sun or will be killed if the grain gets hot.

When the grain is dry look carefully again for insects. If insects are still present, remove them by sieving and winnowing the grain. Sweep up the insects and burn them.

Sun-drying and sieving and winnowing will only remove the adult insects. The eggs and larvae of many storage pests develop inside the grain. If insects have been found mix the grain with an approved insecticide before storing. This will kill the adults when they eventually come out of the grain.

Keeping the store in good condition

A good store should keep the grain cool and dry. It should also protect it from rodents, birds, farm animals and thieves. Most stores except some solid wall stores that can be sealed, do not provide a barrier to entry by insects.

Build the store in a well-drained location. Build the store away from branches of trees otherwise rats may be able to jump from the branches onto the store.

Keep the store under a roof that will provide shade and keep rainwater out.

Raise the store off the ground to prevent water soaking into it and to prevent rodents and farm animals reaching the stored grain.

Fix rat guards to the legs of the grain store to stop rats from climbing into the store.

Keep the grain store clean. Remove grain residues and rubbish. Burn the debris.

Practising good storage hygiene

This means keeping the store and the area around it clean and free of breeding sites for pests. Rats and mice will breed in rubbish heaps. Insects will breed in old stocks of grain. Remove all rubbish from around the store, clean out old grain residues, dirt, straw and chaff from the store and burn it.

Clean the containers that grain is to be stored in.

Clean grain bags thoroughly by turning them inside out and brushing

them to remove grain residues. Dip the bags in boiling water to kill any insects present, dry the bags in the sun. Repair holes.

Do not mix new grain with old. Store old grain separately and use it first.

Insects which hide in the timbers, basketwork or thatch of grain stores are difficult to kill. Spraying the empty store with an appropriate insecticide may help to reduce insect infestations.

SPECIAL TREATMENT IF LARGER GRAIN BORER IS PRESENT

Spraying the store will not be effective against the larger grain borer which can bore deep into timber. If the store has been infested by the larger grain borer in the previous year the risk of damage to the new crop may be reduced by changing any wood that shows signs of larger grain borer damage. Burn the discarded wood quickly. Do not keep it long because firewood because the larger grain borer may come out of the timber to infest newly stored grain.

Making sure that the crop and the store remain in good condition throughout the season

If insect infestation in the stored grain is expected, treat the grain with an approved insecticide before storing. Insect infestation might be expected if:

- the farmer's store was infested in the previous season
- the crop was infested in the field before harvesting, or during drying
- a neighbour's store is infested.

Rats, mice, birds and insects may attack the store at anytime. Look at the store regularly so that signs of pest attack are found early and action can be taken before the damage becomes too severe.

Look for insects and signs of insect damage such as holes in the grain, large amounts of dust in the grain, on the outside of maize cobs or on the outside of bags.

If insects are found take action quickly to control the infestation as follows.

For Maize Stored on the Cob

Shell the maize and treat it with an approved insecticide.

As cobs are removed from store, put the heavily damaged ones to one side for immediate use or disposal. Burn unwanted cobs and damaged grain that cannot be used.

For Shelled Grain and Pulses Stored in Bags, Baskets or Bins

Remove the grain from store and get rid of as many adult insects as possible by sun-drying or sieving and winnowing the grain. Sweep up the dust and insects and burn them. If the grain is not going to be used immediately, mix it with an approved insecticide before storing again. Clean the bags, baskets or bins before putting the grain back.

Look for signs of mould damage. If maize cobs become mouldy remove them and dry them in the sun. Check grain stored in bags by smell. If the grain is going mouldy it will have a bad smell. Spread the grain in the sun to dry and then store it in clean dry bags.

Repair the store quickly if it becomes damaged. If repairs are delayed a lot of grain may be lost to rats, mice and birds.

5. Choosing a Storage Method

Traditional methods of on-farm storage that have evolved over long periods are generally well suited to agro-climatic regions and social needs. They will continue to meet the needs of many small-scale farmers and are the obvious choice for farmers where practicable. Consideration should be given to transferring techniques that are working well in one area to other areas where conditions may be similar.

However, there will be other groups of farmers who may need to improve their existing method of storage or change it completely for various reasons including:

- a need to hold more grain for longer periods at the farm
- a need to reduce loss caused by pests
- a shortage of local traditional construction materials as supplies of timber and thatch for roofing become exhausted
- availability of alternative construction materials such as plastic sheets and galvanized roofing sheets
- the loss of traditional store construction skills such as basket making or mud silo construction, when these are not passed on to the younger generation.

Improved storage systems include: modifications to traditional systems and introduction of new store types that incorporate or are made entirely from industrially produced materials, such as prepared timber, cement and galvanized iron sheets. Farmers may have difficulty in accepting improved storage systems unless they can see the benefits for themselves and are able to afford them. The individual farmer's level of production and dependence upon storage will influence his/her willingness or ability to change and the type of storage adopted.

Subsistence farmers

Subsistence farmers rely on their own production to feed their families. They are the most vulnerable group and the most dependent upon storage. They may not produce enough food for their own requirements

and the shortfall may be made up by labouring for others and receiving payment in cash or in kind. These farmers are likely to grow more traditional varieties than improved high yielding ones and risk of insect damage in stored grain may be relatively low.

Subsistence farmers cannot participate in serious grain trading and are unlikely to have cash to invest in storage. Their storage systems will be the simplest and cheapest possible and may include bags and small baskets or other containers made from natural materials. Only simple, low-cost or no-cost improvements will be possible. The farmer will have to rely mainly on basic good storage management and use of traditional methods of pest control to minimize losses.

Subsistence farmers with some cash-cropping

These farmers depend on the major part of their production to feed their family but have a modest surplus to sell. They are likely to grow a mix of traditional and high yielding varieties. Traditional varieties will be mostly for home consumption and the high yielding varieties for sale. If the surplus is not sold immediately after harvest some additional storage will be necessary. They will have some cash to invest in storage.

The farmer's storage options will be similar to those of the subsistence farmer but will also include construction of additional improved stores and storage of grain in bags, either in the house or in a separate store. Some farmers will have to invest in insecticides to protect their grain, especially if they have to store high yielding varieties that are more susceptible to insect attack.

Cash-crop farmers with some grain for consumption

These farmers depend on only a minor part of their production to feed the family and produce a larger surplus for sale. In the past this surplus may have been stored for some time to take advantage of seasonal price rises or more likely will have been sold soon after harvest.

Traditional storage facilities may be used but investment by these farmers in new, improved, long-term storage systems and storage insecticide are likely to give a good return.

Farmers with double-cropping and alternative staples (root crops)

These farmers may be small- or medium-scale producers. They can harvest more than one grain or pulse crop each year and have the opportunity of growing a staple root crop. They will be less dependent upon storage from one season to the next and their storage requirements for surpluses may only be medium term.

Multiple cropping may mean that one crop has to be harvested in the rainy season and this may lead to problems in drying, handling and storage.

These farmers require a flexible storage system that can: cope with crops that are harvested under wet or dry conditions; conserve grains and pulses in the medium to long term; and be adapted for uses other than grain storage, e.g. storage of root crops.

Traditional and improved methods of storage

The commonly used methods of storage for the major grain and pulse crops are summarised below.

The descriptions of the basic types of store which follow are generally suitable for storing up to 2 tonnes of grain, some may hold more. The designs and construction may vary from region to region.

Grain crop	Methods of storage							
	Raised platform or frame	Drying/storage crib or basket	Basket	Mudded basket/mud granary	Metal bin	Brick bin	Bags	Underground pits
Cob maize	✔	✔	✔					
Shelled maize			✔	✔	✔	✔	✔	✔
Unthreshed sorghum	✔	✔	✔					
Threshed sorghum			✔	✔			✔	✔
Unthreshed millet	✔	✔	✔					
Threshed millet				✔			✔	✔
Wheat			✔	✔	✔	✔	✔	
Unthreshed pulses	✔		✔					
Threshed pulses				✔	✔	✔	✔	
Rice				✔	✔	✔	✔	
Groundnuts	✔	✔	✔	✔		✔	✔	

Raised platforms and frames

Construction and Use

Platforms constructed in the open may be four cornered or circular racks made from timber or bamboo. They are usually raised on legs about 2 m from the ground. Grains and pulses are stored unthreshed in heaps or in regular stacks.

The commodity may be placed on the platform soon after harvest and so the structure can be regarded as a drying and storage system. A fire, often the cooking fire, may be lit underneath the platform to speed up drying and to deter pests. The platforms may be completely covered with a detachable thatch roof, which can be lifted off from time to time to aid drying or to remove produce. In humid areas unshucked maize on the cob may be stacked in layers to form a cylindrical stack which is then covered by a cone-shaped roof.

Instead of being flat, the platform may be cone-shaped with the point at the bottom. These platforms, common in humid areas facilitate drying. Other variants of the flat platform include platforms or racks constructed inside the house, often over the cooking fire and a storage loft below the roof of the house, kitchen or general storage building.

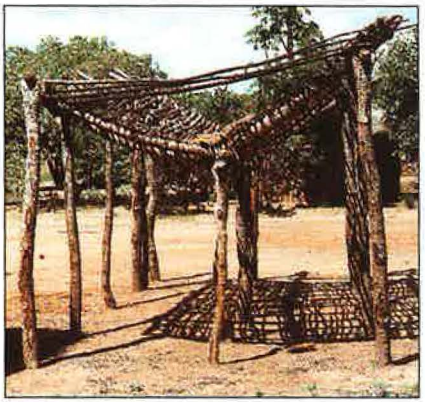
Drying frames consisting of narrow timber or bamboo poles fixed horizontally to heavy upright poles embedded in the ground can be used for holding maize cobs or unthreshed sorghum heads during drying.

Platforms and frames can be made at minimal cost from local materials. Improvements to platforms in the open are limited to the fixing of rodent guards to the legs.

Loading and emptying platforms and frames is easy although skilled stackers may be required when maize cobs are stacked in layers on platforms.

Platforms and frames provide no protection against theft.

Drying/storage platform, West Africa



Drying/storage platform, East Africa

'Ewe' barn, West Africa

Cone-shaped platform

Drying/storage frame, East Africa

Maintaining Grain Quality

The quality of grain stored on platforms will be influenced by: the presence of pest infestation; design and construction and the variety of the grain being stored.

If a fire is lit underneath the platform the smoke and heat may kill insects or drive them out of the grain.

Treating produce stored on platforms with insecticide may be difficult, except in the case of maize cobs in regular stacks. (*See 'How to apply insecticide powders to maize stored on the cob' page 28.*)

Drying/storage crib

Construction and Use

Traditional cribs are circular or rectangular with a framework of wooden poles.

Ideally, the crib should be between 0.5 m and 1.5 m wide and it should be erected in the open, with the long side across the prevailing wind.

This will ensure good ventilation and drying. Grain dries better in a narrow crib.

Walls can be made from raffia, bamboo, poles, sawn timber or wire netting. At least half of the wall area should be open to ensure good ventilation. Roofs can be of thatch or corrugated iron sheets. The floor of the crib should be at least 0.7 m above ground level and legs should be fitted with rodent guards.

Cribs are primarily intended for drying produce, especially maize on the cob. If they are to be used for storage after drying is complete the walls of the cribs should be covered with mats to protect the grain from driving rain.

Traditional cribs can be made at minimal cost when local materials are readily available. Improvements can be made using both traditional and non-traditional materials. The cost of cribs will increase if materials have to be bought and if a builder is employed.

Cribs provide flexibility in use. They can be used for drying grain (usually maize cobs) and then for storage of shelled grain in sacks. They can also be modified easily for storing other commodities such as root crops. Cribs can be used to hold early harvested maize cobs so losses during field drying are lower. They also allow land to be cleared and prepared in good time for a new crop.

The open structure allows for easy cleaning and for periodic inspection for grain quality. Loading and emptying is relatively easy through the open framework or through a door in the end wall. Segregation of several different lots of grain is not very practicable (although it may be possible to fit one or two partitions).

Traditional cribs usually require a high level of maintenance and may have to be replaced completely after 2–3 years. Improved cribs made with sawn timber and with metal roof sheets may last for about 10 years. Improved cribs made of local materials will not last as long. Maintenance costs will be higher as side timbers may have to be renewed and thatch replaced.

Stored grain is on display in a crib and thus reveals the size of the farmer's harvest. It may be difficult to protect against theft.

Cribs may be attractive to farmers wishing to hold damp grain on the farm for longer periods. However, their adoption may be constrained by shortage of local wood and thatch.

Maintaining Grain Quality

The quality of grain stored in cribs will be influenced by: local climate; the presence of pest infestation; design and construction; and the variety of the grain being stored.

The maximum width of the crib is determined by climatic conditions. To ensure that maize dries properly and mould spoilage is avoided the maximum width should be as follows:

- 0.6 m in humid areas where maize is harvested at high moisture content (30–35%)
- 1.0 m in drier zones with a single rainy season where maize is harvested about 25% moisture content
- 1.5 m in very dry places.

It will usually be necessary to treat produce, especially of maize cobs of high yielding varieties, with an insecticide at the time of storing. (*See 'How to apply insecticide powders to maize stored on the cob' page 28* and *'How to apply liquid insecticides to maize stored on the cob' page 30.*)

Produce should be inspected regularly. If insects are seen the grain should be threshed or shelled as quickly as possible and mixed with an approved insecticide, and then stored in bags or other containers.

When maize cobs are removed, the heavily damaged ones should be set aside for disposal. If damaged cobs are to be used, they should be shelled quickly and the grain kept separate for immediate use.

Baskets

Construction and Use

Baskets with an open weave are suitable for drying grain, e.g. sorghum heads and maize cobs. Dry, shelled grain can be stored in close weave baskets or baskets that have mudded walls.

Mudded walls provide protection from rain, strengthen the structure and prevent uptake of moisture by dry grain.

Baskets may be used for drying and storage. They can be used without mud plaster for the drying phase and then plastered for the storage period. Baskets may have tight-fitting lids and some may have additional loading or unloading hatches.

Basket stores can be kept inside the house or outside in the open. They should be raised off the ground, placed on stones or brick foundations or on a wooden platform to prevent uptake of ground moisture. If they are kept outside they should be placed under a shelter or have an extended thatched roof to provide protection against rain and shade from the sun.

Traditional basket stores are built in different shapes and sizes. Small baskets are easily portable. All basket stores are suitable for storage of both unthreshed and threshed grains and pulses.

The material costs will be low for baskets made entirely from local materials. Village specialists may be employed to make basket stores and they may charge for their skills.

Maintaining Grain Quality

Grain will keep satisfactorily as long as the basket is well maintained and steps are taken to control insects and to exclude rodents, e.g. fitting rodent guards to supporting legs. Mud-plastered baskets with sealed lids may deter entry by insects, but grain that is vulnerable to insect attack, especially improved high yielding varieties may need to be protected with insecticide.

Simple woven basket stores are vulnerable to theft. Plastered and sealed baskets may deter theft. They may also help to exclude goats, birds and rodents. Baskets kept inside the house will be more secure.

Baskets that are well made may have a life of up to 15 years. Maintenance will include: mending holes or splits in the basket weaving, repairing cracks in plastered walls and repairing or replacing thatched roofs. A mudded basket kept outside will need replastering annually. A cement plaster may last for several seasons.

Before loading, baskets should be cleaned thoroughly and insecticide dust should be sprinkled inside if insect infestation is expected.

Solid wall bins

Construction and Use

Solid wall bins may be round, cylindrical or rectangular in shape. Designs are often characteristic of communities or localities. The bins may be made of clay (sometimes strengthened by mixing with straw or twigs) or from clay blocks or burnt bricks.

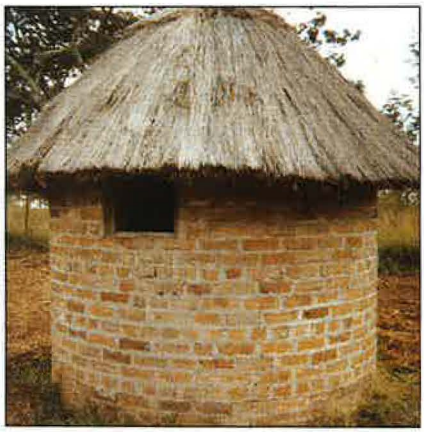
Bins are either raised off the ground or isolated from it by means of wooden poles, clay pedestals or large stones. Packed earth should not be used as the base because it may permit termites and rodents to enter the store.

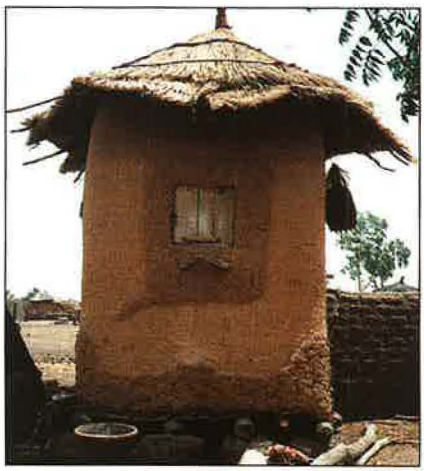
Improved solid wall bins made of stones or bricks and mortar may have a concrete pedestal or foundation. A plastic sheet or tar paper may be used in the base to prevent uptake of moisture.

Thin-walled structures are commonly used for storage of unthreshed pulses, sorghum and millet and maize cobs. Thick-walled structures are much stronger and suitable for storage of threshed grain.

Some bins have internal dividing walls making several compartments. This gives some flexibility in the different quantities or types of grain that can be stored. Separate openings for filling and emptying are usually included at the top and bottom of the structure. Covers for these openings can be secured with padlocks.

Costs increase in proportion to the amount of non-traditional material used in construction. Traditional solid wall bins may be constructed by skilled artisans who may charge for their skills.





The life of solid wall bins will depend on construction and local climatic conditions. With good routine maintenance and careful use a bin may last for more than 20 years. Solid wall bins are strong and their contents are not displayed to prospective thieves. The durability and security provided by traditional or improved solid wall bins may make them attractive to small-scale farmers wishing to store grain for longer periods at relatively low cost.

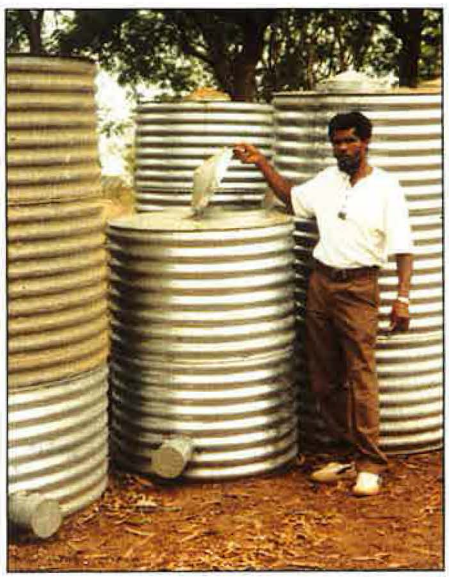
Maintaining Grain Quality

The quality of grain stored in solid wall bins may be affected by climate, risk of insect pest infestation and the standard of design and construction. All bins using mud in their construction are susceptible to termite attack. Insect infestation in grain may be readily controlled using insecticide dusts. Fumigants may also be used provided the store is airtight but most traditional stores are unsuitable without modification.

The area around the bin must be kept clean and the bin should be thoroughly swept clean at the end of each storage season. Smoke from a small grass fire lit inside the empty bin will kill insects. Cracks in plaster should be repaired quickly.

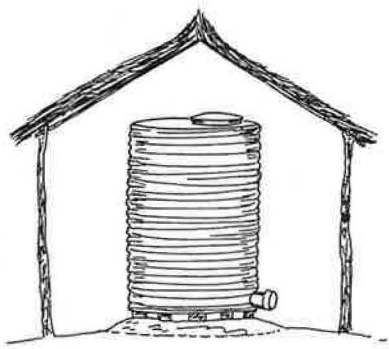
Metal storage bins

Construction and Use



Metal storage bins are made from smooth or corrugated galvanized metal sheets. They are cylindrical in shape with flat top and bottom. Most bins used for small-scale storage have a capacity of up to 1 tonne. Grain is loaded through a hatch in the top and can be emptied through a spout in the side at the bottom of the bin. Metal bins can provide maximum protection and security when padlocks are fitted to the filling hatch and emptying spout.

Metal bins should be placed on platforms or legs to allow air to circulate around the base to prevent corrosion from ground moisture. They should be placed under a roof to provide shade and to help reduce moisture migration and heating of the grain inside.



The cost of bins varies with the size, charges made by skilled metal workers and the distance they have to be transported from manufacturer to farmer. Although bins can be constructed in different sizes (capacities) the cost per tonne of small units may be prohibitive.

There is little experience of the use of metal grain bins in Africa outside of Swaziland. However, the durability and security offered by the system may appeal to the more affluent farmers. Adoption of metal grain bins is more likely in those areas where metal containers are already used for holding water and they can be made locally by sheet metal workers.

Large metal bins are more difficult and expensive to transport to rural areas and are easily damaged in transit over rural roads. As grain must be very dry for storage in metal bins the system is more suited to areas where drying facilities are available, or where the crop is harvested in a distinct dry season followed by storage of grain through a rainy season where good protection is desirable.

With routine maintenance and careful use, metal grain bins can remain serviceable for more than 20 years. Maintenance includes:

- cleaning out residues at the beginning of every season
- protecting against corrosion
- ensuring that the roof shelter is kept in good repair.

Maintaining Grain Quality

A well made and well sealed metal bin will provide good protection against insects, mould, rodents and birds. Insect control using insecticides or fumigants is essential, the metal bin being one of the most suitable structures for fumigation by small-scale farmers.

Before storage, grain must be well dried, threshed or shelled and then sieved or winnowed. Grain stored in metal bins should be drier than that stored in traditional stores that are well ventilated (e.g. baskets) or bags.

Underground storage

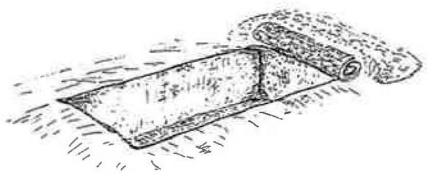
Construction and Use

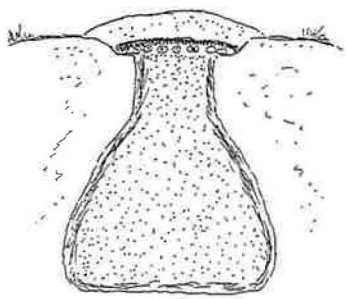
Pit stores are used in some parts of Africa, primarily for storage of sorghum, although other commodities such as maize and beans may also be stored. The best pit stores provide a reliable, hermetic method of long-term storage.

Farm-level pit stores may have capacities ranging from 0.5 tonnes to more than 20 tonnes. Pits may be straight sided, circular or square and some are constructed in the shape of a flask. Pits must always be dug above the water table.

An absorbent pit lining made from grass matting and straw, or chaff and grain husks, will help to reduce damage from moisture that might seep through the walls of the pit. The lining may need replacing every year.

Lining the pit with plastic sheets may also help to restrict moisture damage to the stored grain.





A fire can be lit inside the empty pit to aid drying and to kill micro-organisms and insects.

Filling of pit stores is easy but emptying and inspection are not.

Pit storage is popular because the entire store can be completely concealed underground and the grain is unlikely to be stolen. In some other types of pit store the top cover forms a mound above ground level and the risk of theft increases. There is no risk of damage by fire.

Maintaining Grain Quality

Well sealed pits will prevent entry by insects. Some initial mould growth in filled pits is likely but this may reduce oxygen levels which in turn can asphyxiate insects and inhibit further mould growth.

Grain stored in pits often has a characteristic smell associated with development of moulds.

Grain stored in pits is sometimes damaged by termites. Occasionally burrowing rodents may gain access to the stored grain.

Bag storage

Bag storage is a convenient way of keeping threshed grain and pulses. The need to thresh or shell grain may deter farmers from using bags if labour is in short supply at harvest time. These difficulties may be overcome by the use of shellers or threshers.

Bags are usually made from jute or woven polypropylene, but hemp, sisal, grass and polythene sacks are also available. Sometimes plastic bags (old fertilizer bags) may be used for storage of grain. Durability of bags will depend on their quality and how they are handled. Jute sacks are more expensive but last longer than woven polypropylene ones. With careful use and repair bags should last for several seasons.

Bags provide the flexibility to store different types and different quantities of grains and pulses. The storage capacity is limited only by the number of bags available and the size of the storeroom. Small numbers of bags may be kept in the farmer's house, or in a separate store. This might include a room attached to the house, a simple pole and thatch shelter or a separate building made from traditional or non-traditional materials (bricks and cement). Bags of grain may also be stored in maize cribs. Ideally, one room or store should be kept for use entirely as a grain store.

It is important that bags of grain are never placed directly on the floor. They should be stored on small storage platforms made from wooden poles (dunnage). This will allow air to flow under the stacks and will stop the bags getting wet from uptake of moisture from the ground. If no wood is available the bags should be stacked on a plastic sheet.

The area around the stack should be kept clear of household items that might provide hiding places for insect and rodents.

The stack should be well constructed to prevent collapse and kept away from the walls of the store if possible. In the house the stack should be kept away from the kitchen and fireplace.

Bag storage is a convenient way of handling and storing grain and pulses. The commodity can easily be removed for consumption, inspection or sun-drying. It is immediately available for sale.

Bags can be easily carried away. Bags stored in a farmer's house or shed are fairly secure, especially if doors are locked and windows barred. Bags stored in maize cribs will be less secure.

The initial cost to make a storage space for a few bags is low. Costs of building a separate secure store room may be high but the store could have other uses. There will be recurring costs of sacks and insecticide for treatment of grain.

Maintaining Grain Quality

Successful bag storage depends on adoption of good storage management practice rather than construction and operation of a special storage

structure. Bags provide little protection against insects, rodents and moisture. If the risk of insect attack is high the grain must be treated with an appropriate insecticide dust. Sacks should be brushed clean and dipped in boiling water to kill any insects present at the start of each season.

Damage to sacks and contamination by rodents can be a problem and risk of grain loss is high unless preventative measures are taken.

Damage by moisture can be prevented by keeping bags off the floor and by maintaining a sound roof over the stored bags.