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GRAIN STORAGE MANAGEMENT TECHNICAL MANUAL FOR FRONT-LINE AGRICULTURAL EXTENSION WORKERS

Compiled By

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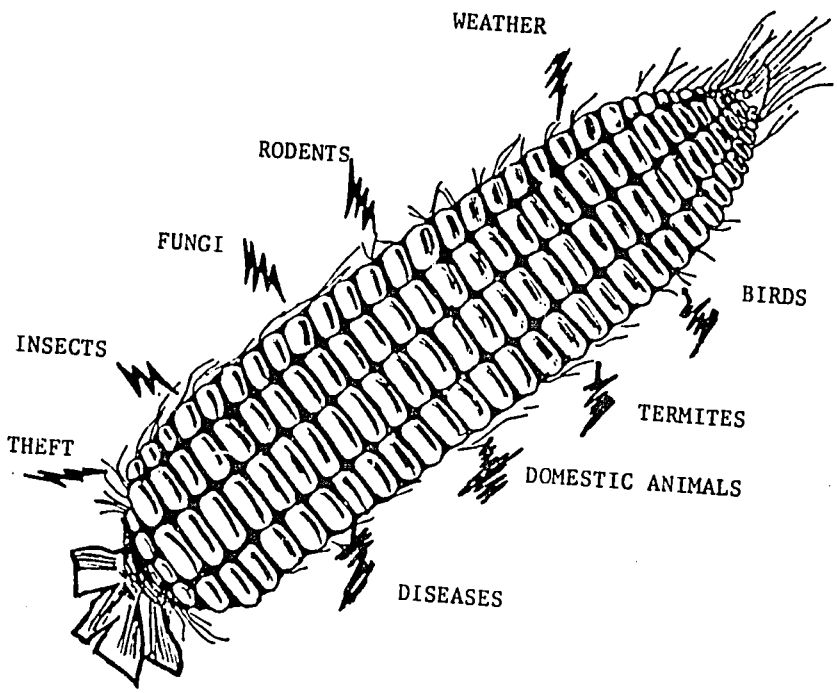

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NOTICE

This manual is still in draft form. Before publishing, it should be reviewed for technical accuracy and proofed.

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PREFACE

The On-Farm Grain Storage Project is pleased to make this crop storage management technical manual available to Kenya's Ministry of Agriculture. Though labelled technical, the purpose of this manual is to present technical information on the subject in practical language which will serve Kenya's front-line agricultural workers for many years.

Front-line extension workers are necessarily general agriculturalists, who deliver information to farmers on a wide range of subjects. Their effectiveness in this task depends both on knowledge of their technical fields and on their ability to communicate. In working with hundreds of front-line extension workers, the project's staff learned that they either had no technical knowledge on the subject of crop storage management or they did not understand some of the important technical details.

The compilers of this manual reviewed all available technical literature pertaining to grain storage structures and management. They selected that which should serve as practical (useful) information to front-line extension workers. Then they reduced it to as practical a language as possible.

The technical information in this manual can be used at the Institutes of Agriculture, where Kenya's front-line extension workers receive their formal training, or as an on-the-job manual, which is its main purpose.

Since this manual is designed to be used as a field reference book, it is hoped that the owners of this manual will, at every opportunity, add technical notes to it for future reference. Especially information on crops, other than maize; should be added as it becomes available, since this manual focuses primarily on maize storage and handling.

The project responsible for the preparation of this manual was funded by the U.S. Agency for International Development and implemented by Development Planning and Research Associates, Inc., headquartered in Manhattan, Kansas, U.S.A. The project was active in Kenya from 1984 through 1991, with the last year being devoted to the implementation of a national crop post-harvest management programme.

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INTRODUCTION

Communicating effectively with farmers requires special skills. It is hoped that the design of this manual will help you, the front-line extension worker, deliver technical information concerning post-harvest management of grains, including improved storage methods. The style of the manual is intended to allow communication skills to develop which effectively get your message across.

In your role as extension worker, you are an adult educator. To adequately fulfill this role you must have a working knowledge of many technical details related to the subject matter that you are presenting to farmers. A teacher's credibility is often attached to his or her grasp of technical information -- to superior and timely knowledge. This manual will help you to achieve that level of credibility and hopefully boost your confidence as a teacher. However, a simple discussion or lecture usually is not enough when teaching agricultural practices. As you develop your communications skills, you will note that this manual offers guidelines for you to use when presenting field day demonstrations, guidlines that should encourage more participation from farmers themselves.

The first four chapters in this manual provide a basic understanding of the importance or magnitude of post-harvest losses and the causes of losses. Chapter Five provides the technical information needed to conduct five grain storage management field days. Chapter Six presents decision making tools from an economic standpoint; Chapter Seven, a description of recommended structures.

1.0 IMPORTANCE OF CROP STORAGE

1.1 The Goal of Self Sufficiency

It is important for you, as an extension agent, not just to know how to do your job, but to believe in the importance of what you are doing. This section outlines why you should take pride in your job. We cannot emphasise enough your role in Kenya's future.

Kenya's rate of population growth is one of the highest in the world. By the year 2000 the population will be almost four times that at independence in 1963.

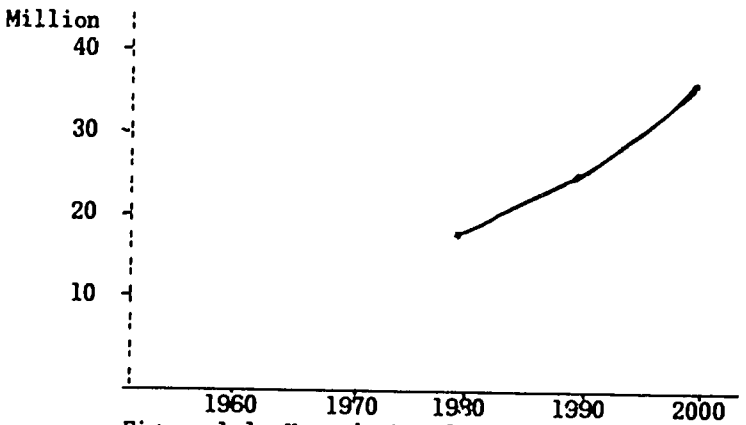


Figure 1.1. Kenya's Population Growth Curve

Urban populations are growing at a pace twice of that in rural areas as many young people move away from villages in search of employment.

One problem that the country will face in the coming years will be the feeding of an enlarged population. How will all these extra people be fed? Will there be enough food for everyone? How will the nation's farmers be able to provide for themselves, their families and also produce a surplus to sell to the people in the towns with no shambas? You, the extension worker, have a unique opportunity to help the people of your area feed themselves and others by giving them advice which will help them increase their farm output.

Perhaps the farmer will argue that these issues are not his concern and expect the government to find solutions. Food, however, will have to be found from somewhere! There is no better alternative than to produce it within the country.....by doing your job effectively you can help ensure that the people of your area do not go hungry. It hurts the economic condition of the whole nation when commodities like food have to be imported.

1.1.1 Self-Sufficiency for the Farmer

While the farmer may not be interested in the complexities of these broader issues, he will surely be concerned about providing food for his immediate family and earning some extra money for school fees, medical fees and other family needs such as clothing. Self-sufficiency no longer includes food needs alone. The gradual change from extended family to a money economy is affecting small-scale farmers in rural areas as well as Kenyans living off farms. How can farmers increase their cash income? Does the farmer buy additional land or does he increase the yield of crops? These are difficult to achieve quickly. What about trying to reduce losses?

The extension worker has the means opportunity to help individuals save up to 25% (5 bags out of 20) of their maize crop, for example, by improving on-farm grain storage methods. This 25% is a large part of the farmer's crop. This grain could be sold for school fees or clothing. It can provide food for the growing urban population. But more than this, not only will the grain be saved it will be of a higher quality and therefore have a higher value.

Market demand will in the foreseeable future continue to grow rapidly, and so will the value of the harvest as urban demand increases. Farming will gradually become an important business rather than merely offering security and subsistence as the country develops and life-styles change. A knowledge of market trends and prices will create new opportunities for farmers to make money and provide for their families. The extension worker will need to communicate this to the farmers. Do farmers realise the true value of their crops? Do they appreciate how this value can be easily increased if the crop is of high quality? Do they understand the factors that contribute to good or bad samples of grain? Do they realise that these factors can be easily controlled by the implementation of a few simple steps to reduce losses to quality and quantity?

How many front-line extension workers can inform farmers of the market value of various qualities or grades of maize?, or explain to them how to sell their maize in a commercial market outside their local municipal market? How many can explain transport alternatives for delivery?, or know the going rates? i.e. maize prices and transportation costs? Kenya has some excellent large-scale grain stores. Good prices will be offered to fill these stores in coming seasons. However, if a grain sample has a high moisture content or it is infested with storage pests, the value of the produce will fall. It may even be totally rejected. One bad sample can destroy an entire store or silo of grain if not properly managed.

By helping the farmer to better manage his crop, harvest at the right time, store the grain with few losses, sell at the right time, you will increase the farmer's income. The small scale farmer will become self-

sufficient, and even produce a surplus. By improving the individual's production and therefore his quality of life you will in fact be helping Kenya.

1.1.2 Self-Sufficiency for the Nation

Small-scale farmers are in fact producing nearly all of Kenya's grain. Little, however, is sold off the farm. What is sold is normally marketed in the nearest town. For the country to feed all its people in the next few years the situation must change. If people in towns are to be fed as well as the rural populations, more of the grain harvested will need to be sold off the farm.

Remember, Kenya has more mouths to feed every day:

* Over half of the population will eventually move to towns to find work
* Most of the developed agricultural land is now being farmed
* It is expensive to import food.

Farmers can increase their yields by adopting two important technologies: commercial fertilizer and new seed varieties. They can also improve tillage and other practices. But if they don't adopt recommended post-harvest management practices at the same time they are essentially throwing away one shilling in four that they invest.

Fortunately, another option exists, that of reducing post-harvest losses. It should be easier to save what is presently being produced than to produce more. If you can help farmers reduce their losses, valuable time can be gained in order to overcome the more difficult long-term solution of feeding the nation.

The increase in maize production for the whole country has been estimated at between 4-5% for the next few years. If we look at the past, the annual growth has been 6-7%. This means that in the year 2000, Kenya might be producing 4.4 million tonnes of maize, just enough to supply the demand. But what happens if there is a bad year like 1984/85: Then there could be a serious problem requiring importation of maize.

However, if the on-farm grain storage extension project works well, it is hoped that about 90% of farmers will improve their management by the year 2000 and 60% will improve their grain storage. This would mean saving 15.6 million tonnes of grain between now and the year 2000. Even if only 25% of the farmers adopt the improved grain storage, the country will still benefit by saving over 6 million tonnes.

How can these vast savings be made? Well, the Government may spend something like 68 million shillings between now and the year 2000 to pay for extension agents. Further millions will be spent on the structures themselves. Is this expense worthwhile?

The potential saving based on reducing losses as above, are between 16 and 21 BILLION shillings, depending on the adoption rate.

This is why you have been asked to tell the farmers about improved storage and other management techniques. For the sake of the country's economy and the country's children, go and share the good news of grain storage.

1.2. Why Store On-Farm?

We have said that it is a good national strategy to reduce grain losses, but why is it best to promote on-farm grain storage? You need to convince farmers that this is the right strategy. You must provide not only information but MOTIVATION. You will communicate this only if you yourself are fully convinced about the benefits of on-farm storage. So what are the benefits and how do you convey the message? Let's us look at the market for grain.

1.2.1 Playing the Market (The Economic Advantage)

What factors will cause grain to rise or fall in value?

a) Time

b) Place

c) Form

Ask farmers if they can see what is meant by the three points above. Then explain it like this:

a) Time

Because grains are only semi-perishable their quality can be maintained for many months in a proper store. This is a major advantage over products like milk and vegetables that normally need to be consumed quickly before they begin to go bad. Usually farmers will store only from one harvest to the next, either for their own food needs, or as they await higher prices. The further from the past harvest the higher the expected price in most seasons.

You may use the term "seasonal pricing". This means the price is affected by availability (grain supply) which will be affected by the season.

good season ——————> high availability ————————> low price

bad season ——————> low availability ————————> high price

b) Place

Moving your grain to a new place can also increase its value. There will be a transport cost of course, but you may find that grain in a place like Nairobi will command a price high enough to cover the transport cost and still leave a margin for profit. In some cases small-scale farmers can market their grain through co-operative societies and thereby receive a higher price than if they sell it at the farm to a private trader.

c) Form

By processing grain its value also increases. For example, you change it from grain to flour or meal which will fetch a higher price on the market. Likewise, preventing maize from becoming insect infested preserves its form and results in a higher price than for maize that has been damaged.

When you hear people talking about a "free" market, what do they mean?

They mean prices are not government controlled. Prices reflect:

- supply and demand
- costs of storage
- costs of transportation
- costs of processing

All these relate to time, place and form.

The government is encouraging the development of good storage facilities within the grain industry. Kenya is improving its roads in many rural areas. Traders will have better access to smaller towns and so to farmers' grain. These traders will want to purchase good quality grain that has been carefully stored. They should pay more for high quality grain than for low quality grain. How will farmers know if they are getting a fair price?

Front-line extension workers will need to help farmers understand quality standards and market prices. If farmers are to avoid losing out (becoming price takers) they will need market information. They will also need to understand the factors that influence the market situation.

So what are the benefits of storing on-farm?

1. Food security.
2. Being able to sell during seasonal price peaks.
3. Added farm income.
4. Greater marketing choice.

But remember poor storage can mean:

1.2.2 Quantity and Quality Losses which Result in Lost Money

If the farmer's store is of a low standard and the standard of storage management is poor, then the farmer will do better to sell early—BUT ONLY if he has excess grain beyond his family's needs.

If the farmer SELLS his harverst at harvest time, remember, he will likely

receive a low price. Then if that farmer BUYS back maize to feed his family as the time approaches the next harvest, he will likely pay a higher price per gorogoro. In this case he becomes the victim of seasonal price changes.

On the other hand good storage gives good security. For example, in a bad season, the farmer stores his grain well and later in the dry season he not only has enough for his family but is able to bring flour to sell in the town. The price is higher than when he harvested (TIME), there is a shortage of good quality flour (FORM) and the people in the town are seaching for posho (PLACE).

So the farmer can benefit by increasing the value of his grain. For him to reap these benefits of this increase in value, the grain needs to be kept in his possession for as long as he wants. This brings us to ON-FARM GRAIN STORAGE.

On-farm storage is much more than just a maridadi store. Good storage involves:

1) Pre-Storage Hygiene;
2) Harvesting on Time and Drying;
3) Shelling and Treating;
4) Using an Improved Store;
5) Periodic Inspection.

Points 1-3 and 5 will cost little more than the value of the farmer's own family labour.

Point 4 (For example, a raised structure with rat guards) can be paid for in under 5 years. As the structure should easily last 10 years it will be well worth the farmer's time and effort. These steps will improve farm income and also help the nation feed itself.

Benefits

Reducing losses means either:

----------> less shillings spent to supplement family food

----------> additional grain to sell

The resulting benefits are:

----------> added income: with this increased income the farmer will be able to utilize...

----------> improved hybrid seed

----------> beneficial fertilizers

----------> simple irrigation....where appropriate.

----------> These will all help generate even more income. So good storage management can be seen as a first step to improving agricultural production and general development benefits for Kenya.

2.0 ASSESSING POST-HARVEST LOSSES

2.1 Attitudes Towards Storage and Storage Losses

Losses due to animals (chickens, goats, cows, etc.) may not be regarded as losses by most farmers. Likewise, sharing with neighbours and relatives can account for large losses to the individual. Such losses are neither recorded nor regarded as losses. For these assessment purposes, losses due to sharing are regarded only as losses to the individual family and not as a net loss to the country.

A number of surveys have found that farmers were not well-motivated to take steps to improve storage management and that the knowledge of simple steps to improve stores was low before the beginning of the On-Farm Grain Storage Project. It would appear that this lack of interest resulted from low awareness of the extent of the losses, as from well as from a lack of concern as long as there was enough food available to feed the farmer's family.

The time is past when such losses are unimportant or inconsequential to the Government of Kenya (the same is true in other countries.) In the future every kilogram of food that can be produced will be needed to feed the nation.

Larger and larger volumes of grain and other food must be moved from production areas to distant consumption areas as more and more people move to urban centres. Sufficient quantities of high quality food can be made available in this urban market place ONLY if high quality food leaves the farms.

Thus, as mentioned earlier in this manual, you as the front-line extension worker have an important role to play in communicating the post-harvest management message to farmers and motivating them to produce and market for the whole country's needs -- not just for their family's subsistence.

The first and most important step, therefore, will be to demonstrate the magnitude and value of the harvest that is being lost every year.

2.2 Spoilt Grain: What Effect Will It Have On Your Food And Family's Health?

In the previous section we looked at the importance of recognising the value and scale of losses resulting from poor post-harvest management. This will have already prompted you to seach for ways to reduce these losses. However, it is important that everyone in the family recognises the importance of improved storage.

The women in the home have the responsibility of preparing nutritious meals for the family. The women are therefore most likely to look regularly into the store.

We have already seen that some grain losses in volume are hard to detect. It is even more difficult to observe nutritional deterioration (quality losses). Most people rarely consider the loss of quality because it cannot be seen. But think: A 50% loss in quality of spoilt grain means that you would have to eat twice as much bulk to get the same benefit cf eating a good serving. The spoilt grain may also contain toxins (poisons) apart from demanding more preparation time and consuming more fuel to cook!

Let us just remind ourselves of what food contains. Our food should normally contain the following essential components:

1. Carbohydrates which provide the body with energy and may also be converted into fat;
2. Fats which provide energy and may also be converted into body fat;
3. Proteins which provide material for growth and repair of body tissue; also they provide energy and can be converted into fat;
4. Minerals which provide material for growth and repair and for regulation processes within the body; and
5. Vitamins which are used in chemical processes within the body, required in small amounts and cannot be manufactured by the body from raw materials.

Most foods contain some or all of these components but in different proportions; thus there are more cabohydrates in cereals, root crops and sugar; proteins in meat, milk, cheese, eggs, fish, peas, nuts and beans; minerals and vitamins in oil-seeds, fruits, vegetables and dairy produce.

The proper maintenance of health and efficient functioning of the body depends on the consumption of appropriate quantities of all these nutrients. Effective storage of pulses, cereals and oil-seeds will contribute to providing a balanced diet.

What causes the quality and nutritive value to deteriorate? Quality losses often occur at the same time and for the same reasons as quantity losses.

Losses start in the field after ripening due to delayed harvesting, through poor handling and drying, and in the store. The use of wrong chemicals can also cause serious contamination. Over-cooking or poor food preparation will also have an effect.

Storage losses result from:

- insect infestation
- moulds and other micro-organisms
- rodent contamination
- chemical contamination

1. Insects

   Weevils are some of the most common grain pests. They like to feed especially on maize. This is because they thrive on the carbohydratess found in it.

2. Moulds and Micro-Organisms

   These are other names for fungi and bacteria. They are well-known for the production of mycotoxins in contaminated grain stores. An example of a mycotoxin is AFLATOXIN, which is responsible for a cancer condition of the liver. Aflatoxins can cause death to humans livestock, poultry and other animals.

3. Rodents

   Rodents reduce the quality of stored grain by contaminating it with excreta and urine. This is often hidden as it is hard to see. However, it causes a deterioration in quality and can be a disease risk.

4. Chemicals

Shelling and treating of maize is recommended. However, make sure that only recommended chemicals are used and in the correct amounts. Advise the farmers to look for the "Blue Cross" label to be sure which chemical is safe to use on shelled maize.

Visits to farms reveal that some people have used DDT and other insecticides to treat their stored maize. These insecticides, which are designed for other forms of pest control, can be very dangerous to health if used on stored grain. It is important that farmers realise the dangers of this practice.

If grain is consumed that has been treated by these or other chemicals not recommended for grain storage then toxic substances can accumulate in the body. These can be most harmful.

2.3 What is Lost in a Store and How Much?

When addressing the subject of post-harvest losses you are really concerned about the post-maturity losses--any quality or quantity loss occuring from the time the crop reaches physiological maturity

(explained in section 5.4, Harvesting on Time and Drying). Post-harvest losses may be analyzed according to cause: insects, moulds, rodents, or birds, and according to point: in field (pre-harvest), while harvesting (shattering), while drying on the cob, during shelling (spillage), or while in storage (shelled).

Being aware of the causes and points of post-harvest losses will help you to recommend changes in farmers' existing harvesting, handling and storage practices.

2.4 Assessing of Post-Harvest Losses

In this section we are identifying the losses. Although there is discussion over exactly how much is lost, everyone agrees that on most small-scale farms the amount is substantial.

The first problem for, the extension worker is to help farmers recognize the size of their losses. The losses are not always obvious because of poor record keeping, hidden insects and invisible quality factors.

The most obvious way of trying to find out how much has been lost is to compare the volume of grain going into the store with the volume coming out. This however gives a FALSE PICTURE.

Types of Losses: There are, in fact, four more accurate methods of assessing losses:

1) loss of weight
2) loss of quality
3) loss of nutritional value
4) economic losses.

Quantity Loss (or Weight Loss): defined as a loss in weight of the consumable part of the produce over a period of time, excluding its content of moisture.

Before a discussion of real losses, the effects of changing moisture content should be understood. The term "moisture content" refers to the amount of moisture in the grain. For example, 100 kg of maize with a moisture content of 20% contains 20 kg of water. A debe of maize with a moisture content of 13% will weigh less than a debe of maize with a moisture content of 18%. In other words as maize dries to a safe storage level the weight for a given volume will become less and less. This weight loss does not result in a decrease in volume or quality.

Though you will probably not have an instrument to measure the exact moisture content of maize when visiting a farmer's shamba, from experience you can probably estimate the percentage moisture. The following sets of figures will give you some insight as to the amount of water stored in a 90 kg bag of maize:

TABLE 2.1 WEIGHT OF SHELLED MAIZE PER BAG

Moisture Content (%)	Weight (Kgs) Per bag
30	109.5
28	106.6
26	103.7
24	101.0
22	98.8
20	95.9
18	92.6
15	90.9
13*	90.0

* Safe level for long-term storage.

If all the moisture was removed from a 90 kg bag of maize the dry matter would weight about 76.8 kg. When you study the following amount of water in a 90 kg. bag of maize, think of the potential for mould damage.

TABLE 2.2. KILOGRAMS OF WATER PER BAG OF SHELLED MAIZE

Moisture Content Control (%)	Weight (Kg) Per Bag
30	32.7
28	29.8
26	26.9
24	24.2
22	22.0
20	19.1
18	15.8
15	14.1
13	13.2

Volume loss may be due to several factors. These may include consumption by insects, rodents and birds, spillage, shattering and theft. Not all of these will show as a quantity loss. Some insects, for instance, eat the centre of grains and leave the shell to keep the same volume. By measuring grain in a container, losses in hollow grains are not counted.

It is important to note, however, that dust, insects, rodent waste and so on may not increase the volume but may add weight. Thus, such materials should be removed by sieving or winnowing prior to weighing. For example, if the apparent weight loss is, say 9% - the real loss may well be 11% - once material which would not be eaten is removed. Weight loss is relatively easy to measure and is therefore commonly used instead of volume to quantify food losses.

Quality Loss: can be defined as any change in characteristics which reduce the value of the crop for its intended use. Quality loss need not be accompanied by any apparent loss in quantity. Some may also be hard to detect without the benefit of a laboratory analysis. Nevertheless, when inspecting a farmer's maize, look for the following clues:

1. The grain is often darker in colour.
2. The grain is of a coarser texture.
3. The grain may have an unusual smell or flavour.
4. There is evidence of frass (excrement of insect larvae) and secretions in broken grains and kernels.
5. It may be possible to see or smell rodent excreta.
6. A smell of fermenting indicates acid and gas produced from the breakdown of carbohydrates.
7. Putrid odours and flavour indicate protein breakdown.
8. Rancid smells and taste result from decomposed fats.
9. The grain contains cracked, weathered, diseased, shrivelled or abnormally small kernels.
10. The grain contains foreign materials such as parts of plants, weed seeds, other crop seeds, stones, earth and other impurities.

As seen, many factors can influence the quality of grain. Several of them can unfortunately not be measured accurately, and must therefore be assessed by subjective judgements and opinions. It is therefore difficult to exactly state what should be defined as grain of satisfactory quality. Value placed on a specific quality may differ between various areas and is influenced by supply and demand, time of the year, etc.

Grade Standards: The Government of Kenya has established four grade standards. Commercial market prices reflect the quality differences expressed by these standards. The grades are included in an Appendix to this manual.

Nutritional Loss: relates to the loss of food nutritional value. In the simplest instance this would be real weight loss. What is not there cannot be eaten. However, insect pests feeding on the germ will cause a reduction in protein and vitamin content which win be a greater loss than the corresponding weight difference. Some elements of the nutritional loss can be measured whilst other are difficult to measure or it may be impossible to evaluate the effects.

Heating of grain, such as in "hot spots" (*see below) caused by a concentration of fungi and insects may cause chemical changes which affect the digestibility of the grain proteins.

Likewise, urine, faecal, or hair contamination of grain in storage may carry disease (e.g. salmonellosis), alter the appearance, and lower the market value. To measure the extent of such damage will require a laboratory test that cannot be done in the field. Therefore, extension workers should learn the procedure for taking samples from farm-stored grain and sending them to a quality analysis laboratory for testing.

*"HOT SPOT"...An isolated area (spot) usually towards the centre of a container of grain (either within a bag, in a storage jar or other structure) where biological action (insect activity and/or fungal growth) generates temperatures much higher than the normal temperature of the grain.

These laboratory tests use ultraviolet light to measure contamination. The degree of contamination can then be compared to the limits allowed in the grade standards. By these procedures, both the nutritional value and the economic value (loss) can be estimated.

Economic Loss: damaged and discoloured grain, grain containing moulds and insects and contaminated grain will be more difficult to sell than good grain and will frequently sell for a lower price. Economic loss may also result from reduced germination capacity which forces the farmer to buy seeds instead of using the seed from the previous season's crop.

When grain is kept on the farm for consumption, physical losses will reduce the quantity which may have otherwise been consumed, and the farmer may even have to buy grain to compensate for the losses. Thus, the net revenue from the grain crop is reduced.

The farmer suffers another type of economic loss when he has to sell his produce because facilities for storage are lacking or inadequate. Grain that is sold soon after the harvest period obtains a lower price on the local market than the grain which the farmer purchases later in the season.

These may sound like convincing reasons for farmers to adopt improved post-harvest management practices, but remember many small-scale farmers traditionally have been concerned only with producing enough maize and other food crops to feed their family. Most do not keep records.

Therefore, to be effective, you will need to draw upon some technical examples to convince farmers to change their habits.

If a front-line extension worker can explain the magnitude of the losses that occur - what they mean in net farm income, nutrition, health, etc. - then this should go a long way toward motivating farmers to adopt the recommended grain storage managment practices.

You can present your evidence of losses at various times when you visit individual farmers or at group meetings. Some of the essential information that you might use in making these presentation is shown next.

You may also be able to use some of these loss estimating procedures in the suggested field day presentation, shown in Section 5.6, Periodic Inspection of stored Maize.

2.5 Essential Information

1. How do we calculate % weight loss?

   This formula is useful for a quick estimate of losses:

   % Weight Loss = % bored kernels x 1/8

   This is a simplified method for use in the field but gives very good results in practice when compared to more complicated ways of estimating losses.

   A random sample of 100 - 1,000 grains is taken and the number of bored grains is counted and expressed as a percentage. This percentage is converted into a weight loss by means of a conversion factor (for maize 1/8) which has been established by careful assessment in the laboratory.

   Its usefulness is limted however, to levels of weight loss below 12.5%. If, for example, all the kernels in a sample were bored, then 100% x 1/8 = 12.5% weight loss.

2. **How can we assess quality losses?**

This is difficult. When 2% of grain weight is lost as a result of moulding, most farmers consider the grain unfit for human consumption and in a sense a 100% loss. Weight losses cannot help us to determine losses as a result of poor quality.

We sort through a sample of 100 - 1,000 grains and divide into portions as follows:

- undamaged
- broken
- damaged by insects
- diseased
- mouldy
- germinated.

Express the number of diseased, mouldy and germinated as a percentage. Compare these with the Kenya Bureau of Standards "Purity Standards for Shelled Maize" below.

Table 2.3 Grade Requirements
(percentage by weight maximum)

	K1	K2	K3	K4
Foreign matter	1	1	1	1
Broken grains	2	3	4	1.5
Pest-damaged grains	4	7	10	15
Other coloured grains	2	3	4	8
Total defective grains	10	13	20	30

Maize not meeting the above standards may be termed Undergrade or Reject.

Reject maize: "shelled maize which has any commercially objectionable faulty oduor or taste or which is otherwise of distinctly low quality shall be classified as reject maize and shall be considered unfit for human consumption"

Undergrade maize: "Shelled maize which does not come within the requirements of grades K1 - K4 and is not reject shall be termed as undergrade"

Refer to the official Kenya Bureaus of Standards specification for Dry Shelled Maize.

3. How do we place an economic value on quality losses?

This can be calculated from the price difference for different quality maize per bag multiplied by the number of bags.

4. **How can we compare costs and benefits of the traditional and new storage practices?**

This question is examined in detail in Sections 6.1 and 6.2 of Chapter 6.

Generally, the added costs of improved storage structures or practices are compared to the benefits. For example, the costs and labour of buying and using storage chemicals can be compared to the value of maize saved.

Some benefits, such as improved nutritional quality or reduced risk of disease, are difficult to measure and to put into economic terms.

When comparing costs and benefits with farmers, use locally-determined figures for the levels of losses, the amount of grain saved, the prices of grain or chemicals, etc. If possible, use loss estimates measured in local field trials. The District Post-Harvest Officer may also have recent information, and the farmers themselves can give the current costs of inputs.

Use the "Comparative Losses" chart (see Appendix Form No. 2 of this manual) to record and compare the value of grain lost in storage.

5. **What is the extent of field losses in maize harvested and stacked in the field to dry to about 20% moisture content?**

Grain is lost in the field when:

- consumed by rodents, birds or insects (including termites and ants)
- wet weather causes germination, rotting and mould growth or discolouration

- shaken from the cob by wind, rain and hail
- exposed to weather and pests by poor husk cover and lodging (the plant falling over)
- removed by thieves, both human and animal.

And grain is lost during harvesting when:

- cutting method causes shattering, especially when cobs are dry
- hand tools or mechanical equipment cut or break the kernels
- cobs are lost or kernels stripped from the cobs during transport from the field.

All these losses are reduced by early harvest at a higher moisture content.

Results from field trials at Maseno indicated a reduction of field losses from 11% to 5% by use of improved storage management (specifically harvesting at physiological maturity as opposed to stacking in the field to 15-20% moisture content).

6. How do we calculate the quality losses in store as a result of down-grading or rejection of maize?

For example, down-grading from grade K1 to K3 of 25 bags would be Kshs: (Price K1 - Price K3) x 25 bags = Kshs. loss.

This can be calculated in the same way for smaller quantities of maize. For example, consider the sale of two debes of maize on the local market:

Price 1 = price of 1 debe of good quality maize.

Price 2 = price of 1 debe of poor quality maize.

(Price 1 - Price 2) x 2 debes = KSh lost.

7. **What is the feed value of stover?**

If maize stover (stalks and leaves remaining after harvest) is used for feeding animals it will have greater value when maize is harvested early.

Discuss this with farmers and find out how many of them use stover for animal feed, and if so what additional value it has.

If the farmers agree that a value can be put on maize stover then estimate the tonnage from their field and enter the difference in feed value in the losses column on your chart (Appendix Form No. 2) under the traditional storage systems.

8. **How do we compare total losses to costs of construction?**

Add in Kshs the losses associated with each storage system.

Then, taking the common traditional structure in the area, show the gain of an improved structure over the traditional.

Refer to Table 2.4.1 and note that this is <u>for 25 bags per year.</u> That is, Table 2.4.1. compares the costs of storing 25 bags of maize in a trational basket, a traditional crib, an improved crib, and an improved basket. Discuss the lifespan of different types of stores and estimate the total savings over the traditional method during the lifespan of each store. Then, estimate the cost of construction and/or modification of stores to bring them to the standard of an improved drying crib or basket.

A 1986-87 survey in Trans-Nzoia and Kericho Districts covering a large number of farmers showed (for a 25-bag capacity) the following average figures:

Table 2.4. Costs Related to Four Types of Storage Structures

	Materials (Kshs)	Labour (Kshs)	Total (Kshs)	Life Years	Annual Maintenance
Improved crib	1,552	346	1,898	10	7%
Improved basket(x2)*	755	213	1,936	8	7%
Traditional basket(x2)*	705	155	1,720	N/A	30%
Traditional rectangular crib	2,465	448	2,913	15	9%

* Two baskets were needed to store 25 bags.

The traditional basket granary with its high maintenance cost of 30% per year is partly rebuilt each year, hence its "unlimited" lifespan. You can collect the cost estimates for your area from the farmers. Only question their costs if there appears to be a wide divergence from the ratios found above.

This information is what you will need not only to calculate total losses for farmers, but also to show them the benefits and costs of building an improved store. Though this relationship of losses and economics is discussed here for clarification, please turn to Section 6.2 to learn how to estimate economic payback.

2.6 Summary

Remember:

Badly stored grain leads to losses in volume for home consumption and for sale. In addition the quality of spoilt grain is much lower, reducing nutritional value.

Carbohydrates, oils, proteins, minerals and vitamins can all deteriorate from the harmful effects of delayed harvesting, poor drying, poor handling and the effects of insects, fungi, and bacteria, and rodents. These problems not only reduce the quality and quantity but can allow toxic materials to contaminate the stored grain.

Storage losses are monetary losses. Depending on each farmer's situation, losses may be translated into either: 1) the need to purchase more maize for family consumption, or 2) foregoing the sale of the amount lost.

3.0 MAIZE PHYSIOLOGY

You have enough information to convince farmers that losses do occur and can be quite large. We now need to explain how these losses occur and the conditions which encourage the losses. Let us first look a little more closely at the grain.

3.1 Grain is a Living Thing

Grain kernels are living things. Grain which is used for seed must be kept alive. Living seeds store better.

Healthy grains can be kept in storage longer. This why it is important not to damage grains during threshing (shelling). Grains that are healthy and have not been damaged are less likely to be affected by moulds or attacked by insects.

All living things breathe and we call this RESPIRATION. Live grain takes in oxygen and the food in the grain is gradually consumed. In the process carbon dioxide and some heat is released slowly. This has to happen to keep the grain alive. Dry, cool grain breathes very slowly.

There is a problem of overheating when the grain is too wet because high moisture levels cause the grain to breathe faster. This causes more carbon dioxide and heat to be produced and released, resulting in a "hot spot." This is why it is important to dry maize to about 13% moisture content for long-term storage. Maize kernels may be preserved safely at this moisture level. In storage this heat which builds up in higher moisture maize creates ideal conditions for the growth of storage fungi and for insect attack.

It is important for the farmer to understand this. The thing to remember is this: when grain becomes moist and warmer it will behave like a seed that is planted. It will therefore not be in a "sleeping" state as it is when it is stored.

The seed "wakes up" and starts to grow, generating heat as more energy is required for growth. As the seed "wakes up", it is germinating. A germinating seed loses the protection of the seed coating and is then more vulnerable to attacks from insects or fungi. Insects and fungi also want to grow and grain is an ideal food supply for their rapid development.

3.1.1 The Grain

Grain cereals are grown by farmers for food and for sale. Most grain is stored, sometimes for long periods between harvest and sale. During this storage period losses can occur. A close look at an individual grain kernel can give us an understanding of how and why losses occur. This knowledge can help you understand the REASONS for some of the advice you give to farmers on how to protect their stored grain from loss and damage.

All grain cereals - maize, sorghum, wheat, millet, rice and others, belong to the same grass family (Graminae). The grain kernels look different but their basic structure is the same and consists of three different parts:

- the seed coat (pericarp)
- the food storage reservoir (endosperm)
- the embryo or germ, which grow into a plant.

The diagram below shows the main parts of a grain kernel (or seed).

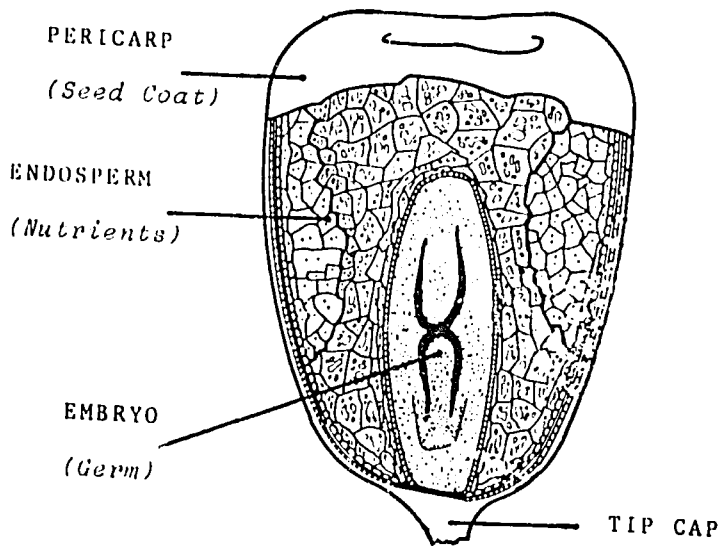


Figure 3.1 Cross Section of a Maize Kernel

3.1.2 The Seed Coat (Pericarp)

This is the outer protective covering of the seed, and is about 5.5% of the weight of the maize kernel. When the coat is dry and undamaged it protects the kernel from insects, moisture and fungi. Damaged seed coats, on the other hand, allow numerous destructive agents easy entry into the kernel. The seed coat is weakest around the embryo.

3.1.3 The Food Storage Reservoir (Endosperm)

This is the source of food for the developing embryo both during storage and when the kernel is planted. The very young plant uses this food to grow and develop to the stage where it has roots and leaves and is able to produce its own food.

The endosperm is about 82% by weight of the maize kernel and consists mostly of starch (carbohydrate) and protein. It provides the biggest part of the grain's food value for man and unfortunately for many storage pests. As it dries, the endosperm hardens and becomes more resistant to insect attack.

3.1.4 The Embryo or Seed Germ

This is the part of the kernel which can develop into a new plant. The tip cap, the part of the kernel which is attached to the cob, has many tiny pathways which connect the embryo and the endosperm. Water passes easily through these pathways and, if the water is sufficient, causes the germination of the seed.

The tip cap is easily attacked by fungi and some kinds of insects. Such attacks can destroy the seed so that it cannot germinate and is useless for planting. Again higher moisture levels in and around the tip cap makes it easier for fungi and insects to enter.

Because of the weakness of the seed coat around the embryo and the weakness of the tip cap, the embryo is usually the first part of the grain to be attacked and destroyed. This is a major loss because most of the grain's protein, fat and vitamins are contained in the embryo.

This kind of damage is one of the main reasons why measuring weight loss in storage does not give a full picture of losses. The loss of the embryo is a small weight reduction, but a large loss of the most valuable foodstuffs and nutrients in the grain.

Some grains have extra protection. Rice, for example, has both a bran coat and a tough outer husk which gives each kernel better protection from pests.

Maize kernels have only the husks around the cob to protect them, and husk protection is reduced the longer the crop stays in the field. Modern maize hybrids give very good yields but have poor natural husk cover and expose the kernels to insect, bird, rodent and fungal attack.

3.2 Storage Factors That Contribute to Deterioration in Stored Grain

Major factors causing grain to deteriorate in-store are moisture, temperature, and humidity.

3.2.1 Moisture Content

Drying grain, and keeping it dry in storage is the most important part of good storage. Many problems of grain storage are caused by moisture:

- grain can germinate
- insects grow and multiply
- fungi can germinate and grow.

Both grain and air contain some moisture and interact in important ways. Temperature and moisture also relate to one another, so we shall look at these interactions.

3.2.2 Temperature

It is easier to store grain safely in areas where the air temperature is low and never gets too hot. In very cold weather, insects and fungi grow slowly or not at all. Seeds also do not breathe as much. In warm places, the grain is warm when it is put into storage. As the outside temperature goes up, the temperature in the stored grain is likely to get even higher. When this happens:

- insects grow and multiply faster
- fungi grow faster
- fungi, insects and grain all breathe faster, causing heat, water and carbon dioxide to increase in the stored grain.

It is easy to see the need for keeping grain cool.

We should keep the temperature of the storage place as cool as the climate allows. Keeping storage containers protected from the hot sun is important.

3.2.3 Respiration

Grain breathes. Respiration is slow when grain is COOL and DRY. The embryo is kept alive but growth does not take place. Slow respiration is good for storage.

- Each grain is a living thing.
- Each grain breathes, taking oxygen from the air and burning food from its endosperm.
- In the process of breathing grains give off HEAT, WATER and CARBON DIOXIDE.
- This process is called respiration.

If stored grain is exposed to too much moisture and heat, the grain respires faster. When grain is planted, for example, it germinates (grows) because respiration has been speeded by water in the ground and the warmth of the soil.

For safe storage, grain must be dried to 12-13% moisture content. With maize, the simplest guide for moisture content is to bite the grain. If your teeth sink in rather than the grain shattering then the moisture is higher than 13%.

Insects and fungi respire (breathe). Insects not only produce heat, but also moisture. Once they start growing they create their own ideal conditions for multiplication.

The solution is to prevent the process from getting started by DRYING the grain as quickly as possible and keeping it DRY and COOL.

3.3 Drying Principles

Grain contains moisture which must be removed if we are going to be able to store it safely. We dry the grain with air. Warm air generally dries grain faster than cool air. Air contains moisture, but the amount of moisture the air can hold changes with temperature. Warm air can hold more moisture than cool air.

This is why you can find dew on the ground after a cold night. The cold night air cannot hold as much moisture (humidity) as the warmer daytime air, and so the moisture in the air condenses into dew as the air cools.

If the air contains less moisture than the grain, it will carry away the moisture from the grain. This is why it is important to allow free air movement through a drying crib.

Maize dries rapidly at first, but as moisture content falls it dries more slowly. At this late drying stage the free movement of air is particularly important.

If the air contains more moisture than the grain, the grains will take up moisture from the air. This is why we restrict free air movement through a store of dried maize, and why we bring sun-dried maize indoors in the evening.

At 25-30 degrees Centigrade and 70% relative humidity (a measure of the amount of moisture in the air) maize at 13.5% moisture content will not exchange moisture (lose or gain) with the air. We can say that in these conditions, common in many parts of Kenya, the grain has reached the equilibrium moisture content (EMC). Ways of measuring moisture content are discussed in the demonstration notes on Shelling and Treatment (see Section 5.5). (Practical information on grain drying and structures is included in Section 5.2.2.)

Remember that some farmers may want to continue drying on the ground or in drying trays. These are good methods of drying small quantities as long as the layer of grain is not too deep. The main problem is the extra labour involved in handling the grain at the beginning and end of each day and the risk of losses through animals or theft. There is also possibility of rain.

3.4 Summary

- Maize Physiology— Early harvest and protection in store is the logical answer to the poor protection of grains offered by the husks in modern hybrids.
- Early and rapid drying ensures that the endosperm is less susceptible to insect attack.
- Early harvest and rapid drying ensures the least chance of the tip cap and embryo being attacked by fungi and insects, or the seed germinating in the field.
- Careful handling of the grain during harvest and threshing will reduce damage to the coat of the grains so as to maintain the grain's natural protection.

- Inspect stored grain regularly, and take appropriate measures if grain is spoiling.
- Check moisture content levels. Here is a a guide, but note that the variety of the grain also influence the safe moisture content.

Table 3.1 Moisture Contents for Safe Storage

Maize	- below	13.5% moisture content (m.c.)
Soya beans	- "	12.0% m.c.
Groundnuts (shelled)	- "	7.0% m.c.
Sorghum	- "	13.5% m.c.
Millet	- "	15.0% m.c.
Paddy Rice	- "	14.0% m.c.
Milled Rice	- "	12.0% m.c.

4.0 MAJOR CAUSES OF POST-MATURITY LOSSES

Now that you have a basic understanding of the physiology of a kernel of grain and the factors which invite quality deterioration, let's look closely at the three major causes of post-maturity losses. These are losses which occur in the field after physiological maturity and those that occur in storage after harvest.

The purpose of these next sections will be to present specific and practical information on the major loss factors, insects, moulds and rodents. Chapter 5, besides giving additional technical information, then discuss how this information can be presented to farmers.

4.1 Insects

Insects eat and spoil large quantities of stored grain worldwide. There are about 100 species which attack stored foods and they vary in their habits and in the damage they cause. These next sections will explain:

- how to identify the major storage pests
- how they behave
- the damage they cause
- where to look for them
- how to control them.

Insect activity, and the damage which results from this activity, is closely related to temperature and moisture in stored grain. Warm, moist grain provides conditions which allow insects to multiply very rapidly indeed. A concentration of insects produces even more warmth and moisture, spreading the ideal conditions for insects to multiply. The warm moist conditions caused by insects also create the conditions for the growth and spread of fungi.

Insects infest grain because grain provides food. Poorly managed grain stores provide ideal places for insects to live and multiply because food, air, moisture and warmth are all provided.

There are three main types of pests in grain stores:

1. Primary pests.
2. Secondary pests.
3. Tertiary pests.

Primary pests break down the hard seed coat of the whole grain.

Secondary pests follow and feed on grain with broken and cracked seed coats. They do not attack undamaged grains.

Then tertiary pests feed on the broken grains, dust and powder left by the primary and secondary pests.

Examples of primary pests are the Angoumois Grain Moth, the Lesser Grain Borer, the Rice Weevil and the Grain Weevil. An example of a secondary pest is the Rust-Red Grain Beetle. Tertiary pests include the Red Flour Beetle. These now follows some information on identification.

4.1.1 Weevils

Weevils are easily identified by their long snouts and elbowed antennae. When giving a demonstration try to have some specimens to show the group. It is important that farmers appreciate their size.

Common Name	Latin Name
Grain Weevil	Sitophilus granarius
Rice Weevil	Sitophilus oryzae
Maize Weevil	Sitophilus zeamais

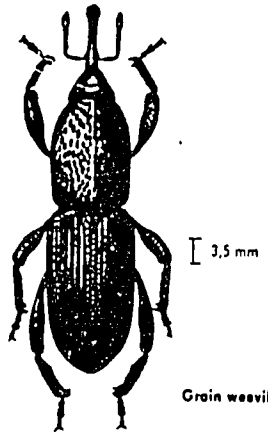


Figure 4.1 Weevil

Some common questions about weevils:

Q. What food do weevils prefer?

A. S.zeamais, S.oryzae and S.granarius can develop on all cereals and solid processed cereal products. S. zeamais is mostly associated with maize, S. oryzae is associated with wheat and other small grains, and S.granarius is a frequent pest of wheat and barley. In addition, S.zeamais and S.oryzae frequently attack dried cassava. Both the adults and larvae feed on grain.

Q. What are larvae?

A. The adult female will lay one egg in a small hole chewed into the cereal grain, then seal the hole with a waxy substance call and "egg-plug". When the eggs hatch, the larvae, which resemble small white worms, feed inside the grain. There are four growth stages, or instars, of larval development. The larvae the pupate inside the grain. The pupa is an immobile stage in which the transition from larva to adult takes place. The new adults then chew their way out, leaving holes in the grain.

Q. How long does this take?

A. The length of the life cycle will depend upon the quality of the grain being infested, its moisture content and the temperature. Under the most favourable conditions (around 25°C - 28°C) the development period may be as short as 31 days; under unfavourable conditions it can take over 110 days. The incubation period for the egg is about 6 days at 25 C, although eggs can be laid between 15 - 35°C and above 10% moisture content. Pupation takes place in about 25 days, although it takes much longer at low temperatures.

Q. How rapidly do weevils reproduce?

A. Each female may lay 150 eggs, and depending upon conditions a population can multiply by 100 times in one generation. Using these figures, a population of 1000 weevils could grow to 100,000 in 1 month.

Q. How long do they live?

A. Adults can live up to 1 year

Q. Do weevils fly?

A. S.zeamais and S. oryzae have wings, although S.oryyae rarely flies. S.granarius cannot fly.

Q. How do we control weevils?

A. It is important to have a complete storage programme that includes early harvesting, pre-storage hygiene, shelling, treatment with a recommended chemical, and inspection. This is discussed in detail in Chapter 5.

When discussing weevils and other pests with farmers it may be helpful to have a thermometer and moisture meter to demonstrate the actual conditions inside a granary.

4.1.2 Moths

There are only a few species of moths that are known storage pests. Only one moth, the Angoumois Grain Moth, or Sitotroga cerealella, is a primary pest. This moth is a serious storage pest of whole cereal grains throughout the tropics, including Kenya, and in many warm temperate regions. It can infest cereal grains in the field as well as during storage.

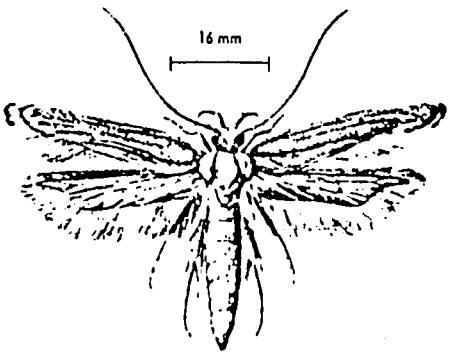


Figure 4.2 Angoumois Grain Moth (Sitotroga cerealella)

The adult Angoumois Grain Moth is a light yellow-brown colour. It is about 8-10 mm long and about 15 mm from wing tip to wing tip. It has a noticable fringe on its back wings (see Figure 4.2). The larvae is rarely seen because it usually completes its development within a single grain. The larva is different from beetle larvae in that it has true legs.

Some common questions about the Angoumois Grain Moth:

Q. What do they prefer to eat?

A. It infests all types of cereal grains, including paddy rice, but particularly attacks maize and wheat.

Q. How much damage can it cause?

A. The weight losses can be as high as 50% in wheat and 24% in maize. In addition, badly infested grain has a sickening smell and taste that makes it unfit for human consumption. Only the larvae feed. The adults are very delicate and cannot penetrate far into densely packed grain, so infestations in bulk grains are usually found only in the outermost exposed layers.

Q. How does it reproduce and how fast does if multiply?

A. The female moth lays eggs singly or in clumps on the grain. The number of eggs from one female can vary from 50 to 200. When the eggs hatch the larvae bore into the grain where they remain until fully grown. Before pupation, the larvae create an opening just beneath the surface of the seed coat, creating a small circular "window". The newly emerged adult then pushes the "window" open, leaving a small round hole partially covered by a trapdoor".

The complete life cycle takes about 28-35 days at 30 C. A population of moths can multiply by 50 times per month.

Q. What environmental conditions does the moth require?

A. The temperature limits for successful development are 16-35 C, and humidities between 50-90% have little effect on developement.

Q. How long do they live?

A. The adult moth does not feed and lives only 5-10 days.

4.1.3 Beetles

Beetles vary widely in shape and size. Weevils, in fact, are actually beetles (of the order Coleoptera) although here they are discussed separately for case of identification and because of their importance as storage pests.

Beetles are generally the most common storage insects, and alsmost all ecological inches are occupied by some beetle species. That means that some beetles are either primary pests, secondary pests, carrion feeders of animal products, mould feeders, predators or wood borers.

Adult beetles are either long or short-lived. The larvae always feed. Adults can be recognized by the hardened "shell" on their back, which are actually modified fore-wings called elytra. Illustrations of the major grain eating pests are given here. Try to have some specimens on hand to show farmers during demonstrations.

Common Names	Latin Names
1. Lesser Grain Borer	Rhizopertha dominica
2. Greater (or Larger) Grain Borer	Prostephanus truncatus
3. Dried Bean Beetle (Bean Bruchid)	Acanthoscelides obtectus
4. Red Flour Beetle	Tribolium castaneum
5. Rust-Red Grain Beetle	Cryptolestes ferrugineus

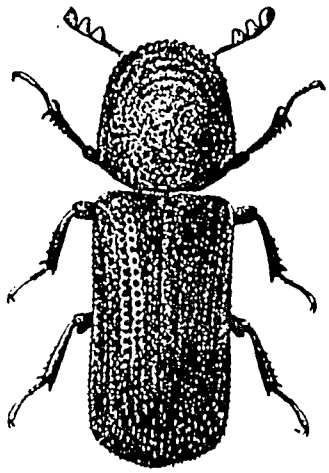


Figure 4.3 Lesser Grain Borer

Figure 4.4 Greater Grain Borer (or Larger Grain Borer)

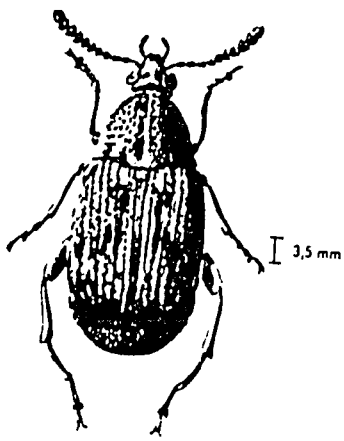


Figure 4.5 Dried Bean Beetle (or Bean Bruchid)

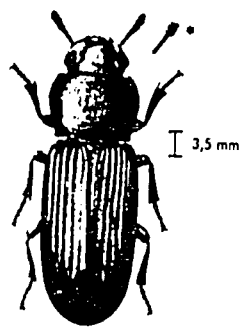


Figure 4.6 Flour Beetle

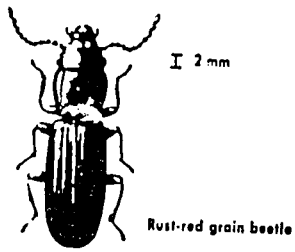


Figure 4.7 Rust-Red Grain Beetle

4.1.4 The Greater Grain Borer - A Special Pest.

One beetle requires a special mention because it is such an important storage pest. The Greater (or Larger) Grain Borer (*Prostephanus truncatus*) is a relatively new pest in Kenya. It is originally from Central America, although it is now found in South America and parts of North America, West Africa and East Africa. GGB was accidentally introduced to Togo and Tanzania, and then entered Kenya at Taveta in 1983. It has since spread from Taita-Taveta District to neighboring areas of the country.

Some common questions about GGB:

Q. How do I recognize if GGB is in my area?

A. The adult GGB is dark brown and a cylindrical body and about 3-4 mm long (see Figure 4.4). The Lesser Grain Borer, in contrast, is about 2-3 mm long (see Figure 4.3). The posterior end of the GGB's elytna has such a steep inclination that it appears to have been cut straight and is especially recognizable.

The damage it causes is also a clue in its identification. The adults bore right through maize sheaths and kernels, leaving large amounts of dust. The damage can be particularly severe, and farmers have been supervised to find little more in their stores than maize shreaths bored full of holes and only dust inside the sheaths.

Q. What does GGB eat and what levels of loss have been recorded?

GGB is a serious pest of cob maize and dried cassava, maize, and it can also attack other cereals, groundnuts, dried bananas and even cause damage to wooden structures.

Weight loss in cob maize is much higher from GGB than from the more usual storage pests under comparable conditions: Weight losses of up to 40% have been recorded in Nicaragua and 34% after 3-6 months in Tanzania and Taveta. In dried cassava weight losses up to 70% have been recorded after just 4 months of storage.

Q. What conditions does the GGB require to reproduce?

The adult bore tunnels through maize grains, and the female lays eggs in a chamber bored at right angles to the tunnel. Egg-laying is more successful and done at a faster rate on cob maize rather than on unstable, shelled maize kernels. Research has shown that under the optimal conditions of 32 C, 80% relate humidity and a maize diet, development from larva to adult took just 27 days. A decease in relative humidity to 50%, giving and equilibrium moisture content of just 10.5%, did not have much effect on the development period or mortality (the death rate). This means that GGB can tolerate very dry conditions, as confirmed in Kenya and Tanzania.

Q. How do we control GGB?

Since the GGB is such a serious threat it is of great importance that this pest is controlled. Fortunately there are effective control measures that can be implemented.

Even the simple act of shelling maize will decrease the GGB's rate of reproduction. GGB needs stable grains to bore into, and cob maize is the ideal food for it. After shelling, grain should be treated with appropriate chemical.

The chemical approved for use in Kenya is called "Super Actellic", and it contains the active ingredient of regular Actellic (pirimiphos methyl) blended with another pesticide called permethrin. The dosage rate is the same as other storage chemicals, 50 gms per 90 kg of grain.

Biological Control is another method under investigation. A predatory beetle that attacks GGB in Central America has been released in Togo, and after sufficient study a decision will be made whether this method is appropriate for Kenya.

4.2 Moulds

This simplified view of moulds is quite sufficient for the farmer. Of course if you were a highly trained mycologist, you would know that a fungi can be distinguished from other microorganisms by:-

Metabolism:	They are chemo-organotropic
Cell Structure:	Eucaryopic, filamentus
Reproduction:	They have sexual and asexual spores
Thallus:	Consisting of tabular filaments called hyphae

Latin names of the more common fungi are:

Aspergillus
Penicillium
Alternaria tenuis
Botrytis cinerea
Cladosporium spp
Ulocladium ssp

Since you are not a highly trained mycologist, your best bit is to have a practical knowledge of fungi (mould) identification, and prevention. You should also learn the produce for collecting samples of infested maize and sending them to a nearby laboratory for analysis. Check with your Agricultural Officer.

Keeping in mind that the farmer will not want a detailed biology lesson, ask the farmer the following:-

Q. What does mould infested grain look like?

A. Sticky mass of grains sometimes whitish

Q. How does the mould get inside the store?

A. The seeds are always on the grain.

Q. If the seeds are always there, why isn't all the grain infected all the time?

A. The moulds need the right conditions and time to grow.

These conditions are:

Storage Air (Farenheight)	Temperature (Centigrade)	Corn Moisture Content 15%	20%	25%	30%
Degrees		Days	Days	Days	Days
75	23.9	116	12	4	2.5
70	21.1	115	16	6	3.5
65	18.3	207	21	8	4.5
60	15.6	259	27	10	6.0
55	12.8	337	35	13	8.0
50	10.0	466	48	17	10.0
45	7.2	725	75	27	16.0
40	4.4	906	94	34	20.0
35	1.7	1140	118	43	25.0

The time given are those above which mould growth will cause enough loss in corn quality to bring about a lowering of the grade.

Q. Are these conditions likely to occur in the store?

A. Most definitely.

Action: Minimise moisture and temperature fluctuations.

Q. Why are moulds bad?

A. - They destroy grain

- They put poisons in and around the grain
- Their spores (seeds) are harmful to hums and animals
- They make the grain taste strange
- They change the grain so that it will not germinate if planted
- They reduce the nutritional value of grain.

Did you know that hayfever, asthma and farmer's lung (fever and breathlessness) are all caused by the spored (seeds of fungi and moulds? Do you know that in 1975 more that 100 people in India died of aflatoxin poisoning in grain which caused by moulds.

4.3. Rodents

Most rodents are not pests. However, some like the common rat are very destructive consumers of grain. So far we have dealt with pests which depend on certain conditions inside the store. We will now show that rodents can destroy grain whatever the internal conditions of the store.

Figure 4.8 Rodent and Rodent-Damaged Maize

Rodents Facts-- There are three main storage rodents:

Norway, Common or Brown Rat	- Rattus norvegicus
Roof Rat	- Rattus rattus
Common House Mouse	- Mus muscullus

Q. How do rodents destroy the grain?

A. They simply feed on it. As Figure 4.8 shows, rodents only eat part of each maize kernel. However, the part they eat is the most nutritious part. They leave many damaged kernels which can easily be attacked by insect pests.

Rodents eat maize in the field or in storage.

Q. What other harm do rodents cause?

A. Rodents help spread many diseases by contaminating peoples' food and water. A few of the diseases are viral fevers, food poisoning, trichinosis and tapeworm.

In surveys conducted by the Grain Monitoring Unit in Maseno, <u>every</u> maize sample taken from traditional stores had been contaminated by rodents.

Rodents also cause damage to gunny bags and granary walls and floors.

Q. Are all rodents the same?

A. No. The table below will help you identify the type of rodent that is damaging your grain. This is important because some rodenticides (poisons) and traps work better for certain types of rodents. For example, a rat trap is too large to catch a mouse, and a mouse trap is too small for a rat.

Q. What do we know about the behaviour of rodents?

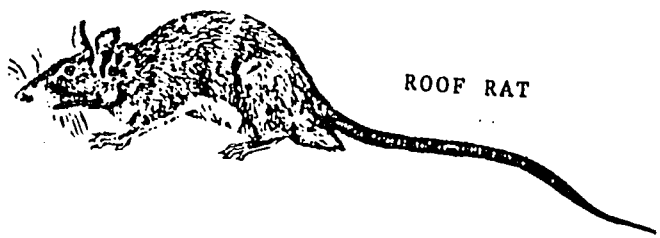
A. In a discussion with farmers, make sure the following points are covered:

- Rats and mice have a routine they do daily.
- Rodents always use the same route and path and usually travel
- along the walls or stacks. They do not like open places.
- Rodents stay away from new things. Some rodents therefore never touch anything new until they get used to seeing the same object in the same place.

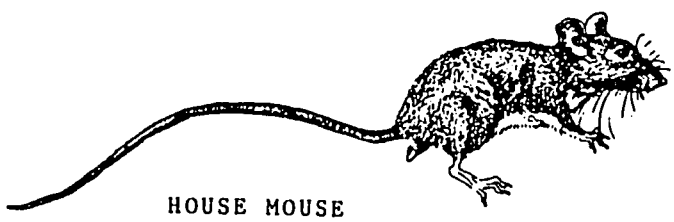
Table 4.2 Characteristics of Norway Rat, Roof Rat and House Mouse

	Norway Rat (Rattus norvegicus)	Roof Rat (Rattus rattus)	House mouse (Mus musculus)
Adult weight	150 to 600 g	120 to 350 g	15 to 25 g
Snout	Blunt	Pointed	Pointed
Eyes	Small	Large	Small
Ears	Small, furry	Large, thin, few hairs	Large, few hairs
Tail	Thick, shorter than head plus body, usually dark above and pale underneath	Thin, longer than head plus body, dark above and below	Thin, about the same length as head plus body, dark above and below.
Fur	Usually brown-grey above, grey or white below	Brown with grey or white belly or black with grey belly.	Brown-grey above with pale or white belly
Occurrence	Tends to burrow in and and around farm buildings or food stores and in cereal or sugarcane fields. Somewhat dependent on presence of free water and moist conditions.	Very widespread in tropical subtropical regions, mainly in dwellings, farm buildings and food stores. Rarely an important field pest. An agile climber, it usually nests above ground level, though it burrows sometimes.	Very widespread in subtropical regions. Mainly a pest in bagged food storage, dwellings and similarly well-protected situations. Field populations are common in some areas, but are usually inconspicuous and of very minor pest significance.

Brown or Norway rat.



ROOF RAT



HOUSE MOUSE

Figure 4.9 Three Types of Rodents

- Rodents can climb straight up and down surfaces as long as they find a place for their claws to grip. They can also do a standing jump of 60 cm and a running jump of 90 cm.
- Rodents can swim and for this reason they can survive in sewers and drains.
- Rodents can dig.

Rodents, especially rats, live near sources of water and food.

- Most rodents prefer to eat meat, grain, eggs and potatoes.

Q. How will this knowledge help you to give pest control advice to farmers?

A. The farmer can use knowledge of rodent behaviour to find and destroy the pest. He will be able to discover the rodents because they have:

1) Holes, nests and burrows. Rat holes are usually more than 7.5cm diameter while those mice are 2.5cm. Nests are made from grain, paper, straw or cloth.

2) Runways and smears. A runway is usually a clear path which is easily noticed.

3) Footprints and tail marks.

4) Droppings.

5) Damage and claw marks.

6) Smell.

Q. How many rats are there in your compound?

A. The population size is hard to determine. For every rat you see, there are several that you have never seen.

Q. How long does it take for a rat to reproduce?

A. The house mouse can reproduce at the age of 6 to 8 weeks; the roof rat and Norway rat at 12 to 16 weeks. Gestation from conception to birth lasts 19 to 20 days in the house mouse and 5 weeks in rats. The normal maximum rate of increase in a large rodent population is around 10% per week. That means that even 2 rodents could increase to 200-250 rodents within one year.

Q. And how will rodents affect your grain?

A. A rat can eat about 1 kilo of grain per month and can spoil ten times as much.

Q. Then how many kilos will 30 rats eat a year?

A. They will eat 360 kilos of grain. That's 4 bags (90 kg per bag)!

Q. Why do you let the rats eat your children's food?

A. .....

Control Methods

There are many methods of rodent control, namely:

1) Sanitation - clearing weeds, bushes, etc. and reducing food supply through proper disposal of trash.

2) Natural methods - use of predators such as cats and dogs.

3) Cultural methods:

a) Traps - breakback (snap)

- box/cage/tunnel (live trap)

- glue board.

b) Improved storage structures

-raised structures fitted with rat guards

-rodent-proof storerooms.

4) Chemical poisons called rodenticides

a) acute or single

b) chronic or multiple (anticoagulant).

4.3.1 Sanitation

Proper sanitation is cheap and easy to do. It is also an important and effective way to reduce rodents access to food, water and place to hide. See Section 5.3.2 for more information on cleaning a store.

4.3.2 Natural Methods

Cats and dogs will chase and kill rodents, but they cannot control a rodent population by themselves. This is because the predators will have other sources of food besides just rats and mice. Also rodents are so secretive that only a small part of the population will be caught. This population reduction is easily replaced by reproduction.

4.3.3. Cultural Methods

a) Traps for Rats and Mice

Trapping is a very old method of rodent control. Although traps can be effective under certain conditions and if used properly, in most areas traps have been replaced by rodenticides.

Advantages of Traps

- safer for farmers to handle than poisons
- can be effective, especially if only a few mice have entered a store
- traps can be used over again
- traps can be repaired and can last along time
- traps may be easier for farmers to obtain than poison.

Disadvantages of Traps

- can be expensive if a farmer needs to buy many (the number of traps used is usually 2 or 3 times the estimated number of rodents)
- must be used correctly to be effective
- trapping requires time and labour to bait, set, empty and re-set the traps; traps should be checked every day and old bait should be replaced
- not effective if the rodent population is large and covers a large area
- slow working with large infestations

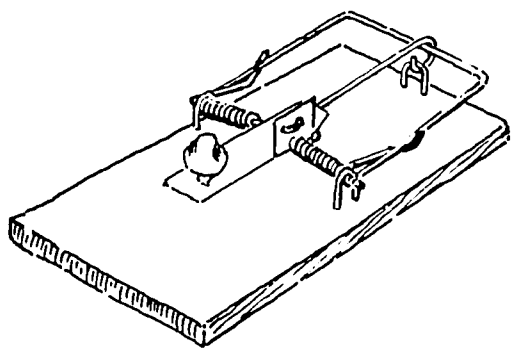


Figure 4.10 Breakback (or Snap) Trap

Breakback (Snap) Traps

This is probably the most common and effective type of trap. There is a small trap for mice and a larger traps for rats.

This trap is usually used with bait. The bait must "stick" or be fastened to the trigger, or else the rodent will steal the bait. Set the trigger carefully so that the slightest contact will release the spring. If bait is being stolen without catching any rats or mice, the trap probably needs to be repaired. Inspect for bent or rusted triggers, weak springs, or loose wires.

Box, Cage or Tunnel Traps

These traps do not need bait. They are put in places where the rodents normally go. The rodents can enter but they cannot get out.

Glue Boards

A piece of cardboard or wood can be coated with a very sticky non-poisonous glue as a way to trap rodents. The board is then placed where rodents pass, for example along runways or near a hole. The board can be used with or without bait. In Kenya there is an imported glue available called Atrarat.

Glue boards are not usually recommended because of some problems with their use. First of all, this method of trapping is widely considered to be unnecessarily cruel. Also, the glue can lose its stickiness and is then no longer effective. The loss of stickiness can be due to very hot or cold weather, rain, or dust or other debris accumulating on the glue.

b) Baiting Traps

Bait may be any food that rats or mice like to eat. Place a small amount of bait on the trigger of the trap (see Figure 4.10). Either use a bait that will cling or else fasten the bait to the trigger. Change food baits every three days, because rodents will not be attracted to the old food. If one type of bait doesn't work, switch to another type.

When trapping rats it may be necessary to "pre-bait" the traps. To do this the traps are baited, but not set, and left in place for 2 or 3 days. In this way the rats lose their fear of the traps and can then be caught once the traps are set.

c) Placing Traps

Trap placement is very important. A poorly placed trap will probably catch nothing. Therefore traps should be:

- placed along rodent runways or smears;
- placed at right angles to the wall, with the trigger closest to the rodent's path along the wall. This can trap a rodent from either direction (see Figure 4.11).
- placed near holes, nests and burrows;
- on dirt floors, set the base of the trap right into the floor;
- hidden with dust, light soil, grass, etc. (do not hide the bait). Do this only where people or animals will not step on the trap;
- covered with a board, sticks, box, etc. so that only rodents can enter the trap. Be careful not to block the release of the trap spring.

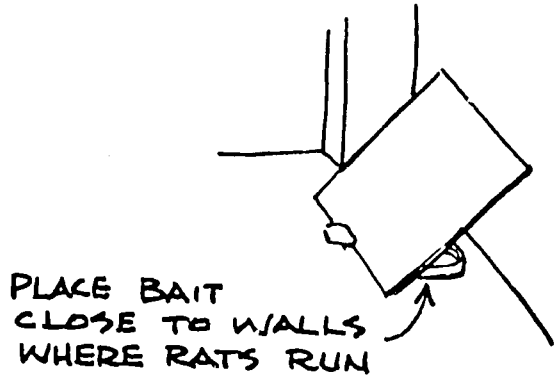


Figure 4.11 Placement of Trap Near Wall

If traps catch rodents in a few places and traps in other places catch nothing, move more traps to the areas of greatest rodent activity.

d) Rodent-Proof Structures

Raised Granaries

Because rodents dig, gnaw and climb so well, granaries made with mud walls or woven basket material will not keep out all rodents. There is, however, a way to construct granaries with local materials so that not even a single rodent can enter. This is done by building a raised granary so that rodents cannot climb or jump into the store.

A raised granary should be built one meter above the ground and every leg should be fitted with a rat guard (see Figure 4.12). The rat guards prevent any rodent from climbing the legs. Rat guards can be made from a plain iron sheet or from an old debe, kerai, Kimbo or Cowboy tin, etc.

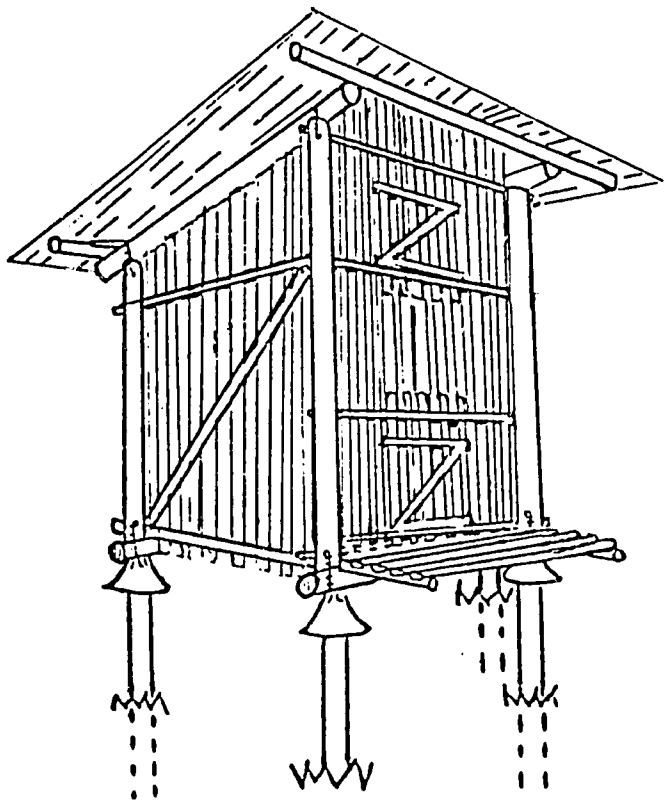


Figure 4.12 Granary Raised One Metre and Fitted with Rat Guards

Section 7.5 explains how to make rat guards. A raised granary must also be clear of alternate pathways for rodents, such as nearby bushes, overhanging tree branches, or ladders or other tools left leaning against the store. For information on the construction of raised stores refer to Chapter 7 and the Appendix.

Store-room or Storehouse --

Rodents commonly enter grain stores through openings in the walls, along the floor, next to doors and windows, or under eaves (under the roof). If the store is not raised one meter, to keep rodents out it must be made of rodent-proof materials such as brick, concrete or metal. In addition:

- the floor should be concrete
- there should be no cracks or openings over 7 mm wide
- wooden doors need thick metal sheets along the bottom (galvanized iron, at least 20 gauge, around 30 cm high, fitted within 6 mm from the ground).
- there should be wire mesh over all windows or ventilation openings
- the eaves should be sealed with concrete or wire mesh
- metal surfaces can be painted to prevent rusting.

Outside of the store, remove nearby bushes or overhanging tree branches which can help rodents in climbing. Inside the store, shelled grain should be kept in gunny bags stacked neatly off of the ground and not touching the walls. There should be room around each stack to allow inspection. Do not leave small spaces between the sacks where rodents can hide (see Figure 4.13).

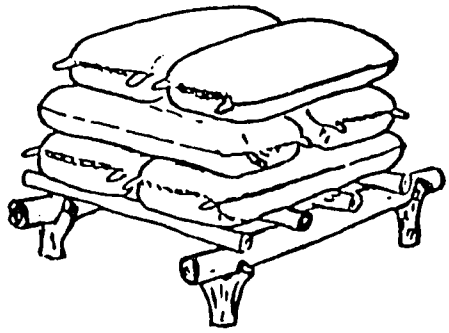


Figure 4.13 Stacking Sacks of Grain

The storage area should be inspected and swept clean every week. The person inspecting should go around each stack of grain, looking for evidence of rodents such as droppings, holes in sacks, footprints, runways or nests between sacks. The floor should be swept clean and there should be no piles of rags, gunny bags or building materials either inside or near the store. Rodents will use these areas for hiding and nesting. For this reason, a detached store separate from other structures and surrounded by a clean area is less attractive to rodents.

4.3.4 Rodenticides (Poisons)

When there is a problem with rodents anywhere in the world the most common method of control is through the use of poisoned baits. This is because the use of rodenticides (poisons for rodents) has proven to be easier and more effective than hunting or trapping. Although rodenticides have an established role in rodent control they must be used properly to be effective and safe.

Many farmers are not aware of the extent of rodent damage to their grains, and so they are often slow to recognize a serious problem with rodents. They may then wait before taking any action, which allows the number of rodents to build up even more. By this time the level of damage is high and it becomes more difficult and more expensive to control the rodent population.

There are two kinds of rodenticides: acute rodenticides, which kill the rodent quickly (usually within one hour) after it eats just a few mouthfuls of bait, and chronic rodenticides, which must be eaten for several days before the rodent dies.

It is important that the correct rodenticide is used for each situation. Of course, not all types of rodenticides are available in rural areas and so a farmer may have no choice in the type of rodenticide used. Ideally, the rodenticide should suit the rodent problem. Also, the number of bait stations, the bait used and where the bait is placed all depend upon the particular situation.

To obtain this information there must be a survey of rodent infestation. The objectives of the survey are to learn as much as possible about the rodent problem, including the type of rodent, the level of damage, the types of food being eaten and to locate burrows, entrance holes, runways, smears and nesting sites. When the survey is complete and yet before any rodenticide is used, the farmer should clear the area of all food sources, hiding and nesting places, and eliminate all of the openings holes or cracks used by rodents to enter the granary. This provides a balanced rodent-control program which includes sanitation and rodent-proofing as well as the use of rodenticides. A more complete discussion of the different rodenticides is included in this section.

CAUTION!!
RODENTICIDES ARE POISONS THAT CAN KILL PEOPLE AND ANIMALS. IT IS THEREFORE VERY IMPORTANT THAT AGRICULTURAL STAFF AND FARMERS KNOW WHICH POISONS TO USE AND HOW TO USE THEM.

a) Acute Rodenticides

Many types of acute rodenticides have been tried for rodent control. Some are very effective poisons but are very hazardous to use, others are relatively safe to use but not very effective. There are several advantages in using acute rodenticides. Because they are highly poisonous, less bait is required, and less labour is required in distributing it. They also take effect very quickly, to give a farmer some immediate relief from a serious rodent problem. Because their effect can be seen overnight, acute rodenticides tend to be adopted more easily by peasant farmers.

On the other hand, there are disadvantages with acute rodenticides. They tend to be less effective than chronic rodenticides if you look at the control of rodents over a longer period of time. Even very careful and effective baiting procedures will leave some survivors, which will be "bait shy" and "poison shy". This means that the surviving rodents will learn to avoid the bait and rodenticides that were used, and they will therefore be harder to poison in the future.

The main disadvantage, however, is safety. A single dose of an acute rodenticides can kill livestock, wildlife and even people. It is most important that acute rodenticide are used carefully and responsibly.

Acute rodenticides will poison the most rodents in the first day, although there may be some advantage in leaving poisoned bait undisturbed for two or three days. The same rodenticide should not be used more than once or twice a year, or the rodents will remember its smell and not take the bait.

Prebaiting --

Since the poisoned bait will attract the most rodents on the first day, "prebaiting" ensures that the rodents will readily eat the bait before they realize that it is poisoned. This is done by distributing unpoisoned bait where rodents will find it and then replacing what they eat every day or two until they are eating it freely. This may take up to five days for mice and five to ten days for rats. At this time all the prebait is collected and replaced with poisoned bait, using the same kind of bait as the prebait. For example, if the rodents accepted maize flour as the prebait, then maize flour should be mixed with the acute rodenticide. The amount of poisoned bait should be about half of the amount of prebait eaten in the previous twenty-four hours. Other than replacing the prebait with poisoned bait, the area should be disturbed as little as possible.

Bait Preparation (Acute Rodenticides) --

The bait must be a food that the rodents like, and often a cereal bait works well. Rodents especially like damp baits, although these can dry out if left unattended. Either soak cereal grains overnight or soak coarsely-ground cereal for one hour and drain any excess water. Even old bread can be soaked in water. Now the poison can be added, following the directions on the container or package. If there are no instructions for proper use on the containers, then do not use the poison. It may not be safe.

It is very important to handle acute poisons with great care. The poison must not come into contact with bare skin or be inhaled. To avoid this, the user should wear a mask, long sleeves, and rubber gloves.

If there are no gloves, then plastic bags can be pulled over the hands and tied at the wrist. The poison should not be mixed when there are any draughts that might blow the poison into the user's face. After mixing the poison the person should wash all exposed skin and change his clothing.

NOTE: DO NOT carry mixed baits in a vehicle or other enclosed space. Some poisons, such as zinc phosphide, give off a dangerous gas when mixed with a damp bait. Mixing should be done IMMEDIATELY BEFORE USE and only in a WELL-VENTILATED place.

Placing the Bait --

Baits must be placed where the rodents will find them and there must be enough poisoned bait so that every rodent can eat a lethal dose. It is usually better to have a large number of small bait points than to have the same amount of bait in just a few locations. At each bait station,

- Use 5-15 g of bait for mice, 25-100 g for rats.
- Bait can be put in small containers or trays (for example, a small box or the lid of a jar), or rolled inside a piece of paper.
- Place these paper packets into rodent holes or burrows, in pipes and other places where traps will not reach.
- NEVER PLACE POISON WHERE CHILDREN OR LIVESTOCK CAN FIND IT.
- Do not allow bait containers to get wet.
- Place bait along rodent runways, entrance holes and feeding sites.
- Cover any open bait containers (for example, with a wooden board, piece of iron sheet or a small grass "house") to keep other animals away (see Figure 4.14).
- Collect and destroy poisoned bait after one to three days.

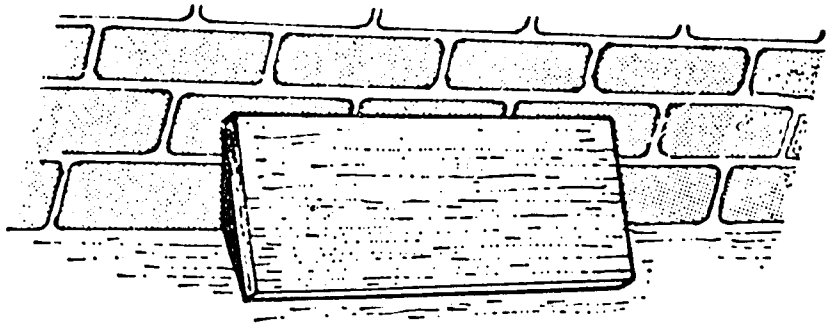


Figure 4.14 Protect Bait Containers

Recommended Acute Rodenticide --

Based on its availability in Kenya, effectiveness, cost, and safety, the recommended acute rodenticide is zinc phosphide. Zinc phosphide is contained in the commercial rodenticide called "Rat & Rat", and probably in other brands as well.

Zinc phosphide is potentially poisonous to both man and animals, both as a primary poison (when the bait is eaten directly), or as a secondary poison, when a dog or cat eats a poisoned rodent. Its main safety feature is its unusual odour, which is very disagreeable to people but does not bother rodents.

To prevent bait shyness, zinc phosphate should only be used once or twice per year, and at a concentration of two to three percent. If protected from rain zinc phosphide remains toxic for up to nine months.

Non-recommended Acute Rodenticides --

According to a World Health Organization Expert Committee, the following acute rodenticides are unsafe:

- arsenic trioxide
- thallium sulphate
- alphanaphthylthiourea (ANTU).

The following are considered outdated due to reasons of safety or efficiency:

- red squill/scilliroside
- barium carbonate
- sodium arsenite
- strychnine
- yellow phosphorus.

The following are too dangerous to use except under strictest professional supervision and under conditions of high security:

- sodium fluoroacetate
- fluoroacetamide
- crimidine.

Follow-up Treatment --

Rodents poisoned by an acute rodenticide may die in their burrows or some other hiding place. Thus one way to determine if any rodents have survived is through continued monitoring of unpoisoned baits. In addition, the rodents may have become bait-shy and so a new bait may be needed. Because the surviving rodents are now more careful a chronic rodenticide is an effective follow-up to an acute rodenticide.

b) Chronic Rodenticides

Chronic rodenticides must be eaten by rodents over several days to cause death. Rodents may start dying after three days of poisoning but often in the field it may take two to four weeks to kill all of the rodents. Most chronic rodenticides are also called "anti-coagulant" rodenticides because they affect blood clotting, which leads to internal bleeding and then death. The one type of chronic rodenticide that is not an anti-coagulant is called Calciferol.

The advantages of chronic rodenticides are:

a) they are relatively safe to use, because they do not kill in a single dose and non-target animals (such as livestock) usually do not eat enough poison to cause death.

b) because of the delayed effects of the poison, the rodents usually eat a fatal dose before they even start to feel ill. In this way they do not link their illnes to the bait, and so they do not develop bait-shyness.

c) chronic rodenticides are reliable and can even totally elimitate a rodent infestation.

The disadvantages of chronic rodenticides are:

a) they take longer than acute rodenticides to kill rodents, and so their effectiveness is not immediately visible.

b) They require more labour over a longer period of time.

c) They require more bait, which increases their cost of use.

Prebaiting with Chronic Rodenticides --

Prebaiting is not necessary with chronic rodenticides and so it is not recommended.

Bait Preparation (Chronic Rodenticides) --

As with acute rodenticides, chronic poisons and poisoned baits must be handled with great care. The poison must not come into contact with bare skin or be inhaled. To avoid this, the user should wear a mask, long sleeves and rubber gloves. If there are no rubber gloves, then pull plastic bags over the hands and tie them at the wrist. Avoid draughts when mixing poisons. After mixing the poison wash all exposed skin and change clothing.

The base of the bait must be something the rodents like to eat, such as ground or crushed cereals, or small broken or whole grains. However, in areas such as food stores where rodents are accustomed to a regular diet, the bait must be of good quality to attract them. An attractant such as sugar (five percent by weight) will improve the taste of the bait. Also, the instructions on the rodenticide container must always be followed. Do not add too high a concentration of poison, or the rodents will taste it and refuse the bait. For example, with the popular rodenticide Warfarin, the concentration should be between 0.005-0.05%. Any higher concentration will be tasted.

To make ten kg of a dry anticoagulant rodenticide bait:

a) take 9.5 kg of dry ground cereal (19 parts by weight), and

b) mix with 0.5 kg of the anticoagulant master mix (which contains a standard amount of poison).

To make an oily bait, which is more attractive to rodents:

a) combine 17 parts cereal (by weight), with

1 part sugar

1 part Warfarim master mix

stir well until all the ingredients are completely mixed.

b) add 1 part (by weight) of oil (either a vegetable oil or liquid paraffin)

c) Stir until evenly mixed.

If the rodents still prefer to eat grain from the granary rather than the bait, then try damp bait. Instructions for preparing damp bait appear earlier in "Bait Preparation" under "Acute Rodenticides". The problem of damp baits with chronic rodenticides is that they may dry out or become mouldy, which will cause rodents to reject them.

In some cases anticoagulant rodenticides may be available in ready-to-use wax blocks. Although more expensive and not generally available in Kenya, they are convenient to use and safe to handle.

Placing the Bait (Chronic Rodenticides) --

Since the amount of poison must slowly build up in the rodent's body, the rodent must eat the poisoned bait repeatedly until it dies. Normally each bait point should contain 15 to 50 g of bait for mouse control or 200 to 250 g for rat control. The bait is checked every day and refilled as needed. DO NOT let any bait point run out of bait.

The first rodents should start to die after four days, with most deaths occuring after seven to ten days. It may take two to three weeks to eliminate all of the rodents.

- Place bait in jar lids, in shallow tins, in pipes or other containers.
- To protect and hide the bait, cover bait containers with boxes, boards, thatch or other materials. Make sure rodents can still reach the bait!
- Place bait where signs of rodents are found.
- Inspect bait points every day.
- Replace mouldy or insect-infected baits.
- Move the bait container if bait is not being eaten.
- Use 15-50g of bait for mice, 200-250g for rats.

List of Recommended Chronic Rodenticides --

Warfarin (the most common worldwide)

Bromadiolone (found in "Lanirat")

Brodifacoum (found in "Klerat")

Diphacinone

Difenacoum (Ratak)

Coumatetralyl (Racumin)

Calciferol

Coumachlor

Always follow the instructions that come with a rodenticide. HANDLE ALL POISONS WITH EXTREME CAUTION!

c) Liquid Baits

Liquid baits are rodenticides dissolved in a tin of water and left for rodents to drink. Either acute or chronic rodenticides are used. They are inexpensive and especially useful in dry areas, although other sources of water should be removed.

However, liquid baits can lose their power in two or three days of warm weather. Because the water is easy to spill, liquid baits are more hazardous to use than solid baits.

Safety --

- Handle all poisons with extreme caution!
- Always follow instructions that come with a rodenticide.
- Store poisons carefully, in a locked cabinet, and with poisons clearly labelled. Keep the store clean and orderly, and do not store poisons where they could be contaminated by agricultural chemicals. Never let poison contaminate food!!
- Avoid skin contact with poisons.
- Wear rubber gloves (or plastic bags tied at the wrists), long sleeves or protective clothing and a face mask if handling dusts. Wash after use.
- Wash off accidental skin contamination at once.
- Warn everyone in the area that poison is being used and tell them to keep their animals under control.
- Use many smaller bait points rather than a few large points.
- Collect dead rodents and burn them or bury them deeply. This prevents "secondary" poisoning.
- Collect bait containers and residues after the treatment is over.

Failure of Rodent Control Treatments --

There are three basic reasons why a rodent control programme may fail:

1) Underbaiting: Either not enough bait was used, or there were too few bait containers (so that some rodents never found the bait), or empty bait containers were not refilled.

2) Bait was mixed incorrectly: Failure will occur if the poison concentration is too high or too low.
Sometimes the type of bait simply fails to attract the rodents, which calls for the use of a better grade of cereal for the base, the addition of sugar as an attractant, or the use of a damp bait.

3) Bait-Shyness: This is a problem with acute rodenticides only. If some rodents survive after eating an acute poison, they will not eat that poison or that type of bait again. This "bait-shyness" may last for several months. To avoid this, do not use the same cereal base bait more than once every six months.

- Early harvesting will reduce field losses from rodents and insects Remember, higher yielding hybrids are more susceptible to attack because of their weaker husks.
- Fit rat guards as shown in Section 7.5
- If not controlled insects and rodents can reproduce rapidly.
- Keep a cat.
- Do not store things under the store which will also allow rodents to jump up into the store/crib.
- Keep your compound tidy.
- Burn rubbish that encourages rodents and insects.

- Make sure your store is on a platform raised 100 cms (3 feet) above the ground.
- If you use poisons, handle them with care and make sure they are used and stored in a lace where children cannot reach them.
- Store only clean, healthy grain which has been dried to safe storage levels.
- Protect dried grain from the rain and from cool, moist air.
- Keep the store cool.
- Protect the grain from condensation by storing in a well-ventilated store which does not allow a great temperature difference to develop between the inside and outside of the store.
- Take steps to ensure that your store is clean and free of insects at the start of the storage period and that the grain is brought into the store with as few insects as possible. This is the basis for many of the practical recommendations you will be making during demonstrations.

4.4 SUMMARY

This chapter covers their important crop loss factors, insects, moulds, and rodents. In addition to these causes of post maturity losses, you should also be acquainted with such loss agents as:

. birds
. lodging
. theft

Each of these problems with which farmers must contend have solutions. However, some are less easy to solve, and certainly less costly to prevent, than others. Thus, in addition to understanding the technical solutions to each of these loss agents, you should be able to assist the farmer with the economic solution to the problem. (Reference Chapter Six.) Each solution has a cost-benefit ratio. Learn to partition these losses so that you know the likely magnitude of each loss.

5.0 INTEGRATED GRAIN STORAGE MANAGEMENT

So far we have dealt with the importance of reducing losses and explained the problem of identifying losses. This chapter now deals with the solutions which fall into two categories. One is to improve management; the other is to improve the structures. You could recommend one solution without the other, in cases when farms are too small to justify a structure. In many cases, however, you will want to recommend a total integrated grain storage management package. We said in Chapter 2 that post-harvest management (which actually starts just before harvest) was an intergrated system with five components:

Modifying and improving a storage structure;

Pre-storage Hygiene;

Harvesting at the correct time;

Shelling and treatment;

Periodic inspection of the store.

To gain the maximum benefits, all of the above management practices should be implemented as they all complement each other. In other words, the full benefit from the farmers investment will only be realised when all the techniques are used.

The real key to success will depend on the management skills of the individual farmer. The timing of investment decisons and the sequence of adoption will require planning and forethought.

For example, if you store dirty, moist grain in a new improved crib, i will grow fungi and be eaten by insects. The use of an improved crib o its own would bring only minimal advantages.

This chapter contains the technical information that you need to know i order to conduct successful farmer field days on the on the topic relate to post-harvest management. Space is provided at the end of each set o technical information for you to prepare for yourself a basic outline o what you plan to accomplish during the day. As you prepare your outlin think of the objective of your demonstration and the time you plan t spend on each segment of the day. As you make your outline list th equipment you'll need to take along so that you don't forget an importan item.

Although the chapter focusses of field day demonstration, this technical information will be equally useful to you as go around on your fortnightly visits.

5.1 How to Prepare for Field Day Presentations

Step 1: Read carefully through your chosen topic for the demonstration you are planning to give at the next farmers field day.

Step 2: Study carefully notes headed "Essential Information".

Step 3: Read the demonstration notes again.

Step 4: Rehearse (practice) giving the demonstration with a friend or fellow Agricultural Assistant.

Step 5: Revise and check any points you are not sure about. If you find it helpful, make "Key Notes" to take to the field.

Step 6: Before giving the demonstration make sure everything is prepared, as far as possible. Refer to your checklist before going to the farm.

Step 7: When giving the demonstration, take time to listen to the comments from the group and encourage discussion of important points. Try to see things fron the farmers' points of view. Sharing the experiences of different farmers will help the group to learn and remember.

Help members to identify problems themselves. The farmers will then appreciate your advice and suggestions more fully. Try to encourage the women as well as the men to give their points of view.

If something very helpful is raised in the discussion, make note of the point. This encourages participation.

MOTIVATE YOUR GROUP

Do this by explaining the benefits

- Saving a possible 3 months extra maize for an average family
- Out of every 20 bags harvested you could save on average almost an extra 4 bags of maize
- How much will this be worth in Shillings?
- Think how much this would help:
  a) with schooling
  b) medical needs, etc
  c) new seeds and fertilizers

5.2 Modifying and Improving a Storage Structure

The objectives of this demonstration are to (1) help farmers to understand the main factors which determine the effectiveness of their storage structures for both drying and storing grain and (2) to provide farmers with the knowledge and skills they need to modify, maintain and improve their structures.

For this field day you will need:

1. A demonstration site carefully selected to provide the maximum learning opportunities for the farmers.

   Preferably the site should have:

   - A poorly-sited granary or crib in need of modification and repairs
   - A well-sited improved granary or crib.

It is best to have these on one storage site, but if it is not possible try to identify a site where you can use a neighouring farm to illustrate those things not available at your main demonstration site.

2. A farmer(s) at the demonstration site who is willing to assemble all the materials required to carry out modification and repairs to his or her store(s). Explain your requirements to the farmer, and ensure that the materials are ready on site before the date fixed for the demonstration. This farmer could be either building his own improved granary, or renovating an old granary, or a demons- tration farmer who has received materials to build a granary.

3. Following is a list of the items you will need for your demonstration (add other supplies to the checklist provided at the end of this section.):

CHECKLIST OF TOOLS AND EQUIPMENT REQUIRED
FOR STORE MODIFICATION DEMONSTRATION

Description		Quantity
Pangas		2
Bow-saw		1
Claw hammers		2
3m Tape measure		1
Hole diggers		2
Nails 1"	appr.	1 lb
Nails 2"	"	1 lb
Nails 3"	"	1 1/2 lb
Nails 4"	"	1 1/2 lb
Paint brush, 4 inch		1
Old engine oil		5 ltres
Tin for rat guard construction (mabati, Kimbo tins, Karai, Cowboy tins)		6-2kg tins
Sample of weldmesh wire 1 ft x 1 ft		1
Sample of treated post		1
Sample of posts, 10cm dia.		1
Sample of posts, 12cm dia.		1
Poles 5-6cm dia.		1
Sample of loosely woven lantana 1 ft x 1 ft		1
Sample of papyrus mat		1

If a fundi is available in the area to construct improved granaries then encourage him to attend the demonstration. Rehearse and arrange his contribution.

5. Drawings, perhaps as a flip-chart to show the stages in construction of new, improved granaries and cribs. (The drawings are in the section on construction. You can decide yourself whether or not you think this will be helpful and appropriate for the group.)

5.2.1 Begin the demonstration near one of the crop stores and follow these steps.

1. Explain the objectives of the demonstration to the assembled farmers.
2. Explain that the discussions and demonstration will be in two parts:
   - modification and repair of structures designed for safe drying and storage of maize.

3. Ask the farmers to estimate what percentage of their crop is lost in the field before bringing it into the store.
   -Discuss this subject briefly.
   -Tell them the results of project field tests. Ask why it is advisable to dry maize in a store rather in the field.
   -Ask for discussion, but keep it brief. You have a long day ahead of you.
   -Explain why it may be necessary to modify storage structures for drying early-harvested maize.

4. Ask the farmer what are the major factors affecting the time it takes to dry maize in the store.

5. Discuss other ways of drying maize which may be more appropriate for small-scale farmers who produce only a few bags of maize. These are drying trays, drying on mats or drying in sacks or baskets. If farmers are interested in these low-cost drying methods plan another field day demonstration for later. But now return the group's attention to the structure.

Discuss

- position of the crib in relation to usual wind direction;
- width of the crop store and the effect of wind speed (explain reasons for limiting the width or diameter of stores to 1.5m).

Emphasise:

- The rate of drying of maize is determined by the amount of air passing through the store.

6. Gather the farmers around a poorly-sited store and ask them to comment on its suitability for drying maize. Allow time for comments and if necessary encourage comments by asking:

- What is the direction of the wind at harvesting and drying time?
- Is the store placed where the wind blows?
- Can the wind easily pass through the store to dry the maize?

Again point out that the drying rate of stored maize depends upon the amount of air passing through the store.

7. Ask the farmer what important points should be considered when deciding where to place a store. Give examples of common mistakes made.

8. Ensure that all farmers understand the importance of siting the crib by discussing and agreeing upon the best location for an improved crib on the demonstration site.

9. Gather the farmers around a basket-type granary.
   - Tell them to look at the roof and ask them:
     a) will the roof allow rain to run off easily?
     b) what effect does the roof overhang have on the way the air flows through the store?

   -Discuss with the farmers and explain why:
     a)the recommended slope for thatched roofs is 45 degrees.
     b)the overhang on a granary basket should be 30cm.

10. Explain why a single-pitched roof is better and cheaper on a crib than a double-pitched roof.
    - Tell the farmers that double-pitched roofs should have at least a 30-degree slope and explain why.
    - Tell the farmers the minimum overhang on a roof (30 cm).

11. Let the farmers look at the walls and the floor of the structures and ask them whether air can pass freely through.

- Explain that 50% of the wall and floor should be open for better ventilation.
- Show the farmer the samples of posts, poles, loosely woven lantana, weld mesh wire and treated posts.
- Discuss alternative construction materials-those available on farms and lowest cost alternatives.
- Discuss importance of long-life structures and strong durable structures.

12. Ask the farmers whether a smeared granary basket will be suitable for drying maize.

-Explain that to serve as drying store, the walls of basket-type granaries should loosely woven and NOT smeared.

-Show the farmers an example of loosely woven material.

-Discuss the use of basket-type granaries for drying maize and agree upon the essential features of a good store for this purpose.

13. If there is a crib-type store, gather the farmers around it and let them look at the arrangement of sticks and poles in the floor and the walls.

- Ask them whether air can pass freely through the store.
- Show the farmers how to arrange floor and wall poles and explain why sticks of less than 5 cm diameter should not be used.

14. Explain to the farmers that the features they have been discussing are those which ensure that the store is good drying store.

Ask the farmers whether a store so open to the air is really the best for storing maize.

Discuss and explain how a farmer can convert a good drying structure to a good storage structure. Put a piece of papyrus mat up against the wall poles to show how it should be attached.

15. Ask the farmers if the store should be repaired, or modified.

Discuss and agree the reasons for carrying out repairs and modifications.

Help them identify what needs to be done and discuss what to check on their own stores and what problems they expect to have in repairing them.

16. Explain to the farmers the purpose of the information on the flip-charts(or drawings):

- the recommended structure and its construction.
- the improved structure and how to construct it.

Show the farmers the charts, explaining important points on each chart. Stop and show the farmers the tools they'll need as you give this presentation.

Before moving from one chart to another, and after your explanations, ask for questions.

Stop for a short discussion after showing the stages in crib construction and then again showing the stages in basket-type granary construction.

Since up to 5% or more of post-harvest losses may be rodent damage make the farmers aware of the need for a raised structure.

- Raise structures one meter off the ground.
- Place structures away from trees or other structures so rats cannot jump to the store.
- Add rat guards - show farmers the tins you've brought, how these need not be costly.
- You may want to quickly demonstrate how to make a rat guard from old Kimbo tins (its impressive and well worth your time!)

17. Ask farmers whether they need to know the capacity of their stores.
- Ask for volunteers to tell you the type and dimensions of stores they would build to dry:

a) 25 bags of cob maize;

b) 100 bags of cob maize

- Discuss with the farmers ways of estimating the capacities of stores or of determining the type and size of store to build.

18. To make sure the objectives of the demonstration have been achieved, ask the farmers a number of questions, including:
- Why should maize be dried in a store rather than in the field?
- What determines the rate at which maize dries in a store?
- What should be considered when deciding where to build a store?
- How should a rectangular crib be positioned in relation to the wind?
- What are the features of a suitable roof?
- What are the features of suitable walls and floors?
- How high above the ground should the floor be?
- What points should be checked when looking at a store to determine whether it is in good repair?

Summarise the demonstration by adding to the farmers' answers or correcting them when necessary the ensure that the correct answer is understood.

19. Explain that the purpose of the demonstration is for the farmers to go home and repair and improve their storage structures.

- Ask the farmers if they feel they can do so. Ask if they foresee any problems in doing so and if so, arrange to see those concerned after the meeting.

Emphasise that improved storage structures and structures in good repair reduce storage losses.

Thank them for attending and hand out a "General Storage and Drying Structures" leaflet if it is available.

Arrange the next demonstration date and farm visits.

5.2.2. Essential Information

(1) Why dry maize in a store rather than in the field?

Field tests in Maseno by the On-Farm Grain Storage Project have shown that when drying maize in the field (late harvest and stooking) 8-9% of maize is lost. These losses can be avoided by harvesting early and drying the grain in a store.

(2) Why do we need to change our storage structure to be able to use them for drying?

Maize harvested early (at physiological maturity) has a much higher moisture content (up to 30%) compared to maize harvested late and stooked (18%). Therefore, improved structures are needed to dry maize safely and rapidly.

If maize is harvestd early and placed directly into sealed traditional structure there would be high losses from fungi. Air passage between the cobs is of utmost importance.

(3) What determines the rates at which maize dries in a store? (see Section 3.3 Drying Principles).

The rate of drying depends on:

- The grain moisture content (grain dries rapidly when it is moist and more slowly as it becomes drier).
- The weather conditions (grain dries more rapidly at higher temperatures and low relative humidities or the hotter and drier the weather is.)
- The airflow through the mass of grain (air moving over the grains removes the moisture from them).
- The only factor which we can do anything practical about is the amount of air which is able to flow through the grain.

(4) What affects the amount of air which flows through the grain and the time it takes to dry maize in store?

- Whether the husks of the cobs are removed or not. Maize cobs in their husks dry more slowly because air movement near to the grains is restricted. This is one good reason for harvesting early and not relying on field drying.
- Where the store is placed in relation on the wind. A maize store placed where it will catch the wind will dry maize faster than one placed in a sheltered place.
- The orientation of crib-type stores in relation to wind direction.

-The type of structure. The way in which a store is constructed affects the flow of air through the store.

Particularly:

(a) Because of reasonably high day and nighttime air temperature and humidity, structures in western Kenya should be a maximum of 1.5m in width or diameter.

(b) Shed-type roofs should have a slope of 30 degrees; thatched roofs 45 degrees slope, and have an overhang of 30cm.

(c) The construction of the walls and floors for a drying store should be 50 percent open for proper airflow.

(d) For protection against rats the floor of the structure should be 1m above ground level with rat guards fitted directly under the floor beams (see Section 6).

(5) What factors should we consider when deciding where to build a store?

Security of maize must be a consideration. The positioning of the store is another consideration. A store built where it will catch the wind will dry maize faster than one palced in a sheltered spot. Therefore, when deciding where to build a store, if at all possible:

Place the store away from buildings, hedges or trees which prevent the wind from reaching the store.

Place the store where it is visible from the home for security purposes (a chain and lock can also be used).

To make the correct decision on where to build the store in relation to buildings, hedges and trees, the farmers will need to be sure of the direction that the wind blows at harvest and drying time.

Discussion with farmers at the demonstration should enable you to establish the direction of the prevailing wind at drying time.

Place the store at the highest point in the compound in direct sunlight if this is possible.

(6) Why is the orientation of cribs in relation to wind direction important?

Cribs have a long and short side. They also have a taller front and shorter back. The amount of air passing through the store depends on which side faces the prevailing wind.

The longest and tallest side of the crib should face the direction from which the wind normally blows at drying time.

This ensures that the maximum possible quantity of air passes through the store and ensures the best possible drying.

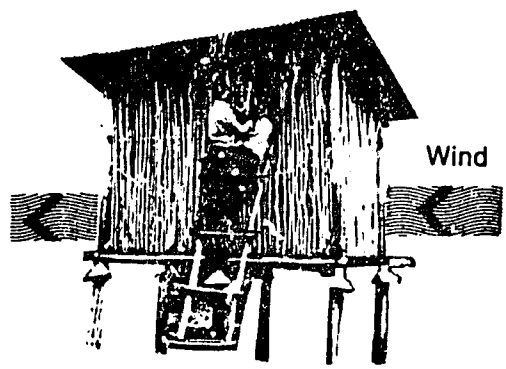


Figure 5.1 Crib Position in Relation to Wind Direction

(7) How does the width of the store store affect the way air flows through it?

The wider the store, the greater the bulk of maize that the air has to move through, and the slower will be the speed at which it circulates through the store. The air will remove less moisture, especially from the middle of the crib.

Field trials in western Kenya have shown that a store 1.5m width is suitable for drying maize of 30% m.c. and still allowing good storage capacity. This recommended wide may not apply in other agro-ecological zones.

(8) How does the and slope of the roof affect the way air flows through the store?

A low roof overhang can prevent wind passing through the upper part of a store, resulting in poor drying of maize in this part of the store. This is a common problem with traditional basket-type granaries, especially if the roof hangs within a few feet of the ground. The roof of a basket-type granary should have a slope of 45 dgrees to allow rain to run off easily. The overhang should be about 30cm to keep the granary dry and allow the wind to pass through the top part of the granary.

A single-pitch roof on crib is advantageous because the air that comes in the top of the store is deflected downwards into the crib, promoting drying.

(9) How do we measure or estimate store capacity?

	Calculated Capacities of Stores
Baskets:	1.5m dia x 1m deep - 7 bags shelled maize
	1.75m dia x 1m deep - 10 bags shelled maize
	2m dia x 1m deep - 13 bags shelled maize
Crib:	1.5m wide - one-section - 26 bags cob maize
	1.5m wide - one-section - 10 bags shelled maize
	1.5m wide - two-section - 52 bags cob maize
	1.5m wide - two-section - 21 bags shelled maize

Outline

Modifying and Improving a Storage Structure

CHECKLIST:

Equipment and Supplies Needed
For Demonstration of Modifying
a Storage Structure.

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

8. _____

9. _____

10. _____

11. _____

12 _____

NOTES:

5.3 PRE-STORAGE HYGIENE

We now move to the first component of post-harvest management, pre-storage hygiene. The objectives of this demonstration are to help the farmers to: understand the importance of cleaning a store; know why this should be done; and know exactly what to do on their own farms.

Explain to the farmers at the field day that by adopting the practice of the pre-storage hygiene, they eliminate the existing insects that might be living in and around the structure; they take away all old spider webs, debris, etc. in which the insects may hide; and they remove all things under the structure which rats may use as "ladders" or "homes".

In addition to your own charts and hand-outs, you will need:

1. A demonstration site with a dirty grain store.
2. The equipment required for the demonstration. (Ensure that the equipment is on site or that you carry it with you.)

   - 1 brush or broom
   - 1 jembe
   - 1 panga
   - 1 slasher
   - 1 rake or shovel
   - 2 scrubbing brushes
   - 1 spray pump (or brushes, brooms, rags)
   - Omo (soap powder)
   - 1 Treetop bottlecap

- 1 bucket
- a box of matches
- "Green Circle" Malathion
- Actellic 25% emulsifiable concentrate
- plastic sheet 2m x 3m or a tarpaulin, or similar material
- measuring jug
- a debe of water
- a 1-metre long piece of string
- rubber or plastic gloves or plastic bags to use as gloves
- 2 dirty gunny bags
- dust mask or cloth to tie over the face of the person operating the sprayer
- protective clothing or change of clothes for the person operating the sprayer.

3. Ensure that the farmer on whose farm you are demonstrating is willing to cooperate fully.

He has agreed to move his chikens and his animals from under the store (if he keeps them there) and has prepared another place for them. But tell him not to move them until the day of the demonstration.

He has agreed not to remove the pile of last season's remaining cobs and other trash from the store until demonstration time.

If you are working with a farmer who has a raised traditional basket ask him in advance if you can remove the smearing materials. Unless the farmer will use the basket for drying do not remove the smear. He may be using it to store sorghum or other small grains.

5.3.1 The Demonstration

Begin the demonstration near a grain store and follow these steps.

1. Explain to the farmers that the demonstrations aims:
   - to enable tham to understand the importance of cleaning a store and when this should be done.
   - to enable them to know exactly what to do themselves on their farms and how to do it successfully.

2. Ask the farmers why it is important to clean the store before harvesting the new crop and storing it.
   Discuss what will happen if the store is not cleaned and if the new harvest is palced in a dirty store.
   Point out the untidy surroundings and problems these can cause.

3. Ask the farmers to look inside the store and to comment on the state of cleanliness.

4. Ask for volunteers (4-5 people) to carry out the jobs which need to be done:
   - removal of items from the store
   - sweeping inside and outside the granary
   - removal of rubbish and sweeping it into a heap.

   Ensure that all the jobs are properly completed.

5. Ask the farmers what should be done to the rubbish and the spoiled harvest. Discuss and explain why it should be burned. Let one or two farmers burn the rubbish and spoiled harvest.

6. Ask the farmers to look at the outside of the store and to comment on the state of cleanliness of the store and its surroundings. Discuss and explain the importance of cleaning the areas around the store. Help the farmers to identify what needs to be done.

7. As for volunteers (4-5 people) to carry out the jobs that need to be done, e.g.:
   - clearing of grass and removal of debris within a 2-metre radius around the store
   - removal of livestock from around the store.

   Ensure that all the jobs are properly completed and explain the need to keep this area clear and clean.

8. Show the farmers how to clean gunnies and other containers.
   Let the farmers practice cleaning these items.
   Explain to the group how to dust gunnies and containers when they are dry (see (6) under Essential Information). Let the farmers practice dusting.

9. Ask the farmers what growth stage the maize has reached now (it should be tasselling).
   Explain why the demonstration has been arranged for this time.
   Explain why the store should be sprayed, now that it has been cleaned and repaired.

10. Explain to the farmers that stores of different sizes have different areas to be sprayed and require different quantities of chemical mixtures. Use a prepared flip chart or illustration. Seeing your recommendations will help the farmers to remember them. Tell the farmers the surface area which can be spread with a litre of:

    (a) Actellic;

    (b) Green Circle (Green Circle code - see question 9.

11. Explain to the farmers how to calculate the surface area of the store to be sprayed.

    Let 2-3 farmers tell you the size of their stores, and calculate with them the amount of chemical needed.

    Tell the farmers what to do if they cannot do the calculations.

12. Show the farmers how the chemicals should be mixed. Let one farmer mix the chemicals under their supervision.

13. Show the farmers the sequence in which to spray the store, and how to spray. Let the farmers carry out the spraying under your supervision

    - each wall to be sprayed by one farmer
    - the floor to be sprayed by another
    - the roof to be sprayed by another
    - the outside to be sprayed by others.

    Explain that if it is not possible to use a sprayer, alternative application methods can be used <u>as a last resort:</u>

    (a) the mixed chemical can be painted on to the surfaces with a brush;

    (b) rags can be dipped into the mixed chemical and the liquid then dabbed on the surfaces to be treated.

If you use these alternative methods wear gloves or put plastic bags over your hands.

Explain that the farmers should wash off any chemical immediately if it splashes onto any part of the body.

NOTES:

IT IS IMPORTANT TO AVOID CHEMICAL CONTACT ON SKIN AND EYES.

WEAR PROTECTIVE CLOTHING AND A DUST MASK.

14. Show the farmers how to wash the spray pump and containers used. Show the farmers how to dispose of the waste and used containers (chemical containers and the Treetop measuring cap).

    Explain why it is necessary to take these precautions.

15. To make sure that the aim of the demonstration has been achieved, ask the farmers a number of questions, including:

    - Why should we clean the inside of the store?
    - Why should we clean the sacks and containers?
    - Why should we clean the area around the store?
    - Why should we check and repair the store?
    - Why should we spray at this time?
    - Why should we measure the size of our store?
    - Why should we burn the rubbish and spoiled harvest?
    - What quantity of chemical do we use in 1 litre of water:
        (a) Actellic
        (b) Green Circle?

Increase the benefit of the training by adding to the farmers' answers or correcting them when necessary. Ensure that the correct answer is understood.

16. Explain that the purpose of the demonstration is for the farmers to now go home and clean their own stores. Ask the farmers if they now feel they could do so. Ask if there are any problems they may encounter while doing the job. Emphasize that delay carries the risk of greater crop losses due to insect infestation or rodent damage. Thank them for their participation and wish them success. Arrange a date for the next demonstration.

5.3.2 Essential Information

(1)Why should we clean the store before harvesting the new crop and storing it?

- to remove the storage pests from the store so that the new harvest will not become infested with insects. The insect pests are the beginning of a crop loss problem. They multiply rapidly when given a new source of food (new crop). Some fly out to the field from the store to start attacking the crop in the field and come back to the store with the harvest.

- to remove droppings (mavi), dirt and wet material from the store. Droppings can spoil food and encourage other organisms to multiply and cause damage to stored grain

- to remove items and dirt which prevent air from moving freely through the floors and walls of the store. Free movement of air helps our stored grain to dry quickly. Stored grain is safest when it is dry. If air cannot pass freely through the store when high moisture grain is being dried, then it remains moist and the air in the store is moist. This encourages fungi to grow and multiply, causing losses.

If the granary is smeared, this smearing material should be removed if the farmer intends to dry and store grain. This is to allow free movement of air through the store for the reasons described above.

(2) What should be removed from the store?

- items like old jembes and tins
- all sacks and containers
- all old grains whether loose or in sacks.

Sweep inside and outside the granary starting with the underside of the roof, then the walls and the floor, removing:

- any old smearing materials
- dust and dirt
- loose grains
- spiders webs.

It is best to remove everything from the store. This allows you to clean the store thoroughly. Only return the old harvest after you have inspected it to make sure it is of good quality and has been treated to control pests.

Old harvest found to be infested with pests should be treated with Blue Cross insecticide. Then it should be stored elsewhere and checked regularly to ensure it does not become a source of possible re-infestation. Badly infested material should be removed and destroyed.

Then pile all sweepings and rubbish in a place suitable for burning them. Burn at the appropriate stage in the demonstration.

(3) Why should we burn the rubbish and spoiled old harvest?

- rubbish and spoiled harvest contain insects and pests and their eggs. We do not want them to live and the only certain way to kill them is to burn them.

(4) Why should we clean the outside of the store and the area around the store?

- plants and rubbish around the store can harbour pests which may attack the stored grain.
- moisture from plants around the store, or from birds and animals kept under the store can get into the store and cause moulding in the stored grain.
- rodents (especially rats) can be attracted if animals and birds are kept under the store, or can hide in the plants, rubbish, poles or timber, to get into the store and steal the harvest. Rats also spoil grain with their urine and droppings (faeces).

Completely clear underneath the store and an area 2 metres around the store.

- cut the grass and all other vegetation
- remove all farm tools, tins and other items
- remove any poultry house or other animal pens
- remove all rubbish and sweep clean.

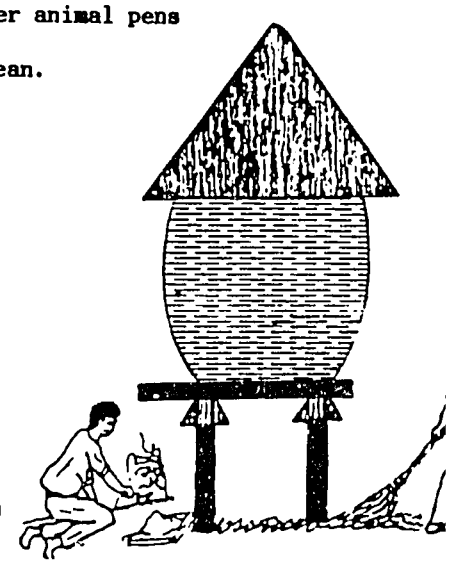


Figure 5.2 Keep Area Around Granary Clean

(5) Why should old sacks and containers be cleaned?

To remove traces of dirt, fungi and contamination (e.g. rat urine, diseased grains, insect pests and their eggs).

If these are not removed, they will spoil the new harvest.

(6) How do we clean the sacks and containers?

- Wash them thoroughly in soap and water if possible.
- Dry them in the sun so that the sun can kill or drive away any insects not killed while washing.
- When dry, dust all the containers, particularly gunny sacks, with one of the BLUE CROSS chemical powders.

(7) Why should we spray the store before harvest?

- We wish to remove storage pests and their eggs by cleaning the store. We wish to kill any remaining insects and eggs which were not removed from their hiding places when we cleaned the store and burned the rubbish.
- Weevils fly out from the store to attack the new crop in the field as soon as it reaches the tasselling stage.

Weevils will also fly back from the field and re-infest your maize. So by killing them at this time it will help to break the cycle of the pest.

(8) What parts of the store should be sprayed?

- Start inside the store by spraying the floor and walls.
- Then move out of the store and lean in to spray the under-side of the roof.
- On basket-type stores, you should also spray the outside of the basket.

(9) What chemical should we use to spray the store?

At present there are two chemicals available in the shops:

(a) Actellic 25, an emulsifiable concentrate, in 1-litre cans;

(b) Green Circle Grain Store Spray, a wettable powder.

Advise farmers to look for the "Green Circle" on the label when purchasing. The Green Circle label indicates that the insecticide is to be used on structures (the store) but not on the grain.

Note: Actellic 25 is also a Green Circle insecticide.

Advise farmers to use whichever Green Circle chemical is available.

(10) How should the chemical be mixed?

"Actellic 25" is mixed at the rate of 40ml (one Treetop capful) per 1 litre of water; this is enough to cover 10 square metres.

"Green Circle" is mixed at the rate of 100gms (four Treetop capfuls) per 1 litre of water; this is enough to cover 25 square meters.

(11) How do we calculate the amount of chemical solution to mix?

Strictly speaking we should calculate the surface area of the store to be sprayed. This is difficult and beyond the ability of most farmers so you will find below the best approximations to give practical guidance to the farmers.

The following rules of thumb may be helpful:

For basket-type stores with diameter of 1.5m:

- A mix of 1 litre water and 4 Treetop caps (100 gms) "Green Circle" will be enough.
- Or a mix of 2.5 litres water and 2.5 Treetop caps (100 ml) of "Actellic 25" concentrate chemical.

For basket stores with a diameter of more than 1.75m:

- A mix of 1.25 litres water and 5 Treetop caps (125 gms) full of "Green Circle".
- Or a mix of 3 litres of water and 3 Treetop caps (120 ml) of "Actellic 25".

AREA OF WALL SURFACE FOR SELECTED SIZES OF BASKET-TYPE STORES

Height(m)	Diameter(m)	Area(m2)
1.5	1.25	16
1.5	1.50	20
1.5	1.75	23
1.5	2.00	28
1.75	1.25	17
1.75	1.50	22
1.75	1.75	26
1.75	2.00	31

Crib-type Store 1.5m wide

For a recommended store 1.5m wide, built in one section 1.6m long and with a height of 2.1m at the front sloping to 1.7m at the back:

- A mix of 1.5 litres water and 1.5 Treetop caps (60 ml) of "Actellic 25" concentrated chemical.
- Or a mix of 0.75 litres water and 3 Treetop caps (75 gms) of "Green Circle" powder.

And add for each additional 1.6m long section:

- A mix of 1.5 litres water and 1.5 Treetop caps (60 ml) "Actellic 25" concentrated chemical.
- Or a mix of 0.5 litres water and 2 Treetop caps (50 gms) "Green Circle" powder.

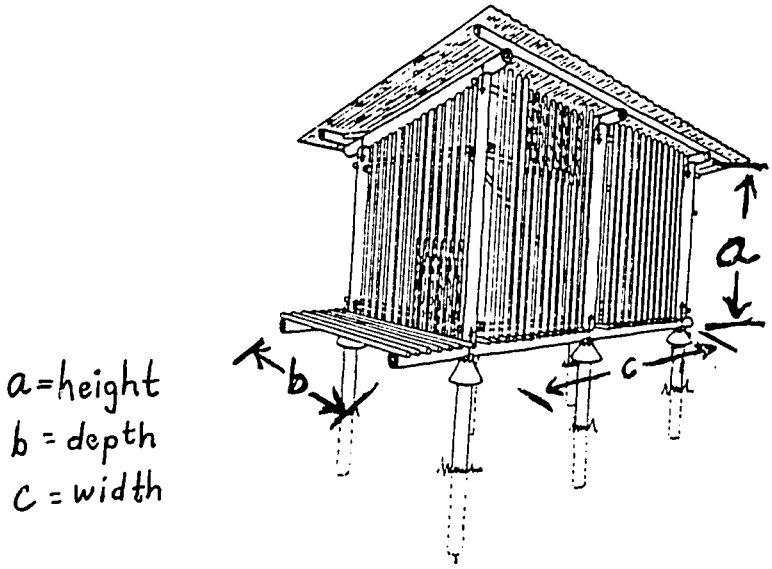


Figure 5.3 Measuring Crib Dimensions

<u>For Crib-type Stores of Different Dimensions</u>

You will be forced to calculate the surface area of the store:

1. Take the full length of the store and multiply by the width.
2. Take the full length of the store and multiply by the height at the back.
3. Take the full length of the store and multiply by the height at the front.
4. Add the height at the front to the height at the back and then multiply by the width.
5. Add together to get the surface to be sprayed.

HOW TO FIGURE WALL AREA OF RECTANGULAR CRIB

Add:

Length (m) x height (m) of front wall = _____m2
+ length (m) x height(m) of back wall = _____m2
+ length (m) x average height (m) of end walls x = ____m2
+ length (m) x width(m) if floor = _____m2
Total = _____m2

NOTE: If thatched roof, its surface area (outside) should be included

For example:

A store: 5m long 1.5m wide

2.5m high at front 2.0m high at back

1.	5 x 1.5 =	7.5 square metres floor area
2.	5 x 2.0 =	10.0 square metres back wall
3.	5 x 2.5 =	12.5 square metres front wall
4.	2.5 + 2.0 = 4.5 x 1.5 =	6. 75 square metres side walls
	Total	36.75 square metres

So we would require:

- A mix of 4.0 litres water and 4 Treetop caps (160 ml) of "Actellic 25" concentrated chemical.
- Or a mix of 1.5 litres water and 6 Treetop caps (150 gms) of "Green Circle" powder.

A useful "rule of thumb" would be to recommend:

For each 2m length of store:

- A mix of 2 litres water and 2 Treetop caps of "Actellic 25" chemical concentrate.
- Or a mix of 0.75 litres water and 3 Treetop caps (75 gms) of "Green Circle" powder.

Table 5.1 gives a summary of chemicals required for different types of store.

Table 5.1—Summary of Chemical Required

STORE TYPE	"Actellic" Treetop caps full	Litres water	"Green Circle" Treetop caps full	Litres water
Basket stores with diameter of 1.5 meter	2.5 (100 ml)	2.5	4 (100 gms)	1.00
Basket stores with diameter of 1.75m	3.0 (120 ml)	3.0	5 (125 gms)	1.25
Shed type stores 1.5m wide - first 1.6m length - additional 1.6m length	1.5 1.5 (60 ml)	1.5 1.5	3(75 gms) 2(50 gms)	0.75 0.50
Rule of thumb for shed-type stores of varying dimensions (per 2m length & per 2m width	2.0 (80 ml)	2.0	3 (75 gms)	0.75

(12) How should we protect ourselves and our families when working with chemicals?

- Avoid spilling concentrated chemical or chemical mixture onto the body.
- Keep children and onlookers well away from the store when you are spraying, applying by brush or other means.
- If chemical gets on the skin, wash away immediately with plenty of water.
- Dispose of empty chemical containers, measuring caps and excess chemical mixture by burying. Any extra chemical mixed with water can be sprayed on the ground surrounding the store and on empty gunny bags.

- Keep chemical containers, measuring caps and spray pumps well away from children and in a locked store.
- Remember to clean your spray pump with plenty of water and dispose of waste safely.
- Do not spray when a strong wind is blowing.
- Wear old clothes or a protective coat while spraying. Wash clothes or coat before wearing again.
- Wear gloves or use plastic bags on your hands while spraying.
- Wash your hands carefully when you have finished spraying.
- Always follow instructions carefully when working with chemicals. Do not put on too much or too little.
- Record the name of the chemical used, the date and the quantity for future reference.

Outline

Pre-Storage Hygiene Demonstration

CHECK LIST

Equipment and Supplies Needed
for Pre-Storage Hygiene Demonstration

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____

NOTES:

116a

When to Harvest

Project of:
Ministry of Agriculture
and Livestock Development

Sponsored by:
United States Agency for
International Development

Implemented by:
Development Planning and
Research Associates, Inc.

Produced by Agriculture Information Centre

1. It is recommended that maize be harvested at physiological maturity. What does this mean? This is when the maize is no longer developing but only drying. A field looks like this at physiological maturity.

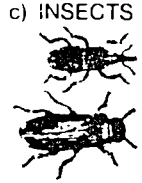
2. When maize is left in the field to dry it is exposed to many dangers which may result in maize losses. These losses are caused by weather conditions such as hail or heavy rains and wind or by field pests.

3. Six loss agents are

a) BIRDS

b) RODENTS

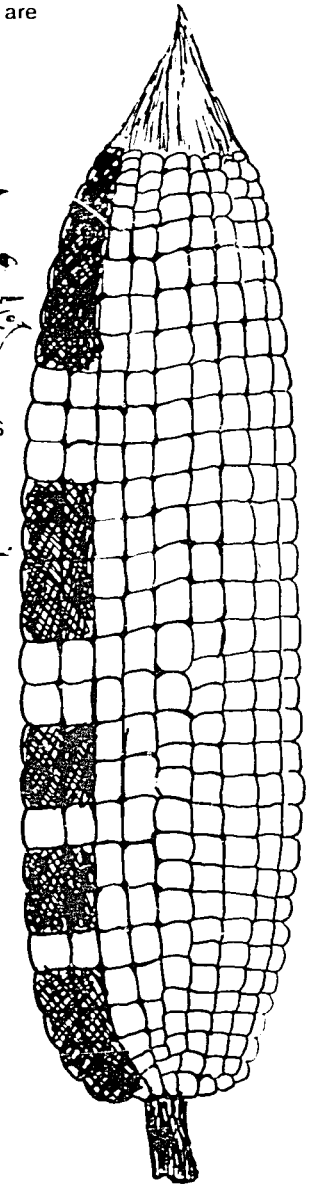
c) INSECTS



d) LODGING

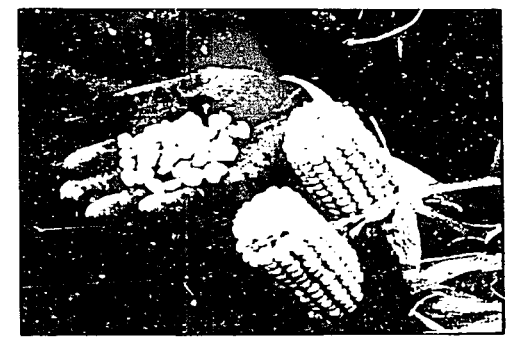
e) MOLD

f) THEFT



4. It is important then to remove maize from the field when it is mature and to dry it in your drying and storage structures.
One way to determine whether your maize is mature is by doing the black layer test
How is this done?

a) Select 10 cobs from different parts of the field.



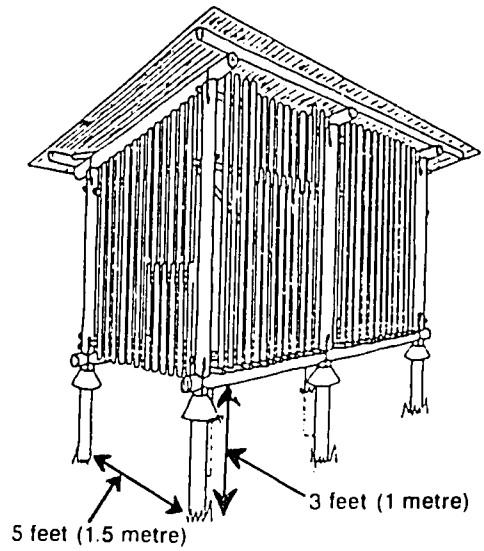
b) Bring cobs together, remove a few grains from the centre of each cob.
c) After mixing the pile of grains select 10.

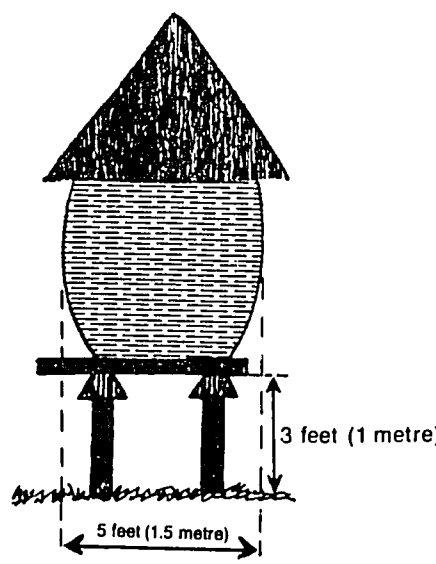
d) Peel back the covering at the base of the grain.

e) If the colour is black like this in most of the grains, your field is mature and ready for harvest.

5. Other indicators that can be used to determine maize maturity are:
   — Stalk system turns yellow or brown
   — Cobs begin to droop on the stalk
   — Maize no longer good for roasting.

6. After determining that your maize is physiologically mature, remove maize from field and load it into your rodent-proof drying and storage structures to dry. Your maize will dry in approximately 60 days.





5.4. HARVESTING ON TIME AND DRYING

The objectives of this demonstration are:

To enable the farmers to understand the importance of harvesting on time; to know why this should be done and what the advantages are; and, to know when to do it and exactly what they should do on their own farms.

In advance of announcing this demonstration, select a field of physiologically mature maize near an improved structure. Just before demonstration day collect 3 debes (or other containers) of maize:

- 1 with unripe maize cobs
- 1 with ripe maize cobs
- 1 with over-ripe maize cobs

You should also have the following at the demonstration:

Maize samples of pest damage (insect, birds, rats)

Maize samples of fungi damage

2 gunny bags

3 pangas

1 suitable drying structure on which pre-storage hygiene practices have been performed.

5.4.1 The Demonstration

Explain the purpose of the demonstration -- that 7-9% of a farmer's maize is likely to be lost to insects, fungi, birds, etc. if left in the field after physiological maturity -- not counting theft! Gather the farmers near the field that is ready for harvest. Explain that this is the second step in integrated storage management. Now that the store is ready, we want to tell them the advantages of harvesting on time.

- Farmers should know when to harvest.
- They should understand the importance of harvesting and removing all the maize from the field to a suitable drying structure.
- They should understand the elements that make up a suitable drying structure.

Time to Harvest—

1. Ask the farmers what signs they use for deciding when maize is ready for harvest.

   Show them three samples of cob maize, one which has not reached physiological maturity, one which is ready for harvest, and one which is well past this point.

   Ask them which maize they think is ready for harvest.

   Ask the farmers if they know of any certain method to tell when the maize is mature.

2. Show them the black layer and explain what it is.

   Ask the farmers to take a cob from each pile and find the black layer.

   Explain that the maize is ready for harvest when 90% of the grains in the field have got the black layer.

   Ask for 4 volunteers and conduct the black layer test.

   Demonstrate how they are to gather cobs from 10 parts of their field (walk out to the field to gather these 10 cobs). Show them how these 10 cobs are broken in half and a few kernels are selected from each cob.

Mix the pile of grains and ask farmers to select 10 kernels.

Ask farmers to check for the black layer; if 9 kernels have this layer explain that it is time to harvest.

3. Explain to the farmers that they should look for signs of maturity as clues when to sample for this black layer. Three visual signs of physiological maturity are:

- stalk system turns yellow or brown
- cobs begin to droop on the stalk (may not on some hybrids)
- maize no longer good for roasting.

BLACK LAYER TEST

From a sample of 10 kernels, peel back the covering at the tip of each kernel. If the colour is black in 9 or 10 of the kernels, the field is physiologically mature and ready for harvest
If, however, only 7 or 8 of the 10 kernels in the sample show a black layer the maize is about one week from maturity. If only 5 or 6 kernels show a black layer the field may be two weeks away from time. Farmers should sample their field weekly as harvest time approaches.

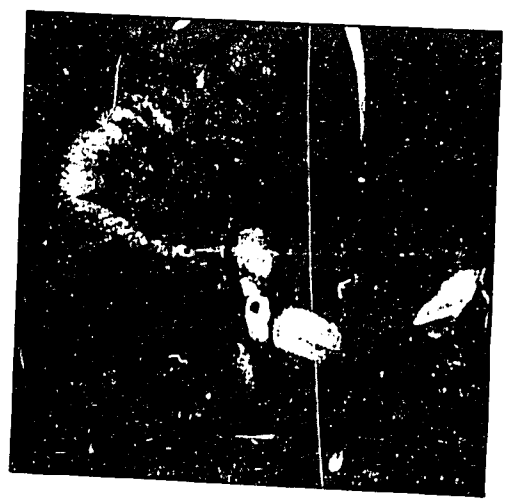


Figure 5.4 Testing Maize for Maturity.

4. Ask the farmers to take a vote as to whether your demonstration field is ready for harvest or not.

   Those that do not think it is ready should be questioned further and encouraged to understand the purpose of early harvesting during the next part of the demonstration.

NOTE:
Be absolutely sure that the field is ready for harvesting. Samples may not reveal the same results each time. Suppose that before your demonstration you sampled the field and found the black layer in 9 of 10 kernels, but on the day of the demonstration two farmers find the black layer in 9 of 10 kernels and two farmers find it in only 8 of 10 kernels. In such circumstances you have two choices. Either collect more samples or tell the farmers that this field appears to be 2-3 days away from physiological maturity

Advantages--

5. Ask the farmers if they can think of any advantages of early harvest.

   Show them some maize stalks in the demonstration field which is ready for harvest. Explain that the longer these are left in the field the more likely it is that losses will occur. Ask farmers what these losses might be.

   Encourage answers such as insects, rodents, termites, theft, bad weather, fungi, lodging, humid conditions.

   Show farmers samples of damage caused by the above - ask them if they have seen these effects on their crops. Explain what they are.

   Ask farmers what they think is best - leaving the maize outside to dry or taking it to a safe place to dry it.

   Discuss the advantages of storing the maize in a suitable structure in order to reduce the above losses.

6. Ask the farmers if they were to harvest the field immediately (at physiological maturity) what advantages would there be?

Encourage answers such as:

- getting onto the land quickly whilst moisture is still in the ground and in some areas getting another crop on (new maize crop or beans).
- cattle can be fed stover as it still has nutritional value.
- easier, better, timelier preparation of soil for next crop.
- in-field losses can easily reach 7-9 percent of the potential harvest.

A farmer who both plants early <u>and</u> harvests early will be able to sell more maize when the price is at its peak.

Magnitude of Pre-Harvest Loss Have the farmer who is hosting the demonstration estimate his yield in bags per acre (or hectare). Then calculate is potential loss if he doesn't harvest at physiologic maturity: Number of acres or (hectares)x yield x 8% = loss in bags Loss in bags x Kshs_____per bag = economic loss

Encourage farmers to agree (by quickly reviewing the advantages) that now is the time to harvest this field.

<u>Harvesting</u>—

7. Explain that cobs should be harvested and transported carefully to avoid mechanical damage.

Show farmers how to cut the stalks and remove cobs.

Explain and show husk removal to allow for quick drying.

Move the cobs to the store.

8. Sort the cobs according to quality.

Ask the farmers what they think the signs are for a cob that should not be stored.

Encourage them to sort out a pile that has been harvested.

Point out the following bad cobs:

- fungi
- rodent damage
- bird damage
- insect damage.

Explain that these should be separated from the good cobs and suggest alternative uses for the bad cobs, for example to feed them to animals.

9. Show a cob which has excessive moulding. Ask what should be done with such cobs. Recommend burning as they are poisonous.

Loading the Crib--

10. When a pile of good cobs has been collected at the structure show the farmers how to load their crib.

Ask for 2 volunteers to start loading the crib. Show how to load a pile away from the door.

Show how to avoid standing on the cobs in the crib.

Show how to prevent cobs from falling through the floor or sides.

Note: It may not be practical to fill the whole store but 2-4 gunny sacks of cobs will be sufficient to show these points.

Loading a Drying Tray--

11. Explain to the farmers that cob maize should be stacked no more than 10cm deep if the moisture content is 28-30% (harvested at physiological maturity) and no more than 20 cm deep if moisture content is lower.

WARNING Cover drying trays in case of rain or remove the maize to a dry place.

Spreading on Ground Cloth --

12. Explain that for the smallest farmers who have only a few (8 or less) bags of maize and little money, this method is quite acceptable when combined with early harvest and shelling and treating. High moisture maize will dry down to 13% faster when spread on the ground than when placed in a drying structure.

WARNING Protect maize from rain, chickens, livestock, and theft.

13. Ask the farmers if they think they can do this on their own farms with their own structures.

Discuss general problems for different structures (e.g. structures with 2 doors - 1 at the top and 1 at the base; stores with only 1 top entrance).

Drying--

14. Ask farmers what they think will now happen to the cobs.

Emphasise that the cobs are drying and are not yet being stored.

Ask them how long they think it will take the cobs to dry by each method of drying.

15. Explain the process and the importance of checking the store regularly.

    Ask the farmers what should be done with any damaged cobs they see later.

16. Give an estimation of drying time based on other results.

    (Note: maximum time of two months in a crib or basket-type structure; 15-21 days in drying trays or on ground).

Summarise—

To make sure that the aim of the demonstration has been achieved, ask the farmers a number of questions, including the following:

-How do we know when the maize is ready for harvest?

-Why do we harvest at the black layer stage?

-What are the advantages?

- What pests damage the maize in the field?
- Why should our structure be clean before harvest?
- How should harvesting be done?
- What is the aim of sorting cobs before putting them in the structure?
- How long should they remain in the structure before the next step?
- What is the next step?

Summarise the training by adding to the farmers' answers or correcting them if necessary.

Ensure that the correct answer is understood. Follow up with the farmers who have any difficulty in understanding the demonstration.

Explain that the purpose of the demonstration is for farmers to see if their maize is ready for harvest, to harvest as soon as it is ready and to place it correctly in a suitable structure (or on mats, etc.) for drying.

Ask the farmers if they can go to their own farms and follow the demonstration. Ask what problems they may have in doing the job.

Emphasise that delay will cause losses.

Thank them for attending your demonstration and outline the subject and date for the next demonstration.

5.4.2 Essential Information

(1)When is maize ready for harvest?

When the maize reaches physiological maturity. At this point the maize kernel stops growing and no longer receives food from the plant. The kernel seals itself off from the plant by growing what is called the black layer.

This can be seen on the kernel at the tip cap by scraping away the light covering material. When this black layer has occurred in 90% of the maize it is time to harvest. This however is not the time to store the maize but to dry it. The maize at this time has a moisture content of between 27% and 32%.

The cobs should be harvested and transported carefully so as not to inflict any mechanical damage. (When maize contains almost 30% moisture, the pericarp is still soft and tender). The husks should be removed from the cobs as these will slow the drying.

(2) How to conduct the black layer test:

a) Select 10 cobs from different parts of the field.

b) Bring cobs together, remove a few grains from the centre of each cob.

c) After mixing the pile of grains select 10.

d) Peel back the covering at the base of the grain.

e) If the colour is black in 90% of the grains, the field is ready for harvest.

Before being loaded into a drying structure the cobs should be sorted out. Those cobs showing damaged kernels, fungi or any other damage by rodents, insects or birds should be set aside. Any cobs showing evidence of excessive fungi - which may be toxic - should be disposed of immediately and not even used for fodder. Instead they should be burnt.

(3) What are some other good signs that maize is ready for harvest?

There are a number of field signs that indicate maize is ready for harvest.

- the leaves of the maize start to dry out.
- the husks have dried considerably.
- the cobs are no longer good for roasting.
- the inside of a broken kernel is no longer milky.
- at least 25% of the cobs have started to drop.

(4) What are the advantages of harvesting at physiological maturity?

Advantages are:

- the maize cobs undergo lower levels of losses due to insects, rodents, fungi, rain, lodging and theft.
- the maize stover (stalks and leaves) have a higher nutrional value and are better as fodder.
- the field is clear for early preparation for the next crop.
- the farmer can sell maize earlier than other farmers and obtain a better price.

(5) What are the advantages of drying in an improved structure?

Drying is the process whereby the moisture content is reduced to a level safe for storage.

The objectives and benefits of drying are:

- maintain high quality.
- avoid or reduce the growth of fungi and bacteria.
- prevent or delay infestation of insects.

- reduce respiration (see Section 3.2.3).
- prevent the germination of the seed while retaining its germination capacity.
- increase storage life of the produce.

(6) Why should our structures be clean?

See Pre-Harvest Hygiene (See Section 5.3).

(7) How should harvesting be done?

The maize, once ready, should be harvested and taken for drying immediately.

Harvesting and handling should be done carefully; grain is lost when damaged by hard handling, throwing, standing on it, dropping sacks, etc. Handle it carefully; keep grains on the cob.

Discourage stacking, leaving in the field, etc. Losses are reduced by harvesting/de-husking immediately and carefully transporting to the structure.

Poor harvesting and handling procedures can result in the loss of 1% or more.

(8) Why should maize be sorted before drying?

The maize will have been damaged in the field by the weather, insects, fungi and pests.

This damaged maize should not be placed in the structure with good, clean, undamaged maize. The damaged kernels are more likely to be affected by fungi and pests and will soon result in damage to good maize as well.

Outline

Harvesting on Time and Drying

CHECKLIST

Equipment and Supplies Needed
for Demonstration of Harvesting
on Time and Drying

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NOTES:

5.5 SHELLING AND TREATMENT

The objectives of this demonstration are to enable farmers to learn the importance of shelling and treating all their maize at one time; to know when this should be done; and to understand exactly how to do it themselves.

Note that this practice, along with early harvesting and drying, offers the biggest single reduction in losses. Losses can be cut by 7-9% if maize is properly treated after shelling. By treating shelled maize, the farmer can easily store his maize supply until the next crop. If some maize is produced as a cash crop, a small investment for treatment will allow him to store it on the farm until seasonal prices are highest (see Chapter 6). The cost of treatment is very small when compared to the value of the maize saved.

For this demonstration you will need:

1) A demonstration site having a store filled with maize on the cob that is dry and ready for treatment.
2) Samples of maize on the cob that are dry, nearly dry and not dry.
3) A clean, dry surface on which to lay cob maize before shelling.
4) Equipment needed:

CHECK LIST OF TOOLS AND EQUIPMENT NEEDED FOR SHELLING AND TREATMENT DEMONSTRATION
- moisture tester (available from District Agricultural Extension Officer)
- plastic or canvas sheet 8'x4'
- 2 cast aluminium hand shellers
- 2 gunny sacks
- a shovel and two pieces of wood 2'x 8"
- a bottle of Actellic and examples of other Blue Cross dusts
- a Treetop bottletop or a matchbox
- matting--sample of papyrus mat to enclose the structure, (carry a small piece of mat, say 1 foot x 2 foot that you can roll up to transport and enroll to show how to place it on the inside of the crib.)

5.5.1 The Demonstration

Begin the demonstration near the maize store and the clean, dry surface. Follow these steps:

1. Explain to the farmers the aim of the demonstration:
   - that they will know why they should shell and treat their maize
   - to know how exactly to shell it
   - to know when maize is ready for shelling
   - to know how exactly to treat it
   - to know how they should do it on their own farms.

2. Ask the farmers when do they shell their maize for milling.
   Encourage answers such as:
   When it is dry. That is, it cracks when bitten.
   Explain that moisture content can be measured. Measure with the moisture meter some of the maize shelled from the sample cobs.
   Explain that 13-14% moisture content is when it is dry enough for shelling and treatment.
   Let different farmers try biting and inspecting different samples and explain their moisture contents.....Ask farmers if they have other traditional ways of testing the moisture content of their grain.
   Ask the farmers what they think will happen to the maize that is not dry when they shell and store it.
   Discuss the above and highlight the importance of not shelling maize until it is dry.

3. Ask the farmers if they shell all the maize at one time or only when they need it.

Explain to the farmers why they should shell all their maize and not store it on the cob.

Show how it is:

- easier to treat shelled maize. Explain that the earlier they treat all the maize the more protection it has from pests.
- easier to bring chemical into contact with all kernels when dusting shelled maize than maize on the cob.
- more difficult for rodents to gain access to shelled maize.
- more difficult for moths to fly between the spaces of the cobs of
- safer because insect pests like the Greater Grain Borer reproduce more slowly on shelled maize.
- easier and takes less space to store shelled maize than maize on the cob.
- much easier to inspect and control the shelled maize when it is in sacks.

4. Ask the farmers to help you remove all the cobs from the granary and place them on a clean, dry surface.

- Explain that you are about to start the demonstration on shelling but there are some things to be done first. Ask them what they think these things are. Show the farmers the difference in the quality of various cobs. Put the bad cobs in a separate pile and break the partly bad cobs, putting the bad parts in the separate pile.
- Show each farmer the infested and/or mouldy cobs.

  Explain that these should not be put together with the cobs for shelling and why.

- Ask the farmers to separate the good and bad cobs and keep a close eye on this activity until it is completed and you are satisfied that all participants have done it correctly.
- Discuss what should be done with the bad cobs.

Selecting a Method for Shelling--

5. Ask the farmers how they usually shell their maize. Discuss the advantages and disadvantages of the various methods.

   Encourage all hand shelling and show whatever other equipment you have that can be used. Warn against beating maize in the sack and explain why.

   Ask for volunteers to shell some of the good cobs. Encourage the farmers to try different hand methods if you have more than one type of sheller or get friends or the family to demonstrate them.

   Make sure all the maize is shelled onto a clean, dry surface. Once enough maize has been shelled to fill one gunny sack ask the farmers what they think the next step is.

6. Ask the farmers if they clean the shelled maize. Get volunteers to winnow maize by tossing in the air and allowing chaff and dirt to be blown away. Discuss the importance of this.

Treatment--

7. Explain that the shelled maize should be placed in a gunny sack until full. Choose two or three volunteers.

   Explain that a full gunny sack of shelled maize is approximately 90 kilograms and why it is important to know the weight.

   Ask the farmers if any of them use a dust to treat their maize.

Explain that Actellic 1%, Malathion 2% and Nexion 2% are dusts used to protect grain. Apply at 50 grams chemical to 90 kgs of shelled maize.

50 grams is equivalent to 2 level capfuls of a Treetop bottle cap or 3 1/2 match boxes heaped full of the dust.

RECOMMENDED CHEMICALS FOR TREATING FOOD GRAINS MAY CHANGE OVER TIME. TELL FARMERS TO ASK THEIR CHEMICAL SUPPLIER OR THEIR AGRICULTURAL OFFICER WHAT TYPES THEY SHOULD USE AT EACH HARVEST TIME. CHEMICALS STORED FOR TOO LONG LOSE THEIR STRENGTH.

8. Ask for volunteers. One person will spread the maize out of the sack onto the ground cloth and the other will pour the chemical into a Treetop bottlecap (or match box) and spread it evenly over the surface of the maize. Another volunteer will be required to spread the second bottlecap all over the surface. Point out the importance of an even spread.

Check the wind direction. Ask anyone sitting downwind to move so as not to breath the dust that might blow off the maize.

Ask a volunteer to take a shovel and mix the powder and the maize thoroughly. Encourage others in the group to help.

Explain that a piece of wood can be used. Show this and how to move the pile from one place to another and back again. Ask for volunteers.

Ask the farmers why it is important to mix the chemical so thoroughly.

Stick your hands into the different piles of maize. When you take your hands out they should have equal amounts of dust on them. Have some farmers perform this demonstration.

Explain this test and how it indicates that the dust is completely mixed.

WASH HANDS AFTERWARDS

9. Ask farmers to help refill the gunny bags now that the maize is thoroughly mixed with the chemical.

Storing Treated Maize—

Place sacks in store or in a clean, dry place that is rodent-free. Ask farmers why it is best to store shelled maize in a sack. If placed in a traditional granary or improved store show farmers how to wrap the reed mat around the granary to keep it cool and dry.

Remind farmers to keep chemicals locked up and out of children's reach. Wash any equipment used thoroughly. The spade, wood and Treetop bottlecap should also be stored well out of children's reach.

Summarise--

To make sure the aim of the demonstration has been achieved ask the farmers a number of questions including the following:

-When is our maize ready for shelling?

- Why shell all the maize?
- Why separate bad cobs?
- Why winnow the shelled maize?
- Why place the maize in a gunny sack before treatment?
- What chemicals do we use?
- How much chemical is used for each gunny sack?
- What is the purpose of mixing thoroughly and how can we tell that this has been done?
- Where do we place the treated maize?
- Why do we store it in sacks?
- How do we convert the granary into a proper store?

Add information to farmers' answers or correct them where necessary. For any point that is not correctly answered by the group, repeat that part of the demonstration and stress corrections.

Explain to the farmers that the point of the demonstration is that they should now go home and test their maize and if dry follow these instructions.

Discuss the cost of practising the exercise at today's rate. Give examples of the cost of treatment for a gunny sack of shelled maize and explain the possible losses if shelling and treatment are not carried out.
Ask the farmers if they plan to do the shelling and treatment.
Ask if they foresee any problems in adopting the practice. If some feel unable to, speak to them after the meeting.

Visit as many farmers as possible as soon as possible after the demonst ation. Explain that the activity should happen as soon as their maize is dry.

Thank them for attending and hand out a "Shelling and Treatment" leaflet if available.

Arrange the next demonstration date and farm visits.

5.5.2 Essential Information

1. When is the maize ready for shelling?

When the maize reaches 13-14% moisture content. This can be accurately tested with a moisture meter (or by biting to see if it is hard and brittle. This is normally after approximately 60 days in the drying and storage structure or 20 days in a tray or on the ground).

The problems associated with high moisture content (above 14%) include the following:

- The condition of the maize will favour fungui
- hot spots will occur in sacks of shelled maize, causing spoilage
- conditions are good for insects to feed and breed in the maize
- unwanted seed germination may occur.

2. Why shell the maize?

- it is more efficient and allows the easier application of Blue Cross insecticide dust
- the maize will store longer without deterioration (spoiling)
- it is more difficult for rats to burrow into the stored maize

- reduced losses from insects which thrive on maize cobs
- less space required for storage
- it is easier to check and inspect stored gunnies of shelled maize
- easier to calculate accurately the quantities stored
- winnowing removes the materials that encourage deterioration (spoiling by pests and moulds)
- mouldy cobs that can encourage insects and moulds can be removed.

3. **How do we measure maize and apply dust correctly?**

One full gunny bag equals approximately 90 kilograms of shelled maize.

A 90-kilo gunny bag of maize requires 50 grams of Blue Cross dust

50 grams of dust (check for the Blue Cross code) is equal to:

- 2 Treetop level capfuls.
- 3 1/2 matchboxes heaped full.

4. **What chemicals do we use?**

For shelled maize, only use those marked with the Blue Cross, such as:

ACTELLIC	1%
MALATHION	2%
NEXION	2%

5. **Why is thorough mixing important?**

To make sure that every kernel is coated or protected.

This can be demonstrated by putting your hand in two piles when mixing and estimating the amount of dust left on your hands. It should be same on both hands if it is evenly mixed in both piles and in the correct quantities.

DO NOT FORGET TO WASH YOUR HANDS AFTERWARDS

6. **Why use gunny sacks?**

- It is easier to make regular checks on sacks.
- Sacks can be separated more easily for any necessary follow-up treatment.
- Sacks are easier to count and weigh.
- Sacks can be stored in a rodent-proof store.
- Some sacks can be stored inside the house if necessary.
- A crib or granary basket can hold the sacks, enabling longer-lasting protection.
- Sacks can be removed for inspection from the store if necessary with less effort.

7. **How do we store inside the house?**

If sacks are stored inside the house stack them on a raised platform or a pallet to prevent the bottom sacks from absorbing floor moisture and to remove pathways for rats between sacks. Stack the sacks closely together so that no rats can crawl between the sacks, claw holes in the sacks, and build nests. Keep stacks away from the wall, again to avoid moisture and rodent damage. The platform should be high enough off floor to allow room for a cat to crawl under it. **MAKE SURE THE MAIZE IS DRIED TO 13% MOISTURE CONTENT BEFORE STACKING IN THE HOUSE.** Figure 5.5 illustrates a home made pallet.

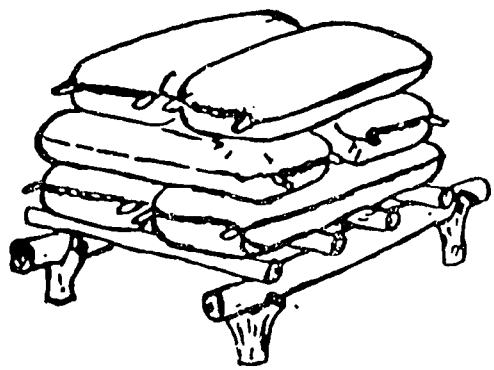

Figure 5.5-- Homemade Sack Storage Pallet for Use in House.

Outline

Shelling and Treatment

CHECKLIST

Equipment and Supplies Needed for Shelling and Treatment Demonstration

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NOTES:

5.6. PERIODIC INSPECTION OF STORED MAIZE

The objectives of this demonstration are:

- to enable farmers to see the effects of storage management on the quality and value of the maize after 3 and 6 months storage;
- to convince farmers of the economic benefits to be gained by integrated storage management; and
- to enable farmers to inspect their stored maize regularly in order to determine its condition and to take practical steps to ensure its continued safe storage.

The main goal of this demonstration is for farmers to see for themselves the differences in quantity and quality between well-maintained maize and infested maize. If possible, farmers can also be shown the posho derived from good and bad samples of maize.

Under field conditions you may not have time to follow all of the procedures included in this section, but each extension agent can include what he considers appropriate for the farmers of his area.

For this demonstration you will need:

1. One or two farmers who live close to a posho grinding mill.
   - Ideally a farmer who has both a traditional store managed in a traditional way and an improved store loaded and managed according to improved grain storage practice.
     This, however, would be unusual.

- Alternatively, select a farmer who has adopted the improved storage management system, and a close neighbour who has not, and both of whom are willing to participate in the demonstration and will allow samples to be taken. A word of caution: unless very carefully prepared, ill-feeling can arise as a result of this demonstration which involves comparisons. Careful preparatory discussions and possibly incentives will be needed with the traditional farmer.

2. Following is a list of items you will need for this demonstration (add other supplies, communications equipment, etc. to the checklist provided at the end of this section):

CHECKLIST OF TOOLS AND EQUIPMENT REQUIRED FOR INSPECTING LONG-TERM MAIZE STORAGE

Description	Quantity
- Plastic sheet of 2m x 3m	1
- Piece of plywood 50cm x 30cm	1
- Debes of equal size	4
- Sensitive balance (e.g. used to weigh letters)	1
- Spring balance (to weigh to 20kg)	1
- Blue Cross storage dust, 400gm container	1
- Shovel	1
- Hand-held maize shellers	2
- Posters (one for each anticipated farmer present)	-
- Felt-tip pens	3
- Sampling spear	1
- Bucket	1
- Jam jar	1

5.6.1 The Demonstration

Gather the farmers around the storage structure and follow these steps:

1. Remind the farmers that they have been attending a series of demonstrations during the year and that they have been given advice, practical skills, and knowledge which should have enabled them to reduce losses and to gain considerably from their new practices.

2. Ask the farmers to summarise the advice they have received during the year. Ask a series of questions, pausing after each question to correct the farmer where necessary and to add points which he may have missed. If possible, allow the correct answers to come from the farmers themselves.

   - Why should we harvest maize early?
   - Why do we need to modify our structures?
   - Why do we need to clean and spray our storage structures and when?
   - Why should we shell and treat our maize?

3. Tell the farmers a local proverb to the effect that "seeing is believing" and that they will be convinced of the benefits of all these practices by seeing the results.

   Ask the farmers how many of them were able to adopt all the practices being promoted.

   Explain that the next step is to take samples from an improved crib (or granary) and from a traditional granary to show the differences.

4. Explain why samples should be selected at random and how the procedure should be carried out. Demonstrate the correct sampling procedure.

   Let 2-3 volunteers select sacks at random in the improved crib and draw a sample of maize. Place the sample in a debe. Let 2-3 volunteers remove maize cobs at random from the traditional store. Let them shell the cobs and place in another debe.

To save time during the demonstration the maize samples can be collected and shelled just before the demonstration begins. This should still be done by volunteers so that the farmers believe that the samples are typical of the granary.

5. Let a volunteer tip the maize from the traditional granary onto a clean, dry surface, into a conical heap. Show him how to use a piece of plywood or thin board to divide the heap to obtain a small sample from the layer sample. Obtain a small sample of about 300 grains (enough to fill the jam jar you've brought to the demonstration).

6. Transfer the sample to a separate surface and let volunteers:

   a) count the grains;

   b) separate the grains into small piles according to whether they are:

      - undamaged
      - damaged by pests (bored kernels)
      - diseased (rotten kernels)
      - mouldy
      - germinated.

   c) Count the number of grains in each portion and express the number of kernels in each category as a percentage of the total number of grains in the sample. (see (5) in Essential Information Section).

7. Calculate the weight loss due to insect damage

   - use scales, if available
   - use formula if no scales available (see Essential Information Section (6).)

     Weight loss for shelled maize = number of bored kernels x 1/8.

8. Discuss with the farmers the problems of assessing quality losses.

   - Ask for a volunteer, preferably a woman, to sort through the damaged, diseased, mouldy and germinated portions, setting aside in each case those grain considered unfit for human consumption.
   - Discuss the percentage level of poor quality grains which could cause a farmer to sort his maize or discard it for animal feed.

9. Ask a volunteer to tip the maize from the improved crib onto a clean, dry surface into a conical heap. Let him divide the heap to obtain a sample as was done before.

   Follow the same procedure followed with the debe of maize from the traditional granary:

   - coning and quartering
   - separating damaged and undamaged portions
   - selecting and calculating % quality loss (rejects).
   - counting and calculating % weight loss

10. Compare the losses between the traditional and improved storage methods, and calculate the value of the maize saved (that would have been lost) by using the improved storage system:

a) for 25 bags maize;

b) for 50 bags maize;

c) for 100 bags maize.

Number of bags stored x % total loss (damaged) = number of bags lost x price per bag

11. Tell the farmers that you will now make a direct weight loss comparison.

Explain why it is necessary to use debes of exactly the same size.

Let the farmers satisfy themselves that this is so.

Ask for a volunteer to fill a debe of maize from each store using the same random method applied previously.

12. Weigh each debe of maize. (If you don't have a scale see if the debes can be weighed at the posho mill).

Discuss with the farmers the cause of the difference in weight.

Calculate the % weight loss for each following the previous method.

Discuss the quality of the debes of maize and their suitability for milling and as food. Compare with your earlier discussions.

13. Take both of the debes to the posho mill.

- Grind each sample separately, filling the flour back into your debes.
- Discuss with the farmers the difference in volume.

  Let the participants, especially the women, examine the flour and discuss whether there are any differences in quality.

14. Ask the participants whether tasting ugali made from the two samples could help in deciding whether there are differences in quality.
   - If so, arrange for the samples to be cooked. Ensure that the cook keeps the samples separate and clearly identified.
   - Let the participants taste the ugali made from the two samples.
   - Let the participants discuss the causes of poor food and possible solutions.

15. Take the comparative losses chart (see Appendix Form 2) and explain to farmers that you intend to discuss total losses and compare for different storage management systems.
   Present field loss % figures obtained from field trials, showing the extent of field losses by delaying harvest until maize has reached about 13-14% moisture content in the field.
   Discuss and explain, and enter loss figures on the poster.

16. Now let a farmer remind you of the % loss figures (weight and total loss) the group just found.
   Enter these figures on the poster.

17. Explain to the farmers that where maize stover (stalks and leaves) are used for feeding animals they will have greater value when maize is harvested early.
   Discuss with farmers and agree whether or not they use stover for animal feed and if so what additional value it has.

18. Ask for a volunteer to add up the value of losses for each type of store.
   Discuss comparative losses.

19. Talk to the farmers about the approximate cost of each type of structure of about equal size (capacity).

- Discuss with farmers the cost of construction of the different types of structures. Note the difference between cash outlay and the cost of labour and materials available on the farm.
- Discuss with farmers the cost of improving traditional stores. Again, note the difference between cash outlay and the cost of labour and materials available on the farm.
- Agree upon cost figures and enter them on your chart.

20. Ask farmers to compare the annual savings resulting from improved storage practices with the costs of construction and improving of stores.

- Discuss whether the savings achieved are worth the additional costs of construction and management.

21. Tell the farmers that you will now discuss how to ensure continued safe storage of their maize.

- Explain that chemical treatment should protect the stored maize for 3-6 months. (This may vary by agro-eco-zone). Explain why sometimes it does not protect the maize for so long.
- Explain that although the maize is safe, farmers should not use treated grain for immediate consumption. There is no need to treat maize that will be consumed in the next 2-4 weeks because insect damage will be minimal.
- Tell the farmers that in the process of periodic inspection they should:

a) Inspect the store for signs of insects.

b) If insects are found in the shelled maize they should remove all bags and retreat.

c) bags should be cleaned by washing them, after turning them inside-out.

22. Tell farmers that they should inspect their stored maize every 2 weeks.

- Ask the farmers to list the points to check when inspecting.
- Remind the farmers of the points to observe during an inspection:
  - Surroundings
  - Exterior
  - Interior
  - Bags or Containers
  - Inside the bag/container.

23. To make sure that the aim of the demonstration has been achieved, ask the farmers a number of questions, including:

- How often should stored produce be inspected?
- What should we look for when checking to see if our stored maize is safe?
- What should we do when we find spoilt (insect-damaged, mouldy) grain?
- What factors, or management practices, led to the difference we saw in large storage losses?

- What benefits do we gain from adopting the new management practices being promoted by the Ministry of Agriculture?
- What extra costs (money, time, materials) are involved in adopting the new practices?
- In your opinion, are the extra benefits worth the extra costs?

Summarize—

Summarise the demonstration by adding to the farmers answers or correcting when necessary to ensure that the correct explanation is understood.

- Explain that there were two purposes to this demonstration. One was to ensure that the farmers can go home and inspect their stored produce and take steps to ensure that they avoid storage losses.

  The second purpose was to show practically the losses that can occur in store as a result of different storage management practices.
- Tell those who have not adopted the new practices to observe the results of those who have, and to consider carefully the benefits of better storage management systems.

  Thank all the farmers for their participation, and especially those on whose farms demonstration were held.

  Wish them all success in practising better storage management.

5.6.2 Essential Information

(1)Why is it necessary to conduct a results demonstration?

- Throughout the season you have been extending advice to farmers aimed at helping them to reduce storage losses through improved storage management. You should complete the process by showing them the actual results achieved by using these improved management practices.
- Some will have accepted the practices, but other will not have. You should make a final attempt to convince those who have not adopted the practices by showing them the results achieved, and by reviewing all the changes in management practice which are recommended.
- The end of the storage period is a good time to measure the benefits of the new storage management system and to compare these benefits with the costs incurred.

(2) Why do we need debes of the same size and weight when making comparisons?

- It is always easiest to compare like with like. If the containers are the same size (volume) and weight, then we can compare the weight of the contents directly without making any corrections for differences between containers. Farmers can see that the results are comparable.

(3) Why do we need to be careful when sampling?

- It is not possible to examine every kernel or grain in the mass of stored grain, so we take out a small amount from the bulk of the grain to test or measure.

If the quality of the grain is totally uniform, the measurement from any sample would be the same.

In practice these are variations in quality throughout the bulk of stored grain and it is not easy to take a sample that is truly representative.

- If a sample is always taken from the first bag of shelled maize right by the entrance to a granary a systematic error called bias will be incorporated in the sample. If grain which is easy to reach is avoided then grain from places hard to reach may, unconsciously, always be chosen resulting in over-correction!
- To avoid such bias when sampling to determine average conditions, it is best to take the choice out of human hands and sample at random. Such samples are called possibility samples and are obtained on the basis of the use of a table of random numbers.

Following is a rule of thumb for sampling bags of maize.

Up to 10 bags	Sample every other one
11 to 25 bags	Sample every third or fourth one
over 25 bags	randomly sample 10 percent.

(4) How to sample:

a) Shelled maize

- Coning and Quartering

When the shelled maize is poured onto a mat or piece of plastic it will form a cone; as in Figure 5.6.

Figure 5.6-- Maize cone

If you are sampling maize from your jam jar, you should take a spoon and mix the pile as follows: Dip the spoon into the maize from the bottom edges to the top, dumping your spoonfull back on top of the pile. Go all around the edge of the pile in this manner.

Next divide the pile into half and then quarters and so on, using a flat thin piece of wood or piece of iron sheet.

You can sample in this method by dumping a whole bag and then dividing the maize not just in quarters, but into 1/8th, 1/16th, 1/32nd, etc. subsamples (if you start with a bag of shelled maize then you'd use a shovel for mixing rather than a spoon.)

Have the farmers divide the cone until each pile will go into your jam jar. This should be about 500-700 kernels--you only need 100 for each group of farmers you'd like to involve in the count and analysis.

- Spear Sampling
- Bag sampling with a spear, Figure 5.7, is an ideal method of obtaining a representative sample. It is cheap, simple to use and a quick method of obtaining maize or other bagged commodities, such as beans, rice, coffee, etc.
- The correct sampling procedure is:

a) make six probes, each inserted at an angle, (Figure 5.8)
b) push the tip of the spear into the bag
c) insert the spear with the open face down
d) collect grain by twisting the spear so that open face is up
e) withdraw, letting the grain fall into a container or on a piece of plastic where it can <u>all</u> be collected.

Spear sampling can be of no use if not done properly. If the spear is inserted as in Figure 5.9 large insect populations can be overlooked. Insects are often found in pockets associated with the dust or meal material at the bottom of the bag or in areas of local heating (hot spots) or wetting (wet spots). If the insect population shown at the bottom of the bag,

Figure 5.9 is missed, then the farmer would not retreat his maize and before the next inspection heavy losses could occur. Therefore, one of the six probes should be made through the areas of the sack that was on the bottom in its stored position. This could be the sack bottom or one side.

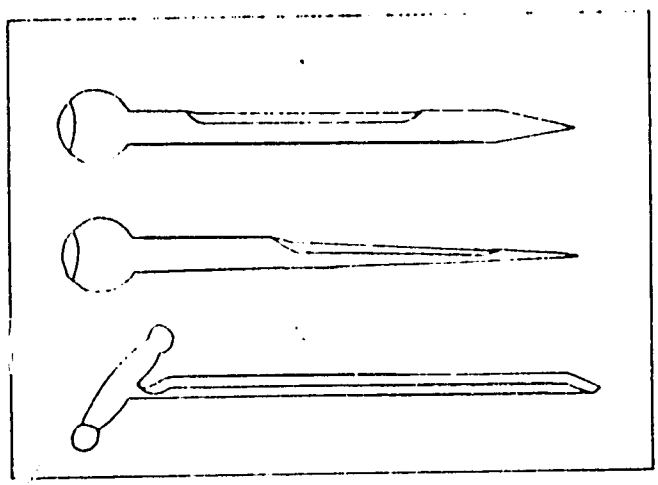

Figure 5.7 Spears for Sampling Bagged Grain.

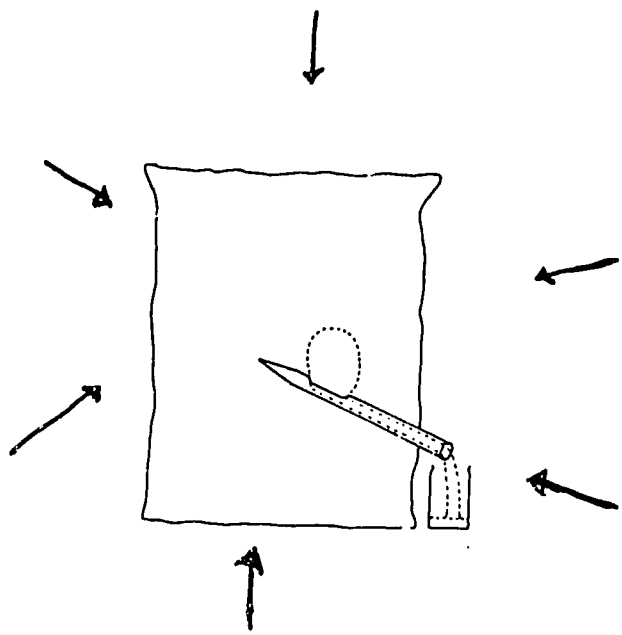

Figure 5.8 Insert Spear at an angle.

Make sure you show the farmers the importance of inserting the spear so that the open face when turned collects maize just inside the sack.

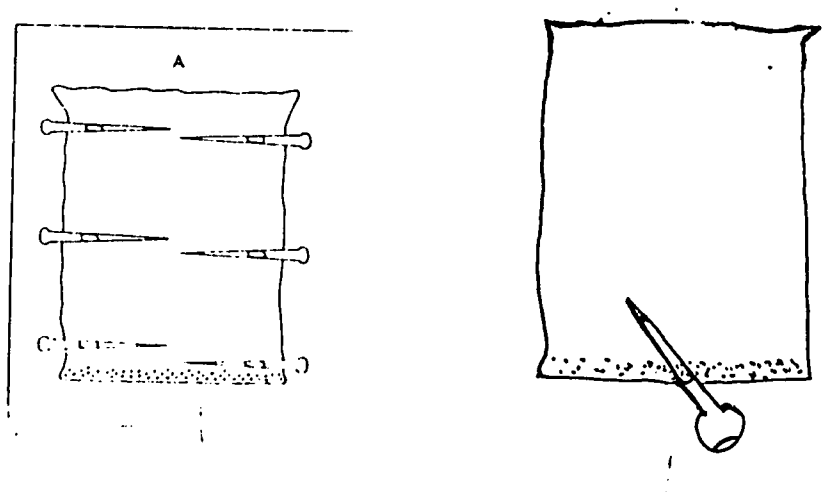

Figure 5.9 Problems of Spear Sampling.

5. How do we compute percentage losses?

a) Spread the jam jar of kernels out on a clean space. (A full jar should contain 600-800 kernels of maize). Separate the kernels according into the following separate piles.

- undamaged
- damaged by pests (bored kernels)
- rotten or mouldy kernels
- germinated kernels
- broken kernels.

b) count the number of kernels in each pile (Estimate the number of whole kernels the brokens might represent. Usually these may be kernels broken in half due to rough handling or shelling or kernels which were damaged by birds or rodents.)

c) determine the total number of kernels in your sample

calculate the percentage in each pile as follows:

$\frac{\text{Number damaged by pests}}{\text{Total number}} \times 100 = \%$ damaged by pests

$\frac{\text{Number rotten or mouldy}}{\text{Total number}} \times 100 = \%$ rotten and mouldy

$\frac{\text{Number germinated}}{\text{Total number}} \times 100 = \%$ rotten and mouldy

$\frac{\text{Estimated number of broken}}{\text{Total number}} \times \%$ germinated

$\frac{\text{Total number damaged or germinated}}{\text{Total number}} \times 100$ % damaged 1/

6. How to estimate weight loss without a set of scales: 2/

- Use what is termed a "conversion factor".
- Start with the % of bored grains in your sample as follows (the same procedure can be used for other cereals):

$\frac{\text{Number of bored grains} \times 100}{\text{Total number of grains counted}} = \%$ bored grains in sample

This percentage is converted into a percent wieght loss by dividing it by the conversion factor (C) or multiplying it by I/C.

To determine the conversion factor, a random sample of 100-1,000 damaged grains is taken which contains 10% or more damaged grains. The percentage wieght loss is determined by the count and weigh method, and the conversion factor is calculated as follows:

1/ While some of the damaged kernels may be edible, if they are sold in the marketing system, they will command a lower price then if entire lot is of high quality.

2/ Source: Harris, K.L and Lindblad C.J., Post-Harvest Grain Assessment Methods, American Association of Cereal Chemists, 1978.

The following conversion factors have been established in practice where the larval stages develop within the grain, for example, Sitophilus species and Sitotroga cerealella:

		I/C
Maize (stored as shelled maize or as ears without husks)	% bored grains x	1/8
Maize (stored as ears with husks)	% bored grains x	2/9
Wheat	% bored grains x	1/2
Sorghum	% bored grains x	1/4
Paddy	% bored grains x	1/2
Rice	% bored grains x	1/2

This conversion factor becomes less accurate when the level of damage reaches 100% damaged grains. With shelled maize, for example,

100% damaged grains x 1/8 (conversion factor)

= 12.5% weight loss.

This method does not estimate weight loss above 12.5%.

A form for recording percentage losses and weight loss due to insects is given in Appendix Form No. 1.

Once you have collected sufficient information on quality and quantity losses in your area, you can use Appendix Form No. 2 to show your findings at this or other field days.

Outline
Periodic Inspection of Stored Maize

CHECKLIST

Equipment and Supplies
Needed for Periodic Inspection
of Stored Maize Demonstration

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

8. _____

9. _____

10. _____

11. _____

12. _____

NOTES:

6.0 ECONOMIC DECISION-MAKING TOOLS

Do not be frightened by the term "Economic Decision Making". This is simply away of saying, "what will it cost and is it worthwhile?" This can be an useful and interesting exercise. It would really help if farmers develop the habit of keeping records. Try to encourage them to write down all of their cash expsenses and income if bags of maize are sold. Information like this is necessary if a farmer is to make a rational decision regarding crop storage investments or any other change in farming practices.

6.1 Budgeting

Budgets are simply tools for decision making. Let us now look at three examples of calculations that will help farmers make decisions about storage. The examples will be:

1. A complete budget
2. A partial budget
3. A calculation called "economic payback".

6.1.1. A Complete Budget

A complete budget for a farm sets out all the expenses and all incomes for the farm before the happen, so that the farmer can estimate, or ancipate, whether he/she will make or lose money. If you have an agricultural certificate, you may remember covering these subjects at the Institute of Agriculture that you attended.

As a reminder, the complete budget may be used to determine (1) the profitability of the total farming operation, or (2) the total expenses and receipts from only one enterprise (activity) of the farm. For example, a complete budget showing all expenses and receipts (including the value of maize used on the farm) related to maize production will tell the farmer whether or not it is a profitable enterprise -- whether or not the returns are greater that the costs. An enterprise (such as dairy, sugar cane, poultry, etc.), abandoning unprofitable ones and adding profitable ones.

The storage function is a separate farm enterprise, just as maize or sorghum production. The farmer needs to know if it is profitable to store maize. A sample of a complete budget is given.

Example of a Complete Budget:
Assumed Crib Capacity = 20 bags

	All New Materials	Some Materials Produced on Farm	Most Materials Produced on Farm
	Kshs	Kshs	Kshs
Fixed Costs (costs don't change with changes in amount stored.)			
Depreciation (decrease in value due to wear and tear) (assuming 10 year life and no surcharge value)	288.00	200.00	100.00
Interest on Investment (1/2 the original value x current interest rate, 14% assumed)	20.00	14.00	7.00
Annual repairs (10% of original value)	288.00	200.00	100.00
Total Fixed Costs	596.00	414.00	207.00
Variable Costs (costs change with changes in amount stored)			
Prestorage hygiene (chemicals)	25.00	25.00	25.00
Dusting shelled maize	60.00	60.00	60.00
Labour	149.00	149.00	149.00
Total Varaiable Costs	234.00	234.00	234.00
Total Enterprise Costs	830.00	648.00	441.00

	All New Materials	Some Materials Produced on Farm	Most Material Produced on Farm
	Kshs	Kshs	Kshs
Gross Returns (Previous Loss 5 bags @ Kshs 300 = 1500 Kshs. Present Loss 1 bag @ Kshs 300 = Net Return of 1200 Kshs)	1200.00	1200.00	1200.00
Net Return	+370.00	+552.00	+759.00

This is a tool that you can use either with a group of farmers, using a fli chart, or with and individual farmer, using a sheet of paper.

Note that a complete budget includes four major parts. Annualized fixed costs variable costs, gross returns, and net returns.

The budget considers the costs and returns involved in the use of new improve crib for drying and storing maize, of the type recommended by the On-Farm Grai Storage Project in western Kenya. The bottom line of this budget indicate that profitability of improved storage.

The results in this illustration are positive but not sufficient for goo decision making. The farmer needs to know at least two other bits o information: first, what are his/her alternatives? and second, what will b his/her economic payback (in years) if the decision is made to invest in a storage crib.

Any time you are advising a farmer on a decision that involves spending a lot of money you need to go slowly and make sure that you are making the correct choice. Many small-scale farmers do not have the available cash necessary to: 1) make such an investment without borrowing, and 2) make the periodic loan payments if they could borrow. Therefore, study the situation further.

Let's now turn to second decision making test, that of a partial budget.

6.1.2. Partial Budget

The farmer already has a traditional crib. Maybe, therefore, it would make more economic sense to improve it than to build a new improved crib.

A partial budget is used whenever considering relatively small changes in the farming practices. Two examples are given. Both relate to decisions concerning grain storage.

Partial Budget No: 1

Decision to Raise and Existing Traditional Basket to be Used for Drying and Storage (Capacity is 10 bags of Shelled Maize)

A.	ADDED COST 1/	Kshs	B.	ADDED RETURNS	Kshs.
	Foundation posts (4)	140		Maize seed (.5 bags per year for 5 years or 2.5 bags at Kshs 300/bag	750
	Rat Guards (4)	110			
	Nails	10			
	Hired Labour	200			
	Subtotal	460		Subtotal	750
C.	REDUCED RETURNS		D.	REDUCED COSTS	
	None	---		None	
	Subtotal	0		Subtotal	0
	Total	460		Total	750

Change in income (B-A) = gain of Kshs 290 over the assumed 5 year period.

1/ This example assumes that the improved basket will last 5 years. (Your alternative is to look at these costs and returns for a single year.)

Partial budget No. 1 shows the added cost and added returns over an assumed 5 years period, the added returns (savings) coming from reduced rodent damage only.

This example shows the farmer that for a small investment of Kshs 400/- he can save about Kshs 750/-. Of course this storage improvement makes it possible for the farmer to adopt other associated storage management practices, bringing his total savings far above the cost shown.

If you were to compare the economic benefits of raising an existing basket using this partial budgeting technique with the benefits from constructing an improved single-section crib having a 10-bag capacity, you would, likely, be able to show the farmer that he/she could sharply reduce his/her capital investment costs (cash costs) without seriously risking his/her benefits.

Partial Budget No. 2:

Decision to Dust Shelled Maize and Store in Bags vs. Cob Storage (10 Bags of Shelled Maize)

A.	ADDED COSTS	Kshs	B.	ADDED RETURNS 1/	Kshs
	Chemical	25		Maize saved = 1.5	
	Labour	30		bags x Kshs 300/bag	450
	Subtotal	55		Subtotal	450
C.	REDUCED RETURNS		D.	REDUCED COSTS	
	None	--		None	—
	Subtotal	0		Subtotal	0
	Total	55		Total	450

Change in income (B-A) = a gain of Kshs 395/-

1/ Assume that dusting reduces losses from insects equal to 150% of the 10 bags in store.

With an improved structure and assuming the farmer has harvest early and properly dried his maize, he can adopt this practice of dusting his shelled maize at an expected high rate of return. Obviously not all changes will reflect such positive benefit-cost relationships. That, of course, is the importance of using this partial budgeting technique — to estimate the economic outcome if a certain change in farming practices is made.

In both examples, you will notice a space has been left for "reduced returns" and "reduced costs". This are explained next.

Reduced Returns--

This is another consideration for a partial budget. The farmer should ask himself/herself whether the raising of the existing store will actually decrease or increase his/her income. For example, what if he/she had needed to use two new floor beams when raising the existing basket? These beams, cut from trees on the farm, could have been sold instead. So, in addition to the actual expenditure for the store, his/her added costs, he/she must consider the reduced income from not selling the two beams.

Another example of reduced returns may be the saved grain. In the past the farmer may fed the spoilt grain to his/her livestock. Although he/she now has some extra bags to sell to the market or to use for the family, he/she has less food for the farm animals. Returns (income), therefore, are reduced by the amount now spent on buying feed for the livestock.

Ask the farmers to think of other examples of Reduced Returns. (With fewer rats, he/her may have to buy cat food!)

Reduced Costs--

There may also be some reduced costs. For instance, the farmer may find it quicker and easier to unload his/her store by adding special platform onto the improved store.

In the past he/she may have spent a whole day taking out the grain and sorting it into good and bad bags. Or if the farmer harvests early, the stover (stalks and leaves) of the maize can become a valuable feed source for the livestock. This may result in less money spent on livestock. Ask farmers to think of some other examples of reduced costs.

Net Change in Farm Income

Although we have talked about everything in terms of money, the farmer may not sell the saved grain. He/she may just use it to feed his/her family. It is important that you help the farmers understand that every item on the farm has a value. For example, Labour can be sold to neighbours. Therefore, even if he/she is working on his/her own farm his labour has a COST. The stover, wasted grain and sticks all have a value. They could be sold. Likewise, all maize used on the farm should be valued at the current market price — what the farmer would have received for it, if it had been sold.

With a partial budget, make sure every change in added costs, added revenue (returns, or income), reduced costs and reduced revenue are considered. The costs and revenue additions minus the revenue and cost reductions are the net change in farm income. That is, looking at the partial Budget examples:

$$[(B + D) - (A + C) = \text{Change}]$$

This change could end up being negative; this shows that the farmer should not change his/her system. This may be the case if the farmer has a good traditional store and what little is spoilt is used for animal feed.

6.2 Economic Payback

Economic payback is the recovery time required to recover the money used for a new investment. This money is recovered from the value of additional annual income. A simple formula to follow is:

$$P = I/R$$

Where P = Payback, I = Initial Investment and R = Annual Added Returns.

Example:

Assume that a farmer invests Kshs. 2,400 in a crib. The crib saves him/her an extra two bags of grain. He/her sells the grain four months after the harvest for Kshs. 400 per bag. This enables him/her to benefit from extra cash of Kshs. 800 per year. Now look and see how this can be expressed as "Payback".

$$P = \frac{2400}{800}, \text{ or } 3$$

The figure 3 represents three years. This is the time it takes for accumulated savings to cover the cost of the initial investment. After that period, the savings can be treated as extra income for the farmer.

The payback figure also gives the farmer a useful guide for decisions concerning borrowed money. Remember these useful tips:

1. The payback figure should never exceed the loan period for money which is borrowed to make the investment.
2. The payback figure should never exceed the life expectancy of the investment.
3. The payback period divided into 100 should always exceed the interest rate for borrowed capital (money).

Research has shown that the usual payback for a new crib ranges from 1 to 4 years depending on the final cost of the store and the grain saved. For an improved traditional basket the range is 1 to 3 years.

Even with this short payback period the farmer may be reluctant to take a loan to pay for the crib. There are ways to reduce the risk and some suggestions are found in the next section.

6.3 Cost Savings Tips

Many people do not like borrowing money because of the risks associated with not being able to meet the repayments. Some people find it hard to borrow money because they have no security (assets) which can be recovered by a lender if the repayment is not made as agreed.

"Debt-free" adoption and the "group" scheme are possible ways to acquire a store or improved structure without borrowing money.

6.3.1 Debt-Free Adoption

The following section looks at the Step-by-Step" approach to improving a store. "Step-by-Step" mean makaing gradual improvements each year to minimise the risks of debt or of increasing the demand on a farmer's limited resources.

Although it often can be shown that it may be worthwhile for a farmer to take a loan to build a new crib, many farmers are reluctant or simply cannot take this step. For some farmers, it is a big risk to borrow money as the harvest for the next year may be very bad. For others, they have almost no cash flow (money available to invest.) Therefore, let us look at a way the individual farmer minimise the risk of debt.

The first thing the farmer has to do is to identify where the losses are occurring. He/she will then be able to work out the cost of preventing each type of loss.

On a sample farm it was found that the most cost-effective (best return for money invested) areas for concentration (improving storage practices) were:

1st: Reduction of insect damage

2nd: Harvesting at the right time.

The following example is a guide to give the farmer some sort of indication of the possible savings. Suppose a farmer losses 27 bags out of a total of 100 bags. The following table shows where these losses would be most likely to occur.

Management Practice	Savings (Bags)	Cost
Careful handling	2	Smallest
Early harvest and storage hygiene	8	Very small
Shelling and treatment	10	Small
Raising store with rat guards	5	Higher than others
Other measures	2	Low
	27 out of 100 bags harvested 1/ 2/	

Note: 1/ 27 bags out of 100 is about the same as 13 out of 50 bags
This is nearly the same as 6 out of 25 bags harvested or the same as 3 out of 12 bags harvested.
You can see from these figures the biggest saving comes from shelling and treating. What is even more interesting is that the cost of shelling and treatment is comparatively small.
2/ Losses on individual farms will differ slightly from these assumptions, but the relationship of the losses will normally be similar.

One Step at a Time

Small-scale farmers cannot afford to do everything at once. Therefore, as long as the sequence its possible, they should look at what is causing the greatest return and spend to reduce that loss first.

What is causing the greatest losses?

- Insects

- Late harvest.

So consider recommending that the farmer harvest early (by drying on the ground), shelling the maize and treating with an approved chemical dust as a first step. This leads to the greatest savings for the lowest costs. The farmer can then gradually make the other improvements afterward.

The next best step will be for the farmer to construct a drying platform and/or improve his present store.

While good grain storage management involves a whole package of recommended practices, these are ways of delaying the cost of the complete management system (one that is effective and requires little labour) until a farmer has accumulated sufficient savings to make debt-free investments.

The key to achieving the ultimate objective of owning a new improved store for large umbers of low-income, small-scale farmers may well lie in a slow, deliberate management scheme that will allow accumulated savings to pay for future investments. And, for many smal scale farmers, budgeting may show that investment in an expensive out-side store is not a good economical decision.

Because early harvested maize will have 28-32% moisture content, it must be dried. But it does not have to be dried in an expensive structure in order to achieve the advantages of early harvest. Drying at first can be done on the ground or on a drying tray similar to those used to dry coffee beans.

A partial budget might show that this method will require some extra labour. In the long run, however, the added cost for a period of 1-2 years may be less, for example, than interest charged on a loan for an expensive drying structure.

After the 1-2 year period of low cost drying you can recommend that the farmer is ready to adopt or renovate his/her existing basket for drying (see Chapter 7.0, section 7.4.), if this is an appropriate step in your opinion.

By being patient and following this debt free scheme the farmer can achieve his/her ultimate goal in about 5 years. The following 5-step (5-year programme) can be recommended to small-scale farmers:

Step 1: Early Harvest
Dry on Ground
Shell and treat

Step 2: Early Harvest
Dry on Ground
Shell and Treat
Pre-Storage Hygiene
Renovate Store

Step 3: Early Harvest
Dry on Raised Platform Tray
Shell and Treat
Pre-Storage Hygiene
Use Renovated Store

Step 4: Early Harvest
Pre-Storage Hygiene
Shell and Treat
Use Improved Crib for Drying and Storing

Step 5: Save 4 but purchase the following:
(1) Papyrus mat (protection and security)
(2) Ground Sheet (for shelling and treating)

If for any reason, sufficient savings to pay for building a new improved structure by Year No. 4, the Year No. 3 practices can be repeated for an additional year to allow more savings to accumulate.

Costs Associated with Adoption

Steps	Cost of Materials	Annual Cost(KShs)	Accumulated Cost (KShs)
Step 1:	Insecticide dust	48	
	Plastic sheet for ground cloth	135	
	Total cost	183	183
Step 2:	Prestorage hygiene	25	
	Insecticide dust	48	
	Raising existing basket 1/	457	
	Total Cost	530	
Step 3:	Prestorage hygiene	25	
	Insecticide dust	48	
	Drying tray	570	
	Total Cost	643	
			1,356
Step 4: 2/	Prestorage hygiene	25	
	Insecticide dust	48	
	Total Cost	73	
			1,429
Step 5:	Prestorage hygiene	25	
	Insecticide dust	48	
	Improved crib	2,293 3/	
	Papyrus mat	220	
	Total Cost	2,586	
		======	4,015

1/ Costs include lower main posts, beams, upper main posts, all supports, rat guards, and preservative.

2/ The farmer in Step 4 is repeating Step 3 to accumulate savings, in order to purchase an improved crib in Step 5, debt-free.

3/ Assumes some materials are available, on farm, including materials from the dismantled drying tray.

Savings Associated with Adoption

Year	Improved Adoption Method[1/]	Bags Saved	Savings Annual	Savings Accumulated (KShs)
Year 1:	(1),(2)	2.8	840	840
Year 2:	(1),(2),(3),(4)	3.5	1,050	1,890
Year 3:	(1),(2),(3),(5),(6)	4.0	1,200	3,090
Year 4:	(1),(2),(3),(6),(7)	4.0	1,200	4,290
Year 5:	(1),(2),(3),(6)[2/],(7),(8),(9)	5.0	1,500	5,790

1/ (1)= Early Harvest, (2)= Dust Shelled Maize, (3)= Pre-storage Hygiene, (4)= Raise Existing Basket, (5)= Build Raised Platform Dryer, (6)= Store in Raised Basket, (7)= Dry on Raised Platform, (8)= Build New Improved Crib, (9)= Store in New Improved Crib.

2/ Farmer has the choice of using both the raised existing basket and the new improved crib, or he/she can dismantle either the raised existing basket, or both the raised existing basket and the raised platform dryer, using some of the materials from those structures to construct the new improved crib in Year 5. (If this 5-year debt-free scheme is plannned in advance, then some of the materials used in the improvement of the existing basket and the platform dryer can be chosen and/or cut with ultimate use in the new improved crib in mind.)

A summary of this example of the step-by-step approach shows a positive cash flow over 5 years. At the end of this section you will find some graphs that express this in different ways. It may help you to make this point about cash flow clearer if you can reproduce a graph on a flip chart or board using different colours for costs and savings.

Annual Cash Flow

Year	1	2	3	4	5
Savings	840	1,050	1,200	1,200	1,500
Costs	183	530	643	73	2,586
Net	647	520	557	1,127	(1,086)
Accumulated Cash Flow		1,167	1,724	2851 1/	1,765

1/ Farmer has accumulated enough savings to afford a debt-free new, improved crib.

Assumptions (You can use costs appropriate for your area and the time.)

Assumptions are as follows:

(1) 25% loss to be reduced to 5%. Farmer produces 20 bags.

(2) One bag of good quality maize sells for Kshs. 300.

(3) Cost of raising existing basket - Kshs 457.

(4) Cost of building a drying tray - Kshs 570.

(5) Cost of chemicals for pre-storage hygiene spraying - Kshs 25.

(6) Cost of constructing new raised crib using some home-grown materials and hired labour - Kshs 2,293.

(7) Cost of insecticide to treat 20 bags of maize - Kshs 48.

(8) Cost of papyrus mats to line crib - Kshs 220.

(9) Added costs cannot exceed accumulated savings from previous year.

6.3.2 Group Adoption Scheme

In Kenya today many people have benefitted from working together in groups. Women's groups are a good example. Considerable progress has been made, especially in marketing farm produce and handicrafts. Some other groups have combined resources to purchase mabati (corrugated sheets) for roofing or to build water storage tanks. These are just a few examples.

When an individual's resources are limited a group approach can make things possible. Very often members may all contribute or join the group by paying a membershp fee of say Kshs. 100-500 and make similar annual contributions over a given number of years. These contributions, then, are a means of forced savings. When enough money has been accumulated the funds are used in some way to achieve the group's objectives. For example, mabati sheets are purchased and the group decides which member's house will have the first improved roof. After a few years, all the members will have new roofs.

This principle of group involvement can be used for purchasing the materials for an improved store. Improved storage management will yield savings in terms of extra grain saved as outlined in the previous section. This means that very little money need be contributed and only in the initial stage, which is a big advantage. Each member will then only need to pool the savings (either cash from grain sales or extra bags of grain saved each year) to make the scheme work.

Here is an example:

Assume that 8 store owners form a group and the membership fees are Kshs.150, giving a total of Kshs.1,200. The members then carry out step 1 as outlined in the manual, namely harvesting on time, drying as recommended on the ground and shelling and treating to save Kshs.852 each or a total of Kshs. 6,816.

This, in addition to the Kshs. 1,200 collected, totals Kshs. 8,016, enough to build a new crib for 4 members before the next harvest.

In Year 2, four members see the benefits of improved storage management as outlined earlier in this manual.

	Kshs.
4 members x 1,320	5,280
The other 4 members carry on as in the previous year	
4 members x Kshs. 852	3,408
Total Group Saving	8,638

Now the other 4 members can build their improved cribs and there may be some change which can be shared out or used to purchase matting or chemicals. The group may well decide to continue working together to purchase in bulk or share a sprayer or any other need identified by the group.

Let us look at the figures again:

Year One	Year Two
8 x 150 = 1,200	4 x 1,320 = 5,280

Let us look at the figures again:

Year One	Year Two
8 x 150 = 1,200	4 x 1,320 = 5,280
8 x 852 = 6,816	4 x 852 = 3408
8,016	8,688

Kshs. total in two seasons = 16,704

Cost of 8 stores = 16,000

These two approaches, the step-by step and group adoption can work together to make the improvement of post-harvest grain mangement a realistic task.

6.4 Summary

The adoption of improved methods will only be accepted if the economic advantages outweigh the disadvantages as seen through the eyes of the farmer. If the new ideas create fear and uncertainity that risks are being increased these fears will delay implementation or prevent it altogether. The doubts and fears that may arise because of the farmer's limited resources that would be needed are the need for building materials, labour and for purchasing chemicals. In addition to that cash needed for paying other bills e.g. repaying loans) and funds for normal home and farm expenses.

There may also be fears created by social pressures such as:

- fear of failure (being the focus of ridicule or the possibility of incurring debts)
- fear of stepping out of traditional norms
- fear of additional demands from the extended family and harambee requests

- theft from store
- maintaining harmoney between family members who are reponsible for other stores
- fear of disrupting the accepted way of doing things (status quo) and the pressure of new responsibilities.

What appears as an excellent opportunity to increase farm and family income to one farmer may be viewed very differently by another. And what may appear to be a good investment to you may seem to be a high risk in the eyes of the farmer. In other words, you may have higher expectations of success because you are not restricted in your view of what is possible. You can clearly see the benefits and the hopes or aspirations you have regarding improved grain storage.

For the farmer this is more difficult; he may have a stifled vision or dampened spirit which means that he only sees added demands from you on his limited resources. These imply greater risks for him and his family. Try looking at the idea from his point of view. Your job, as you do your part in helping the Government of Kenya to realize its goal of food self-sufficiency, is to help the low income small-scales farmers find an economically feasible way to improve their storage management.

The following differences in view indicate some of the challenges you could have as you do your job.

Extension Agent's View	Farmer's View
Minimize losses	2,000 shillings!
Extra bags	Advertising my wealth!
More to Market to feed urban population	Good idea but it will have to wait.
Increased Security	Family demands!
Added money for schooling, medicine and new seed.	The other wives will all want one!
Food for growing family, etc.	I must repay my other loans first!

The step-by-step approach is designed to reduce some of the farmer's fears. If each step is not too big (does not create new debts) and is acceptable to the family, improved storage can be achieved with little stress on the home or group. As each step is accomplished, the farmer will be motivated to move on to the following step.

Remember: Always try to see things through the farmer's eyes and do not forget to consider these points:

1) The farmer (or decision maker) may be a woman.
2) He and/or she may want to discuss and agree upon a new idea before the plan is implemented.
3) Does the group really believe that maize or grain is being lost in store? If so, how do they think this occurs and how much do they believe is lost this way?

Try to understand the following:

- Who is responsible for grain storage
- Who is reponsible for estimating the family needs for:
  1) Food
  2) Grain sales.
- Are different people responsible for different stores?

Check with other wives, sons and daughters. In subsistence agriculture where farmers may be near the poverty line, economic investment may be both impractical and unjustified. For such farmers, a limited range of improved practices and the use of locally available materials will be more meaningful.

How do the measures recommended for reducing losses, and the resultant added costs, measure up to the added returns? Is the recommended technology affordable and easily managed?

Keep reminding the farmers of the BENEFITS of adopting the new recommendations.

1. Better household food security
2. Increased income as a result of reduced weight losses.
3. Improved quality, less aflatoxin and other types of contamination proved crib.

NOTE: Make sure that if the farmer goes to the expense of improving an existing structure or builds a new improved structure that he/she at the same time makes a firm commitment to use it for both drying and storage. A drying and storage structure used only for drying sits idle most of the year and thus becomes a very expensive monument!

Table 6.1 COMPLETE BUDGET FORM

Annualized Fixed Costs		
	_____	
	_____	
	_____	
	_____	
	_____	
	_____	
	_____	
Subtotal		_____
Annual Variable (Operating) Costs		
	_____	
	_____	
	_____	
	_____	
	_____	
Subtotal		_____
Total Annual Costs		_____
Gross Returns		_____
Less Total Costs		_____
Net Return before Taxes		_____

Table 6.2 PARTIAL BUDGET FORM

A	B
1. Added Costs (Variable and annualized Fixed)	3. Added Returns
_____	_____
_____	_____
_____	
_____	
Subtotal _____	Subtotal _____
2. Reduced Returns	4. Reduced Costs (Variable and annualized Fixed)
_____	_____
_____	_____
_____	_____
_____	_____
Subtotal _____	Subtotal _____

Estimated charge in Net Farm Income (B-A) = _____

7.0 APPROPRIATE STRUCTURES

This chapter gives some engineering factors to consider regarding storage structures. You will remember that two types of structures must be considered by the farmer who is concerned about having proper post-harvest management of grains and other crops, i.e., drying and storage. The appropriateness of one or both of the structures must be determined by the individual farmer's situation.

7.1 Appropriateness

The appropriateness of structures depends on the total production of maize and other crops, the farmer's intended use of the structures and cultural factors. For example, if a farmer harvests 10 bags of maize at physiological maturity and plans to store it outside his home for several months, then a crib in which his maize can be dried and stored would be appropriate. Such an investment, however, would not be appropriate if he plans only to dry his maize in the structure and later store it in his home or sell it. Neither would the structure be appropriate if there is a traditional basket on the farm which could be raised and renovated. A very small harvest could be, and probably should be dried on the ground and stored in the home. Needs of individual farmers will differ. They will differ not only according to volume of production and existing farm structure, but also according to economic status and cultural factors.

As you make your recommendations regarding the structure, you will need to think not only in terms of the type of structure but also in terms of alternative materials. Does the farmer have some materials available that could be used for wall sticks or thatch?

Will the farmer be able to construct his own crib or will he require help from a fundi?

TIME STANDARDS FOR USE BY FARMER IN NEGOTIATING PAYMENT FOR HIRED CONSTRUCTION	
Type of Structure	Man-Days to Complete
One-Section Crib	4
Two-Section Crib	5
Double-Wide Crib	12-15
New Raised Basket	4
Improved Existing Basket	4
Fixed Location Platform dryer	2
Portable Drying Platform (5 tray)	2

You should have several requirements that you insist upon. One priority should be to use resources readily available to the farmer. Another priority should be for the farmer to erect a well-built structure. In addition, advise the farmer to use material that will last, preferably for 10 years.

Generally you will be asked to recommend structures for drying and storage. Since you are probably not a highly-trained engineer, you can use the structures suggested by the MOA. In the future, research institutions may release new and improved designs. Then recommend them. Structures currently (1991) recommended by the Crop Post-Harvest Management Programme have been designed for:

- adequate structural strength to support the weight of maize or other grain when filled to capacity
- correct dimensions to allow for airflow and thus safe drying and storage conditions
- economical choice of materials and construction methods.

Examples:

The following examples are structures that have been tested and found most appropriate for Kenya. All are for non perishable crops except the potato store. If you have any questions concerning the appropriateness of any of the structures in the agro-ecological zone in which you work, you should check with the officer handling grain storage in your division or district. Likewise, you may need to request detailed construction plans. Slight modifications may be necessary to suit the individual farmer's preferences.

7.2 Improved Crib

The improved crib, though developed primarily for storage, can be used safely for drying high moisture maize (maize harvested at physiological maturity).

Cribs of this type are shown in Appendix Figures 1-3. They can be used to dry cob maize and for storing bagged maize. When storing bagged, shelled maize or other crops, the structure should be lined with mats or some other kind of protection from the rain. This will also conceal the grain, thus ensuring the farmer's privacy. Cribs of this type are not economical if they are only used as dryers.

The recommended maximum width of the improved crib in western Kenya is 150cm (1.5m) while the length, in principle, is unlimited. The crib is designed in sections so that it can easily be built to a length appropriate to each farmer's needs.

The one and two-section cribs, (Appendix Figures 1 and 2), have a small platform which is used by the farmer to stand on and to hold bags of grain as they are loaded into and out of the store. If a crib with three or more sections is constructed, then a series of platforms should be constructed to facilitate handling. Materials for the one and two-section cribs are listed in Appendix Tables 1 and 2.

In areas where there is a shortage of poles, or where a farmer wants a crib with a longer life (at a higher initial cost), weld mesh wire may be substituted for the wall poles and floor sticks. Other materials may be substituted for better utilisation of available materials. Sisal poles in Coast Province were found to have a life of only about 2 years.

Remember two important points.

- Do not recommend a substitution that will weaken the crib.
- Foundation posts and floor beams must be treated to prevent rot and termite damage.

Appendix Figure 3 shows a double-wide (of Four-Section) crib, popular among large farmers. The accompanying bill of materials is shown in Appendix Table 3. Designs for these three sizes of cribs are available from The District or Provincial Post-Harvest Officer.

7.3 Improved Basket

There are two ways to construct an improved basket. The farmer can build a new one or he can improve an existing structure.

Baskets are common traditional stores in Kenya. Some farmers prefer them to cribs for customary reasons. They are adquate and suitable stores if properly constructed.

If a traditional mud-smeared basket will be used to dry as well as store maize, then the smear must be knocked off. This is necessary to allow adequate air flow for drying maize with a high moisture content.

Remember, when the smear is removed, the basket will no longer hold small grains or shelled maize except in gunny bags. Therefore, before recommending that the smear be removed or not added to a new basket, make sure that you understand the farmer's plan for its use.

Recommended baskets have the following dimensions:

Height - 1.75m.

Width - 1.50m.*

A basket of these dimensions has a capacity of 11-12 bags of cob maize. A traditional basket is shown in Appendix Figure 4. Note the platform and the thatched roof. The platform is constructed just like the one for the crib. The roof can be constructed from thatch or mabati, and it can be circular of else flat and inclined, like that of the crib.

A list of materials needed to construct an improved basket is shown in the Appendix Tables 4 and 5.

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*Recommended maximum width for Western Kenya.

7.4 Renovating Existing Baskets

For many farmers the most appropriate method of improving their storage is to raise their existing structure see Figure 7.1. If a repairable traditional basket exists on any small-scale farm, the first conversation you have with the farmer should focus on the improvement and use of that structure. It has great value to the farmer and should not be torn down in favour of perhaps a more eye-catching structure. The existing structure can be improved for a fraction of the cost of a new structure.

Key points to include when explaining why the basket should be raised are:

- it should be one metre off the ground and it should have rat guards installed on every leg (to keep rats out and to improve ventilation).
- any holes that may be in the old basket's bottom or sides should be repaired (to prevent wastage which will encourage rats, insects etc.)
- the roof, if leaking, should be repaired (if the grain gets wet, especially at the centre, fungi will develop).

a) How Do You Raise Your Store

Explain the following seven steps to your audience whether a group of farmers or an individual. If all of the materials are readily at hand, it should only be a day's work for 3 people to raise the existing store.

If farmers need to purchase materials for the foundation posts and platform, the cost should not exceed Kshs 200 (1991 prices). The bill of materials for raising an existing basket, Appendix Table 5, reflects the option of purchasing beams and floor sticks. Whether the farmer will need to make these purchases depends on the suitability and condition of materials under the existing basket.

Remember, the farm should be encouraged to use as many of materials from the existing structure as can be re-used for elevating the new one. Also, suggest that the farmer should use other materials that might be available on the farm, such as old tins for the rat guards.

Figure 7.1 Traditional Basket Granary.

b) Steps to Renovate an Existing Basket

First: Take apart the old store, but be sure to be very careful, because most of the materials can be re-used in constructing the raised store. Take the roof off first. Then remove all supports to the basket. Now remove the basket. Be sure the basket is in good condition. Repair any holes in the sides or bottom.

Second: Now the artisans (or farmers) are now ready to build the platform on which the store will be placed. Pick a level and open place on the compound which is not obstructed by other buildings, trees or fences. Mark out a place for four holes on the ground. Make sure the four are in a square (see Figure 7.2) Each hole should be about 120cm from the other. The posts which go in these holes should be approximately 10 cm in diameter and 200 cm in length. The posts should also be treated with creosote oil or an approved insecticide to guard against termites.

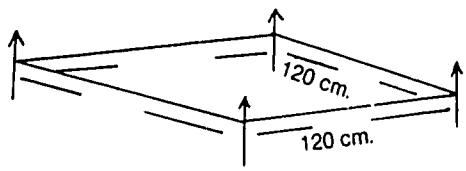


Figure 7.2 Location of Posts Holes

<u>Third</u>: Dig four holes about 75cm into the ground and place a flat stone at the bottom of each hole. This will prevent the posts from sinking. Now place a post in each hole and fill soil in around each post so they are straight and stand firmly in the ground (see Figure 7.3) Cut the top off all the four foundation posts so that they are level with each other and so that they stand about 100cm above the ground.

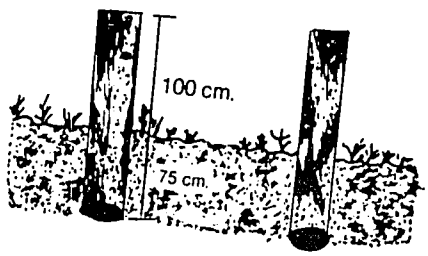
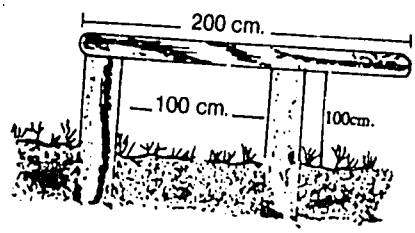


Figure 7.3 Foundation Posts

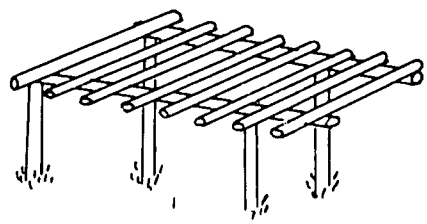
Fourth: Now place two strong beams across the tops of the foundations posts. They should be approximately 200cm in length and 10cm in diameter. The beam overhang should be on the side where the farmer wishes the door of his store to face (see Figure 7.4).

Figure 7.4. Placing Beams on Posts



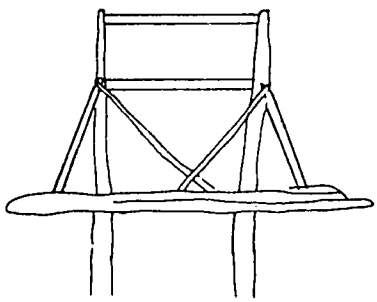
Place sticks across the top to make the platform on which the store will stand. Perhaps most, if not all, of the wood which was taken from the old store can be used to do this, but remember that the wood should be strong. The sticks should be at least 8cm in diameter and 130cm in length (see Figure 7.5).

Figure 7.5 The Platform



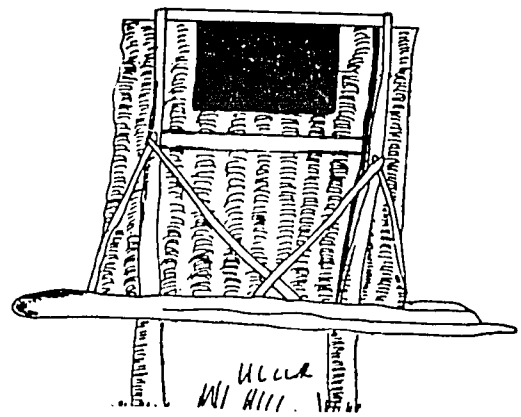
Fifth: Now place the basket on top of the platform. Make sure the door of the basket is facing the overhang of the platform. Now support the basket on all sides. This is done by placing four upright posts around the basket in a box. The posts should be about 15cm taller than the basket. They should be connected together at the bottom, in the middle and at the top, with the bottom being nailed to the platform (see Figure 7.6). These supports will prevent the store from being damaged by strong winds.

Figure 7.6 Supporting the Basket on the Platform.



Box Support (shown without basket)

Fig. 7.6A



Box Support With Basket

Fig. 7.6B

Sixth: Now put the roof on. The roof is very important, so be sure that it is in good condition and that it does not leak. Also, it should not hang over the edge of the granary too much: about 50cm is good. The roof should be tied to the upper part of the basket supports to prevent it from being blown off by the wind.

Seventh: The final step is to place rat guards at the top of each post, just under platform. These should be made from "mabati", old Kimbo tins or debes and should go all the way around the post. They should also extend at least 15cm out from the post. For more information on rat guards, read the following section.

Once the renovation is completed, the basket should look much like the one shown in Appendix Figure 4.

If the farmer needs help in figuring the cost of improving his existing basket or of building any of the other structures shown in this manual, use the form shown in Appendix Form 4 for listing materials and associated costs.

7.5 Installing Rat Guards

At this point we should mention rat guards. Every ground post in either a crib or a raised basket should have a rat guard. These prevent rodents from climbing up the posts and getting into the store.

The rat guards can be made out of old tins or 30 gauge sheet metal. Appendix Figure 6 shows the shape in which to cut the debes, tins or pieces of sheet metal. These are fitted around each lower main post, just under the beams.

If installed correctly and if there are no other pathways for rodents to climb (for example, a jembe left leaning against the store or wood stacked under the crib) rat guards can be 100% effective in preventing rodents from climbing beyond the guards and entering the store.

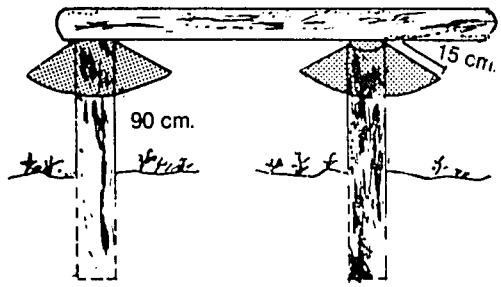


Figure 7.7 Installing Rat Guards

7.6 Drying Trays

An alternative to drying grain inside the store is to have a separate drying tray. There are various structures and methods for drying trays. The simplest is a platform dryer.

This platform dryer, or tray, can be constructed out of various building materials. Examples of a permanent open platform tray and a portable open platform tray are illustrated in Appendix Figures 7 and 8, respectively. In three illustrations and the accompanying bills of materials, Appendix Tables 7 and 8, offcut (slab) wood is utilized. This type of material is sometimes available at local sawmills and would be a reasonably low-cost material. Sawn timber can also be used for the framing. The floor can be filled with offcut timber, sticks, or wire mesh like that used on coffee drying trays.

Open platform trays should be raised a minimum of 60cm off the ground to allow for proper air flow, and the sides should be of about 30cm high. A permanent tray should be protected from rain when in use. (The portable tray boxes can be moved inside or covered in case of rain. They can also be moved inside at night as protection from theft.)

The layer of cob maize should not exceed 20cm. A permanent platform dryer of 1.6m by 2.4m will hold 7 bags of cob maize. This equals around 290kg (3.2 bags) of dry shelled maize.

A portable tray that is 1.2 x 0.7m will hold one bag of cob maize which weighs around 60 kg. Depending upon the amount of maize a farmer has, any number of portable trays can be built, as shown in Appendix Figure 8.

Remember, portable trays should not be so big that they are too heavy for two people to carry. Also, the width of the tray must not exceed the width of the doorway into the house. The tray must pass easily into the house, without tilting or pushing.

Since it takes about 10-15 days to dry maize using open trays, it may be necessary to dry one crop of maize in two or more shifts or build more drying space. Although it requires more labour, the cost is far less than for a drying crib, especially if the maize or other crop is not going to be stored in the structure.

7.7 Stores for Other Crops

The structures shown in this manual can often be used to dry and store other crops. It is economically wise to use the drying and storage capacity for as many months of the year as possible. In a tropical climate when crops are harvested at several times during the year, a diversified farmer should find several uses for his stores.

Of course, these drying and storage structures were designed for maize; other uses, especially drying other crops should be done carefully. Ask the advise of a local grain storage specialist before making recommendations to farmers.

Success in drying crops like sorghum will depend upon the weather conditions at harvest time. Small grains restrictventilation much more than cob maize does, and so a crib or basket should not be filled with high moisture content sorghum. This would otherwise lead to moulding, especially in the center. Also, as the sorghum dries it can shatter, and the floor of the drying structure will need to be lined with mats or gunny bags. Overall, the same general principles apply to many crops:

-keep the crop dry

-protect the crop from insects, rodents and birds.

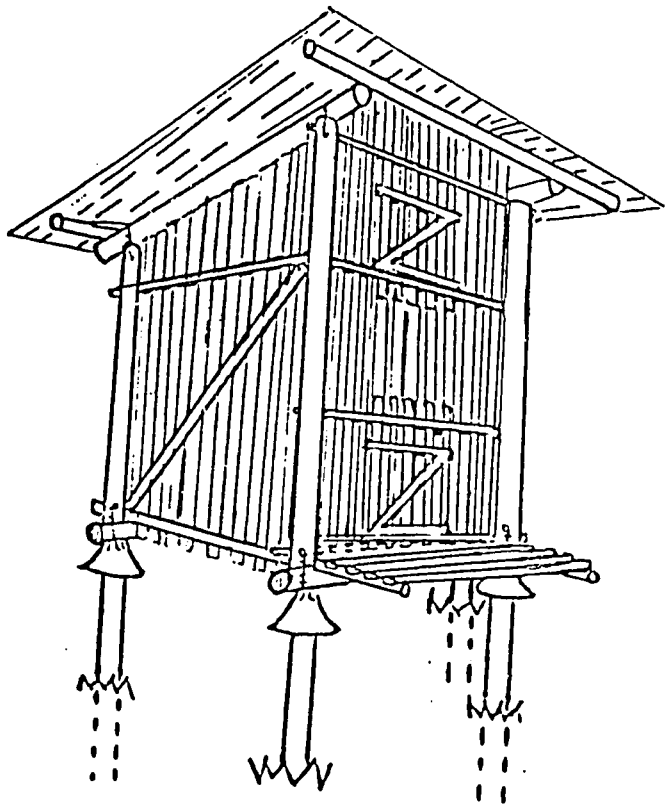
7.8 Summary

Design of storage structures is very important, because even food crops that are often thought of as non-perishable will spoil; if not preserved properly. However, with the proper care, most grains can be kept in storage for many months.

If the farmer is not capable of maintaining the quality of his produce in storage, then he should be encouraged to market it at harvest. It is, however, to his advantage economically to store enough maize both for his family's food needs and for cash income in the following months, when the local market price is at its peak.

Two forms are presented in the Appendix to help you assist individual farmers in their planning process. Appendix Form No.3 is a typical Bill of Materials. Appendix Form No.4 will help you and the farmer to see the materials that may be available on the farm and those that must be purchased.

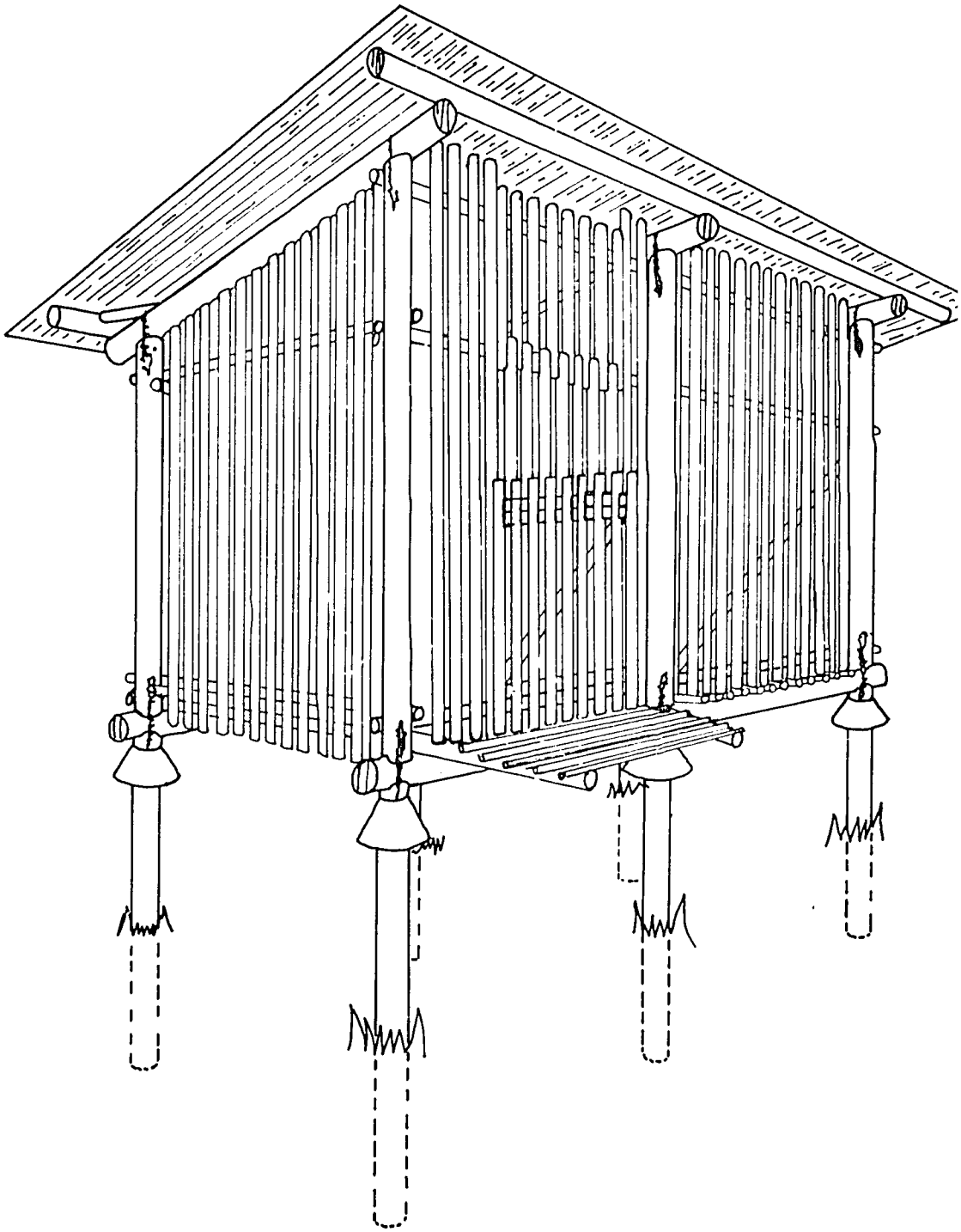
APPENDIX



Appendix Figure 1-- Illustration of a Single-Section Crib

Appendix Table 1--Bill of Materials for Single-Section Crib

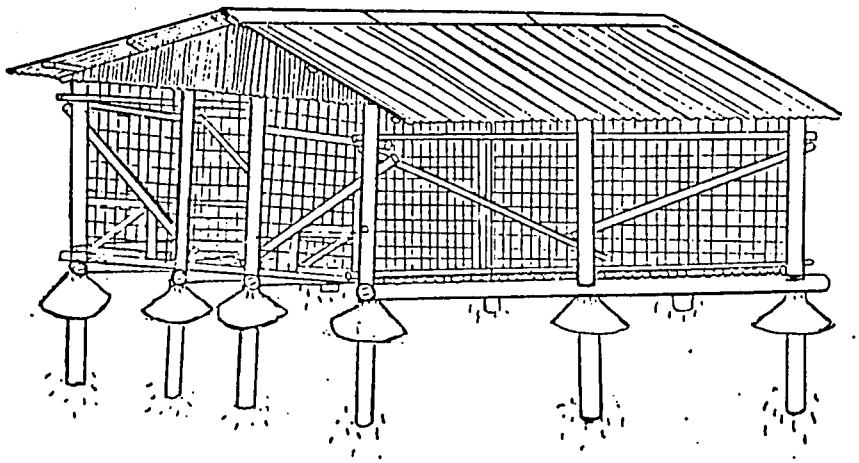
MATERIALS	QTY	SIZE
Lower Main Posts	4	200cm
Beams	2	250cm
Upper Main Posts	4	220cm
Rafters	2	210cm
Wall Sticks (Rear) & floor sticks	8	175cm
Wall sticks (Front) & Gables	80	220cm
Wall Supporters & Purlins	9	400cm
Nails (wire)	2 Kg	2"
"	4 Kg	3"
"	2 1/2 Kg	4"
"	2 Kg	5"
Roofing Nails	1 1/2 Kg	3"
Staples	1 1/2 Kg	1/2"
Plain Sheets	1 Unit	1 x 2 1/2m
Corrugated Iron Sheets	3 Units	2.5m
Reinforcement Wire	1 1/2 Kg	8 gauge
Preservative	2.5 liter	
Labour	4 man-days	



Appendix Figure 2-- Illustration of a Two-Section Crib.

Appendix Table 2. Bill of Materials for a Two-Section Crib

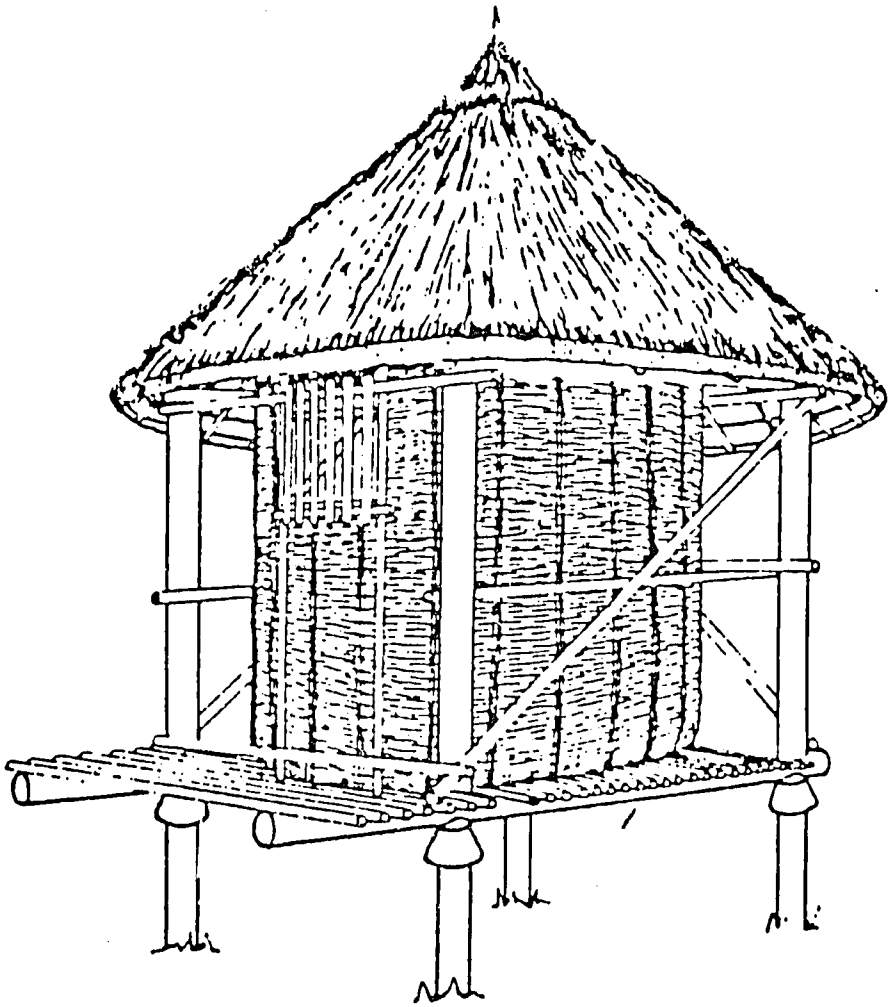
MATERIALS	QTY	SIZE
Lower Main Posts	4	200cm
Beams	2	250cm
Upper Main Posts	4	220cm
Rafters	2	210cm
Wall sticks (Rear) & (Floor) sticks	160	175cm
Wall sticks (Front) & Gables	160	220cm
Wall Supporters & Purlins	9	400cm
Nails	5 Kg	3"
Nails	1 Kg	4"
Nails	1 Kg	5"
Nails (Roofing)	1/2 Kg	
Staples	1/2 Kg	1"
Plain Iron Sheets (30 gauge)	1	1 x 2 1/2m
Corrugated Iron Sheets(30 g)	5	2 1/2m
Reinforcement Wire	3 Kg	8 Gauge
Preservative	5 Litres	
Labour	5 man-days	



Appendix Figure 3-- Illustration of Double-Wide Crib (Four-Section Crib)

Appendix Table 3-- Bill of Materials for Double-Wide Crib (Four-Section Crib)

Description	QTY	DIA	SIZE	GAUGE
Lower main posts	12	13cm	200cm	
Upper main post (front)	6	10	220	
Upper main posts (rear)	6	10	175	
Beams	4	12	350	
Wall supporters	16	8	400	
Floor sticks	80	5	400	
Purlins	8	8	400	
Rafter	6	10	240	
Wall supporters	20	5	400	
Finishing gables	135	5	220	
Finishing side ways	450	5	400	
Wall sticks rear	90	5	175	
Wall sticks gables	90	5	220	
Wall sticks front	90	5	200	
Ridges	3		200	30
Plain sheet	2		200	30
Corrugated iron sheet	10		250	30
Wire (Binding)	6 Kg			8
Plain wire	4 Kg			
Staple	7 Kg			
2-inch nails	20 Kg			
3-inch nails	10 Kg			
4-inch nails	2 Kg			
5-inch nails	2 Kg			
Roofing nails	10 Kg			
Wire mesh	14 pieces (2.4 x 1.2m)			
Aldrex 48	250 ml			
Wood preservative	10 litres			
Labour	12-15 man-days			



Appendix Figure 4--Illustration of a Raised Basket (Grass-Thatched Roof)

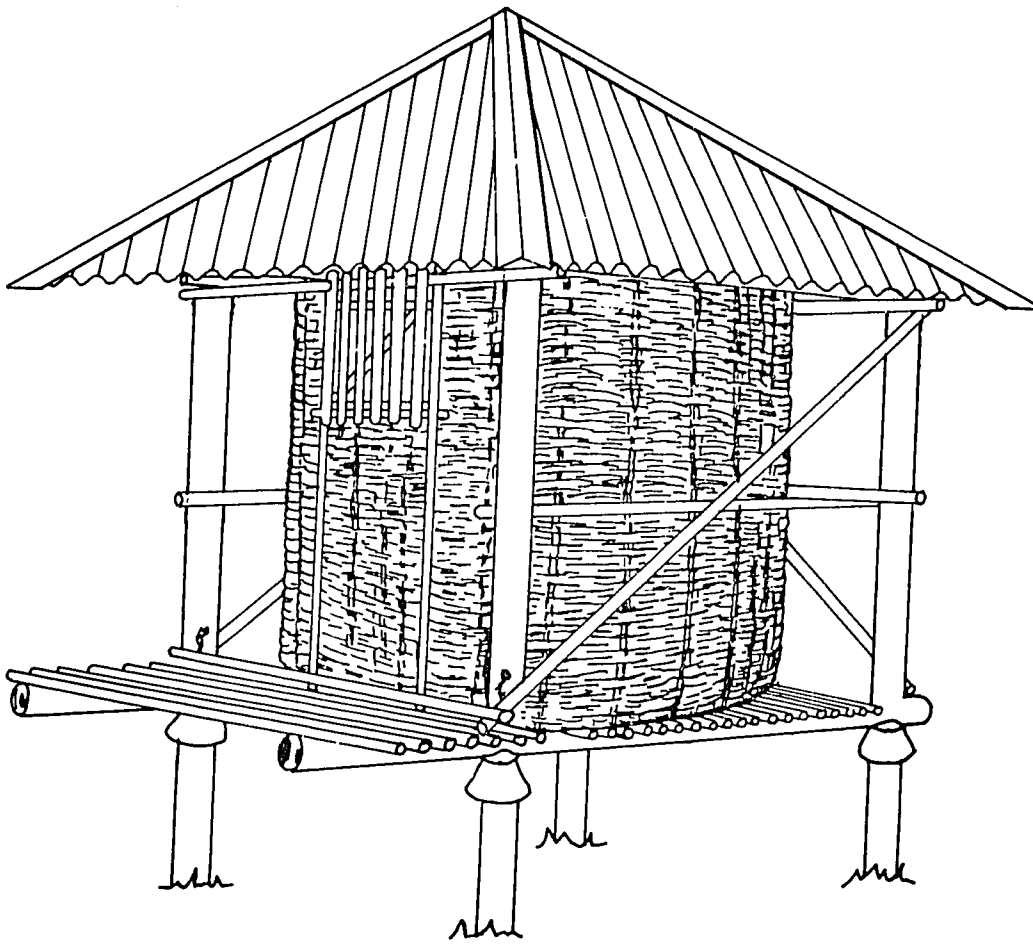
Appendix Table 4-- Bill of Materials for a New Raised Basket (Grass-Thatched Roof)

Description	DIA	QTY	SIZE
Lower main post	12cm	4	160cm
Beams	12cm	2	260cm
Floor sticks	5cm	60	175cm
Upper main posts	8cm	4	175cm
Wall supporters and diagonals	5cm	10	175cm
Purlins	6cm	8	220cm
Rafters	8cm	4	175cm
Floor sticks for front platform	6cm	18	175cm
Nails		3 Kg	3"
Nails		1 Kg	4"
Nails		1 Kg	5-6"
Roofing nails		1 Kg	1"
Corrugated Iron Sheet (30 gauge)		4	2 1/2 x 1m
Plain sheet (30 gauge) for rat guards		1	2 x 1m
Roof Ridges (30 gauge)		4	1m
Binding wire		13.5m	
Basket	1.5m	1	1.75m high
Preservative		2.5 litres	
Labour		4 man-days	

Appendix Table 5 -- Bill of Materials for Raised Existing Basket (Renovation)

Description	DIA	QTY	SIZE
Lower Main Post	12cm	4	200cm
Beams*	12cm	2	274cm
Floor sticks*	5cm	45	175cm
Nails			
		1/2kg	2"
		1/2kg	3"
		1kg	4"
		1kg	5"
Plain sheet (rat guards)(30 gauge)		1	1 x 2m
Roofing-Thatch		4 bundles	
Preservative		1.5 litres	
Labour		3 man-days	

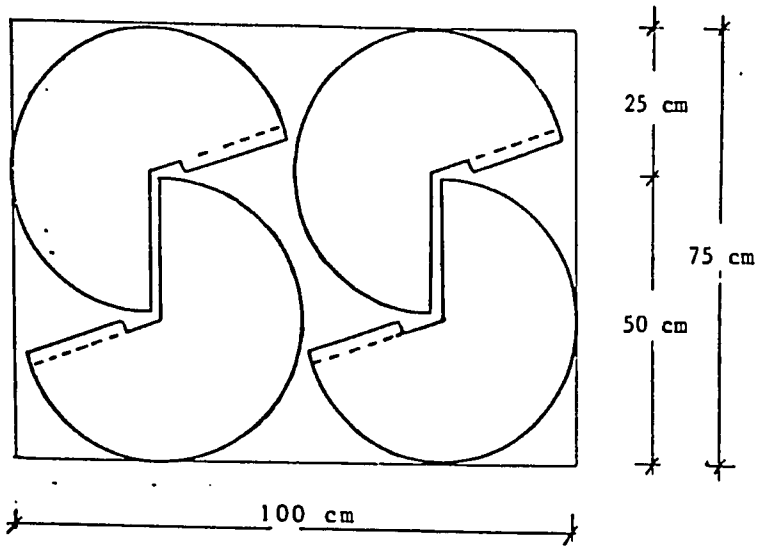
*Note: Quantities needed will vary depending on condition of materials salvaged from old granary.



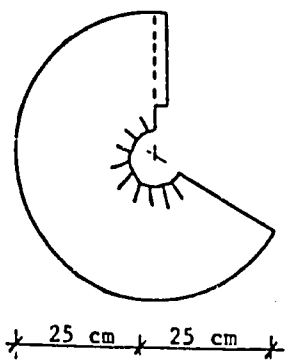
Appendix Figure 5 - Illustration of a Raised Basket (Iron-Sheet Roof)

Appendix Table 6— Bill of Materials for New Raised Bask (Mabati Roof)

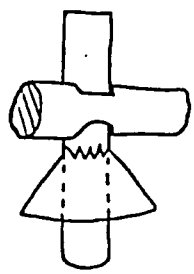
Description	DIA	QTY	SIZE
Lower main post	12cm	4	160cm
Beams	12cm	2	260cm
Floor sticks	5cm	60	175cm
Upper main posts	8cm	4	175cm
Wall supporters and diagonals	5cm	10	175cm
Purlins	6cm	8	220cm
Rafters	8cm	4	175cm
Floor sticks for front platform	6cm	18	175cm
Nails		3Kg	3"
Nails		1Kg	4"
Nails		1Kg	5-6"
Roofing nails		1Kg	
Corrugated Iron Sheet (30 gauge)		4	2 1/2 x 1m
Plain sheet (30 gauge) for Rat Guards		1	2 x 1m
Roof Ridges (30 gauge)		4	1m
Binding wire		13.5m	
Basket	1.5m	1	1.75m high
Preservative		2.5 litres	
Labour		4 man-days.	



PATTERN OF CUTTING OUT THE RAT GUARDS FROM AN IRON SHEET

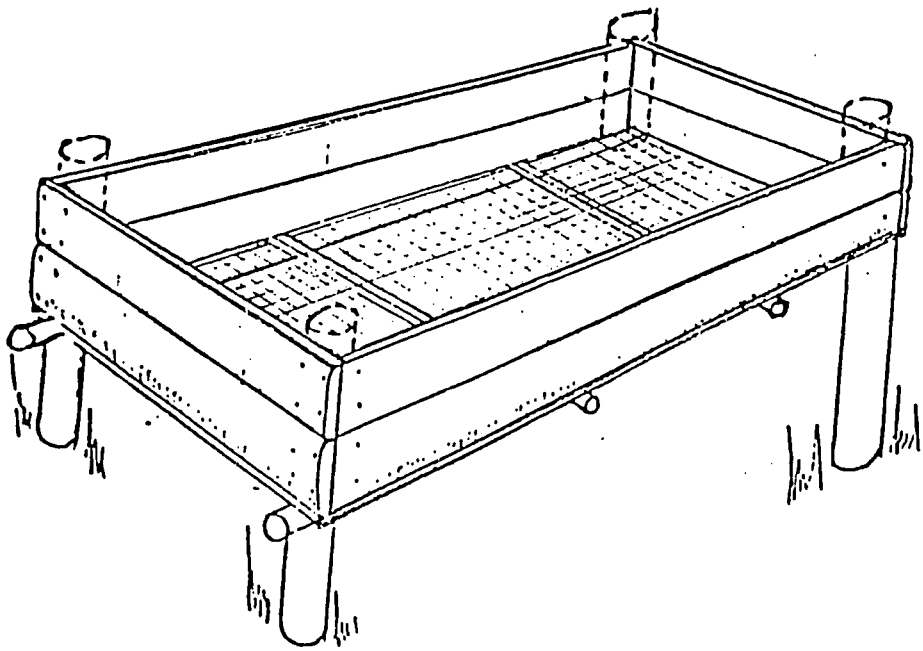


MEASSUREMENT



CONNECTION AT THE MAIN POSTS

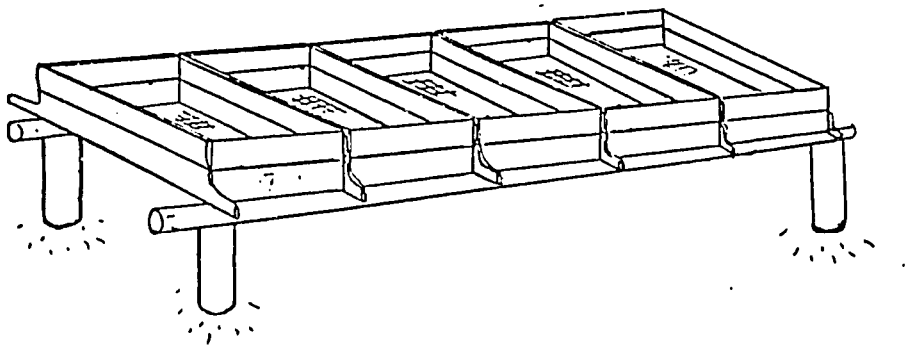
Appendix Figure 6— Illustration of Rat Guards with Dimensions



Appendix Figure 7 -- Illustration of a Permanent Platform Dryer

Appendix Table 7 -- Bill of Materials for a Permanent Platform Dryer

Description	DIA.	QTY.	SIZE
Ground Posts			
Front	10cm	2	1.50m
Back	10cm	2	1.30m
Beams	8cm	2	2.50m
Tray corner posts	6cm	4	0.40m
Tray sides (offcuts)			
Long		4	2.40
Short		4	1.50
Floor offcuts or boards		10	1.70
or wire mesh		1	1.6x2.4m
Hardware			
2" nails		1/2 Kg	
3" nails		1/2 Kg	
1/4 nails		1/4 Kg	
Preservative		1 litre	
Labour		2 man-days	



Appendix Figure 8 -- Illustration of a Portable Open Tray Dryer

Appendix Table 8 -- Bill of Materials for a Portable Open Tray Dryer.

DESCRIPTION	DIA.	QTY.	SIZE
Ground Posts			
Front	10cm	3	1.3m
Back	10cm	3	1.5m
Beams	8cm	2	3.0m
Tray corner posts	5cm	4	0.30m
Tray sides (offcuts)			
Long upper		2	1.30m
Long Lower-Handle		2	1.70m
Short		2	0.70m
Floor			
Floor support	5cm	2	0.80m
Floor (offcuts or boards)		4	1.25m
(wire mesh)		5	0.7 x 1.2m
Hardware			
2" nails		1/4	kg
2 1/2" nails		1/4	kg
Preservative		1 litre	
Labour		2 man-days	

Appendix Form No. 1

INSPECTION OF STORED MAIZE QUALITY

Farmer's Name _____ Location _____ Type of Store _____ Date Filled _____

Date of Inspection 1/	Kernels in Sample (No)	Number of Kernels Damaged					Percent Damaged 2/	Estimated % Weight Loss	
		Bored	Rotted	Broken	Germinated	Total		% Bored 3/	Col. I x 0.125
A	B	C	D	E	F	G	H	I	J

1/ Select farmer to be monitored and sample, preferably monthly, from date store is filled.
2/ Number Damaged Divided by Total Number in Sample (G/B x 100) = % Damaged.
3/ $\frac{\text{Number of Bored Kernels} \times 100}{\text{Total Number of Kernels in Sample}}$ = Bored Grains in Sample

Appendix Form No.2

COMPARATIVE LOSSES CHART

	TRADITIONAL BASKET TYPE	IMPROVED BASKET	TRADITIONAL RECTANGULAR	IMPROVED CRIB
FIELD LOSSES %				
Value (Kshs.)				
STORAGE LOSS % (Weight)				
Value (Kshs.)				
STORAGE LOSS % (Quality)				
Value (Kshs.)				
REDUCED VALUE OF STOVER FOR FEED				
Value (Kshs.)				
COMPARATIVE LOSSES (ANNUAL)				
GAIN OVER TRADITIONAL				
COSTS Cost of new store				
Cost of modifying old store				

Table to demonstrate economic gains of adopting recommended storage practices and structures. Use a flip chart and felt-tip pen if addressing a group.

Appendix Form No.3

BILL OF MATERIALS

Type of Structure: _____ Farm: _____

Date: _____

MATERIALS	QTY	DIA.	SIZE OR LENGTH	GAUGE
Wood				
Hardware				
Other				
Labour				

Appendix Form No.4

MATERIALS AVAILABILITY 1/

Type of Structure: _____ Farmer: _____

Date: _____

List of Materials	Materials Available On Farm	Materials to be Purchased	Cost of Items to be purchased

1/ Use this form along with the Appendix Form No.1

Make a complete list of materials needed to improve or build a storage structure, then tick (-/) whether the farmer has the material or must purchase it. Finally, the costs of the items to be purchased.